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Rapid assessment of wildlife tourism risk posed to cetaceans in Asia

Abstract

Dolphin-watching tourism is growing globally. In developing countries, the typically low environmental awareness of operators and poorly-enforced or non-existent regulations exacerbate risks to wildlife. Ecological indicators like behavioural responses are useful to assess wildlife tourism, but obtaining such data is slow and expensive. We modified the Driver-Pressure-State-Impact-Response (DPSIR) framework to rapidly assess the risk of dolphin-watching tourism harming, displacing or causing local extinction to dolphin populations, using human dimension data to complement limited ecological data. We assessed industries at seven dolphin-watching sites in six countries in Asia: Cambodia, India, Indonesia, Malaysia, Thailand, and the Philippines. All sites have reached or almost reached financial saturation except Malaysia. We find high risk to dolphins at the sites in India and Indonesia and intermediate risk at the site in Cambodia. Pending more ecological data, the risk at Thailand, the Philippines, and Malaysian sites might be low. Our analysis also indicates site-specific conservation recommendations for Driver, Pressure and Response. We suggest that the DPSIR framework is useful to assess the risk of a wildlife watching industry, even when the impact is uncertain due to insufficient ecological data.

Introduction

Wildlife tourism connects people to iconic wildlife, provides economic opportunities, and supports conservation of local biodiversity (Green & Higginbottom, 2000). Dolphin-watching tourism is a growing industry worldwide, and can contribute to local economies and reduce poverty in many developing countries where it is growing fast (O'Connor, Campbell, Cortez, & Knowles, 2009; Cisneros-Montemayor, Sumaila, Kaschner, & Pauly, 2010). However, the success of the industry can be its downfall: unmanaged industry growth is commonly associated with greater risk to focal wildlife, which in the long-term could mean loss of biodiversity, and industry viability. Dolphin-watching tourism must be regulated to remain sustainable (Higham, Bejder, & Williams, 2014; Higham, Bejder, Allen, Corkeron, & Lusseau, 2015), but regulations for wildlife tourism are often non-existent or poorly enforced in developing countries (Beasley, Bejder, & Marsh, 2014; D'Lima, 2015).

In developing Asia, the dolphin-watching industry has been growing fast. With 857 individual and private operators in Asia in 2008 (O'Connor, Campbell, Cortez, & Knowles, 2009), the whale and dolphin-watching industry could have a significant potential impact on local cetaceans. In 2016 the number of operators may easily be double. For example, the number of boats in Chilika grew to over 900 in 2010/2011 (D'Lima, 2015) and two new dolphin-watching sites have emerged in Indonesia (i.e., the Kiluan Bay in Lampung and Bondalem in north Bali). With such growth, the welfare of targeted dolphin populations and subsequently the

sustainability of the industry may be drawn into question. However, ecological data to monitor the effect of the dolphin-watching industry on the dolphins is generally scarce and intermittent in developing countries.

Risks from cetacean-watching tourism

In an attempt to halt biodiversity loss worldwide, the United Nations (UN) adopted a strategic plan in October 2010, which sets out strategies to support biodiversity in the following ten years (UNEP, 2010). One of the UN goals is to reduce direct pressures on biodiversity and promote sustainable use. Dolphin-watching tourism can be an example of a direct pressure on biodiversity – especially if unmanaged. Many studies show that boat-based tourism affects whales and dolphins. Tourist boats can change cetacean behaviour in both the short- and long-term, and affect population dynamics and habitat use (Constantine, 2001; Bejder, Samuels, Whitehead, & Gales, 2006; Christiansen, Lusseau, Stensland, & Berggren, 2010). In particular, increasing the number of boats around a group of dolphins has been shown to reduce the frequency of resting behaviours. In Zanzibar, female bottlenose dolphins have been shown to spend less time resting when they were within 50 meters of three or more tour boats (which are typically 6 meters long traditional wooden fishing boats) (Stensland & Berggren, 2007). The same phenomenon has been observed in New Zealand where bottlenose dolphins rarely rested when at least four tour boats were within 300 meters from the dolphins (Constantine, Brunton, & Dennis, 2004).

Understanding the ecological effects of boat-based tourism on dolphins is the key to assessing the risk that tourism poses to them and determining the biological, and therefore in part the economic sustainability of a dolphin-watching industry. Short-term ecological indicators for dolphins include surface and dive patterns, swim speed, and behavioural changes, while long-term ecological indicators include habituation, sensitisation and changes in reproductive success (Bejder & Samuels, 2003). Long-term ecological changes may take 15 years or more to detect (Bejder et al., 2006). Since ecological indicators need long-term monitoring, they can be impractical for rapid decision making, particularly in developing countries where baseline data on behaviour is generally lacking, as is the long-term funding to collect such data. Baseline data might be further obfuscated at crowded tourism sites, where the high number of boats around local dolphin populations often makes the establishment of control units difficult (Mustika, Birtles, Everingham, & Marsh, 2014).

Given these constraints, an approach that is cheaper and faster than employed in the studies above is needed to gauge the ecological impact of dolphin-watching industries. This method will largely rely on non-ecological (human dimension) data where fieldwork is executable at a relatively low cost compared to the cost of boat surveys. Human dimension indicators have been used to successfully assess the social and economic sustainability of wildlife tourism in developing countries at a relatively low cost in Indonesia and India (Mustika, 2011; D'Lima, 2015), yet the surveys were conducted over two years of data collection. The question is thus whether we can rapidly assess the likely risk of dolphin-watching tourism harming, displacing or causing local extinction to the dolphins using such human dimension data to complement limited ecological data.

As an illustration, suppose one wants to quickly assess the sustainability of a dolphin-watching industry (or any other wildlife tourism industry), where limited funding is available. Collecting

human dimension data is more realistic than collecting ecological data due to time and financial constraints, but the question is what type of human dimension variables should and can be assessed to ascertain whether this industry is likely to be a threat to the dolphin population. We use the Driver-Pressure-State-Impact-Response (DPSIR) framework to establish a set of relevant variables required to answer that question.

The driver-presesure-state-response (DPSIR) framework

DPSIR provides a framework to use human-dimension data to rapidly assess the biological risks that can be applied to dolphin-watching tourism. DPSIR is a set of components developed to assist environmental reporting in a simple format as an improvement for the preceding Pressure-State-Response model (Smeets, Weterings, & voor Toegepast-Natuurwetenschappelijk, 1999). In the DPSIR framework, "social and economic developments (the Driver) exert Pressure on the environment and, as a consequence, the State of the environment changes, such as the provision of adequate conditions for health, resource availability and biodiversity. It finally leads to Impacts on human health, ecosystems and materials that may elicit a societal Response that feeds back on the Driving forces, or on the state or impacts directly, through adaptation or curative action" (Smeets, et al., 1999, p. 6). The DPSIR framework has been used in freshwater management (Borja et al., 2006), fisheries (Mangi, Roberts, & Rodwell, 2007), coastal zone management (Sekovski, Newton, & Dennison, 2012) and tourism research (Rozīte & Vinklere, 2011). However, using DPSIR in analysing wildlife tourism is still a novelty.

DPSIR can be used to qualitatively analyse a problem. For instance, Sekovski, et al. (2012) listed several drivers, pressures and states to understand the environmental impacts of coastal megacities and recommended responses. Mangi, et al. (2007) listed DPSIR indicators of Kenya reef fisheries, including tourist visits per year, the number of fishers per square kilometre, fish abundance, catch per unit effort, the number of Marine Protected Areas to correspond to Driver, Pressure, State, Impact, and Response. As an indicator for fishing pressure, Knudsen, Zengin, and Koçak (2010) used the number of boats, and their engine power as a proxy for catch capacity. However, DPSIR indicators can also be analysed quantitatively. Gerven, Block, Geens, Cornelis, and Vandecasteele (2007) quantitatively combined environmental criteria to suggest Response indicators for environmental issues in Belgium. The authors used criteria developed by the European Environmental Agency and the Flemish Environmental Agency (i.e., policy relevance, target reaching, methodology, availability, spatial coverage and temporal coverage) for suitable Response indicators by assigning weighted scores between 0 and 4 to produce arbitrary final scores.

Despite its utility, DPSIR is not without criticism. For example, it assumes single and unidirectional causalities between indicators (Niemeijer & de Groot, 2008). DPSIR users can also mix up indicators at different levels, thus creating unsuitable Responses that are not applicable at a local level (Carr et al., 2007). However, DPSIR works well at simplifying issues for policy makers and can be utilised to develop management indicators (Mangi, et al., 2007). DPSIR is also good to analyse small-scale problems (Carr, et al., 2007; Tscherning, Helming, Krippner, Sieber, & Paloma, 2012).

In this article, we use insights from the DPSIR framework to obtain an indicator of the risk of dolphin-watching tourism harming, displacing or causing local extinction to dolphin

populations at seven different sites, using human dimension data to complement limited ecological data. We do this by comparing the pressure of the size of local industries, the economics of the industry (which indicates the expansion potential of the industry), local state for species involved and the Code of Practice. Given availability of data and assembled expertise, we focus this assessment at seven dolphin-watching sites in six developing countries in Asia; Cambodia, the Philippines, India, Indonesia, Malaysia and Thailand.

Methods

Theoretical framework and indicator selection

The indicators included in our application of the DPSIR framework relate to dolphin-watching tourism only. We are aware of other risks to the wellbeing of the dolphins, but we focus on the specific contribution of dolphin watching tourism in order to make targeted recommendations for that industry. However, to acknowledge other anthropogenic risks to the dolphins, we discuss them separately.

Putting the DPSIR framework in the context of dolphin-watching tourism in the developing countries in which we focus (Figure 1), the major **Driver** is local livelihood needs that encourage local people to take tourists to view the dolphins. Both pull (attractiveness of dolphin-watching tourism as an employer) and push factors (unattractiveness (or absence) of alternative industries as an employer) as well as the presence of potential barriers to entering the dolphin-watching industry (skill requirements (for example boat driving) and set-up costs (for example acquisition of a boat)) play critical roles in this respect. Tourism creates **Pressure,** which includes the number of boats per spatial unit, the way boats are driven and engine noise. Pressure affects the current situation or **State** of the system, including the current number of dolphins and home range. Pressure can create **Impacts** in the future. Here, possible Impacts are changes in the number of dolphins, habitat use, occupancy, reproductive behaviours, or avoidance towards the boats. Managers and stakeholders then need to develop **Responses** to mitigate the Impacts. Here Responses may range from the establishment of a Code of Practice, maximum quota on boat trips per day, the introduction of economic intervention tools (such as tax or transferrable permits), development of alternative livelihoods, or even a moratorium on the industry. Responses can, in turn, affect the system's Drivers, Pressures, States and Impacts.

The original DPSIR framework (Figure 1) implies the application of all five components, i.e., the Driver, Pressure, State, Impact and Response (Niemeijer & de Groot, 2008; Tscherning, et al., 2012). In order for the DPSIR framework to work, Smeets, et al. (1999, p. 6) suggest that "clear and specific information" on the five components should be available. However, data deficiency is one of the key issues for cetacean conservation management (Parsons et al., 2015). Since historical ecological data are largely absent from most dolphin-watching sites in this region, Impact is mostly unknown or difficult to measure.

Using indicators of the other four components of the DPSIR framework and the relationships between the five components as suggested by the DPSIR framework, we can establish an indicator of the missing component: the Impact. Impact is approached using an indicator of risk as a proxy. Specifically, the 'risk' here is the risk of a dolphin-watching industry harming, displacing or causing a local extinction to a target dolphin population. Table 1 provides the Driver, Pressure, State and Response indicators used for this purpose. A relative value from 0

to 5 was assigned for each Driver-Pressure-State-Response indicator. The upper limit of each indicator was arbitrarily set after examining all data ranges for that particular indicator. A higher risk score reflects a more concerning effect of the dolphin-watching industry to the target dolphin population. The 0-5 values can also be interpreted as ranging from zero risk (0), through very low risk (1), low risk (2), medium risk (3) and high risk (4) to very high risk (5). In selecting the indicators for this assessment, we consulted the variables obtained in Lovina, Indonesia (Mustika, Birtles, Welters, & Marsh, 2012; Mustika, Birtles, Everingham, & Marsh, 2013; Mustika, et al., 2014) and Chilika, India (D'Lima, 2015; D'Lima, Welters, Hamann, & Marsh, 2016) that were used to construct effective indicators to assess the sustainability of the industries at both sites.

The current Driver for this framework is the development potential of the dolphin-watching industry at the time of data collection. This development potential depends on the industry's profitability. The industry generates a profit if the net revenue of carrying out boat trips is positive (i.e. revenues of carrying out boat trips outweigh the costs involved). If the industry generates profits, new boats will enter the industry trying to exploit the profit opportunity, thus increasing the total fleet size. Here we define the total fleet size as the total number of dolphin-watching boats available on the beach, riverbank or at the port (Mustika, 2011). All else being equal, an increase in the total fleet size will reduce the average number of tourists per boat. This reduces revenues per boat trip, but leaves costs per boat trip largely unaffected, i.e. a reduction in the average number of tourists per boat, reduces the profits per boat trip. Market entry will occur until it is no longer profitable to do so, at which point the total fleet size stabilizes. We call this point the 'market saturation fleet size'. The current Driver is defined as the ratio of the market saturation fleet size and the current total fleet size at the location. If the Driver ratio is larger than one, the industry is projected to grow (positive development potential). If the Driver ratio is smaller than one, the industry is projected to decline (negative development potential).

To understand the entry decision in the industry more fully, we must distinguish two types of participants: tour operators and independent boat drivers. Tour operators own the boat and pay boat drivers to carry out the boat trips, i.e. tour operators are not involved in carrying out boat trips, hence can engage in alternative income generating activities in addition to being a tour operator. Tour operators continue their business as long as they generate profits. Independent boat drivers both own and drive the boats, i.e. they are involved in carrying out boat trips and must surrender alternative income generating activities while carrying out boat trips. As a result, they continue their business as long as the surplus income of driving boats (defined as the difference between the profits of driving boats and the income they can generate from pursuing their best alternative occupation) is positive. Mustika (2011) and D'Lima (2015) show that independent boat drivers at the Indonesian and the Indian site respectively are mostly of low education or unskilled. This situation is also true for other sites based on the experience of the authors. Hence, we set the income of the best alternative occupation (also known as the opportunity cost) equal to the income that other unskilled workers (such as fishers and farmers) could earn in the region where dolphin-watching takes place.

The current Pressure for this framework is the number of boats per spatial unit (km^2) of usual interaction area at the time of data collection. The current Pressure is expressed as the current total fleet size divided by the size of usual interaction area (the core dolphin-watching area in km^2). In general, the core dolphin-watching area coverage was estimated by the authors based on their conversations with the local operators and their observations of the industry. We chose this indicator because of its established link to dolphin behaviour and its ease of data collection.

Alternative, more accurate albeit more time consuming (hence expensive) indicators would focus on the 'encounter fleet size' or "the number of boats around a school of dolphins within a 150 m radius" (Mustika, et al., 2014, p. 2) or on the behaviour of the boat drivers. The encounter fleet size reflects the actual pressure to a group of dolphins. The total fleet size may not reflect the actual pressure to the dolphins, for not all available boats go to take tourists every day.

The current State for this framework is the local IUCN status of the target species based on the IUCN Red List of Threatened Species (IUCN, 2001). The Red List is the benchmark system for assessing conservation status and is shown to be a good predictor of extinction risk (Keith et al., 2004). Species assessed using the Red List with adequate data are classified in one of a number of ordered categories relating to extinction risk, while those without sufficient data to make a rigorous analysis are considered data deficient (DD). We rank risk in order with Critically Endangered as the highest risk, and to Least Concern as lowest (Table 65). Data deficiency is often misinterpreted as 'no concern' (Parsons, et al. (2015), while, on the contrary, recent research predicts most data deficient species are likely to be threatened (Bland, Collen, Orme, & Bielby, 2015). Hence, we treat Data Deficient (DD) the same as Vulnerable (VU). If the site has more than one species with different Red List status, we choose the more threatened one. Several of our target populations have had Red List assessments conducted that are not part of the IUCN official list. However, we make use of these assessments, referring to them in terms of 'likely' status. Here we use likely status in the Philippines (Alava, Dolar, Sabater, Aquino, & Santos, 2012), Chilika (Sutaria & Marsh, 2011), and unpublished data from Jutapruet was used for Thailand.

Non-compliance to Code of Practice has been shown to be associated with reduced resting behaviour among dolphins (Englund & Berggren, 2002). Whilst economic intervention tools or capping the number of boats will also have beneficial effects to the dolphins, such measures have drastic consequences for the livelihood of the boat drivers in developing countries, where alternatives can be limited. Mustika (2011) indeed showed that the dolphin-watching industry is more open to discuss and hence comply to regulating their code of conduct around a group of dolphins rather than capping the number of boats or other economic intervention tools. Therefore, as our proxy for current Response, we use the presence and form of a dolphin-watching Code of Practice at the time of data collection (Carlson, 2013) that exist in various degrees in the region. A Code of Practice typically involves limits to the number and size of boats around a group of animals, limits to distance between the boats and the animals, limits to interaction time and controlling behaviours and noise of the boats around the animals (Carlson, 2013). We include in the Response 1) the distance between the dolphins and the boats, 2) the boat speed, 3) the number of boats around the dolphins, 4) the driving conducts and 5) the boat positioning around the dolphins (Table 1). Compliance to Code of Practice is considered as the most important factor that minimises the risk of this industry, regardless of the legal aspect of the Code.

We then proceed to calculate an indicator of the risk of local extinction of a dolphin population in seven locations. To calculate this indicator, we use the three components from the DPSIR framework that matter to the risk of local extinction directly[1]:

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[1] The development potential of the industry (the Driver) does not directly affect the dolphins. If the potential materialises, the pressure will increase, which affects the dolphins. Consequently, the Driver is indirectly included through its effect on Pressure.

1) Pressure – to establish the magnitude of the impact of the dolphin-watching industry on the dolphin population;
2) State – to establish to what degree a dolphin population in a location is endangered.
3) Response – to establish to what extent potential impact of the dolphin-watching industry on the dolphin population is eliminated through good practice;

The risk indicator is defined as the product of the indicator values for Pressure, State and Response (Equation 1).

$$Risk\ Indicator = Pressure \cdot State \cdot Response \qquad (1)$$

We use a multiplication rather than a summation in Equation 1 because of the presence of interaction effects. For example, the effect of Pressure on the risk indicator is dependent on the indicator value for Response. That is, a good Code of Practice is more powerful in reducing the risk of many boats (high Pressure level) than fewer boats (low Pressure level). Multiplication rather than summation captures such interaction effects.

Finally, any plan or policy based on the risk indicator would almost certainly incur a time lag between inception and implementation, such that the final risk indicator will be obsolete at time of implementation if based on current values for Pressure, State and Response. Consequently, we use the market saturation fleet size (the projected total fleet size in the future) instead of the current total fleet size to transform current Pressure into future Pressure, which we include in the risk indicator. The current Response may deviate from the future Response if for example stakeholder consultation is underway about the prevailing Code of Practice, indicating a Response change in the near future. No such consultation is ongoing in any of the seven sites; hence, we assume that future Response is equal to the current Response. The future State in relation to the current State depends on the Impact, which is unknown (hence we must use the current State).

Study sites

This study focuses on eight known cetacean species at seven dolphin-watching sites in six countries, i.e., Cambodia, India, Indonesia, Malaysia, Thailand, and the Philippines (Figure 2, Table 2). All authors have worked on conservation-related issues in these sites for at least four years prior. For simplicity, we refer to our sites by their country names (Table 2), but each site is not necessarily representative of the entire dolphin-watching tourism industry in that country. These sites cover coastal marine, estuary, brackish lagoon, and riverine habitats. The species targeted in tourism at these sites are Irrawaddy dolphin (*Orcaella brevirostris*), Indo-Pacific humpback dolphin (*Sousa chinensis*), spinner dolphin (*Stenella longirostris*), Fraser's dolphin (*Lagenodelphis hosei*), bottlenose dolphin (*Tursiops sp.*), Risso's dolphin (*Grampus griseus*), short-finned pilot whale (*Globicephala macrorhynchus*), finless porpoise (*Neophocaena phocaenoides*), and Brydes whale (*Balaenoptera brydei*) (see Table 2). We provide most of the relevant information on these sites such as tour boat fleet size, number of annual visitors, ticket prices, regulation, and site locations in Table 2, with further detail in Table 3. Note that the Philippines has two types of tour boats: the bridge and the canter boats with their own passenger capacity. Differences in the bridge and canter boats have been accommodated in our financial calculation. The tourism industry has not been well-studied at most of these sites, with the exceptions of India and Indonesia (Mustika, et al., 2014; D'Lima, 2015).

Kampi Village, Kratie (Cambodia)

The Kampi dolphin-watching site is based at a deep-water section of the Mekong River at Kampi Village, near to the major town of Kratie in North-Eastern Cambodia. The Mekong is home to a Critically Endangered population of Irrawaddy dolphin (Smith & Beasley, 2004) and Kampi is one of the major-subpopulations in the river; used by around one third of the 85 remaining dolphins (Ryan, Dove, Trujillo, & Doherty, 2011). Dolphin tourism at the site is managed centrally through provincial government agencies, with boats owned and operated by local villagers. Boat trips last around an hour during which time the motorized vessels locate and follow dolphin groups. Most tourists visit over the dry season (Dec-May), when dolphins are always present in the area immediately near Kampi Village. Boats follow dolphins around and probably disturb the animals (Beasley, Bejder, & Marsh, 2014). The major livelihoods in the area are rice farming over wet season, subsidized by fishing over the dry season, which complements driving tourist boats. Dolphin-watching tourism has also spawned a significant local industry in the making and selling of mostly dolphin-themed wooden statues and handicrafts, which extends beyond those immediately involved with driving boats, as well as the large tourism and hospitality industry in the town of Kratie.

Chilika Lagoon, Orissa (India)

Chilika is a brackish water Lagoon located in the eastern state of Odisha in India and a designated RAMSAR site (RAMSAR, 2002). The lagoon provides the main livelihood for approximately 200,000 fishers who belong to approximately 150 villages (Nayak & Berkes, 2010). Chilika is also home to a small subpopulation of Irrawaddy dolphins, which is probably declining and likely Critically Endangered (Sutaria & Marsh, 2011). Dolphin-watching in Chilika was initiated locally in 1989 when fishers took tourists to watch dolphins in the lagoon (Sutaria, 2009; D'Lima, 2015). In 2013, the industry had 155,000 visitors, with over 900 boats operating through four tourist boat associations (D'Lima, 2015). The most recent estimate indicates that the dolphin-watching industry is worth approximately USD 1 million annually to the economy of Chilika (D'Lima, et al., 2016). Despite being a lucrative industry, dolphin-watching tourism at Chilika is very likely unsustainable in the long-term (D'Lima et al., in review).

Lovina, Bali (Indonesia)

The first dolphin-watching site in Indonesia (Hoyt, 2001), Lovina is a coastal area in Buleleng Regency in north Bali. Spinner dolphins are the main target species, but Risso's dolphins, Fraser's dolphins, pantropical spotted dolphins (*Stenella attenuata*), bottlenose dolphins and short-finned pilot whales are often observed here. With at least 37,000 dolphin-watching visitors staying overnight per annum in 2008/9, this industry is an important income generator for Lovina, contributing to at least USD 4.1 million per annum of tourist direct expenditures to the village (Mustika, et al., 2012). A total of 179 dolphin-watching boats were available in 2008/9, and 192 in late 2011. Dolphin-watching is the primary occupation of almost 60% of the boat drivers (Mustika, 2011). Only a quarter of the boat drivers were also fishers; the rest also worked part time as farmers, teachers, tour guides or drivers (*Ibid*). The boat drivers often drove the boat in a way that risked injuring the dolphins (Mustika, et al., 2014), decreasing tourist satisfaction (Mustika, et al., 2013). From December 2011, Lovina is designated as a Marine Protected Area with the primary focus of conserving the local dolphin populations. However, although Marine Protected Areas in Indonesia must have a management plan that addresses tourism activities, Lovina has none so far.

Santubong, Sarawak (Malaysia)

Santubong is a mangrove area in Sarawak, Malaysia. The Santubong River flows between Santubong and the capital Kuching 10 km south of Santubong. The beaches of Santubong are frequently visited by the Kuching locals making tourism the main livelihood there. Several marine and terrestrial protected areas surround the Santubong Bay. Irrawaddy dolphins are the most commonly observed species, with finless porpoise and Indo-Pacific humpback dolphins occasionally seen. Tour operators offer dolphin-watching alone or in combination with mangrove cruises and other wildlife viewing. Weather permitting, tours operate year-round and are conducted both morning and evening. Only one boat driver feeds dolphins; while the other tour operators are part of the local Tourism Association and have expressed concern about the illegal practice. Boat drivers operate under voluntary regulations, and cooperate to sharing the site where dolphins have been observed.

Balicasag Island, Panglao, Bohol (Philippines-1)

Balicasag Island in the municipality of Panglao is home to spinner dolphins, Fraser's dolphins and bottlenose dolphins (all Data Deficient). Scuba diving, island hopping and dolphin-watching are the main tourist attractions here. Dolphin-watching was triggered by the industry in Pamilacan Island; initially boat operators followed the boats from Pamilacan to spot the dolphins before they learned to search for dolphins on their own. The demand for dolphin-watching attracted a high number of unregulated tour boats, so that tourism is now an important livelihood. Aside from tourism, the main livelihood of local communities is fishing.

Pamilacan Island, Bohol (Philippines-2)

Pamilacan is an island approximately 27 km east of Balicasag in Bohol, the Philippines where Fraser's dolphins, spinner dolphins and bottlenose dolphins can be observed offshore. Fishing is the main livelihood in Pamilacan. The island is known for the subsistence harvesting of whales; hunting accelerated in the 1990s (Dolar et al., 1994), prompting authorities to impose a ban in 2000. This ban led to the establishment of dolphin-watching tourism as alternative livelihood and fishers later gave up whale hunting permanently (Sorongon, 2010). Given their skill in whale-spotting, the transition was easy. Assisted by the local tourism office and NGOs, the locals were able to conduct dolphin-watching activities with voluntary regulations. Regulations are in place and the Code of Practice is implemented, including the practice of dividing the boats to observe different groups to reduce stress on the animals.

Khanom, Nakhon Si Thammarat (Thailand)

Khanom is a coastal district in the Nakhon Si Thammarat Province, Thailand. Indo-Pacific humpback dolphins (likely VU), finless porpoise, Irrawaddy dolphins, and occasionally Bryde's whale (*Balaenoptera brydei*) may be located at this site. Rubber, oil palm, coffee plantations and fishing are the main livelihoods here. The dolphin-watching industry is an alternative source of income with annual visit of approximately 10,000 tourists. Feeding the dolphins is practiced with tourists buying small fish from fishers (usually around THB 20 for 500 grams), thus enabling close and predictable encounters with cetaceans at this location.

Data analysis

This article used existing data collected in previous projects by the authors or collated from other sources. Table 3 presents all information used and the first column outlines all computations made to establish the market saturation fleet size (required to establish the current Driver at each site). It firstly indicates whether the industry is run by tour operators or independent boat drivers (to whom opportunity costs apply).[2] It then provides information required to calculate boat revenues and demonstrates how revenues are established. Subsequently, we calculate boat operational costs before calculating net revenue per boat (relevant for tour operators) or net revenue per boat driver (relevant for independent boat drivers). We then calibrate the total fleet size that will saturate the market, which is the total fleet size for which net revenue per boat is zero (for tour operators) or surplus income per boat is zero (for independent boat drivers). Table 4 provides an overview of the main findings. It shows how industry economic performance (net boat revenues for tour operators and surplus income for independent boat drivers) translates into projected changes in the total fleet size.

Table 5 then presents the calculation of the risk indicator, which starts with the calculation of current and future Pressure (measured as the current total fleet size and the market saturation fleet size per km^2, respectively), which is then converted into a risk value as per Table 1. The final column produces the risk indicator, multiplying future Pressure, future Response and current State. Considering the values range between 0 to 5 for each individual element, the risk indicator is anywhere between 0 and 125. Darker shadings in the table correspond to higher risk values.

Tourism is likely to be one of many threats to a dolphin population (Williams, 2014). To supplement our assessments of tourism-based risks, we also briefly assess several possible threats known to marine mammals in the region as follows:

1) Sewage and chemical run-offs from terrestrial-based industry and settlement,
2) Solid waste and debris (including plastic and discarded fishing line/net),
3) Traffic from non-tourism, motorized boats,
4) Destructive practices from artisanal, commercial and/or recreational fishing industry,
5) Other tourism-related activities, and
6) Habitat destruction.

These threats are expressed in simple categories from 'possibly exists', 'exists', where the potential threat is known or considered possible to occur, and 'known threat', where it is known to threaten animals at the site. The threats are rated based on authors' prior knowledge from at least four years of working in related sites on conservation-related issues.

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[2] We confirmed that wages paid by tour operators to boat drivers to carry out boat trips outweigh the opportunity costs of these boat drivers in that region (not shown in Table 4). Otherwise, tour operators would struggle to attract boat drivers to the industry and hence the industry would struggle to grow even if it was profitable to increase the number of boats.

Results

There are some general patterns in our findings (Table 3); although most industries project industry expansion, those in India and Thailand may contract due to overcapacity. General findings on wildlife tourism risk to dolphins in Southeast Asia are hard to draw, as the risk posed by industries varies widely among sites. In our analysis, we find the highest risk to dolphins in India, followed by Indonesia and Cambodia. Risk calculations are displayed in Table 5.

Cambodia

Cambodia's theoretical driver was 5, but due to the imposed fleet size (maximum 26 boats), we scored Cambodia's Driver as 1. This score thus made the current Pressure and future Pressure of Cambodia the same (3), with a risk indicator of 60/125. However, considering the low performance of Response (4), questions remain about the enforcement of the current fleet size limitation. If poorly enforced, Cambodia might still face Pressure explosion in the future.

India

India's current Pressure is very high (5) and, because the industry has reached saturation (Driver = 1), will remain very high in the future (5). This result, coupled with the insufficient Response (4) and the potentially Critically Endangered dolphin status, leads to a risk indicator of 100/125 for India.

Indonesia

Indonesia has a very high current Pressure (5). The industry operates around saturation point (Driver is 1), which implies future Pressure is likely to remain very high (5). Combined with insufficient Response (4) this industry generates a high risk indicator of 75/125.

Malaysia

Malaysia has a medium Driver (3), which is not strong enough to elevate future Pressure to a higher category than current Pressure (1). Combined with a sufficient Response (3), this leads to a risk indicator for Malaysia of 9/125.

Philippines–1 (Balicasag Island)

Philippines-1 has a very low Driver (1), which would decrease future Pressure from 2 to 1, producing a risk indicator of 12/125.

Philippines–2 (Pamilacan Island)

Philippines-2 has very low Pressure (1). Because of a low Driver (2), future Pressure is predicted to remain in the very low level (1). Combined with a near-perfect Response (2), the risk indicator is low at 6/125.

Thailand

Dolphin-watching tourism in Thailand generates negative surplus income (the income generated is below the average income of a low skilled worker), hence the driver is 1, which means Pressure will remain at its current low level in the near future. Coupled with the excellent Response (1), the future Pressure would remain low in the foreseeable future (risk indicator is 6/125).

Other anthropogenic activities that may pose threats are also present at these sites (Table 6). Of the other anthropogenic, other non-tourism boat traffic and fishing are the most common, while sewerage is not known as a threat at any site. In particular, other tourism activities and

traffic from non-tourism motorised boats at the first Philippines site (Balicasag) are possible threats to the local dolphin populations. A small amount of illegal gill netting also persists at the Indian site as another anthropogenic activity. At the Cambodian site, the construction of the Don Sahong Dam upstream in the Mekong River has been identified as a threat to the Critically Endangered population of the local Irrawaddy dolphins (Ryan, 2014), as well as ongoing threats from gill net entanglement. Artisanal fishing and non-tourism boat traffic might be the major threats to the dolphins at the Thailand site, while solid waste (including marine debris) is the most prominent threat at the Indonesian site. Other anthropogenic activities do not seem to pose immediate threats to the dolphins at the second Philippines site (Pamilacan). Marine debris, fishing industry and traffic from non-tourism motorised boats have also been identified as threats to the local dolphin populations at the Malaysian site (Williams, 2014).

Discussion

Application to study sites

We have used insights from the DISPR framework to assess the likely risk of dolphin-watching tourism harming, displacing or causing local extinction to the dolphin populations using human dimension data to complement limited ecological data. Our study assumes that a profitable industry is likely to lead to fleet size expansion. The number of boats has been correlated with behavioural disturbance to the dolphins at other sites (Constantine, et al., 2004; Stensland & Berggren, 2007), while non-compliance to Code of Practice has been shown to positively correlate with stress-related behaviours of the dolphins (Englund & Berggren, 2002). Thus, industry profit (Driver), total fleet size (Pressure) and compliance to Code of Practice (Response) can be used as proxies to assess the risk of this industry harming, displacing or causing local extinction to the dolphins.

We scored the Driver, Pressure, State and Response components of seven dolphin-watching industries at six Asian developing countries targeting eight dolphin species. The result produced a risk spectrum from very low, to intermediate and very high. The industries at India and Indonesia are likely to pose a very high risk of harm, displacement or local extinction to the dolphins. The industry in Cambodia is posing intermediate risk to the dolphins. The risk of the industry in Philippines-1, Thailand, Philippines-2 and Malaysia to the dolphins is most likely lower than that of other sites. Our result is consistent with our qualitative observations at the higher end of the spectrum, for D'Lima and Mustika have independently concluded the likely unsustainable practices of the industry in India (D'Lima, 2015) and Indonesia (Mustika, 2011).

Our analysis produces site-specific management recommendations. With poor Response, Philippines-1 needs to invest in a proper strategic plan to manage the industry, which is important if the industry were to grow as a result of factors external to our study (e.g. increases in the number of tourists). India and Indonesia need to focus their management plan on economic tools to reduce future Pressure and improve Response. Although Cambodia has capped its total fleet size, its poor Response requires improvement to prevent future Pressure expansion. At the other end of the spectrum, the dolphin-watching industry in Philippines-2, Malaysia and Thailand pose relatively lowest risks to the target populations. Managers at these sites may consider focusing their efforts at other anthropogenic threats, particularly marine debris, fishing industry and traffic from non-tourism motorised boats.

Several tools are available to manage the Driver, the Pressure and the Response. A quota on the number of tourists and the development of alternative livelihood opportunities (Gjertsen & Niesten, 2010) could be used to manage the Driver. Boat operating permits, daily boat quotas and tradeable permits (Ellerman, 2005) are some tools available for managing the Pressure, while improving Codes of Practice, policy and enforcement may be opted for Response.

In addition to providing recommended site-specific conservation actions, the article has also provided a relative ranking of conservation priority across sites, particularly relevant for those in the same country. The two Philippines sites are the appropriate example for this article due to the short distance between them and being located in the same municipality. The final value of Philippines-1 would place it as a higher priority for the local government. The ranking can also be used to assist in conservation priority exercises across countries, particularly to understand how far the industry has developed in the region and whether the general cluster is in the high risk or the low risk area.

Model performance and improvement

Half of the future growth of the whale and dolphin-watching industry is predicted to take place in developing countries, for this industry is relatively easy to enter by fishers with little initial investment (Cisneros-Montemayor, Sumaila, Kaschner, & Pauly, 2010). Anticipating this growth, the methods described in this article are applicable to dolphin tourism industries in developing nations and where data are sparse. Our method suggests that DPSIR is useful to summarise the current nature of the industry, including financial growth, governance, and the possible saturation of the industry in a rapid and low-cost manner. The framework is useful for internal or site-specific management priority, i.e. to identify the driver, pressure, or response components that need more focus per site. The analysis also indicates which sites are facing low-level threats from tourism to enable the managers to focus on other anthropogenic threats. The article demonstrates how the industry's business model can be used to make projections of future pressure as one element of the risk indicator. The forward-looking nature of the model helps site managers and conservation agents understand what measures they should take now to address future concerns.

Our model has some limitations. Future research should refine our simplified version of the industry's business model to more accurately project future pressure, especially at sites with independent boat drivers. For example, we assumed that dolphin-watching tourism is a perennial rather than a seasonal activity. If the industry is seasonal, independent boat drivers have the opportunity to supplement their boat driving income with other sources of income outside the dolphin-watching season. This opportunity would raise the relative attractiveness of participating in the dolphin-watching industry by reducing the opportunity cost. We also assumed that alternative employment to driving boats (i.e., the opportunity cost) is readily available. However, if unemployment rates[3] in the studied countries are sizeable, i.e. the boat drivers may not necessarily find alternative employment, which raises the attractiveness of the industry that leads to a higher future pressure. Conversely, if boat drivers are of higher skill, their opportunity cost is likely to be higher, making the industry less attractive to a boat driver,

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[3] Though data on the official unemployment rate are available for the six countries (World Bank, 2016), it is a poor indicator of employment availability in developing countries (i.e., defining one hour work per week as already being employed (Willemyns, 2016)). Hence, we did not use it in our modelling. If a better indicator of the availability of employment were available, it could be easily incorporated in the model.

reducing future pressure. Finally, if data on projected tourism growth were available, they could be easily included in the model, predicting its effect on future pressure.

The categorisation of the Pressure indicator (total fleet size per km^2) was arbitrary. Discussions with other experts are needed to refine the categories. The accuracy of the risk indicator would be enhanced if future values of the Status were available. Changes to Status (projected changes to the IUCN status of the species) can be easily incorporated into the model. Adjustments are needed to improve the model for other settings or other wildlife tourism cases. Boat drivers in developed countries or urban areas (e.g. large ports) in developing countries may have higher skills and hence different opportunity costs, hence the Driver assumptions have to be modified. The number of boats might have to be adjusted with regards to boat size; large tourist boats with more than 20 passenger capacity might need to be treated differently from small fishing boats prominently featured in this article. For other wildlife tourism sites: the boats might be replaced with whale shark snorkelers/divers (Yohana, 2014) or rainforest walking track users (Turton, 2005).

Our method is comparable to the quantitative DPSIR analysis by Gerven, et al. (2007), where a simple computation of several elements is used to achieve a final score (although other applications have used addition instead of multiplication). The simplicity and intuitive nature of our method brings a different benefit to more complex quantitative computations, e.g., fuzzy logic (Phillis & Andriantiatsaholiniaina, 2001, also using Pressure-State-Response in the computation). Our method is simple enough in its current form to be used by tourism managers or conservation strategists with basic mathematics/accounting skills. Nevertheless, we still recommend model improvement to include more than one DPSIR indicator per component (e.g., more than one Driver or Pressure) in the future.

Conclusion

Wildlife-based tourism can both promote conservation of the environment, while also posing a threat to the species it targets. Tourism is often touted as a friendly alternative to consumptive uses of wildlife and natural ecosystems. However, notwithstanding the cost, the industry's willingness to manage the wildlife and natural ecosystems sustainably depends on the availability of evidence, or at least the likelihood, of the industry's impact on the target species.

We used the Driver-Pressure-State-Impact-Response (DPSIR) framework to build an overall risk indicator to gauge the risk of a dolphin-watching industry harming, displacing or causing a local extinction to a target dolphin population. Rather than relying on ecological data, this tool relies on human dimension data, which is often more easily available. We used the fleet size of the dolphin-watching industry as a proxy for the pressure exerted on the dolphins by the industry. We built a stylised version of the business model of the industry to understand the Drivers of industry growth, which determines future Pressure. We used the local IUCN-status of the dolphin population as a proxy for the State and the existence of and if so compliance to a Code of Practice for the Response. We developed risk ratings for each component and then defined the overall risk indicator (or in DPSIR terms the impact) as the product of (future) pressure, state and response.

Our examination of the seven Asian dolphin-watching locations shows (1) where the risks to the welfare of local dolphin populations is highest (at the Indian and Indonesian sites) and (2) how that risk can be best managed by targeting the main contributing component(s) to the

overall risk score. In both the Indian and the Indonesian sites, the overall high risk is a combination of high pressure and poor response. The introduction of and compliance to a Code of Practice would significantly reduce the pressure on the local dolphin populations.

Our overall risk indicator and its components facilitate an easier and much-needed understanding of tourism sustainability. Our results are encouraging and we believe that our indicators and the accompanying framework are realistically applicable for wildlife tourism assessment more broadly, particularly in developing countries where funding is limited and ecological data are either insufficient or absent.

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Tables and figures

Table 1 The Driver-Pressure-State-Response used to predict the likely impact of dolphin-watching industries in South and Southeast Asia

No	DPSIR component	Value†	Remarks (also see Table 3 for C and S)
1	**DRIVER**: Development potential of the dolphin-watching industry	0	$\dfrac{\text{Market saturation fleet size (S)}}{\text{Total fleet size (C)}} \leq 0.75$ $\dfrac{\text{Market saturation fleet size (S)}}{\text{Total fleet size (C)}} \leq 0.75$
		1	$0.75 < \dfrac{\text{Market saturation fleet size (S)}}{\text{Total fleet size (C)}} \leq 1.25$
		2	$1.25 < \dfrac{\text{Market saturation fleet size (S)}}{\text{Total fleet size (C)}} \leq 1.75$
		3	$1.75 < \dfrac{\text{Market saturation fleet size (S)}}{\text{Total fleet size (C)}} \leq 2.25$
		4	$2.25 < \dfrac{\text{Market saturation fleet size (S)}}{\text{Total fleet size (C)}} \leq 2.75$
		5	$\dfrac{\text{Market saturation fleet size (S)}}{\text{Total fleet size (C)}} > 2.75$
2	**PRESSURE**: Number of boats per km^2 of the usual cetacean watching area	0	0 boats per km^2
		1	$0 < x \leq 5$ boats per km^2
		2	$5 < x \leq 10$ boats per km^2
		3	$10 < x \leq 15$ boats per km^2
		4	$15 < x \leq 20$ boats per km^2
		5	> 20 boats per km^2
3	**STATE:** IUCN-based local assessment	0	n.a.
		1	Least Concern (LC)
		2	Near Threatened (NT)
		3	Vulnerable (VU) or Data Deficient (DD)
		4	Endangered (EN)
		5	Critically Endangered (CR)
4	**RESPONSE:** Code of Practice (including at least: 1) the distance between the dolphins and the boats, 2) the boat speed, 3) the number of	0	A ban on dolphin-watching tourism
		1	Compliance of all five elements, with or without legal instruments
		2	Enforcement of all five elements; with 100% compliance

boats around the dolphins, 4) the driving conducts and 5) the boat positioning around the dolphins)	3	Enforcement of some or all elements; not necessarily 100% compliance
	4	Sporadic implementation of all five elements; not enforced
	5	Code of Practice absent or just being discussed

† These values can also be interpreted as follows: 0 = zero risk; 1 = very low risk; 2 = low risk; 3 = medium risk; 4 = high risk; 5 = very high risk

Table 2 Summary information on study sites†

Site (country)	Location, water body type	Target species	Annual visitors	Fleet size	Ticket price	Regulation
Cambodia	Mekong River, Kampi Village, Kratie	Irrawaddy dolphin	24 134	26	USD 4.8	Statutory
India	Chilika Lagoon, Orissa	Irrawaddy dolphin	154 036	900	INR 224	None
Indonesia	Coast, Lovina, Bali	Spinner dolphin*, Risso's dolphin, Fraser's dolphin, pantropical spotted dolphin, bottlenose dolphin, short-finned pilot whale	42 000	179	IDR 60 000	None
Malaysia	Santubong Bay & estuary, Sarawak	Irrawaddy dolphin*, finless porpoise, Indo-Pacific humpback dolphin	1 875	11	RM 160	Voluntary
Philippines –1	Balicasag Island, Bohol	Spinner dolphin, Fraser's dolphin, bottlenose dolphin	11 700	120	PHP 392	None
Philippines –2	Pamilican Island, Bohol	Spinner dolphin, Fraser's dolphin, bottlenose dolphin	3 900	12	PHP 392	Voluntary
Thailand	Coast, Khanom, Nakhon Si Thammarat	Indo-Pacific humpback dolphin, finless porpoise, Irrawaddy dolphin, Bryde's whale	10 000	83	THB 1 100	None

Note:
† See Table 3 for years quoted and other details for annual visitors, fleet size, and ticket price (which may vary depending on number of people per boat and nationality)
* Main target species

Table 3 Predicted business outlook of the dolphin-watching tourism industry in South and Southeast Asia (all figures in local currencies where applicable)

Site (year of data collection):	Cambodia (2014)	India †† (2010/2011)	Indonesia (2008/2009)	Malaysia (2014)	Philippines-1 † (2013)	Philippines-1 ‡ (2013)	Philippines-2 † (2013)	Philippines-2 ‡ (2013)	Thailand (2013)
Operator structure:									
Operator uses boat driver				✓	✓	✓	✓	✓	
Operator is boat driver	✓	✓	✓						✓
General Information:									
Core dolphin-watching area coverage	2	12	4.4	16	36	36	128	128	10
Annual # dolphin tourists (= A)	24 134 §	154 036	42 000	1 875	11 700	6 300	3 900	2 100	10 000
Average # tourists per boat trip (= B)	6.5	6	3.2	8	4	18	4	18	7
# Current fleet size (= C)	26	900	179	11	120	90	12	8	83
Currency	USD	INR	IDR	MYR	PHP	PHP	PHP	PHP	THB
Ticket price per tourist (= D)	4.8 §	224	60 000	160	392	231	392	231	1 100
# Income dep. boat drivers per trip (= E)	1	1	1	1	2	3	3	5	2
Boat revenues:									
Revenue per boat trip: B x D (= F)	31	1 344	192 000	1 280	1 567	4 039	1 567	4 039	7 700
# Boat trips per year: A / B (= G)	3 713	25 673	13 125	234	2 925	360	975	120	1 429
# Trips per year per boat: G / C (= H)	143	29	73	21	24	4	81	15	17
Annual revenue per boat: F x H (= I)	4 477	38 338	14 078 212	27 273	38 188	16 155	127 292	60 581	132 530
Boat costs:									
Fuel cost per trip (= J)	2.5	170	5 000	100	500	1 150	500	1 150	375
Annual fuel costs: H x J (= K)	357	4 849	366 620	2 131	12 188	4 600	40 625	17 250	6 454
Annual boat maintenance costs (= L)	35	456	200 000	2 500	4 000	15 000	4 000	15 000	6 000
Annual tax / contribution (= M)	0	5 705	1 099 978	0	4 875	3 500	0	0	861
Annual wage costs (= N)				10 200	16 165	3 979	80 826	24 870	
Annual cost per boat K+L+M+N (= O)	392	11 011	1 666 598	14 831	37 228	27 079	125 451	57 120	13 315
Annual net revenues:									
Net revenue per boat: I – O (= P)	4 085	27 327	12 411 615	12 442	960	- 10 924	1 840	3 461	119 215
Net revenue per boat driver: P / E (= Q)	4 085	27 327	12 411 615						59 608
Business outlook:									
Opportunity cost boat driver (= R) †††	954	28 191	10 714 750						68 796
Market saturation fleet size (= S)	108	872	207	21	149	24	17	9	72
Market saturation fleet size (S) / Current fleet size (C) ‡‡	4.15 §§	0.97	1.16	1.91	0.82	0.82	1.30	1.30	0.87
Current Driver (risk value)	1 §§	1	1	3	1	1	2	2	1

† Figures refer to bridge type of boats used by the dolphin-watching tourism industry.

‡ Figures refer to canter type of boats used by the dolphin-watching tourism industry.

†† D'Lima et al (2016)

††† Opportunity costs are established calculating the average annual income that a low skilled worker can earn in the locality if not employed as a boat driver. Figures are based on Pattnaik and Kobayashi (2009) for Chilika, World Bank (2015) for Cambodia, NSO (2013) for Thailand and BPS Buleleng (2013) for Indonesia.

‡‡ For Philippines-1 and Philippines-2 this ratio represents the location as a whole, e.g. for Philippines-1 it is (149 + 24) / (120 + 90).

§ Consists of 9,270 domestic and 14,864 international dolphin tourists (unpublished data, Kratie Department of Tourism). Domestic tourists pay USD 10 per boat (groups up to 10), while international tourists pay USD 9 per person if 1 or 2 people per boat, or USD 7 per person if more than 2 people per boat. The reported ticket price per tourist is a weighted average.

§§ Market entry in Cambodia is legally restricted to 26 boats (the current fleet size). Hence the reported market saturation fleet size is a hypothetical fleet size for Cambodia if free entry prevailed, which in reality does not; the Driver score for Cambodia is therefore set equal to 1 (i.e. a stable fleet size).

Table 4 Industry economic performance and subsequent market entry/exit projections (+ means industry participation is financially attractive, – means industry participation is financially unattractive)

Site	Industry economic performance		Driver (see Supplementary Table 1)	Fleet size	
	Tour operator (net revenues)	Independent boat driver (surplus income)		Current, total	Market saturation
Cambodia		+ USD 3,131	1	26	108 †
India		– INR 864	1	900	872
Indonesia		+ IDR 1,696,865	1	179	207
Philippines-1 – bridge	+ PNP 960		1 §	120	149
Philippines-1 – canter	– PNP 10,924		1 §	90	24
Philippines-2 – bridge	+ PHP 1,840		2 §	12	17
Philippines-2 – canter	+ PHP 3,461		2 §	8	9
Malaysia	+ MYR 12,422		3	11	21
Thailand		– THB 9,188	1	83	72

† The reported market saturation fleet size for Cambodia is a hypothetical fleet size in case free market entry prevailed. In reality, fleet size is restricted to 26.

§ The Philippines Drivers were obtained by dividing the combined numbers for bridge and canter boats per site instead of individually calculating the Driver by boat type.

Table 5 The risks of dolphin-watching industries to dolphin populations in South and Southeast Asia

Site	Current Pressure		Future Pressure		Current State	Future Response	Risk indicator
	# boats per km^2	Value‡	# boats per km^2	Value‡	Value‡	Value‡	
Philippines-1 †	5.8	2	4.8	1	3	4	12
India	75.0	5	72.7	5	5	4	100
Cambodia	13.0	3	13.0	3	5	4	60
Thailand	8.3	2	7.2	2	3	1	6
Indonesia	40.7	5	47.1	5	3	5	75
Philippines-2 †	0.2	1	0.2	1	3	2	6
Malaysia	0.7	1	1.3	1	3	3	9

† Fleet size used is the sum of canter and bridge boats.

‡ As per Table 1.

Table 6 Other human activities that may pose threats to the dolphins targeted by dolphin-watching industries in South and Southeast Asia

| Other possible threats	Philippines-1	India	Cambodia	Thailand	Indonesia	Philippines-2	Malaysia
Sewage	possibly exists	exists	exists	possibly exists	possibly exists	possibly exists	exists
Debris	possibly exists	exists	exists	possibly exists	**known threat**	does not exist	**known threat**
Non-tourism motorised boats	**known threat**	exists	**known threat**	**known threat**	exists	exist	**known threat**
Fishing industry	Exists	exists	**known threat**	**known threat**	exists	exists	**known threat**
Other tourism activities	**known threat**	does not exist	exists	does not exist	exists	does not exist	exists
Habitat destruction	does not exist	**known threat**	**known threat**	possibly exists	does not exist	does not exist	possibly exists
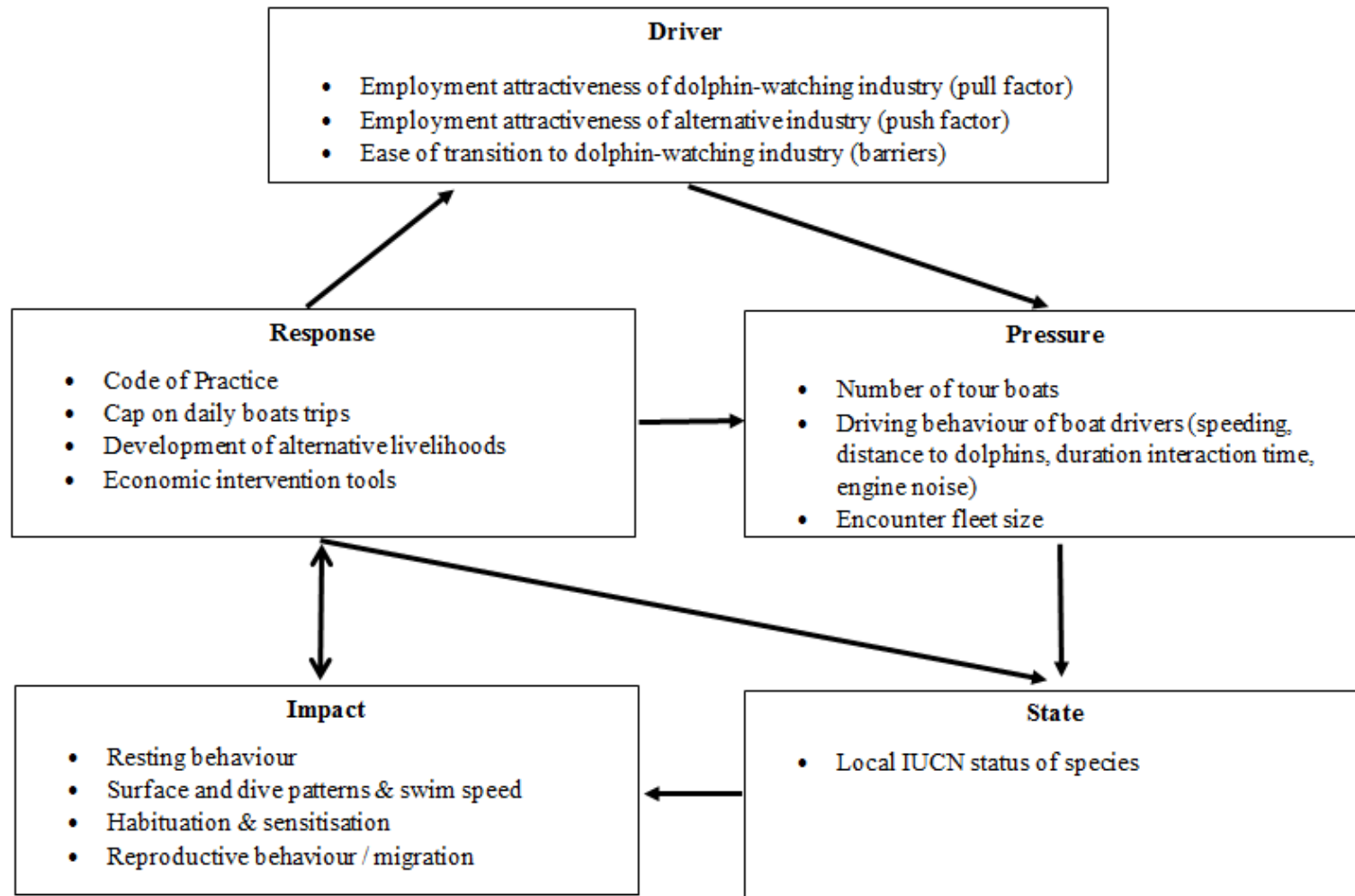
Figure 1 The DPSIR framework used in this article (adapted from Atkins, Burdon, Elliot, and Gregory (2011) and Niemeijer and de Groot (2008))
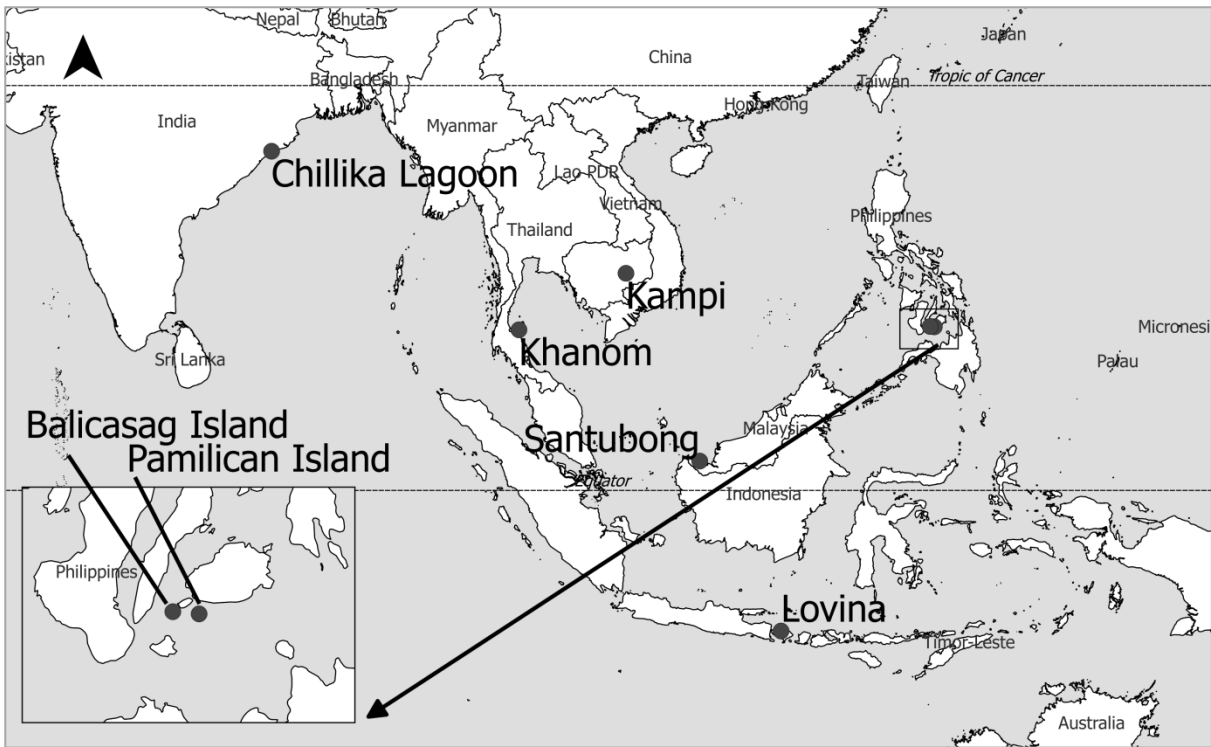
Figure 2 The location of the seven dolphin-watching sites in this paper