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Collaborative development of management options for an artisanal fishery for seahorses in the central Philippines

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This paper is dedicated to the memory of Bob Johannes in recognition of his great contribution to the understanding of artisanal fisheries.

Abstract

Overexploitation and habitat degradation threaten small-scale, artisanal fisheries around the world. Management of these fisheries is often inadequate or absent, partly because they are data poor. We here present the development of management options for such a fishery, using collaborative input from a variety of interested groups. Qualitative and semi-quantitative assessments of seahorse populations in central Philippines suggest that they are overfished. Management objectives focus on rebuilding seahorse stocks, maintaining income for fishers and ensuring long-term persistence of seahorse populations. We developed a list of 11 management options at a workshop of fisheries experts from a variety of backgrounds. We then undertook an iterative process of consultation involving fishers, traders, consumers, conservationists, aquarists, national and international policy groups. The creation of no-take

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Marine Protected Areas and minimum size limits for seahorses were strongly supported by all groups, emerging as the preferred options. Tenure over marine estate was strongly supported but may prove difficult to implement in the Philippines. Sex-selective fishing (leaving pregnant males) had moderate support across all groups but may be relatively easy to introduce because of fisher acceptance. In collaboration with international efforts to ensure sustainable trade in seahorses we recommend that a minimum size limit of 10 cm height and more no-take Marine Protected Areas be implemented as soon as possible to help restore this seahorse fishery in the Philippines.

1. Introduction

New forms of collaborative management are becoming essential as fisheries resources decline around the world [1]. Fisheries are in crisis, with failures apparent in sustainable utilization, economic efficiency and equity in access to resources [2,3]. Global catches have been declining since the late 1980s [1] and, for marine capture fisheries, about half of the world's stocks are considered to be fully exploited, a further 15–18% overexploited and 10% depleted or recovering from depletion [4]. Overfishing is considered to be one of the three most significant threats to coral reef ecosystems [5].

Extensive overexploitation is worrisome given the socio-economic importance of fisheries: FAO estimated that, in 2000, marine capture fisheries provided more than 16% of the animal protein for the world's population and employed approximately 23 million people worldwide [4]. An estimated 12 million of these fishers are directly employed in small-scale, artisanal fisheries [6]. In the developing world artisanal fisheries are particularly important, representing 67% of all food fish capture in Asia and 80% in Africa [6,7].

Although capture for food represents the bulk of fisheries exploitation, there are also significant fisheries for non-food purposes including fishmeal production [4,8], the marine aquarium trade [9,10], marine medicinals, and curios [11,12]. For example, the global trade in seahorses and their relatives as medicinals, ornamentals and curios in 2000 was estimated to amount to at least 56 tonnes of dried animals.[1] In some areas these can be a considerable source of income to artisanal fishers [13].

Involving stakeholders in decisions affecting the fishery is increasingly considered essential for successful fisheries management [14–16]. Management and conservation of resources in artisanal fisheries remain an enormous challenge, with few alternatives to fishing for food and/or income and few data with which to formulate management decisions [17–19]. Furthermore, many of the fisheries catch a wide range of species and are spatially dispersed [20]. Yet, declines in resources and threats to populations or even species mean that management measures have to be instituted. Where it is impractical to collect data for all species, we often focus conservation and management on particular species [21].

[1] B. Giles pers. comm.

In this paper, we examine the management options for an artisanal fishery that targets one non-food species, seahorses, in the Philippines. We seek to develop a management plan for *Hippocampus comes* by incorporating expertise from a wide cross-section of involved parties: fishers, traders, consumers, conservation groups, management agencies and fisheries experts. This process is unusual, as most co-management deals with only the fishers and managers, not end-user groups; our hope is that this model could also be used in developing, refining and implementing management options in other fisheries.

An additional consideration in the management of this particular fishery was the decision by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) to list all species of seahorse in Appendix II. This decision, agreed in November 2002 with implementation delayed until May 2004, requires that all signatories demonstrate that their international trade in seahorses will not have detrimental effects on wild populations. We hope that the recommendations developed for this Philippines fishery can be incorporated into management of other seahorse populations around the world.

2. Description of the fishery

The fishery that we considered is located in Bohol province, central Philippines (Fig. 1). Almost 200 fishers, from more than 19 villages, spread along 150 km of the Danajon Bank reef system, were identified as seahorse fishers [16], although the true number may be considerably higher than this. Seahorses are hand-caught by either breathhold diving or the use of compressor-driven, surface-supply breathing apparatus (SSBA). Breathhold fishers operate at night using a kerosene lantern. They spearfish for food fish and hand collect other resources such as seahorses,

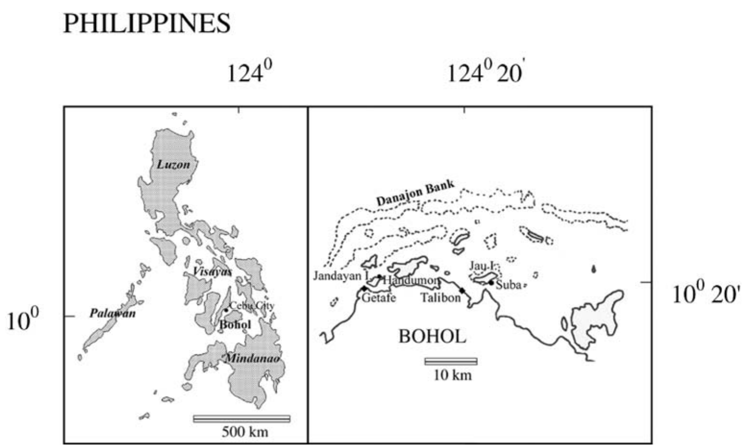

Fig. 1. Map of the Philippines showing location of the island of Bohol (left-hand panel) and Danajon Bank double barrier reef system on the northern side of Bohol (right-hand panel). Some barangays (village municipalities) where Project Seahorse works are shown.

sea-cucumbers, crustaceans and molluscs. Studies have shown that these 'lantern fishers' derive up to 40% of their annual income from seahorses, which they target [13,16]. Fishers using SSBA comprise a minority proportion of total fishers (<25%) but they are able to target seahorses in greater depths than breathhold divers [16].

The tiger tail seahorse, *Hippocampus comes* (Family Syngnathidae), is the most exploited seahorse species, particularly by breathhold divers. This species is listed as Vulnerable (Vu A2cd) on the 2003 IUCN Red List with major threats from habitat loss and artisanal fisheries [22]. A second species, the hedgehog seahorse, *H. spinosissimus*, is generally found in deeper water than *H. comes*, but was been recorded as a significant catch from SSBA fishers in 2003.[2] The hedgehog seahorse is also listed as Vulnerable (Vu A4cd) on the 2003 Red List with similar threats to *H. comes* [22].

Many aspects of the biology of *H. comes* (Table 1) are typical of other coral reef-associated fishes including estimated values for size, growth rate and natural mortality [23,26]. However, in common with other syngnathids, *H. comes* has an unusual reproductive system wherein the male becomes pregnant and broods the embryos in a pouch for up to 21 days before giving birth to fully developed juveniles. In contrast to broadcast spawning fish or those with parental care of eggs, seahorses have a relatively low reproductive output, although this may be counterbalanced by higher survival of the well-developed young on release from the pouch [23].

Seahorses from the fishery are sold dried for the Traditional Chinese Medicine (TCM) trade or live for the aquarium trade. Decisions on the market for a seahorse are generally dependent on size. Seahorses realize a fixed price per individual in the aquarium trade, but are sold by length for TM. The size at which the seahorse is worth more dried than alive is also the upper limit for the aquarium trade. In addition, dried seahorses can always be sold while the aquarium trade is less reliable.[3]

3. Are seahorse populations overfished?

At least six different categories of overfishing have been proposed [27,28]. We qualitatively assessed the seahorse fishery described above against definitions of all these categories (Table 2). For all categories, there was some evidence that populations were overfished (Table 2). We then conducted a semi-quantitative assessment of the fishery using criteria proposed by Carl Walters (Fisheries Centre, UBC, pers. comm.) using catch data from the fishery,[4] fishery-independent biological data[5] [25] and estimates of fisheries parameters. There was direct or indirect evidence of overfishing in all of the criteria used (Table 3).

[2] S. Morgan & D. McCorry pers. comm.

[3] M. Pajaro, N. Perante, A. Cruz-Trinidad, A. Vincent, unpublished data.

[4] A. Vincent, J. Meeuwig, M. Pajaro, N. Perante, unpublished data.

[5] M. Samoilys, J. Meeuwig, Z. Villongco, H. Hall, unpublished data.

Table 1
Summary of the biology of *Hippocampus comes*

Distribution	Central Philippines, Singapore, Vietnam, Malaysia
Maximum recorded size[a]	205 mm standard length and 21 g weight
Standard length-height conversion[b]	Standard length (mm) = 1.16*height (mm) + 1.2
Sexual dimorphism	Mature males with brood pouch and greater exponent in length/weight relationship
Habitat	Coral reefs, soft corals and sponges, seagrasses, soft sediments, *Sargassum*
Depth range	0 to >20 m
Estimated size at first reproduction	102 mm SL (87 mm Ht) for males; females assumed to be similar
Reproductive system	Male incubates brood, monogamous pair bonds, breeding year round with peaks in Sep–Oct, Dec–Feb in Philippines
Broodsize	Mean = 489 (range 223–758)
Gestation period	14–21 days
Estimated parameters of von Bertalanffy growth equation	$L_\infty = 26$ cm $k = 0.89\,\text{yr}^{-1}$
Estimated longevity	2.7–3.6 yr
Estimated generation time	1.0–1.2 yr
Estimated natural mortality (*M*)	0.8–1.6 yr^{-1}

Data sources: [23–25].
[a] Seahorse size is commonly given as height (Ht) or standard length (SL)—see [24] for details.
[b] Equation derived by S. Lourie (unpublished data).

We considered that the seahorse fishery in the central Philippines was overfished and that management action should be taken. As Johannes [18] pointed out, precautionary management must proceed even in data-poor or data-less situations. We directed management actions towards the following objectives that were developed through our long-term involvement with the fishing community in Bohol:

(1) increases in populations of seahorses;
(2) long-term sustainability of populations of seahorses (i.e. low probability of extirpation);
(3) maintenance or increase in catch-per-unit-effort of seahorses;
(4) maintenance or increase in value for the seahorse fishery.

4. Developing collaborative management options: the process

We developed and refined management options using an iterative process with feedback from stakeholder groups. Following concerns about the status of the fishery in the mid-1990s [30], we gathered information on the fishery through a variety of methods including catch calendars, fishery-independent censuses of seahorse populations[6] and fishers' knowledge [16]. Given continuing local and

[6] M. Samoilys, J. Meeuwig, Z. Villongco, H. Hall, unpublished data.

Table 2
Assessment of central Philippines seahorse populations for qualitative evidence of overfishing

Type of overfishing	Assessment of seahorse fishery	Conclusion
Economic	Economic optimum for seahorse fishery is unknown. Reported historical declines in catch-per-unit-effort (CPUE) leading to decreased income	Almost certainly overfished
Growth	High proportion of juveniles taken and strong size-dependent value	Almost certainly overfished
Recruitment	Level of recruitment required to maintain population is unknown. Adult standing stock vs. low ($<0.02\,m^{-2}$) and high proportion of catch is juveniles	Probably overfished
Biological	Time series (1996–2001) for CPUE not really sufficient to evaluate biological overfishing. Although CPUE was stable for 3 yr and then increased, fishers report declines from historical CPUE	Probably overfished as both growth and recruitment overfishing appear to be taking place
Ecosystem	Historical declines in proportion of species from higher trophic levels. Declines in catches of piscivores	Total fishery suffering ecosystem overfishing. Effects on seahorse component unknown
Malthusian	Seahorses are not caught with gears that are destructive. However there is abundant evident that these gears are being used for other species. Effects of degraded habitat on seahorse populations are unknown	Total fishery suffering Malthusian overfishing. Effects on seahorse component unknown

Data sources: [13,16,29].
Definitions of each category of overfishing can be found in Pauly [27] and McManus [28].

Table 3
Quantitative assessment of seahorse fishery for evidence of overfishing against unpublished criteria developed by Carl Walters (Fisheries Centre, UBC, pers. comm.)

Criterion	Direct evidence	Indirect (inferred) evidence
1. High proportion of individuals of at least one life-history stage must be accessible to fishery	High levels of fishing effort across known seahorse habitat	Fishers' knowledge of habitat preferences of *H. comes* (coral reefs, *Sargassum* beds) Reported historical declines in CPUE
2. Age/size at recruitment to fishery substantially less than age/size at first maturity	Calculated size at 50% maturity = 102 mm Smallest individual recorded in fishery = 52 mm.18% of catch recorded as juveniles	
3. Current biomass substantially less than virgin biomass	None (no surveys of virgin biomass were undertaken)	Fishers reported declines of 70% over the 5 yr to 1995 Population densities of only $0.02\,m^{-2}$ very low, even for coral reef species
4. Fishing mortality (*F*) greater than approx. $0.6 \times$ natural mortality (*M*)	None (estimates of *F* and *M* from catch data only)	Estimates of *F* range from 1.7 to $2.5\,yr^{-1}$ (from catch data[a]) Estimates of *M* range from 0.8 to $1.6\,yr^{-1}$
5. Population biomass will increase in response to lower *F*	Increases in population size within no-take Marine Protected Areas	Increased CPUE in 1999 following period of reduced fishing pressure (seaweed farming)

Data sources: [25,30].

[a] J. Meeuwig, unpublished data.

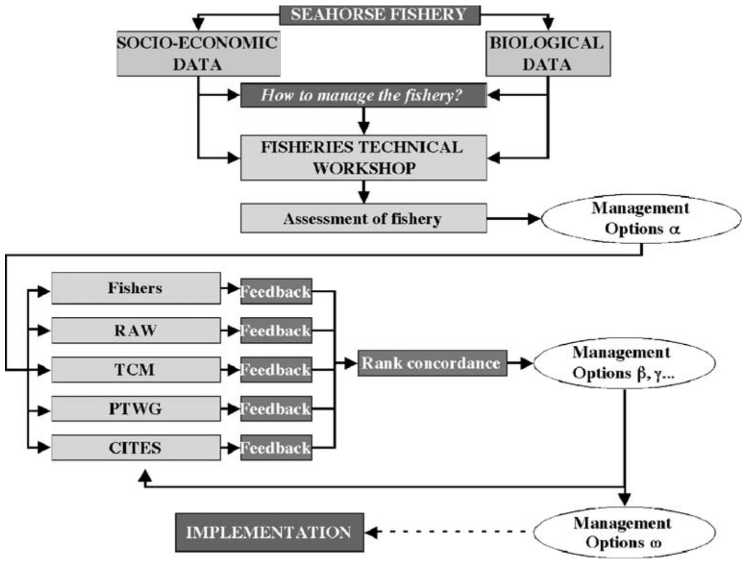

Fig. 2. Flow diagram showing consultative process for developing management options for a seahorse fishery. Solid arrows indicate passage of information, dotted arrow the final phase in translating the recommended options to implementation in the fishery. Abbreviations for groups consulted: RAW—Regional Aquarium Workshop of the American Zoo and Aquarium Association, TCM—Traditional Chinese Medicine traders association, PTWG—Philippines Technical Working Group on syngnathids, CITES—workshop on syngnathids mandated by the Convention on International Trade in Endangered Species.

international concerns about the status of seahorse populations [30,31], the process of formally developing management guidelines was initiated in 2001 (Fig. 2). We identified, discussed and assessed management options with six diverse stakeholder groups, using different methods to match each group. The format of the consultation depended on cultural or organizational context and on logistics, with some questions omitted as inapplicable or inappropriate to particular stakeholder groups. Some of the data collected were quantitative while other data represented the synthesis of discussion and were qualitative. We have attempted to standardise these data sets within a common framework in order to make realistic comparisons across groups.

We should note that terminology and definitions of Marine Protected Areas have not been used in a standardized manner in previous studies. In our discussions we will specifically use no-take Marine Protected Areas (ntMPAs) for studies considering areas where all exploitation was banned. In other situations, where some exploitative uses were permitted, or if it was not clear from the study, we use simply use MPA.

4.1. Fisheries technical workshop (FTW)

A small technical workshop was organized by Project Seahorse on 3–4 June 2001 to bring together international skills in fisheries modelling, management, socio-economic and biological aspects of small-scale and developing country fisheries with 13 participants in total. Project Seahorse provided syntheses of all available information on the fishery. The objective of the technical workshop was to produce an initial set of clearly identified management options that could be taken forward to other stakeholder groups.

Ten management options were explicitly formulated by the FTW to be taken forward to other stakeholder groups, while one additional option, caging pregnant males (see below), was discussed and formally added after the workshop (Table 4). Options were ranked into three qualitative categories of Low, Moderate or High preference based on discussions on their presumed biological effects, probability of successful implementation and likely effectiveness in achieving management objectives (Table 4). For comparison with other fisheries, we have defined a restriction on catching pregnant males as 'sex-selective fishing', although it is selective on a particular reproductive state only. Caging pregnant males, a variation on sex-selective fishing, involves holding pregnant males in sea cages until they give birth. The young are then released and the male harvested.

Fisheries experts assessed three management options as High preference—ntMPAs, tenurial systems and minimum size limits (Table 4). Growing evidence suggests that ntMPAs allow recovery of populations therein (particularly those of exploited species), sometimes with spill-over into fisheries [58,59]. Tenurial systems were considered essential to the long-term success of any management measures as a means of restricting fishing effort while minimum size limits were very effective in rebuilding stocks in simulation models. Some of the other options (ranked as Moderate in Table 4) were thought to have value in biological terms, but to suffer from problems with implementation or enforcement. The options ranked Low (reduction in the number of fishers, restriction of gear type and total allowable catches) were considered to be almost impossible to implement in this subsistence fishery.

4.2. Consultation with seahorse fishers

Seahorse management options were discussed in one of the workshops held as part of the Danajon Bank Fishers Consultative Assembly meeting, organized by Project Seahorse in Cebu, Philippines, 20–21 November 2001. A total of 46 fishers from Bohol (Fig. 1) participated in the Assembly, together with one of the authors of the paper (MS).

We divided fishers into two groups, each comprising representatives from nine villages, on the basis of their familiarity with seahorse fishing: one group consisted of lantern fishers from villages that contain a large number of seahorse fishers, whereas the other group was from villages with few seahorse fishers. Such separation reflected our concern that these two groups of fishers might hold different opinions. We used a participatory group discussion method to solicit feedback from the fishers on the management options. First, we asked the fishers "*What are the ways to manage seahorses*?" without offering recommendations from the FTW. Fishers were required to suggest two management options each. We displayed the individual cards in

Table 4
Possible management options for an artisanal seahorse fishery in the central Philippines

Management option	Preference assessment by stakeholder group						Recent examples of application
	FTW	Fishers	RAW	TCM	PTWG	CITES	
Input controls (*acting to regulate fishing effort*)							
Reduction in the number of fishers	Low	Moderate	High	n/a	Low	Low	[32,33]
Restriction of gear type (reduction or ban on compressor divers)	Low	High	n/a	n/a	High	n/a	[34]
No-take Marine Protected Areas	High	High	n/a	n/a	High	High	[19,29,35–40]
Temporal closures	Moderate	High	n/a	High	Moderate	Moderate	[41,42,43]
Tenurial systems (village/barangay ownership)	High	Moderate	n/a	n/a	High	n/a	[44,45,46]
Output controls (*acting to regulate catches*)							
Total Allowable Catch	Low	High	Moderate	Moderate	Low	Low	[47,48]
Minimum size limit	High	High	High	High[a]	High	High	[49–51]
Maximum size limit	Moderate	Low	Moderate	Low	Moderate	Moderate	[52,53]
Slot size (combination of minimum and maximum size limits)	Moderate	Low	Moderate	Low	Moderate	Low	[53–55]
Sex-selective fishing (restriction on capture of pregnant males)	Moderate	High	High	Low[a]	Moderate	Moderate	[56,57]
Caging pregnant males to allow them to release brood before being sold	Moderate	High	n/a	n/a	Moderate	Low	—

Preference for each option was assessed as described in the text. n/a indicates that the option was not applicable or not assessed by a stakeholder group. Abbreviations: FTW—Fisheries Technical Workshop; RAW—Regional Aquarium Workshop (North America); TCM—Traditional Chinese Medicine traders (Hong Kong); PTWG—Philippines Technical Working Group; CITES—international policy workshop held to discuss potential listing of seahorses under the Conventional on International Trade in Endangered Species of Wild Fauna and Flora.

[a] Translation errors mean that questions on both of these options were phrased in terms of current practice. Whilst future minimum size limits appear to be acceptable to the TCM community, opposition to sex-selective fishing is at odds with our longer-term understanding of TCM receptiveness to management change (see Synthesis).

columns on a central board, grouping those that were the same. All suggestions were then aligned with the management options recommended from the FTW. Second, having been retained in groups, we presented fishers with the complete set of options from the FTW and asked them to indicate support, uncertainty or opposition: this step in the process yielded our ranking system. Third, we asked fishers to provide reasons for their position on each of the management options.

Participation rates were generally high in the Consultative Assembly with up to 39 fishers providing responses to the questions posed. The fishers spontaneously suggested four of the options from the Technical Workshop, with a further nine options proposed (Table 5). We converted the quantitative scores into the same qualitative categories as the FTW using the following reference points: $>66\%$ support was assigned as High preference, 33–66% support as Moderate preference and $\leqslant 33\%$ support as Low preference (Table 4). When all 11 options were presented to the groups of fishers seven options were ranked as High preference (Table 4). However, there was a range of responses within this High preference category with three options eliciting unanimous support (ntMPAs, minimum size limit and sex-selective fishing) (Table 5). Groups containing seahorse fishers also unanimously supported caging pregnant males. Although the majority of fishers supported restriction of gear type, temporal closures and total allowable catches (TACs), there was some opposition (Table 5).

Recognizing that ntMPAs protected habitat, allowed reproduction and produced spill-over, fishers suggested ntMPAs ranging from 10 ha to 20% of the village fishing area. Similarly, the fishers thought that minimum size limits would allow successful reproduction before capture and potentially increase income as they would catch larger animals. Fishers suggested minimum size limits of 3.0–12.5 cm height.

Sex-selective fishing and caging pregnant males were supported primarily because the fishers perceived that populations would increase. The many reasons for wishing to ban or restrict use of SSBA included anxieties about overexploitation, fisher safety and the greater catch rates of compressor divers. Temporal closures were perceived to prevent population depletion and to allow seahorses to breed.

The remaining options from the FTW elicited various levels of support from the fishers with two options (maximum size limits and slot sizes) producing unanimous opposition (Table 5), primarily because larger seahorses command higher prices in the market.

4.3. Consultation with aquarists

Seahorses are sold live for the aquarium trade with the majority of animals sent to North America or Europe [30]. In order to assess the opinions of the professional aquarium community, we organized a session on syngnathids at a Regional Aquarium Workshop (RAW) of the American Zoo and Aquarium Association on 25 March 2002: this group of professional aquarists did not include traders or hobbyists. Project Seahorse gave a brief presentation on the seahorse fishery and a questionnaire was distributed to the participants. We asked whether participants supported, opposed or were neutral towards the following options: reduction in

Table 5
Feedback provided by fishers in discussion on seahorse management options

Management option	# Fishers suggesting option	% Fishers in opinion group for option							
		Group containing seahorse fishers				Group without seahorse fishers			
		Support	Uncertain	Opposed	*n*	Support	Uncertain	Opposed	*n*
Reduction in number of fishers	—	45	30	25	20	52	30	18	23
Restriction of gear type	—	86	0	14	22	71	5	24	21
No-take Marine Protected Areas	9(+8)[a]	100	0	0	18	100	0	0	21
Temporal closures	—	91	5	5	23	67	14	19	21
Tenurial systems	—	63	0	37	19	52	0	48	23
Total allowable catch	—	67	24	9	21	78	13	9	23
Minimum size limit	6	100	0	0	18	100	0	0	21
Maximum size limit	—	0	0	100	18	0	0	100	21
Slot size	—	0	0	100	18	0	0	100	21
Sex-selective fishing	15	100	0	0	19	100	0	0	20
Caging pregnant males	5	100	0	0	19	75	25	0	24

Other suggestions by fishers (n): Increased education (5); increased legislation (4); total ban (2); prevent illegal fishing (2); aquaculture (2); release of bycatch (1); foreign intervention (1); protection of all male seahorses (1); fishers' alliance (1)

[a] Additional votes for 'protection of habitat' were considered to be de facto votes for no-take MPAs.

Table 6
Feedback provided by participants at a Regional Aquarium Workshop of the American Zoo and Aquarium Association on 25 March 2002 to fisheries management options for seahorses

Management option	n	% aquarists in opinion group for option		
		Support	Uncertain	Opposed
Reduction in number of fishers	48	92	4	4
Total allowable catch	48	63	17	21
Minimum size limit	47	72	19	9
Maximum size limit	47	55	26	19
Slot size	47	57	23	19
Sex-selective fishing	47	85	6	9

number of fishers, TACs, minimum size limit, maximum size limit, slot size and sex-selective fishing. We converted these quantitative data to three preference categories the same manner as described in Section 4.2.

Forty-eight participants provided feedback on the management options presented. The options ranked as high preference were a reduction in the total number of fishers through alternative livelihoods, a ban on collecting pregnant males and minimum size limits (Table 6). Total allowable catch, maximum size limits and slot sizes were ranked as Moderate preference (Table 6).

4.4. Consultation with the traditional Chinese medicine community

Hong Kong is a major trading location for seahorses and seahorse products [30]. Project Seahorse has developed links with the TCM community in Hong Kong, particularly associations of TCM traders, through its Marine Medicinals Programme. First, we sent 50 questionnaires to the Hong Kong Chinese Medicinal Merchants Association (HKCMMA) in July 2002 for distribution to its active members. The questionnaire was designed to present relevant management options to the TCM community. Second, we gauged opinions about size limits through informal discussions with members of the HKCMMA rather than structured questions: our previous experience suggested that there would be low levels of participation with written questions on maximum size limits or slot sizes, given the perceived value of large seahorses in TCM [30]. Third, we asked TCM traders to quantify possible acceptance of periods of supply restriction (equating to temporal closures), levels of supply reduction (TAC), or minimum size limits. The questionnaire was translated into Chinese and modified for the appropriate cultural context. However, confusions in the translation meant that we phrased some of the questions in the context of current practice rather than of proposing future measures; such rendering may have influenced our results. We converted quantitative data into qualitative categories as described in Section 4.2.

We received 32 completed questionnaires of the 50 distributed. The majority of respondents described themselves as marine medicinals traders (29) involved in both import and export (27). Approximately one third were retailers (12) with smaller numbers of wholesalers (9) or involved in re-export (9). The highest preference options were temporal closures and minimum size limits, while reductions in total supply (TACs) were moderately supported (Table 7). Sex-selectivity was apparently strongly opposed (but see Synthesis as this result may not reflect real preferences). TCM traders were unanimous in their opposition to maximum size limits or slot sizes from our informal discussions. For the preferred options a range of ideas were suggested for both the time period for temporal closures and the minimum size limit (Table 7). The majority of respondents thought that temporal closures would need to vary with the area while only four had suggestions for specific time periods (Table 7). Similarly, a wide variety of minimum size limits were suggested ranging from 5 to 15 cm height, although the majority suggested a minimum size limit of 8 or 10 cm height (Table 7). Twenty-three of 32 respondents did not think that this size limit could be applied universally to all species.

4.5. Consultation with a Philippines national policy group (PTWG)

A workshop on the formation of a Philippines technical working group (PTWG) for the conservation and management of seahorses in the Philippines was organized by Project Seahorse in Cebu City from 22 to 23 November 2001. A total of 13

Table 7
Feedback provided by members of the Hong Kong Chinese Marine Medicinals Association in July 2002 to fisheries management options for seahorses

Management option		% respondents in opinion group for option			Comments (with number of respondents)
	n	Support	Uncertain/ no answer	Opposed	
Temporal closures	32	88	3	9	Time periods suggested for closures: variable for different areas (18); breeding period (2); Feb–Mar (2); Jun–Jul (2); Winter (1)
Total allowable catch	32	38	16	47	Acceptable supply reduction: 50% (2); 60% (4); 70% (4); 80% (2)
Minimum size limit[a]	32	81	0	19	Suggested minimum height[b]: 8 cm (7); 10 cm (18); 13 cm (1); 15 cm (1); 5–10 cm (2); 8–10 cm (1); 5–15 cm (1); 8–15 cm (1)
Sex-selective fishing[a]	32	3	0	97	

[a] Translation errors mean that questions on both of these options were phrased in terms of current practice. Whilst future minimum size limits appear to be acceptable to the TCM community, opposition to sex-selective fishing is at odds with our longer-term understanding of TCM receptiveness to management change (see Synthesis).

[b] Minimum heights have been converted from inches to cm and rounded to the nearest whole number.

participants attended this workshop, comprising resource managers from the national fisheries agency, researchers from three universities, members of a conservation team, a representative from a fisheries research facility and a national museum, and one of us (MS).

The fisheries management options from the FTW were presented to the group with brief explanations. Each option was then discussed in turn by the complete group to establish whether they supported the option or not, and to discover any issues or reservations associated with the option. We rapporteured the discussion and synthesised the comments into the same three preference groups (High, Moderate, Low) as we had done with the FTW.

Four options emerged as High preference—gear restriction, ntMPAs, tenurial systems and minimum size limits (Table 4). The group considered that ntMPAs were easy to implement and have had a successful history in the Philippines. Furthermore, they have biodiversity conservation functions beyond any effects on seahorses, and legislation already exists for creation and operation of ntMPAs. Tenurial systems were considered to be essential for the successful operation of any other management measures. The group thought that minimum size limits would be a good option to sustain or rebuild stocks, could be enforced by traders and the national fisheries agency, and would be acceptable in the trade because larger seahorses are preferred. A minimum size of 8 cm height was identified as a possible option based on size at maturity (Table 1).

The majority of other options discussed were assessed as Moderate preference with significant challenges including anticipated difficulty of enforcement, poor acceptability to fishers, potential inter-village conflict, a dearth of education, and a lack of biological information. Reduction in the number of fishers or TAC were both assessed as Low preference as they were deemed unacceptable to the fishers.

4.6. *Consultation with international policy group*

Decision 11.153 by CITES in 2000 mandated a technical workshop to discuss the possible listing of seahorses and/or other syngnathids on one of the appendices of the Convention, which together regulate international trade. This was held in Cebu (Philippines) on 27–29 May 2002 and was attended by a diverse group of 36 participants from 13 countries including CITES Animal (technical) Committee members, CITES authority representatives from major trading nations, experts on syngnathid fisheries (including KMS, MS, AV), experts on seahorse aquaculture and the aquarium trade, and representatives of the TCM trade. Briefing documents describing the fisheries management options were given to all participants who also attended presentations on both the fishery and possible management measures. A breakout group of 12 participants discussed the options in detail and reported back to a plenary session. We used rapporteur notes from the discussions to make qualitative assessments of the support for the different options.

The CITES group assessed ntMPAs and minimum size limits as High preference options (Table 4). No-take MPAs were considered to provide considerable community benefit, particularly if they are locally enforced and/or tied to eco-certification. Similarly, minimum size limits were recognized as key elements to protect stocks and potentially to assist countries in meeting requirements for export permits under CITES. The group thought that temporal closures and maximum size limits posed challenges in enforcement, education and loss of income to fishers while the biological effects of sex-selective fishing and subsequent skewed sex ratios needed further investigation. All other options were ranked as Low preference primarily because of difficulties in enforcement, effects on the fishers and suitability to achieve management objectives.

In addition to the 11 options presented, the international policy group suggested further options or combinations including: zones with gear or fishery restrictions (i.e. combination of spatial restriction and other measures), post-harvest controls (regulate number of wholesalers or selective sourcing) or post-sale controls (consumer responsibility or alternative materials). Some of these options may provide complementary methods of ensuring sustainability but cannot be directly implemented within the fishery and so will not be discussed further in this paper.

5. Synthesis and discussion

We found significant concordance between the preferences of stakeholders with two management options ranked High by all groups that offered opinions—ntMPAs and minimum size limits (Fig. 3, Table 4). Tenurial systems and temporal closures were also generally supported being ranked Moderate or High by all groups, though only three of the six groups ranked tenurial systems. Stakeholders held divergent opinions on four options (reduction in the number of fishers, gear restriction, sex-selective fishing and caging pregnant males, gear restricted and reduction in the number of fishers) suggesting areas of conflict in the use of the resource. All stakeholders considered total allowable catch, maximum size limits and slot sizes to be of lower preference (Low–Moderate) and difficult to implement, with maximum size limits marginally preferred to the other two (Fig. 3, Table 4). We have synthesised the current state of knowledge and theoretical and practical issues associated with each of the options in the sections below, with more emphasis placed on those ranked more preferable:

5.1. Management options ranked universally high by all stakeholders

5.1.1. No-take marine protected areas (ntMPAs)

No-take MPAs have been demonstrated to provide spatial refuges for fish populations in many coral reef fisheries around the world including the Philippines [29,36], Kenya [60,61], Tanzania [39] and the Caribbean [62,63]. All stakeholder groups that responded identified ntMPAs as providing a refuge for species from exploitation, and thus potentially providing an 'insurance policy' against population declines in exploited areas. Mosquera et al. [19] used meta-analyses to review the use of MPAs as conservation tools and concluded that they offered significant protection for fish populations—overall abundance was 3.7 times greater within MPAs

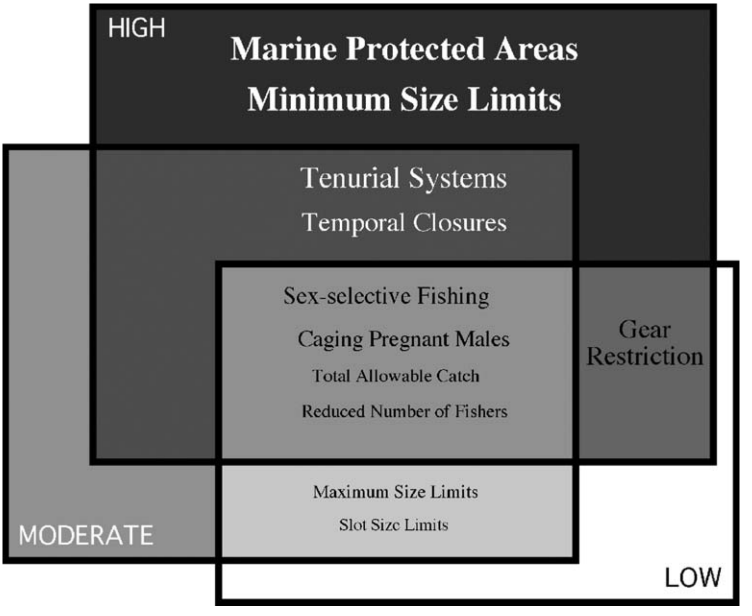

Fig. 3. Graphical representation of preferences for management options in a seahorse fishery by stakeholder groups. Each large shaded box represents one of three preference levels: High, Moderate or Low. Areas of overlap indicate different preferences levels by different groups, e.g. temporal closures lie in an area of overlap between High and Moderate preference (see Table 4). Deeper shading represents higher preference levels. Font size for each option is proportional its level of support with maximum size indicating High preference from all stakeholder groups consulted for that option.

compared with adjacent areas. Halpern and Warner [58] found that densities in MPAs increased quickly (within 1–3 yrs of establishment) and remain consistent through time (up to 40 yrs). Similarly, Ward et al. [59] conducted an extensive review of MPAs and concluded that "*there is an overwhelming body of ecological theory and knowledge that suggests that sanctuaries can provide important benefits to marine capture fisheries, provided the reserves are appropriately designed, sited and managed*".

It would appear difficult to predict the population response of seahorses to ntMPAs a priori. Although, it seems clear that MPAs are valuable conservation tools, response of individual species to protection varies [19]. Target species showed greater increases in abundance in MPAs than non-target species, with a significant positive correlation between body size and increase in abundance [19].

Some life history parameters for seahorses (Table 1) suggest that they should show a reasonably rapid response to the creation of ntMPAs. In data-poor situations, Jennings [46] suggested that rates of population recovery in ntMPAs can be predicted from maximum body size or age-at-maturity as a proxy for intrinsic rate of population increase, *r*. Furthermore, species that are site-attached and have small home ranges may show faster rates of recovery [64–66]. Given the site-attached nature of the adult seahorses, the dispersal of juveniles may be the determining factor for recovery of seahorse populations. The recovery of the *H. comes* population in the Handumon ntMPA established by Project Seahorse in northern Bohol in 1996 suggests a fairly rapid response of seahorses.

Very few empirical studies have documented the effects on the adjacent fishery as opposed to the effects within the reserve [36,59]. Indeed, the efficacy of ntMPAs as fisheries management tools has been the subject of some debate, with conflict over the evidence for spill-over or export of fish from ntMPAs to surrounding exploited areas [36,40,58,61–63,67]. Arguably, if fishing effort stays constant, remaining stocks may experience greater exploitation pressure through concentration of effort into a smaller total area [68–71]. The amount of spill-over to adjacent, exploited areas will depend on attributes of the MPA—its shape, habitat availability within and outside—and attributes of the species—its rates of movement and its density-dependence [40]. Although Guénette et al. [69] found that theoretic models predicted increased yield with ntMPAs, Chapman and Kramer [63] found that empirical spill-over of coral reef fishes was weak.

No-take MPAs must have broad acceptance to work as conservation or fishery management measures. Local support is crucial to effective enforcement of protected areas [29,72–74]. Where local support breaks down, benefits of ntMPAs may be rapidly lost [29]. Modelling has suggested that the initial decrease in income with the introduction of ntMPAs is less than with other management measures, which may increase the probability of successful adoption by fishers [71]. Conversely, the same model suggested that the length of time before increased income is achieved is longer [71].

Philippines law on protected areas is progressive. All waters within 15 km of the coast fall under the jurisdiction of the municipality, and can thus be managed quickly, at the risk of inconsistency along the coast. The National Integrated Protected Area System (NIPAS) Act of 1992 (RA 7586), was enacted by Congress to respond to the profound impact of human activities on all components of the natural environment. This is enforced through the Fisheries Code (FAO 8550, 2001) which states that every coastal municipality must establish a MPA, of which the core area (sanctuary) is designated no-take. MPAs have had considerable public acceptance in the Philippines and may be more readily adopted than other management measures [16,75,76].

5.1.2. Minimum size limits

All groups recognised that recruitment overfishing was taking place and that a minimum size limit could help address this. Minimum size limits are a common fisheries management tool [77], often in conjunction with other measures (e.g. [50,51]).

The response of seahorses to a minimum size limit should be much easier to predict than the response to ntMPAs, because standard single-species modelling methods can be used. A yield-per-recruit model by Lowe et al. [78] suggested that minimum size limits are most effective at high fishing mortality (greater than 0.2), with little effect at low values. As fishing mortality for this seahorse fishery is estimated to be very high (Table 1), minimum size limits may have a high probability of increasing stock size.

To be effective at preventing recruitment overfishing, a minimum size limit needs to be set at a size greater than mean size at first reproduction. For *H. comes* this parameter is unknown, but the mean size at which the brood pouch appears in males, approximately 9 cm height (10.2 cm standard length, Table 1) may be used as a proxy for size at first reproduction. Discussions at the CITES technical workshop in the Philippines and a subsequent CITES workshop on implementation of the listing in Mexico in February 2004 concluded that a minimum size limit of 10 cm height would be suitably precautionary and could potentially be applied across a range of species.

A height of 10 cm was at the upper range suggested by the fishers and TCM traders were generally ready to set limits greater than 8 cm height (Table 7). This was primarily because smaller seahorses were difficult to sell. Adjustments in minimum size limit can be made as mean male size at first pregnancy and female size at first reproduction are determined. If increases in minimum size limits are required, they are usually more acceptable to fishers if they are changed gradually over a number of years [79], thereby reducing immediate losses of income [71].

Global minimum size limits for seahorses have been suggested as one potential measure to ensure sustainability in international trade under CITES.[7] Trying to enforce a minimum size limit to prevent recruitment overfishing for all seahorse species caught in the Philippines (*H. barbouri*, *H. kelloggi*, *H. kuda* and *H. spinosissimus*: [30]) might appear problematic. However, all species except *H. kelloggi* are similarly sized [24], so a general minimum size limit could probably be applied. A similar situation is seen in the coral trout fishery (*Plectropomis* spp.) on Australia's Great Barrier Reef. All species are currently managed under one minimum size limit (38 cm TL). The one species with a substantially larger minimum size at first reproduction (*P. laevis*) is easily recognised by fishers and may soon by managed with a greater minimum size limit (60 cm TL: [53]).

5.2. Management options with general support—ranked moderate–high preference by stakeholders

5.2.1. Temporal closures

Stakeholders considered this management option to be potentially useful, although the FTW and the Philippines and international policy groups expressed reservations (Fig. 3, Table 4). One concern was the lack of information about when a closure might be appropriate: there is little evidence suggesting that seahorses are more vulnerable at particular life-history stages. However, we have some information suggesting that dieback of *Sargassum* in March–April may increase visibility and thus catches of *H. comes*.[8] As well, temporal closures are generally complicated and require a high level of knowledge of the biology of the target species

[7] Briefing document 8.2 supplied to International Workshop on CITES implementation for Seahorse Conservation and Trade, Mazatlán, Mexico, 3–5 February 2004.

[8] A. Vincent, J. Meeuwig, M. Pajaro, N. Perante, unpublished data.

[70]. Furthermore, temporal closures have been insufficient to prevent the collapse of fish stocks even where the biology was well understood [57,70]: part of the problem is that fished populations only recover under very long closure regimes, and then are quickly depleted again when fishing resumes [80]. Models of different management measures indicated that temporal closures did not ensure long-term sustainability of populations [71].

Given the subsistence nature of the seahorse fishery [16], temporal closures for seahorses may prove difficult to enforce. Nevertheless, the national policy group recommended that if the fishery is critically overexploited there should be a temporary moratorium (total closure for 1–2 years), an option also recommended by seahorse fishers during interviews across northern Bohol [16]. Temporal closures have been generally used as fishery management tools to protect certain life-history stages of the population, such as aggregations of spawning adults, where a large proportion of the population is concentrated in a small area at certain times of the year [42,43].

5.2.2. Tenurial systems

This option was considered essential to successful management of the seahorse fishery by the FTW and the Philippines policy group who ranked this option higher than the fishers did (Fig. 3, Table 4). This was perhaps because the option was presented to the fishers as a discussion of ownership by the village or barangay rather than by the individual. Alternatively, the fishers' opinions may reflect open-access traditions for exploitation of marine resources or scepticism about the possibility of local ownership. Tenure helps limit the scramble competition for resources that leads to overexploitation [81,82]. Indeed, it has been argued that tenure is a prerequisite for sustainability [18,44] and that tenure of local fisheries resources is crucial to management successes in Indonesia [83]. Tenure may, however, be difficult to implement in areas that lack social tradition for ownership or that have experienced significant breakdown of social structures from population growth or migration. Moreover, tenurial systems take longer to become effective than ntMPAs and minimum size limits, although all require consultation, education and legislative changes to be effective.

5.3. Management options producing divergent responses

5.3.1. Reduction in total number of fishers

Most non-fisher stakeholder groups ranked this management option as low for its negative social effects (i.e. creating unemployment among fishers) and unworkability (Table 4). Fishers, however, gave this option a Moderate ranking. In addition, the aquarium community were strongly supportive, apparently because they presumed that fishers had other alternative livelihood options to replace income from fishing.

It is difficult to predict the outcome of reducing the number of fishers. A lower number of fishers would only result in lower total fishing effort if remaining fishers avoided compensatory increase in their fishing effort. On the one hand, fishers are already fully engaged in fishing so may not be able to increase effort. Fishers who continue to fish would expect to see greater catch-per-unit-effort as populations of seahorses increased. Moreover, the fishery is open-access and there are few alternative livelihoods for fishers. Were remaining fishers to experience improved returns, it might be difficult to keep other people from entering or re-entering the fishery. Restriction in total effort requires strong enforcement capability and only appears to have been successfully achieved with community ownership of resources [44].

5.3.2. Gear restriction

Fishers and PTWG were supportive of this option while FTW expressed serious reservations (Table 4). The total catch of *H. comes* using SSBA was thought to be small compared to those caught by breathhold divers since there were fewer SSBA fishers. However, these fishers exploit deeper water that might otherwise provide a spatial refuge from catches by breathhold fishers [16].

The potential for rapid depletion of seahorse stocks by SSBA fishers is illustrated by an example of boom-and-bust during 2003.[9] In May 2003, a previously undocumented population of a deep-dwelling seahorse *H. spinosissimus* was discovered and exploited by compressor divers from one island on the Danajon Bank. Catch monitoring documented a decline of greater than 90% in total seahorse catch by October and a 75% reduction in number of fishers targeting this species.

Reduction or elimination of SSBA would create a spatial refuge for seahorses, although the implications of this action would be uncertain. Length-based analysis suggests that *H. comes* may show an ontogenetic habitat shift from shallow to deep water at larger adult sizes.[10] If further research confirms this inference, then gear restriction might produce similar results to implementation of a maximum size limit (see below). Alternatively, if seahorses in deeper water represent self-recruiting populations, then management effects of a SSBA ban would be similar to the use of spatial closures (see above). Fishers' support for this management measure suggests that our focal group included few SSBA fishers, as their capital investment is high enough to deter them from seeking alternative livelihoods. Enforcement of unpopular restrictions is difficult in the Philippines. Nevertheless, several municipal offices in Bohol have banned or are banning the use of SSBA (MS pers. obs.). Bans or restrictions on the use of SSBA are probably warranted on the grounds of fisher safety, but the effects on the seahorse fishery will depend on the number of fishers using SSBA and the frequency of use. Four fishers of 80 surveyed had a compressor[11] which may indicate that an SSBA ban would not have a large effect in this fishery.

5.3.3. Total allowable catch (TAC)

Fishers were the only group that showed high preference for this option, although their support was by no means unanimous (Table 5). It is unclear why TACs should

[9] D. McCorry, pers. comm.
[10] J. Meeuwig, unpublished data.
[11] J. Erediano, pers. comm.

have higher levels of support among the fishers when compared with reduction in the number of fishers, but perhaps it was perceived as more equitable. All the other groups consulted showed lower preference because of the potential to restrict fishers' income if TACs could be enforced and associated scepticism about the possibility of enforcement; in this, they did not give credit to the fishers' good intentions, at least. Although TACs are designed to reduce overall fishing mortality, they can lead to scramble competition between fishers to exploit the resource as rapidly as possible [70]. Thus, if enforcement breaks down after a TAC is reached, then overall fishing effort actually increases. While TACs might have similar economic costs to minimum size limits if both were implemented and enforced, the latter would be more consistent in its effect. Once a TAC was reached, income from seahorses could not be received until the commencement of the next fishing period whereas minimum size limits would act year-round. It appears very unlikely that TACs could be successfully enforced in the seahorse fishery, given the management resources available, and the subsistence nature of the fishery.

5.3.4. Sex-selective fishing (leaving pregnant males)

Fishers were strongly supportive of this management option while the TCM community was recorded as being strongly opposed (Table 4). Such an apparent difference may represent a real divergence of opinion between these groups. Alternately, however, our phrasing of the question in the present tense may mean that the TCM community wished to sell the pregnant males already in their possession. The latter is more likely: (a) pregnant males have the same economic value as females or non-pregnant males in TCM [30]; (b) three representative Hong Kong importers called on Philippines fishers and exporters not to take pregnant male seahorses during a November 2000 workshop in Cebu;[12] and (c) seven TCM trade associations in Hong Kong called for colleagues "*not to purchase seahorses during their breeding seasons, so that their resources can be sustainable*" on 25 March 2002.[13] We need to explore the response of TCM community to sex-selective fishing further before we can fully gauge the potential efficacy of this management option

Fishers tacitly acknowledge recruitment overfishing by favouring the conservation option of leaving pregnant males in the sea. It is unclear whether they realised that such a policy would result in a substantial catch reduction: the sex ratio is 1:1 [25] and males are pregnant approximately 50% of the time. An alternative option to achieve the same ends without this cost would be to cage pregnant males (see below).

Both the biological and economic consequences of sex-selective fishing on seahorses without broods are dependent on the frequency of pregnant animals in the population. If males are pregnant for the majority of each reproductive cycle [84], then total reproduction may be significantly enhanced by restricting take, but with significant loss of earnings. However, if overall population densities are so low that males have difficulty finding a partner, then avoiding pregnant males may have little effect on either population recovery or earnings from seahorses. This management

[12] B. Kwan, in litt., November 2000.
[13] S. Lee, in litt., March 2002

option is analogous to sex-selective fishing as practised in many crustacean fisheries, although berried females are avoided in such cases [57]. Sex-selective fishing did not mitigate the race-to-fish associated with large fisheries in OECD countries, while enforcement costs increased [70].

One anxiety is that selective release of brooding males might severely skew the population sex ratio. A simple theoretical model suggests that the degree of skewness is related to the fishing effort, frequency of pregnancy and the rate at which animals re-pair.[14] In reality, the sex ratio skew may be acceptable. The fishers are currently taking all they can, so reducing take in pregnant males is unlikely to increase the take of females. The bias in the sex ratio, then, will occur in a population with more seahorses.

5.3.5. Caging pregnant males

Fishers, particularly those with experience in the seahorse fishery, strongly supported this management option while other stakeholder groups expressed reservations (Table 4). The biological effect of caging pregnant males is to allow the release of one extra brood of young that would otherwise not survive. Economically, the fishers can retain their whole catch, although there is a delay cost involved and the possibility of mortality in, or escape from, the cage, or weight loss. Caging pregnant males was attempted in 1999, which may explain the dichotomy between the attitudes of the two groups of fishers. Those with previous experience were more supportive of the option than those without (Table 5).

However, analysis of caging trials revealed a number of serious shortcomings in this management option:[15] (1) caging required a labour intensive input from fishers for the well-being of the caged seahorses; (2) considerable intervention by conservation organizations was needed to maintain community engagement; (3) seahorses lost condition as a result of handling when caught and when held in the cages reducing their economic value; (4) mortalities of seahorses in cages further reduced the economic return and; (5) there were limitations on the number of seahorses that could be caged at any one time. This study concluded that caging was only a short-term management option and less preferable to a ban on taking pregnant males.

5.4. Management options of lowest preference

5.4.1. Maximum size limit and slot sizes

Both of these options were strongly opposed by fishers and the TCM community, and slot sizes were considered unworkable by the international policy group (Table 4). Other stakeholders groups recognized the biological utility of maximum size limits but also noted the fishers' and traders' economic dependence on large seahorses. The economic value of seahorses above 12 cm height is strongly correlated with size [13], such that declines in income could be expected, were maximum size

[14] K. Martin-Smith, unpublished data.
[15] D. McCorry, pers. comm.

limits implemented. The same argument was presented by fishers for opposition to slot sizes, with the additional loss of smaller individuals from the catch, further reducing their income. It appears very unlikely that maximum size limits or slot sizes could be enforced except through trade bans, which would create financial distress for fishers and force them on to other (often depleted) resources.

The benefits of maximum size limits for exploited species are dependent on the allometric scaling of fecundity with body size [85,86]. In *H. comes,* brood size was not related to body size over the size range of animals caught in the fishery.[16] However, the proportion of pregnant males increased proportionately with body size over the range 10.5–20.0 cm SL. Thus, the increased total reproductive gain from this relationship was likely to be modest as it was sigmoidal (logistic) rather than exponential.

6. Conclusions and recommendations

The collaborative process described in this paper has produced clear suggestions as to management options for the *Hippocampus comes* seahorse fishery in the Philippines. We recommend that a combination of the highly preferred options (MPAs and minimum size limits) is instituted as soon as possible to ensure the management objectives for the fishery are achieved. Use of multiple management measures should help to spread the risk, if some of the biological or economic assumptions are invalid. In addition, these highly preferred options have different temporal scales for their implementation and subsequent effects. Long-term sustainability would only appear to be achievable with the introduction of a tenurial system, which could be a protracted process and would not of itself create security for seahorse populations. Minimum size limits may operate more quickly than MPAs in re-building seahorse populations [71,79] although their negative economic effects on fishers may be greater. However, gradual introduction of minimum size limits can mitigate the loss in income [79].

No-take MPAs should also serve as strong management tools for the Philippines seahorse fishery. Current requirements that every coastal municipality establish a no-take zone could perhaps be extended to every coastal village, especially as this is already the de facto practice in some areas. Such small-scale ntMPAs are effective in the Philippines context (e.g. Apo Island, [29]). Additionally, an array of small MPAs might connect to serve as a network [87]. We recognize that partial-take MPAs may also serve as useful conservation tools in the Philippines, if they are part of a zoning scheme or other conservation planning, and are fully supported for active enforcement.

A minimum size limit of 10 cm height could serve as a viable fisheries management tool for this fishery. This value is greater than estimated size at first reproduction and appeared acceptable to fishers and TCM traders. Implementation will need to be achieved with the co-operation of management and enforcement agencies. We

[16] A. Vincent, J. Meeuwig, M. Pajaro, N. Perante, unpublished data.

suggest that monitoring of the size of *H. comes* in trade is undertaken to assess the effectiveness of this management measure. This in turn could help the Philippines government show non-detriment findings for the fishery after the activation of CITES Appendix II listing for all seahorses in May 2004 [31].

Marine Protected Areas offer greater benefits for marine ecosystems than do minimum size limits for particular species. These set-aside zones create considerable benefits for many species [88,89] and protect habitats of seahorses and other species, otherwise at risk from destructive fishing practices such as blast fishing and from coastal development. A consensus statement by the National Center for Ecological Analysis and Synthesis has used extensive global analyses to recommend MPAs as effective fisheries management and biodiversity conservation tools [90], and they are also recommended as important precautionary conservation measures [19,40,89].

This study has demonstrated that it is possible to identify science-based management options for small-scale fisheries through consultation. Such a model for arriving at fisheries management options provides a good chance of successful uptake and implementation by stakeholders. The recovery of seahorses in the Philippines is in many sets of hands, all of which have to be pulling in the same direction.

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