RESEARCH ARTICLE

The Catch and Trade of Seahorses in the Philippines Post-CITES (2019)

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ABSTRACT

The catch and trade of seahorses (*Hippocampus* spp.) has been illegal in the Philippines since 2002, but the revision of the Philippines' domestic Fisheries Code in 2015 opened an opportunity to legalize seahorse fisheries and exports if they could be managed for sustainability. To generate vital knowledge in support of this option, we conducted 268 interviews with fishers and traders across seventeen coastal provinces in 2019. We estimated a total median annual catch of ~1.5 to 1.6 million individual seahorses, with the tally depending on the method used. Fishers reported catching seahorses from ten different types of fishing gears. The gear with the highest CPUE was a modified push-net, which is pulled across the ocean floor (locally named a "micro-trawl"), with 100 seahorses caught gear^{-1}day^{-1}, while compressor divers contributed half the total estimated catch. Other important gears were spear/skin divers and standard push nets. The provinces of Iloilo, Masbate, Sulu, Bohol, and Palawan together accounted for over 80% of the total national catch estimate. We found little evidence of live trade or domestic use, suggesting that most captured seahorses were exported dried. Buyers reported selling seahorses for between three and five times the price they paid fishers. Of conservation concern, nearly all (98%) fishers reported a decline in seahorse catch over time and highly skewed sex ratios across all species. Our data will help the Philippines' management agencies decide whether to support the re-opening of legal trade and, if so, how to make it sustainable.

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1. INTRODUCTION

Seahorses (*Hippocampus* spp.) comprise a charismatic genus of 46 fish species known for their male pregnancy, long-term pair bonds, and capacity for camouflage (Foster and Vincent 2004). Most species are subject to enormous pressures from directed fishing, nonselective fishing gear (especially bottom trawls and gillnets), and degradation of their seagrass, mangrove, and coral habitats (Vincent et al. 2011). Captured seahorses are heavily traded for traditional medicines, with smaller trades for curios and aquarium display (Foster et al. 2016; Foster et al. 2022; Vincent et al. 2011). Fourteen of the 42 seahorse species on the IUCN Red List of Threatened Species are assessed as globally threatened, with 17 more classified as Data Deficient because not enough is known to assess their conservation status (Pollom et al. 2021).

The vast scale and detrimental effects of the global trade in seahorses led to all species being added to Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 2002 (with implementation in 2004; Vincent et al. 2014). Such a listing obliges the 183 CITES member countries and the European Union to ensure that international exports of all seahorses do not damage wild populations, are legally sourced, and are traded humanely if exported live (CITES 1973).

The Philippines' coastal waters are home to at least ten species of seahorses that are highly vulnerable to anthropogenic pressures, with patchy distributions, low densities, and living in threatened marine habitats (coral reefs, mangroves, and seagrass beds; Foster and Apale 2016b). The country has historically been a dominant source of these fishes in international trade (Pajaro and Vincent 2015). Field surveys in the Philippines before the CITES listing, from 1998 to 2001, estimated that five million seahorses (range 2–8 million) were exported annually, of which about four million were traded dried for traditional medicine and about one million were traded live for ornamental display (Pajaro and Vincent 2015). Most seahorses were apparently obtained in the small-scale fisheries that engaged 90% of Filipino fishers (via free/compressor diving and scoop/push nets). However, some were also caught in non-selective fishing gears, including otter trawls, beach seines, and push nets. Seahorses significantly contributed to some fishers' small overall earnings (Meeuwig et al. 2006; Pajaro and Vincent 2015; Vincent 1996; Yasué et al. 2015).

All available evidence suggested that fisheries were having a detrimental impact on wild seahorse populations in the Philippines. Survey estimates indicated declines in seahorse populations of up to 95% over a ten-year period (Pajaro and Vincent 2015). 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 fishers due to increased seahorse prices (Christie et al. 2011).

The Philippines, as a Party to CITES, met its CITES obligations for Appendix II-listed marine species, including seahorses, in an unexpected way, as a consequence of its domestic laws and policies. The Philippines' Fisheries Code from 1998 banned even the extraction of any marine and freshwater species, listed on any CITES Appendix (DA-BFAR 1998), whereas a CITES decision actually has no direct role in regulating take or domestic trade. However, fisheries and seahorse trade continued as illegal activities despite the ban (e.g., Christie et al. 2011; Foster et al. 2019a; O'Donnell et al. 2012; O'Donnell et al. 2010).

A revision to the Fisheries Code in 2015 opened the door to legal and sustainable seahorse fisheries and trade in the Philippines. The Fisheries Code was adjusted to address illegal, unreported, and unregulated (IUU) fishing in the Philippines and to strengthen protection of endangered marine and freshwater species and critical conservation areas, based on the precautionary principle and an ecosystem-based approach to fisheries management (DA-BFAR 2014). In revising the Fisheries Code, the Philippines brought into force new provisions for legal take and trade in CITES Appendix II species, once Authorities set terms for their sustainable exploitation (Foster et al. 2016).

As the first step in implementing the revised Fisheries Code, the Philippines' CITES authorities need information that would allow them to make non-detriment findings (NDFs). These are science-based evaluations of whether exports may cause harm to wild populations, with positive findings required before CITES export permits can be granted (CITES 1973; Foster and Vincent 2016). With positive NDFs, the Philippines' CITES authorities would have the option of allowing legal fisheries and trade in a precautionary manner, monitoring and managing these activities in support of sustainable populations. Unfortunately, the only information required to set the terms for sustainable seahorse exports – information on seahorse exploitation and trade in the Philippines – came from trade surveys carried out in the early 2000s, twenty years ago (Pajaro and Vincent 2015).

Our 2019 research addressed the pressing need for an updated national assessment of seahorse fisheries and trade, marking a crucial first step toward implementing CITES regulations under the new Fisheries Code. The study's findings were initially released as a research report in 2019 (Foster et al. 2019b). However, we are now highlighting the key results to support the Bureau of Fisheries and Aquatic Resources' (BFAR) renewed commitment to seahorse conservation through its collaboration on the three-year Philippine Seahorse Program (PSP) (CITES 2024; Project Seahorse 2024). The PSP aims to promote sustainable trade in compliance with CITES regulations, develop seahorse-specific management measures, and strengthen enforcement against illegal fishing gear. Our updated surveys will assist national authorities in (i) assessing changes since the late 1990s, (ii) developing a management plan to ensure sustainable fisheries and exports, and (iii) establishing a baseline for new monitoring programs.

2. MATERIALS AND METHODS

2.1. Data collection

We conducted semi-structured interviews with a total of 323 seahorse fishers and traders from 17 provinces in the Philippines between March and July 2019. Ethics clearance for the interviews was obtained from the University of British Columbia (permit H12-02731), based on Canada's national standards. We further obtained authorization allowing our research from the Bureau of Fisheries and Aquatic Resources (BFAR, in the form of a Memorandum of Agreement with ZSL-Philippines) and the Palawan Council for Sustainable Development Staff (PCSDS, Wildlife Gratuitous Permit grant to ZSL-Philippines).

2.1.1. Survey areas

We selected survey areas based on previous trade surveys completed in the late 1990s and early 2000s (Vincent 1996; Pajaro and Vincent 2015), supplemented by research carried out by Project Seahorse and the Zoological Society of London-Philippines (ZSL-Philippines) teams over the last 20+ years (Foster and Apale 2016b). We carried out interviews at (i) fishing ports, communities, or villages, and (ii) larger communities and cities where seahorses are bought, sorted, and sold for international export (Figure 1).

2.1.2. Interviewees

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.

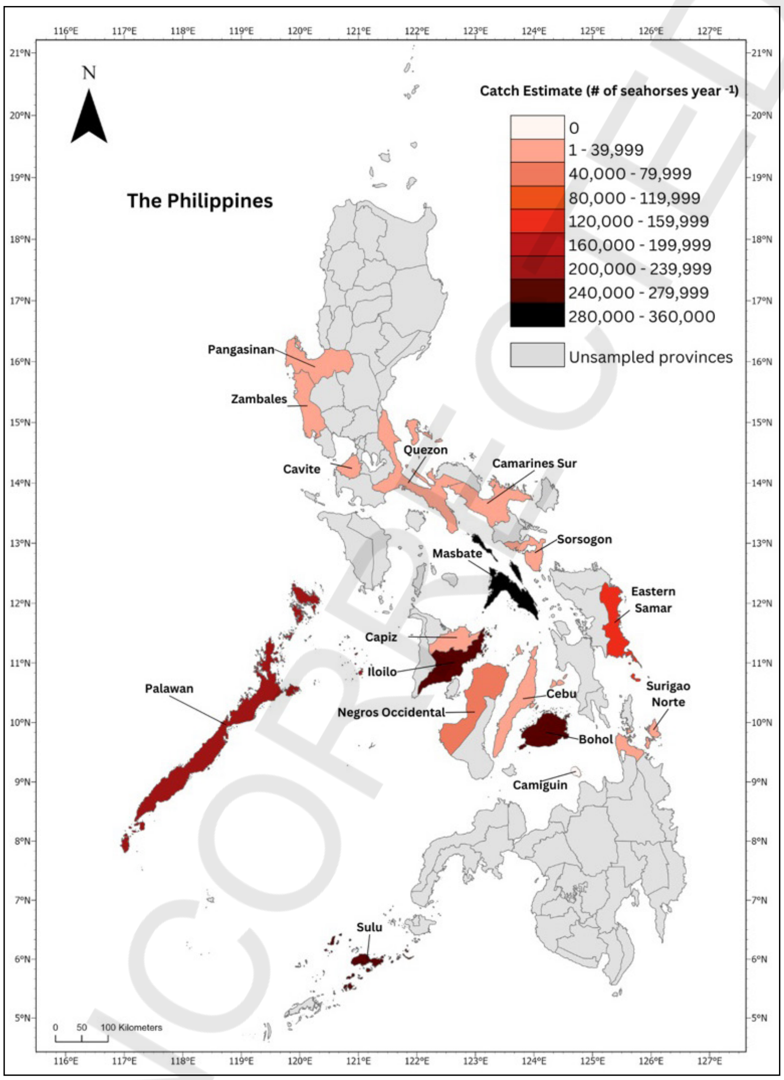

Figure 1. Estimated number of seahorses caught annually, accounting for effort and seasonal variations in catch per unit effort, across 17 provinces in the Philippines. Estimates are based on interviews with seahorse fishers and traders carried out from March to July 2019.

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2.1.3. Interviewers

Most interviews were carried out in local Filipino or Cebuano languages by two of the authors, both Filipino biologists trained in seahorse trade study protocols. One had been a senior biologist with Project Seahorse Foundation/ZSL-Philippines for more than 15 years, and both authors had previous experience in seahorse fisheries-dependent (catch landings) and fisheries-independent (underwater) surveys in the Philippines. Interviews in the island province of Sulu were completed in July by ZSL-Philippines colleagues from The Fisheries, Coastal Resources and Livelihood Project (FishCORAL).

2.1.4. Survey questions

We developed a set of questions to guide semi-structured interviews targeted at three groups of informants: fishers, primary buyers, domestic retailers, and exporters (guiding questions in supplemental material). Probably due to the illicit nature of the activities under investigation, our success at obtaining interviews declined as we proceeded up the trade chain (from fisher → primary buyers → domestic retailers/exporters). As a result, most of our reporting is limited to fishers (total n=237) and primary buyers (total n=31), with just small amounts of information from domestic retailers (total n=3).

Fishers were first asked whether they caught seahorses. If they did, we proceeded to ask about the gears they used for fishing, the corresponding fishing effort for each gear type, estimates of seahorse catch for different gear types and effort levels, the species caught, their uses for the seahorses they landed, and any changes in seahorse catch over time.

Primary buyers were asked about seahorse trade routes (sources and destinations), volume of trade (throughput, not standing stock), trading effort, species, state of seahorses (live/dried), buying and selling prices for seahorses, and changes in any of these factors over time.

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).

2.1.5. Species identification

Seahorse species and sizes in fisheries/trades were obtained by taking photos of specimens held by fishers (n=5) and buyers (n=14) beside a ruler for calibration. Seahorse species were identified with reference to Lourie et al. (2004). Seahorse size was measured on photos 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/absence of a swollen brood pouch (Lourie et al. 2004).

2.2. Data analysis

2.2.1. Seahorse catch

We calculated catch per unit effort (CPUE), annual catch per gear, and total annual catch for each gear type (i) overall and (ii) within each province.

Per fisher catch per unit effort ($CPUE_i$) **:** Fishers provided information on their catches for discrete time periods (i.e., per day, fishing trip, week, month, or year), which we standardized to a daily per fisher CPUE of seahorses gear^{-1} day^{-1}, where gear is the unit of effort appropriate to the fishing method being used (see supplemental material for gear descriptions and units of effort). When fishers provided a range for their seahorse catch and/or number of days fished, we used the median of the minimum and maximum values to calculate their CPUE, as our data were highly right-skewed.

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. When fishers reported seasonality to their catches, we calculated per fisher low and/or high season CPUE in addition to their average season CPUE, as above.

Catch rates were summarised by calculating the median, 1st, and 3rd quartiles (Q1 and Q3, which measure the spread of values above and below the median) across fishers for each gear type within each province. Average season catch rates were further summarised for each gear type overall.

Per gear annual catch (G_i)**:** We scaled up per fisher CPUE for each gear type ($CPUE_i$) to per fisher annual catch (seahorses gear^{-1} year^{-1}) using fisher-reported number of days fished per week and weeks fished per year ($CPUE_i$* fishing days week^{-1} * fishing weeks year^{-1} = per fisher catch year^{-1}). When fishers reported the number of months they fished instead of weeks, we converted them to weeks using 4.34 weeks per month and applied this to all fishers.

We accounted for seasonality of catches, where it was reported, by calculating per fisher annual catch for average, high and low seasons and then adding them together to obtain an estimate for the full year [e.g., G_i = ($CPUE_i$ average season * fishing days week^{-1} * fishing weeks year average season^{-1}) + ($CPUE_i$ low season * fishing days week^{-1} * fishing weeks year low season^{-1}) + ($CPUE_i$ high season * fishing days week^{-1} * fishing weeks year high season^{-1})].

Per gear annual catches (G_i) were determined by calculating the median, Q1, and Q3 of per fisher annual catches (i) overall and (ii) within each province.

Total annual catch: We calculated the total annual catch of seahorses for each gear (i) overall and (ii) within each province as follows:

$$Total\ catch = \sum_{i=1}^{n} \mathrm{G}_i \times \mathrm{N}_i$$

where G_i is the per gear annual catch of gear type *i* and N_i is the documented number of gears of type *i*, across the Philippines, or in each province. We did this calculation using each of the median, Q1 and Q3 G_i . We then summed across all gear types to generate a minimum total annual seahorse catch across the Philippines.

Statistics on the number of gears (N_i: e.g., fishers, traps, nets, boats, as appropriate to the fishing method, see supplemental material) within each municipality were obtained from our interviews or fisheries statistics data. Fisheries statistics data were obtained from the Philippine Rural Development Program (PRDP) final report on Resource and Social Assessment for Resources Management in Bohol (PRDP 2016) and the United States Agency for International Development (USAID) Fish Right program (details in supplemental material; NFR-ZSL 2018). In general, the numbers provided by Fish Right matched closely with numbers reported by fishers in our interviews, but where discrepancies arose, we favoured the inventory data provided by Fish Right, the latest published information at that time. Where statistics on the number of gears were unavailable, we used the number of fisher interviews per gear as a minimum estimate.

Our total values will underestimate the total seahorse catch across gear types, in each province, and across the Philippines. 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, so not all municipalities or gear types are included.

***Missing data*:** Where we lacked information for individual fishers with respect to the number of days fished per week and/or the duration of high/low season (number of weeks), we used the mean values 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 catches.

Number of weeks or months fished in a year: While most fishers did not report the total number of weeks or months fished in a year, those who did reported a median of ten months or 43.4 weeks per year (n=38). This estimate was applied to all fishers who did not provide specific information on the number of weeks fished per month or year.

2.2.2. Seahorse trade

2.2.2.1. Trade volume

We calculated the annual volume of seahorses acquired and sold per buyer across all 31 buyers we interviewed. We have not presented trader findings by province because of limited sample sizes, though these results are available (Foster et al. 2019b). We could not scale up per buyer volumes to total annual trade volumes as we lacked data on how many primary buyers trade seahorses across the Philippines.

***Trade per unit effort ($TPUE_i$)*:** Buyers provided information on their trade volumes (in either number of individuals, grams or kilograms) per day or month, which we standardized to a TPUE of number of seahorse (bought or sold) day^{-1} using a conversion factor of 300 seahorses per kilogram, based on trader reported numbers from our interviews, and an assumed 20 days worked per month. When a buyer provided a range for the number of seahorses bought or sold, we used the median of the reported value in our calculations. We summarised TPUE across the Philippines by calculating the median, Q1 and Q3 across all primary buyers that provided relevant information (n=31 for bought, n=14 for sold).

***Per buyer annual trade (bought/sold)*:** We estimated the number of seahorses each buyer bought or sold annually by multiplying TPUE by an assumed 20 days month^{-1} and 12 months year^{-1}. We summarised per buyer annual trade across the Philippines by calculating the median, Q1, and Q3, across all primary buyers that provided relevant information (n=31 for bought, n=14 for sold).

2.2.2.2. Price

Traders reported prices for seahorses they bought or sold by weight or number. Reported weights were converted to the number of individual seahorses using a conversion factor of 300 seahorses per kilogram. 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/). We summarised the price across the Philippines by calculating the median, Q1, and, Q3 across all primary buyers that provided relevant information.

2.2.3. Changes over time

Fishers and traders were invited to comment on changes in the number of seahorses they had caught or traded over time. We summarized changes by gear type and/or province from such information. When our interviews generated historical information 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. We then compared fisher reported catches across the time periods for which we had data. We followed the same methods to calculate CPUE and per gear annual catch as described above.

3. RESULTS

We obtained interview data from 268 respondents in 17 provinces, including 237 fishers across the 17 provinces and 31 buyers across 10 provinces.

3.1 Species

We identified the species, sexed, and measured a total of 200 seahorses from 54 photographs taken at five fishers' and 14 buyers' premises in 11 municipalities across eight provinces in the Philippines. We identified seven seahorse species in the photographs, including (in declining relative frequency across the photographs): *Hippocampus kuda*, *H. comes*, *H. spinosissimus*, *H. histrix*, *H. barbouri*, *H. kelloggi,* and *H. trimaculatus* (Table 1; species photos and diagnostic features can be found in Project Seahorse (2013, 2016). The two most commonly observed species, *H. kuda* and *H. comes*, were photographed in six provinces each. Photographs from the provinces of Bohol, Eastern Samar, and Masbate showed the highest species diversity, with four species observed (refer to Foster et al. (2019b) for species by province breakdown).

The seahorse library we photographed included more female than male seahorses (Table 1). Among our photographs, we observed pregnant *H. barbouri*, *H. comes*, *H. kuda*, and *H. spinosissimus*; half of the *H. barbouri* and *H. kuda* were pregnant. The mean size of seahorses varied by species: individuals of *H. histrix* and *H. trimaculatus* were the smallest, and *H. kelloggi* individuals were the largest. The largest *H. barbouri* and *H. kuda* we measured exceeded the maximum height documented for this species based on Lourie et al. (2004). Finally, the mean height of observed individuals was greater than the documented height at maturity for all species except *H. kuda*.

Table 1. Specimens of seahorses photographed in fishers' and primary buyers' premises, indicating the number of individuals, the sex ratio of males to females, the number of pregnant males, the mean height, the maximum height, the maximum recorded height, and the recorded height at maturity. SE = standard error.

Seahorse (*Hippocampus*) spp.	# individuals photographed	Sex ratio (n males: n females {n unknown})	# and % of pregnant males	Mean height [SE] (cm)	Max observed height (cm)	Max recorded height^ (cm)	Recorded 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 {4}	4 (24%)	13.6 [0.4]	18.1	18.7	8.1*
H. histrix	10	1:8 {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 {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†

^ Maximum recorded heights for species of *Hippocampus* are based on values reported in Lourie et al. (2004).
* Recorded height at maturity comes from Table 2 of Foster and Apale (2016) and references cited therein.
† Recorded height at reproductive maturity comes from Lawson et al. (2015).

3.2. Fisheries

Most fishers we interviewed (n=237 of 284) reported that they were catching or had previously caught seahorses. Respondents reported active seahorse fisheries in all provinces we visited except for Camiguin, where the four fishers we interviewed reported only catching seahorses in the past.

3.2.1. Gears

Across all fishers, ten different gear types had been used to catch seahorses (Table 2). The most common gear type reportedly used among our respondents was spear/skin diving (39%), followed by bottom set gill nets (25%; Table 2). Other respondents included compressor divers (11%), or fished using otter trawls (7%), floating gill nets (7%), modified push nets locally referred to as "micro-trawls" (4%), standard push nets (3%), fish traps (3%), gleaning (1%), or seine nets (<1%). Spear/skin divers, compressor divers, modified push net fishers, standard push net fishers, and gleaners were reported to target seahorses, while fishers using bottom and floating gill nets, seines, fish traps, and otter trawls were reported to catch seahorses incidentally.

The fishing gear reportedly used to catch seahorses in the greatest number of provinces was bottom set gill nets, reportedly used in 11 provinces (Table 3). The next most common were spear/skin divers and floating gill nets. Other gears were documented to catch seahorses in a few provinces. For example, modified push nets ("micro-trawls") and standard push nets were documented from just one province each. A range of one to five gears was documented to catch seahorses across the provinces we sampled (Table 3). The greatest diversity of gear types documented to catch seahorses was in the provinces of Eastern Samar, Iloilo, Negro Occidental, and Bohol (Table 3).

We were able to retrieve information on the number of gears in operation for 35 gear/province combinations, for which we also had estimates for per gear annual catch (Table 3).

3.2.2. Catches

3.2.2.1. Average season CPUE

The gear type with the highest estimated average season CPUE was modified push nets ("micro-trawls"), which were an order of magnitude higher than any other gear we sampled (Table 2). Modified push nets ("micro-trawls") were followed by standard push nets, compressor divers, seine fishers, and spear/skin divers (in descending order of median CPUE), with median CPUEs of between 1.5 and 10 seahorses gear^{-1} day^{-1}. The remaining gears caught a median of one or fewer seahorse gear^{-1} day^{-1}. Indeed, fishers using floating gill nets and fish traps reported negligible catches. The median CPUE across gears that targeted seahorses (6.0 seahorses gear^{-1} day^{-1}) was about 150 times greater than the CPUE of gears that caught them incidentally (0.04 seahorses gear^{-1} day^{-1}).

Table 2. As reported by fishers, catch per unit effort (CPUE), per gear annual catch, effort, and total annual catch by gear of seahorses (sh) in the Philippines, in order of decreasing CPUE. Median per gear annual catch and total annual catches account for seasonal data where available. Q_1 and Q_3 = quartiles 1 and 3, n = number of fishers that provided the information on which calculations are based.

Gear type	# fishers interviewed	Median CPUE [Q1, Q3] (n) for average season (sh/gear/day)	Median per gear annual catch [Q1, Q3] (sh/gear/year)	Effort (# gears or # fishers)	Total annual catch (sh/year)	Total annual catch Q1 (sh/year)	Total annual catch Q3 (sh/year)
Modified push net ("micro-trawls")	10	100.0 (10)	4 340.0	60	260 400	260 400	260 400
Standard push net	7	10.0 [5.8, 15.5] (7)	2 170.0 [570.0, 2724.0]	100	217 000	56 963	272 370
Compressor	27	6.0 [2.9, 10.0] (24)	989.5 [699.8, 1654.6]	704	696 622	492 677	1 164 856
Seine	2	2.0 (1)	562.9	15	4 230	4 230	4 230
Spear/skin diver	91	1.5 [0.3, 2.5] (88)	260.4 [32.6, 694.4]	906	235 922	29 490	629 129
Gleaning	3	1.0 [0.8, 1.3] (2)	206.2 [146.5, 265.8]	150	30 923	21 971	39 874
Otter trawl	16	0.1 [0.0, 1.0] (16)	10.9 [0.0, 157.3]	259	2 810	0	40 747
Gill net (bottom)	59	0.0 [0.0, 0.3] (58)	10.9 [0.2, 146.8]	659	7 150	158	96 708
Gill net (floating)	16	0.0 [0.0, 0.2] (16)	5.4 [0.0, 36.6]	35	190	0	1 282
Fish trap	6	0.0 [0.0, 0.0] (6)	0.0 [0.0, 1.3]	132	0	0	172
Total	**237**				**1 455 247**	**865 889**	**2 509 768**

Table 3. As reported by fishers, seahorse (sh) catch per unit effort (CPUE), per gear annual catch, and total annual catch by gear across 17 provinces in the Philippines during average, high, and low fishing seasons. Q1 and Q3 = quartiles 1 and 3, SE = standard error, n = number of fishers that provided the information on which calculations are based. Provinces organized from north to south.

Province	Gear type	# fishers interviewed	Median CPUE [Q1, Q3] (n) in average season (sh/gear/day)	Median CPUE [Q1, Q3] (n) in high/low season (sh/gear/day)	Median per gear annual catch [Q1, Q3] accounting for seasonal CPUE and effort (sh/gear/year)	Effort (# gears or # fishers)	Median total catch [Q1, Q3] accounting for seasonal CPUE and effort (sh/year)
Pangasinan	Spear/skin divers	1	1.5 (1)	NR	325.5	50	16 275
	Sub-total	1					16 275
Zambales	Spear/skin divers	5	0.1 [0.0, 0.9] (5)	HIGH: 17.5 (1)	162.8 [21.7, 217.0]	35	5 696 [760, 7 595]
	Gleaning	1	NR	NR	NR	NR	NR
	Sub-total	***6***					***5 696 [760, 7 595]***
Cavite	Gill net (bottom)	4	0.5 [0.4, 0.8] (4)	NR	151.9 [113.9, 227.9]	100	15 190 [11 393, 22 785]
	Gill net (floating)	3	NR	NR	NR	NR	NR
	Sub-total	***7***					***15 190 [11 393, 22 785]***
Quezon	Gleaning	1	0.6 (1)	NR	86.8	100	8 680
	Gill net (bottom)	9	0.0 [0.0, 0.1] (9)	NR	1.0 [0.0, 10.7]	48	46 [0, 512]
	Gill net (floating)	1	0.2 (1)	NR	44.3	1	44
	Sub-total	***11***					***8 770 [8 680, 9 192]***
Camarines Sur	Gill net (bottom)	4	0.0 [0.0, 0.0] (4)	NR	1.5 [1.1, 1.5]	90	131 [97, 131]
	Otter trawl	3	0.0 [0.0, 0.0] (3)	NR	0.0 [0.0, 1.0]	40	0 [0, 39]
	Gill net (floating)	1	NR	NR	NR	NR	NR
	Sub-total	***8***					***131 [97, 170]***
Sorsogon	Gill net (bottom)	16	0.0 [0.0, 0.3] (16)	HIGH: 4.0 (1)	10.9 [1.1, 147.5]	200	2 170 [218, 29 492]
	Gill net (floating)	5	0.1 [0.0, 1.0] (5)	NR	16.3 [10.9, 173.6]	11	179 [119, 1 910]
	Sub-total	***21***					***2 349 [337, 31 402]***
Masbate	Compressor	8	8.0 [6.3, 11.3] (8)	HIGH: 18.5 [15.3, 21.8] (2)	1 517.9 [960.2, 1 920.5]	200	303 583 [192 045, 384 090]
	Seine	1	2.0 (1)	NR	564.2	15	8 463
	Gill net (bottom)	6	0.1 [0.1, 0.3] (6)	HIGH: 3.4 [3.0, 4.5] (3)	106.3 [49.1, 149.7]	131	13 919 [6 426, 19 615]
	Sub-total	***15***					***317 502 [206 934, 412 168]***

Table 3. As reported by fishers, seahorse (sh) catch per unit effort (CPUE), per gear annual catch, and total annual catch by gear across 17 provinces in the Philippines during average, high, and low fishing seasons. Q1 and Q3 = quartiles 1 and 3, SE = standard error, n = number of fishers that provided the information on which calculations are based. Provinces organized from north to south.

Province	Gear type	# fishers interviewed	Median CPUE [Q1, Q3] (n) in average season (sh/gear/day)	Median CPUE [Q1, Q3] (n) in high/low season (sh/gear/day)	Median per gear annual catch [Q1, Q3] accounting for seasonal CPUE and effort (sh/gear/year)	Effort (# gears or # fishers)	Median total catch [Q1, Q3] accounting for seasonal CPUE and effort (sh/year)
Palawan	Push net	7	10.0 [5.8, 15.5] (6)	HIGH: 20.0 [15.0, 25.0] (3)	2 170.0 [596.8, 2 723.7]	100	217 000 [56 963, 272 370]
	Gill net (bottom)	4	0.8 [0.1, 1.8] (4)	NR	148.1 [2.4, 328.2]	33	4 887 [81, 10 831)
	Gill net (floating)	4	0.0 (4)	NR	0	23	0
	Sub-total	***15***					***221 887 [57 044, 283 201]***
Eastern Samar	Compressor	1	10.0 (1)	HIGH: 35.0 (1) LOW: 5.0 (1)	2 929.5	25	73 238
	Spear/skin divers	23	1.5 [1.0, 2.5] (23)	HIGH: 6.5 [5.0, 12.5] (8) LOW: 1.0 [0.8,1.3] (2)	303.8 [97.7, 542.2]	240	72 912 [23 436, 130 135]
	Gill net (bottom)	3	0.0 [0.0, 0.0] (3)	NR	0.0 [0.0, 13.6]	40	0 [0, 543]
	Fish trap	1	0.0 (1)	NR	NR	NR	NR
	Sub-total	***28***					***146 150 [96 674, 203 916]***
Capiz	Seine	1	NR	NR	NR	NR	NR
	Otter trawl	6	2.0 [0.3, 3.4] (6)	NR	249.6 [27.1, 410.9]	119	29 696 [3 228, 48 902]
	Sub-total	***7***					***29 696 [3 228, 48 902]***
Iloilo	Compressor	9	5.5 [2.0, 6.6] (9)	HIGH: 7.5 [5.8, 10.0] (2)	1 002.5 [390.6, 1 253.2]	219	219 556 [85 541, 274 445]
	Spear/skin divers	9	1.0 [0.0, 1.5] (9)	HIGH: 10.0 (1)	130.2 [8.3, 555.5]	158	20 572 [1 317, 87 772]
	Gill net (bottom)	1	NR	NR	NR	NR	NR
	Gill net (floating)	1	NR	NR	NR	NR	NR
	Fish trap	3	0.0 [0.0, 1.0] (3)	NR	0.0 [0.0, 303.8]	130	0 [0, 39 494]
	Sub-total	***23***					***240 138 [86 858, 401 711]***
Negros Occidental	Compressor	6	3.3 [1.8, 4.4] (6)	HIGH: 8.0 [7.0, 9.0] (2) LOW: 2.8 [2.1, 3.4] (2)	755.2 [455.7, 937.4]	60	45 310 [27 342, 56 246]
	Spear/skin divers	3	0.1 [0.1, 1.5] (3)	NR	10.9 [10.9, 122.6]	120	1 302 [1 302, 14 713]
	Gill net (bottom)	2	0.8 [0.4, 1.1] (2)	NR	195.3 [97.7, 293.0]	2	391 [195, 586]
	Otter trawl	7	0.1 [0.1, 0.2] (7)	NR	10.9 [8.1, 65.1]	100	1 085 [814, 6 510]
	Sub-total	*18*					*48 088 [29 463, 78 055]*

Table 3. As reported by fishers, seahorse (sh) catch per unit effort (CPUE), per gear annual catch, and total annual catch by gear across 17 provinces in the Philippines during average, high, and low fishing seasons. Q1 and Q3 = quartiles 1 and 3, SE = standard error, n = number of fishers that provided the information on which calculations are based. Provinces organized from north to south.

Province	Gear type	# fishers interviewed	Median CPUE [Q1, Q3] (n) in average season (sh/gear/day)	Median CPUE [Q1, Q3] (n) in high/low season (sh/gear/day)	Median per gear annual catch [Q1, Q3] accounting for seasonal CPUE and effort (sh/gear/year)	Effort (# gears or # fishers)	Median total catch [Q1, Q3] accounting for seasonal CPUE and effort (sh/year)
Cebu	Spear/skin divers	10	0.5 [0.1, 2.0] (10)	HIGH: 9.8 [7.1, 12.4] (2) LOW: 3.3 [2.6, 3.9] (2)	141.1 [15.5, 288.9]	80	11 284 [1 243, 23 111]
	Sub-total	***10***					***11 284 [1 243, 23 111]***
Bohol	Compressor	3	3.5 [3.4, 4.8] (3)	HIGH: 5.0 (1) LOW: 0.5 (1)	759.5 [713.9, 1 161.0]	200	151 900 [142 786, 232 190]
	Spear/skin divers	31	2.5 [1.0, 3.5] (31)	HIGH: 10.0 [8.5, 11.8] (18) LOW: 2.3 [1.4, 3.0] (16)	683.6 [376.3, 1 085.0]	123	84 077 [46 282, 133 455]
	Gleaning	1	1.5 (1)	NR	325.5	50	16 275
	Gill net (bottom)	9	0.1 [0.1, 0.5] (9)	NR	42.5 [10.9, 151.9]	15	638 [164, 2 279]
	Sub-total	***44***					***252 890 [205 507, 384 199]***
Surigao del Norte	Spear/skin divers	6	0.3 [0.0, 0.8] (3)	NR	16.3 [0.0, 53.2]	100	1 628 [0, 5 317]
	Gill net (floating)	1	NR	NR	NR	NR	NR
	Fish trap	2	0.0 [0.0, 0.0] (2)	NR	0.9 [0.4, 1.3]	2	2 [1, 3]
	Sub-total	***9***					***1 630 [1, 5 320]***
Camiguin	Spear/skin divers	3	0.0 [0.0, 0.0] (3)	NR	NR	NR	NR
	Gill net (bottom)	1	0.0 (1)	NR	NR	NR	NR
	Sub-total	***4***					***0***
Sulu	Modified push net ("micro-trawls")	10	100.0 [100.0, 100.0] (10)	NR	4 340.0 [4 340.0, 4 340.0]	60	260 400 [260 400, 260 400]
	Sub-total	10					260 400 [260 400, 260 400]
TOTAL		**237**					**1 572 380 [984 904, 2 188 402]**

Estimated average season CPUEs were comparable across the provinces we sampled. The CPUE of compressor divers showed the greatest geographic difference, ranging from 3.3 to 10 seahorses gear^{-1} day^{-1} across the five provinces with data (Table 3). On the other hand, CPUE of spear/skin divers only ranged from <1-2.5 seahorses gear^{-1} day^{-1} across the nine provinces with data, and CPUE for bottom gill nets, which we documented for ten provinces, was consistently <1 seahorses gear^{-1} day^{-1}.

3.2.2.2. Per gear annual catch

Variation in the number of days fishers reported fishing per week was largely responsible for variation in country-wide annual catch by gear (Table S1, supplemental material). For example, while modified push nets ("micro-trawls") had the largest CPUE by an order of magnitude, respondents reported using the gear one day a week (on average) which meant annual seahorse catch per modified push net was estimated at just two times that of standard push nets – the gear with the next highest per gear annual catch, and which fishers reported using five days a week (Table 2). However, for the rest of the gears, per gear annual catch patterns largely reflected those of CPUE.

Per gear, annual catches were more variable than CPUE across provinces (Table 3). For example, individual compressor divers were calculated to catch 755–2,930 seahorses per year, individual spear/skin divers captured 11–684 seahorses per year, and individual bottom set gill nets obtained <1–195 seahorses per year.

3.2.2.3. Total catch

Our annual catch estimate for the Philippines totalled ~1.5 [0.9, 2.5] to ~1.6 [1.0, 2.2] million seahorses across 24 municipalities in 16 provinces; the lower estimate was generated by scaling up country wide gear specific annual catches (Table 2), whereas the higher estimate arose from scaling up provincial gear specific annual catches (Table 3).

By gear, compressor fishers seemingly accounted for 48% of our estimated total catch volume across the Philippines (Table 2). Modified push nets ("micro-trawls") were estimated to have the second highest annual catch of seahorses, accounting for 18% of the total, followed by spear/skin divers and standard push nets, which accounted for approximately 16 and 15% of the total catch, respectively. The relative contribution of different gears to the total catch was the same when looking across gear/province combinations (Table 3).

By province, Masbate fishers reported the highest seahorse catch, contributing to 20% of the total national catch estimate (Figure 1, Table 3). Masbate was followed by Sulu, Bohol, Iloilo, and Palawan, each contributing between 14 and 17% of the total estimated catch per year. These five top provinces together accounted for over 80% of the estimated annual national catch, based on the provinces we surveyed.

3.3. Trade

We documented seahorse trade in ten provinces (Pangasinan, Quezon, Palawan, Masbate, Eastern Samar, Capiz, Iloilo, Negros Occidental, Cebu, and Bohol). The majority (77%) of our interviews concentrated on Level 2 primary buyers, who sourced their seahorses directly from fishers. In addition, we interviewed three retailers in Roxas City in the province of Capiz and four buyers, whom we categorized as primary buyers but who seemingly may also have operated as secondary buyers.

3.3.1. Trade form and use

Buyers reported most commonly procuring seahorses in the dried form (n=29, 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. Seven more buyers reported collecting and trading live (n=6) and dried (n=2) seahorses in the past, but were no longer doing so because of the ban. These seven interviews were excluded from our analysis.

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).

3.3.2. Trade routes

Primary buyers generally sourced their seahorses from fishers in the same municipality and/or province they operated (n=**). Six primary buyers reported they travelled locally to sell seahorses to secondary buyers, or secondary buyers would come in person to collect seahorses from them. One buyer reported sending seahorses by bus.

Information on reported destinations was patchy. Buyers reported Cebu City (n=6) and Manila (n=1) as 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). No specific information was provided on international destinations.

3.3.3. Trade volumes

Data on seahorse acquisition were obtained from 31 primary buyers across ten provinces (Table 4). We estimated individual primary buyers to acquire a median of 9 seahorses day^{-1} or ~ 2,200 seahorses year^{-1} (Table 4). Data on the volume of seahorses sold to higher-level buyers were obtained from just 14 in six provinces (Table 5). We estimated individual primary buyers to sell a median of 4.7 seahorses day^{-1} and ~1,100 seahorses year^{-1} (Table 5).

Both TPUE and annual per buyer trade volumes seemed highly variable across the provinces we sampled (Tables 4 and 5). The number of seahorses acquired per buyer may have been highest in Pangasinan and Bohol; the volume estimates for these provinces were more than ten times higher than the overall median.

Table 4. As reported by buyers, number of individual seahorses (sh) acquired per buyer daily and annually, by province across the Philippines. Buyers were assumed to work a 5-day work week throughout the year, as per Foster et al (2019b). Q_1 and Q_3 = quartiles 1 and 3. Locations organized from north to south.

Province	# of traders interviewed (type of trade)	Median per buyer daily seahorses acquired [Q1, Q3] (sh/buyer/day)	Median per buyer annual seahorses acquired [Q1, Q3] (sh/buyer/year)
Pangasinan	1 (dried)	130.0	31 200
Quezon	2 (dried)	8.3 [4.9, 11.6]	1 980 [1 170, 2 790]
Masbate	7 (dried)	30.0 [24.0, 85.0]	7 200 [5 850, 20 400]
Palawan	1 (dried)	2.5	600
Eastern Samar	6 (dried)	5.8 [2.5, 6.0]	1 395 [608, 1 440]
Capiz	3 (dried	0.2 [0.1, 0.9]	207 [29, 207]
Iloilo	2 (dried)	17.5 [11.3, 23.8]	4 200 [2 700, 5 700]
Negros Occidental	1 (dried)	15.0	3 600
Cebu	2 (dried); 1 (live)	6.0 [6.0, 10.5]	1 440 [1 440, 2 520]
Bohol	5 (dried)	102.5 [15.0, 170.0]	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 5. As reported by dried trade buyers, number of individual seahorses (sh) sold per buyer daily and annually, 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 per buyer daily seahorses sold [Q1, Q3] (sh/buyer/day)	Median per buyer annual seahorses sold [Q1, Q3] (sh/buyer/year)
Pangasinan	-	-	- t
Quezon	1	6.0	1 440
Masbate	3	37.5 [3.7, 54.7]	1 050 [885, 13 125]
Palawan	-	-	-
Eastern Samar	3	3.3 [2.5, 3.8]	900 [600, 1 050]
Capiz	2	0.1	12
Iloilo	1	30.0	7 200
Negros Occidental	-	-	-
Cebu	-	-	-
Bohol	4	36.9 [17.6, 47.8]	6 750 [4 230, 11 475]
Overall median across 14 buyers	**14**	**4.7 [1.9, 28.1]**	**1 125 [450, 6 750]**

3.3.4. Trade values

Only seven buyers, from four provinces (Pangasinan, Eastern Samar, Capiz, and Bohol), reported how much they paid fishers per individual seahorse; together they reported a median purchase price of USD 0.58 per seahorse [0.58, 0.67]. One fisher from the northern province of Pangasinan reportedly being paid the least for their seahorses (USD 0.19, n=1), whereas a fisher in Bohol reported being paid the most (USD 1.90, n=1).

Buyers reportedly sold their seahorses for about three to five times what they paid for them. Eight buyers reported a selling price per kg, across six provinces, and six buyers reported a selling price per individual seahorse, across three provinces. The median selling price per kilogram across all provinces was ~USD 460 kilogram^{-1} [324, 575], which translates into ~USD 1.50 per seahorse using a conversion factor of 300 seahorses per kilogram. The median reported sale price per kilogram apparently ranged from USD 288 (in Quezon; n=1) to USD 604 (in Bohol; n=2). The median selling price for an individual seahorse was reported to be proportionately higher than if sold by kg, at USD 2.30 [2.01, 3.16].

3.4. Changes over time

3.4.1. Fishers

Ninety-eight percent of fishers who commented on changes in seahorse catches over time (n=93 of 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.

We obtained enough information from spear/skin divers in Bohol and Surigao del Norte to calculate changes in catch rates (CPUE) and per gear annual catch across two time periods each: Bohol from 2000-2009 and 2010-2017; Surigao del Norte from 1990 to 1999 and 2000–2009 (Table 6). Fisher data for Bohol indicated that CPUE and per gear annual catch had decreased by 86% within two decades. Declines in seahorse catch rates were similarly inferred from spear/skin divers in Surigao del Norte, where fisher data indicated CPUE and per gear annual catch had declined over 98% from 1990 to the present.

3.4.2. Traders

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

4. DISCUSSION

4.1 Seahorse fisheries and trade persisted in the Philippines despite the ban

Despite the ban, seahorse fishing and international trade in the Philippines were continuing in significant numbers. Our surveys estimated that

Table 6. As reported by fishers, changes observed in seahorse (sh) catch over time for spear/skin divers in Bohol and Surigao del Norte. 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 [Q1, Q3] (n) (sh/fisher/day)	Mean effort [SE] (n) (# days/week)	Mean effort[1] (# weeks/year)	Median annual catch rate [Q1, Q3] (sh/fisher/year)
Bohol				
2019	2.5 [1.0, 3.5] (28)	5.2 [0.3] (30)	43.4	684 [376, 1 144]
2010-2017	6.0 [4.5, 13.0] (9)	5.3 [0.6] (5)	43.4	1 562 [1 172, 2 760]
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				
2019	0.3 [0.0, 0.8] (5)	5.3 [2.4] (3)	43.4	16 [0, 53]
2000-2009	77.5 [41.3, 113.8] (2)	6.0 (2)	43.4	20 181 [10 741, 29 620]
1990-1999	12.5 [11.3, 13.8] (2)	5.0 (2)	43.4	2 713 [2 441, 2 984]

[1]Mean # of weeks fished annually was estimated at 43.4 weeks, which is the mean reported weeks per month fished per year across all other gear types and provinces.

millions of seahorses were being landed yearly across eight gear types and 17 provinces. As is common to seahorse fisheries globally, most gears caught few seahorses per day, but these low catch rates (CPUEs) scaled up to large numbers after accounting for individual and collective fishing effort (Lawson et al. 2017). It appears captured seahorses were destined for export, as we found evidence of limited domestic use. Our findings are supported by 2016–2017 study from Hong Kong SAR, the largest hub for dried seahorses, which identified the Philippines as the second-largest source of dried seahorse imports after Thailand (Foster et al. 2019a), and are also backed by data on seahorse seizures by Philippine Authorities (Sy and Melgar 2022). Our research found that the once significant live seahorse trade was no longer prominent, likely because live animals are much harder to smuggle than dried ones (Foster et al. 2016).

We believe our data in 2019 significantly underestimated seahorse catches for five key reasons, which may explain why the numbers were lower than before the ban (4 million per year in 1998-2001; Pajaro and Vincent 2015). First, there were more fishers and vessels than we recorded. For example, we could not get data on the number of compressor fishers in some areas, so their catches are missing from the estimated total. Second, additional fishing gears, like beach seines and trammel nets, also caught seahorses but were not included. Third, some municipalities and provinces we did not visit were likely catching seahorses. Fourth, more gear/municipality combinations existed than we documented. Finally, the illegal nature of seahorse fishing after the ban may have made respondents less willing to share information.

4.2 Concerns about levels of seahorse exploitation

Though all catch and trade we documented was illegal, the revised fisheries law in the Philippines allows for a re-opening of seahorse fisheries and trades once the government has set the terms for sustainable exploitation (DA-BFAR 2014). Setting these terms is akin to making a positive CITES non-detriment finding (NDF) – a science-based assessment that exports will not be detrimental to the species' survival in the wild (CITES 2013). NDFs can take many forms (CITES 2013; Foster and Vincent 2016; Leaman and Oldfield 2014; Mundy-Taylor et al. 2014; Rosser and Haywood 2002). A pragmatic approach proposed for seahorses (but of relevance to all CITES species) is based on answering five questions: (i) where have the species been found?; (ii) what pressures do the species face?; (iii) what measures are in place to manage the pressures?; (iv) how well are the management measures implemented?; and (v) what is happening to wild populations? (Foster and Vincent 2023).

Our trade surveys provide the Philippine government with information regarding (i) and (ii) – where the seahorses are and what pressures they are facing. Three of the species we documented appear to be widespread across the Philippines: *H. comes, H. kuda,* and *H. spinosissimus*. Previous trade surveys also documented *H. kelloggi* and *H. trimaculatus* across the Philippines (Pajaro and Vincent 2015), whereas we only observed them in one province each. Both surveys were consistent in only encountering *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 in the same province where 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 Masbate, Sulu, Bohol, Iloilo, and Palawan. The main gears affecting seahorses in the Philippines—compressor diving, skin/spear diving, and standard push nets—have stayed the same over time (Pajaro and Vincent 2015). However, our research found large seahorse catches from modified push nets ("micro-trawls") in Sulu, which had very high CPUE, even though seaweed farmers reported using them only four times a month for extra income. Philippine authorities need to understand the use of these modified nets better, as increased use could significantly raise pressure on wild seahorse populations.

Further research is needed to understand the current threat posed by non-target fisheries in the Philippines. A key difference between past trade studies and ours was the potential impact of otter trawls, which are responsible for a huge volume of seahorse catch elsewhere in the world (Lawson et al. 2017). Our study documented a 97% decline in otter trawl CPUE and one-fifth as many boats operating across the study area (Pajaro and Vincent 2015). These estimates need further investigation. We also did not document the destructive and illegal Danish seine fishing (*Liba-liba*; Meeuwig et al. 2005), which could put significant pressure on seahorses where they are used.

Updated information is needed to understand (iii) what management is in place to mitigate fishing impacts on seahorses nationwide and (iv) how effectively these measures are implemented.

Conservation efforts so far include the establishment of no-take MPAs and the voluntary adoption of a 10 cm minimum size limit (MSL) by an association of small-scale fishers in the central Philippines (Martin-Smith et al. 2004). The Philippine government has also banned some of the gears that happen to catch seahorses. For example, trawls and motorized push nets are prohibited in municipal waters, bays, and fishery management areas (Department of Agriculture 2000), and compressor fishing is illegal in many municipalities (DA-BFAR 2014). Authorities must provide data on how well these measures are being implemented, which requires proper monitoring and analysis.

In addressing (v), it seems wild seahorse populations in the Philippines are declining. The large catch volume, combined with fisher-reported drops in catch rates (CPUE) and the species' threatened status, is concerning. The seven species we documented are listed as Vulnerable on the IUCN Red List (Pollom et al. 2021), but no national assessments exist. Most fishers who commented on changes in seahorse catches reported declines, and the drop in CPUE in Bohol and Surigao del Norte mirrors past findings (O'Donnell et al. 2012; O'Donnell et al. 2010; Pajaro and Vincent 2015). CPUE estimates for spear/skin divers, seines, gleaners, gill nets, and otter trawls are lower than those at the start of the century, though similar for compressor divers and higher for standard push nets. Other worrying signs include many photographed male *H. barbouri* and *H. kuda* being pregnant, and the average size of *H. kuda* caught being smaller than their size at maturity (Hutchings and Baum 2005; Meeuwig et al. 2006), though we do not know to what extent fisher selectivity may have affected these results.

4.3 Discerning the way forward

Findings from our 2019 research remain highly relevant today, as seahorses in the Philippines continue to face intense pressure from unregulated and unreported fishing. These threats are far from historical. Interviews conducted in 2024 with municipal fishers in the Danajon Bank reveal that seahorses are still actively targeted by compressor divers and spearfishers, and are also caught incidentally in bottom-set gillnets—at catch rates ranging from two to nine seahorses per fisher per hour per night (Project Seahorse and ZSL-Philippines, unpublished data). Fishers in at least one community also reported a long-term decline in perceived seahorse populations. Reinforcing these concerns, the Philippine Seahorse Program: Saving Mr. Mom (collaboration between Project Seahorse and ZSL-Philippines), and DA-BFAR coordinated the country's first-ever NDF assessments in 2024 for four species: *H. comes*, *H. histrix*, *H. kuda*, and *H. spinosissimus* (DA-NFRDI 2024). All four received negative NDF determinations, underscoring the vulnerability of wild seahorse populations in the Danajon Bank under current fishing pressures and habitat conditions (Project Seahorse et al. 2024).

Action is needed to reduce the many pressures facing seahorses in the Philippines. For example, enforcing the ban on compressor diving, a major contributor to seahorse catches, is crucial. This issue extends beyond seahorses — up to half of the fish caught in the Philippines in 2019 came from illegal fishing (NCWC Secretariat 2022). For legal gears, an MSL could help manage seahorse populations by ensuring they reproduce before being caught (Foster and Vincent 2005), as endorsed by CITES (CITES 2004). In the central Philippines, the voluntary MSL seems to have stabilized seahorse CPUE (Yasué et al. 2015). Additional measures like catch quotas and protecting pregnant males could further support legal fisheries (Foster and Vincent 2016). For non-selective fisheries, better management can include enforcing and expanding MPAs and trawl exclusion zones (Foster and Vincent 2016). MPAs have been shown to increase seahorse size, which could lead to enhanced reproduction (Yasué et al. 2015), and some have shown an increase in seahorse numbers (Foster and Apale 2016b). Success will require cooperation among law enforcement, local governments, fishing communities, and traders (NCWC Secretariat 2022).

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 can monitor landings and fishing effort repeatedly (developing a time series; Foster et al. 2014), and address conservation concerns as they emerge. Data collection by or from primary buyers may also offer a pragmatic approach to monitoring because, if properly designed, such surveys would provide information across many fishers, gears, and municipalities (CITES 2023). To make monitoring tractable, it is possible to set up specific "sentinel" or indicator fisheries or trades in seahorse hotspots, for example, in Bohol, Iloilo, Masbate, Palawan, and Sulu, which all our data suggest cover the diversity of seahorse species, and fishing gears that catch them.

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SUPPLEMENTARY MATERIAL

Link to the electronic supplementary material. [Supplementary file](#)

AUTHOR CONTRIBUTIONS

Foster SJ: Conceptualization, Validation, Formal analysis, Writing - Original Draft, Writing - Review & Editing, Funding acquisition. **Stanton LM:** Methodology, Validation, Formal analysis, Data Curation, Writing - Original Draft, Visualization, Supervision. **Nellas AC**: Investigation, Data Curation. **Arias MM**: Investigation, Data Curation. **Apale CM**: Conceptualization, Methodology, Writing - Review & Editing, Supervision, Funding acquisition. **Vincent ACJ**: Conceptualization, Methodology, Writing - Review & Editing, Supervision, Project administration, Funding acquisition

CONFLICTS OF INTEREST

The authors indicate no conflicts of interest.

ETHICS STATEMENT

Research permission was secured through a Memorandum of Agreement between BFAR and ZSL-Philippines, and a PCSDS Wildlife Gratuitous Permit was granted to ZSL-Philippines. Ethics clearance for the interviews was obtained from the University of British Columbia (permit H12-02731), based on Canada's national standards.

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