CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA

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Panama City (Panama), 14 – 25 November 2022

MAKING NON-DETRIMENT FINDINGS FOR SEAHORSES

1. This document has been submitted by the Secretariat on behalf of IUCN in relation to agenda item 69.1.[*]

2. Seahorses were the focus of the first CITES Review of Significant Trade (RST) for fully marine fishes, with three rounds initiated in 2008, 2011 and 2014.[i] The RST process for seahorses triggered development of an NDF framework for the genus. With support from the CITES Secretariat and funds from the European Union (EU), Project Seahorse (which hosts the IUCN SSC Seahorse, Pipefish & Seadragon Specialist Group (SPS SG)) worked with the Management Authorities (MAs) and Scientific Authorities (SAs) in Thailand and Viet Nam to create the first NDF framework for marine fishes. It was later refined in consultation with Authorities in the Philippines. This most recent version is available on the SPS SG website.[ii] The NDF framework guides Authorities to identify the pressures facing the seahorse species under consideration, evaluate the ability of existing management to mitigate identified or unknown risks, and consider options for making NDFs.

3. Despite its methodical and measured approach, this NDF framework for seahorses has been little used. Indeed, most historically important export Parties for the vast dried trade in seahorses have chosen to end legal exports due to challenges in making NDFs.[i] Despite the general prevalence of trade suspensions, exports of dried seahorses persist at high levels, primarily in forms of illegal trade.[iii] Both before and after the CITES listing, tens of millions of dried seahorses have been traded internationally each year, involving countries on all populated continents.

4. As the seahorse example reveals, an important step toward sustainable trade under CITES will be to improve Parties' willingness and capacity to make NDFs that restrict exports meaningfully. We need a modified process that still acknowledges the complex ecological, economic and social issues involved in export regulation but reduces the difficulty of making NDFs. Whatever its imperfections, an easier process that is applied is more effective than a more difficult process that has been set aside.

5. Project Seahorse proposes that governments might find it easier to make NDFs by mapping the answers to four questions: (1) where are the species found?; then, for those areas, (2) what pressures do the species face?; (3) what measures are in place to manage the pressures?; and (4) how well are the management measures working?

6. Project Seahorse is preparing a guidance document based on more tractable advice for making NDFs which it will share with Parties for feedback at an Asia region workshop focused on advancing CITES implementation for seahorses, to be held in the Philippines March 14-17, 2023.

[*] *The geographical designations employed in this document do not imply the expression of any opinion whatsoever on the part of the CITES Secretariat (or the United Nations Environment Programme) concerning the legal status of any country, territory, or area, or concerning the delimitation of its frontiers or boundaries. The responsibility for the contents of the document rests exclusively with its author.*

7. To encourage dialogue on simplifying NDFs, for seahorses and other taxa, Project Seahorse is sharing two NDF cases studies with the Parties, one which demonstrate the application of the original NDF framework for seahorses, and one that offers guidance for an easier approach.

   i. Aylesworth, L., Foster, S. J. & A.C.J. Vincent (2020). Realities of offering advice to governments on CITES. *Conservation Biology,* 34(3):644-653. https://doi.org/10.1111/cobi.13451

   ii. Vaidyanathan, T., Foster, S. J. & A.C.J. Vincent (2022). A practical approach to meeting national obligations for sustainable trade under CITES. IOF Working Papers 2022 (05), 28 pp., Institute for the Oceans and Fisheries, University of British Columbia. https://fisheries.sites.olt.ubc.ca/files/2022/11/2022-05-Working-Paper-Vaidyanathan_et_al_2022.pdf.

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[i] Foster, S.J. & A.C.J. Vincent (2021). Holding governments accountable for their commitments: CITES Review of Significant Trade for a very high-volume taxon. Global Ecology and Conservation 27:e01572. https://doi.org/10.1016/j.gecco.2021.e01572.

[ii] Foster, S.J. & Vincent, A.C.J. 2016. Making Non-Detriment Findings for seahorses – a framework, Version 4. Project Seahorse, The Institute for the Oceans and Fisheries (formerly the Fisheries Centre), The University of British Columbia. 72 pp https://www.iucn-seahorse.org/cites-toolkit#ndf

[iii] Vincent, A.C.J., Foster, S.J., Fowler, S.L., Lieberman, S., and Sadovy de Mitcheson, Y. (2022) Implementing CITES Appendix II listings for marine fishes: a novel framework and a constructive analysis. *Fisheries Centre Research Report,* 30(3), 189 pp.

Conservation Biology

Contributed Paper

Realities of offering advice to governments on CITES

Lindsay Aylesworth,*,† Sarah J. Foster, and Amanda C.J. Vincent

Project Seahorse, Institute for the Oceans and Fisheries, The University of British Columbia, 2202 Main Mall, Vancouver, V6T1Z4, Canada

Abstract: What happens when those who provide conservation advice are required to take policy and management action based on that advice? Conservation advocates and scientists often try to prompt regulatory change that has significant implications for government without facing the challenge of managing such change. Through a case study, we placed ourselves in the role of the government of Thailand, facing obligations to seahorses (*Hippocampus* spp.) under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). These obligations include ensuring that its exports of seahorses do not damage wild populations. We applied a CITES-approved framework (which we developed) to evaluate the risks of such exports to 2 seahorse species. We used the framework to evaluate the pressures that put wild populations of the species at risk; whether current management mitigates the risk or offsets these pressures; and whether the species is responding as hoped to management policy. We based our analysis on information in published and grey literature, local knowledge, citizen science data, results of government research, and expert opinion. To meet CITES obligations, exports of both species would need to be prohibited until more precautionary adaptive management emerged. The risk of any exports of *Hippocampus trimaculatus* was above a tolerable level because of a lack of appropriate management to mitigate risks. In contrast, the risk of any exports of *Hippocampus kuda* could become tolerable if monitoring were put in place to assess the species' response to management. The process we developed for Authorities to determine risk in response to CITES guidelines was challenging to implement even without the need for government to consider social implications of conservation action. Despite the imperfections of our risk evaluation, however, it still served to support adaptive management. Conservationists need to keep implementation in mind when offering advice.

Keywords: assessment, fisheries, Hippocampus, sustainable trade, Thailand

Realidades al Ofrecerle Consejos sobre CITES a los Gobiernos

Resumen: ¿Qué ocurre cuando se requiere que quienes proporcionan consejos para la conservación realicen acciones políticas y de manejo basadas en aquellos consejos? Los científicos y partidarios de la conservación tratan con frecuencia de provocar cambios legislativos que tienen implicaciones significativas para el gobierno sin enfrentar el reto que implica manejar ese cambio. Mediante un estudio de caso, nos colocamos en el papel del gobierno de Tailandia, el cual enfrenta obligaciones con los caballitos de mar (*Hippocampus* spp.) bajo la Convención sobre el Comercio Internacional de Especies Amenazadas de Flora y Fauna Silvestre (CITES). Estas obligaciones incluyen asegurar que las exportaciones de caballitos de mar no causen daño a las poblaciones silvestres de este grupo. Aplicamos un marco de trabajo aprobado por CITES (el cual desarrollamos) para evaluar los riesgos de dichas exportaciones para dos especies de hipocampos. Usamos el marco de trabajo para valorar las presiones que ponen a las poblaciones silvestres de ambas especies en riesgo; si el manejo actual mitiga o compensa el riesgo de estas presiones; y si las especies están respondiendo como se esperaba a las políticas de manejo. Basamos nuestro análisis en información tomada de literatura publicada y de la literatura gris, del conocimiento local, los datos de la ciencia ciudadana, los resultados de investigaciones realizadas por el gobierno y de la opinión de expertos. Para cumplir con las obligaciones de CITES, las exportaciones de ambas especies necesitarían estar prohibidas hasta que existiera un manejo adaptativo más preventivo. El riesgo de cualquier exportación de *H. trimaculatus* quedó por encima de un nivel tolerable debido a la falta de un manejo apropiado para mitigar los riesgos. Como contraste, el riesgo de cualquier exportación de *H. kuda* podría volverse tolerable

*Address correspondence to Lindsay Aylesworth, email lindsay.aylesworth@gmail.com
†Current address: Oregon Department of Fish and Wildlife, 2040 SE Marine Science Drive, Newport, OR, 97365, U.S.A.
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si se realizaran monitoreos para evaluar la respuesta de la especie al manejo. Fue todo un reto implementar el proceso que desarrollamos para que las autoridades determinen el riesgo siguiendo la pauta de CITES incluso sin la necesidad de que el gobierno considerara las implicaciones sociales de la acción de conservación. Sin embargo, a pesar de las imperfecciones de nuestra evaluación de riesgo, todavía funcionó como apoyo para el manejo adaptativo. Los conservacionistas necesitan seguir considerando la implementación cuando ofrecen consejos.

Palabras Clave: evaluación, hipocampos, mercado sustentable, pesquerías Tailandia

摘要: 当要求保护的进言者采取相应政策和管理行动时, 会发生什么?在现实中, 环保倡导者和科学家常常试图推动对政府有重大影响的管理制度改革, 但却从未直接应对这些变化所带来的挑战。我们通过案例分析, 将自己置身于泰国政府的角色来执行《濒危野生动植物种国际贸易公约》(CITES) 中保护海马 (*Hippocampus* spp.) 的义务, 包括确保泰国的海马出口不会危害野生种群。我们应用由本团队开发且 CITES 认可的框架, 评估了出口对两个海马物种的风险。这一框架评估了野生种群的致危因素; 当前的管理是否能减缓风险或抵消胁迫; 以及物种对管理政策的响应是否符合预期。我们还基于已发表文献及灰色文献中的信息、地方性知识、公民科学数据、政府研究结果和专家意见进行了分析。结果表明, 为履行 CITES 公约的义务必须禁止这两个物种的出口, 直到有更具预防性的适应性管理措施。由于缺少恰当的管理措施来减缓风险, 三斑海马 (*H. trimaculatus*) 的出口风险超出了可接受的水平。相比之下, 如果采取监测措施来评估管海马 (*H. kuda*) 对管理的响应, 则其出口的风险都可以接受。即便政府不需要考虑保护行动的社会影响, 我们根据 CITES 指导方针为当局制定的风险评估步骤也难以实施。虽然风险评估本身存在缺陷, 但它还是能够为适应性管理提供支持。此外, 保护主义者在进言献策时也应考虑实施的可行性。【**翻译: 胡怡思; 审校: 聂永刚**】

关键词: 渔业, 海马, 可持续贸易, 泰国, 评估

Introduction

Although conservationist scientists are constantly urging policy makers and resource managers to do better (Hamann et al. 2010; Young & Van Aarde 2011), it is much less common for them to make concrete suggestions, beyond urging monitoring for more data (EDF 2016). Moreover, they seldom put themselves in the place of the people and agencies tasked with implementing proposed policy changes. The result is intractable advice.

Implementation of natural resource policy is never easy given imperfect data, divergent stakeholder views, and limited budgets, but this is especially so with marine fisheries (Walters 2007; Salomon et al. 2011). Marine fisheries contribute substantially to domestic and international commerce (FAO 2018). They are sources of local pride because they are linked to cultural values, and livelihoods (Song et al. 2013). Yet, marine wildlife is increasingly threatened by fishing (Costello et al. 2012) to an extent that demands creative reconciliation of conservation with marine fisheries (Salomon et al. 2011).

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) has relatively recently been used to secure sustainable exports of marine fishes (Vincent et al. 2014; Guggisberg 2016). Marine fishes are not usually considered wildlife or part of wildlife trade (Vincent et al. 2014), despite that trade policy measures help shape global patterns in fish supply and demand (Bellmann et al. 2015). However, CITES member countries must ensure their exports (and hence their fisheries leading to the export trade) do not damage wild populations for marine fishes listed in CITES Appendices (Vincent et al. 2014; Cochrane 2015). In this, countries are commonly in new territory, needing to ask their maritime and fisheries agencies to prioritize sustainability over production. Their challenge is particularly acute because national expertise in conservation and understanding of CITES policy and obligations exists primarily in environment or forestry agencies (Vincent et al. 2014).

A large part of CITES' potential to contribute to fisheries conservation comes through the requirements associated with an Appendix II listing (Vincent et al. 2014; Guggisberg 2016). Regulation of international trade of species, including very few marine fishes, under CITES occurs through listing in 1 of its 3 appendices (CITES 1973): Appendix I, end exports; Appendix II, regulate exports; or Appendix III, support national policy. Countries that trade in Appendix II species must prove, among other things, that exports do not harm wild populations. This is called a nondetriment finding (NDF) (CITES 1973). Member countries must overcome uncertainties about trade levels, population status, management options, and institutional issues associated with stakeholder involvement, financial resources, and capacity (Vincent et al. 2014). Countries are free to make their own decisions on how best to arrive at positive NDFs for listed Appendix II species (Foster & Vincent 2016). They can choose whether to follow proffered advice in the form of a general framework or a detailed checklist (Rosser & Haywood 2002; Mundy-Taylor et al. 2014; Foster & Vincent 2016). Most guidance is generic and intended to be relevant to many species and countries, each with different cultural situations, institutional limitations, and opportunities (Mundy-Taylor et al. 2014; Foster & Vincent 2016).

We focused on Thailand because it has been the world's largest exporter of seahorses and a focus of CITES action on behalf of these fishes. Since 2008 Thailand has undergone the CITES Review of Significant Trade (RST) process for 4 species (*Hippocampus kelloggi, Hippocampus kuda*, *Hippocampus spinosissimus*, and *Hippocampus trimaculatus*) to determine whether its exports of 3.0–6.5 million seahorses/year (Foster et al. 2016) were detrimental to wild populations. The RST asks countries to justify their NDFs and requires changes for countries that cannot do so for focal species. Because Thailand could not make positive NDFs for its large export volumes, Thailand's trade in these 4 species was considered to pose "urgent concern" (UNEP-WCMC 2012; CITES 2014). Thus, the CITES Animals Committee provided 10 actions Thailand would need to implement to continue exporting seahorses legally (CITES 2012). Thailand found this process difficult (A.V., personal communication), so we considered Thailand's responsibility from their perspective.

We sought to place ourselves, the providers of conservation advice, in the role of Thailand's CITES Authorities (government agencies) who are being asked to take advice on their implementation of CITES for seahorses. Throughout CITES' history with seahorses, virtually all scientific and technical advice on this taxon has come from Project Seahorse, the organization the International Union for the Conservation of Nature (IUCN) considers the global authority on seahorses and their relatives. We focused on the nonbinding NDF framework for seahorses, which we developed (Foster & Vincent 2016), informed by NDF frameworks for other species listed on Appendix II. We wanted our analysis to represent problems CITES Authorities may face with implementation of other CITES export regulations.

In line with the NDF framework, we assessed the risk to Thai seahorses from fishing, trade, and habitat destruction and evaluated the ability of existing management to mitigate the identified risks. We used this assessment to consider NDF options and what actions may be needed to improve management action and fill knowledge gaps. We explored what we would consider sufficient knowledge for countries to make an NDF under CITES. We also examined the implementation process, beginning with the initial CITES recommendations to Thailand based on our advice. Our analysis considered the context and data available as of 31 December 2015. On 1 January 2016, Thailand declared a suspension of seahorse exports until they were confident of making positive NDFs, and the policy landscape shifted.

Methods

We ran through the NDF framework with the 2 (of 7) Thai seahorse species CITES identified as "urgent concern": *H. trimaculatus* in 2014 and *H. kuda* in 2012. These 2 species are the most susceptible to trawling and gillnet fishing and represent dominant offshore (*H. trimaculatus*) and inshore (*H. kuda*) seahorse species in Thai fisheries and trades (Aylesworth et al. 2018). This preselection allowed us to skip over sections 3 and 4.1 of the framework (Fig. 1).

As requested in the NDF framework (Fig. 1), we extracted all available information on the selected 2 species. Sources included published literature, grey literature, local knowledge, citizen science contributions, government research, and expert opinion (Foster & Vincent 2016). We incorporated data sets not explicitly requested in the NDF framework and included data that were available only at the genus level.

We documented and evaluated the risks to our 2 seahorse species by gathering data related to their fishery and trade and destruction of their habitat (sections 4.2–4.5) (Fig. 1 & Supporting Information). This information came from the Thai CITES Authorities, including documents submitted to the CITES Secretariat and relevant CITES Committees by Thailand in support of the RST process. We also consulted published literature (Google Scholar searchers) and local experts ($n = 150$) and drew on our own seahorse field research from 2013 and 2014 in Thailand (Supporting Information). We described pressures on the 2 species (section 4.2 of the framework) and assessed the risk of the various pressures on them (sections 4.3–4.5). We drew on the framework's suggestions in assigning the 4 categories of risk from fishing, trade, and habitat destructions: low, moderate, high, and unknown (Supporting Information).

We evaluated the capacity of existing management to mitigate the risks we identified, as recommended in section 5. To do so, we considered whether existing management was appropriate for the risks, being implemented, and effectively reducing identified pressures on seahorse populations to levels that did not damage wild populations (section 5) (Fig. 1). We based our evaluation on Thai marine management measures in place as of 31 December 2015 (DoF 2015) (Table 2 & Supporting Information). We evaluated the implementation of such management measures, defined as either stakeholders following the rules (compliance) or authorities taking action to ensure rules are followed (enforcement). The framework infers management effectiveness from evidence of stable or increasing (seahorse) population sizes over time. We did a second evaluation of appropriate management measures based on spatial overlap of sightings for the 2 species and known marine management measures. We used 3 data sources for observations of seahorses by species: DoF research trawls, scientific surveys, and citizen science contributions. We also used 3 data sets on management measures: Thai national parks, no-trawl zones, and seasonal closures (Supporting Information). If >70% of sightings for either species occurred in any 1 management area

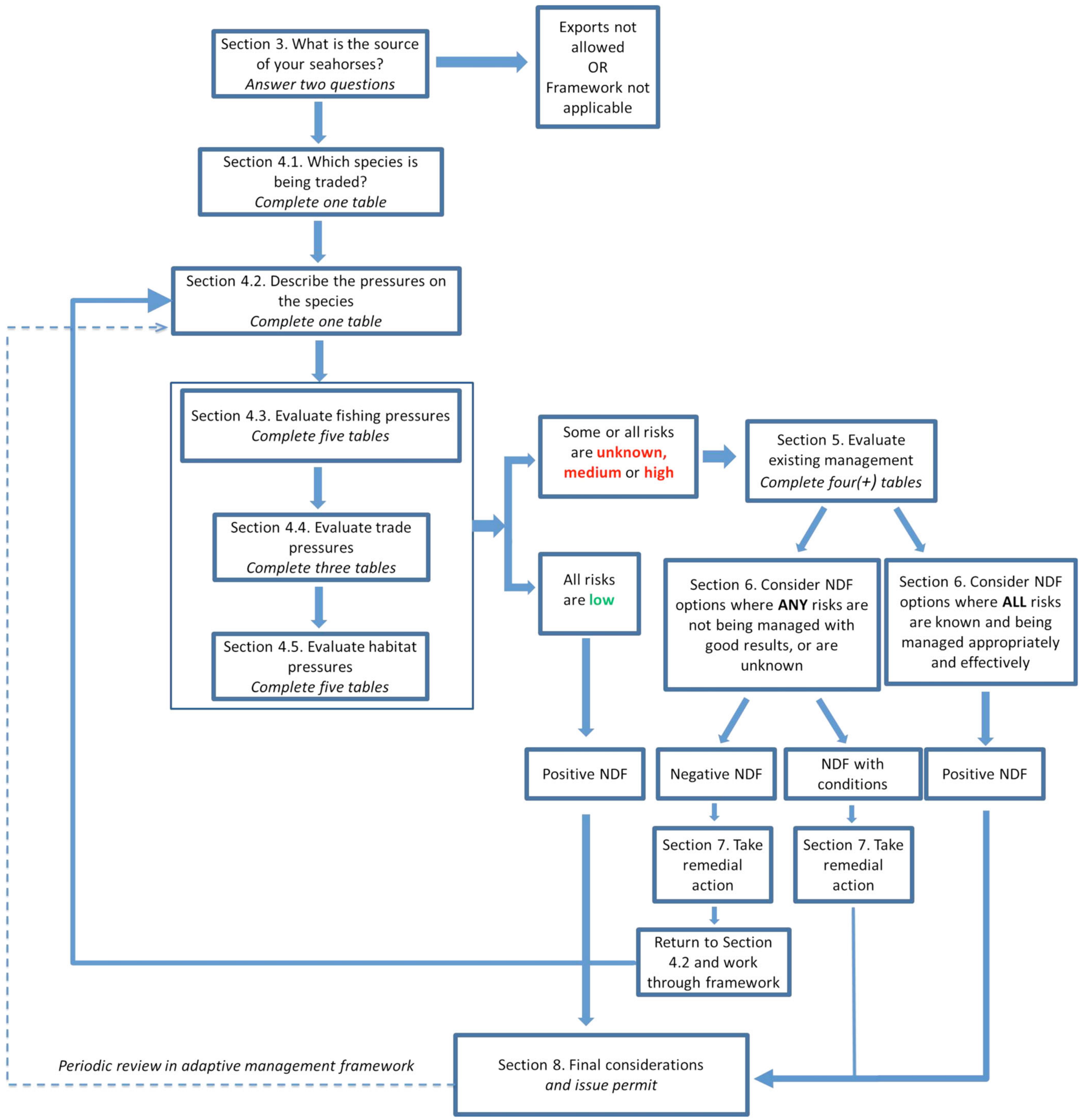

Figure 1. Flow chart describing the nondetriment finding (NDF) framework for seahorses. Section numbers are sections of the NDF framework. From Foster and Vincent (2016), reprinted with permission from Project Seahorse.

or in all management areas combined, we deemed management appropriate. Our rationale was that effectively managing areas with >70% of the sightings could reduce the population risk of extinction from vulnerable to near threatened on the IUCN Red List (IUCN 2012).

We put ourselves in the position of the Thai CITES Authorities and tried to determine whether we could make a positive, conditional, or negative NDF (section 6) (Fig. 1) (Foster & Vincent 2016) based on general practice. In this context, a positive NDF can be made when all the risks are known and are being managed appropriately and effectively (Mundy-Taylor et al. 2014; Foster & Vincent 2016). An NDF with conditions would allow for precautionary levels of exports while risks are reduced, gaps in management are addressed, or quality of information is improved (Mundy-Taylor et al. 2014; Foster & Vincent

2016). An NDF with conditions might be assigned when at least 1 appropriate management measure is in place but improvements on enforcement and data on effectiveness are needed. A negative NDF could be made when risks are not being managed with good results or are unknown (Mundy-Taylor et al. 2014; Foster & Vincent 2016).

We explored the guidance and advice in support of adaptive management that emerged from section 7. Using the framework to inform a national action plan for seahorses (section 7), we considered how to improve management and fill knowledge gaps. Where risks were not being managed with good results or were unknown, we identified 3 key management approaches for each species that were essential to moving forward and creating an action plan (section 7). These were based on which of the many options were the most pressing, the most tractable, and already required through another policy commitment (e.g., Aichi). Such selection criteria were intended to focus implementation efforts and encourage pragmatism.

We did not address the final steps before issuing a permit (section 8). Our end was determination of whether permits should be issued, not how they might materialize.

Results

We found 5 sources of data on fisheries, 6 sources of data on trade, and 30 sources of data on habitat (Supporting Information). Information on fisheries and trade primarily emerged from research prompted by the RST recommendations (CITES 2012), whereas most information on habitat came from published literature. We found 10 sources of data on appropriate management responses and enforcement (Supporting Information). We were unable to find any information on the effectiveness of marine management measures for seahorses as inferred by long-term monitoring of trades, catches, or populations.

Management Measures

Six existing management responses were appropriate to address pressures on seahorses in general in Thailand. None were developed specifically for seahorses, but their implementation should help mitigate pressures on seahorses. The 4 management responses appropriate to fisheries pressures (mostly nonselective gear) included limited entry, marine protected areas, and spatial and temporal gear restrictions (Supporting Information). A new national fisheries management plan addressed illegal fisheries and trade (Supporting Information). To address habitat destruction, management responses were marine protected areas, spatial gear restrictions, and habitat restoration (Supporting Information).

All management measures could address human pressures on Thailand's seahorses. There was purported limited entry for all gears that catch seahorses (DoF 2015). National parks (marine protected areas) in Thailand encompassed substantial amounts of seahorse habitat; 25% of national waters included 75% of Thailand's coral reefs and 71% of its seagrass beds (DoF 2015). However, implementation and enforcement were a consideration (see below). Thailand officially banned trawling within 3–5 km along all coasts and implemented 3 seasonal closures to protect spawning stock and juvenile fish, closures that would also benefit seahorses (DoF 2015). Thailand had also developed 96 artificial reefs with the stated aims of preventing trawling and restoring fish habitats (DoF 2015), although these could increase fishing pressure elsewhere.

Management Implementation

Appropriate management was in place but, evaluating its implementation (i.e., compliance or enforcement) proved challenging because of conflicting data. The majority of data for limited entry, national parks, and spatial and temporal gear restrictions indicated that many fishers did not comply with these measures (Supporting Information), leading us to decide that these were not well implemented. However, unpublished data from the Thai Department of Fisheries enforcement office showed limited enforcement for marine fisheries generally. A new fisheries management plan was enacted in late 2015 with the goal of increasing fisheries enforcement and compliance. Its objectives included improving management efforts and establishing tracking systems, check-points at ports, and improved data collection and management (Supporting Information). We confirmed the number of artificial reef units and their geospatial locations, but the conservation value of such reefs to seahorses was unknown.

Management Effectiveness

A dearth of monitoring data (in water, onboard, port-side) meant we had to consider effectiveness of marine management measures for seahorses unknown (Supporting Information).

Results specific to H. trimaculatus

We judged risk high for *H. trimaculatus* in 11 categories (7 fisheries, 3 trade, and 1 habitat) (risk levels defined in Supporting Information). High-risk fisheries pressures included capture in many different fishing gears, but specifically in otter and pairs trawls and gillnets. Catch was sex-biased (indicator of overfishing), and local knowledge indicated declines in catch per unit effort. High-risk trade pressures included many uses of *H. trimaculatus* in trade; illegal, unreported, and unregulated (IUU) fishing and trade, and large price increases. High risks from habitat

Table 1. Summary of spatial overlap of marine management measures and sightings of *H. trimaculatus* and *H. kuda*.

	Sightings (%)	
Management measure	H. trimaculatus *(n = 556 sightings)*	H. kuda *(n = 38 sightings)*
National parks	2	8
No-trawl zones	3	100
Seasonal closures	2	74
Total inside all management combined	6	100

destruction came primarily from marine-based activities (e.g., tourism, shipping, dredging). Seahorse bycatch in gillnets, land-based activities, climate change, and declines in indicators of habitat function posed moderate risks. Capture in purse seines and pushnets, catch under length at maturity, and habitat specialization posed low risks. No categories had unknown risk (Supporting Information).

No existing management measures mitigated risks for *H. trimaculatus* (section 5). Only 6% of 556 sightings of *H. trimaculatus* occurred inside all managed areas combined (Table 1), and 2% of sightings occurred in national parks or areas with seasonal fishing closures (Fig. 2 & Supporting Information). Just 3% of sightings occurred in the no-trawl zones (spatial gear-restricted area) (Fig. 3 & Supporting Information). Moreover, for seahorses, limited entry and habitat restoration would only be appropriate when combined with national parks or spatial gear restrictions (Supporting Information). The only appropriate means to mitigate the fisheries risks for *H. trimaculatus* was through implementation of the Marine Fisheries Management Plan of Thailand, but its enforcement and effectiveness were unknown (Table 2 & Supporting Information).

We assigned a negative NDF for *H. trimaculatus.* The dearth of management measures to mitigate the risks for this offshore species meant that, were we the government of Thailand, we would not be able to justify ongoing trade (an NDF with conditions) for this species.

The most pressing problem facing *H. trimaculatus* was unmanaged and unregulated capture in trawling gears. We would need to know more about how catches and pressures varied spatially to deduce whether existing national parks and no-trawl zones—if implemented—would serve this species or if additional management would be needed. Such information could be obtained through portside monitoring or onboard logbooks. Thailand is already committed to implementation of a new fisheries management plan to reduce IUU fishing and trade. Continuing efforts to limit entry and increase enforcement measures should help ensure nonselective fishing is addressed. Portside monitoring for seahorses

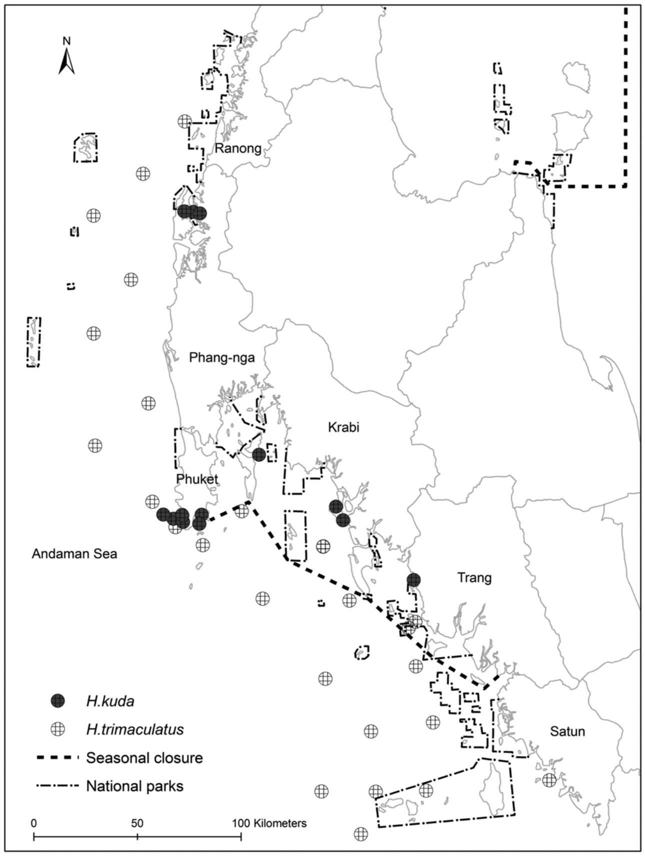

Figure 2. National parks and seasonal closures on the Andaman coast of Thailand and locations of H. kuda *and* H. trimaculatus *observations from research trawls, scientific surveys, and citizen science contributions in relation to the no-trawl zones. Approach used to generate data sets and map detailed in Supporting Information. Additional maps of seahorse and management locations on the Gulf Coast of Thailand detailed in Supporting Information.*

would support adaptive management by helping to identify effectiveness of management actions and ongoing adverse effects from fishing over time.

Results specific to *H. kuda*

We judged risk to *H. kuda* as high in 8 categories (4 fisheries, 3 trade, 1 habitat) (Supporting Information). High-risk fisheries pressures included capture in a large diversity of fishing gears, including gillnets, catch under length at maturity (indicator of overfishing), and local fisher reported declines in catch per unit effort. High-risk trade pressures included many uses in trade, IUU fishing and trade, and large price increases over time. High-risk habitat destruction came primarily from marine-based activities (e.g., tourism, shipping, dredging). Gillnet bycatch, land-based activities, climate change, and declines

Table 2. Fishing gears and management measures stemming from the Marine Fisheries Management Plan of Thailand (DOF 2015) relevant to *H. trimaculatus* and *H. kuda*.

Risk	*Gear*	*Management measures*	*Enforcement*	*Effectiveness*
High	otter trawl	gear restriction, spatial	unknown	unknown
		gear restriction, temporal	unknown	unknown
		habitat restoration	yes	unknown
High	pair trawl	gear restriction, spatial;	unknown	unknown
		gear restriction, temporal	unknown	unknown
		habitat restoration	yes	unknown
High	gillnet	gear restriction, temporal	unknown	unknown
Low	purse seine	gear restriction, temporal	unknown	unknown
Low	pushnet	gear restriction, spatial	unknown	unknown
		gear restriction, temporal	unknown	unknown
		habitat restoration	yes	unknown

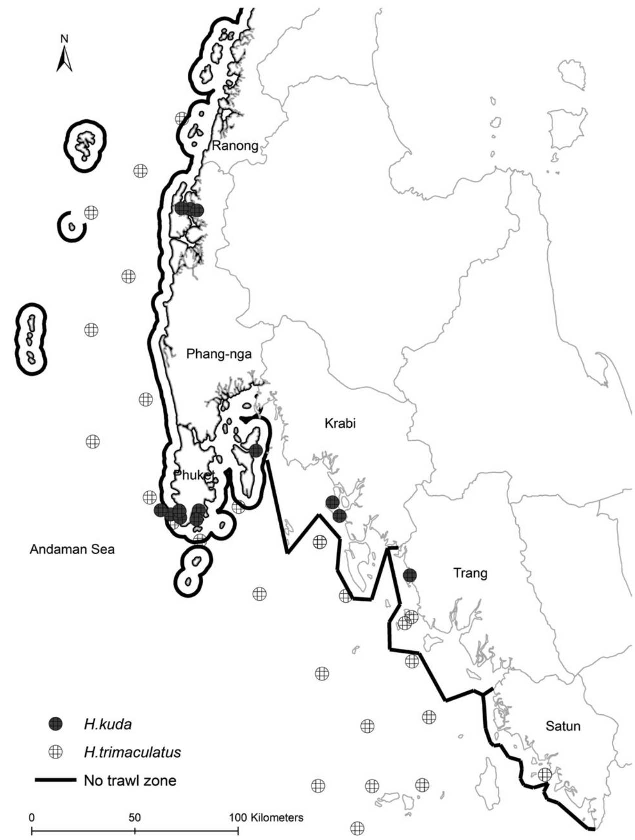

Figure 3. No-trawl zones on the Andaman coast of Thailand and locations of H. kuda *and* H. trimaculatus *observations from research trawls, scientific surveys, and citizen science contributions in relation to the no-trawl zones. Approach used to generate data sets and map detailed in Supporting Information. Additional maps of seahorse and management locations on the Gulf Coast of Thailand detailed in Supporting Information.*

in indicators of habitat function were moderate risks. Low risk fisheries pressures included catchability in fishing gears generally, capture in otter and pair trawls, capture in pushnets, and sex bias in capture. No categories had unknown risk (Supporting Information).

We deemed Thailand's designated spatial and temporal gear restrictions could—if well implemented—mitigate risks for *H. kuda* (Table 2 & Supporting Information). All 38 sightings of *H. kuda* occurred inside at least 1 of the marine management areas (Table 1). Just 8% of sightings occurred within national parks, but this may reflect limited sampling effort in these areas (Fig. 2 & Supporting Information). All sightings for *H. kuda* occurred in designated no-trawl zones (Fig. 3 & Supporting Information), and 74% of sightings were in areas with seasonal fishing closures, which specifically address gillnets, the main fishing pressure on this species (Fig 2. & Supporting Information). It is possible that current distribution reflects sampling bias or a reduced area of occupancy (sensu IUCN Red List) because of fishing effort, but it at least indicates some level of protection, which was clearly lacking for *H. trimaculatus*. Because limited entry and habitat restoration were combined with national parks or spatial gear restrictions, these measures also addressed risks (Table 2 & Supporting Information). The new Fisheries Management Plan theoretically could provide an appropriate response to fisheries risks for *H. kuda* (Supporting Information), although information on its enforcement and effectiveness remains unknown.

We made an NDF with conditions for *H. kuda*. Because many management measures had the potential to mitigate the risks for this inshore species, but there was a lack of data to determine its effectiveness, we believed trade in *H. kuda* could continue only with annual portside monitoring efforts and adaptive management. Such monitoring and associated responses would allow evaluation of existing management and identification of unmanaged risk. These efforts could supplement on-going monitoring for other marine species at select sites for both commercial and small-scale gears. Were we the government of Thailand, we would set trade at precautionary levels (e.g., quota capped at the mean volume of the number of exports over the last 5 years) until results from monitoring became available and could inform management decisions.

The most pressing issue facing *H. kuda* was capture in gillnets. Although gillnets are regulated in Thailand, regulations have not been developed for seahorses. The numerous small-scale gillnet fisheries in Thailand are monitored through fisher self-reporting. A national action plan that included encouraging gillnet fishers to record their seahorse catches when documenting other catch would provide useful data to evaluate risks to *H. kuda.* The most tractable action would be to fully implement management measures aimed at reducing threats to habitat, primarily focusing on better enforcement of protected areas and underwater monitoring of seahorse populations to inform adaptive management.

Discussion

As conservationists, trying our hand at national implementation of an international wildlife trade treaty added to our respect for government challenges with implementation. Because our original advice (NDF framework) had been designed to serve as guidance not a prescription—it had to be applicable to many situations—the effectiveness of its implementation depended heavily on national opinion and interpretation. It is common for advice in multilateral agreements to be vague, including when implementing CITES for terrestrial species (Castello & Stewart 2010; Smith et al. 2011), both to allow it to be applied to many situations and to avoid appearing to dictate to national governments. Countries are expected to deploy what data they can access to reach best possible decisions, hopefully while collecting more information to support adaptive management. We followed their lead, moving on with implementation in spite of imperfect data (Smith et al. 2011). We focused on reproducible ways to evaluate the data in hand and on identifying management options that were most pressing, tractable, or required by other commitments (Bottrill et al. 2008). Such a pragmatic approach allowed us to complete the NDF process for our 2 case study seahorse species, despite imperfect data sets, just as countries are required to do. Nonetheless, it was indeed somewhat challenging to make a series of decisions about progressing with poor data through a rather generic framework.

Our experience with making CITES NDFs was filled with judgment calls—based on our collective level of expertise and risk tolerance—as would be the case for any country working through this process (Mundy-Taylor et al. 2014; Foster & Vincent 2016; Friedman et al. 2018). We identified 4 steps in the NDF process where judgment was particularly important: deciding how data fit into the various categories; assessing risk based on available information; evaluating conflicting data; and determining the NDF outcome. Government would further have the challenge of integrating socio-economic considerations into its decisions, which we did not tackle (Rice & Legacè 2007). Thanks to our close ties with the CITES scientific and management Authorities in Thailand, we accessed a substantial amount of data that might not otherwise have been publicly available. Even so, and given our extensive expertise—cumulatively working on seahorses for 63 years and members of the IUCN Seahorse Specialist Group (www.iucn-seahorse.org)—making a CITES NDF for these 2 seahorse species was challenging.

We found that our process for making an NDF for 2 marine fishes was dependent on presence of appropriate management and understanding its effectiveness, yet this is seldom documented for CITES Appendix II species (Smith et al. 2011). Marine management measures and monitoring in Thailand were focused on other species, priority habitats, and economically important fisheries (DoF 2015). Such challenges may be common for newly listed Appendix II fishes, or other non-target, low-value, or data-poor species (Costello et al. 2012). However, an Appendix II listing for sharks and rays improved national level species governance including existing regulations (Friedman et al. 2018). Our work similarly demonstrates how CITES may help advance national fisheries management while furthering species conservation (Vincent et al. 2014; Friedman et al. 2018). In playing the role of government, we were forced to examine a suite of measures, guidelines and designations in a holistic manner and to consider their effectiveness.

We found that spatial data, often overlooked in CITES NDF literature (Rosser & Haywood 2002), were critical in evaluating the potential for existing management to offset species risk, especially given the lack of data on management effectiveness. Our analysis of spatial overlaps between species observations and management areas helped us differentiate possible outcomes for the 2 species. Even where spatial distribution data are not available for particular species per se, they can commonly be cobbled together, as here for seahorses and for sharks in Costa Rica (Clarke et al. 2018). Species distribution can often be inferred from local knowledge (Thornton & Scheer 2012) and is relatively cheap to generate (Aylesworth et al. 2017). Such efforts matter because many current ocean management strategies are spatial (Chape et al. 2005; NOAA 2014). Overlaying spatial data on species distribution and management gets to the core of the NDF process—which essentially comes down to whether management is in place to mitigate risks to listed species (Foster & Vincent 2016).

The conditional NDF was a valuable tool for our focal seahorse species, given that management measures were in place but data on management effectiveness were lacking. Similar to the SMART management criteria (specific, measurable, assignable, realistic, time-related [Doran 1981]), conditional NDFs must have clearly defined provisions, actors and timelines (Foster & Vincent

2016). For *H. kuda,* our conditions would include the establishment of long-term monitoring to evaluate how populations are faring under the management regime. Such monitoring could be accomplished through regular port sampling by the Thai Department of Fisheries or monitoring of wild populations in management areas by the Thai Department of Marine and Coastal Resources, the agency responsible for marine national parks (Foster et al. 2014; Loh et al. 2014). However, the advice from the NDF framework for seahorses should have indicated the importance of funding to implement CITES Appendix II listings and how to meet such costs especially where they exceed the value of a resource.

In our guise as government agents, we could avoid an urge to fall into management inaction, common when data are lacking and next steps are unclear, by applying conservation triage procedures (Bottrill et al. 2008). Identifying actions for each species that responded to the most pressing, tractable, and already prescribed management commitments enabled us to maintain momentum with the NDF process for seahorses, as for any species requiring conservation action (Mundy-Taylor et al. 2014). For example, even given uncertainty about management implementation and effectiveness, the greatest risk for both seahorse species clearly came from certain fishing gears. As a matter of domestic policy, increasing enforcement efforts to ensure these gears are constrained in time and space would be important in reducing pressure on wild populations of seahorses and other species. Increased enforcement of these gears is a pragmatic goal because it is a priority under the new Fisheries Management Plan and so would deploy available resources effectively (Bottrill et al. 2008). As ever with most species, improved implementation of existing national laws would offer seahorses some relief from fisheries and habitat related pressures.

Once an NDF has been made, a country must decide how to respond to that positive, conditional or negative finding, balancing conservation with fisheries and trade goals (Salomon et al. 2011; Guggisberg 2016). After making a negative NDF CITES countries have often suspended exports (through bans or zero quotas) to avoid violating their duty under the Convention (Foster et al. 2019). However, the real issue from a conservation perspective is what a country does after it suspends trade. Do management, data collection, and monitoring relevant to export regulation improve in a timely fashion or is no further attention paid to the species? If the latter, then the intent of CITES is undermined, even where the legality is not. In the case of species obtained in bycatch, like seahorses, ongoing capture in nonselective gear may mean that export suspensions do very little to help a country move toward eventual sustainable exports. Further complicating matters, suspensions often drive trade underground rather than stopping it (Foster et al. 2019). That said, Thailand responded to the RST process—and the country's limited progress on recommendations—by announcing just such a suspension of exports for all seahorse species on 1 January 2016, even in the face of continued heavy bottom trawling and associated seahorse bycatch (CITES 2016).

The policy and management path to sustainability involves finding creative solutions that move societies, spaces, and species toward sustainable management (Meffe & Viederman 1995). Rarely do conservationists place themselves in the role of policy maker or government actors tasked with implementing policy changes. Our attempt in this direction confirmed the importance of moving forward despite imperfect data, in a documented and justified way that allows for future adaptive management (Meffe & Viederman 1995). Most conservation studies inevitably call for more data (Hamann et al. 2010; Young & Van Aarde 2011) in a failed quest for perfect advice (Johannes 1998). Yet government does not have the luxury of waiting until such an unlikely scenario emerges and must plunge forward with imperfect knowledge. It is only when conservationists tackle implementation that we realize taking a dose of our own medicine poses real challenges. Greater respect for these challenges, meaningful consultation with managers, and a pause for reflection before making recommendations might go a long way toward bridging the gap between science and policy.

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Supporting Information

Data sets used to evaluate pressures and risk on 2 seahorse species (Appendix S1), risk assessment criteria (Appendix S2), potential management responses (Appendix S3), and data sets available to evaluate management measures in Thailand (Appendix S4) methods and data sets used to identify spatial overlap of management measures and seahorses (Appendix S5), maps from spatial overlap analysis (Appendix S7), and evaluation of data, risk, management, enforcement, and effectiveness for H. trimaculatus (Appendix S6) and H. kuda (Appendix S8) are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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A practical approach to meeting national obligations for sustainable trade under CITES

T. Vaidyanathan, S.J. Foster and A.C.J. Vincent

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Email: s.foster@oceans.ubc.ca

This working paper is made available by the Institute for the Oceans and Fisheries, University of British Columbia, 2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada

A practical approach to meeting national obligations for sustainable trade under CITES

T. Vaidyanathan, S.J. Foster and A.C.J. Vincent

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

Contact: s.foster@oceans.ubc.ca

Abstract

Reconciling conservation and resource use requires adaptive management. The Convention on International Trade of Endangered Species (CITES) is a key tool in species conservation, regulating international trade for a list of species (Appendix II) that are or may become threatened by trade. To export such species, CITES member countries are required to evaluate if their exports are damaging wild populations (dubbed making a non-detriment finding or NDF). When countries find this challenge too great, they often default to banning international trade, thus imposing economic costs on stakeholders and/or driving the trade underground where it is more difficult to control. What, then, are the easiest ways for countries to make NDFs? We propose a simplified spatial approach to making NDFs using the case study of India, which has banned catch and trade of seahorses (*Hippocampus* spp.), but where rampant illegal trade continues. Our approach involves mapping the answers to four questions: (1) where are the species found?; and then, for those areas, (2) what pressures do the species face?; (3) what measures are in place to manage the pressures?; and (4) how well are the measures working? Information came from fishers' knowledge and published literature. Overall, reported seahorse presence was greatest in the southern Palk Bay region. This region theoretically offered protection to seahorses through a 3 nm bottom trawl exclusion zone and a 60 day closed season. Implementation was problematic. Both bottom trawl and dragnet fishers reported respecting the closed season but three-quarters of bottom trawl fishers reportedly catching seahorses in the trawl exclusion zone. Our conservation assessment identified the opportunity to better implement existing management measures as well as the need for further management action (that would do more than simply banning capture). This pragmatic geographic analysis provides managers in India with a tractable route towards regulating exports at sustainable levels. Our assessment approach can be deployed broadly in assessing sustainability of exploitation and provides an alternative to the current futile bans.

1. Introduction

When governments struggle to reconcile species conservation and resource use, they may default to bans on exploitation and/or or trade, but such bans may not achieve the conservation gains that were intended. Bans may take many forms: i) the creation of fully protected areas (e.g., Lubchenco & Grorud-Colvert, 2015); ii) precluding certain extractive activities such as hunting and logging (e.g., Blackie, 2019); iii) preventing any harmful methods of extraction (e.g., McConnaughey et al., 2020); or iv) protecting certain threatened species even while allowing more extensive exploitative activities (e.g., Collins et al., 2020). Though bans may appear to be a pragmatic approach to addressing problems associated with species population declines, rarely is it so straightforward (Moyle, 2003). Bans on extraction and/or trade are often met with resistance where they result in a loss of revenue to local communities and/or reduced revenue for conservation (e.g., Broad et al., 2003; Lindsey, 2010; Mbaiwa, 2018). Bans can also provoke or strengthen underground markets, where increased prices further incentivize exploitation and trade in spite of the prohibitions (Abensperg-Traun, 2009; Lemieux & Clarke, 2009). Such underground markets are more difficult to monitor and regulate than legal trade (Martin, 2000), exacerbating sustainability challenges rather than addressing them.

The Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES) is a key instrument used to reconcile conservation and resource use (www.cites.org). CITES aims to ensure that international trade in specimens of animals and plants does not threaten the species' survival in the wild by providing a framework that directs all member States (Parties, 184 at the time of writing; CITES, 2022a). International trade for commercial purposes is banned for species listed on Appendix I, whereas it must be regulated to ensure sustainability and legality for those on Appendix II. Parties wanting to export an Appendix II species must first provide evidence that such exports will not be detrimental to wild populations, called making a non-detriment finding (NDF; CITES, 2016). Making an NDF requires data on factors such as the magnitude of trade, the population status, pressures faced at the level of the species and on their habitats, and management possibilities (e.g., CITES, 2013; Foster & Vincent, 2016; Leaman & Oldfield, 2014; Mundy-Taylor et al., 2014; Rosser & Haywood, 2002). However, Parties often lack the resources, capacity, and information to undertake the detailed work required under most NDF framework protocols.

Parties that struggle to meet the CITES requirement for an NDF prior to allowing export sometimes choose to end international trade altogether, rather than trying to manage it for sustainability (Foster & Vincent, 2021). In a first set of cases, CITES Parties may legislate or declare stricter domestic measures than required by CITES (examples in Vincent et al., 2014). In a second set of cases, Parties that are asked to justify the scale and nature of their exports (in a CITES compliance process called the Review of Significant Trade – RST; CITES, 2022d) sometimes turn to bans as a way of deflecting scrutiny of their exports (e.g. Foster & Vincent, 2021). In a third set of countries, a Party's difficulties in meeting its obligations for defensible NDFs may lead CITES to impose an export ban as a consequence of the RST (called a suspension: e.g., Foster & Vincent, 2021). Although trade suspensions have sometimes been effective in improving the implementation of CITES listings (UNEP-WCMC, 2016), incomplete enforcement of such bans often leads to illegal trade and higher black-market prices (Abensperg-Traun, 2009). Compounding this is the reality that Parties that end export (whether through a zero quota, legislated ban, or temporary suspension) tend to do little else, feeling that they have met the provisions of CITES, and thus generally fail to address any illegal trade.

Seahorses (46 species of *Hippocampus*) provide a well-documented example of how ending exports may not translate into effective implementation of CITES. Seahorses were the first marine fishes to be included on Appendix II of CITES since its inception (Vincent et al., 2014), the first marine fish for which an NDF framework was created (Foster & Vincent, 2016), and the first to go through the RST (Foster & Vincent, 2021). Further capacity building has included the development of monitoring protocols, simplified identification guides, and the generation of information on seahorse distribution, fisheries, and trade in most key source countries, *inter alia* (as reviewed in CITES, 2018). Nonetheless, while the CITES listing for seahorses appears to have reduced any pressure of international trade for aquarium display (Foster et al., 2022) the much larger trade in dried seahorses continues to pose a significant threat to seahorse species, involving millions of smuggled seahorses (Foster et al., 2019; Foster & Vincent, 2021; Vincent et al., 2022). The RST for seahorses has ultimately resulted in export bans or suspensions in most countries that had historically exported the most dried seahorses (Foster & Vincent, 2021). The worry is that, although jurisdictions have declared an end to exports instead of making NDFs, most have not actively enforced their rules… and the result is vast illegal international trade (as reviewed in Vincent et al., 2022). For example, it was estimated that about 95% of dried seahorses in Hong Kong SAR in 2016-17 had been imported from source countries with export bans in place, indicating a widespread lack of enforcement (Foster et al., 2019).

As the seahorse example reveals, an important step toward sustainable trade under CITES will be to improve Parties' willingness to make NDFs that restrict exports usefully. This can be partly achieved by simplifying advice on how Parties might more easily balance export of animals (or plants) and the health of wild populations. We propose that governments could achieve adequate analysis of NDFs – helpful, even if not perfect – by mapping the answers to four questions: (1) where are the species found?; then, for those areas, (2) what pressures do the species face?; (3) what measures are in place to manage the pressures?; and (4) how well are the management measures working? (Figure 1). Core data on the first two sets of information – spatial distribution of species and pressures – can be generated relatively rapidly, cheaply, and with few technical challenges using local/traditional ecological knowledge (Berkes, 1993; Huntington, 2000). For the third and fourth sets of information, governments can draw on their own management protocols and experiences in time and space (Aylesworth et al., 2020; Mundy-Taylor et al., 2014). The resulting NDF evaluation, although imperfect, should enable Parties to make progress in assessing the status of wild populations under their regulatory regimes and to move towards adaptive management (Meffe & Viederman, 1995; Smith et al., 2011).

We used a case study in India for testing our concept of simplified NDFs, as a country with an export ban on seahorses that isn't working to support the species' conservation. India banned all exploitation and trade of seahorses in 2001, under Schedule I of its Wild Life Protection Act, 1972,[1] as a result of its involvement in the consultations that led to the CITES Appendix II listing for these fishes in 2002 (A.C.J. Vincent, personal communication). Nonetheless, the catch and trade of seahorses has continued virtually unabated (Vaidyanathan et al., 2021; Vinod et al., 2018). The take of seahorses, an estimated 13 million individuals per year (Vaidyanathan et al., 2021), is primarily landed as bycatch from non-selective gear such as bottom trawls and dragnets (modified wind powered shrimp trawls; Perry et al., 2010; Salin et al., 2005; Vaidyanathan et al., 2021; Vinod et al., 2018). A large proportion of the seahorse catch (30-90%) was reportedly still exported (Perry et al., 2010; Salin et al., 2005; Vaidyanathan et al., 2021). Fisher compliance with the ban on exploitation was low, partly because they were not involved in the decision-

[1] https://legislative.gov.in/sites/default/files/A1972-53_0.pdf

making process and questioned the legitimacy of the law, but mostly because the seahorses were caught incidentally during their other fishing activities (Vaidyanathan, 2021). The seahorses are no better off in spite of the ban – available data suggest a marked decline in catch per unit effort between 1999 and 2017 (Vaidyanathan & Vincent, 2021). As such, India is a perfect case study for exploring how a country might work toward making positive NDFs – and permitting ongoing trade – should they choose to consider adaptive management instead of an ineffective blanket ban.

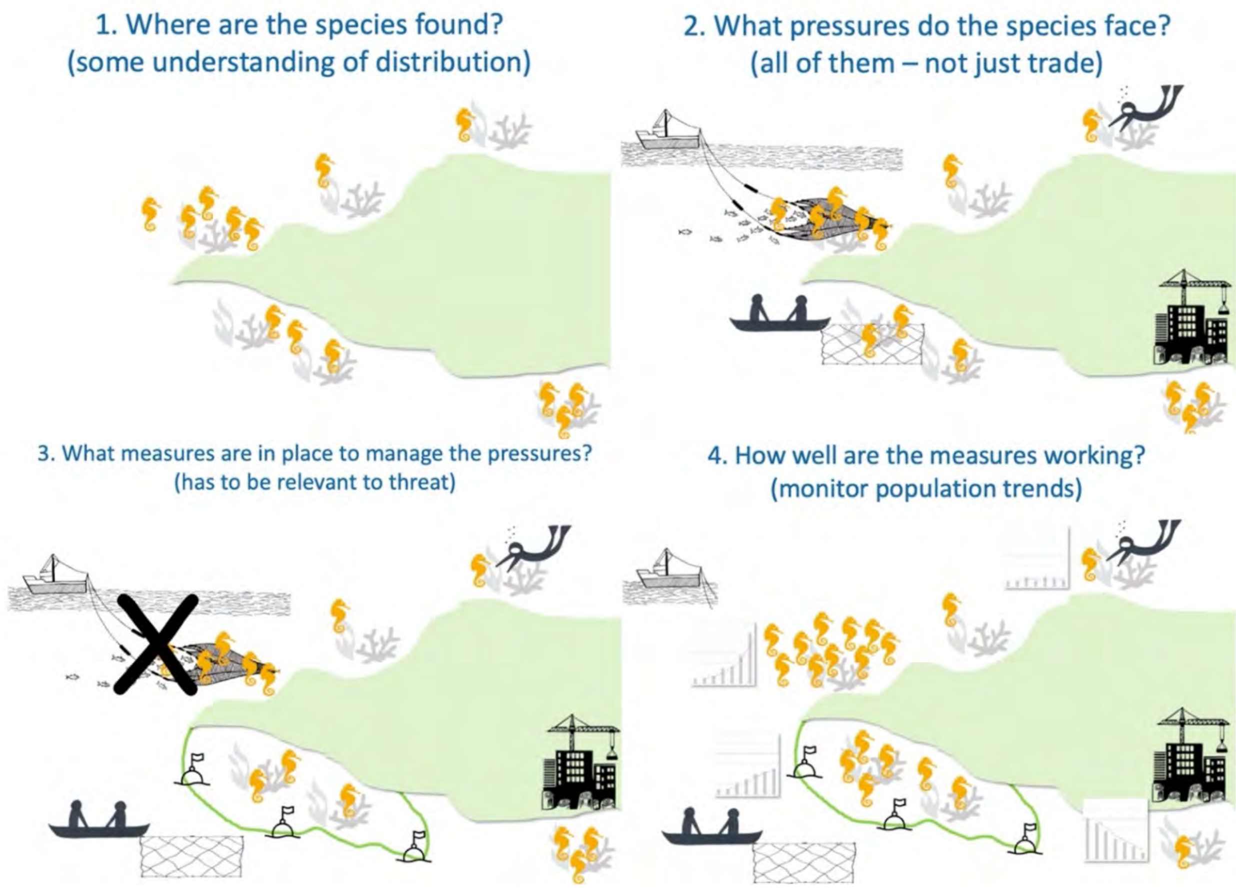

Figure 1. Pictorial depiction of the core questions of a simplified NDF. From left to right: (1) where are the species found? (distribution); then, for those areas, (2) what pressures do the species face? (e.g., fisheries, coastal development); (3) what measures are in place to manage the pressures? (e.g., fisheries regulations, MPAs); and (4) how well are the management measures working? (e.g. is there evidence of increased or decreased abundance). (R. Bestbier/Project Seahorse).

2. Methods

Using data generated from fisher interviews we conducted and from existing published literature, we probed the viability of our proposed four step mapping approach to making NDFs in India. First, we identified seahorse locations by generating distribution maps based on fishers reports of seahorse presence/absence in their catches, and then overlayed these maps with spatial information on seahorse habitats. Second, we identified threats to seahorses from fishing by generating a map of fishing effort using the active number of fishing hours per day by different boat types. Third, we overlaid the distribution of existing spatial management efforts. Finally, we evaluated whether existing management was sufficient to mitigate the pressures on the seahorses.

2.1 Study Area

Our research is anchored in an area of the southeastern state of Tamil Nadu called Ramanathapuram District (Figure 2), a hotspot for illegal seahorse catch and trade (e.g., Murugan et al., 2011; Perry et al., 2010; Salin et al., 2005; Vaidyanathan et al., 2021; Vinod et al., 2018). Around 10 million seahorses were caught annually between 2015 and 2017 from Tamil Nadu alone (Vaidyanathan et al., 2021; Vinod et al., 2018). Tracking this illegal trade is challenging because of the organized and underground operations of the smuggling activities, but exports were estimated to be in the range of ~3.4 to 9.2 million individuals (Vaidyanathan et al., 2021).

2.2 Data sources

Information on seahorses for the Ramanathapuram District came from fishers' knowledge and published literature. We used information at the genus level (*Hippocampus* spp.) because i) that was the level at which fishers' knowledge was expressed, and ii) all species of *Hippocampus* are protected under India's WLPA and listed in CITES Appendix II.

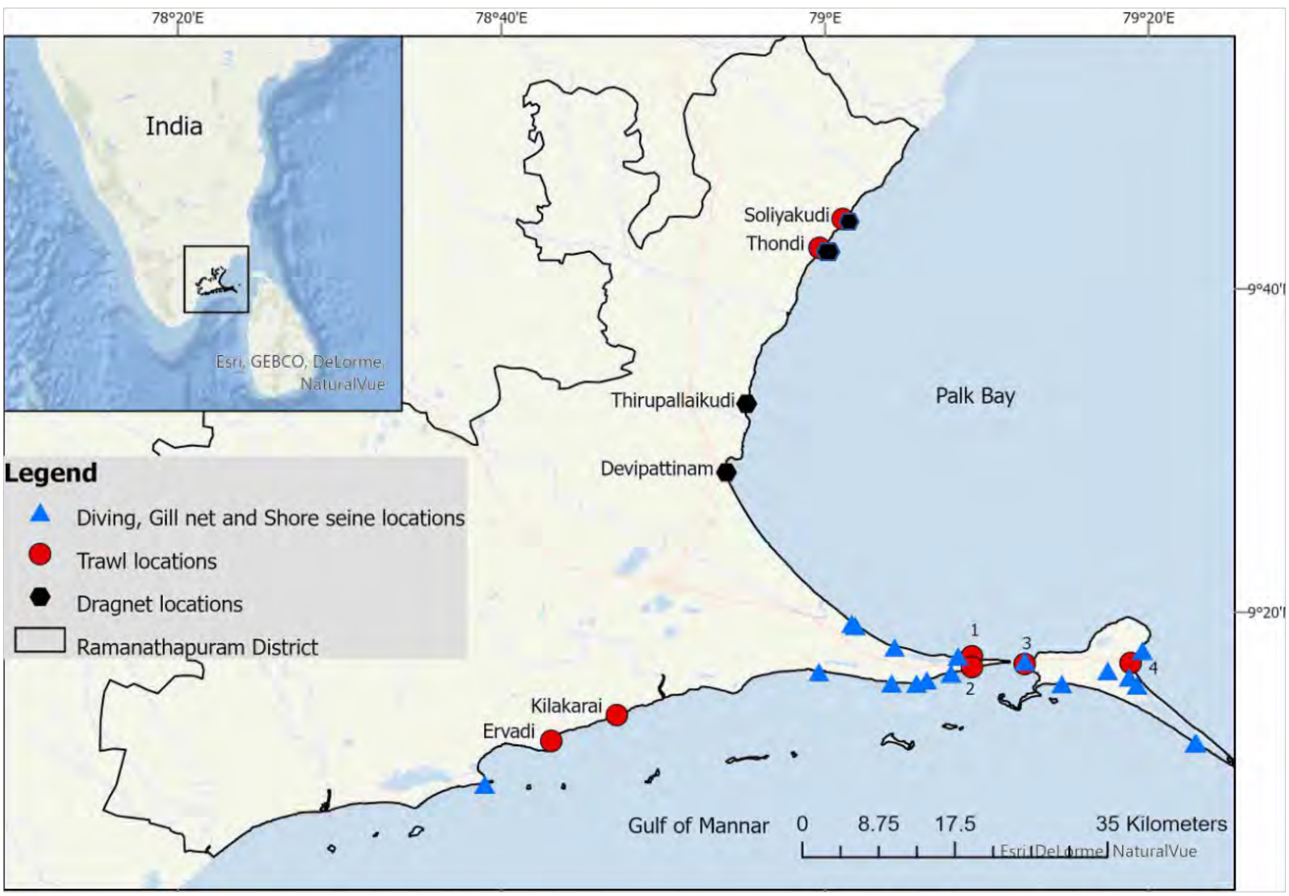

Figure 2. Locations where fisher interviews were carried out between 2015-2017 at coastal villages and fish landing centres of the Ramanathapuram District. Major bottom trawl landing centres and drag net landing sites are labeled. Bottom trawl centres along the Rameswaram Peninsula have been numbered (from west to east): 1. Mandapam North; 2. Mandapam South; 3. Pamban; 4. Rameswaram Fishing Harbour. Note that although Thondi is a major drag net centre, the few drag-netters interviewed in the region did not provide information about locations in which they caught seahorses.

2.2.1 Fishers' knowledge

We obtained fisher knowledge for this study from interviews conducted along the Tamil Nadu coast to understand the extent of seahorse occurrence, fisheries and trade in the state after the ban. Our sampling methodology involved maximizing geographical coverage as well as respondents interviewed to increase the reliability of our estimates. To obtain fishers' knowledge, we conducted semi-structured interviews at 56 locations, including fish landing centres and fishing villages, eight of which were bottom trawl landing centres, along the Ramanathapuram District coast (Figure 2). We obtained information on seahorse species distribution and fishing pressure from 118 interviews conducted between 2015 and 2017 across 29 locations in the district. Fishers from 19 locations reported primarily fishing in the shallow, seagrass rich Palk Bay region of the state, and fishers from 15 locations reported fishing along the highly biodiverse Gulf of Mannar region (Figure 2). Note that some fishers in the Ramanathapuram peninsula reported fishing in both the Gulf of Mannar and Palk Bay regions. Over half of our interview data came from bottom trawl fishers (n=69 interviews) because our second field season, beginning in 2016, focused on the pressures of bottom trawl fisheries in Tamil Nadu.

We chose interview locations based on where seahorses could be found according to published literature (Marichamy et al., 1993; Murugan et al., 2008; Perry et al., 2010), information from local colleagues, and from snowball sampling (in which one respondent indicated other potential locations). At each location, we spoke with respondents recommended by local researchers and those we encountered haphazardly. We conducted our interviews with fishing crew, boat drivers and boat owners across five types of fishing methods: bottom trawls (n=69 interviews), gillnets (including trammel nets and bottom-set gillnets; n=20), dragnets (n=16), shore seines (n=12) and diving (n=4). Gillnets, dragnets, shore seines and diving are considered traditional gears in India because they are non-motorized; we retained this classification in our analysis. However, we sometimes separated dragnets from other traditional gear in our analysis, as they are one of the most significant fishing pressures on seahorses in this district. We conducted all interviews at landing sites, such that multiple fishers from the same boat often participated in a single interview. In some landing sites, fishers from different boats took part in the mapping process, allowing for cross-validation amongst fishers. All research received approval from the University of British Columbia's Human Behavioural Research Ethics Board (H12-02731 and H15-00160).

During interviews, we asked fishers to draw regions where they caught and did not catch seahorses on nautical charts. We sometimes guided mapping efforts by pointing out features on the map (e.g., islands). In interviews where fishers could not draw because of time constraints or other reasons, we used their narrated details to draw polygons for seahorse presence or absence (as per Zhang & Vincent, 2017). We asked fishers to identify locations in which they (a) fished and caught seahorses (i.e., presences) and (b) fished but did not catch seahorses (i.e., absences). We also asked about the depth, distance from shore and habitat in which they caught seahorses, and the fishing gear, fishing effort and fishing seasons. We mapped and analysed the data using ArcGIS, with coordinates measured by the WGS84 spatial referencing system.

2.2.2 Published literature

We extracted available data about seahorse distributions and fishing effort in the Ramanathapuram District from the published literature (Table 1). If specific localities were not documented, we included the entire study/sampling area described in the paper as part of the species' range. All species maps from the validated records in literature were digitized using ArcGIS Pro.

We attempted to obtain seahorse sightings (SS) from online biogeographic databases including the Global Biodiversity Information Faculty (GBIF, www.gbif.org), Oceanic Biodiversity Information System (OBIS, www.iobis.org), FishNet2 (www.fishnet2.net), FishBase (www.fishbase.org) and iSeahorse (www.iseahorse.org). However, the only records of seahorse sighting within the coordinates of our study sites were located on land and hence could not be used for this study.

The published literature was also a source for information on the spatial distribution of documented seahorse habitats, which include corals, dead corals and seagrass (Murugan et al., 2008; Vinod et al., 2018). We extracted seagrass occurrence data originally published by Geevarghese et al. (2018) that used Landsat 8 LI imagery to map seagrass distribution in the Palk Bay region (Geevarghese et al., 2018). For the Gulf of Mannar Marine National Park, we used habitat data (coral and dead coral with algae, dead corals and seagrass beds) from (Mathews et al., 2010), which used line intercept transect methods to map the habitats.

Table 1. Peer reviewed literature used in our study to map seahorse presence in the Ramanathapuram District of southern India.

Location	Objectives	Study
Multiple locations in the Palk Bay region	First estimate of extent of seahorse fisheries in the Palk Bay region	Marichamy et al., 1993
Palk Bay region	First look at seahorse trade after the 2001 exploitation ban	Lipton & Thangaraj, 2002
Thondi, Palk Bay	Estimates of the volumes of seahorses exported until the imposition of an exploitation ban	Salin et al., 2005
Mullimunai, Palk Bay	First reported occurrence of *H. mohnikei* from the Palk Bay region from bycatch	Thangaraj & Lipton, 2007
Multiple locations in both the Palk Bay and Gulf of Mannar region	Identification of seahorses and pipefishes, and estimation of their catches in fishing gear	Murugan et al., 2008
Three locations in the Gulf of Mannar	Estimation of seahorse catches from the Gulf of Mannar	Murugan et al., 2011
Multiple locations from Coromandel coast to Kanyakumari (Both Palk Bay and Gulf of Mannar)	Primarily for genetics from seahorse samples obtained from fishing boats	Lipton & Thangaraj, 2013
Multiple locations in the Palk Bay and Gulf of Mannar region	Estimation of seahorse catches in the Palk Bay and Gulf of Mannar region by non-selective fishing gear, and the impact of the seahorse fishing ban on fisher livelihoods	Vinod et al., 2018

2.3 Data analysis

2.3.1 Where are the species found? Seahorse locations based on fisher reports.

To create maps of seahorse distribution (occurrence), we used fisher reports on the presence or absence of seahorses from our interviews and published literature. We created presence/absence maps by overlaying individual fisher's maps showing where they caught (presence) or did not catch (absence) seahorses. We then calculated (i) the number of fishers reporting presence/absence of seahorses in a given location and (ii) the proportion of fishers reporting presence/absence of seahorses compared with the total number of fishers who reported fishing in either Palk Bay or the Gulf of Mannar. We used these two metrics to understand the extent of spatial agreement on seahorse presence among fishers. We only kept areas in the maps that included at least two observations by fishers reporting presences or absences (as per Zhang & Vincent, 2017).

We identified seahorse priority habitats by overlaying seahorse presence maps, generated from fisher reports, over our layers of natural/biogenic habitats (from 2.2.2) to estimate the proportion of seahorse presence in coral and seagrass bed habitats compared to these habitats' overall extent. Our estimates were done for each distinct habitat type, and also for the Palk Bay and Gulf of Mannar region separately.

2.3.2 What pressures do the species face? Pressure on seahorses from fishing.

To estimate the fishing pressures that seahorses faced, we mapped fishing effort for the fishing grounds in the district as measured by the duration that fishing gear was actively employed. We obtained information on the mean number of hauls in a fishing day and each haul's duration from our interviews. We then overlaid the effort data obtained from the individual fishers to obtain the cumulative number of hours all fishers we interviewed spent fishing in a day. For interviews where information on either the number or duration of hauls was missing, we filled the gap using either published literature (Table 1) or by using information from fishers using similar gear from the same location. However, in the case of the highly variable and diverse gillnet operations, if we could not obtain information from other fisher interviews in the same location, we ignored the data altogether.

2.3.3 What measures are in place to manage the pressures? Existing spatial management.

We considered three existing management measures: (i) The Gulf of Mannar Marine National Park – a 560 km^2 no-take marine protected area (MPA), forming the core of the Gulf of Mannar Biosphere Reserve (G.O. Ms. No. 962, Forests and Fisheries Department, September 1986; Government of Tamil Nadu, 1986; Melkani et al., 2006); (ii) India's trawl exclusion zone – a three nautical mile (3 nm) limit from the coastline where bottom trawlers are not allowed to operate, but traditional fishing gears including dragnetters are permitted (Government of Tamil Nadu, 1983); and (iii) a seasonal closure – a 60-day period from April to June, when a majority of the important fish species are believed to spawn, and during which bottom trawlers and dragnetters in the district are not allowed to operate (Government of Tamil Nadu, 2017, 2018; Kumaraguru et al., 2000).

2.3.4 How well are the management measures working? Analysing the implementation of existing management.

To address this dimension of our framework, we analysed spatial management violations in two ways: (1) total area that bottom trawlers reported seahorse catches within the trawl exclusion zone; and (2) total areas that fishers reported catches from the no-take MPA. To do this, we mapped the trawl exclusion zone and the MPA in ArcGIS Pro, and then executed a simple geospatial analysis to calculate the overlap (percent coverage) of these two management measures with our seahorse presence and habitat maps (from 2.3.1). For bottom trawlers, we had to analyze the protection offered by the 3 nm trawl exclusion zone and MPA together because of overlaps in the boundaries (overlap of ~158 km^2 or 9% of the total area protected).

To understand the effect of the closed season, we compared the overall area covered by traditional fishers (without dragnetters) throughout the year with the overall area that bottom trawlers and dragnetters reported operating in. We acknowledge limitations in our comparisons as we only compared the overall area fished by the different gears over the year and did not compare the effort among the gear types.

3. Results

Our proposed approach to assessing sustainability of exploitation depends on integrating four sets of data, on seahorse presence, seahorse habitats, pressures and management.

Overall, we observed both the greatest number of fishers reporting seahorse presences in their catches, and the greatest fishing effort, in southern Palk Bay, a region rich in seagrass habitats. Bottom trawls and dragnets put pressure on both the seahorses and their habitats, with fishing operations on large tracts (~90%) of critical seahorse habitats in this study. The entire district of Ramanathapuram is protected in principle by a 3 nm trawl exclusion zone, where bottom trawlers are prohibited but dragnetters may still operate, and a closed season for fishing for both bottom trawls and dragnets. The Gulf of Mannar also has one MPA. Throughout the district, bottom trawl and dragnet fishers reported respecting the closed season everywhere but bottom trawl fishers continued to catch seahorses in the trawl exclusion zone outside that closed period. As well, our analysis indicates large violations of the MPA, and continued catches of seahorses from this region. We now provide details on these general findings.

3.1 Where are the species found? Seahorse locations based on fisher reports.

Overall, our analysis showed that seahorses present in 68% of the portion of India's EEZ considered for this study (7746 of a total 11 357 km^2), and at least 88% of areas in which respondents stated they fished within the EEZ (7746 of 8807 km^2).

Our interviews with fishers along the Ramanathapuram coast indicated that more fishers reported the presence of seahorses in the southern Palk Bay region, extending from Devipattinam to Thondi (Figure 3). In the Gulf of Mannar, a greater number of fishers reported the presence of seahorses closer to the shore, near the southern portion of the Rameswaram Peninsula and along the northern section of the Gulf of Mannar (Figure 3). The distribution pattern of seahorse presence was similar whether maps were generated using the number of fishers reporting seahorse presence in their catches in that location (Figure 3) or using fisher presence data scaled by the number of fishers who reported fishing in either Palk Bay or Gulf of Mannar (Annex 1).

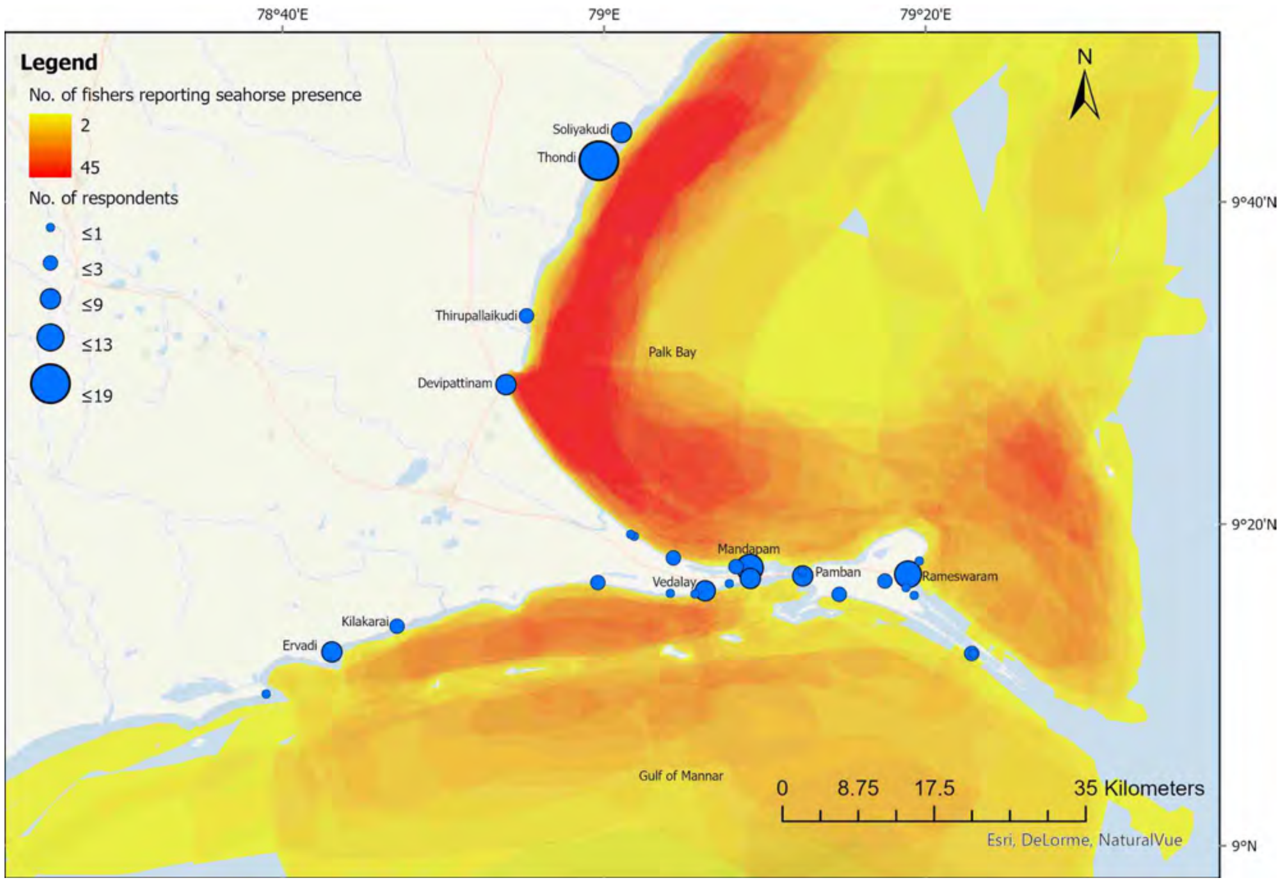

Figure 3. Map indicating seahorse presence across the Ramanathapuram District region as measured by the number of fishers that reported catching seahorses. The greatest number of fishers reported catching seahorses in the Palk Bay region (n=45). In the Gulf of Mannar, fishers reported catching most seahorses along the coast and towards the seaward side of the islands of the Gulf of Mannar Marine National Park.

Overall, only nine fishers reported locations where they did not report the presence of seahorses, with never more than three fishers per location (Annex 2). These locations occurred across 11 fishing areas compared with the 196 fishing grounds where fishers did report the presence of seahorses. Locations with absences may not be true absences, given that in some of these areas many other fishers reported presences (Figure 3 and Annex 2); the difference could potentially be attributed to the type of fishing gear being operated (e.g., passive gear like gillnets may be less likely to catch seahorses than active bottom trawlers).

When we separated fishers by gear type (bottom trawlers vs. traditional including dragnetters), we found that fishers still reported the greatest percentage of seahorses in the Palk Bay region (Annexes 3 and 4). The greatest percentage of bottom trawl fishers (~43%) and traditional fishers (~26%) reported presences of seahorses along the Devipattinam coast. Distinguishing among gear types, it appears that the absence of dragnetters and the smaller areas fished by other traditional fishers in the Gulf of Mannar region drove the observed patterns.

We found that fishers reported seahorse presence in ~ 90% (483 of 536 km^2) of seagrass and coral habitats in the Palk Bay and Gulf of Mannar regions (Figure 4). Fishers reported seahorse presence in 90% of seagrass bed (316 of 350 km²) and 92% of seagrass beds with sand (155 of 169 km²) in Palk Bay and Gulf of Mannar, respectively (Figure 4). However, fishers reported seahorses in only 70% (14 of 20 km²) of the area covered by coral (alive, dead, or covered with algae). This difference may be because corals were only found only in the Gulf of Mannar region (Figure 4), where fewer people reported fishing (n=49).

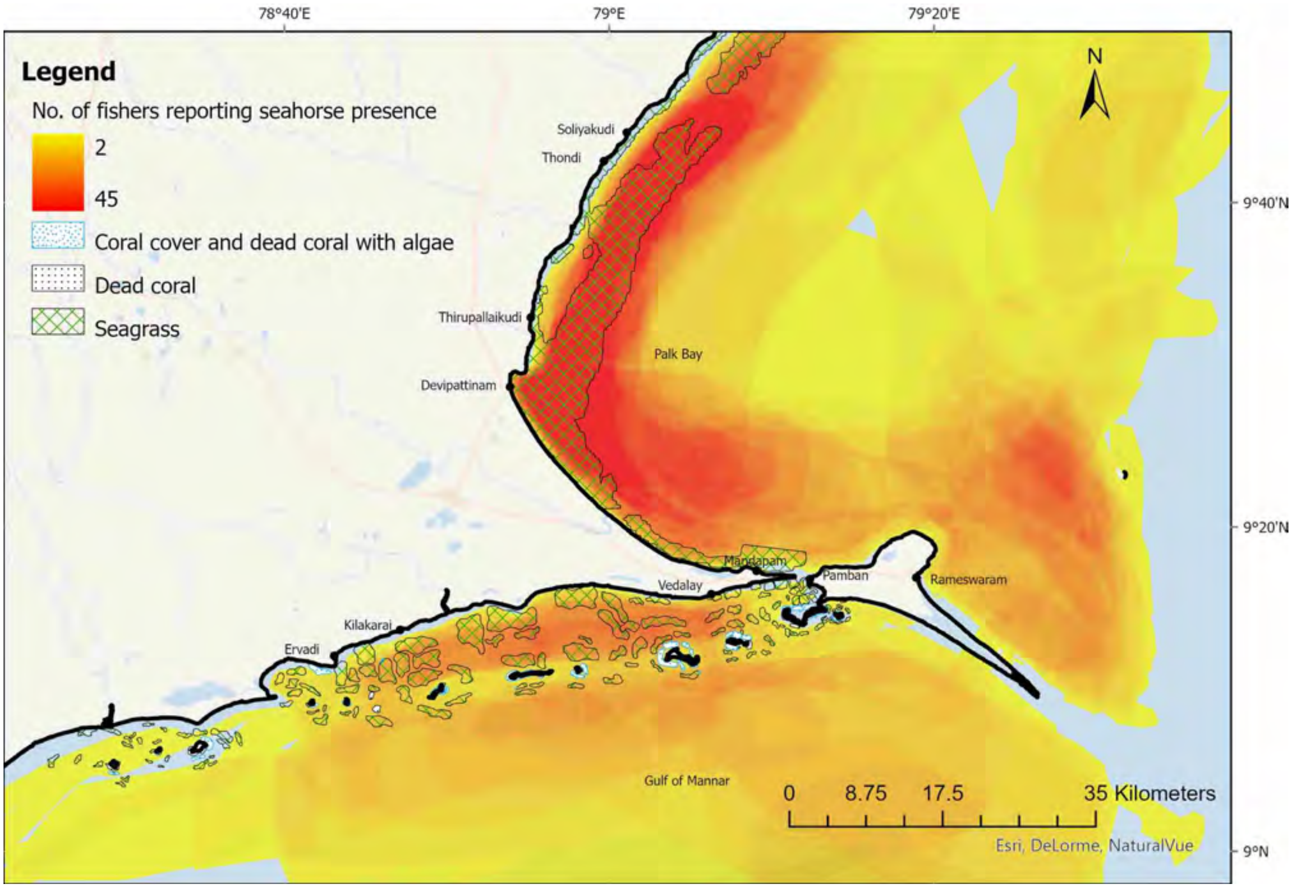

Figure 4. Map showing seahorse habitats along the Palk Bay and Gulf of Mannar regions of the Ramanathapuram District overlaid with maps of seahorse presence. Seagrass data for the Palk Bay region was extracted from Geeverghese et al. (2017) and for the Gulf of Mannar region from Mathews et al. (2010).

3.2 What pressures do the species face? Pressure on seahorses from fishing.

We found that the fishing pressure (measured by the cumulative hours spent actively fishing per day across all fishers) was greatest in the entire Palk Bay region, in shallow waters and near the coastline (Figure 5). Within this region, the greatest effort (197 combined active fishing hours per day) was reported off the coast of Devipattinam, primarily from non-selective bottom trawlers and dragnetters. We found a similar trend in effort when we removed traditional gear (other than dragnetters) from this analysis (Annex 5), probably because we had less information on these gears than active non-selective fishing gears.

In terms of seahorse habitats, altogether fishers reported operating in more than 94% of seagrass and coral reef habitats in Palk Bay and Gulf of Mannar (505 of 539 km²).

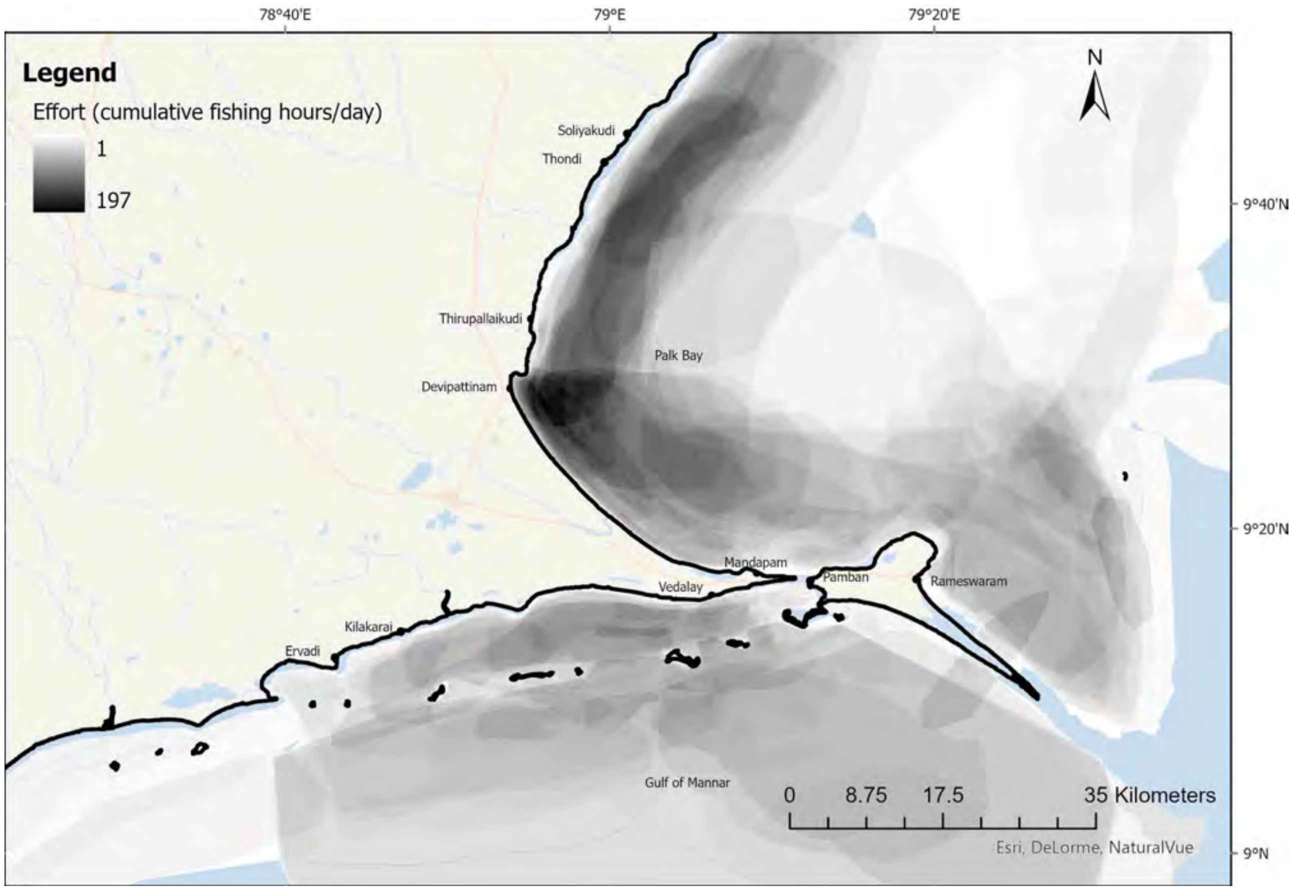

Figure 5. Pressures seahorses faced from fishing in the Ramanathapuram District, as measured by the collective duration of time that fishers of all gear types actively deployed their nets (hours per day). Fishing pressure was greatest closest to the shore along the entire extent of the Palk Bay region.

3.3 What measures are in place to manage the pressures? Existing spatial management.

We found that around 1727 km² of our study area (15% of the total 11 357 km² of ocean within India's EEZ considered for this study) was covered by either the no-take MPA (404 km² or 3.5% of ocean within India's EEZ considered for this study) or the trawl exclusion zone (1481 km² or 13% of study area falling with India's EEZ), amounting to ~ 81% of seagrass and coral habitats (435 of 539 km²; Figure 6). However, only ~13% of these habitats lay within the MPA and were, in theory, completely protected from fishing pressure (72 of 539 km²).

3.4 How well is the management working? Analyzing the implementation of existing management.

Overlaying seahorse presence maps with the MPA boundaries and the 3 nm trawl exclusion zone revealed that fishers reported catching seahorse in 85% of the area covered by both the no-take MPA and the trawl exclusion zone (around 1476 of 1727 km²; Figure 6). We further found that fishers reported catching seahorses in 92% of the area covered by the no-take MPA alone (370 of 404 km²).

When we considered fishing pressure from bottom trawls alone, we found that bottom trawl fishers reported fishing in about ~90% of the protected areas (1548 of 1727 km^2) and reported seahorse presence in their catch in about 90% of the area they fished (~1388 of 1548 km^2) in these supposedly protected areas. When we assessed the violations separately, we discovered that bottom trawlers reported fishing in 98% of the MPA (396 of 404 km^2) and reported catching seahorses in 91% of the MPA (366 of 404 km^2). They further reported operating in 88% of the trawl exclusion zone (1303 of 1481 km^2) and reported catching seahorses in 78% of this area (1149 of 1481 km^2). Indeed, we found that fishing pressure from bottom trawls was greatest within the trawl exclusions zone of the Palk Bay region off the coast of Devipattinam (Figure 7). Our findings further indicate that bottom trawl fishers operated on almost all the seagrass and coral habitat that was theoretically protected (91%, 394 of 435 km^2).

In contrast, traditional fishers, including dragnetters, reported operating in only about 44%, and seahorse presence in 39%, of the no-take MPA (178 and 158 of 404 km^2, respectively); that said, we interviewed fewer traditional fishers (n=19) in the Gulf of Mannar region.

Overall, we found that ~18% of areas with reported seahorse catches within India's EEZ were violations of existing management measures (1392 of 7746 km^2). Seahorse conservation was further undermined by illegal, unreported and unregulated (IUU) fishing *outside* India's EEZ. About 16% of the total area where respondents reported fishing lay within Sri Lankan waters in which bottom trawling is prohibited (~1627 of 10 434 km^2; Parliament of the Democratic Socialist Republic of Sri Lanka, 2017). Such Sri Lankan waters comprised about 11% of the entire area where fishers reported catching seahorses (~ 946 of 8692 km^2).

The only fisheries management measure that may have been effective for seahorse conservation was the 60-day annual fishing ban on the use of bottom trawls and dragnets, both significant pressures, which is highly enforced. During the ban, the remaining fishers use more selective and/or less damaging methods such as passive fishing gear (gillnets), targeted active fishing methods (diving), or non-selective gear more constrained in its extent of operation (shore seines). Such traditional fishers also reported operating in only 19% of the area where bottom trawl and dragnetters fished within India's waters through the year (1544 of 7936 km^2). As such, the temporal closure should effectively eliminate a great deal of the fishing pressure where seahorses live for two months of the year.

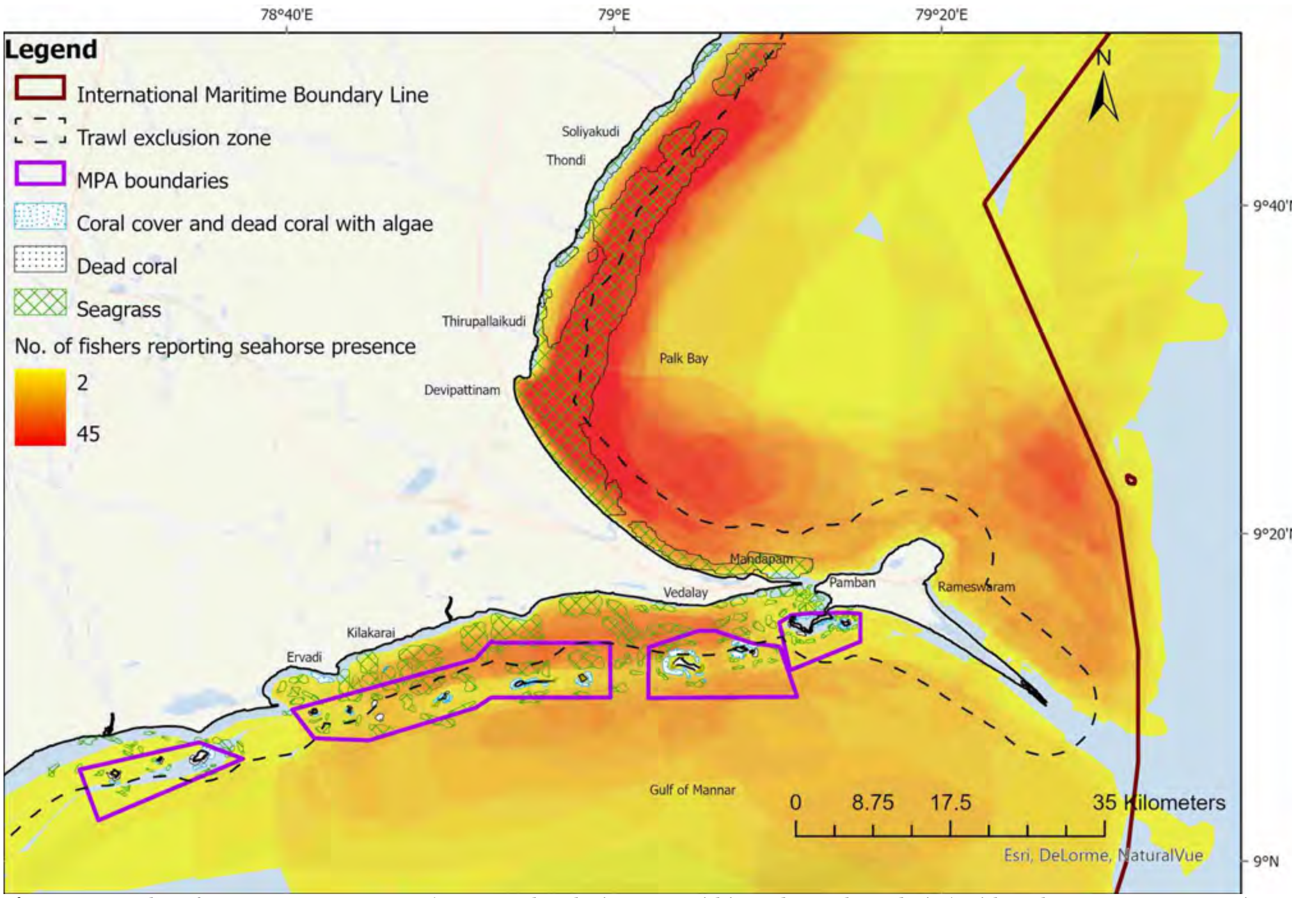

Figure 6. Overlay of management measures (3 nm trawl exclusion zone within and MPA boundaries) with seahorse presence maps in the Ramanathapuram District. For temporal closures, during the 60-day ban, both bottom trawlers and dragnetters are prohibited from operating for an extent ranging from the coastline to the international maritime boundary line.

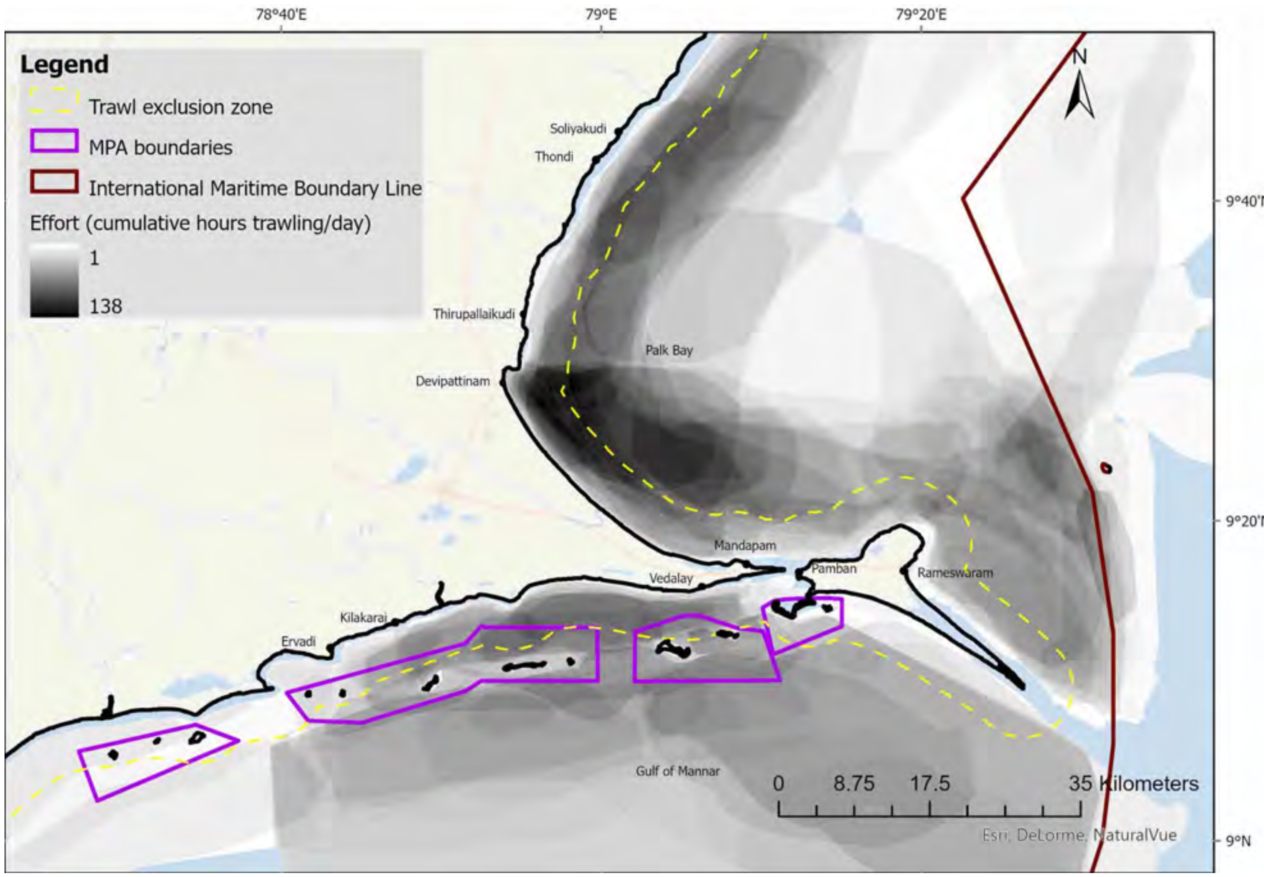

Figure 7. Pressures faced by seahorses from bottom trawlers, as measured by collective duration that fishers employed their nets while fishing (hours per day) in the Ramanathapuram District. Fishing pressure was found to be greatest closest to the shore along the entire extent of the Palk Bay region, and within regions where bottom trawlers should not have been operating.

4. Discussion

Our simple four step process proves helpful in supporting a pragmatic analysis of the status of wild seahorse populations in support of evaluating probable impacts of exploitation and export trade. While it is imprecise in details, the process produces an adequate indication of the well-being of wild populations – as is needed for making CITES NDFs. Overlaying spatial data of animal or plant locations with threats and existing management addresses the core question of sustainable exploitation – and most certainly the core question of an NDF – as to whether management is sufficient to avoid detrimental effects on wild populations (Foster & Vincent, 2016). The important point to remember under CITES is that exports need not be the primary threat; whatever their relative role among pressures on wild populations, exports must be constrained yet further if they are detrimental to those populations. Our intention is for managers and policy makers to use such broad analyses as starting points, and then to refine layers of data, reduce threats and enhance implementation. Such an approach, when married to stakeholder engagement in an explicitly experimental framework, constitutes adaptive management, a paradigm that is increasingly advocated in both conservation and resource exploitation. In conservation, as in so much else, the perfect is the enemy of the good.

The pragmatic approach we suggest here provides a first and useful approximation of where – and indeed how – managers might improve the status of wild populations. In the case of seahorses in the Ramanathapuram District of southern India, we found notable levels of concern. Fishers reported seahorse presence more frequently close to the shore and in shallower waters, commensurate with where their critical seahorse habitats are found. Given that our observations on seahorse presence were based on fisher catch, fishers are clearly operating extensively in these areas. In addition, we found that seahorse habitats also faced great stress, with destructive fishing occurring on large tracts (~90%) of critical seahorse habitats such as corals (dead and live) and seagrasses. Finally, we calculated that about 18% of the area where fishers reported catching seahorses was ostensibly "protected", but that fishers clearly operated within the no-take marine protected area and used bottom trawls in areas that had banned the gear. We also note insufficient management of dragnet fishing, a key pressure on seahorses in Palk Bay. Though deployed by traditional fishers, dragnets are destructive because their target of juvenile shrimp leads them to operate directly through seagrass beds and thus also to catch seahorses and numerous other non-target species (Sampson Manickam et al., 1987).

Our conservation assessment identified the opportunity to better implement existing management measures as well as the need for further management action (that would do more than simply banning capture). Once we consider all four steps of our analysis together, it not surprising that fishers reported seahorse populations in the Ramanathapuram region (and surrounding districts) had declined over the 20 years since the ban was implemented (Vaidyanathan & Vincent, 2021; Vinod et al., 2018). Ideally, the question "*how well is the management working"* would be answered with data from long term monitoring of wild populations – but India joins most source countries in lacking any such programs for seahorses (CITES, 2022b, 2022c). However, evidence of wide spread violations of existing management combined with fisher reported population declines suggest the answer to this critical question is "no". Authorities in India need to enforce and enhance existing management measures such as preventing the operation of bottom trawls within the trawl exclusion zone, providing official demarcation of the MPA boundary, and actively preventing all fishing within the MPA. They also need to prevent Indian bottom trawlers from actively fishing in Sri Lankan waters. In the case of dragnets, the fishing villages are cohesive enough that community based MPAs may be a possible means of reconciling fisheries with conservation. Such measures would alleviate some of the pressure faced not just by seahorses and numerous other species obtained as bycatch, but also on their habitats and the other species they support (e.g. seagrass and dugong; Anand et al., 2015). Moreover, such management would do rather more for seahorses (and other species) than the current national approach of banning their capture (and subsequent export)… by a wholly nonselective gear. One encouraging step for seahorse and marine conservation in this region lies in the recent formation of an exclusive agency to enforce regulations and prevent illegal fishing (Government of Tamil Nadu, 2020).

As well as highlighting the need for more management action, our approach to collecting the data had benefits in generating dialogue that is needed to improve such management change. Deployment of local knowledge has been strongly advocated, especially in the case of co- management (Grafton & Silva-Echenique, 1997; Smith, 1995), with the contribution of data by fishers helping increase the legitimacy of management regimes in the long-run (Neis et al., 1999). Through our interviews, we initiated the conversation with fishers about their thoughts on the ban, what worked, what did not, and ways forward for seahorse conservation (Vaidyanathan et al., 2021). Communities often possess a wealth of knowledge about management structures that may be effective within their belief systems, on practical approaches on improving compliance, and about fishing methods that may work well (effective/conservative) in a local context (Charles, 2001). During our interviews, we found that fishers largely agreed that non-selective fishing gears were particularly damaging and probably caused the decline in seahorse populations. They also noted that implementation of existing rules such as enforcing the trawl exclusion zone was essential for conservation. Other studies from the region have also reported that fishers advocated the use of gear limitation (reducing bottom trawl numbers), no-take zones and enforcing prohibitions on banned gear were key to seahorse conservation (Vinod et al., 2018). Management authorities will do well to focus on this commonality of views about necessary steps for marine management and conservation, and work with stakeholders to create the conditions for collective action on such measures.

Our "good-enough" approach should be broadly useful for other countries that have decided to end exports to meet their obligations to CITES, rather than creating the NDFs that depend on knowing the species and its status (Foster et al., 2019; Vincent & Foster, 2017). Many key exporting countries decided to end seahorse exports as a means of avoiding the Review of Significant Trade (RST) but are now confronting significant illegal trade in dried specimens, supplied in large part by nonselective fishing gears (Foster et al., 2019; Foster & Vincent, 2021). Such Parties must do more to meet their obligations under the Convention to seahorses. To constrain smuggling, Parties will need to be vigilant and effective in enforcement along supply chains and at national borders. Such enforcement will not be easy. Many factors contribute to the difficulty of enforcement: financial benefits to participants commonly far outweigh the low risks of being caught fishing or trading illegally; dried seahorses can be kept and stockpiled for long periods; dried seahorses can be hidden in shipments, often mixed with other wildlife; and global demand for dried seahorses remains high (CITES, 2022c). On the other hand, supporting Parties to make meaningful NDFs for seahorses would refocus their attention on doing the management that is needed to reduce pressures on wild populations, and that is required by CITES. Such NDFs might be somewhat tentative at first but could be strengthened in an adaptive management approach as information improves through monitoring.

Our pragmatic mapping approach to conservation assessment could be used by a variety of resource managers in assessing and planning for conservation, including when trying to make NDFs for CITES. Our simplified approach would be particularly useful for countries in the developing world, which are often daunted by the process of making NDFs because of the limited understanding of CITES, anxiety about capacity and resources, and lack of baseline data (Abensperg-Traun et al., 2011; De Angelis, 2012). While spatial approaches have historically been neglected in work on NDFs (Rosser, 2008; Rosser & Haywood, 2002; Smith et al., 2011; Thorson & Wold, 2010) their applicability in making NDFs is now being recognised (Aylesworth et al., 2020). Spatial data may be derived from local knowledge (Thornton & Scheer, 2012), can be generated relatively quickly and cheaply (Aylesworth et al., 2017), can be deployed with limited technical training, and is central to many management measures. In proposing this qualitative mapping approach to reconciling conservation and resource management, we follow a practical path that has also been taken, although with some controversy, for establishment of MPAs and terrestrial reserves (e.g., Grantham et al., 2009; Hansen et al., 2011), one where ad hoc or pragmatic action is more imperative than systematic or ideal analyses. Although we used ArcGIS for our analysis, a much simpler approach – such as sketching answers to the four questions on a map – would have largely reached the same conclusions.

Our pragmatic stakeholder-oriented approach has real general value for managing fisheries and other exploitation for long-term sustainability, well beyond its utility in making CITES NDFs. Using spatial data generated from local fisher knowledge and published literature we were able to rapidly evaluate the distribution and key threats, and therefore infer the effectiveness of existing management measures, despite large uncertainties and imperfect data. We find that in data-limited situations, rather than feeling stalled by inadequate information, countries would do well to make decisions based on existing and imperfect data while building on such knowledge for adaptive management (Aylesworth et al., 2020; Johannes, 1998; Meffe & Viederman, 1995; Smith et al., 2011). In fact, adaptive management is increasingly recommended as the best way forward for reconciling conservation with resource management, in a whole host of scenarios (Smith et al., 2011).

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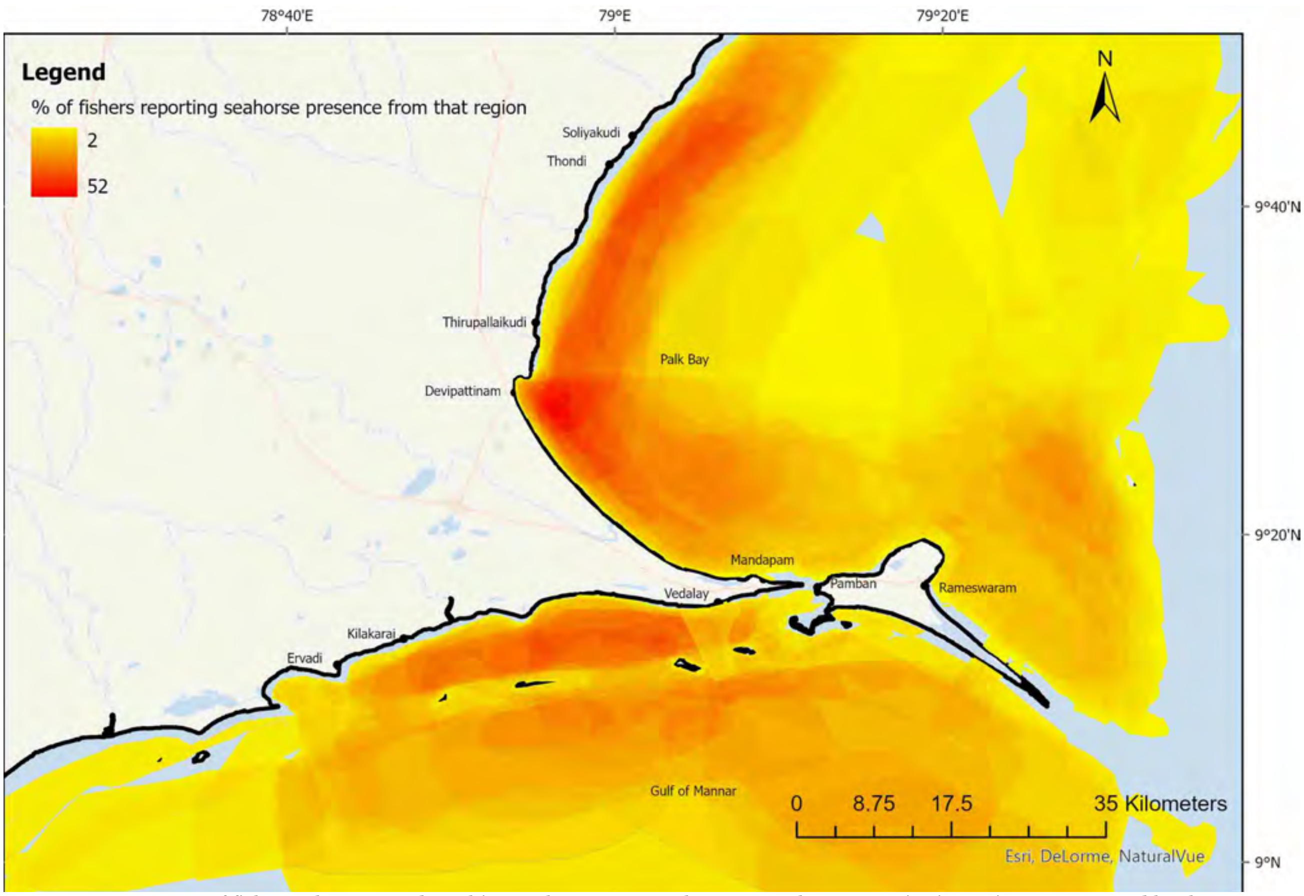
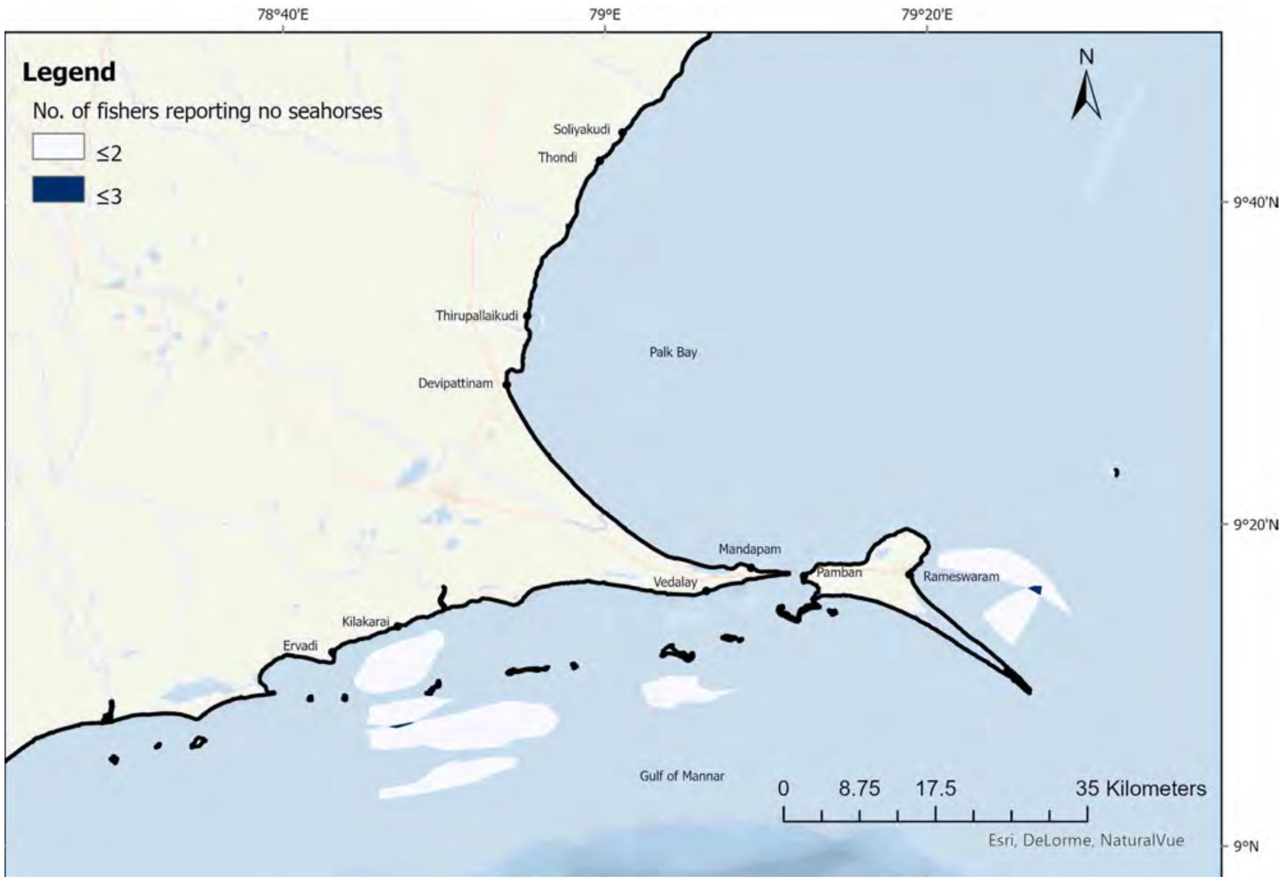
Supporting Information

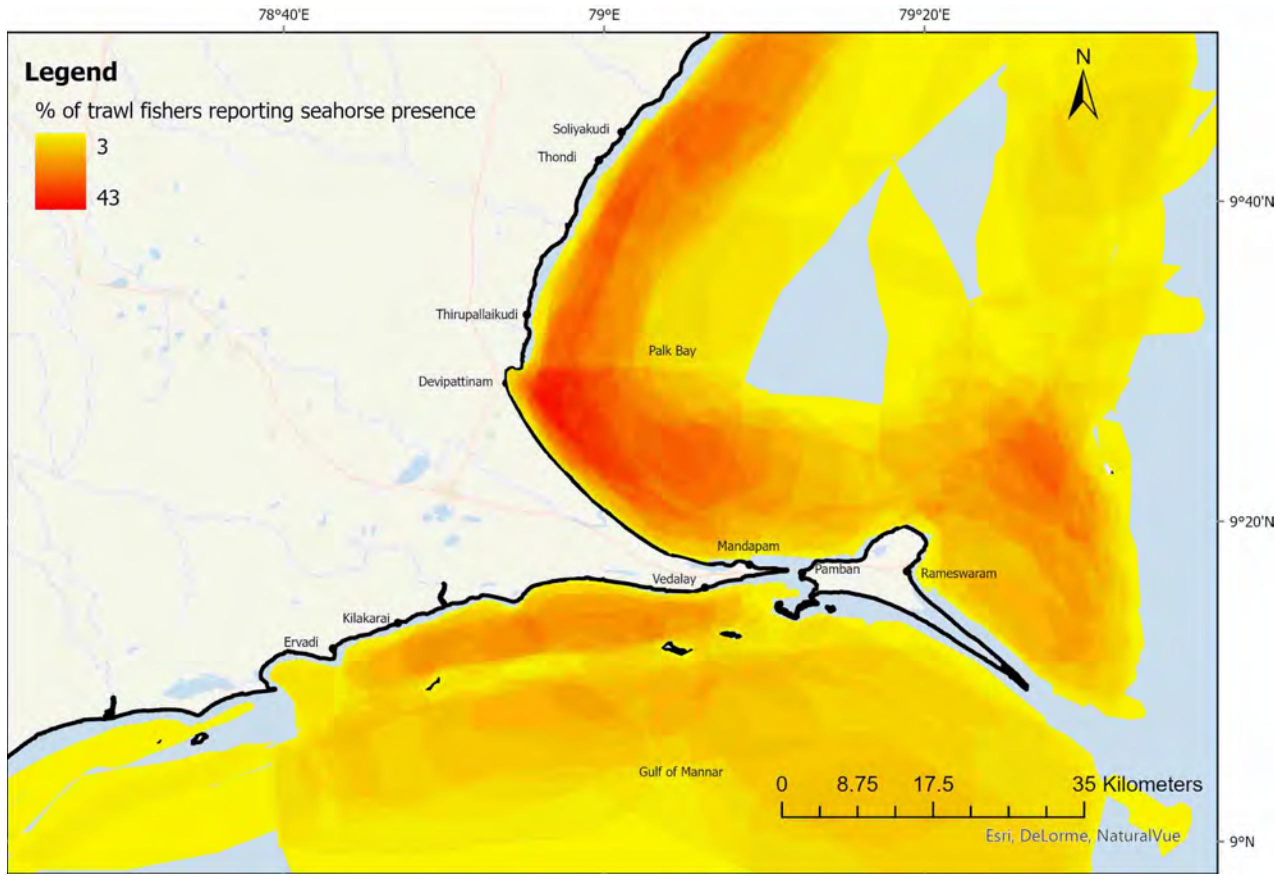
Maps using fisher presence data scaled by the number of fishers who reported fishing in either Palk Bay or Gulf of Mannar (Annex 1), places where fishers reported not catching seahorses (Annex 2), percentage of bottom trawl fishers reporting seahorse presence (Annex 3), percentage of traditional fishers (Annex 4) and pressures faced by seahorses from dragnetters and bottom trawlers (Annex 5).



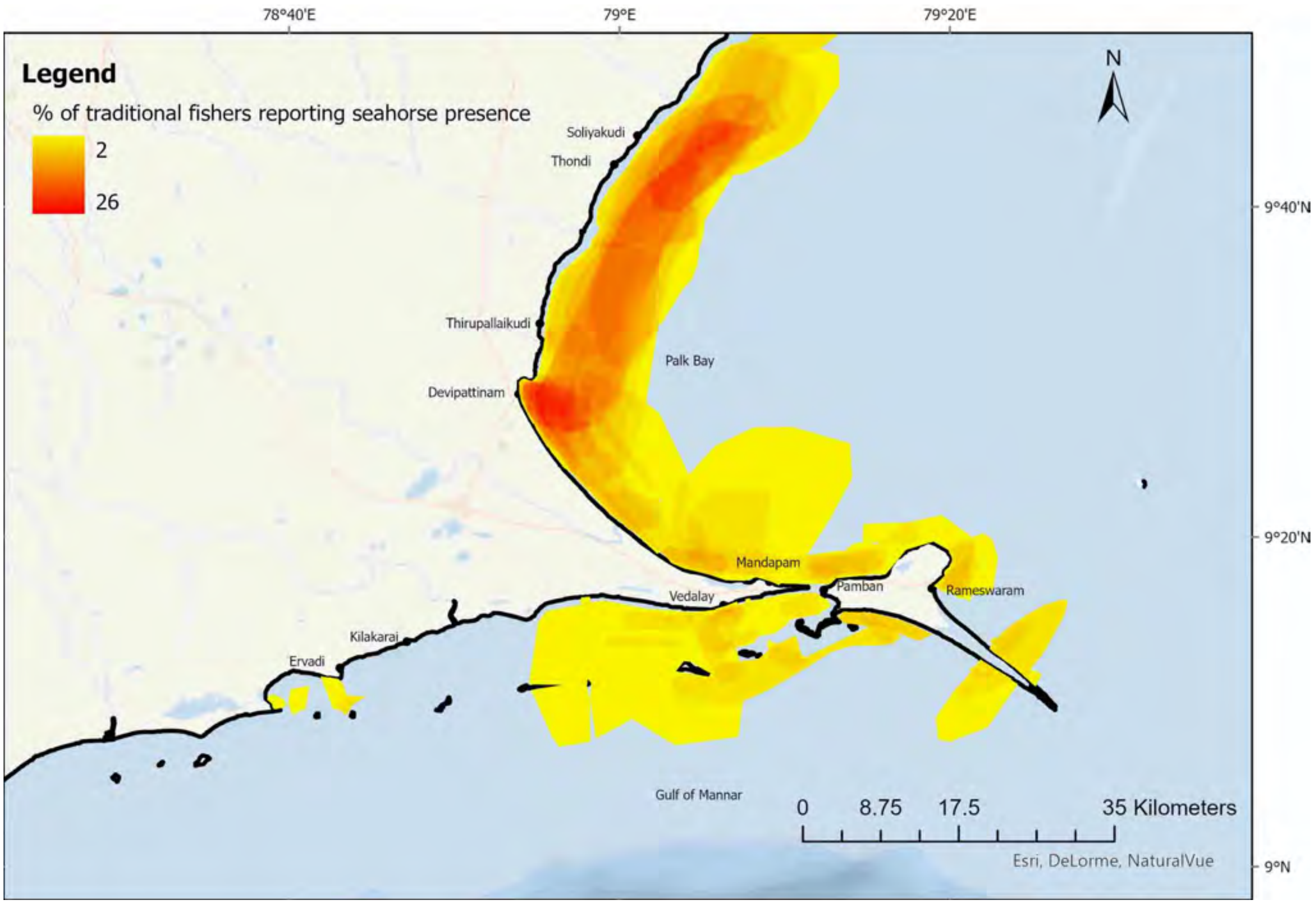
Annex 1. Percentage of fishers who reported catching seahorses across the Ramanathapuram District region, represented by the number of fishers reporting seahorse catches as a percentage of the number of fishers that reported fishing in each of Palk Bay (n=86) or the Gulf of Mannar (n=49). Fishers operating from the Rameswaram peninsula tended to fish in both the Gulf of Mannar and Palk Bay.



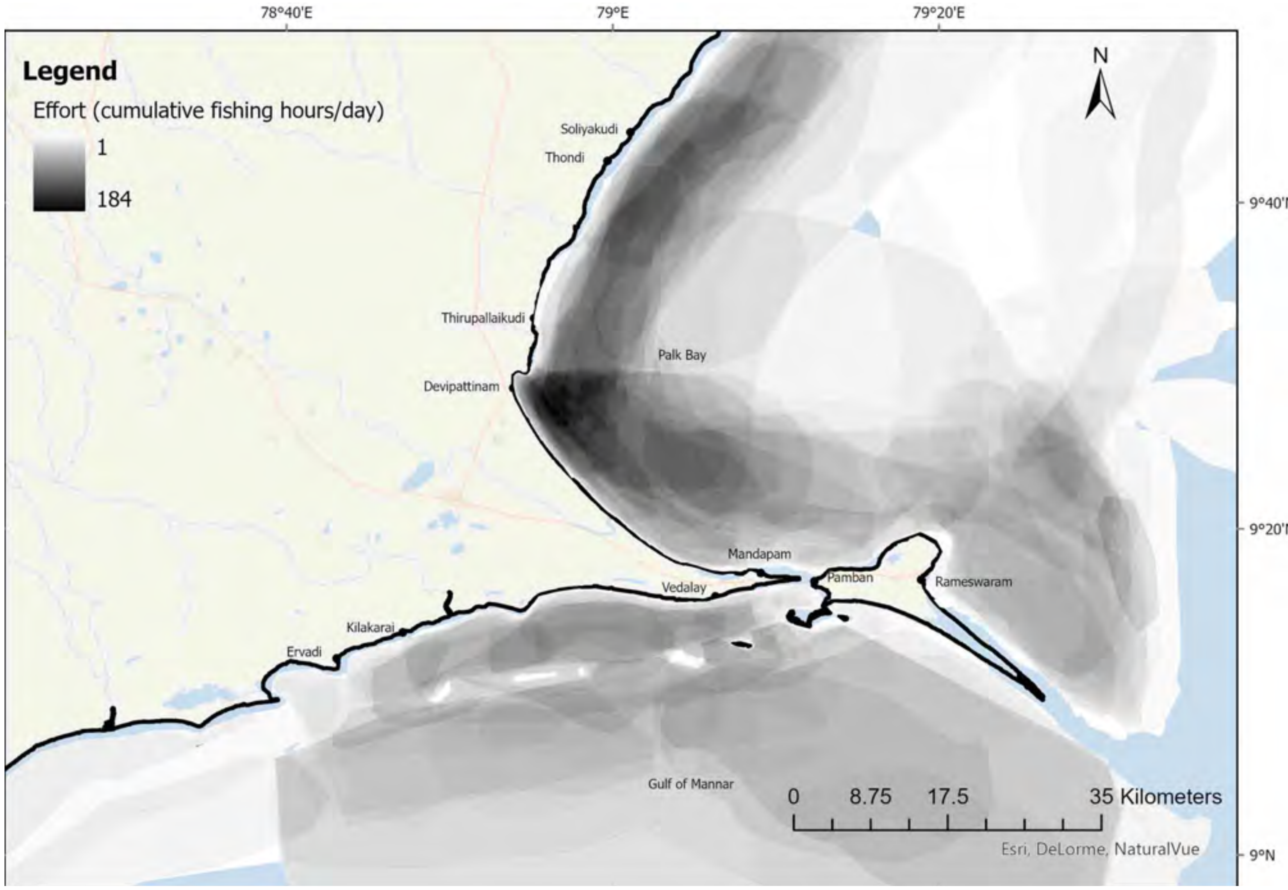
Annex 2. Locations at which fishers reported an absence of seahorses in their catches across the Ramanathapuram District region. A maximum of three fishers reported not catching seahorses in any given region - on the seaward side of the islands of the Gulf of Mannar and along the eastern part of the Rameswaram Peninsula.



Annex 3. Percentage of all bottom trawl fishers in the Ramanathapuram District from our interviews and published literature reporting presence of seahorses (total n=72 bottom trawl fishers). Most fishers reported seahorses in the Palk Bay region extending from Mandapam to the North of Soliyakudi.



Annex 4. Percentage of traditional fishers from the Ramanathapuram District from our interviews and and published literature who reported the presence of seahorses (total n=62 traditional fishers). Most fishers reported seahorses in the Palk Bay region off the coast of Devipattinam, and further north off the coast of Soliyakudi.



Annex 5. Pressures faced by seahorses from bottom trawlers and dragnetters across the Ramanathapuram District, as measured by the collective active time that fishers employed their nets while fishing (hours per day). Fishing pressure was found to be greatest closest to the shore along the entire extent of the Palk Bay region.