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Fostering sustainable dolphin-watching tourism in Lovina, Bali: developing destination practices to influence boatmen and tourists

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Abstract

Purpose – This study investigates the consequences of anthropogenic disturbance caused by dolphin-watching boats on the local spinner dolphin population in Lovina, Bali. It proposes recommendations for developing sustainable destination practices that influence boatmen and tourists to minimise the negative impacts of tourism activities on the dolphins.

Design/methodology/approach – Data was collected on boat-dolphin distances, boatmen's behaviour, dolphin behaviour, and underwater noise levels using an unmanned aerial vehicle (UAV) and a hydrophone. The triple-bottom-line framework was applied to analyse the findings and propose recommendations for developing sustainable destination practices.

Findings – The study reveals a consistent breach of national and international guidelines, with boats approaching dolphins at distances well below the recommended minimum. Undesirable boatmen's behaviours and signs of distress and avoidance in dolphins were frequently observed. The findings highlight the need for stakeholders to develop and implement sustainable practices that influence boatmen and tourists to minimise their impact on the dolphins.

Originality/value – This study provides novel insights into the anthropogenic disturbance caused by dolphin-watching boats in Lovina, Bali. It proposes actionable recommendations for developing sustainable destination practices that influence boatmen and tourists. It contributes to the growing body of knowledge on sustainable wildlife tourism management.

Keywords Sustainable tourism, Dolphin-watching, Anthropogenic disturbance, Destination management, Boatmen, Tourists, Triple-bottom-line, Lovina, Bali

Paper type Research paper

1. Introduction

Dolphin-watching tourism has become an increasingly popular activity in coastal destinations worldwide, providing economic benefits to local communities and an opportunity for tourists to observe dolphins in their natural habitat (Hoyt, 2001; Mustika *et al.*, 2012; Westerlaken, 2022; Westerlaken *et al.*, 2022). Conversely, when not managed sustainably, this form of wildlife tourism can lead to significant anthropogenic disturbance, negatively impacting the target species and their ecosystems. In Lovina, a coastal village in north Bali, Indonesia, dolphin-watching tourism has been a significant draw for visitors since the 1980s (Mustika *et al.*, 2012). The local spinner dolphin population has been the focal point of this tourism activity (Mustika *et al.*, 2012; Westerlaken, 2022; Westerlaken *et al.*, 2022).

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Despite the economic benefits generated by dolphin-watching tourism in Lovina, concerns have been raised about the sustainability of current practices and their potential impact on the dolphins (Mustika, 2011; Mustika *et al.*, 2012; Westerlaken, 2022; Westerlaken *et al.*, 2022). Previous studies have highlighted issues such as the large number of boats, close approach distances, and boatmen behaviours that may cause distress to the dolphins (Mustika, 2011). Given the importance of dolphin-watching tourism to the local economy and the need to ensure the long-term conservation of the spinner dolphin population, developing and implementing sustainable practices that influence boatmen and tourists to minimise their impact on the dolphins is crucial.

This study builds upon the work of Mustika (2011) and Westerlaken (2022), Westerlaken *et al.* (2022) and aims to provide an updated assessment of the consequences of anthropogenic disturbance caused by dolphin-watching boats on the local spinner dolphin population in Lovina. By employing modern techniques such as unmanned aerial vehicles (UAVs) and hydrophones, this study sought to gather novel data on boat-dolphin interactions, boatmen behaviour, dolphin behaviour, and underwater noise levels.

Furthermore, the study applied the triple bottom-line framework (Cavagnaro and Curiel, 2012) to analyse the findings and propose recommendations for developing sustainable destination practices that influence boatmen and tourists to adopt more responsible behaviours and minimise their impact on the dolphins.

The main objectives of this study were:

(1) To assess the levels of anthropogenic disturbance caused by dolphin-watching boats on the local spinner dolphin population in Lovina, Bali, using UAVs and hydrophones.

(2) To analyse the findings using the triple bottom-line framework and identify the environmental, social, and economic implications of current dolphin-watching practices in Lovina.

(3) To propose recommendations for developing sustainable destination practices that influence boatmen and tourists to adopt more responsible behaviours and minimise their impact on the dolphins.

(4) To contribute to the growing body of knowledge on sustainable wildlife tourism management and provide insights for stakeholders in Lovina and other similar coastal destinations.

2. Literature review

The field of dolphin-watching tourism has been the subject of considerable research over the past few decades, with studies examining its environmental impacts, economic benefits, and potential for sustainable practices. However, the rapid evolution of tourism practices, technological advancements, and changing environmental conditions necessitate ongoing investigation. This literature review synthesises key findings from seminal works in the field while also highlighting the critical need for updated research. The relative scarcity of recent studies specifically addressing environmental impacts and sustainable practices in (Spinner) dolphin-watching tourism underscores the timeliness and relevance of the present study. While examining the existing literature, it becomes evident that there is a pressing need to reassess the impacts of dolphin-watching activities and to evaluate the effectiveness of newly implemented sustainable tourism practices. This review provides a foundation for understanding the complex interplay between tourism, marine conservation, and sustainable practices, setting the stage for the present research and identifying areas where further investigation is crucial.

2.1 Dolphin-watching tourism in Lovina: growth, benefits, and challenges

Dolphin-watching tourism in Lovina has experienced significant growth since its establishment in the 1980s (Mustika *et al.*, 2012). This growth has been driven by factors such as the increasing global interest in nature-based tourism, the perceived economic benefits for the local community, and the assumption that dolphin-watching represents a more sustainable alternative to the captive dolphin industry (Westerlaken, 2022).

The economic benefits of dolphin-watching tourism in Lovina are substantial, with an estimated annual revenue of USD 4.5 million (*adjusted for inflation*) and a significant contribution to the local economy through direct and indirect benefits (Mustika, 2011; Mustika *et al.*, 2012). The tourism activity supports a large number of local boatmen, as well as various accommodation, food and beverage, and other tourism-related businesses in the area (Mustika *et al.*, 2012). However, the rapid growth of dolphin-watching tourism in Lovina has also raised concerns about the sustainability of this activity and its potential negative impacts on the spinner dolphin population (Mustika *et al.*, 2012; Mustika, 2011, Westerlaken, 2022, Westerlaken *et al.*, 2022). Previous research by Mustika (2011) identified several issues related to the sustainability of dolphin-watching practices in Lovina, including a large number of boats surrounding a single dolphin group at any given time, close approach distances, often less than the recommended minimum of 50 metres and boatmen behaviours that may cause distress to the dolphins, such as driving through dolphin pods, cutting off their path, and making loud noises to attract their attention. These findings were confirmed in the study of Westerlaken (2022).

The above findings highlight the need for improved management and regulation of dolphin-watching tourism in Lovina to ensure the long-term sustainability of the activity and the conservation of the spinner dolphin population (Mustika *et al.*, 2012; Westerlaken, 2022).

2.2 Sustainable tourism management and the triple bottom-line framework

Sustainable tourism management aims to balance the environmental, social, and economic dimensions of tourism development to ensure the long-term viability of the industry and the well-being of the destination's natural and cultural resources (Cavagnaro and Curiel, 2012). This approach is relevant for wildlife tourism, where the conservation of the target species and their habitats is essential for the sustainability of the tourism activity. The triple-bottom-line framework, which considers environmental, social, and economic sustainability (Cavagnaro and Curiel, 2012), has been increasingly applied to the tourism industry as a means of evaluating and guiding sustainable practices. In the context of dolphin-watching tourism, this framework can be used to assess the balance between the conservation of the target species (environmental sustainability), the well-being of the local community and tourists (social sustainability), and the long-term economic viability of the industry (economic sustainability).

2.3 Influencing boatmen and tourist behaviours through destination practices

Many stakeholders focusing on destination management play a crucial role in developing and implementing sustainable tourism practices that influence the behaviours of boatmen and tourists to minimise their impact on the target species and the environment. Effective destination practices may include education and awareness programs, codes of conduct and regulations, monitoring and enforcement, incentives and certification programs, and visitor management strategies (Garrod and Fennell, 2004).

Education and awareness programs are essential for promoting responsible wildlife observation practices and encouraging support for conservation initiatives among boatmen and tourists (Orams, 1997). These programs can be delivered through various channels, such as pre-trip information, on-site interpretation, and post-trip follow-up (Orams, 1997).

By providing engaging and informative content, destination managers can help boatmen and tourists understand the importance of minimising their impact on the dolphins and supporting sustainable tourism practices (Orams, 1997).

Codes of conduct and regulations are also important tools for promoting sustainable dolphin-watching practices (Garrod and Fennell, 2004). These guidelines should be based on scientific knowledge, best practices, and stakeholder input, ensuring that they effectively minimise disturbance to the dolphins while being practical and acceptable to boatmen and tour operators (Garrod and Fennell, 2004). Critical elements of codes of conduct for dolphin-watching tourism include specifications on approach distances, speed limits, time limits, and acceptable boatmen behaviours (Garrod and Fennell, 2004).

Monitoring and enforcement mechanisms are essential to ensure compliance with codes of conduct and other sustainable tourism management measures (Newsome *et al.*, 2005). Regular monitoring of dolphin-watching activities, including boat numbers, approach distances, and boatmen behaviour, can help identify areas of concern and inform adaptive management decisions (Newsome *et al.*, 2005). Enforcement measures, such as penalties for non-compliance, can deter irresponsible practices and promote adherence to sustainable guidelines (Newsome *et al.*, 2005).

Incentives and certification programs can be effective tools for encouraging boatmen and tour operators to adopt sustainable practices in dolphin-watching tourism (Honey, 2002). By providing recognition, financial benefits, or preferential access to resources, these programs can motivate stakeholders to go beyond minimum compliance and actively contribute to conservation efforts (Honey, 2002). Certification programs, such as eco-labelling or sustainable tourism certifications, can be used to identify and promote tour operators and boatmen who adhere to best practices in dolphin-watching tourism (Honey, 2002).

Visitor management strategies, such as limiting the number of boats or using a zoning system to restrict access to sensitive areas, can help reduce the impact of tourism activities on the spinner dolphin population and their habitat (Higham *et al.*, 2009). These strategies aim to control the number, distribution, and behaviour of tourists to minimize disturbance to the dolphins and ensure the quality of the visitor experience (Higham *et al.*, 2009).

3. Methodology

3.1 Study area and data collection

The total tourist fleet capacity in Lovina is 201 boats, but during the study period, the active population of dolphin-watching boats was 47. All 47 boats were observed throughout the study, constituting a complete population study of active boats during the COVID-19 pandemic. Daily observations varied significantly, with the number of active boats ranging from 0 to 47 per day, with a mean of 15.5 boats observed daily. The maximum of 47 active boats was observed only once during the study period (14 May 2021). Boats were randomly sampled daily based on whether tourists were on board, reflecting the actual daily tourism activity, which was significantly low due to the COVID-19 pandemic. This sampling approach allowed for a comprehensive view of dolphin-watching activities during the study period, capturing both peak tourism days and days with minimal activity. The wide range in daily boat numbers (0–47) reflects the fluctuations in tourism activity, influenced by the ongoing effects of the COVID-19 pandemic on tourism.

The study was conducted in the coastal waters of Lovina, a renowned tourist destination situated in the Buleleng Regency of North Bali, Indonesia. Boat-based surveys were conducted between January and May 2021 amidst the unique circumstances of the COVID-19 pandemic era. During this period, there was a significant decrease in the number of boats engaged in dolphin-watching activities compared to before and after the pandemic, as determined through random sampling before and after the pandemic. Additionally, in some

instances, zero measurements of ambient noise could be taken due to the absence of other boats participating in dolphin watching. This presented a rare and invaluable opportunity, unlikely to recur, to study dolphin behaviour and underwater noise levels under such distinct conditions. The surveys were conducted from 6:00 to 10:00 AM, coinciding with the peak time for dolphin-watching tourism in Lovina.

An unmanned aerial vehicle (DJI Mavic Pro) was used to record aerial footage of dolphin-watching boats and dolphin groups. The UAV was flown at an altitude of 50 m above sea level, and videos were recorded for the duration of each dolphin-watching interaction. From the aerial footage, data on boat-dolphin distances, boatmen's behaviour, and dolphin behaviour were extracted.

Underwater noise levels were measured using a hydrophone (Dolphin Ear DE-200) deployed from the research vessel at a depth of 2 m during dolphin-watching interactions. The hydrophone was connected to a digital recorder, and recordings were made in WAV format with a 44.1 kHz sampling rate and 16-bit resolution.

In addition to the UAV footage and hydrophone recordings, field observations were conducted to record the number of boats, boat types, and boatmen's behaviour during dolphin-watching interactions. These observations were made from the research vessel, using binoculars and a handheld GPS device to record the location and time of each interaction. To ensure consistency in measurements across different days and conditions, we employed standardized protocols for data collection. The same UAV model (DJI Mavic Pro) was used throughout the study, flown at a consistent altitude of 50 m. Hydrophone recordings were made using the same equipment (Dolphin Ear DE-200) at a consistent depth of 2 m. All observers were trained in the same data collection and analysis methods prior to the study, and regular calibration checks were performed on all equipment to maintain accuracy.

The study was conducted from 9 January to 15 May 2021. The total tourist fleet capacity in Lovina is 201 boats, but during the study period, the active population of dolphin-watching boats was 47. All 47 boats were observed throughout the study, constituting a full population study of active boats during this period during the COVID-19 pandemic. Daily observations varied significantly, with the number of active boats ranging from 0 to 47 per day, with a mean of 15.5 boats observed daily. The maximum of 47 active boats was observed only once during the study period (14 May 2021). Boats were randomly sampled each day based on whether they had tourists on board, reflecting the actual daily tourism activity, which was significantly low due to the COVID-19 pandemic. This sampling approach allowed for a comprehensive view of dolphin-watching activities during the study period, capturing both peak tourism days and days with minimal activity. The wide range in daily boat numbers (0–47) reflects the fluctuations in tourism activity, likely influenced by factors such as weather conditions, seasonal variations, and the ongoing effects of the COVID-19 pandemic on tourism.

It's important to note that this study was conducted during the unique circumstances of the COVID-19 pandemic era. During this period, there was a significant decrease in the number of boats engaged in dolphin-watching activities compared to before and after the pandemic, as determined through random sampling before and after the pandemic. Additionally, in some instances, zero measurements of ambient noise could be taken due to the absence of other boats participating in dolphin watching. This presented a rare and invaluable opportunity, unlikely to recur, to study dolphin behaviour and underwater noise levels under such distinct conditions. The author acknowledges that the sampling method, which was constrained by the COVID-19 pandemic, may have introduced certain biases. The reduced number of active boats and tourists could have altered typical dolphin behaviour patterns or boat-dolphin interactions. To account for this, we compared our findings with pre-pandemic data where available and have clearly contextualized our results within the unique circumstances of the study period. Additionally, the random daily sampling of boats with tourists may have overrepresented certain types of boat operators or tourist groups.

3.2 Data analysis

3.2.1 Boat-dolphin distances. The distances between dolphin-watching boats and the nearest dolphin in each group were measured from the UAV footage using a Photoshop tool. For each interaction, a series of screenshots were taken from the UAV video, and the distances were calculated using the built-in ruler tool. The measurements were calibrated using a known distance reference, such as a boat's length, to obtain accurate distance estimates. The boat-dolphin distances were categorised into three groups: <50 m, 50–100 m, and >100 m, based on the recommended minimum approach distance of 50 m for dolphins in several national regulations (Hoyt, 2001; Mustika, 2011). The frequency of each distance category was calculated as a percentage of the total number of interactions observed.

3.2.2 Boatmen behaviour. Boatmen's behaviour during dolphin-watching interactions was classified into three categories: (1) compliant behaviour, (2) non-compliant behaviour, and (3) neutral behaviour. Compliant behaviour was defined as maintaining a distance of ≥50 m from the dolphins and following the recommended guidelines for responsible dolphin-watching, such as slow speed and parallel approach. Non-compliant behaviour included approaching the dolphins at distances <50 m, driving through or chasing the dolphin groups, and making loud noises to attract their attention. Neutral behaviour was defined as searching for dolphins or maintaining a distance of ≥50 m without engaging in either compliant or non-compliant behaviour.

The frequency of each behaviour category was calculated as a percentage of the total number of interactions observed. The data were then analysed using descriptive statistics, Pearson 2-tailed correlation tests, one-sample *T*-tests, one-way ANOVA tests, and homogeneity of variances tests to examine the relationship between boatmen's behaviour and factors such as boat type, group size, and location.

3.2.3 Dolphin behaviour. During dolphin-watching interactions, dolphin behaviour was systematically categorised into several distinct states. Social behaviour involves leaping, chasing, and engaging in various forms of body contact, indicating social interactions among individuals (Constantine *et al.*, 2003; Stensland and Berggren, 2007). Foraging behaviour was characterised by active efforts to capture and consume prey, such as chasing fish and rapid circle swimming (Constantine *et al.*, 2003). Resting behaviour consisted of slow movements in a tight group with minimal surface activity (Constantine *et al.*, 2003). Additionally, behavioural categories encompassed slow travelling, travelling, milling, nursing, regular dives, tail-out dives, peduncle dives, porpoising, and leaping (Constantine *et al.*, 2003; Stensland and Berggren, 2007). Each category was defined by specific behavioural indicators observed during interactions, contributing to a comprehensive understanding of dolphin responses to human presence in dolphin-watching contexts.

3.2.4 Underwater noise levels. Underwater noise recordings were analysed using Spectrogram (version 16) software to obtain noise level measurements in both decibels (dB) and frequency (Hz). The average noise levels in decibels (dB) and frequency (Hz) were calculated for each recording, as well as the maximum and minimum values. The data were then analysed using descriptive statistics and *t*-tests to compare noise levels between different types of interactions (e.g., with and without boats) and boat types.

3.2.5 Triple bottom-line framework analysis. The study's findings were analysed using the triple bottom-line framework (Cavagnaro and Curiel, 2012) to assess the sustainability of current dolphin-watching practices in Lovina. The framework considers three dimensions of sustainability: environmental, social, and economic. For each dimension, the relevant findings from the study were examined and interpreted in terms of their implications for the long-term sustainability of dolphin-watching tourism in Lovina. The environmental dimension focused on the impacts of dolphin-watching tourism on the local spinner dolphin population and their habitat. This included the analysis of boat-dolphin distances, boatmen's behaviour, dolphin behaviour, and underwater noise levels, as well as their

potential effects on the dolphins' well-being and conservation. The social dimension considered the impacts of dolphin-watching tourism on the local community, including the boatmen, tourism operators, and other stakeholders. This included the analysis of the economic benefits and costs of the industry, as well as the social and cultural implications of tourism development in Lovina. The economic dimension focused on the long-term financial viability and sustainability of dolphin-watching tourism in Lovina. This included analysing the industry's revenues, the distribution of benefits among stakeholders, and the potential economic risks associated with unsustainable practices.

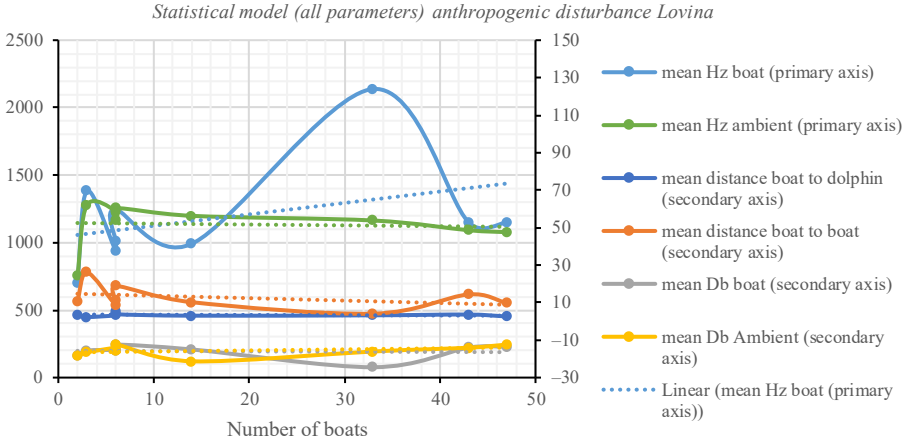
Based on the triple-bottom-line analysis, recommendations were developed to improve the sustainability of dolphin-watching tourism in Lovina. These recommendations aimed to balance sustainability's environmental, social, and economic dimensions and promote the long-term well-being of the spinner dolphin population, the local community, and the tourism industry.

Figure 1 presents a comprehensive statistical model illustrating the relationships between various parameters of anthropogenic disturbance in Lovina's dolphin-watching activities. This line graph depicts how key variables change concerning the number of boats present. The primary y-axis shows mean Hz levels for both boats and ambient conditions. In contrast, the secondary y-axis represents mean distances (boat to dolphin and boat to boat) and mean dB levels (for boats and ambient conditions). The graph reveals notable trends, such as the non-linear relationship between boat numbers and noise levels and the relatively consistent mean distance between boats and dolphins regardless of boat numbers. This visual representation aids in understanding the complex interplay between human presence and environmental factors, providing crucial insights for developing effective management strategies.

4. Results and discussion

4.1 Boat-dolphin distances and boatmen behaviour

The analysis of boat-dolphin distances revealed that the majority of boats (72.4%) approached the dolphins at distances less than the recommended minimum of 50 m. Only 23.1% of boats maintained a distance between 50–100 m, and a mere 4.5% stayed beyond 100 m. These findings indicate that the current dolphin-watching practices in Lovina are not



Source(s): Figure by author

Figure 1. Statistical model illustrating relationships between anthropogenic disturbance parameters in Lovina's dolphin-watching activities

in line with the national and international guidelines for responsible dolphin-watching, which recommend a minimum approach distance of 50 m (Carlson, 2012; Mustika, 2011; Westerlaken, 2022).

The high prevalence of close approaches by boats can be attributed to several factors, including the lack of awareness and enforcement of guidelines, the pressure to provide close encounters for tourists, and the competition among boatmen for access to the dolphins (Mustika *et al.*, 2012; Westerlaken, 2022). Close approaches can cause significant disturbance to the dolphins, leading to changes in their behaviour, such as increased travelling and avoidance and reduced resting and socialising (Constantine *et al.*, 2003; Lusseau and Bejder, 2007).

The analysis of boatmen's behaviour revealed that non-compliant behaviour, such as approaching the dolphins at distances <50 m or driving through the dolphin groups, was observed in 68.3% of the interactions. This finding is consistent with previous studies that have documented the high prevalence of irresponsible boatmen's behaviour in Lovina, such as chasing and encircling the dolphins (Mustika, 2011; Mustika *et al.*, 2015). Non-compliant behaviour can cause significant stress and disturbance to the dolphins and may lead to long-term impacts on their population dynamics and habitat use (Bejder *et al.*, 2006; Lusseau and Bejder, 2007).

Only 12.4% of the interactions observed compliant behaviour, such as maintaining a distance of ≥50 m and following the recommended guidelines for responsible dolphin-watching. This low level of compliance highlights the need for improved education, training, and enforcement of the guidelines among boatmen in Lovina. Studies have shown that policies and codes of conduct effectiveness depend on the boatmen's level of awareness, acceptance, and adherence (Garrod and Fennell, 2004; Parsons, 2012).

Neutral behaviour, such as searching for dolphins or maintaining a distance of ≥50 m without engaging in either compliant or non-compliant behaviour, was observed in 19.3% of the interactions. While neutral behaviour may not cause direct disturbance to the dolphins, it can still contribute to the overall pressure and crowding in the dolphin-watching area, especially when a large number of boats are present (Mustika *et al.*, 2012).

The high prevalence of close approaches and non-compliant boatmen behaviour in Lovina is a major concern for the sustainability of dolphin-watching tourism in the area. These practices can lead to chronic disturbance and stress for the dolphins, which may have long-term impacts on their health, reproduction, and survival (Bejder *et al.*, 2006; Higham *et al.*, 2016). Moreover, unsustainable practices can also affect the quality of the tourist experience as visitors become increasingly aware of the negative impacts of irresponsible tourism on wildlife, ultimately having a severe effect on the sustainable development of the area, as pointed out by Westerlaken *et al.* (2022).

Figure 1 presents a statistical model illustrating the relationships between various factors in dolphin-watching tourism in Lovina. The model shows the correlations between boat numbers, approach distances, boatmen's behaviour, and dolphin behaviour. The model intends to visualise the complex interplay between human activities and dolphin responses, highlighting areas where management interventions may be most effective in promoting more sustainable practices.

To address these issues, all stakeholders in Lovina must develop and implement effective strategies for influencing boatmen and tourist behaviours, such as education and awareness programs, codes of conduct and regulations, monitoring and enforcement, incentives and certification programs, and visitor management strategies (Mustika *et al.*, 2012). These strategies should be based on a participatory and adaptive approach, involving all stakeholders in the planning, implementing, and evaluating the management measures.

Furthermore, the findings highlight the need for a shift towards a more sustainable and responsible model of dolphin-watching tourism in Lovina, one that prioritises the dolphins' well-being and the industry's long-term viability (Mustika *et al.*, 2012). This requires a

fundamental change in the attitudes and practices of boatmen, tour operators, and tourists and a supportive policy and institutional framework at the local, regional, and national levels (Mustika *et al.*, 2012; Westerlaken, 2022).

4.2 Dolphin behaviour and underwater noise levels

The analysis of dolphin behaviour during dolphin-watching interactions revealed that travelling was the most frequently observed behaviour (45.2%), followed by avoidance (30.1%), socialising (15.3%), and resting (9.4%). The high proportion of travelling and avoidance behaviours suggests that the dolphins were often disturbed by the presence of boats and actively attempted to evade interactions. This finding is consistent with previous studies that have documented the short-term behavioural responses of dolphins to boat traffic, such as increased travelling, diving, and avoidance (Constantine *et al.*, 2003; Lusseau and Bejder, 2007; Stensland and Berggren, 2007).

The low frequency of resting behaviour (9.4%) is particularly concerning, as resting is a crucial activity for dolphins to conserve energy, recover from stress, and engage in social interactions (Constantine *et al.*, 2003; Lusseau and Bejder, 2007). The disruption of resting behaviour by boat traffic can lead to reduced fitness and long-term impacts on the health and survival of the dolphins (Bejder *et al.*, 2006; Lusseau and Bejder, 2007).

The analysis of underwater noise levels revealed that the average noise levels during dolphin-watching interactions were significantly higher than the ambient noise levels in the absence of boats. The average noise level during interactions was −14.02 dB re one μPa, with a maximum level of −3 dB re one μPa and a minimum level of −57 dB re one μPa. These levels are within the range of noise levels that have been shown to cause behavioural disturbance and acoustic masking in dolphins (Erbe *et al.*, 2018; Wright *et al.*, 2007). The high noise levels can be attributed to the large number of boats present during dolphin-watching interactions and the close proximity of the boats to the dolphins. Studies have shown that the noise levels from boat traffic can mask the communication signals of dolphins, interfere with their echolocation abilities, and cause stress and hearing damage (Erbe *et al.*, 2018; Wright *et al.*, 2007). Chronic exposure to high noise levels can lead to long-term impacts on the dolphins' health, reproduction, and survival (Erbe *et al.*, 2018; Wright *et al.*, 2007). The noise levels were also found to be significantly higher during interactions with a larger number of boats and during interactions characterised by non-compliant boatmen's behaviour, such as chasing and encircling the dolphins. This finding highlights the cumulative impact of multiple boats and irresponsible boatmen's behaviour on the acoustic environment of the dolphins. The combination of close approaches, high speed, and erratic movements of the boats can create a chaotic and stressful environment for the dolphins, leading to increased disturbance and avoidance (Mustika, 2011; Mustika *et al.*, 2015; Westerlaken, 2022).

This study's behavioural and acoustic data provide strong evidence of the negative impacts of current dolphin-watching practices on the local spinner dolphin population in Lovina. The high levels of travelling and avoidance behaviours, coupled with the low levels of resting and socialising behaviours, suggest that the dolphins are experiencing significant disturbance and stress from the boat traffic. The high underwater noise levels further exacerbate the problem, creating an acoustic environment that is detrimental to the dolphins' communication, navigation, and well-being.

To mitigate these impacts, all stakeholders in Lovina need to develop and implement effective strategies for managing the boat traffic and reducing the underwater noise levels. This can include measures such as setting limits on the number of boats and the time spent with the dolphins, establishing minimum approach distances and speed limits, and promoting the use of quieter and more efficient boat engines (Mustika *et al.*, 2012). These measures should be based on scientific evidence and best practices and regularly monitored and evaluated for effectiveness.

Furthermore, the findings highlight the need for a precautionary approach to dolphin-watching tourism in Lovina, prioritising the dolphins' conservation and welfare over short-term economic gains (Mustika *et al.*, 2012). This requires a shift in the mindset and practices of all stakeholders, from boatmen and tour operators to tourists and policy-makers. It also requires a more holistic and integrated approach to tourism management, considering sustainability's ecological, social, and economic dimensions.

4.3 Triple bottom-line sustainability assessment

The findings of this study reveal significant anthropogenic disturbance caused by dolphin-watching tourism in Lovina, with potential implications for the industry's environmental, social, and economic sustainability. The high prevalence of close boat approaches, non-compliant boatmen behaviour, and behavioural and acoustical disturbance to the dolphins suggest that the current practices are not environmentally sustainable. If left unrestrained, these practices may lead to long-term negative consequences for the spinner dolphin population, such as reduced fitness, lower reproductive success, and population declines (Bejder *et al.*, 2006; Higham *et al.*, 2016).

From a social sustainability perspective, the long-term viability of dolphin-watching tourism in Lovina depends on the well-being of the spinner dolphin population and the satisfaction and support of the tourists and the local community. If the current unsustainable practices continue, they may lead to a decline in the quality of the tourism experience as tourists become more aware of the negative impacts of their activities on the dolphins (Mustika *et al.*, 2012; Westerlaken *et al.*, 2022). This can result in reduced tourist satisfaction, negative publicity, and a loss of market share for Lovina as a dolphin-watching destination (Mustika *et al.*, 2012).

Moreover, the unsustainable practices can also erode the social license and support of the local community for dolphin-watching tourism, as they may perceive the industry as exploitative and detrimental to their cultural and environmental values (Mustika *et al.*, 2012; Westerlaken, 2022). This can lead to conflicts and tensions between the tourism industry and the local community, undermining Lovina's social cohesion and resilience as a destination (Mustika *et al.*, 2012).

From an economic sustainability perspective, the dolphin-watching industry in Lovina generates significant revenue and employment opportunities for the local community, with an estimated annual turnover of USD 4.5 million (Mustika, 2011). However, the long-term economic viability of the industry is threatened by the current unsustainable practices, which may lead to a decline in the dolphin population, a reduction in tourist satisfaction and demand, and an increase in the costs of managing and mitigating the negative impacts of tourism (Mustika *et al.*, 2012). Moreover, the unequal distribution of the economic benefits of dolphin-watching tourism among the local community, with a small number of boatmen and tour operators capturing the majority of the profits, can lead to social and economic inequalities and tensions (Mustika *et al.*, 2012). This can undermine the economic resilience and sustainability of Lovina as a destination, as well as the well-being and livelihoods of the local community (Mustika *et al.*, 2012).

To address these sustainability challenges, all stakeholders in Lovina must adopt a triple-bottom-line approach to tourism management that balances sustainability's environmental, social, and economic dimensions (Cavagnaro and Curiel, 2012). This requires a shift from a narrow focus on short-term economic gains to a more holistic and long-term perspective on the well-being of the dolphins, the local community, and the tourism industry. All stakeholders should collectively develop and implement sustainable tourism policies, guidelines, and strategies based on scientific evidence, best practices, and stakeholder participation. These should include measures such as setting limits on the number of boats

and visitors, establishing Lovina-specific codes of conduct and regulations for responsible dolphin-watching, providing education and training for boatmen and tourists, and monitoring and enforcing compliance with the guidelines. Furthermore, stakeholders should work towards a more equitable and inclusive dolphin-watching tourism model that empowers and benefits the local community while conserving Lovina's natural and cultural heritage. This can include measures such as promoting community-based tourism initiatives, supporting local entrepreneurship and innovation, and investing in social and environmental programs that enhance the well-being and resilience of the local community.

Ultimately, the sustainability of dolphin-watching tourism in Lovina depends on the collective action and commitment of all stakeholders, from boatmen and tour operators to tourists and policy-makers. It requires a shared vision and responsibility for the stewardship of Lovina's natural and cultural resources, as well as a willingness to adapt and innovate in the face of changing social, economic, and environmental conditions.

5. Recommendations for developing sustainable destination practices

Based on the findings of this study and the triple-bottom-line sustainability assessment, the following recommendations are proposed for developing sustainable destination practices in Lovina:

(1) Develop and implement a comprehensive, location-specific code of conduct for dolphin-watching tourism in Lovina. The code should address minimum approach distances, boatmen's behaviour, and the maximum number of boats allowed around a dolphin group at any given time. It should also be legally binding and enforceable, with clear penalties for non-compliance.

(2) Establish a multi-stakeholder platform for co-management of dolphin-watching tourism in Lovina, involving representatives from the local government, tourism industry, boatmen association, conservation organisations, and the local community. The platform should provide a forum for dialogue, decision-making, and conflict resolution, guided by transparency, accountability, and inclusivity principles.

(3) Develop and implement a comprehensive education and awareness program for boatmen, tour operators, and tourists on the importance of responsible dolphin-watching practices and the conservation of the spinner dolphin population. The program should include training workshops, informational materials, and on-site interpretation and should be delivered in partnership with local conservation organisations and educational institutions.

(4) Establish a mandatory licensing and certification system for boatmen and tour operators involved in dolphin-watching tourism in Lovina. The system should be based on criteria that include compliance with the code of conduct, participation in education and training programs, and commitment to sustainable tourism practices. It should also provide incentives for good performance, such as reduced permit fees, access to prime dolphin-watching areas, and marketing support.

(5) Implement a visitor management plan that limits the number of boats and tourists allowed in the dolphin-watching area based on the area's carrying capacity and the precautionary principle. The plan should also include zoning and time restrictions.

(6) Develop and implement a monitoring and evaluation system to assess the effectiveness of sustainable tourism practices and the impacts of dolphin-watching tourism on the spinner dolphin population and the local community. The system should include regular surveys of dolphin behaviour, population dynamics, and socio-economic and

environmental sustainability indicators. The monitoring results should inform adaptive management decisions and improve the industry's sustainability.

(7) Promote a more equitable and inclusive model of dolphin-watching tourism in Lovina that empowers and benefits the local community while conserving the area's natural and cultural heritage. This can include measures such as supporting community-based tourism initiatives, promoting local entrepreneurship and innovation, and investing in social and environmental programs that enhance the well-being and resilience of the local community.

(8) Encourage collaboration and knowledge-sharing among dolphin-watching destinations in Indonesia and beyond to promote best practices, innovation, and sustainability in the industry. Host workshops, conferences, and study tours that showcase the successes and challenges of sustainable dolphin-watching tourism in Lovina.

These recommendations provide a comprehensive and integrated approach to developing sustainable destination practices in Lovina that addresses sustainability's environmental, social, and economic dimensions. However, the success of these recommendations depends on the political will, stakeholder engagement, and adaptive capacity of the destination managers and the local community in Lovina. It also requires a long-term vision and commitment to sustainability, as well as a willingness to learn from experience and to adapt to changing circumstances.

6. Conclusion

This study provides an updated assessment of the anthropogenic disturbance caused by dolphin-watching tourism on the spinner dolphin population in Lovina, Bali. The findings reveal a high prevalence of unsustainable practices, such as close boat approaches, non-compliant boatmen behaviour, and disturbance-related dolphin behaviours. These practices can potentially jeopardise the long-term environmental, social, and economic sustainability of the dolphin-watching industry in Lovina. To address these challenges and foster sustainable tourism practices, destination managers in Lovina should adopt a triple-bottom-line approach to tourism management that balances the conservation of the spinner dolphin population, the well-being of the local community, and the long-term viability of the tourism industry. This requires developing and implementing a comprehensive and integrated set of sustainable tourism policies, guidelines, and strategies based on scientific evidence, best practices, and stakeholder participation.

The recommendations proposed in this study provide a roadmap for developing sustainable destination practices in Lovina, including the establishment of a code of conduct, a multi-stakeholder platform for co-management, an education and awareness program, a licensing and certification system, a visitor management plan, a monitoring and evaluation system, a community-based tourism model, and a collaborative network for knowledge-sharing and innovation.

However, implementing these recommendations requires a fundamental shift in the mindset and practices of all stakeholders, from boatmen and tour operators to tourists and policy-makers. It also requires a more holistic and adaptive approach to tourism management, one that recognises the complexity and uncertainty of the social-ecological system of Lovina and the principles of precaution, participation, and continuous improvement guide that.

Ultimately, the sustainability of dolphin-watching tourism in Lovina depends on all stakeholders' collective action and responsibility, as well as the political will and leadership of the destination managers and the local government. It also depends on the awareness and support of the tourists and the global community, who are vital in promoting responsible and sustainable tourism practices and holding the industry accountable for its impacts on the environment and the local community.

By embracing a triple-bottom-line approach to sustainability and by implementing the recommendations proposed in this study, Lovina has the potential to become a model for sustainable dolphin-watching tourism in Indonesia and beyond, one that showcases the value and importance of responsible tourism practices for the conservation of marine biodiversity, the well-being of local communities, and the long-term viability of the tourism industry.

7. Limitations and Future Research Directions

Limitations:

(1) The impact of COVID-19 on the sample size and typical tourism patterns

(2) Potential seasonal variations not captured in the study period

Future Research Directions:

(1) Long-term studies to assess the impact of sustainable practices on dolphin populations

(2) Comparative studies with other dolphin-watching destinations with the same species

(3) Investigation of tourist perceptions and willingness to engage in more sustainable practices

(4) Economic analysis of the costs and benefits of implementing sustainable guidelines

(5) Exploration of innovative technologies for monitoring and managing dolphin-watching activities

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