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Known unknowns: Conservation and research priorities for soft sediment fauna that supports a valuable SCUBA diving industry

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ABSTRACT

Wildlife tourism can provide sustainable livelihoods, but can also significantly impact vulnerable species if improperly managed. To manage these impacts whilst continuing to support livelihoods, it is important to know the interests of tourists. Using the Best-Worst scaling method, we identified taxa that were most important to scuba dive tourism on shallow soft sediment habitats in Southeast Asia. We further identified differences in interest between demographic groups. We then investigated the current conservation status and research effort into the species driving this branch of tourism. The highest ranked taxa included fishes and invertebrates such as cephalopods and crustaceans. More than 200 respondents indicated that the species most important to muck dive tourism are mimic octopus/wunderpus, blue ringed octopus, rhinopias, flamboyant cuttlefish and frogfish. Diver interests were most influenced by sex, age and dive experience. The extinction risk of six of the top ten species has not yet been assessed by the International Union for Conservation of Nature. On average, the species driving this multi-million dollar tourism industry had less than one paper published every two years over the past two decades. The lack of research and conservation effort toward these species is at odds with their economic and social importance. Considering their high economic tourism value and unknown vulnerability, there is an urgent need for more research on fauna from shallow soft sediment and other habitats important to tourism.

1. Introduction

Nature-based tourism is an important source of income in both developing and developed countries (Balmford et al., 2009). Tourism can be a sustainable alternative to more destructive uses of the environment, but it can also have considerable impacts such as habitat degradation or conflicts between resource users (Wong, 1998; Walpole and Goodwin, 2001), and evolving tourist preferences are likely to alter tourism impacts (Reynolds and Braithwaite, 2001; Gössling et al., 2012). In recent years, a new niche of scuba dive tourism has developed on soft sediment habitats, which focuses on finding and photographing cryptobenthic species that are rarely found on coral reefs: “muck diving” (Lew, 2013).

Muck dive tourism is worth more than US$150 million annually, but the habitats it depends on do not benefit from any formal conservation activities we are aware of (DeVantier and Turak, 2004; De Brauwer et al., 2017). To effectively protect biodiversity, it is crucial that natural resource managers have access to accurate data on how resources are used and threatened (Conroy and Peterson, 2013). Despite its economic importance, it is unclear which species are most important to attract tourists (De Brauwer et al., 2017).

Little is known on the ecology of soft sediment fauna and even less on the potential threats they face (Alongi, 1989). It has been suggested that scuba divers could have a negative impact on soft sediment associated fauna, but the impacts of other common stressors to marine ecosystems (such as overfishing or climate change) remain unknown (DeVantier and Turak, 2004). The high dependence of muck dive tourism on a limited number of taxa could threaten the viability of this industry should the taxa driving it disappear. Identifying the taxa most important for muck dive tourism is a crucial first step in developing adequate management, research and ultimately the conservation of soft sediment habitats and its associated fauna.

The public's preference for particular species has traditionally been measured using a variety of survey methods. Rating scales, either ordinal or Likert-scales (Home et al., 2009; Veríssimo et al., 2009; Schlegel and Rupf, 2010), are not always reliable due to individual or cultural differences, introducing multiple potential biases such as extreme responding, social desirability, or acquiescence bias (Paulhus, 1991; Cohen, 2003). Choice experiments with paired comparisons have been used to test preferences between flagship species for conservation

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programmes (Veríssimo et al., 2009), but these need for large numbers of questions per option to correctly estimate consumer preferences (Louviere et al., 2013), and if more than two choices are available, asking for the most preferred choice gives no information on any of the other options (Louviere et al., 2013). One of the greatest weaknesses of traditional approaches is the difficulty in differentiating between the preferences of different demographic groups (Cohen, 2003; Chrzan and Golovashkina, 2006).

Best-worst Scaling (BWS) is increasingly being used to survey consumers' preferences for products or attributes of products and services (Cohen, 2003; Flynn et al., 2008; Louviere et al., 2013). BWS is a choice experiment which reveals both the least preferred (Worst) and most preferred (Best) choices (Finn and Louviere, 1992). The theoretical basis of BWS is that consumers make the most reliable choices for the most extreme items in a set (Helson, 1964; Louviere et al., 2013). The strength of this approach is that stated preferences are more precisely defined. As a result, BWS performs better at estimating preferences than most traditional ratings tasks (Cohen, 2003). Muck dive tourism relies strongly on a limited set of taxa which might be more or less preferred by divers, so the BWS method has the potential of being a suitable method to test diver preferences.

This study tests if the BWS method can be used to identify the taxa of greatest interest for dive tourism on the poorly studied soft sediment habitats of Southeast Asia. The Coral Triangle in Southeast Asia hosts the highest marine biodiversity in the world, and is the focus of multiple conservation and research initiatives (Hoeksema, 2007; Allen, 2008; Hamilton et al., 2011). Current management and conservation efforts in this region are largely focused on protecting coral reef habitats (Sciberras et al., 2013; Clifton and Foale, 2017), but this approach ignores a large proportion of the diversity found in the region, as more than 50% of the shallow waters in the Coral Triangle region consists of soft sediment (Hayes, 1967). Shallow soft sediment habitats in the tropics are perceived to be of little interest to conservation, and are often seen as depauparate habitats of little value (Alongi, 1989). However, the current prioritisation of charismatic species and ecosystems does not necessarily represent those that are most in need of conservation action (Clucas et al., 2008; McClenachan et al., 2012; Clifton and Foale, 2017).

The goals of this study were to identify the most important taxa for muck dive tourism industry by using BWS and compare them to those identified using traditional survey methods. To assess future research needs, we investigated the quantity of research and the conservation status of the taxa that drive a multi-million dollar tourism industry in Southeast Asia.

2. Methods

2.1. Top taxa

2.1.1. Best-worst scaling

A shortlist of 21 taxa important to muck dive tourism was compiled after consulting with ten experts (Table 1). Experts included dive operators, dive guides and professional underwater photographers active in the area. In some cases, it was not possible to define one single species (e.g. “nudibranchs”), in these cases the most relevant taxonomic clade was chosen. Therefore, we use the term “taxon” when describing important muck diving fauna, depending on what scuba divers perceived as different “species”. Taxon might here refer to a species, a subset of multiple species, a genus, or a family (Table 1). The 21 taxa were arranged in 12 subsets of seven taxa using a randomized block design in R, with each taxon occurring four times over the 12 subsets (Flynn et al., 2008; Louviere et al., 2013). The Qualtrics-platform (Qualtrics, 2015) was used to create an online survey based on these 12 subsets. Respondents were presented with the subsets one at a time and asked to indicate the taxon they would most and least like to see during a dive (Fig. 1). A design issue was whether to use photos to illustrate taxa. An argument for using photos is that divers may not recognize the taxa names, but be familiar with the taxon when they see it. However, photos may induce a bias in response for those who are not familiar with the taxa, in that the photo itself may be the basis for subsequent rankings i.e. having seen the photo of a previously unknown taxon they may now rate it highly. Avoiding induced values from the survey instrument was deemed more important than overcoming lack of name recognition, and we did not use photos. The order of the 12 subsets was randomized per survey, as was the order of the taxa within each subset. Six additional questions were asked regarding diver experience, sex, nationality and age (Full survey in supplementary materials). Surveys were available in English only and were online from June until November 2015 and respondents were not able to take the survey more than once. Links to the survey were spread by email, posted on various social media (Facebook, blog), on scuba dive forums, websites of dive centres, and scuba diving online newsletters.

BWS survey data were analysed using two methods. First we used the counts method to calculate the order for attributes in BWS (Finn and Louviere, 1992; Louviere and Islam, 2008). For each taxon the number of times it was chosen as most and least preferred were totalled. The difference between the best and worst count per taxon give a measure of importance of the taxon (here denoted Best Worst Scores) (Louviere et al., 2015). For the second method we conducted a conditional logit analysis (Flynn et al., 2008). Using the logit rule, the probability of respondents choosing taxon *i* from the set of taxa *i* through *j* as best or worst was calculated using the formulas (Sawtooth Software, 2013):

$$Pbi = e^{Ui} / \Sigma\, e^{Uij}$$

$$Pwi = e^{-Ui} / \Sigma\, e^{-Uij}$$

with:

PBi = Probability of choosing item *i* as best
Pwi = Probability of choosing item *i* as worst
Ui = raw logit weight for i
e^{Ui} = antilog of Ui
e^{-Ui} = antilog of Ui the negative weight for i

Dummy coding was used to avoid linear dependency, the value of the last taxon (Stargazer (*Uranoscopus* spp.)) was set to zero and the value of the other k-1 taxa was estimated with respect to that final taxon held constant at zero (Sawtooth Software, 2013). This dummy variable does not affect the ranking of the taxon that was set to zero (Stargazer), but rather gives values for other taxa relative to that taxon. Results of this model and the counts method are similar, but the logit model allows investigation of heterogeneity in the samples (Flynn et al., 2008; Louviere and Islam, 2008). All data were analysed using R, and the “survival”-package was used for estimating conditional logit models.

2.1.2. Diver surveys

To afford a comparison with traditional preference survey data, self-administered questionnaires were distributed in 15 dive centres across Indonesia (Bali: 2 dive centres, Lembeh strait: 6 dive centres) and Philippines (Dauin: 7 dive centres) between May 2015 and November 2015. Questionnaires (including information about the goal of the study and guidelines for completing the questions) were distributed to all guests by the staff of the dive centres, and collected at the end of the survey period (survey forms in Supplementary materials). The questionnaires were available in English, traditional Chinese and Japanese. These surveys included a wide range of questions about diver demographics and expenditure (De Brauwer et al., 2017). Of relevance here, divers were asked which 3 species they would most like to see during their diving holiday. Summary statistics were obtained using R to describe which taxa were most popular with divers (R Core Team, 2015).

Surveys were approved by the Curtin University Ethics Committee