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The catch and trade of seahorses in the Philippines post-CITES

Institute for the Oceans and Fisheries,
The University of British Columbia, Canada

The catch and trade of seahorses in the Philippines post-CITES
Project Seahorse and the Zoological Society of London-Philippines

A report on research carried out in collaboration with
the Philippines Bureau of Fisheries and Aquatic Resources

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Director's Foreword

UBC's Institute for the Oceans and Fisheries takes pride in contributing original research to help address policy questions of importance to regions, nations and the world. Our vision is a world in which the ocean is healthy and its resources are used sustainably and equitably. We generate notable and effective input into policy questions that include fisheries management, trade regulation, habitat recovery, protected area designation, and climate change amelioration.

One of our valuable contributions to policy change came when Project Seahorse* supported the Convention on International Trade in Endangered Species of Wild Fauna and Flora (www.cites.org) to begin regulating export of marine fishes of conservation concern. In 2002, for the first time since the inception of the Convention in 1975, CITES agreed to place marine fishes on Appendix II. Exports of such species are only permitted when they do not damage wild populations, when they are legally sourced, and, for live animals, when they are humanely transported. CITES had seen considerable vigorous debate on adopting such provisions for marine fishes so it was remarkable when Project Seahorse's pioneering work on seahorses led to them being added to Appendix II, along with whale sharks and basking sharks.

The Philippines is a global marine biodiversity hotspot and home to 10 seahorse species. Project Seahorse has been monitoring seahorse populations in the Philippines since the 1990s and discovered that millions of seahorses were exported annually, dried or live. Unfortunately, the Philippines has not implemented CITES for Appendix II listed marine species (including seahorses) since 1998, when its Fisheries Code banned the extraction of any Appendix II listed marine species. However, we know from Project Seahorse field visits and surveys among importers in other countries that fisheries and trade for seahorses from the Philippines has continued illegally without monitoring or regulation. Four years ago, the Philippines revised its Fisheries Code and brought into force new law-making provisions for legal catch and trade in Appendix II species, once authorities have set the terms for sustainable exploitation. These revised regulations provide an opportunity to manage seahorse fisheries for sustainability.

This report covers new trade surveys and analyses by Project Seahorse. This vital updated knowledge about seahorse biology, fisheries and trade will provide the baseline on which to build a plan for sustainable exploitation and trade in the Philippines. Through consultation with the Philippines government and other experts, this information will contribute to improved management of seahorses in the Philippines, to a level where wild populations can tolerate carefully monitored and regulated catch and exports.

I congratulate the authors on this important work, which will support sound ocean management to the benefit of fish and fishers alike.

Evgeny Pakhomov
Director, Institute for the Oceans and Fisheries

* Project Seahorse is a partnership between UBC and the Zoological Society of London, UK. Its vision is a world in which marine ecosystems are healthy and well-managed. At UBC, Project Seahorse work is led by its co-founder and director, Professor Amanda Vincent. Her team of students and staff are engaged in marine research and management around the world, using seahorses as a way to focus efforts in finding marine conservation solutions in a context of sustainable use. They are committed to interdisciplinary collaboration with stakeholders and partners at scales ranging from community initiatives to international accords.

Abstract

The Convention on International Trade in Endangered Species of Wild Fauna and Flora decided to implement export controls for all seahorses in 2002 to ensure international trade is sustainable, legal and monitored. The Philippines, however, has not implemented the listing because their domestic Fisheries Code banned the extraction of any CITES listed marine species, including seahorses, since 1998. Exploitation continued nonetheless – field visits and surveys among importers in other countries revealed that fisheries and trade for seahorses continued illegally without monitoring or regulation. The revision of the Fisheries Code four years ago has provided renewed opportunity, however, to manage seahorse fisheries and trade for sustainability. Filipino Authorities are now in need of information that would allow them to develop a seahorse management plan, re-open legal fisheries and trades in a precautionary manner, and subsequently monitor and manage them in support of sustainable populations. In order to generate vital knowledge in support of this plan, we gathered information on the biology, fisheries, and trade of seahorses in the Philippines by conducting 268 interviews with fishers and traders across seventeen coastal provinces from May to July 2019.

Fishers reported catching seahorses from ten different types of fishing gear, some of which targeted seahorses (spear/skin divers, compressor divers, micro-trawls, push nets, and gleaners) and others which captured them incidentally in pursuit of other targets (gill nets (bottom), gill nets (floating), otter trawls, fish traps, and seines). The most commonly reported gear type was spear/skin diving. Mean catch per unit effort varied among gear types from fewer than one seahorse per day per gill net (bottom and floating), otter trawl and fish trap, to between one and ten seahorses per day for gleaners, spear/skin divers, compressor divers and fish nets, to as high as 100 seahorses per day per micro-trawler.

Scaling up catch rates (CPUE) to annual catch estimated a total national catch of ~1.7 million individual seahorses per year across the gear type/province combinations for which we had sufficient data. Compressor fishers were estimated to catch more than all other gear types combined, landing approximately 913,000 seahorses per year (54% of the total estimated catch), more than micro-trawls (~260,000 individuals), push nets (217,000 individuals) and spear/skin divers (~214,000 individuals) combined. The provinces of Iloilo, Masbate, Sulu, Bohol and Palawan together accounted for over 80% of our total national catch estimate, each landing between ~222,000 and ~359,000 individuals per year.

Our interviews with 31 buyers across ten provinces produced only limited quantitative information on purchase and sale volumes of seahorses in trade, but can infer that the majority of seahorse catches were dried and destined for export – we found very little evidence of live trade or domestic use. Buyers in the northern province of Pangasinan reported purchasing the largest number of seahorses per year. Seven different seahorse species were identified in trade (*Hippocampus barbouri*, *H. comes*, *H. histrix*, *H. kelloggi*, *H. kuda*, *H. spinosissimus* and *H. trimaculatus*), with *H. comes* and *H. kuda* comprising nearly two-thirds of specimens we surveyed. Buyers reported selling seahorses for between three and five times the price they paid fishers to acquire them; the median buying price per seahorses was USD 0.58, and the median selling price was USD 460 per kilogram or USD 2.30 per individual.

Ninety-eight percent of fishers reported a decline in seahorse catch over time, and spear/skin divers in Bohol and Surigao del Norte reported a decline in seahorse CPUE of 86% over a twenty-year period and 98% over a thirty-year period, respectively. Other indicators of conservation concern included highly skewed sex ratios across all species (more females than males); the proportion of males observed to be

pregnant (about half of *H. barbouri* and more than half *H. kuda* males); and, for *H. kuda*, the mean size of sampled individuals was smaller than the species size at maturity.

Our surveys indicate that the Philippines is not fully implementing CITES regulations: none of the seahorse catch was being monitored or regulated to any extent to assess sustainability, and exports of dried seahorses were occurring illegally without CITES permits. For the Philippines to make progress in conserving seahorses it needs to pay attention to their fisheries, trade and conservation. The results of this study can be used to set the initial terms for sustainable exploitation under the revised Fisheries Code, terms which can be revised as more is learned in an adaptive management framework. The road map is there, the tools are in place, and the protocols are available to make considerable progress.

Introduction

Seahorses (*Hippocampus* spp.) are among the most distinctive and charismatic of fishes, with their male pregnancy, long-term pair bonds, and capacity for camouflage (Foster and Vincent 2004). They are also subject to enormous pressures from directed fishing, nonselective fishing gear (especially trawls) and degradation of their seagrass, mangrove and coral habitats (Vincent *et al.* 2011). These quirky animals are heavily traded for aquarium display, traditional medicines and curios (Vincent *et al.* 2011). Of the 42 seahorse species included on the IUCN Red List, 32 are listed as Endangered, Vulnerable, Near Threatened or Data Deficient (www.iucnredlist.org).

The vast scale and apparently detrimental effects of the global trade in seahorses led to all seahorse species (*Hippocampus* genus) being added to Appendix II of the Convention on International Trade in Endangered Species (CITES) in 2002 (with implementation in 2004) (www.cites.org). Such a listing obliges 182 member countries and the European Union to ensure that exports do not damage wild populations and are legally sourced.

The CITES Appendix II listing requires Parties to make Non-Detriment Findings – essentially promising that international trade will not damage wild populations – before granting export permits (Foster and Vincent 2016). Some Parties have moved well on this, other Parties have encountered difficulties and are under CITES review, and a third set of Parties has not yet implemented CITES listings for diverse reasons (IUCN 2016a,b). As such, they have no experience regulating exports at sustainable levels. The Philippines is among the countries that fall into the third group.

The Philippines, home to ten species of seahorse, has historically been a dominant source of these fishes in international trade, to an extent that raised serious conservation concerns (Pajaro and Vincent 2015; and as reviewed in Foster and Apale 2016). Field surveys, carried out at the start of this century, estimated that 5 million seahorses (range 2-8 million) were exported annually, ~4 million dried (for traditional medicine) and ~1 million live (for ornamental display) (Pajaro and Vincent 2015).

Almost all of these seahorses were obtained in the small-scale fisheries that engage 90% of Filipino fishers (via free/compressor diving and scoop/push nets), but some were also caught in non-selective fishing gears including trawls, beach seines, and push nets. Project Seahorse research revealed that no fisher reported relying on seahorses as their sole source of income, but these fish may contribute important amounts to their small overall earnings (Vincent 1996; Meeuwig *et al.* 2006; Pajaro and Vincent 2015; Yasue *et al.* 2015).

All available evidence suggested that seahorse fisheries were having a detrimental impact on seahorse populations. Project Seahorse research indicated declines in populations of seahorses from direct exploitation and incidental catch of up to 95% over a ten-year period (Pajaro and Vincent 2015; and as reviewed in Foster and Apale 2016). Fishers implicated overfishing, increased competition from more fishers and indiscriminate catch of seahorses in non-selective gear for the declining catches (Martin-Smith *et al.* 2004). Fishers interviewed for an FAO study carried out in 2007 also reported a decline in seahorse abundance and attributed it primarily to an increase in the number of seahorse gatherers, in turn attributed to increased seahorse prices (Christie *et al.* 2011).

The Philippines has not implemented CITES for Appendix II listed marine species, including seahorses, since 1998. Its domestic Fisheries Code from that year banned even the extraction of any Appendix II listed marine species, whereas CITES actually has no direct role in regulating take or domestic trade (as reviewed in Foster and Apale 2016). We know, however, from field visits and surveys among traders in other countries that fisheries and trade for seahorses continued illegally without monitoring or regulation (e.g. O'Donnell *et al.* 2010, 2012; Christie *et al.* 2011; Foster *et al.* 2019). The most recent evidence for ongoing trade comes from our work in Hong Kong SAR, the largest entrepôt for dried seahorses, in 2016-17 (Foster *et al.* 2019). Our 220 interviews with traders produced many reports of imports from countries with bans on seahorse exports, most notably Thailand and the Philippines. Illegal fishing has likely continued because there has been little enforcement, seahorses commanded a high price on the international market and fishers have few alternative sources of income (Christie *et al.* 2011; O'Donnell *et al.* 2012).

The door may be re-opening on legal and sustainable seahorse fisheries and trade in the Philippines. The Philippines Fisheries Code was revised four years ago to address illegal, unreported and unregulated (IUU) fishing in the Philippines, and also strengthen protection of endangered marine species and critical conservation areas, based on the precautionary principle and an ecosystem-based approach to fisheries management. In revising the Fisheries Code, the Philippines brought into force new law-making provisions for legal take and trade in Appendix II species, once Authorities have set the terms for sustainable exploitation (Foster 2016). The revised regulations provide an opportunity to manage seahorse fisheries sustainably, benefiting both fishes and fishers.

Filipino Authorities are now in need of information that would allow them to develop a seahorse management plan, re-open legal fisheries and trades in a precautionary manner, and subsequently monitor and manage them in support of sustainable populations. An end to the ban should be used to demonstrate that CITES can be an effective tool for fish conservation and fisheries sustainability while supporting local livelihoods. Unfortunately, the information required to set the terms for sustainable seahorse exploitation – information on seahorse exploitation and trade in the Philippines – is nearly two decades old; the last trade surveys were carried out in the early 2000s (Pajaro and Vincent 2015).

This research responds to the urgent need for an updated national assessment of seahorse fisheries and trade as a vital first step toward CITES implementation under the new law. Updated surveys will support national Authorities to (i) evaluate change since the late 1990s, (ii) set a baseline for new monitoring programmes, and (iii) develop a targeted management response to unsustainable exports.

Methods

Study overview

Information for this study was obtained by (a) interviewing a wide array of people associated with seahorse exploitation in the Philippines, (b) documenting and measuring seahorses in trade, and (c) accessing existing but overlooked data sets. To spot shifts and trends, we compared the new field results with earlier Philippine trade surveys, official data from other Parties, and CITES data held by UNEP-WCMC.

Interviews

To capture information on seahorse biology, fisheries, and trade in the Philippines we conducted interviews with fishers and traders from March to July 2019. Most interviews were carried out in local Filipino or Cebuano languages by two Filipino biologists trained in seahorse trade study protocols. The senior biologist had worked with partner organization Zoological Society of London Philippines (ZSL-Philippines) for at least 15 years, and both biologists had previous experience in seahorse fisheries dependent (catch landing) and independent (underwater) surveys in the Philippines. Interviews in the island/province of Sulu were completed in July by ZSL-Philippines colleagues from the FishCORAL Project. In total, the trade researchers conducted interviews across 17 provinces spanning 29 municipalities in the Philippines (Figure 1; Table 1). Ethics clearance for the interviews was obtained from the University of British Columbia (permit H12-02731), based on Canada's national standards.

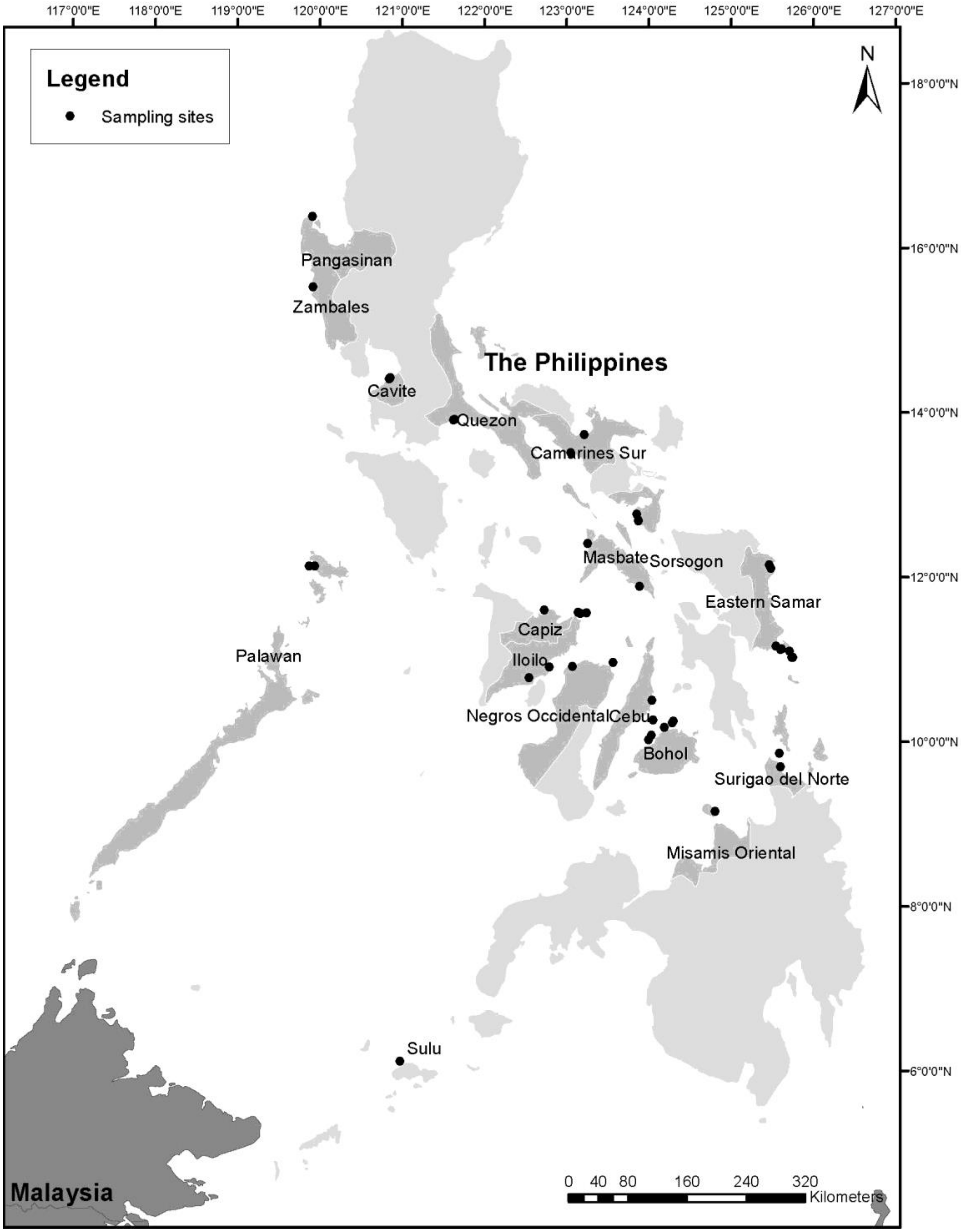

Figure 1. Locations of municipalities across the Philippines where interviews with seahorse fishers and traders were carried out from March to July 2019.

Table 1. The number of fishers and buyer interviews used in our analysis of seahorse exploitation and trade across seventeen provinces in the Philippines from March – July 2019. Locations organised from north to south.

Province	Fishers	Buyers	Total
Pangasinan	1	1	2
Zambales	6	0	6
Cavite	7	0	7
Quezon	11	2	13
Palawan	15	1	16
Camarines Sur	8	0	8
Sorsogon	21	0	21
Masbate	15	7	22
Eastern Samar	28	6	34
Capiz	7	3	10
Iloilo	23	2	25
Negros Occidental	18	1	19
Cebu	10	3	13
Bohol	44	5	49
Surigao del Norte	9	0	9
Misamis Oriental	4	0	4
Sulu	10	0	10
Total	**237**	**31**	**268**

Survey areas were selected based on previous trade surveys completed in the late 1990s and early 2000s by Vincent (1996) and Pajaro and Vincent (2015), and supplemented by research knowledge on seahorse exploitation carried out by the Project Seahorse team over the last 20+ years (as reviewed in Foster and Apale 2016). For fishers and traders, we focused our efforts on (i) fishing ports, communities or villages and (ii) larger communities and cities where they are bought, sorted and sold for international export. A total of 323 respondents were interviewed including 284 fishers across 29 municipalities in 17 provinces, and 39 traders across 15 municipalities in ten provinces (Figure 1). The vast majority of interviews generated usable information; our analyses are based on the information provided by 237 fishers and 31 buyers (Table 1).

Fishers and traders were located through a combination of haphazard sampling (e.g. of fishers at landing sites) and snowball sampling (where first leads guided us to other sources of information; Gubrium and Holstein 2002) for respondents who were more difficult to locate, such as seahorse buyers and exporters. Interviews were semi-structured and triangulation was used to cross-validate information received by (i) asking the same questions in three different ways within an interview and (ii) comparing the answers within and among interviews, at the same trade level and region (i.e. municipality/province).

Seahorses generally follow trade routes beginning with lower-level traders (e.g. fishers and primary buyers), through intermediate-level traders (e.g. secondary buyers), to upper-level traders and finally exporters. Our study focussed on obtaining reliable information from fishers and lower-level buyers. Participants in the seahorse trade were categorized according to their roles (e.g. fisher, buyer or exporter).

Lower-level buyers we interviewed included primary buyers who bought exclusively from fishers typically located within their home province. We were unsuccessful in finding exporters that reported present day seahorse trading. We interviewed two that reported exporting seahorses in the past, but have not included them in our analysis.

Catch information and analyses

Fishers were asked to describe their fishing activities and seahorse catches. For fishing activities, they were asked about the gear types used and typical fishing duration per day, trip, month and/or year. For seahorse catches, fishers were asked to identify the gears they used that caught seahorses, the number and frequency of seahorse catch, the seasonality of catch and changes in seahorse catch over time. Fishers were given the opportunity to report seahorse catch by day, fishing trip, week, month or year. All fishers reported catches as number of individuals caught. Not all fishers answered all questions, so sample sizes vary across types of information used for our analyses.

Determining catch per unit effort

Information from individual respondents on catches were provided for discrete time periods (i.e. per day, fishing trip, week, month or year). These were then standardized to a daily catch per unit effort, CPUE, of number of seahorse gear^{-1} day^{-1}, where gear is the unit of effort appropriate to the fishing method being used (see box A for gear descriptions and units of effort). When fishers provided a range for their seahorse catch or number of days fished we used the median of the minimum and maximum values to calculate their CPUE and number of days fished, respectively.

Fishers were asked about the seasonality of their catches – the months when annual periods of high and low catch volumes began and ended and the frequency of seahorse catch during those periods. We accounted for seasonality of catches, where it was reported, in our calculations of CPUE [e.g. CPUE = (proportion of the year for average season * CPUE average season) + (proportion of the year for high season * CPUE high season) + (proportion of the year for low season * CPUE low season)].

Catch rates were summarised for individual provinces and/or gear types by calculating the median, and we used quartile 1 (Q_1) and quartile 3 (Q_3) to describe the range of CPUE values across fishers within a province and/or gear type.

Determining per gear annual catch

For each fisher, we scaled up their CPUE (seahorses gear^{-1} day^{-1}) to their annual catch (seahorses gear^{-1} year^{-1}) as follows. First, we scaled up their CPUE to catch per week, using their reported number of days fished per week (catch day^{-1} * days week^{-1} = catch week^{-1}). We then scaled their weekly catch to annual catch (seahorses gear^{-1} year^{-1}) using their reported number of weeks fished per year (catch week^{-1} * weeks year^{-1} = catch year^{-1}). We converted months to weeks using a conversion value of 4.34 weeks per month and applied this across all fishers.

Per gear annual catches were summarised for individual provinces and/or gear types by calculating the median, and we used quartile 1 (Q_1) and quartile 3 (Q_3) to describe the range of annual catch values across fishers within a province and/or gear type.

Determining total catches

Estimates for total annual catch for each gear type in each province were extrapolated by multiplying the gear and province-specific per gear annual catch by an estimated total number of gears across each municipality we visited in each province, where such data were available. In order to provide a measure of variation in total catch, we extrapolated from each of the median, Q_1 and Q_3 of the per gear annual catch.

Take spear/skin divers in Bohol, for example. For each municipality visited in Bohol, the estimated median total annual catch across all spear/skin divers = median per gear (i.e. fisher) annual catch across the four municipalities we visited in Bohol * number of gears (i.e. spear/skin divers) across the four municipalities we visited in Bohol.

Scaling up from per gear annual catch to a total catch by gear and province required estimates of the number of gear types being used in each municipality we visited. For spear/skin divers, compressor fishers, push nets, and gleaning we used estimates of the number of individual fishers employing these gears or methods (see box A). Although compressor fishers generally operate with 4-6 people in a boat, we used the number of fishers as opposed to the number of boats as the unit of effort, as the fishers we interviewed reported their individual seahorse catches. For bottom set gill nets, floating gill nets and seines we used estimates of the number of gears, and for otter trawls we used estimates of the number of vessels (see box A). We did not find an estimate of the number of fish traps operating in any municipality in the Philippines and so could not scale up per gear annual catches into a total catch estimate for this gear type.

Statistics on the number of gears (e.g. fishers, traps, nets, boats, as appropriate to the gear type) within each municipality were obtained from our own interviews or from fisheries statistics data. Fisheries statistics data was obtained from the Philippine Rural Development Program (PRDP) final report on Resource and Social Assessment for Resources Management in Bohol (PRDP 2016) and from the FISH RIGHT program (NFR-ZSL 2018). The FISH RIGHT program was implemented by a consortium in the Philippines, involving the Non-Governmental Organization for Fisheries Reform (NFR) and the Zoological Society of London. The program documented fishing boat and gear inventories (FGI) for Capiz and Iloilo in 2018. When using FGI data for spear/skin divers in Iloilo and Capiz, we used the total number of fishers documented under the categories of hand spear, spear gun, spear gun with lights and diving with handpicking. Similarly, for compressor fishers in Iloilo and Capiz, we combined the categories of diving with compressor and spear with compressor. For seine nets, we only used numbers provided for Danish seines as those are what our fishers reported using. In general, the numbers provided by FISH RIGHT matched closely to numbers reported by fishers in our interviews, but where discrepancies arose we favoured the inventory data provided by FISH RIGHT.

We only scaled up to total catch using municipalities for which our study had generated a catch estimate; we did not assume gears caught seahorses in municipalities for which we had no evidence. We further only scaled up to total catch using municipalities for which we had an estimated number of gears. As such, our total values likely underestimate the total seahorse catch in each province – as not all municipalities or gear types are included.

Missing information

Missing or unavailable information was dealt with as follows:

- **Fishing effort (number of days, weeks or months fished) for high/low season**: Where fishers reported high and/or low season catches, but did not report high and/or low season effort (i.e. the number of days fished), we used the mean number of days fished for high and/or low season reported by fishers using the same gear in the same province as a proxy.
- **Duration of high/low season**: When individual fishers reported high and/or low season catches, but did not report the duration of the seasons, we used the mean number of weeks/months for high and/or low season reported by fishers using the same gear in the same province as a proxy.
- **Catch in average season**: If a fisher did not report their catch during the average season but reported catches for the high and low seasons, the average season catch was assumed to be the median of the low and high season seahorse catches.
- **Number of days fished per week**: If a fisher did not report the number of days fished per week, we used the mean number of days fished by fishers using the same gear in the same province as a proxy.
- **Number of weeks or months fishes in a year**: Most fishers did not report the total number of weeks or months fished in a year (n=199 of 237). Those that did provide this information reported a median of ten months fished per year (n=38). This translates to 43.4 weeks in a calendar year. This number was applied to all fishers that did not provide specific information on the number of weeks fished per month or per year. Seasonality of seahorse catch (low and high season) was reported in months but converted to weeks for ease of calculation.

Trade information and analyses

Species

Seahorse species and sizes in fisheries/trades were obtained by taking photos of specimens held by buyers and fishers. Photos of specimens were documented alongside a ruler for calibration. Fishers were not asked and did not report species caught by their known Latin or common names.

Measurements and life history information were processed from the photographs to determine species, size, sex and male reproductive status. Seahorse species were identified with reference to Lourie *et al.* (2004). Seahorse size was measured as height – from the tip of the tail to the top of the coronet (Lourie *et al.* 1999), using ImageJ software (Schneider *et al.* 2012). Sex was determined by the presence of the brood pouch on male seahorses, and reproductive status of males (i.e. whether pregnant or not) was determined by the presence of a swollen brood pouch (Lourie *et al.* 2004).

Trade

All traders interviewed were asked how many seahorses they bought per day or per month, and whether those seahorses were traded dry or live. Traders were free to report their collection metrics in either number of individuals, grams or kilograms. All estimates were converted into number of individuals, using a conversion factor of 300 seahorses per kilogram, based on trader reported numbers from our interviews. Information obtained was summarized by province being careful to obtain information on throughputs – akin to trade rates – rather than standing stock.

Daily per buyer purchase and sell volumes were calculated for each province where information was available. When buyers provided a range for the number of seahorses purchased or sold, we used the median of the minimum and maximum values to calculate the median number of seahorses bought/sold buyer^{-1} day^{-1}. We scaled up daily purchase and sell volumes to an annual estimate per buyer by province.

Specific information on the days per week or months per year spent in trading activities was not provided, therefore, it was assumed that traders work five days per week and 12 months per year. Daily per buyer purchase/sell volumes were multiplied by the number of days acquiring seahorses per month and the number of months acquiring seahorse per year to obtain an estimate of annual per buyer purchase/sell volumes. Annual per buyer purchase/sell volumes were summarised for individual provinces by calculating the median and Q_1 and Q_3 of annual purchase volumes across buyers within a province.

Reported information from traders on buying and selling prices for seahorses were summarized by province and overall. All prices were converted from the Philippine peso (PHP) into United States dollars (USD) using average rates of exchange from the times of the surveys based on mid-point values from Oanda.com (https://www1.oanda.com/currency/converter/). Prices were reported by weight and by number.

Seasonality

Fishers and traders, in response to questions about seasonality of catch, reported the months when annual periods of high and low catch volumes began and ended. Fishers' responses were organized by month to determine whether there were any patterns of seasonality of catch. The limited information provided by traders was summarized and compared to the high and low seasons reported by fishers per province.

Changes over time

During interviews, fishers and traders were given the opportunity to comment on changes over time of the number of seahorses in their catch or trade. We summarized these changes by province and/or by gear type where information was provided. When sufficient historical information was provided on seahorse catch and fishing effort for a particular gear type, we calculated the median CPUE (seahorses $gear_{-1}$ day_{-1}) and per gear annual catch for the time period specified by the fishers. Historical catches were compared to current reported catches. Calculations for CPUE and annual catch followed the same methods as those described above under the Catch information and analyses section.

Other trade datasets

Other key sources of information came from Customs Data from foreign jurisdictions, and CITES trade statistics derived from the CITES Trade Database, UNEP World Conservation Monitoring Centre, Cambridge, UK (UNEP-WCWC 2018). Available post-CITES records should be interpreted with caution due to an immediate national ban on seahorse capture and trade in the Philippines with the listing of seahorses on CITES Appendix II.

Records from the Taiwanese Directorate General of Customs began in 1983, while records from the Census and Statistics Department in Hong Kong SAR date from 1998. Data were accessed in 2010 and 2014, respectively. Information from the Taiwanese Directorate General of Customs contained 19 records of seahorse imports from the Philippines from 1986 to 2004, while data from Hong Kong SAR's Census and Statistics Department contained seven records across 1998-2004, with two additional records in 2006 and 2010.

All nations signatory to CITES are required to submit export and re-export records for seahorses; the submission of import records is voluntary though strongly encouraged. In support of this report, the database of CITES records was queried on 19 October 2018 for all records for which the Philippines was reported as a source of seahorses in trade (UNEP-WCMC 2018). The Philippines was not reported as an importer of seahorses in the CITES database, and records which reported the Philippines as a re-exporter of seahorses were excluded from the analyses. A total of 35 export records were downloaded and analysed as per Foster *et al.* 2016. Because implementation of the seahorse listing was deferred until May 2004, downloaded 2004 data may represent only a partial year of trade.

Results

Gears and provinces

Fishers reported catching seahorses using ten different gear types (Table 2). For the purpose of this report, we separated bottom set gill nets from floating and drift gill nets as the former are more likely to catch seahorses. Micro-trawls were also separated from otter trawls for similar reasons; micro-trawls in the province of Sulu were specifically modified, with a triangular net called sinsoro, to catch seahorses, sea cucumbers and other small fish whereas otter trawls in other provinces were found to catch seahorses incidentally. Push nets in the province of Palawan also reported using a push net modified to target seahorses (see box A). We also interviewed fishers using hook and line (n=16), and fishers using both bottom set and floating gill nets interchangeably (n=4), but none of them reported catching seahorses and so have been excluded from further analyses.

The most common gear type reported among our respondents was spear/skin diving (91 fishers; 38%) followed by bottom set gill nets (n=59; 25%) (Table 2). Other gears reported included: compressor divers (n=27), otter trawls (n=16), floating gill nets (n=16), micro-trawls (n=10), push nets (n=7), fish traps (n=6), gleaning (n=3) and seine nets (n=2). The greatest diversity of gear types documented to catch seahorses was in the province of Iloilo, with five different gear types reported.

Seahorse catches were documented in all but one of the 17 provinces surveyed. Misamis Oriental was the only province with no respondents reporting seahorse catches (n=4, fishers interviewed using bottom set gill nets and spear/skin diving).

The gears being used to catch seahorses – some if which targeted the fishes and some of which caught them incidentally – varied by province, although our surveys may not have been comprehensive in that respect. Spear/skin divers, compressor divers, micro-trawls, push net fishers and gleaners reported targeting seahorses. Fishers using the other gear types reported catching seahorses incidentally – including bottom and floating gill nets, seines, fish traps and otter trawls. The median CPUE across gears that targeted seahorses was ~138 times than of gears that caught them incidentally; the median CPUE of target gears was estimated at 5.5 seahorses gear$_{-1}$ day$_{-1}$, compared to a median CPUE of 0.04 seahorses gear$_{-1}$ day$_{-1}$ for gears that caught seahorses incidentally.

A number of spear/skin divers from the provinces of Surigao del Norte (n=16), Eastern Samar (n=6), Cebu (n=1), Bohol (n=1) and Misamis Oriental (n=1) reportedly saw but did not catch seahorses, or caught them but released them back into the water. In addition, one bottom set gill net fisher from Camarines Sur and one compressor fisher from Cebu also reportedly saw but did not catch seahorses. These fishers were excluded from our analysis of catch rates and volumes as we could not verify seahorse catch.

Table 2. The number of fisher interviews that generated usable information, by gear type, in each of the 17 provinces in the Philippines where interviews were conducted. Provinces arranged from north to south. Gears are arranged from largest to smallest sample sizes.

Province	**Spear/ skin divers**	**Gill net (bottom)**	**Com-pressor**	**Otter trawl**	**Gill net (floating)**	**Micro-trawls**	**Push net**	**Fish trap**	**Glea-ning**	**Seine**	**Total**
Pangasinan	1										1
Zambales	5								1		6
Cavite		4			3						7
Quezon		9			1				1		11
Palawan		4			4		7				15
Camarines Sur		4		3	1						8
Sorsogon		16			5						21
Masbate		6	8							1	15
Eastern Samar	23	3	1					1			28
Capiz				6						1	7
Iloilo	9	1	9		1			3			23
Negros	3	2	6	7							18
Cebu	10										10
Bohol	31	9	3						1		44
Misamsis Oriental	3	1									4
Surigao del Norte	6				1			2			9
Sulu						10					10
Total	91	59	27	16	16	10	7	6	3	2	237

Box A. *Description of gears reported to catch seahorses in the Philippines and the units of effort used in this report.*

Gill nets – A net wall that is weighted by sinkers or by the weight of the net itself with the upper portion of the net being raised by floats. Gill nets are set across the path of migrating fish which become gilled or entangled with the net (SEAFDEC 2003). ***The unit of effort used in this report is number of nets***. There are three different types of gill nets which include:

i. Bottom set gill net – typical gill net anchored at the bottom up to 200 meters for large-scale commercial fishing (Dugan *et al.* 2003).
ii. Set floating gill net – typical gill net that is fixed and anchored at the bottom (Dugan *et al.* 2003).
iii. Drift gill net – typical gill net that is tied to a fishing vessel and allowed to drift by itself (Dugan *et al.* 3003).

Gleaning - Collection of organisms, usually during low tide, through the use of hand or simple collection devices, organisms include mollusks, juvenile fish and invertebrates (Green *et al.* 2004). ***The unit of effort used in this report is the number of individual fishers.***

Spear/skin divers – Are considered a type of hand instrument which is simple in terms of design and structure is can be used by a single person (Dugan *et al.* 2003). ***The unit of effort used in this report is the number of individual fishers.*** Spear/skin divers will use a number of different hand instruments that includes:

i. Spear – a staff like instrument with tip that is pointed, barbed, pronged or flat bladed like a spade.
ii. Spear gun – a firing device used to propel a small to medium-sized spear.
iii. Gaff hook – made out of a steel shaft with a pointed or curved tip.
iv. Scoop and dip net – small to medium scale hand nets, typically circular framed, with netting or wickerwork.

Compressor – Divers who often use the same handheld instruments described above for spear / skin fishers such as spears and hooks but often fish in deeper waters and for longer amounts of time. Oxygen is supplied to divers through a plastic hose attached to an air compressor at the surface. ***The unit of effort used in this report is the number of individual fishers.***

Push nets – A collapsible net fixed on a triangular frame made up of bamboo poles or mangrove wood (Dugan *et al.* 2003). Push nets are generally used in shallow and coastal waters and are pushed along the bottom to capture small fish or invertebrates. Modified push nets locally called "sakag" are specifically designed to capture seahorses and are used in certain areas of the Philippines. ***The unit of effort used in this report is number of individual fishers.***

Traps – Gear that is stationed or set in the water for a certain period of time. Traps can be made from different types of material but are generally constructed to catch fish and/or invertebrates that are prevented from escaping through use of labyrinths and or devices such as gorges or funnels (SEAFDEC 2003). ***The unit of effort used in this report is number of traps.*** Included within traps are:

i. Pots - three dimensional devices constructed out of bamboo splits, rattan, chick wire or polyethylene netting (Dugan *et al.* 2003).
ii. Fish corral – fish guiding barriers made from a combination of bamboo, wooden poles, twigs, coconut trunks, chicken wire and or nets. Often used near shore or in rivers to direct movement of fish to a desired area (Dugan *et al.* 2003).

Seine nets – Primarily a net wall normally set in a semi-circle pattern with the bottom edge held down by weights and top edge containing buoys or floats. It consists of a bag where the fish collect, flanked by wing nets on each side (Dugan *et al.* 2003). The net is normally pulled towards a stationary boat or onto a beach and the wings are normally larger than trawl nets (SEAFDEC 2003). This seine net described here refers to what is often called a Danish seine or the local term of zipper. ***The unit of effort used in this report is the number of nets.***

Trawls – A cone-shaped net with a mouth like opening mounted on and spread by a rectangular frame and generally dragged on the bottom of the ocean floor by boats or vessels. Most trawls have wings that extend the opening and act like guiding barriers that herd fish into the mouth (Dugan *et al.* 2003). ***The unit of effort in this report is the number of vessels.*** Included within trawls are:

i. Otter trawls – can reach depths of two kilometers and are further classified by the size and number of boats used. Smaller boats less than three tonnes are commonly referred to as baby trawls. Otter trawls are balanced by weights and floats to maintain a horizontal position in water (Dugan *et al.* 2003).
ii. Micro-trawls – a modified bottom trawl used to specifically target seahorses, sea cucumbers and other small fish. Uses a triangular net attached to a boat. Round steel bars are dug into the substrate and a rope is used to pull the net by fishers.

Catch rates and volumes

Median CPUE varied among gear types from equal to or less than one up to 100 seahorses gear^{-1} day^{-1} (Table 3, Figure 2). The four gears types with highest median CPUE's were gears used to target seahorses, including in decreasing order, micro-trawls, push nets, compressor divers, and spear/skin divers. Micro-trawls, documented from only ten fishers on the island province of Sulu, had the highest CPUE and each reported catching 100 seahorse gear^{-1} day^{-1}. Push nets and compressor divers were documented to catch a median of ten and over five seahorses gear^{-1} day^{-1}, respectively, and spear/skin divers were reported to catch a median of 1.5 seahorses fisher^{-1} day^{-1}. Gill nets (both bottom and floating), otter trawls and fish traps had the lowest reported median CPUEs, each with a reported catch of less than one seahorse gear^{-1} day^{-1}. Seine nets and gleaners were each found to catch a median of one seahorse gear^{-1} day^{-1}.

CPUE's varied across provinces for compressor divers and spear/skin divers, the two gears that were found to have the highest median CPUEs and were documented in more than one province. Compressor divers in the provinces of Eastern Samar and Masbate had the highest reported median CPUE's out of the five provinces for which we documented this gear catching seahorses. Median compressor diver CPUE's ranged from as high as 8.0 seahorse fisher^{-1} day^{-1} in Masbate to 3.5 seahorse fisher^{-1} day^{-1} in Bohol (Figure 3). Spear/skin divers in Bohol were found to have the highest CPUE of 2.5 seahorses gear^{-1} day^{-1}, followed closely by Pangasinan and Eastern Samar both with a CPUE of 1.5 seahorses gear^{-1} day^{-1} (Figure 4).

Table 3. Per gear median daily seahorse catch rates (CPUE, seahorses gear^{-1} day^{-1}) and median annual seahorse catch estimates (seahorses gear^{-1} year^{-1}), and the effort metrics used to calculate the latter from the former, for various fishing gears across 16 provinces in the Philippines. Q_1 and Q_3 = quartiles 1 and 3, SE = standard error, n = number of fishers that provided the information on which calculations are based. Gears are ordered from largest to smallest median CPUE.

Gear type	Median CPUE (seahorses gear^{-1} day^{-1}) [Q_1, Q_3] (n)	Mean # days fished week^{-1} [SE] (n)	Mean # weeks fished year^{-1} [SE] (n)	Median annual catch (seahorses gear^{-1} year$_1$) [Q_1, Q_3]
Micro-trawl	100 (10)	1 [0] (10)	43.4*	4,340
Push net	10.0 [5.8-11.1] (6)	5.4 [0.1] (4)	39.7 [5.3] (4)	2,170 [570-2,786]
Compressor	5.5 [3.0-9.5] (26)	4.5 [0.3] (25)	43.4*	964 [660-1,557]
Spear/skin divers	1.5 [0.2-2.5] (87)	4.7 [0.2] (81)	42.4 [0.6] (7)	260 [21-654]
Seine	1.0 [0.5-1.5] (2)	6.5 [0] (1)	43.4*	282 [141-423]
Gleaning	1.0 [0.3-1.0] (3)	4.3 [0.4] (2)	43.4*	206 [43-206]
Gill net (bottom)	0.04 [0.002-0.3] (59)	6.0 [0.2] (49)	41.5 [0.8] (16)	11 [0.5-142]
Otter trawl	0.08 [0-1] (16)	4.2 [0.5] (12)	45.0 [0.9] (4)	11 [0-171]
Gill net (floating)	0 [0-0.06] (16)	6.1 [0.4] (15)	42.0 [1.1] (3)	0 [0 – 23]
Fish trap	0 [0- 0.008] (6)	5.5 [0.5] (4)	43.4*	0 [0-1.3]

* We used an estimated 43.4 weeks or 10 months where fishers did not report # weeks or months fisher per year. See methods for details.

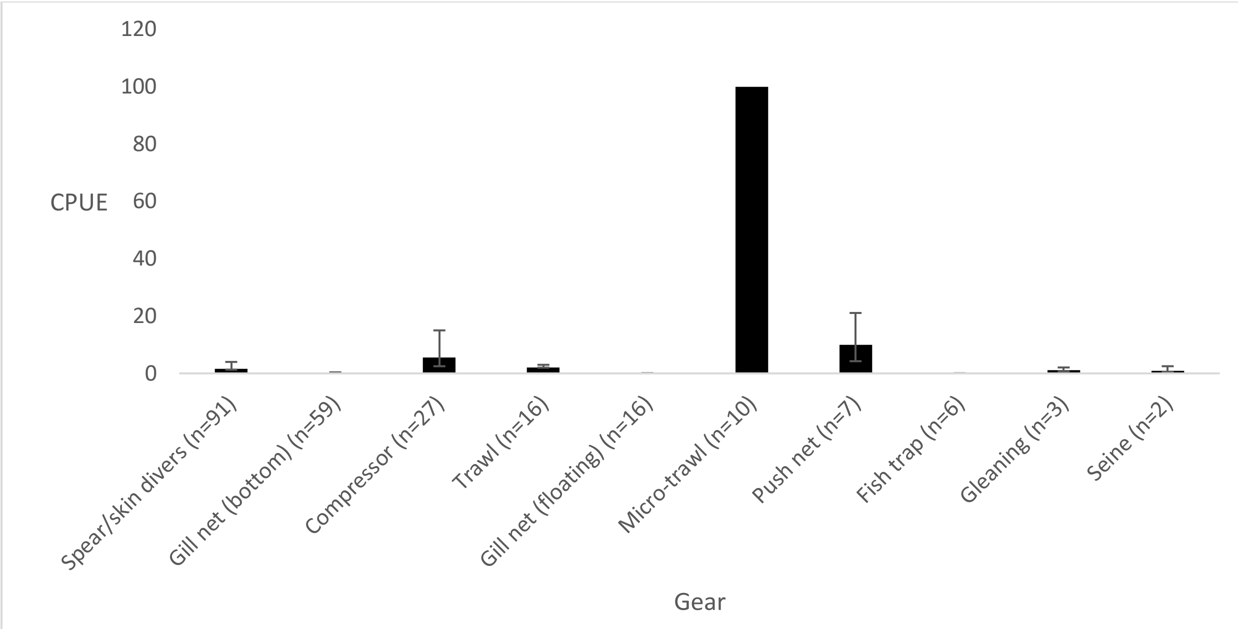

Figure 2. Fisher reported median daily seahorse catch rates (CPUE, seahorses gear^{-1} day^{-1}; error bars = Q_1, Q_3) by gear type across seventeen provinces in the Philippines from March – July 2019. n = number of fishers interviewed.

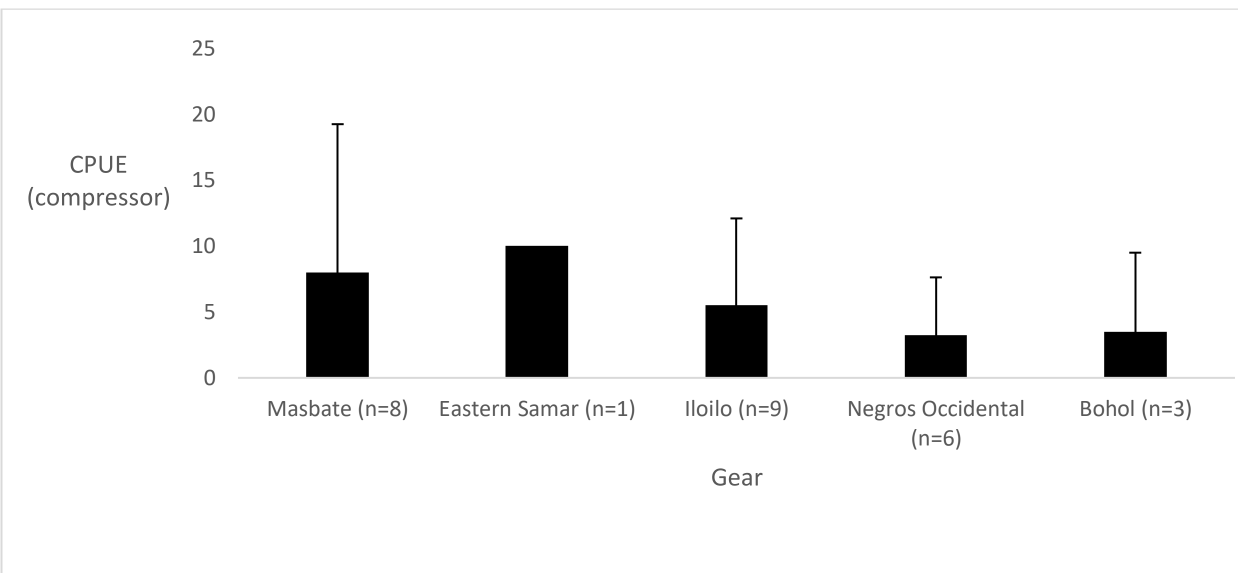

Figure 3. Fisher reported median daily seahorse catch rates (CPUE, seahorses gear^{-1} day^{-1}; error bars = Q_1, Q_3) by compressor divers in five provinces in the Philippines from March-July. n = number of fishers interviewed.

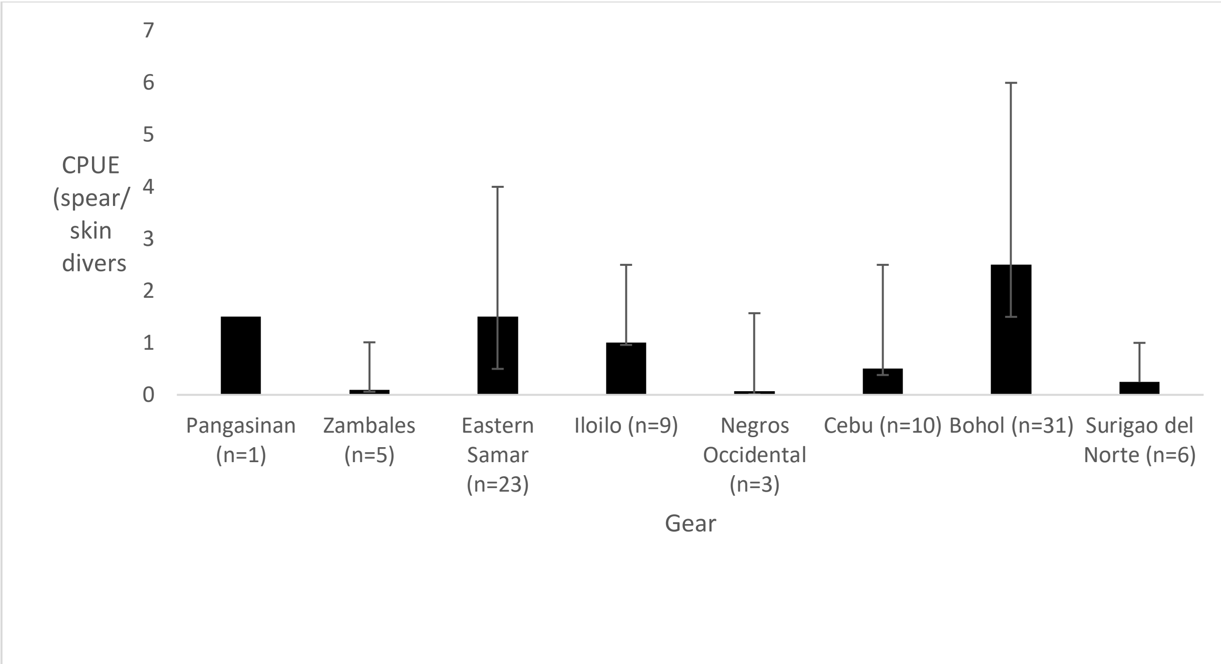

Figure 4. Fisher reported median daily seahorse catch rates (CPUE, seahorses gear^{-1} day^{-1}; error bars = Q_1, Q_3) by spear/skin divers in nine provinces in the Philippines from March-July. n = number of fishers interviewed.

When we scaled up gear specific CPUEs to estimate per gear annual catch, we found that micro-trawls had the highest reported per gear catch volumes across the municipalities/provinces we visited (median ~ 4,300 seahorses gear^{1} year^{-1}) (Table 3, Figure 5). This was two times the number of seahorses compared to the gear with the next highest median annual per gear catch (push nets), over four times more than compressor fishers, and over 15 times more than the estimated median for spear/skin divers, seine nets and gleaning. Gill nets (both types), otter trawls and fish traps had the lowest per gear annual catches, at less than 100 individuals gear^{-1} year^{-1}. We were able to scale up from per gear annual catch to total national annual catch for eight gear type/province combinations (Table 4, Table 5). These are the gear types/provinces for which estimates of per gear annual catch and estimates of total number of fishers/gears in at least one municipality visited were provided or made available. The sources of information for the number of fishers/gears across gear types and municipalities are indicated in Table 4. We were able to retrieve the most information on the number of gears in operation for spear/skin divers in eight of 16 provinces in which we documented those gears to catch seahorses, but had very limited information for other municipalities and other gear types (Table 4).

Scaling up per gear annual catches to total annual volumes for each gear type across provinces estimated that compressor fishers caught the most seahorses in the Philippines, at ~913,000 individuals per year (Table 5). This value is based on scaling up per diver annual catch across five of the seven municipalities from the five provinces in which compressor divers were documented to catch seahorses. The other municipalities/provinces, Guiuan in Easter Samar and Tubigon in Bohol, were excluded because we lacked information on number of divers. Compressor fishers reportedly caught over three times more seahorses than micro-trawls, push nets and spear /skin divers, the gears with the next highest estimated total volumes at ~260,000, ~217,000 and ~214,000 individuals per year, respectively. Indeed, compressor fishers were estimated to catch more than all other gears types combined, accounting for approximately 54% of the total estimated annual seahorse catch.

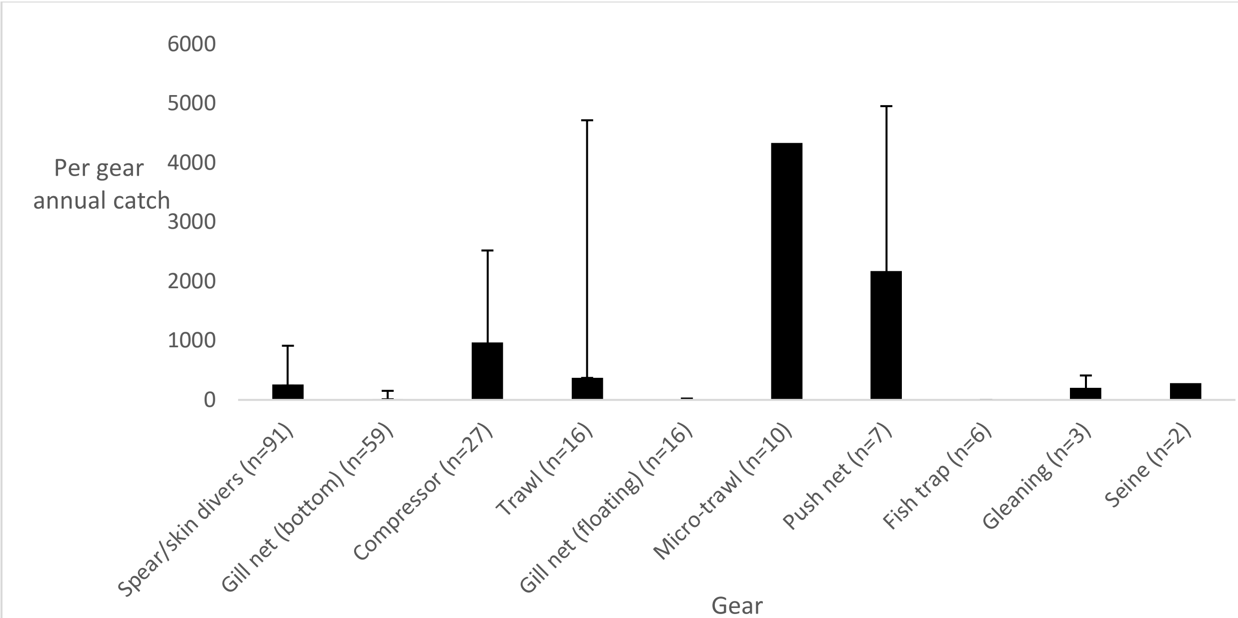

Figure 5. Per gear annual catch (seahorses $gear^{-1}$ $year^{-1}$; error bars = Q_1, Q_3) by gear type from interviews conducted with fishers in 17 provinces across the Philippines from March – July 2019. n = number of fishers interviewed.

Although micro-trawls and push nets were calculated to catch the second and third greatest volumes of seahorses, respectively, the estimates were each based on a single location/province. All seahorses caught using micro-trawls were reported from the island Province of Sulu. Similarly, the total estimated catch for push nets was based on just seven fishers interviewed in a single municipality in the province of Palawan. The estimate for spear/skin divers, on the other hand, was calculated across all 15 municipalities in which we documented fishers catching seahorses.

Bottom set gill nets, with a relatively low median CPUE of just 0.04 seahorse $gear^{-1}$ day^{-1}, were estimated to catch over ~ 37,000 seahorses across nine of the 12 municipalities, and seven of nine provinces, in which we documented this gear to catch seahorses; we lacked information on number of gears in Bohol and Negros Occidental. A lack of available information on number of fish traps and seine nets in any province meant we could not scale up per gear annual catch to total catch for these gear types.

Our total catch estimate for the Philippines, which should be taken as a minimum value, amounted to ~1.7 million seahorses per year – across the 24 municipalities in 16 provinces in which we documented seahorse catch and had data on gear numbers to scale up to a national catch (Table 5). The highest estimates of seahorse catch were generated for the provinces of Iloilo, Masbate, Sulu, Bohol and Palawan, each with a total estimated catch between ~222,000 – 359,000 per year (Table 5), together accounting for over 80% of the estimated national catch. The province of Iloilo had the highest catch estimate of all provinces, being responsible for 20% of the total national catch estimate. By gear type, compressor divers accounted for 54% of our estimated total catch volume. Micro-trawls accounted for 15% of the estimated total catch volume and push nets and spear/skin divers accounted for approximately 12% each (Table 5).

Table 4. Estimates for the number of fishers by Philippine province/municipality and gear type. Data are from either fisher reported values (*), a Philippines Rural Development Program (PRDP) report (** Bohol), or FISH RIGHT (*** Capiz, Iloilo). "–" is used to indicated municipality/gear type combinations for which we did not interview fishers. "No catch" = we interviewed fishers but they reported not catching seahorses. "No gear data" = municipality/gear type combinations for which fishers reported catching seahorses but we could not an estimate in the number of fishers or gears operating in the area.

Province	Municipality	Compressor (# of fishers)	Micro-trawl (# of gears)	Push net (# of fishers)	Spear/skin diver (# of fishers)	Gill net (bottom) (# of vessels)	Gleaning (# of fishers)	Otter trawl (# of vessels)	Gill net (floating) (# of gears)	Seine (# of gears)	Fish trap (# of gears)
Pangasinan	Bolinao	-	-	-	50*	-	-	-	-	-	-
Zambales	Masinloc	-	-	-	35*	-	No catch	-	-	-	-
Cavite	Rosario	-	-	-	-	-	-	-	No catch	-	-
	Tanza	-	-	-	-	100*	-	-	-	-	-
	Total					**100**					
Quezon	Lucena	-	-	-	-	48*	100	-	No gear data	-	-
Palawan	Busuanga	-		100*	-	33*	-	-	No catch	-	-
Camarines Sur	Calabanga	-	-	-	-	80*	-	40*	No catch	-	-
	Pasacao	-	-	-	-	10*	-	-	-	-	-
	Total					**90**		**40**			
Sorsogon	Bulan	-	-	-	-	75*	-	-	11*	-	-
	Magallanes	-	-	-	-	125*	-	-	-	-	-
	Total					**200**		-	**11**		
Masbate	Placer	200*	-	-	-	131*	-	-	-	No gear data	-
Eastern Samar	Guiuan	25	-	-	65*	-	-	-	-	-	No catch
	Oras	-	-	-	100*	17*	-	-	-	-	-
	Quinapondan	-	-	-	50*	-	-	-	-	-	-
	Salcedo	-	-	-	25*	-	-	-	-	-	-
	Total				**240**	**17**					
Capiz	Roxas City	-	-	-	-	-	-	119***	-	No catch	-

Table 4. Continued.

Province	Municipality	Compressor (# of fishers)	Micro-trawl (# of gears)	Push net (# of fishers)	Spear/skin diver (# of fishers)	Gill net (bottom) (# of vessels)	Gleaning (# of fishers)	Otter trawl (# of vessels)	Gill net (floating) (# of gears)	Seine (# of gears)	Fish trap (# of gears)
Iloilo	Carles	186***	-	-	158***	-	-	-	No catch	-	No catch
	Estancia	33***	-	-	-	No catch	-	-	-	-	-
	Total	**219**			**158**						
Negros Occidental	Sagay	60*	-	-	100*	No gear data	-	-	-	-	-
	Victorias	-	-	-	20*	-	-	100*	-	-	-
	Total	**60**			**120**			**100**			
Cebu	Cordova	-	-	-	80*	-	-	-	-	-	-
Bohol	Getafe	-	-	-	48*	-	-	-	-	-	-
	Inabanga	-	-	-	50*	No gear data	-	-	-	-	-
	Talibon	200*	-	-	10*	-	-	-	-	-	-
	Tubigon	No gear data	-	-	15*	No gear data	50**	-	-	-	-
	Total	**200**			**123**		**50**				
Misamis Oriental	Camguin	-	-	-	No catch	No catch	-	-	-	-	-
Surigao del Norte	Surigao City	-	-	-	-	-	-	-	-	-	No gear data
	Taga-naan	-	-	-	100*	-	-	-	-	-	-
	Total				**100**						
Sulu			60*								

Table 5. Median total volume estimates (number of individual seahorses) and calculated interquartile range (Q_1, Q_3) caught across eight gear types from Philippine fisheries in 16 provinces. We indicate "- " for provinces and/or gear types for which we were unable to provide an estimate, either because we did not interview fishers using those gear types or because we lacked an estimate of total number of gears operating in at least one municipality that we visited (see Table 5 for details).

Province	Compressor	Micro-trawl	Push net	Spear/skin diver	Gill net (bottom)	Gleaning	Otter trawl	Gill net (floating)	National catch estimate (seahorses year^{-1})
Pangasinan	-	-	-	16,275	-	-	-	-	**16, 275**
Zambales	-	-	-	5,705 [770-7,595]	-	-	-	-	**5,705** [770-7,595]
Cavite	-	-	-	-	15,190 [11,393-22,785]	-	-	-	**15,190** [11,393-22,785]
Quezon	-	-	-	-	46 [0-512]	8,680	-	-	**8,726** [8,680-9,192]
Palawan	-	-	217,000 [57,031-272,370]	-	4,813 [79-10,667]	-	-	-	**221,813** [57,110-284,037]
Camarines Sur	-	-	-	-	130 [98-188]	-	0 [0-39]	- -	**130** [98-227]
Sorsogon	-	-	-	-	2,170 [217-29,493]	-	-	179 [119-1,910]	**2,349** [336-31,403]
Masbate	303,583 [192,045-384,091]	-	-	-	13,919 [6,426-19,615]	-	-	-	**317,502** [198,471-403,706]
Eastern Samar	73,237	-	-	72,912 [9,765-130,135]	0 [0-540]	-	-	-	**146,149** [83,002-203,602]
Capiz	-	-	-	-	-	-	29,696 [3,228-48,902]	-	**29,696** [3,228-48,902-]

Table 5. Continued.

Province	Compressor	Micro-trawl	Push net	Spear/skin diver	Gill net (bottom)	Gleaning	Otter trawl	Gill net (floating)	National catch estimate (seahorses year^{-1})
Iloilo	338,601 [74,136-349,294]	-	-	20,572 [1,317-87,772]	-	-	-	-	**359,173** [75,453-437,066]
Negros Occidental	45,310 [27,342-56,246]	-	-	1,302 [1,302-14,713]	-	-	1,085 [814-6,510]	-	**47,697** [29,458-77,469]
Cebu	-	-	-	11,284 [1,243-23,111]	-	-	-	-	**11,284** [1,243-23,111]
Bohol	151,900 [142,786-232,190]	-	-	84,132 [46,248-140,712]	638 [164-2,279]	16,500	-	-	**253,170** [205,698-391,681]
Surigao del Norte	-	-	-	1,628 [0-5,317]	-	-	-	-	**1,628** [0-5,317]
Sulu		260,400							**260,400**
Total	**912,631 [509,546-1,095,058]**	**260,400**	**217,000 [57,031-272,370]**	**213,810 [82,237-425,630]**	**36,906 [18,377-86,079]**	**25,180**	**30,781 [4,042-55,451]**	**179 [119-1,910]**	**1,696,887 [956,932-2,222,078]**

Trade

Species

A total of 200 seahorses were photographed, sexed and measured at 14 buyers' and five fishers' premises in 11 municipalities across eight provinces in the Philippines. Seven seahorse species were identified in the photographs including (in order of occurrence): *Hippocampus kuda*, *H. comes*, *H. spinosissimus*, *H. histrix*, *H. barbouri*, *H. kelloggi,* and *H. trimaculatus* (Table 6).

The most commonly observed species were *H. kuda* (n=66) and *H. comes* (n=64), representing 65% of individuals overall. In contrast, *H. trimaculatus* was the least common species, with only one specimen observed in a photograph from Masbate (Table 6). Two more species of seahorse were also observed in just one province: *H. barbouri* in Palawan (n=8) and *H. histrix* in Bohol (n=10). *Hippocampus kuda* was documented in all provinces for which we had data apart from Iloilo and Surigao del Norte, but most *H. kuda* individuals were photographed in Bohol, which is also where the majority of photographs were taken. Photographs from the provinces of Bohol, Eastern Samar, and Masbate showed the highest diversity of species, with four species observed (Table 6). Similarly, *H. comes* was commonly observed in most provinces for which we had data, except for the provinces of Pangasinan, Palawan, and Iloilo (Table 6).

Of the 200 seahorses photographed, we observed more females than males. Sex could not be determined for seven seahorses. Among our photographs, we observed pregnant *H. barbouri*, *H. comes*, *H. kuda,* and *H. spinosissimus* (Table 7). *Hippocampus kuda* and *H. barbouri* had the highest percentage of specimens that were pregnant. The mean size of seahorses varied by species: *H. histrix* and *H. trimaculatus* were found to be the smallest and *H. kelloggi* were the largest (Table 7). *Hippocampus barbouri* and *H. kuda* exceeded the maximum height documented for this species based on Lourie *et al.* (2004). The mean height of observed individuals was greater than the documented height at maturity for all species apart from *H. kuda*, for which the mean height observed was less than the documented height at maturity (Table 7).

Table 6. Seahorse species (*Hippocampus* spp.) photographed at 14 buyers' and five fishers' premises across eight Philippine provinces surveyed from March – July 2019. Corresponding values represent the number of individuals observed.

Province	**# of buyers/fishers**	**# of photographs**	***H. barbouri***	***H. comes***	***H. histrix***	***H. kelloggi***	***H. kuda***	***H. spinosissimus***	***H. trimaculatus***	**Total**
Pangasinan	1 buyer	3					35			**35**
Palawan	1 buyer; 1 fisher	4	8				1	1		**10**
Masbate	3 buyers; 2 fishers	12		8			1	13	1	**23**
Eastern Samar	1 buyer; 1 fisher	7		7		2	16	2		**27**
Capiz	3 buyers	5		1			6	3		**10**
Iloilo	1 fisher	1						1		1
Bohol	4 buyers	20		46	10		7	29		**92**
Surigao del Norte	1 buyer	2		2						2
Total		**54**	**8**	**64**	**10**	**2**	**66**	**49**	**1**	**200**

Table 7. Results of Philippine buyers' seahorse photos indicating number of individuals photographed, sex ratio of males to females, number of pregnant males observed, mean height, maximum recorded height, maximum observed height and height at maturity. Maximum recorded heights for species of *Hippocampus* are based on values reported in Lourie *at al.* 2004. SE = standard error.

Seahorse spp. (*Hippocampus* spp.)	# individuals photographed	Sex ratio (n males: n females)	# of pregnant males (% pregnant males)	Mean height (cm) [SE]	Max observed height (cm)	Max recorded height (cm)	Height at maturity (cm)
H. barbouri	8	2:6	1 (50%)	15.5 [0.4]	17.8	15.0	8.0*
H. comes	64	17:43 Unknown 4	4 (24%)	13.6 [0.4]	18.1	18.7	8.1*
H. histrix	10	1:8 Unknown 1	0	10.7 [0.8]	15.3	17.0	7.9*
H. kelloggi	2	0:2	0	17.6 [0.6]	18.2	28.0	15.0*
H. kuda	66	24:42	12 (50%)	12.1 [0.6]	21.1	17.0	14.0*
H. spinosissimus	49	15:32 Unknown 2	3 (20%)	11.5 [0.5]	19.0	17.2	10.0†
H. trimaculatus	1	0:1	0	10.6	10.6	17.0	9.1†

*Height at maturity was obtained from Table 2 of Apale and Foster (2016) and references cited therein.
†Height at reproductive maturity are based on values reported in Lawson *et al.* (2015).

Uses

Buyers most commonly procured seahorses in the dried form (n=29 or 94% of those interviewed). One buyer reportedly bought live seahorses and sold them dried, and one buyer in Cebu was involved in the live seahorse trade. An additional seven buyers reportedly collected and traded live (n=6) and dry (n=2) seahorses in the past but were no longer doing so because of the current ban. These interviews were excluded from our analysis.

Trade levels

A total of 31 buyers were interviewed from ten provinces and 15 municipalities that represented predominantly one level of trade. The majority (77%) of our interviews concentrated on Level 2 primary buyers, who sourced their seahorses directly from fishers. In addition, we interviewed three domestic retailers in Roxas City in the province of Capiz and four buyers who we categorized as primary buyers but might have also been operating as Level 3 secondary buyers.

Trade routes

Limited information suggested that buyers generally sourced their seahorses from fishers in the same municipality and/or province in which they operated. Information on reported destinations was also patchy. Cebu City (n=6) and Manila (n=1) were the most commonly cited domestic destinations as well as the municipalities of Cawayan (n=4) and Placer (n=2) in the province of Masbate, and Talibon in the province of Bohol (n=3). Six buyers reported they travelled locally to sell seahorses to other buyers, or buyers would come in person to collect seahorses from them. One buyer reported sending seahorses by bus.

No specific information was provided on destinations or trade routes leaving the country, nonetheless we infer the majority of trade was destined for export as we found very little evidence of domestic use of seahorses (i.e. use within the Philippines). Of the 31 buyers we interviewed only three mentioned personal and/or medicinal use of seahorses. Additionally, retailers from Roxas City in the province of Capiz reported customers bought seahorses for the purpose of cleansing mothers after giving birth (n=1) and for stomach pains (n=1).

Trade volumes

Our interviews with 31 buyers from ten provinces produced only limited quantitative information on purchase volumes of seahorses in trade (Table 8). We obtained trade information from ten of 17 provinces surveyed. Volumes of seahorses acquired per buyer per day ranged from 0.2 in the Province of Capiz, where all traders were retailers, to 130 in Pangasinan). After Pangasinan the next two provinces with the highest volume of seahorses collected per buyer per day were Bohol at 102.5, and Masbate with 30. The one live seahorse trader we interviewed reported acquiring 15 seahorses per day. The overall median across all provinces was found to be 9.0 seahorses acquired buyer^{-1} day^{-1} or ~ 2,200 seahorses acquired buyer^{-1} year^{-1} (Table 8). The annual seahorse purchase across all buyers we interviewed totalled ~ 296,000 seahorses.

Data on the volume of seahorses sold to higher level buyers was obtained from just six of the 17 provinces surveyed (Table 9). According to our respondents, the largest sell volumes occurred in the Provinces of Masbate and Bohol, with each buyer selling a median of ~37 seahorses day^{-1}. The overall median across all provinces was estimated at 4.7 seahorses sold buyer^{-1} day^{-1} and ~1,100 seahorses sold buyer^{-1} year^{-1} (Table 9). The annual seahorse sale volume across the buyers we interviewed totalled ~74,000 seahorses.

Table 8. Values used to determine annual number of individual seahorses acquired buyer^{-1} year^{-1}, by province. Buyers were assumed to work a 5-day work week throughout the year. Q_1 and Q_3 = quartiles 1 and 3. Locations organised from north to south.

Province	# of traders interviewed (type of trade)	Median # of seahorses acquired day^{-1} [Q_1, Q_3]	# of days acquiring seahorses month^{-1}	# of months acquiring year^{-1}	Median annual number of seahorses acquired buyer^{-1} year^{-1} [Q_1, Q_3]
Pangasinan	1 (dried)	130.0	20	12	31, 200
Quezon	2 (dried)	8.3 [4.9-11.6]	20	12	1,980 [1,170-2,790]
Palawan	1 (dried)	2.5	20	12	600
Masbate	7 (dried)	30.0 [24.0-85.0]	20	12	7,200 [5,850-20,400]
Eastern Samar	6 (dried)	5.8 [2.5-6.0]	20	12	1,395 [608-1,440]
Capiz	3 (dried	0.2 [0.1-0.9]	20	12	207 [29-207]
Iloilo	2 (dried)	17.5 [11.3-23.8]	20	12	4,200 [2,700-5,700]
Negros Occidental	1 (dried)	15.0	20	12	3,600
Cebu	2 (dried); 1 (live)	6.0 [6.0-10.5]	20	12	1,440 [1,440-2,520]
Bohol	5 (dried)	102.5 [15.0-170.0]	20	12	24,600 [3,600-40,800]
Overall median across 31 buyers	**30 (dried); 1 (live)**	**9.0 [3.7-30.0]**			**2,160 [900-7,200]**

Table 9. Values used to determine annual number of individual seahorses sold buyer^{-1} year^{-1}, by province. Buyers were assumed to work a 5-day work week throughout the year. Q_1 and Q_3 = quartiles 1 and 3. Locations organised from north to south.

Province	# of traders interviewed (type of trade)	Median # of seahorses sold day^{-1} [Q_1, Q_3]	# of days acquiring seahorses month^{-1}	# of months acquiring year^{-1}	Median annual number of seahorses sold buyer^{-1} year^{-1} [Q_1, Q_3]
Pangasinan	-	-	-	-	-
Quezon	1 (dried)	6.0	20	12	1,440
Palawan	-	-	-	-	-
Masbate	3 (dried)	37.5 [3.7-54.7]	20	12	1,050 [885-13,125]
Eastern Samar	3 (dried)	3.3 [2.5-3.8]	20	12	900 [600-1,050]
Capiz	2 (dried	0.05	20	12	12
Iloilo	1 (dried)	30.0	20	12	7,200
Negros Occidental	-	-	-	-	-
Cebu	-	-	-	-	-
Bohol	4 (dried)	36.9 [17.6-47.8]	20	12	6,750 [4,230-11,475]
Overall median across 14 buyers	**14 (dried)**	**4.7 [1.9-28.1]**			**1,125 [450-6,750]**

Trade values

Of the 31 buyers interviewed only seven reported how much they paid fishers per individual seahorse – at a median value of USD 0.58 per seahorse (Table 10). Four buyers provided detailed information on prices paid for different sizes of seahorse (small, medium and large). A single buyer in Pangasinan reported paying less than USD 0.10, 0.19, and 0.38 for individual small, medium, and large seahorses, respectively. In Eastern Samar, three buyers each reported paying the same prices for individual small (USD 0.38) medium (USD 0.58), and large (USD 0. 77) seahorses. Two out of the three retailers we interviewed, who owned shops in Roxas City in the Province of Capiz, reported paying fishers a median USD 0.82 for their individual seahorses but did not specify or provide details on amount paid or sold per size of seahorse. Finally, one buyer in the Province of Bohol reported paying fishers USD 1.92 for a single seahorse, again not specifying the size of seahorse. Fishers from the northern province of Pangasinan were reportedly paid the least amount of money for their seahorses, whereas fishers in Bohol were reportedly paid the highest price per individual seahorse. The median buying price (the amount a fisher received per individual seahorse) was USD 0.58 (Table 10).

Buyers sold their seahorses for nearly three to nearly five times what they paid for them. The median reported sale price per kilogram ranged from USD 288 in Quezon (n=1) to USD 604 in Bohol (n=2). The median price per kilogram across all provinces was ~USD 460 kilogram^{-1} (Table 10), which translates into ~USD 1.50 per seahorse using a conversion factor of 300 seahorses per kilogram. Limited information was provided on the sale price of individual seahorse. The three retail owners we interviewed reported selling individual seahorses for a median of USD 1.92, approximately one dollar more than they bought each seahorse for. Buyers in the province of Iloilo (n=1) and Bohol (n=2) sold individual seahorses at a higher price of USD 2.30 and 2.44, respectively. No information was provided on the variation of sale price with respect to seahorse size. The median selling price for an individual seahorse was USD 2.30 (Table 10).

Table 10. Prices for dried seahorses in USD reported by buyers in different Philippine provinces. Values converted from PHP using 1 USD = 52.15 PHP (From Oanda.com; average rate from March – July 2019).

Province	**Median buyer reported purchase price ($USD) individual^{-1} [SE] (n)**	**Median buyer reported selling price ($USD) individual^{-1} [SE] (n)**	**Median buyer reported selling price ($USD) kilogram^{-1} [SE] (n)**
Pangasinan	0.19 [0] (1)	-	575 [0] (1)
Quezon	-	-	288 [0] (1)
Palawan	-	-	-
Masbate	-	-	575 [0] (1)
Eastern Samar	0.58 [0] (3)	-	316 [29.0] (2)
Capiz	0.82 [0.24] (2)	1.92 [0.70] (3)	
Iloilo	-	2.30 [0] (1)	336 [0] (1)
Negros Occidental	-	-	-
Cebu	-	-	-
Bohol	1.9 [0] (1)	2.44 [0.14] (2)	604 [29.0] (2)
Overall median	0.58 [0.21] (7)	2.30 [0.32] (6)	460 [53.0] (8)

Seasonality

Fishers

Few fishers (57/224; 25%) reported a seasonality to their seahorse catches, and there does not seem to be an obvious pattern in the data they reported (Table 11). All months were reported as a high season by at least one fisher, however, the most frequently reported high season months were part of the rainy season, and included May, June, July, and August. The reported high seasons for seahorse catches were the longest in Bohol, where every month apart from November was reported as a high season, and Iloilo, where nine months were reported as part of the high season. Only one month was reported as a high season in Cebu (May), and two in each of Zambales and Sorsogon (April and May). There was no particular overall pattern to the months reported for low season.

Traders

Few traders (6/31; 19%) reported seasonality to the supply of seahorses from fishers. One buyer in Masbate reported that there was no seasonality in seahorse supply. Overall, the high season reported by buyers was found to be inconsistent and only somewhat comparable to that reported by fishers. Buyers reported the high season as January-May in Quezon (n=1), May in Masbate (n=1), and April to May in Iloilo (n=1). Bohol (n=3) had three different reported high seasons from three different buyers, including March–May, June–September, and December.

Table 11. Fisher responses to seasonality of seahorse catch detailing reported high (H) and low (L) season for each province. n = number of respondents. Locations organised from north to south.

Province	(n)	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Pangasinan	0												
Zambales	2	L			H	H							L
Cavite	2	H	H	H									H
Quezon	0												
Palawan	4			L	L	H	H	H	H	H			
Camarines Sur	0												
Sorsogon	2				H	H							
Masbate	4				H	H	H	H	H	H			
Eastern Samar	11	H	H	L	L	H/L	H/L	H/L	H/L	L	L	H	H
Capiz	0												
Iloilo	7	L	L	L	H	H	H	H	H	H/L	H/L	H/L	H/L
Negros Occidental	3					H/L	H/L	H	H	H			H
Cebu	2					H							L
Bohol	20	H/L	H/L	H/L	H	H	H/L	H/L	H/L	H/L	H/L	L	H/L
Surigao del Norte	1					H	L	L	L	L	L	L	L
Misamis Oriental	2					H	H	H	H				
Total low		**3**	**2**	**4**	**2**	**2**	**4**	**3**	**3**	**4**	**4**	**3**	**5**
Total high		**3**	**3**	**2**	**5**	**11**	**7**	**7**	**7**	**5**	**2**	**2**	**5**

Changes over time

Fishers

Ninety-eight percent of fishers who commented on changes in seahorse catches over time (n=93/95), across 12 of the 17 provinces surveyed, reported a decline in catches over the last several decades. Only two fishers reported an increase in the number of seahorses caught over time. The other 142 fishers interviewed were either not asked or did not comment on a change in seahorse catch or catch rates.

The reported decline across fishers who were catching seahorses at the time of the interviews, using the same gear type as they used in the past, was 74% (n=64/95). Unfortunately, we were not able to obtain information on historic fishing effort or the period over which the reported declines had occurred. From these anecdotal reports, declines across provinces ranged from 53% in Masbate to as high as 85% in Capiz. Among gear types, fishers using otter trawls and bottom set gill nets, both of which caught seahorses incidentally, reported the greatest decline in catches at 85% and 84%, respectively. Gears that targeted seahorses – push nets, spear/skin divers and compressor divers – reported a similar decline in seahorse catch over time, of 79, 74 and 71%, respectively. It was not possible to evaluate the other gears types as fishers reported switching gears over the years and/or did not report catching seahorses during our interviews.

Of the 95 fishers that reported declines in catch over time, sufficient information was obtained from 18 spear/skin divers, in Bohol and Surigao del Norte, to calculate changes in catch rates (CPUE) over time. These two provinces had enough information on spear/skin divers to analyze historical seahorse catch rates across two time periods each: Bohol from 2000-2009 and 2010-2017; Surigao del Norte from 1990-1999 and 2000-2009 (Table 12). For the province of Bohol, we found that reported CPUE decreased from 17.5 seahorses per fisher$_{-1}$ day$_{-1}$ in 2000-2009 to 6.0 in 2010-2017, and down again to the current (2019) CPUE of 2.5, an 86% decrease from the first time period to present day. Declines in seahorse catch rates were similarly inferred from spear/skin divers in Surigao del Norte where reported CPUE increased from 12.5 seahorses per fisher$_{-1}$ day$_{-1}$ in 1990 to 77.5 in 2000-2009, but then decreased to 0.25 in 2019, representing over a 98% decline from 1990 to present day. No information was obtained on changes in body height or seahorse price, although two fishers that reported finding fewer seahorses in their catch also reported the price had increased.

Table 12. Comparison of changes observed in seahorse catch over time for spear/skin divers in Bohol and Surigao del Norte. Mean # of weeks fished year$_{-1}$ was estimated at 43.4 weeks, which is the mean reported weeks/months fished year$_{-1}$ across all other gear types and provinces. Q_1 and Q_3 = quartiles 1 and 3, SE = standard error, n = number of fishers that provided the information on which calculations are based.

Province (time period)	**Median CPUE (seahorses fisher$_{-1}$ day$_{-1}$) [Q_1, Q_3] (n)**	**Mean # days fished week$_{-1}$ [SE] (n)**	**Mean # weeks year$_{-1}$**	**Median annual catch rate (seahorses fisher$_{-1}$ year$_1$) [Q_1, Q_3]**
Bohol (current)	2.5 [1.0-3.5] (28)	5.2 [0.3] (30)	43.4	684 [376-1,144]
Bohol (2010- 2017)	6.0 [4.5-13.0] (9)	5.3 [0.6] (5)	43.4	1,562 [1,172-2,760]
Bohol (2000-2009)	17.5 [12.5-20.0] (5)	6.3 [0.3] (2)	43.4	4,937 [3,255-5,425]
Surigao del Norte (current)	0.25 [0.0-0.8] (5)	5.3 [2.4] (3)	43.4	16 [0-53]
Surigao del Norte (2000-2009)	77.5 [41.3-113.8] (2)	6.0 (2)	43.4	20,181 [10,741-29,620]
Surigao del Norte (1990)	12.5 [11.3-13.8] (2)	5.0 (2)	43.4	2,713 [2,441-2,984]

Traders

Five buyers reported a decline in seahorse supply over a 15-year period. One trader reported an increase in seahorse demand in recent years, however no specific time period was provided. Only three buyers, one each in the provinces of Quezon, Masbate, Eastern Samar, provided estimates of how much supply had declined over 15 years, with estimates ranging from 67 -97%.

Comparison to previous research

In this section we compare our results, from interviews carried out from May to July 2019, to those generated by historic fisheries and trade research carried out in September 1998 and from April 1999 to March 2001 by Pajaro and Vincent (2015).

Fisheries

Gears and provinces

Our study interviewed more respondents but across fewer locations. Our current study interviewed 237 respondents across 17 coastal provinces, compared to Pajaro and Vincent's (2015) study in the late 1990s and early 2000s for which they interviewed a total of 145 fishers and traders in 22 coastal provinces. Our researchers did not visit the previously surveyed provinces of Albay, Antique, Agusan Sur, Davao, Leyte, Mindoro, Surigao Sur, Tawi-Tawi and Zamboanga, but we did visit a number of provinces that were reported to have trade but were not surveyed in the past, including Cavite, Pangasinan, Misamis Oriental, Negros Occidental and Zambales.

Our surveys revealed that the gears previously documented to catch seahorses are still a pressure on Filipino populations. The current survey documented the same gears to be catching seahorses as in the past, with the addition of micro-trawls and fish traps.

Catch rates and volumes

In general, our gear-specific estimated CPUE values were less than those estimated at the turn of the century. Our CPUE was less than that of Pajaro and Vincent (2015) for five gears, similar in value for one gear, and greater in magnitude for one gear (Table 13). Our daily CPUEs values were roughly four times lower for lantern or spear/skin divers and seines, two times lower for gleaners, over 70 times lower for gill nets (bottom and floating) and 100 times lower for otter trawls than in the previous study. Compressor divers were found to have similar CPUEs compared to the surveys conducted over 20 years ago. However, our CPUE estimate for push nets was five times higher than that reported in Pajaro and Vincent (2015). In addition, the current study documented the use of micro-trawls, with high catch rates, which were not encountered or recorded in past surveys.

Our total annual catch estimate was about half of that based on data collected in 1998-2001. This discrepancy could reflect a real decline in catches, or be due to discrepancies in any of the sites visited (we documented catch in 16 provinces versus 20), CPUE estimates (as mention above, our CPUE estimates were less than those previously documented for six of seven gears for which we could compare, Table 13), or discrepancies in gear number estimates, *inter alia*. That said, the estimates we obtained for the number of different gears in operation were much higher than those obtained 20 years ago for compressor fishers, spear/skin divers (lantern fishers), gleaners and gill nets. On the other hand, the estimate we obtained for the number of otter trawls was much lower than that obtained previously. Finally, we did not obtain an estimated number of seines in our current study.

Comparing our findings to past research was challenging for three reasons. First, not all gear types were included in each study. Second, even when gears were comparable (e.g. compressor divers, otter trawls), the geographic locations varied. Third, fleet sizes or estimates of the number of fishers or gears operating in a municipality/province varied across years and by location making it challenging to interpret catch estimates.

Table 13. Comparing the research results from this study to that obtained from seahorse trade surveys carried out at the turn of the century by Pajaro and Vincent (2015). CPUE = seahorses gear-1 day-1.

	1998-2001		2019	
Gear	**CPUE**	**# gears**	**CPUE**	**# gears**
Compressor	6.0	280	5.5	679
Lantern	6.0	485	1.5	906
Gleaning	2.0	100	1.0	150
Gill net	3.0	100	0.04/0 (bottom/floating)	657 (bottom/floating
Otter trawl	11.0	1,085	0.08	259
Push net	2.0	205	10.0	100
Beach seine	5.0	395	1.0	No gear data

Species

This latest survey of trade across the Philippines documented at least seven seahorse species being exploited in the Philippines' coastal waters, six of which were documented in past research conducted by Pajaro and Vincent (2015). Our study encountered one additional species, *H. histrix,* which was not previously reported. The previous study did not document the frequency of occurrence of different species in catches or trade.

Trade

While our surveys did not encounter many fishers involved in the live aquarium trade of seahorses, Pajaro and Vincent (2015) estimated that over 145,000 – 1,000,000 individual seahorses were caught for the aquarium trade. In contrast, our study found that most seahorses entered dried trade. Pajaro and Vincent (2015) estimated that approximately 12,500 kilograms of seahorse per year were traded during 1998-2001, or ~3.8 million seahorse per year, similar to their annual seahorse catch estimate of 4 million individual seahorses. Our study could not scale up to an annual trade estimate due to a lack of information on the number of traders operating in the Philippines.

Other trade data sources

Customs data

Official trade data from importers analyzed for this report show the Philippines to be an important source for dried seahorses prior to the domestic ban. Import data obtained from Hong Kong SAR report average annual imports of 3.1 million (range 1.5-6.2 million) from the Philippines between 1998 and 2004. Import data obtained from Taiwan showed average imports of 440,000 (range 48,000-1.6 million) from the Philippines between 1986-2004. The Philippines was the second most important source for dried seahorses in these jurisdictions' official trade data prior to 2004, behind Thailand, accounting for 19% and 12% of imports by volume recorded by Hong Kong SAR from 1998-2010 and Taiwan from 1983-2011, respectively.

Two further records from the Philippines exist in the Hong Kong database post-CITES: 2006 (56,000 individuals) and 2010 (14,000 individuals).

CITES data

All 35 export records for seahorses related to the Philippines were reported by importing Parties – the Philippines has not reported any trade in these species in its annual reports.

CITES official data reported ~15,400 individual seahorses as exported from the Philippines in 2004 and ~1,700 in 2005; reported exports then mostly ceased as the 2004 national ban on seahorse capture took effect, with just 750 individuals reported across all years thereafter (UNEP-WCMC 2018). Most of the trade reported to CITES for the Philippines was marked as having been seized by importing Parties, suggesting the exports were not accompanied by necessary or valid export permits under CITES – more than half by volume in 2004 (~68%), all of reported trade in 2005, and more than half again across the following years (~66%).

The vast majority of trade reported to CITES as originating in the Philippines was purportedly of dried specimens (~90%, ~15,800 individuals across all years with data). Exports of live specimens were reported in 2004 (1,853 individuals) and 2014 (2 specimens). All trade in 2004 and 2005 was reported as for commercial purposes. The transactions reported after 2005 were composed of a mix of commercial, scientific, personal and educations purposes.

Analysis of reported CITES data revealed reported destinations of dried seahorses from the Philippines were (in descending order): the USA, Portugal, and the UK (UNEP-WCMC 2018). The USA was the main reported destination, reporting 96% of the dried seahorses from the Philippines across all years (~15,100 individuals). Portugal and the UK accounted for just 4% (600 individuals) and <1% (40 individuals), respectively. The reported destinations of live seahorses were Germany (~1,100 individuals), Italy (475 individuals), the USA (243 individuals), the UK (155 individuals), Denmark (34 individuals), and Spain (11 individuals).

Discussion

Our latest research into seahorse fisheries and trade in the Philippines reveals that both have continued in significant numbers in spite of the ban. Our fisher surveys, which involved a fraction of the fishers in just 29 of roughly 750 coastal municipalities (DENR 2001), across just 17 of 66 coastal provinces (Wikipedia 2019), estimated at least a 1.7 million seahorses being landed per year across nine gear types. The vast majority of landings were documented to be destined for the dried trade. As is common to seahorse fisheries globally (Lawson *et al.* 2017), most gears caught less than a few seahorses per day – but these low catch rates (CPUEs) scaled up to large numbers after accounting for individual and collective fishing effort.

Our new trade surveys produced a lower estimate of seahorse catch than previously reported. Our tally that the Philippines lands at least 1.7 million seahorses annually across 16 provinces is less than half the estimate generated in the late 1990s (Pajaro and Vincent 2015). Research at the turn of the century inferred that fishers in the survey areas (predominantly compressor, lantern and net fishers targeting seahorses) landed an estimated 4 million seahorses into the dried trade (Pajaro and Vincent 2015). Our lower estimate could be due, in part, to the fact our surveys covered fewer locations (17 versus 22 provinces) and our gear-specific CPUE estimates were generally lower than those estimated previously – which could reflect declining populations. Furthermore, we cannot discount the fact we were surveying illegal activities, which means respondents would be less likely to share information than they had been in the past.

Indeed, we are confident that the actual catch is much higher than our current estimate because: (1) there are more fishers/vessels than we documented; (2) there are more gears than we documented; (3) more municipalities within provinces, and more provinces, catch seahorses than we documented; and (4) there are more gear/municipality combinations than we documented. First, we are missing fisher numbers and/or fleet sizes for gears with some of the highest reported CPUEs, and for many municipalities. For example, data was lacking on the number of compressor fishers in three municipalities across two provinces. Scaling up from CPUE to total catch is highly dependent on good knowledge of fisher or vessel numbers, and this information is not readily available for the Philippines' fisheries. Generating effort information should be a priority for the Philippines Bureau of Fisheries and Aquatic Resources (BFAR) going forward, as effort is fundamental to the management of all fisheries, not just seahorse fisheries. Second, other fishing gears also need to be considered. For example, anecdotal evidence suggests beach seines, drag nets, trammel nets, falling nets, and other gears catch seahorses in the Philippines. Third, our catch estimate needs to expand to include fishing activities from many coastal municipalities and provinces that catch seahorses but where we did not survey. Finally, we need to find a way to evaluate catch rates where we knew gears were used but we did not interview fishers in that province. For example, micro-trawls and push nets were found to have the highest CPUEs in our study, but we only interviewed fishers using these gears in two provinces we visited. That said, micro-trawls and push nets in those two provinces have been modified to target seahorses, whereas in other provinces otter trawls and push nets are used to target crustaceans/or and other fishes, with seahorses being caught incidentally. Further research is needed to understand if push nets catch seahorses in other provinces.

The large volume of catch is worrying when taken together with the status of the species captured and fisher reported shifts in catch and catch rates (CPUE) over time. All seven species we documented to have been caught by fishers and/or collected by buyers are assessed as Vulnerable on the IUCN Red List, because of suspected declines of at least 30-50% caused by incidental catch, targeted catch and habitat degradation (IUCN 2019). Trade surveys at the start of the century recorded six of the species we observed (*H. barbouri*, *H. comes*, *H. kelloggi*, *H. kuda*, *H. spinosissimus,* and *H. trimaculatus*); *H. histrix*, which we observed, was not previously encountered. Previous fisheries and biological research in the Philippines have focused primarily on *H. comes*, as well as *H. spinosissimus* though to a much lesser extent (Perante *et al.* 2002; as reviewed in Apale and Foster 2016). Though information on the other species can be garnered from elsewhere in the world, it would behoove the Philippines to collect biological and ecological information on all species they exploit. Bohol had the highest diversity of species in our photographs and so would be a key location for future biological research.

Past research has shown that seahorses in Philippines' coastal waters are highly vulnerable to anthropogenic pressures, with very patchy distributions, very low densities, and living in threatened marine habitats (coral reefs, mangroves, seagrass beds) (Fortes and Santos 2004; as reviewed in Apale and Foster 2016) – and all evidence suggests that seahorse populations have continued to decline over time. All but two fishers that commented on changes in seahorse catch volumes over time reported declines. Reported declines in catch volumes must be interpreted cautiously when unaccompanied by information on corresponding changes in fishing effort, but we also documented large declines in catch rates (CPUE) for both the province of Bohol (89% over the last two decades) and Surigao del Norte (98% over the last three decades). These declines are comparable to those reported in the past. Project Seahorse past research indicated declines in populations of seahorses from direct exploitation and incidental catch of up to 95% over ten-year periods (O' Donnell *et al.* 2010; O'Donnel *et al.* 2012; Pajaro and Vincent 2015; as reviewed in Foster and Apale 2016). Other indicators of conservation concern we obtained from photographed seahorses included: highly skewed sex ratios across all species (more females than males in all cases); the proportion of males observed to be pregnant (about half of *H. barbouri* and more than half

H. kuda males); and, for *H. kuda*, the mean size of sampled individuals was smaller than the species size at maturity.

All evidence suggests the Philippines continues to be a dominant player in the international dried trade in seahorses. The majority of seahorse catch documented in our study was dried and destined for international trade. The present findings corroborate those from a study carried out in 2016-17 in Hong Kong SAR, the largest entrepôt for dried seahorses (Foster *et al.* 2019). Interviews with 220 traders produced many reports of imports from countries with bans on seahorse exports, most notably Thailand and the Philippines. Customs data analyzed for this study also reflect the more recent findings in Hong Kong – with the Philippines coming out as the second most important source of dried seahorses into both Hong Kong and Taiwan prior to the domestic ban on take and trade. Unfortunately, the present study generated minimal information on trade volumes – both buying and selling – across the Philippines. In our experience, it is always more challenging to elucidate information from buyers and other upper level traders than it is from fishers, particularly in a climate where trade is illegal.

The historically important live trade did not show up as significant in our research; historic surveys documented a large volume live trade of up to a million animals per year (Pajaro and Vincent 2015). Dried seahorses are very easy to move across borders – they are small and, being dried, keep well over long time periods. They are often moved among shipments of other dried seafoods, or in personal luggage, or via other hard to detect routes. Live trade, on the other hand, is much harder to smuggle. It is possible, therefore, that the trade in live wild animals has mostly ceased post-CITES. That said, the Philippines has been home to seahorse aquaculture operations in the past and interest in developing the industry continues to this day. Should the industry grow, the Philippines will need to make sure that it is not enabling the laundering of wild animals for export and that the dependence on wild broodstock is sustainable.

Though all take and trade we documented was illegal, the revised fisheries law in the Philippines allows for a re-opening of seahorse fisheries and trades once Authorities have set the terms for sustainable exploitation (Foster 2016). Setting these terms is akin to making a CITES non-detriment finding (NDF). A NDF is the "determination" of the Scientific Authority that advises that export will not be detrimental to the survival of the species in the wild, and should be the result of a science-based assessment (Res. Conf. 16.7, CITES 2013). NDFs can take many forms, but to be robust they are ideally based on an understanding of at least four things: (i) geographic distribution of the listed species across its life history; (ii) pressures the species experiences across its distribution; (iii) management being implemented to address these pressures across space and time; and (iv) whether the management is effective in reducing pressures and securing sustainable wild populations (see CoP17 Inf 52 (IUCN 2016c) and Foster and Vincent 2016 for details).

Our trade surveys provide Filipino Authorities updated information regarding (i) and (ii) – where the seahorses are and what threats they are facing. Three of the species we documented appear to be widespread across the Philippines: *H. comes, H. kuda* and *H. spinosissimus*. The first two of these were also the dominant species in terms of numbers. The previous trade surveys also documented *H. kelloggi* and *H. trimaculatus* across the Philippines, whereas in our study these species were seen in just one province each (Eastern Samar and Masbate, respectively). These findings suggest the possibility of dramatic population declines and/or extirpation of these species elsewhere in the country, though further research would be needed to confirm this. Both sets of surveys were consistent in that they only encountered *H. barbouri* in the southwest province of Palawan. While we cannot be certain that species photographed in a province were also caught there, most buyers we interviewed reported sourcing seahorses from fishers operating in the same province from which they operate.

Seahorse fishery hot spots in the Philippines, those estimated to catch more than 200,000 individual seahorses a year, were (in descending order by volume) the provinces of Iloilo, Masbate, Bohol, Sulu, and Palawan – these provinces accounted for over three-quarters of the total estimated seahorse catch by volume. The main gears impacting seahorses in the Philippines have remained constant over time – with most seahorse catch coming from compressor, skin/spear diving and push net fishers. Our research also documented high catch volumes from micro-trawls in Sulu. These gears – together responsible for 95% of our estimated annual national catch – are primarily used to target seahorses, but trade research past and present also documented seahorses being landed as bycatch, primarily by otter trawls.

The estimated impact of otter trawls on seahorses in the Philippines was a notable difference between historic trade research (Pajaro and Vincent 2015) and the present study. The historic study documented trawlers' CPUE at about three seahorses per otter trawl boat per day, whereas our study estimated a CPUE of just 0.08 seahorses per boat per day. Our study also documented one-fifth as many otter trawlers operating across the study area. As otter trawls are responsible for a huge volume of seahorse catch elsewhere in the world (Lawson *et al.* 2017), we suggest further research be carried out to understand the threat to seahorses posed by this gear type in the Philippines today. Filipino Authorities must also keep watch on the use of micro-trawls to catch seahorses. These gears have an usually high CPUE, of 100 seahorses per day, but are reportedly used by seaweed farmers to supplement their incomes just four times a month. Their infrequent use minimizes total catch, but catch volumes could increase dramatically if the farmers start using the gears more often, if the number of gears increases, and/or if other locations in the Philippines start using this gear type.

Information from Authorities is needed to understand (iii) – what management is in place to mitigate fishing impacts on seahorses across the country. Our finding that over 95% of the estimated annual catch was targeted is in contrast to other parts of the world, where seahorses are primarily landed as bycatch (Lawson *et al.* 2017). Target fisheries are theoretically easier to manage, as fishers can be selective about which seahorses they take. This makes management options such as size limits and leaving pregnant males appropriate to the pressures they need to address (Foster and Vincent 2016). It should also facilitate the use of quotas as a management tool, which are more complicated to implement in bycatch fisheries. In the meantime, precautionary management efforts, including improved MPA enforcement and compliance and minimum size limits, should be implemented to mitigate any impacts.

Conservation actions taken for seahorses in the Philippines to date include no-take MPAs and the voluntary adoption of a 10 cm minimum size limit (MSL) by fishers (as reviewed in Foster and Apale 2016). An analysis across MPAs did not show an increase in seahorse numbers, but did reveal an increase in seahorse size, which could lead to enhanced reproduction (Yasue *et al.* 2015). Individual MPAs have, however, shown an increase in seahorse numbers. The MSL seems to have stabilized seahorse CPUE (Yasue *et al.* 2015). MSLs could continue to be an important management tool for target fisheries in the Philippines, but would not be effective for managing bycatch. Non-selective fisheries will be best managed with spatial exclusion of fishing effort – such as more and larger MPAs, or enhanced enforcement of the trawl exclusion zone in municipal waters (Foster and Vincent 2016). Other management options for seahorses are reviewed in the NDF framework for seahorses, available at www.projectseahorse.org/ndf (Foster and Vincent 2016).

The last NDF component (iv) is a measure of management effectiveness. Evaluating effectiveness requires well designed monitoring and associated analysis to inform adaptive management, whereby management is improved (e.g. quotas adjusted, MPA coverage expanded) by learning from management outcomes. In order to be confident that its fisheries and trades are not damaging wild populations, the Philippines needs to implement a robust monitoring plan for seahorses. Monitoring wild populations of seahorses *in situ* is notoriously difficult and not likely to be a feasible option where resources are limited. Instead, national agencies need to monitor landings and fishing effort repeatedly (developing a time series) – possibly using the protocols developed by Project Seahorse (www.iseahorse.org/trends/landings) – and address conservation concerns as they emerge. In addition to monitoring catch per unit effort, monitoring should include body size and proportion of mature of mature individuals in catches, both of which are considered indicators of overfishing (Hutchings and Baum 2005; Meeuwig *et al.* 2006). To make monitoring tractable, it is possible to set up specific "sentinel" or indicator populations and/or fisheries. These sites should cover all species and all gear types that catch seahorses, anchored in information from the current analysis. It will be particularly important to monitor in Iloilo, Masbate, Bohol, Sulu and Palawan, which all our data suggest cover the diversity of seahorse species and fishing gears that catch them. The only gear not documented in these provinces was otter trawls, which would require a focused monitoring effort in Negros Occidental.

This study has provided Filipino Authorities with updated information that should allow them to develop a seahorse management plan, re-open legal fisheries and trades in a precautionary manner, and subsequently monitor and manage them in support of sustainable populations. An end to the ban should be used to demonstrate that CITES can be an effective tool for fish conservation and fisheries sustainability while supporting local livelihoods. In the meantime, the large volume of unregulated and unreported fishing and trade may denote significant risks to wild seahorses in the Philippines, and for the Philippines to make progress in conserving seahorses it needs to pay attention to their fisheries, trades and conservation. The road map is there, the tools are in place, and the protocols are available to make considerable progress.

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