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Opportunities and challenges for analysis of wildlife trade using CITES data – seahorses as a case study

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ABSTRACT

1. In principle, the database generated by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) offers an unparalleled opportunity to analyse trade in species of conservation concern.
2. The value of the database is assessed in the context of trade in 47 species of seahorse (*Hippocampus* spp.), all of which are included on CITES Appendix II. This listing requires that all 180 Parties to CITES (member Parties) limit exports to levels that do not damage wild populations, ensure they are obtained legally, and report their trade to CITES.
3. An evident need for greater universal compliance with CITES reporting requirements was identified. The most glaring problem was a substantial mismatch in species and volumes between export records and import records, indicating that neither dataset is complete nor reliable.
4. The evaluation also showed that Parties should increase compliance with CITES requirements to record all trade shipments, provide units for exports (e.g. individuals, kilograms) and identify exported taxa to species, perhaps supported by automated checking of entries.
5. The challenges with the CITES trade database were more evident for the global trade in dried seahorses than the smaller and more easily-tracked trade in live seahorses. Nonetheless, CITES' data from 2004–2011 revealed a seahorse trade involving millions of animals, tens of species, and scores of Parties.
6. CITES data have also proven invaluable in supporting CITES reviews of how Parties are implementing the Convention for seahorses, and in generating consequent action for their conservation.

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INTRODUCTION

Marine fishes have long been recognized as important sources of food and income, but only recently recognized as wildlife in need of management and conservation. A significant number of people depend on fishing for food security (some 3 billion) and livelihoods (up to 820 million) (FAO, 2012). Many fishes have value owing to demand on international markets; in the early 1990s fisheries constituted about 25% of international trade in wild species, which had a

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total worth of about $US160 billion (TRAFFIC as cited in Dickson, 2002). But while fisheries have existed since time immemorial, it is only since the mid-1990s that fish have been recognized as wildlife that can be overexploited. Thirty per cent of the fisheries tracked by The Food and Agriculture Organization of the United Nations (FAO) are considered overexploited, depleted or recovering from depletion (FAO, 2012), and the small unassessed fisheries are in substantially worse condition (Costello *et al*., 2012). Furthermore there is now evidence that marine fishes can become globally threatened and even extirpated (Hutchings, 2001; Sadovy, 2001; Reynolds *et al*., 2005). While conservation and sustainable use of exploited fishes has traditionally gone to national, regional and global fisheries management agencies and organizations – it is clear that new tools are needed to improve the conservation and management of fished species (Vincent *et al*., 2013).

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is a multilateral environmental agreement that aims to ensure that international trade in specimens of wild animals and plants does not threaten survival of wild populations (CITES, 2014c). It operates by placing species of concern on lists (Appendices) that prohibit or regulate their trade. International trade in species in CITES Appendix I is essentially banned because it is recognized as a threat to the continued survival of the species in the wild. International trade in species listed in Appendix II is permitted but controlled as these species might become threatened with extinction if trade were allowed to continue unregulated. For these species continued trade requires an export permit based on evidence that exploitation is not detrimental to the future of wild populations and legal sourcing.

Despite some concerns regarding the goals and efficacy of CITES (Kievit, 2000; Martin, 2000), the Convention has been hailed as one of the more effective multilateral environmental agreements because of its large number of member Parties (180 at time of writing) and its greater enforcement capacity relative to other treaties (Ong, 1998; Ginsberg, 2002). After 25 years of conservation efforts by CITES member states, for example, eight of 23 historically threatened crocodile species were sufficiently numerous to sustain regulated commercial trade (Kievit, 2000), a reversal often attributed to CITES.

The role of CITES with respect to marine fishes has yet to be fully resolved, with much controversy even about adding them to the Appendices (Vincent *et al*., 2013). As a consequence, CITES currently regulates the international trade of very few marine fish taxa. One of the objections to CITES is that a dearth of high quality information available on the status of populations, fisheries and trades makes it difficult to implement CITES listings (Vincent *et al*., 2013). CITES Parties have highlighted problems with identification and taxonomy, geographical coverage of population surveys, validity of scientific and trade data and evidence of trade as a factor driving declines (e.g. sawfishes, sharks, seahorses, humphead wrasse) (Vincent *et al*., 2013); such concerns are, of course, common with many terrestrial CITES-regulated taxa as well (Phelps *et al*., 2010; Smith *et al*., 2011).

In fact, the requirements of the Convention should improve data collection for species listed on the Appendices, not least because Parties are required to report their trade by species and by volume (CITES, 2006). The Management Authority of each exporting Party of an Appendix II species is obliged under the Convention to issue export permits for trade in such species, and submit annual reports of their exports to CITES. The importing or consumer Party has to ensure that shipments of Appendix II species have an associated export permit or re-export certificate, and submit annual reports of their imports to CITES.

The 2002 listing of all seahorse species (*Hippocampus* spp.) on CITES Appendix II – implemented in 2004 – was the first time CITES had agreed to regulate the international trade of a marine fish in 25 years (Vincent *et al*., 2013). The approximately 47 species of seahorses (CITES, 2014b) are traded in large numbers, worldwide, either dried for use in traditional medicine and curios or live for display as aquarium fish, at levels that raise concern for sustainability of many populations (Vincent *et al*.,

2011a). The vast majority of seahorses in trade is sourced from non-selective fisheries such as trawls although some (including effectively all live-wild animals) are sourced from target fisheries (Vincent *et al.*, 2011a). Early field investigations into the seahorse trade in the mid-1990s to early 2000s revealed that a large number of Parties were trading large volumes of seahorses, and that populations had declined in a number of source Parties (Vincent, 1996; McPherson and Vincent, 2004; Giles *et al.*, 2006; Perry *et al.*, 2010; Vincent *et al.*, 2011b). Indeed, seahorse life-history characteristics (e.g. low population densities, parental care, low fecundity and small home ranges) may make them very vulnerable to overexploitation (Foster and Vincent, 2004).

CITES data should increase capacity to manage trade and so populations, as well as explore the effectiveness of CITES in improving prospects for sustainable exploitation. The field surveys previously used to identify and document the trade in seahorses are so time consuming and costly as to be unsustainable (details of these surveys can be found in Vincent, 1996; McPherson and Vincent, 2004; Baum and Vincent, 2005; Giles *et al.*, 2006; Martin-Smith and Vincent, 2006; Perry *et al.*, 2010; Vincent *et al.*, 2011b). Instead, the mandated completion of standardized CITES annual reports should provide species-specific trade data for seahorses and thus allow the analysis and tracking of their international trade. That said, the challenges inherent in global database management and unreliable data submission are potential impediments to the usefulness of CITES data for such purposes (Blundell and Masica, 2005; as reviewed in Phelps *et al.*, 2010). For example, trade surveys revealed more orchids openly on sale at a border market in SE Asia than had been recorded as being exported from the country in a 9-year period (Phelps *et al.*, 2010). Yet the effectiveness of CITES is, in some measure, linked to its ability to track accurately long-term data for global volumes, species and trade routes, while minimizing reporting inaccuracies (Blundell and Masica, 2005).

This study represents a highly unusual analysis of trade data in that the database was queried to an extreme extent, even writing to Parties for clarification if necessary. The objectives were to: (1) analyse the benefits and challenges of using the CITES global trade database to track the international trade in threatened species, with seahorses as a case study; and to then (2) explore the utility of CITES data in elucidating the global trade of seahorses since implementation of their listing on CITES Appendix II in 2004. Previous studies have generally commented on the likely reliability or unreliability of CITES and other trade data but without mining the database to extract detailed evidence in support of their observations (Pernetta, 2009; Nijman, 2010).

METHODS

Data acquisition and formatting

CITES trade data reported by Parties in their annual report submissions are held in a searchable database that is curated by UNEP-WCMC (UNEP-WCMC, 2013). The database was queried on 05 June 2013 for all sources (except pre-Convention specimens), terms, and export and import Parties for the trade in all *Hippocampus* species from 2004 to 2011 (inclusive), extracting a total of 2210 records. Because implementation of the seahorse listing was deferred until May 2004, downloaded 2004 data may represent only a partial year of trade. Furthermore, although annual reports should be submitted to CITES the year following the one in which the trade occurred, common delays in reporting mean that the most recent year for which comprehensive trade statistics are available is normally 2 years before the present one (UNEP-WCMC, 2010). The CITES trade database is continuously updated and, therefore, data are never considered final.

Sources

The definitions used in this report follow those provided by UNEP-WCMC (UNEP-WCMC, 2004). Records labelled 'R' (ranch-raised) and 'W' (wild) were pooled with those labelled 'F' (specimens born in captivity to wild-caught parents) to encompass wild-caught seahorses: production of 'F' specimens requires taking their

parents from the wild and so their export could negatively impact wild populations. Records labelled 'C' (specimens born in captivity to captive-born parents) were the only specimens designated as truly captive-bred. Records labelled 'U' (unknown source), 'I' (confiscated or seized specimens), or without an indicated source were removed from the analyses when comparing trade in wild vs. captive-bred seahorses.

Terms

Seahorse trade can be divided into two large groups – dried (typically for traditional medicine, but also curios), and live (for public and home aquaria). Reported import or export terms were used to group the trade records into these broad categories. Records with the terms 'derivatives', 'specimens' and 'skeletons' were assumed dried. Records with the term 'bodies' were also considered dried, unless the source was 'C' or 'F' – these were assumed to be 'live'. Records with the term 'live' or 'fingerling' were also categorized as 'live'.

Species

The CITES Wiki Identification Manual recognizes 47 seahorse species (CITES, 2014b). Three species names in the CITES data (*H. japonicas*, *H. ramulosus*, *H. takakurae*) were encountered that are considered synonyms of recognized species based on Lourie *et al.* (2004), as well as subsequent unpublished morphometric and genetic research (S. Lourie, Project Seahorse, unpublished data). These records were therefore changed to *H. mohnikei*, *H. guttulatus* and *H. trimaculatus*, respectively. Another name recorded in trade, *Hippocampus* hybrid is also not considered a valid species, and so this single record was recategorized to the genus level.

Countries/Parties

Mainland China, Hong Kong SAR and Taiwan, Province of China (hereafter referred to as Taiwan) are reported separately in the CITES data and so are here presented as three separate 'Parties' in the analyses. The geographical designations employed in this document do not imply the expression of any opinion whatsoever concerning the legal status of any country, territory, or area, or concerning the delimitation of its frontiers or boundaries. Entries where the importer or exporter Party code was 'XX', which denotes an unknown Party, were retained in all analyses except those of trade routes (source and consumer Parties).

Data conversion and analyses

Trade records

Of the 2210 declared global trade records relating to seahorses from 2004–2011, 23% (N = 507) were classified as re-exports – a shipment imported by one Party only to be re-exported to another. All re-export data were excluded from the analyses (e.g. Figure 1, lines 7 and 8) to avoid double counting.

CITES Trade Database

UNEP WCMC

Comparative Tabulation Report

	Year	Appendix	Taxon	Importer	Exporter	Origin	Imp Quantity	Imp Unit	Imp Term	Imp purpose	Imp Source	(Re-)Exp Quantity	(Re-)Exp Unit	(Re-)Exp Term	(Re-)Exp Purpose	(Re-)Exp Source
1	2004	2	Hippocampus spp.	NZ	CN		822		bodies		I					
2	2004	2	Hippocampus spp.	NZ	CN		1326		derivatives		I					
3	2005	2	Hippocampus kuda	CA	VN							150		live	T	W
4	2005	2	Hippocampus kuda	DE	VN							1300		live	T	W
5	2005	2	Hippocampus reidi	US	IE		6		live	T	C	6		live	T	C
6	2005	2	Hippocampus reidi	AT	UK		130		live	T	C	650		live	T	C
7	2006	2	Hippocampus kuda	US	HK	CN	1000		specimens	T	W					
8	2006	2	Hippocampus kuda	US	HK	CN	1360		specimens	T	C					

Figure 1. Example of output data from the CITES Trade Database when queried for seahorses (*Hippocampus* spp.). Lines 1 and 2 are reported to the genus level only while lines 3 to 8 are reported to the species level. Lines 1 and 2 are entries with import data only and lines 3 and 4 are entries with export data only. Line 5 has both export and import data, which match up exactly. Line 6 has import and export data that do not match up exactly – the reported export volume is greater than the reported import volume. Lines 7 and 8 show examples of re-exports, as the origin Party is different from the export Party.

When export and import records are comparable, they appear in a single line in the output obtained from the CITES trade database (e.g. Figure 1, lines 5 and 6), but separate otherwise (UNEP-WCMC, 2010). A record with both export and import data was treated in the following way, again to minimize double-counting:

- Where import volume equalled export volume, only the export data were retained for the analyses (e.g. Figure 1, line 5);
- Where import volume was less than export volume, the import data were excluded as they would presumably be encompassed in the larger export quantity (e.g. Figure 1, line 6).
- Where import volume was more than export volume, the export data were excluded as they would presumably be encompassed in the larger import quantity.

Export data that were deduced from importing Party records were referred to with the acronym EFI: Exports From Import.

Units

According to the published guidelines for interpreting records in the CITES trade database, records without units should be assumed to be individuals (UNEP-WCMC, 2010). In the case of seahorses, we felt compelled to probe more deeply, as the trade in dried seahorses occurs by weight, and not by individual counts (Vincent, 1996). The CITES Management and Scientific Authorities of Parties that reported dried trade records without units were therefore asked to clarify whether the shipment represented individuals, kilograms or grams of seahorses, and their clarifications were included in the subsequent analyses. When Parties did not respond, the units were assumed to be individuals per UNEP-WCMC guidelines, but the impact of this assumption was explored in a sensitivity analysis where instead the units were assumed to be kilograms (see Sensitivity analyses, below). Where trade volumes were indicated or assumed to be kilograms, dried seahorse weights were converted to number of individuals based on published conversion rates (in Evanson *et al.* (2011), exception is West Africa for which conversion is 189 seahorses kg^{-1} based on unpublished Project Seahorse trade surveys). Region/country-specific conversion factors were used when available; otherwise an average of all published conversions was used. Converting reported seahorse weights into number of individuals means the volume estimates are not exact, indicated by the use of the symbol '≈'; volume estimates were also rounded to the nearest 1000 or 100 000 individuals for ease of presentation.

For seahorses marked as being traded live, it was assumed that all units were 'individuals', but the impact of this assumption was explored in a sensitivity analysis (see Sensitivity analyses, below). It was suspected that any live trade records with the units indicated as kilograms were in error, as the trade in live seahorses is known to occur essentially always in individuals, and not by weight (Vincent, 1996).

On enquiry, mainland China clarified that two records of derivatives represented individual capsules, each containing 1.4 mg of ground dried seahorse – this value was used to convert those records into number of individuals. Finally, the two records that had millilitres (MLT) as their unit (780 mL combined) were assumed to be tonics, which were estimated to contain approximately 0.5 g of seahorse per 100 mL, based on the ingredients list of 'Gekko Hippocampus' tonic from Vietnam.

Sensitivity analyses

Sensitivity analyses were carried out to assess the impact of the two methodological assumptions as outlined above: (1) that combining export and import (here represented as EFI) data encompasses the entire international trade in seahorses between two Parties; and (2) assuming dried trade entries with no confirmed units were in individuals as opposed to kilograms, and live trade entries recorded as kilograms were actually in individuals. This process is cited as 'Base Analysis' in figures and tables.

To test assumption (1), information garnered using (a) only export data was compared with information obtained from (b) export and EFI records, combined. This process is cited as 'EFI

Analysis' in figures and tables, and identified discrepancies in trade between export and import records. Rather than merely comparing export and import records, the two sets of information were integrated into EFI records so as to deduce total seahorse volumes in international trade. This focus on export data acknowledges the roles of range states as the primary custodians of wild populations of species in international trade.

To test assumption (2) the trade records for global trade volumes were reanalysed assuming all dried records that remained without units were in kilograms instead of individuals, and that all live records reported as kilograms were indeed kilograms. Live records reported as kilograms were converted into number of individuals using the average wet weight of seahorses reported in the primary literature – 12.5 g per seahorse (Vincent and Sadler, 1995; Woods, 2002; Baum *et al*., 2003; Planas *et al*., 2008). Analysis based on these assumptions is referred to as the 'Unit Analysis' in figures and tables.

RESULTS

CITES records

Import (EFI) records made up a large proportion of available data for seahorses; almost half of retained records were EFI only (N = 804/1708), while only one third were export only (N = 527/1708). The remaining records contained both EFI and export data. Of the records downloaded, 22% (N = 372/1708) had both export and EFI data on the same line, but only 6% (N = 95/1708) had identical export and EFI volumes. Of those that did not match, export quantity was greater than EFI quantity for 207 records, and smaller than EFI quantity for 70 records. Finally, there were five pairs of records that, although on separate lines, were exact matches. These were assumed to be duplicates and one of each pair was removed, leaving a total of 1703 records for the analyses.

Many of the downloaded records had no reported units (N = 1394), including more than half of dried and the vast majority of live trade entries (N = 340/637 and 1054/1066, respectively). Most Parties that were contacted clarified the units of the dried records (N = 23/27). While many dried trade entries were confirmed as individuals (N = 264/340), some of the larger volumes were instead confirmed as kilograms, grams or number of capsules (N = 61/340). After accounting for Party responses, there were only 15 dried records left without units, which were assumed to be individuals as per UNEP-WCMC guidelines. It was also assumed that 12 live records reported as kilograms were actually for individuals.

Overall reported volumes

All reported volumes are in number of individual seahorses. The average annual volume of seahorses reported to CITES from 2004–2011 in both export and EFI data, and after applying the base assumptions, was estimated at 5.7 million individuals, with a range of 3.3 to 7.6 million individuals (Figure 2, 'A' bars). Reported annual volumes varied across years with no clear temporal patterns (Figure 2). Dried seahorses dominated the reported trade, averaging 98% of total estimated volumes annually (range: 97.0–99.6%). Only a tiny proportion of the reported dried trade was supposedly captive-bred in origin (averaging 0.01% annually, range: 0–0.05%).

The average annual volume of live seahorses reported to CITES over the same time period was much smaller, at 116 000 individuals (range: 22 000–172 000 individuals; Figure 3, 'A' bars). The reported live trade volume in 2004 was lowest, by an order of magnitude, when compared with other years – but the Appendix II listing was only implemented in May 2004. Unlike the dried trade, CITES data indicated a variable reliance on captive-bred seahorses to supply the live trade; the percentage of such trade that was reported as captive-bred almost halved from 53% in 2004 to 29% in 2011, and also apparently fluctuated over time (Figure 3, dark grey bars). On the other hand, the proportion of the live trade that was reportedly F1 increased over time from none in 2004 to as much as 76% and 67% of the total live trade in 2010 and 2011, respectively (Figure 3, light grey bars).

Excluding EFI records from the analysis reduced the estimated average annual volume of seahorses

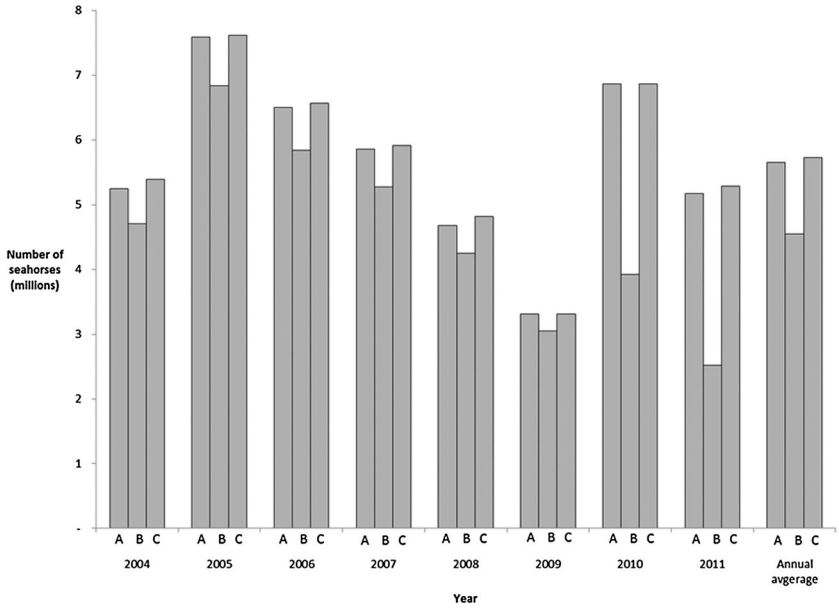

Figure 2. Estimated volumes of all seahorses traded internationally by year based on data in the CITES Trade Database from 2004–2011. 'A' bars represent estimated volumes using the 'Base Analysis', 'B' bars represent estimated volumes using the 'EFI Analysis', and 'C' bars represent estimated volumes using the 'Unit Analysis' (see Methods for details). As the CITES listing of seahorse species took effect in May 2004, all 2004 data represents only a partial year.

reported to CITES from 2004–2011 by 21% to 4.5 million individuals (range of 2.5 to 6.8 million individuals across years) (Figure 2, 'B' bars). The additional volume reported in EFI data was greatest in 2011, but such discrepancies occurred in all years. Likewise, the estimated average annual volume of reported live seahorse exports was reduced by 17% to 96 000 individuals when only export data were analysed (Figure 3, 'B' bars).

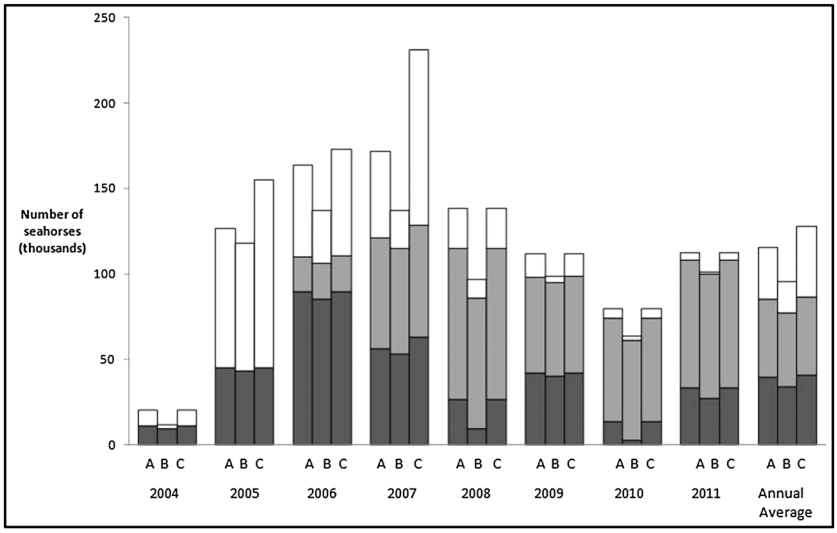

Figure 3. Estimated volumes of live seahorses traded internationally by year based on data in the CITES Trade Database from 2004–2011. 'A' bars represent estimated volumes using the 'Base Analysis', 'B' bars represent estimated volumes using the 'EFI Analysis', and 'C' bars represent estimated volumes using the 'Unit Analysis' (See Methods for details). The top (white), middle (light grey) and bottom (dark grey) portions of each column represent wild, F1 and captive-bred specimens, respectively. As the CITES listing of seahorse species took effect in May 2004, all 2004 data represents only a partial year.

If the base assumptions about units were altered and instead it was assumed that all dry trade records remaining without units were kilograms, and all live trade records reported in kilograms were left as such, the estimated average annual trade reported to CITES from 2004–2011 (based on both export and EFI data) increased by only 1%, to 5.7 million individuals (range of 3.3–7.6 million individuals across years) (Figure 2, 'C' bars). In this case the estimated average annual volume of reported live seahorse exports was increased by 16% to 139 000 individuals (Figure 3, 'C' bars).

Species reported in trade

More than three-quarters of all CITES trade records for seahorses from 2004–2011, excluding re-exports, were reported to the species level (N = 1320/1703), while the remaining records were reported only to the level of genus, *Hippocampus*. A higher proportion of dried trade records were reported only to the genus level than for live trade (dried: 49%; live: 7%). Species level reporting appeared to improve over time for the live trade only (from 85% of records in 2004 to 99% in 2011). But although one-quarter of records reported to CITES did not specify a species, these entries represented only 2% of total reported trade volumes across the 8-year period, with the greatest number reported in 2004.

Based on combined export and EFI data, 31 seahorse species were declared in trade across all years (Table 1). The reported dried trade involved 23 species from 2004–2011, the majority of which were wild, or offspring of wild-sourced (N = 17/23; Table 1). The live trade reportedly involved 30 species across 2004–2011. Only two of these 30 species were reported as captive-bred only, with the remainder fully or partially sourced from wild populations (about one quarter as wild or

Table 1. Seahorse (*Hippocampus*) species reported to the CITES Trade Database from 2004–2011 organized by type of specimen (dried or live), source (wild, captive-bred or unknown) and proportion of estimated mean annual trade volume (% overall)

	Dried			Live			%
Species	**Wild**	**Captive**	**Unknown**	**Wild**	**Captive**	**Unknown**	**overall**
H. abdominalis	x	x	x	x	x	x	0.04%
H. algiricus	x			x			5.64%
H. angustus	x			x	x	x	<0.01%
H. barbouri	x			x	x	x	1.58%
H. bargibanti	x		x				<0.01%
H. biocellatus	x			x			<0.01%
H. breviceps	x	x		x	x		0.01%
H. camelopardalis					x		<0.01%
H. capensis					x		<0.01%
H. comes	x			x	x	x	0.19%
H. coronatus				x			<0.01%
H. denise				x			<0.01%
H. erectus	x		x	x	x	x	0.72%
H. fuscus			x	x	x		<0.01%
H. guttulatus	x			x		x	0.01%
H. hippocampus	x		x	x	x	x	0.14%
H. histrix	x		x	x		x	2.74%
H. ingens	x			x	x	x	1.16%
H. kelloggi	x	x	x	x			18.31%
H. kuda	x	x		x	x	x	6.20%
H. mohnikei						x	<0.01%
H. montebelloensis				x			<0.01%
H. procerus				x			<0.01%
H. reidi	x		x	x	x	x	0.52%
H. spinosissimus	x		x	x		x	29.55%
H. spp.	x	x	x	x	x	x	1.84%
H. subelongatus	x			x	x		<0.01%
H. trimaculatus	x		x	x		x	31.36%
H. whitei	x			x	x	x	<0.01%
H. zebra				x			<0.01%
H. zosterae	x		x	x	x	x	<0.01%

offspring of wild-sourced, N = 8/30; half as both wild and captive-bred, N = 15/30; Table 1).

Of the 31 seahorse species reported to CITES from 2004–2011, just five made up 91% of total reported trade volumes (annual average and range in descending order by volume): *H. trimaculatus* (1.8 million, 1.1–2.5 million); *H. spinosissimus* (1.7 million, 1.0–2.5 million); *H. kelloggi* (1.0 million, 0.73–1.3 million); *H. kuda* (0.35 million, 0.10–0.63 million); and *H. algiricus* (0.32 million, 0.04–0.62 million).

Dried seahorses comprised the vast majority of all reported trade, and the majority of those were extracted from the wild; consequently, species trends for the dried trade were essentially the same as those of trade overall – with only slight variations in volumes. Only four species were reportedly traded dried from cultured sources and only in very small volumes – annual average and range in descending order by volume: *H. abdominalis* (400, 0–1500); *H. breviceps* (125, 0–1000); *H. kelloggi* (37, 0–300); and *H. kuda* (12, 0–93).

The overall volume of live seahorses reported to CITES from 2004–2011 was dominated by two species, *H. kuda* and *H. reidi* (annual average and range: 65 000, 5000–99 000; 29 000, 8100–53 000, respectively). These species also dominated the live trade that was reported as captive-bred (annual average and range for *H. kuda*: 8000, 500–9400; *H. reidi*: 27 000, 8000–50 000); the vast majority of *H. reidi* were therefore sourced as captive bred.

Reported trade routes – source and consumer Parties

In total, 87 Parties were reported in the CITES data from 2004–2011 as sources and/or consumers of seahorses, excluding re-exporters (Table 2). Taken together, the CITES data suggested that many source Parties supplied dried seahorses to fewer consumer nations (N = 45 versus 29; Table 2, Figure 4). In contrast, fewer source Parties supplied live seahorses to more consumer nations (N = 37 versus 55; Table 2, Figure 4). Many source Parties were Asian (N = 18 for dried, 12 for live), with the remaining Parties spread roughly equally across other regions. Consumer Parties were split fairly evenly between Asia (N = 12 for dried, 17 for live), and Europe (N = 12 for dried, 23 for live). Thirty Parties were reported as both sources and consumers of seahorses (Table 2).

Source Parties

Based on CITES export and EFI data, 61 Parties, from all continents except Antarctica, were reported as sources for dried and live seahorses from 2004–2011 (Table 2). A little under three-quarters of reported source Parties (N = 45/61), most of which were on the Asian continent, reportedly exported dried seahorses, and two-thirds (N = 37/61) were reported to have exported live seahorses – seven of which apparently only supplied captive-bred individuals. Half of the documented source Parties for seahorses were reported in EFI records only, and not in the available export records. When EFI data were excluded from the analyses, the total number of Parties reported to have exported seahorses from 2004–2011 was reduced from 61 to 30 (Table 2). Most 'missing' Parties were Asian (N = 10/31), American (N = 6/31) or European (N = 6/31).

When export and EFI records were analysed by volume, just one Party – Thailand – was the reported source of more than three-quarters of estimated export volumes each year (Table 3). Most of the remaining trade volume was reported to originate in two West African (Guinea and Senegal) and three other Asian (China, Malaysia and Vietnam) Parties (Table 3).

The top six reported sources for seahorses in international trade remained the same whether the analyses were based on export and EFI data, or export data alone, but the order and absolute volumes differed; Guinea's reported exports were most sensitive to exclusion of import data (Table 3). On the other hand, only Malaysia's estimated export volume was sensitive to the assumptions with respect to units (Table 3).

Because dried, wild seahorses dominated the seahorse trade reported by both exporting and importing Parties to CITES, trends in source Party volumes for dried seahorses were essentially the same as those for the overall trade: Thailand was the reported source of 88% of export volumes of dried, wild seahorses annually. Only two Parties, Australia

Table 2. Parties in the CITES Trade Database reported to have been involved in seahorse trade from 2004–2011, organized by category (source or consumer), type of specimen (dried or live), and source (wild, captive-bred or unknown). Parties in bold are reported as both sources and consumers of dried and/or live seahorse trade. Parties marked with * are reported as sources only in EFI data; Parties marked with + are reported as consumers only in EFI data

	Consumers						Sources					
	Dried			Live			Dried			Live		
Parties	**W**	**C**	**U**	**W**	**C**	**U**	**W**	**C**	**U**	**W**	**C**	**U**
Argentina				x	x							
Australia	x		x		x		x	x	x	x	x	x
Austria			x	x	x	x						
Bahamas							x					
Barbados +					x							
Belgium				x	x							
Belize									x			
Bolivia									x			
Brazil									x	x	x	x
Brunei Darussalam					x							
Cambodia									x			
Cameroon					x							
Canada	x	x		x	x		x		x	x	x	
China	x			x	x		x	x	x			x
Costa Rica +				x					x			
Côte d'Ivoire									x			
Cuba										x		x
Cyprus	x				x							
Czech Republic			x	x	x				x			
Denmark				x	x						x	
Dominican Republic										x		
Ecuador									x			
Egypt				x			x		x			
Fiji									x			
France	x			x	x	x	x					
Germany			x	x	x	x				x	x	
Ghana									x			
Guam					x							
Guatemala				x								
Guinea							x			x		
Haiti										x		x
Hong Kong SAR	x			x	x		x		x		x	x
Hungary			x		x							
Indonesia							x		x	x	x	x
Ireland	x			x	x						x	
Israel					x					x		
Italy				x	x	x						
Japan	x			x	x				x	x	x	
Kenya									x			
Korea, Republic of		x		x	x				x		x	
Kuwait					x						x	
Lao People's Democratic Republic							x		x			

Lithuania					x							
Luxembourg				x								
Macau									x			
Malaysia	x			x	x		x		x	x		
Malta					x							
Marshall Islands									x			
Mauritania										x		
Mauritius										x		
Mexico				x	x		x		x	x	x	
Micronesia, Federated States of										x		
Monaco				x								
Namibia					x							
Netherlands				x	x						x	
New Caledonia							x		x	x	x	
New Zealand	x	x	x	x	x				x		x	x
Norway			x	x	x							
Oman +	x						x					
Panama									x			
Peru							x		x	x		
Philippines							x		x	x		x
Poland	x		x	x	x							
Portugal			x	x	x		x			x		
Romania					x							
Russian Federation					x							
Saudi Arabia			x		x							
Senegal							x			x		
Singapore	x			x	x	x			x	x	x	x
Solomon Islands										x		
South Africa	x			x	x						x	
Spain	x		x	x	x	x						
Sri Lanka				x						x	x	x
Swaziland					x							
Sweden				x	x	x						
Switzerland	x			x	x							
Syrian Arab Republic									x			
Taiwan, Province of China	x			x	x				x			
Thailand		x			x		x		x			
Togo							x					
Turkey				x	x				x			
Ukraine					x							
United Arab Emirates	x		x	x	x		x		x			
United Kingdom	x		x	x	x	x			x		x	
United States of America	x	x	x	x	x	x	x		x	x	x	x
Vanuatu										x		
Vietnam							x		x	x	x	x
Unknown				x	x	x	x		x			

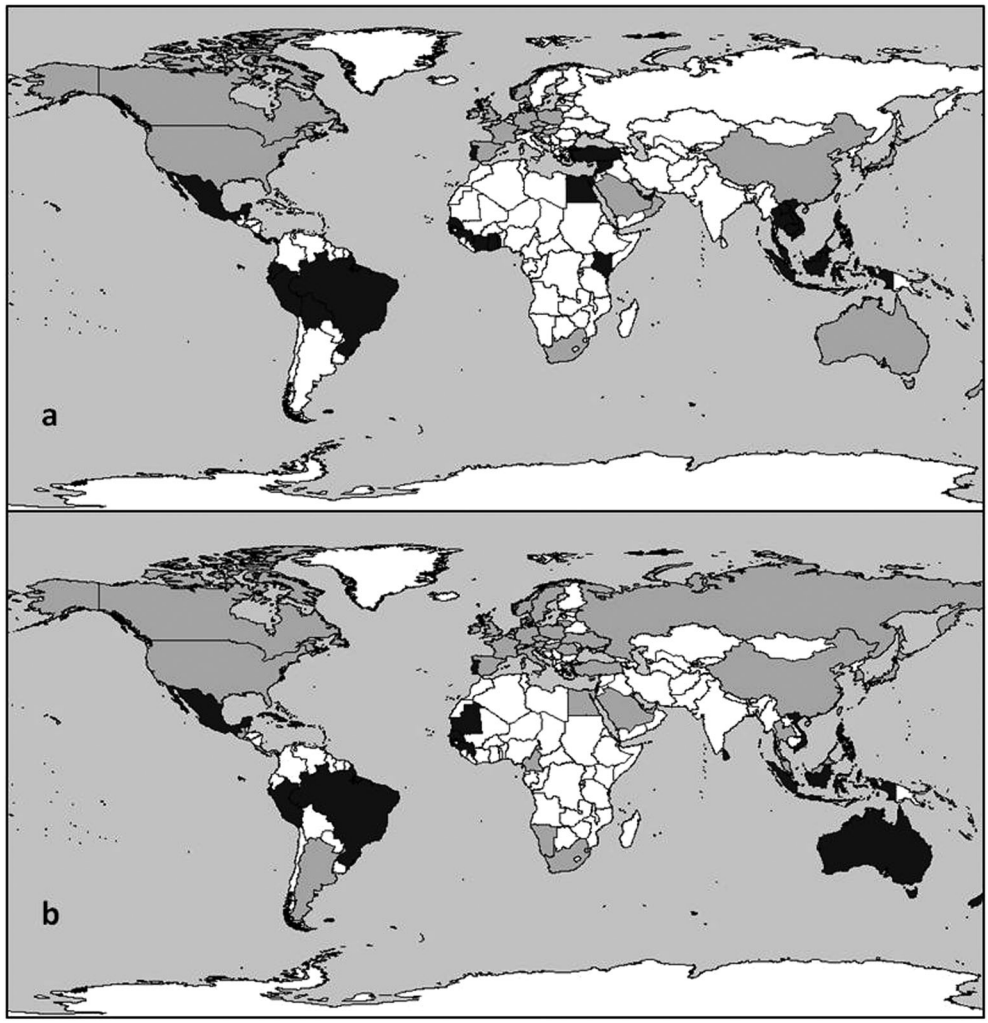

Figure 4. Net importers (dark grey) and exporters (black) for the dry (a) and live (b) international seahorse trade as reported to the CITES Trade Database from 2004–2011.

and mainland China, reported exports of very small volumes of dried, captive-bred seahorses (annual averages of just 628 and 49 individuals per annum, respectively across 2004 and 2011).

Two Parties, Vietnam and Sri Lanka, together comprised the majority of live trade reported to CITES in export and EFI data (Table 3). But while 91% of Vietnam's live seahorses were reportedly wild-caught or offspring of wild-caught individuals, the vast majority (97%) of Sri Lanka's live seahorse exports were reportedly captive-bred. A third source Party, Indonesia, was reported as a significant exporter of live seahorses (Table 3), especially in 2005 when 45 000 live, wild sourced seahorses were reportedly exported.

The top six reported sources for live seahorses in international trade remained the same when analyses were based on export data alone, but the absolute volumes differed – especially for Australia for which EFI contributed to more than 40% of the reported live exports by volume for this Party (Table 3). Estimated export volumes for live seahorses were, however, relatively insensitive to the assumptions about units for the live trade, but the rank order of top sources did change (Table 3) – Malaysia and Guinea come into the list at fourth and fifth place, respectively.

Consumer Parties

Based on export and EFI data, 56 Parties were reported to have consumed seahorses from

Table 3. Top six source Parties for seahorses in international trade (all trade and live trade) based on estimated average annual export volumes as reported in the CITES Trade Database for 2004–2011. Export and EFI data: estimated volumes based on the 'Base Analysis'; Export data only: estimated volumes based on the 'EFI Analysis'; Unit analysis: estimated volumes based on the 'Unit Analysis' (see Methods for details). The percentage difference (% difference) is that of the estimated annual mean when compared with estimated annual mean of the 'Base Analysis'

	Export and EFI data		Export data only		Unit Analysis	
Top sources (all trade)	**Rank**	**Range**	**Rank**	**% difference**	**Rank**	**% difference**
Thailand	1	3.0 – 6.5 million	1	15	1	0
Guinea	2	0 – 435 000	5	70	2	0
China	3	6 000 – 386 000	2	25	4	0
Senegal	4	15 000 – 263 000	3	35	5	0
Malaysia	5	0 – 263 000	6	53	3	-33
Vietnam	6	362 – 105 000	4	21	6	0
Top sources (live trade)	**Rank**	**Range**	**Rank**	**% difference**	**Rank**	**% difference**
Vietnam	1	120 – 103 000	1	16	1	0
Sri Lanka	2	8000 – 51 000	2	13	2	-3
Indonesia	3	2000 – 45 000	3	21	3	0
Australia	4	1000 – 6000	5	43	6	-2
Brazil	5	485 – 10 000	4	31	7	0
Mexico	6	0 – 2000	6	18	8	0

2004–2011 (Table 2). The majority of reported consumer Parties imported live seahorses (N = 55/56), while just half (N = 29/56) were reported as consumers of dried seahorses. The majority of consumer Parties for both trades were Asian or European. Only three consumers were not captured in export data – Barbados (reported live, captive-bred imports for commercial purposes from UK), Costa Rica (reported live, wild and F imports for commercial purposes from USA) and Oman (reported dry, wild imports – no purpose given from United Arab Emirates), which together reportedly consumed just 133 individuals over the entire time period.

Hong Kong SAR, Taiwan and mainland China were together reported to consume the vast majority of seahorse exports reported to CITES (93% of average annual volume; Table 4). Absolute volumes but not rank order of top reported consumers changed when analysis was based on export data only, and the analysis was insensitive to the assumptions about units (Table 4).

Table 4. Top six consumer Parties for seahorses in international trade (all trade and live trade) based on estimated average annual export volumes as reported in the CITES Trade Database for 2004–2011. Export and EFI data: estimated volumes based on the 'Base Analysis'; Export data only: estimated volumes based on the 'EFI Analysis'; Unit analysis: estimated volumes based on the 'Unit Analysis' (see Methods for details). The percentage difference (% difference) is that of the estimated annual mean when compared with estimated annual mean of the 'Base Analysis'

	Export and EFI data		Export data only		Unit Analysis	
Top consumers (all trade)	**Rank**	**Range**	**Rank**	**% difference**	**Rank**	**% difference**
Hong Kong SAR	1	2.5 –5.2 million	1	23	1	-1
Taiwan, Province of China	2	179 000 – 1.8 million	2	0	2	0
China	3	280 000 – 1.3 million	3	22	3	-2
Japan	4	6 000 – 373 000	4	21	4	0
United States of America	5	29 000 – 121 000	5	32	5	-2
Singapore	6	23 000 – 274 000	6	36	6	0
Top consumers (live trade)	**Rank**	**Range**	**Rank**	**% difference**	**Rank**	**% difference**
United States of America	1	8000 – 111 000	1	19	1	0
France	2	1000 – 16 000	2	16	2	0
Canada	3	2000 – 12 000	3	1	5	0
United Kingdom	4	1000 – 9000	4	16	6	0
Netherlands	5	2000 – 7000	5	24	7	0
Germany	6	2000 – 6000	6	23	8	0

Consumer trends reported to CITES for the dried trade reflected those of the trade overall, with only small discrepancies in volumes. New Zealand and the Republic of Korea were the largest reported consumers of dry, captive-bred seahorses, supposedly importing about 500 and 125 individuals per year, respectively.

North American and European Parties were reported as consumers of large volumes of live seahorses (Table 4). Most notably, the USA was reported to CITES as the largest consumer of live seahorses across 2004–2011 (59% of average annual volume; Table 4), consuming the majority of both live-wild and live-captive-bred seahorses (annual average and range ≈ 53 000, 1000–71000 and 15 000, 4000–40 000; 69% and 38% of totals for these categories, respectively). Together, France, Canada and the UK averaged an additional 20% of reported live seahorse imports (combined annual average ≈ 24 000; Table 4), with approximately half of these reportedly captive-bred in origin (annual average ≈ 11 000).

As with trade overall, absolute volumes but not rank order of top reported consumers changed when analysis was based on export data only. Estimated export volumes for live seahorses were also insensitive to the assumptions about units, but the rank order of top consumers did change (Table 4) – Hong Kong SAR and mainland China come into the list at third and fourth place, respectively.

DISCUSSION

This detailed analyses of the CITES trade database revealed that the data are valuable but must be used advisedly. The database is far from perfect but it gives an unparalleled tool to probe the trade in CITES listed species, providing an important substitute for the critical trade-per-unit-effort data that might allow for more direct inferences on population dynamics. Indeed, the CITES trade database's breadth of geographic coverage allows many new insights into the species, volumes, and trade routes of taxa in trade, taxa such as seahorses. That said, the database is also subject to the vagaries of compliance by Parties (Blundell and Masica, 2005; Nijman, 2010; Nijman and Shepherd, 2010, 2011) that are often struggling with limited capacity and unlimited demands on their resources. It is full of substantial and worrying discrepancies, uncertainties and confusions that severely compromise its utility, and tools must be sought to improve its reliability. Nonetheless, the availability of long-term CITES data on seahorses from the 180 Parties advances our understanding of seahorse exploitation, especially once it is married to the pre-CITES field surveys of trade and national/regional official data (Vincent, 1996; McPherson and Vincent, 2004; Baum and Vincent, 2005; Giles *et al*., 2006; Martin-Smith and Vincent, 2006; Perry *et al*., 2010; Vincent *et al*., 2011b). Indeed, the CITES trade database is a vital tool for the conservation of these patchily distributed, cryptic fishes, especially given their huge global distribution.

CITES record keeping

It is vital that CITES Parties strive to submit records of all exports and imports, with accurate descriptors and metrics. The first challenge apparently lies in reporting at all: for example, Guinea, Sri Lanka and Togo traded relatively large volumes of seahorses in most years but filed no reports in other years. Indeed, if EFI data had been omitted from the analyses (and relying only on export records), a very different view of the seahorse trade would have emerged, with estimated trade volumes lower, and key players and species missing from the picture. As well, half of the documented source Parties for seahorses (and three of the destination Parties) were reported in EFI records only, and not in the available export records. An observed lack of consistency between export and EFI data means that reliance on the former alone might result in underestimation of global trade of seahorses and other Appendix II species.

Missing units of measurement create worrying uncertainty in the CITES trade database. For example, Thailand provided 38 records with no units in 2010 and 2011, which would have totalled 19 000 individuals if CITES guidance had been used in assigning units to incomplete records (UNEP-WCMC, 2004). In fact, however, Thailand clarified that all shipments were in kilograms, thus totalling an estimated 6.4 million individuals; this is 337 times higher than would

have been assumed otherwise. As a counter example, assuming that two of China's records without units represented individual animals would have overestimated their reported exports. Clarification from mainland China that two records of derivatives with volumes of 12 000 and 18 000 (no units) represented individual capsules meant that these records were reporting trade in 15, and not 30 000, individual seahorses.

The analysis uncovered a critical need to build capacity with respect to species identification and reporting. Parties to CITES are obliged under Article VIII, paragraph 6(b), to identify specimens to the species level (CITES, 2014a), not least because Parties must prove that proposed exports will not be detrimental to wild populations of a particular species. It is encouraging that entries without species identity represented only 2% of total reported trade by volume but less encouraging that the entries at species level contained many oddities. For example, it is highly unlikely that very large shipments of seahorses would comprise only one species as so many Parties reported: it would be surprising if the dried seahorses in a single 5041 kg shipment, representing approximately 1.6 million individuals, were actually all *H. trimaculatus* as reported. As well, some species names, particularly *H. kuda*, were probably highly overused and probably incorporated a variety of Indo-Pacific species, including *H. comes* and *H. fuscus* (B. Giles, Project Seahorse, unpublished data).

Seahorse trade analysis

CITES data largely support the understanding of the international seahorse trade from pre-CITES trade surveys. The trade clearly comprises millions of seahorses traded internationally each year, both pre- and post-CITES listing. We can also be confident that the vast majority of the international trade in seahorses remains dried and wild-sourced.

Volumes

Given the evident gaps in reporting, one can only speculate on whether volumes in trade have changed post-CITES. It seems unlikely that there has been a reduction in global demand for dried seahorses given the persistent consumption of seahorses for TCM in Asian Parties and increasing TM consumption in Parties such as Canada, France, Germany and the USA (Robinson and Zhang, 2011). The apparently lower number in the CITES data than in pre-CITES estimates (Vincent *et al.*, 2011a) may, therefore have its provenance in (i) unreported trade, (ii) two notable domestic restrictions on exploitation, or (iii) a decline in capacity to supply or CPUE. First, the discrepancies in the CITES trade database point to underreporting of exports, as is very common for species listed on CITES Appendix II (e.g. turtles, tortoises, frogs: Cheung and Dudgeon, 2006; Goh and O'Riordan, 2007; Nijman and Shepherd, 2011). Second, domestic restrictions complicate the story. India and the Philippines were top source Parties for dried seahorses in the 1990s, but the CITES process resulted in both banning the extraction of wild seahorses (the former just before the CITES listing and the latter as an automatic consequence of the CITES listing; Vincent *et al.*, 2011a). Neither reported seahorse exports to CITES but there have been reports of illegal exports from both Parties post-CITES (O'Donnell *et al.*, 2010; Nishan Perrera, Project Seahorse, personal communication). Third, supply may have dwindled, particularly in areas where they are landed as bycatch (so where effort largely persists unabated). For example, previous field surveys found significant Mexican exports of seahorses from trawl bycatch (Baum and Vincent, 2005) and the shrimp trawl fisheries continue unabated (Foster and Vincent, 2010). It is likely, therefore, that the low reported volumes in the CITES trade database reflect a decline in the number of seahorses obtained per trawl, an inference borne out by fishers anecdotes (Baum *et al.*, 2003; Baum and Vincent, 2005). In most cases, as with Tanzania, there is too little information to guess why Parties known to trade seahorses did not report dried seahorse exports in their CITES annual reports.

Species

The post-CITES trade in seahorses remained complex, with many species being traded by many Parties. All 24 species recorded as being traded historically were also found in the CITES trade

database, suggesting that in total, 31 species are of some value in international trade (past or present). The CITES data are the first to document trade by species – this was not undertaken in the field surveys – and shows that four south-east Asian species (*H. kelloggi*, *H. kuda*, *H. spinosissimus*, and *H. trimaculatus*) dominated the international trade in seahorses post-CITES. This is probably because of (a) proximity to key East Asian markets, and (b) the species vulnerability to certain gear (especially trawls), rather than from any particular preference for those species. The CITES trade database also shows high levels of *H. algiricus* exports to mainland China, Hong Kong SAR and Taiwan, perhaps associated with growing Chinese commercial interests in West Africa (Kaczynski and Looney, 2000; Tull, 2006). Nonetheless, new field surveys in Senegal indicated that the Party's significant entries to the CITES trade database are likely to be underestimates and that large exports may be imposing costs on wild populations (West, 2012). All four south-east Asian species and *H. algiricus* are listed as Vulnerable on the IUCN Red List of Threatened Species (IUCN, 2013).

Critically, this analyses of the CITES trade database supported previous findings that captive breeding operations contribute little to the dried trade. It is clear that the many seahorse aquaculture ventures launched over the past two decades (Koldewey and Martin-Smith, 2010) have made no real difference to the number of wild seahorses in the dried trade. This is unlikely to change, because the vast majority of dried seahorses are sourced very cheaply in trawl bycatch in developing countries (Baum and Vincent, 2005; Giles *et al*., 2006; Meeuwig *et al*., 2006), where there is very little cost to extracting the dead animals from the net.

The very much smaller trade in live seahorses may actually be moving toward a greater reliance on captive-bred seahorses. Most seahorses traded live were wild-caught pre-CITES listing (Vincent, 1996), but CITES data indicated a considerable increase in captive-bred seahorses to supply the live trade, particularly from Sri Lanka (which cultures and exports a Caribbean species, *H. reidi*). It is possible that the apparent shift toward a higher reliance on captive-bred seahorses is an artefact of misreporting of wild-caught animals as captive-bred – either intentionally or in error. Such misreporting is an issue of considerable concern for other CITES listed taxa (Brooks *et al*., 2010; Outhwaite *et al*., 2014), and may well be an issue for seahorses. However, it is likely that the reported move toward captive-bred seahorses is for the most part real, facilitated by improvements in seahorse husbandry and captive breeding, a preference for cultured seahorses because they present fewer husbandry challenges (Vincent and Koldewy, 2006), and the favourable circumstances dictated by a CITES Appendix II listing (which provide for much easier paperwork for F2 captive-bred specimens than wild animals). It is unclear, however, how the expansion of captive breeding for live seahorses will affect wild populations. Previous CITES listings for corals and giant clams (Wabnitz *et al*., 2003), sturgeons and paddlefish (Raymakers, 2002), generated more captive breeding without an associated decreased impact on wild populations.

Sources

CITES data are particularly useful for identifying Parties with large-scale exports of wild seahorses that are likely to need support in implementing the Convention. Indeed, the large seahorse exporters of Thailand, Vietnam, Senegal and Guinea are all engaged in CITES reviews of their seahorse export trade because of difficulties in proving its sustainability. CITES data confirmed that Thailand exports a great many wild seahorses for the dried trade (Nijman, 2010; Perry *et al*., 2010), to an extent that may exert significant pressure on these populations. Reported seahorse trade from Vietnam, although still large, may have decreased from pre-CITES levels (Giles *et al*., 2006), with a shift from exports of wild-caught dried seahorses to exports of offspring-of-wild caught (F1) seahorses for the live trade. Finally, CITES data suggested a larger reported trade in seahorses from West Africa (e.g. Senegal), perhaps 10 times higher than inferred pre-CITES (Vincent *et al*., 2011b)), although field surveys show yet higher

numbers (West, 2012): such findings are unsurprising since virtually all data for this Party came as EFI. All these Parties will face considerable challenges in making non-detriment findings for seahorses, given that the fish are primarily obtained in bycatch in trawls and other gear; export quotas may well do nothing to reduce pressure on the wild populations if the nonselective fishing continues unrestrained.

Destinations

The CITES data suggested that trade of seahorses continues to be geared primarily towards meeting the demands of the TCM and other medicinal markets, as it was pre-CITES (Vincent, 1996). Previous field surveys showed that most seahorses were exported to/imported by mainland China, Hong Kong SAR, Taiwan and Singapore (in that order: Vincent *et al*., 2011a). Similarly, CITES data also indicated that most dried exports from 2004–2011 went/came to Hong Kong SAR, Taiwan and mainland China from 2004–2011 (in that order). That said, CITES data also suggested consumer markets for dried seahorses in Europe, Oceania and North America, presumably for TCM (Robinson and Zhang, 2011). In general, however, the dried trade converged from many sources on a few Parties while the live trade diverged from a few sources to many Parties. CITES data showed that live seahorses went primarily to the USA during 2004–2011, as deduced in previous trade surveys (Vincent *et al*., 2011a).

Next steps

CITES records have been invaluable in generating action by Parties (specifically Thailand and Vietnam) to improve the sustainability of their seahorse exports through the CITES process known as the Review of Significant Trade (CITES, 2004). Self-evidently, however, CITES records do not account for domestic trade or for illegal, unregulated or unreported (IUU) exports that may evade the CITES permitting process. In order to obtain a full picture of the extractive pressures on seahorses and other wild species, we will clearly need to maintain representative trade field surveys in critical trade areas (Smith *et al*., 2011). Even so, the CITES Secretariat and Parties need to keep generating technology and building capacity to reduce the many gaps, discrepancies, oddities and contradictions in the CITES trade database. In particular, automated record validation would help eliminate common sources of reporting discrepancies (as per Blundell and Masica, 2005). For example, entries of wild specimens could be automatically refused if the Party was not a range state for the particular species entered, the species was not in an official CITES taxonomic checklist, or if the entry lacked specified terms and/or units. There is a need to enhance hard copy, e-materials, trainings and games to (i) improve species identification, (ii) emphasize the value of accuracy in volumes and units, and (iii) encourage promptness. Records often arrive several years late, belatedly modifying global analyses, sometimes to a significant extent. For all the challenges, however, CITES data allow conservationists to embark on generating adaptive management of seahorse populations, fisheries and trades to an extent that would be much more problematic without such information.

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