Dolphin-watching tourism and indo-Pacific humpback dolphins (Sousa chinensis) in Sanniang Bay, China: impacts and solutions

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SHORT COMMUNICATION

Dolphin-watching tourism and indo-Pacific humpback dolphins (*Sousa chinensis*) in Sanniang Bay, China: impacts and solutions

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Abstract
Cetacean-watching tourism has become an economically important recreation industry, but can compromise cetacean viability and hence tourism sustainability. While current management tactics pay much attention on industrialized cetacean-watching tourisms, impacts of tours operated by motorized boats in inshore waters are seldom discussed. This study investigated the spatial and temporal activities of dolphin-watching tours in Sanniang Bay, China, where tours specifically focus on Indo-Pacific humpback dolphins (*Sousa chinensis*). The primary boat-dolphin interaction directly overlaps with a core habitat of humpback dolphins. Average tour duration was shorter than 40 min and approximately one third of time was spent on following dolphins. Monthly tour activities were extremely high in February, early May, August, and October that corresponded to Chinese national festivals. An eastward shift of primary interaction site during high-tour-activity months implies a long-term tour impacts on habitat use of humpback dolphins in northern Beibu Gulf. We urge a collaboration and coordination between boat captains, tour managers, maritime administrative, academic teams, and NGOs to systematically collect tour statistics in Sanniang Bay, including daily tour and visitor numbers, encounter duration and locations, and unsustainable maritime activities. As eco-tourisms targeting humpback dolphins and other coastal cetaceans adopting small motorized boats are rapidly growing in southeastern Asia, management guidelines involving codes of conduct, allowable daily trips, and sustainable tourism tactics are urgently needed before the tourism becomes industrialized and economically oriented. Variables and statistics presented in this study can provide a baseline proxy to help design management guidelines to minimize unsustainable impacts on the target animals.

Keywords *Sousa chinensis* · Sustainability · Tour impact · Management · Tour activity

Introduction

Ecotourism to see the whales, dolphins, or porpoises in their natural habitat is becoming an economically important recreational activity (Corkeron 2004; Hoyt 2001, 2009). Each year, more than 13 million tourists participate in cetacean-watching trips, which bring in more than 2.1 billion US$ and employ more than 13,000 people in over 100 countries (O'Connor et al. 2009; Cisneros-Montemayor et al. 2010). Profits from cetacean-watching tourism have shifted cetacean exploitation from lethal to non-lethal (Orams 2001; Einarsson 2009; Cisneros-Montemayor et al. 2010; Cunningham et al. 2012), facilitating public awareness to protect cetacean species (Muloin 1998; Stamation et al. 2007; Ballantyne et al. 2009; Chen 2011) and greatly improving economic status in many sites (Parsons et al. 2003; Mustika et al. 2012). However, in some cases, industrialized cetacean-watching has impacted the viability of the target animals (Bejder et al. 2006a, b; Matsuda

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et al. 2011; Visser et al. 2011; Seuront and Cribb 2011; Tseng et al. 2011; Parsons 2012), from changes in behavioral patterns (Lusseau 2003; Constantine et al. 2004; Stockin et al. 2008; Matsuda et al. 2011; Visser et al. 2011), and habitat use (Tezanos-Pinto et al. 2013) to alteration of social/community structures (Lusseau et al. 2006). Finding a practicable management tactic that balances profits for humans and adverse consequences to the animals has become an increasingly important issue (Lusseau and Higham 2004; Higham et al. 2008; Neves 2010; Kur and Hvenegaard 2012).

Approaches to sustainable cetacean-watching tourism range from implementing command-control mechanisms by governments to voluntary obedience of tourists and operators to tour guidelines (Birnie 1985; Carlson 2001; Lien 2001; Garrod and Fennell 2004; Allen et al. 2007; Kessler and Harcourt 2013). These approaches primarily aim to mitigate cetacean-watching impacts through use of a code of conduct (Gjerdalen and Williams 2000; Carlson 2001; Lien 2001; Garrod and Fennell 2004; Allen et al. 2007) that restrict the impacts of tour activities (operational control), such as limitations on access and following target animals (Carlson 2001; Garrod and Fennell 2004; Duprey et al. 2008; Piwetz et al. 2012). Other tactics, such as maximum allowable tours (or tourists) per unit time (the volume control), or allocating different tour boats to different animal groups to reduce disturbance (the disturbance-disperse control), are seldom discussed.

The Indo-Pacific humpback dolphin (*Sousa chinensis*) specifically inhabits near-shore shallow waters (Jefferson and Karczmarski 2001; Jutapruet et al. 2015; Chen et al. 2016; Jefferson and Smith 2016; Wu et al. 2017), and is now considered Vulnerable under IUCN guidelines (Jefferson and Smith 2016). Throughout its range, tours focusing on humpback dolphins have been reported at Sanniang Bay in China (Chen et al. 2016; Wu et al. 2017, Fig. 1), the central west Gulf of Thailand (Jutapruet et al. 2015), western Hong Kong waters (Ng and Leung 2003; Piwetz et al. 2012), and Malaysia (Mustika et al. 2016). Potential disturbance from these dolphin-watching activities has not yet been assessed at all these sites. Management generally adopts voluntary codes of conduct by tour guidelines (Piwetz et al. 2012), but their true efficacy remains questionable.

In Sanniang Bay, an important habitat of humpback dolphins in China (Zhu 2012; Chen et al. 2016; Wu et al. 2017), dolphin-watching tourism has been growing rapidly since 2004 though long-term census on tour activities has not been conducted yet. At first, dolphin-watching tourism was run by local fishermen using their own fishing boats. A fishermen-based company was then established and it adopted small high-speed boats with outboard engines (7 m long, traveling at speeds over 40 km/h) to run dolphin-watching tourism (Fig. 1). The use of small high-speed boats in accessing humpback dolphins prompts concerns over the acoustic impact from outboard engines (Li et al. 2015).

Fig. 1 Photos showing typical dolphin-watching tourism in Sanniang Bay (SNB), Guanxi Province, China

One of the critical questions to assess the disturbance from dolphin-watching tourism is if tour activities exceed an upper threshold at which adverse consequences become apparent (Mustika et al. 2012; Santos 2016). This threshold may be used as an operating proxy for tour operators to coordinate tour boats and adjust operating measures that minimize likely impacts on the dolphins. In present study, the MAT based on currently applied codes of conduct on humpback dolphin tourism in Sanniang Bay was derived and used to evaluate if current tour activities have adverse effects on dolphins. Based on the results, we proposed management tactics to mitigate likely impacts of dolphin-watching tourism on the target animals. Recommendations made from this study can also be applicable to other locations.

Materials and methods

In the present study, we investigated both spatial and temporal characteristics of dolphin-watching boat activities at Sanniang Bay. As the tour guidelines involve codes of conduct that temporally and spatially restrict the tour boat activities, we based the maximal allowable tours per day per dolphin group

(MAT) on these codes and used this MAT as a proxy to evaluate if current tourism activities reached a harmful level.

Study site

The study region encompasses the waters near Sanniang Bay (21.618˚N, 108.767˚E), the Dafengjiang River Estuary and adjacent Qinzhou Bay, in the central coast of Guanxi Province, China (Fig. 2). The Dafengjiang River Estuary area is recognized as a core habitat of Indo-Pacific humpback dolphins (Chen et al. 2009, 2016; Wu et al. 2017). Habitat type in this region is primarily sandy/muddy seabed (Zhu 2012; Tong et al. 2012). Principal taxa of fish fauna include several types known to be prey of humpback dolphin, such as *Leiognathus* and species in the families Clupeidae, Engraulidae, and Sciaenidae (Zhu 2012).

Dolphin-watching tour activities

Tour statistics including number of dolphin-watching tours per day (DWT), location (GPS records) where the boat encountered and followed humpback dolphins, duration (in minutes) of each tour (T_t), and time following the dolphin group (T_f), were logged by tour boat captains from January 2013 to December 2015. The dolphin-watching activities in SNB were measured by the sum of DWT in a month (DWT_M) and the ratio between the days in a month that had $DWT \geq 1$ (DWD) and month days (DWD/MD, MD: month days). To figure the main areas where dolphin-watching boats interacted with humpback dolphins, 50% kernel density estimate (50% KDE) of encounters was estimated to represent the primary interaction site (50% KDE).

To determine if the dolphin-watching activities likely reach a harmful level, a threshold value, the maximal allowable tours per day per dolphin group (MAT), was derived based on local tourist guidelines: “Within 500m diameter around the humpback dolphin, only one boat is allowed to follow the dolphin group for shorter than 20 min.” Based on this rule, the maximal allowable boats per dolphin group per hour were three. We assumed that the dolphin-watching tours run from 8:00 AM to 18:00 PM, 10 h in total. The MAT value was thus 30 boat trips per day per dolphin group. We referenced this

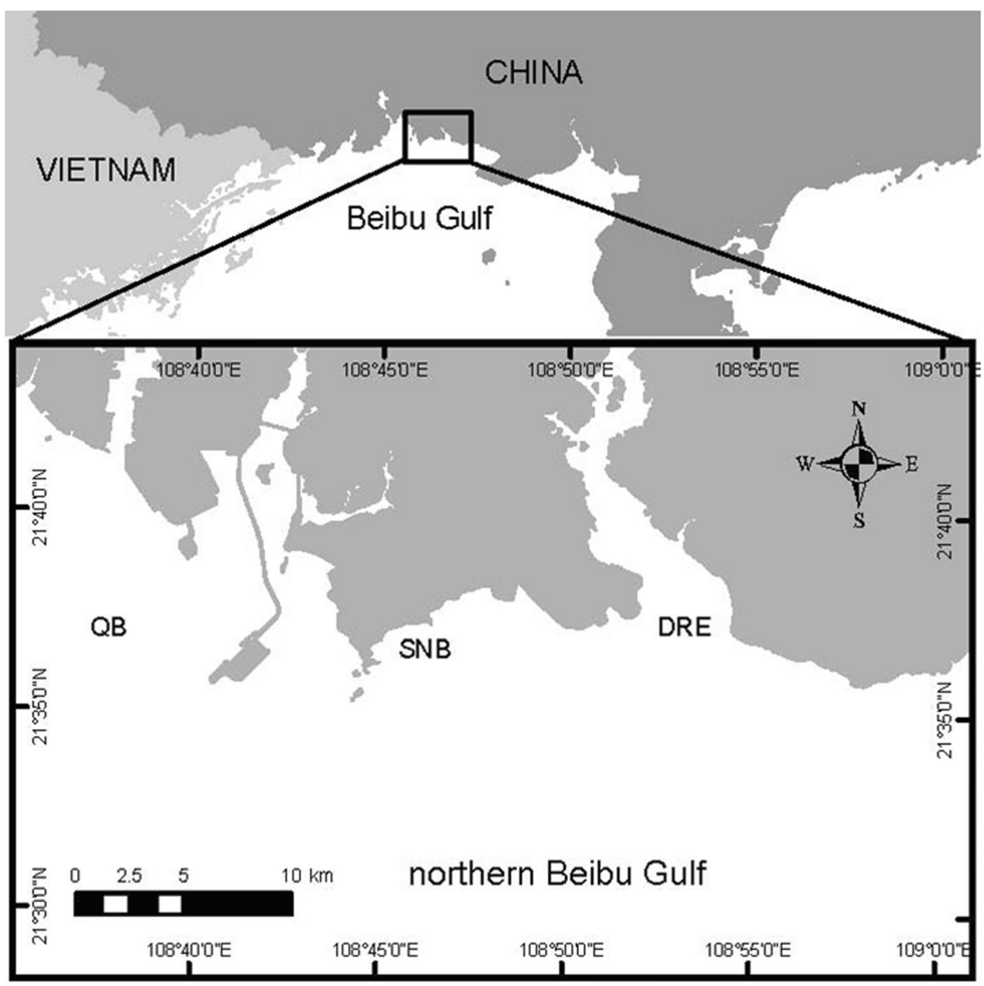

Fig. 2 The study site, including Sanniang Bay (SNB), Dafengjiang River Estuary (DRE), and Qinzhou Bay (QB)

value as a baseline and counted the number of the days in a month that had DWT ≥ 30, which was defined as high-volume DWD (DWD_V). The likely influence of dolphin-watching tours on humpback dolphins ($I_{m,\ y}$, m, y: months and years of investigations) was thus measured by

$$I_{m,y} = \sqrt{\frac{DWDv_{m,t}}{MD_{m,y}}} \tag{1}$$

Out of 12 months in a year, 4 months (February, May, August, and October) were particularly concerned due to their associations with long festivals in China: the Chinese New Year Festival (in February), Labor Day (in early May), summer vacation (August), and National Day (October), which potentially imposes higher tour impacts on humpback dolphins than other months. Differences of primary interaction site and $I_{m,\ y}$ between high- and low-tour-activity months were inspected accordingly.

Results

From January 2013 to December 2015, a total of 9227 dolphin-watching tours were logged. Out of 390 humpback dolphins encounters, 234 encounters were logged from tours in February, May, August, and October, the high-tour-activity months (Fig. 3a) and 154 encounters were recorded from tours in low-tour-activity months (Fig. 3b). Monthly encounters from high-tour-activity months were significantly higher than encounters from low-tour-activity months ($\chi^2 = 26.33$, $p < 0.01$). During high-tour-activity months, primary boat-dolphin interactions concentrated on the Dafengjiang River Estuary (Fig. 3c). During low-tour-activity months, in contrast, humpback dolphin encounters happened across the waters between Sanniang Bay and Dafengjiang River Estuary and concentrated on the western part of core distribution site of humpback dolphins (Fig. 3d). The difference of primary interaction sites implied an eastward shift of humpback dolphin occurrences during high-tour-activity months. Average T_t(tour duration) was 37.7 min (±SD 12.7 min) and T_f was 12.7 min (±SD 9.0 min), accounting for 33.7% of tour duration (Table 1). Differences of T_f between high- and low-tour-activity months were not significant (t test = 0.937, $p = 0.35$).

Annual number of DWTs was 3902 trips in 2013, 2788 trips in 2014, and 2537 trips in 2015. Monthly dolphin-watching activities fluctuated widely (Fig. 4), from a maximum of 1275 DWTs in October 2013 (Fig. 4a, Table 2) to a minimum of 25 DWTs in December 2015 (Fig. 4c, Table 2). Standardized to month days, dolphin-watching activities varied from 9.68% month days in January 2014 to 87.1% month days in October 2013 (Fig. 5a). Monthly DWD_V/DWD ratio was highest in February, April–May, August, and October

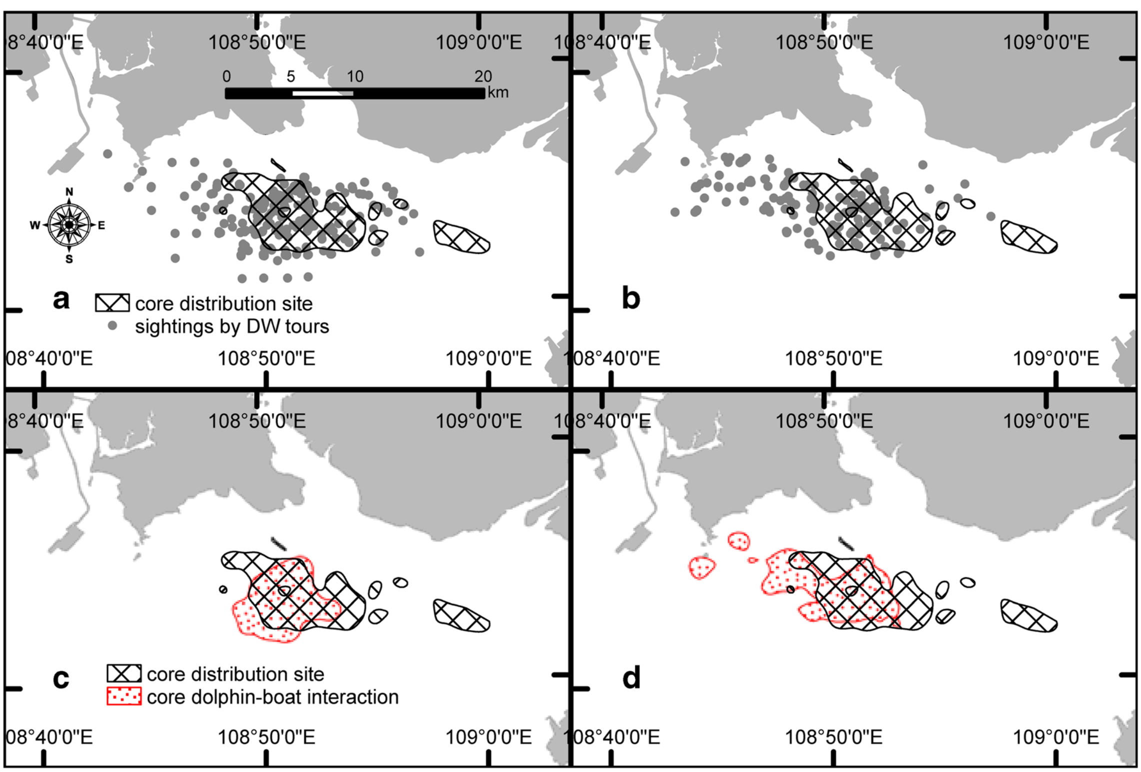

Fig. 3 Humpback dolphin encounters during **a** high- and **b** low-tour-activity months. High-tour-activity months were refereed to February, May, August, and October that correspond to Chinese New Year Festival, Labor's Day, summer vacation, and National Day in China. Primary boat-dolphin interaction sites in **c** high- and **d** low-tour-activity months were presented by 50% KDE of humpback dolphin encounters

Table 1 Durations (in minutes) per dolphin-watching tour (T_t) and time following dolphins (T_f)

	Mean (±SD)	Median	Min	Max	n
T_t	37.7 (±12.7)	40	20	90	124
T_f	12.7 (±9.0)	10	3	72	97

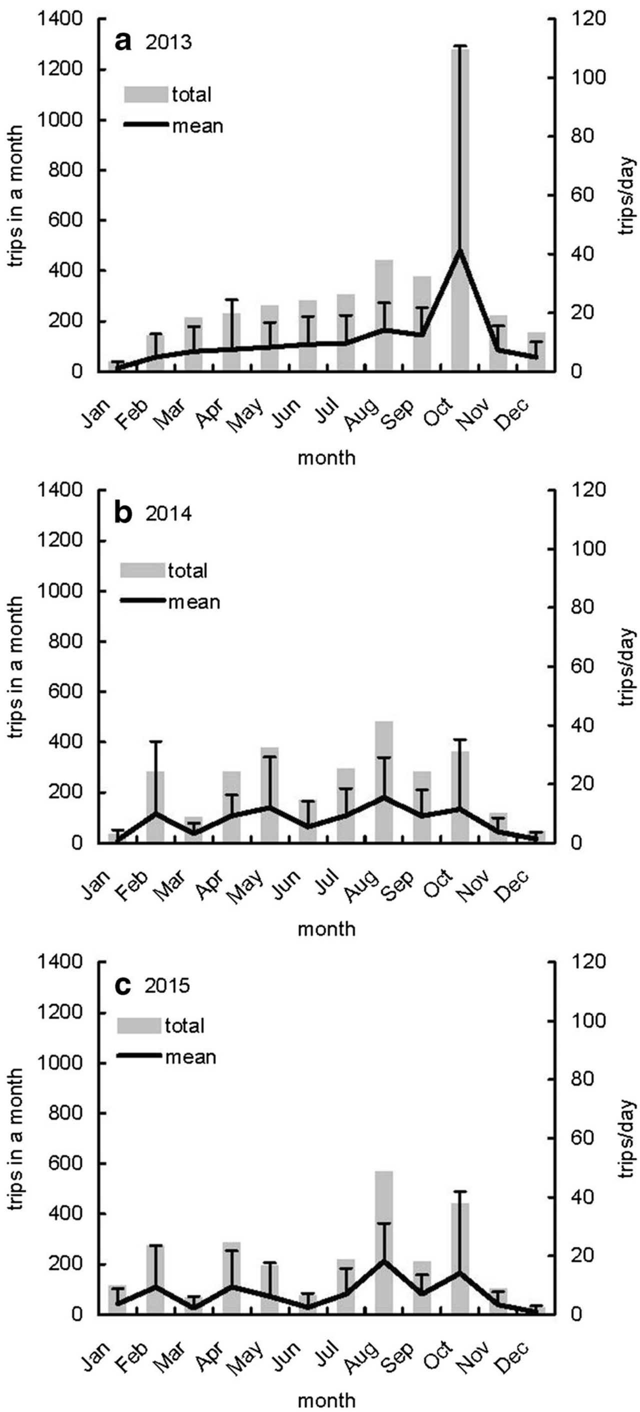

Fig. 4 Monthly dolphin-watching activities, including total trips in a month and average trips per day, in 2013 (**a**), 2014 (**b**), and 2015 (**c**)

(Fig. 5b), with no significant annual variation (Kruskal-Wallis test = 0.546, $p = 0.76$). Pooling records in 2013, 2014, and 2015 together, four I_m peaks were observed in February, May, August, and October (Fig. 6), which indicated high impacts of tour activities during four national festivals.

Discussion

This study collected tour statistics (DWT, humpback dolphins encounters, T_t and T_f) from captains' reports. For the four tour-activity variables, encounters of humpback dolphins were most likely subject to a spatial sampling bias that captains repetitively visited the same humpback dolphin group in a day and conducted more frequent tours on the same area during festival days. The derived "50% KDE of encounters" cannot be literally interpreted into a core habitat of humpback dolphins even if these two sectors were highly overlapped (Wu et al. 2017). Instead, the derived 50% KDE of encounters indicated the sector where boat-dolphin interactions were frequent and hence tour impacts on humpback dolphins were potentially high. Moreover, the primary boat-dolphin interaction sites were different in low- and high-tour-activity month, which implies a long-term consequence of dolphin-watching activities on humpback dolphins by changing their distribution and habitat use patterns.

Accurate tour statistics are essential for evaluating tourism impacts on humpback dolphins and implementing effective managements on dolphin-watching tours. In this study, numbers of tours per day, particularly those in festival days, are likely understated by boat captains. Meanwhile, boats from sites other than Sanniang Bay were not counted though this number might be numerically low. The potential impact of dolphin-watching tours presented in this study was therefore a lower bound rather than true estimation. To inform the sustainable management of dolphin-watching tourism, tour statistics such as tour numbers, encounter sites, following duration, and number of boats following should be registered daily and organized by tour managers. This action, however, is never implemented even though the dolphin-watching tourism has been conducting for more than a decade.

Tourism targeting humpback dolphin watching and other nature resources is recommended as a surrogate of livelihood conversion to mitigate fishery impacts for the humpback dolphin conservation in northern Beibu Gulf. Implementation of this tactic should be cautious in causing collateral consequences on humpback dolphins, which highly depends on feedbacks of accurate tour statistics. Collection of accurate tour statistics requires collaboration of boat captains, tour managers, and management administrative and can be integrated in the context of citizen science. In biodiversity conservation over a wide spatial scale, citizen science has become an important approach informing conservation baselines and

Table 2 Summary of tour activities of dolphin watching in Sanniang Bay, China, from 2013 to 2015, including annual and monthly (mean ±SD) dolphin-watching tours (DWTs) and dolphin-watching days (DWDs), percentage of dolphin-watching days in a month (%DW, mean±SD), and percentage of high-volume days (%DWD$_V$) in monthly DWDs (mean±SD)

Year	DWTs	DWDs	%DW	%DWD$_V$
2013	3902 325±SD 317	235 46±SD 60	64.4%±SD 15.67%	11.1%±SD 8.74%
2014	2788 232±SD 140	205 40±SD 53	56.2%±SD 21.66%	13.2%±SD 15.93%
2015	2537 211±SD 160	216 40±SD 55	59.0%±SD 18.65%	11.6%±SD 12.78%

facilitating regional conservation awareness (Davies et al. 2012; Embling et al. 2015; Chandler et al. 2017; Dennis et al. 2017; Chen et al. 2019; Peter et al. 2019). In this context, eco-tour operators can be a cost-effective platform accommodating ecological education that associates tourists with local livelihoods and biodiversity conservation (Stamation et al. 2007; Kur and Hvenegaard 2012; García-Cegarra and Pacheco 2017) and monitoring unsustainable maritime activities. In this manner, a better management strategy for the dolphin-watching tourism in Sanniang Bay can associate the boat captains and tour managers with local education and maritime activity surveillance, which requires assistance and coordination from maritime administrative, academic teams, and NGOS (Neves 2010; Mayer et al. 2018).

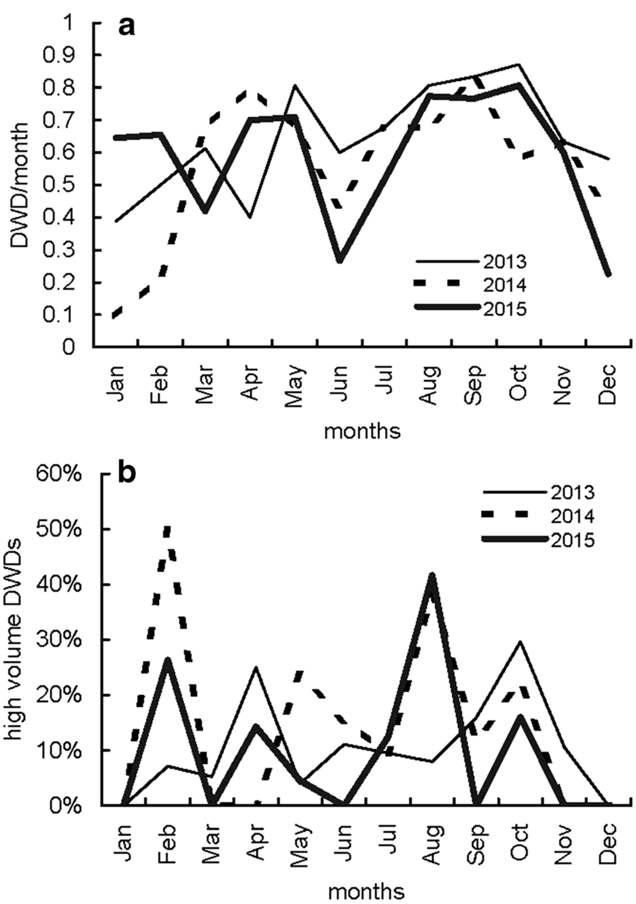

Fig. 5 Monthly ratio of dolphin-watching days (DWD) to month days (**a**), and high-volume days (days DW trips > 30) to DWD (**b**)

Current costs of dolphin-watching tours per tourist generally range between 200 RMB (equivalent to approximate 33 U$D) and 250 RMB, including both tickets (150RMB) and other consumables (estimated between 50 and 100RMB), though accurate expenses are still under investigation. Multiplying this expense by 8 tourists per boat (as in Fig. 1a) and the annual DWTs number (from 2537 to 3902), the annual capital capacity of dolphin-watching tourism in Sanniang Bay is estimated to range from 4 million to 7.8 million RMB (equivalent to 680,000 to 1.3 million US$) per year. This estimate, however, does not include expenses from those tourists who visited the village, but did not join dolphin-watching tours. Thus, actual capital volume related to dolphin-watching tourism in Sanniang Bay could be much higher. This profit capability relies on the persistence of the humpback dolphin population, sound protection of major humpback dolphin habitat at Dafengjiang River Estuary, and sustainable management on dolphin-watching activities. For the sustainable development, this dolphin-watching tourism requires accurate statistics on numbers of tours, visitors, and humpback dolphin records, as previously described. Boat captains and

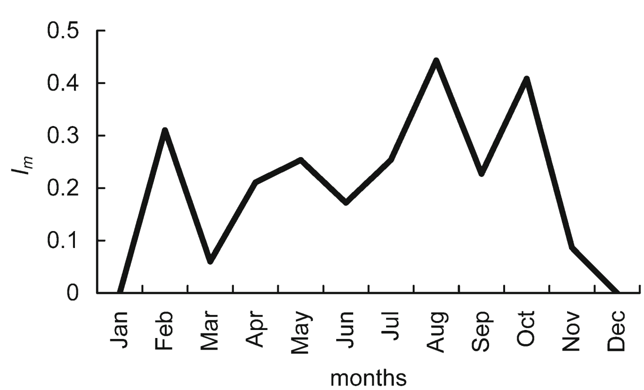

Fig. 6 Likely influence of dolphin-watching tours on humpback dolphins (I_m) between 2013 and 2015, which showed four peaks in Febuary, May, August, and October when impacts of tour activities were high

tour managers in Sanniang Bay, however, are not aware of this, even since this tourism has been running for more than 10 years. This information and action gap needs to be solved immediately.

Impacts of inadequately regulated cetacean-watching activities on the target animals can include behavioral disturbance (Constantine et al. 2004), spatial competition (Tezanos-Pinto et al. 2013), and disintegrating social structure (Lusseau et al. 2006). While acoustic evidence suggests likely behavioral disturbance of dolphin-watching boats on humpback dolphins (Li et al. 2015), the frequent arrival, following, and leaving of dolphin-watching boats in the Dafengjiang River Estuary may further intensify the impact of spatial competition and behavioral disturbance on the dolphins. The eastward shift of dolphin encounters during high-tour-activity months implies these likely impacts can be influential, though their actual long-term consequences demand further investigation.

Compared with boat-animal interaction in other whale/dolphin-watching sites, such as the killer whale (*Orcinus orca*) in coastal British Columbia, Canada, average 46 min (Jelinski et al. 2002), or the Hector's dolphin (*Cephalorhynchus hectori*) in Porpoise Bay, New Zealand, average 78 min (Bejder et al. 1999), the following duration for the dolphin-watching tour in Sanniang Bay, average 12.7 min, seems to be numerically short. This short following duration, however, does not guarantee a "low impact" of dolphin-watching tours (Bejder et al. 2006b) but indicated a frequent arrive-and-leave operation tactic. This frequent arrive-and-leave operation tactic may impose great noise disturbances to humpback dolphins (Li et al. 2015). For the bottlenose dolphin (*Tursiops* sp.) in Shark Bay, Western Australia, the average following duration, 10.63 min (Bejder et al. 2006a), was even shorter than the present study (average 12.7 min) but still cause significant long-term influences on behavior status, individual communication, and population abundance (Bejder et al. 2006a, 2006b; Heiler et al. 2016). Indeed, the eastward shift of primary boat-dolphin interaction sites during high-tour-activity months may be associated with the behavioral response to the frequent arrive-and-leave operations. It is our concern that this consequence may have long-term effect on habitat uses of humpback dolphins in northern Beibu Gulf.

Within current tour guidelines, "Within 500m diameter around the humpback dolphin, only one boat is allowed to follow the dolphin group for shorter than 20 min," the MAT will be numerically 30 trips per day for the entire Sanniang Bay. Under this standard, each boat would merely run one trip per day. Field observation indicates that there can be multiple dolphin groups in the region between Sanniang Bay and Dafengjiang River Estuary at the same time (Wu et al. 2017). Current dolphin-watching tactics, on the other hand, target the same sighting group throughout the entire day, which imposes great behavioral disturbances. Technically, MAT, as well as the allowed tours per boat per day, can increase if the dolphin-watching boats can disperse to target different dolphin groups. This approach requires a better efficiency to locate different dolphin groups and coordinate various boats on different dolphin groups. The use of drones may provide a potential solution here. We suggest adopting this mechanism to locate different dolphin groups and disperse boats to different dolphin groups to increase tour efficiency. Implementation of this "disperse tactic" is not restricted to common days when tour activities are low but also applicable to months with high tour activities. This tactic will require a sophisticated coordination between tour managers and boat captains.

We are highly concerned that extremely high DWTs on national festival days have imposed long-termed impacts on dolphins. In the national festival periods (the Chinese New Year Festival, Labor Day, summer vacation, and National Day), 30–50% of tourism activities exceeded the allowable upper bound. In October 2013, more than 200 trips were logged in a single day and this number can be understated. On these days, the situation of several boats aggregated around one dolphin group (as indicated in Fig. 1) was very common and the dolphin-watching tours followed this process: each day the first trip went to find the dolphins (the scout trip), then, the same location and dolphin group was continuously revisited in following tours and simultaneously surrounded by multiple boats. Similar operating approaches were also reported in other dolphin-watching locations (Coscarella et al. 2003), which results in intense impact on the target animals. On these high DWT days, behavioral disturbance from dolphin-watching boats can be intense. Measures to reduce and minimize the likely impact and disturbance of dolphin-watching tours need further consideration.

Industrialized cetacean-watching tourism generally utilizes magnificent ships to carry dozens or hundreds of tourists in one trip to maximize the profit efficiency. This big boat–based tourism, however, may be less adaptable to humpback dolphin habitats than small motorized boats or fishing vessels due to generally shallow depths ranging between 2 and 5 m (Jutapruet et al. 2015; Wu et al. 2017). To maximize the profit efficiency, the boat number can become high when humpback dolphin tourism is becoming industrialized and economically oriented. Similar tourism pattern also happens in the central west of Gulf of Thailand (Jutapruet et al. 2015) but the scale and impact is still moderately low (Mustika et al. 2016). In other areas, such as the west coast of Taiwan and the western Pearl River Estuary, dolphin-watching tourism has also been proposed, or recently started. Management guidelines involving allowable daily trips and sustainable tourism tactics are urgently needed before these humpback dolphin–watching tourism becomes industrialized and economically oriented. Variables and statistics presented in this study can provide a baseline proxy to help design management guidelines and strategies for dolphin-watching tourism to minimize unsustainable impacts on the target animals.

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