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Research Article

Exploring the potential of interview-based sighting history to estimate the abundance of a coastal dolphin

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ABSTRACT

Estimating the population abundance of marine wildlife is fundamental for developing evidence-based management strategies. However, standard field-based methods for estimating marine animal abundance can be time-consuming and costly, and may not effectively monitor populations over long time frames or large spatial scales. In this study, we attempted to utilize local ecological knowledge (LEK) to estimate population abundance of a marine mammal by collecting interview-based sighting data from a large-scale fisher questionnaire survey in mainland China for the Indo-Pacific humpback dolphin (*Sousa chinensis*). To validate our findings, we compared this information with data obtained from standard field surveys published in the literature. Despite the inability to accurately predict absolute abundance, all four indices (encounter rate, encounter rate in the past decade, sighting frequency, and mean annual sightings in the past five years) derived from interview sighting history had a highly significant correlation with abundance rank from field survey. In addition, the severe population declines and identified causes (water pollution, habitat destruction, overfishing, and bycatch) reported by respondents also aligned closely with independent field survey data. This is the first time that interview data have been shown to provide accurate quantitative information on a marine species' relative abundance. We therefore propose that interview-based surveys can serve as a valuable monitoring technique to assess the population status of cetaceans and other distinctive marine megafauna, particularly in systems where field survey programs are limited in scale and scope.

1. Introduction

Estimating marine animal abundance and monitoring its temporal changes are pivotal for formulating evidence-based management strategies. Such assessments allow practitioners to understand the influence of threats on populations and assess the efficacy of management policies (Lawton, 1993). Traditionally, estimates of marine animal abundance have relied on field-based methods, such as direct individual counting, capture-recapture, and distance sampling (Schwarz and Seber, 1999). Unfortunately, these field-based techniques often require extensive sampling efforts, resulting in significant time and cost investments, which hinder the monitoring of populations over extended periods or across large spatial scales (Camino et al., 2020;Madsen et al., 2020). Additionally, these methods may encounter limitations, such as reduced detection accuracy for rare species (Plumptre, 2000; Braga-Pereira et al., 2022; Hamilton et al., 2023) and inadequate statistical power to detect population trends, especially in aquatic animals (Forney, 2000; Taylor et al., 2007). Consequently, there is a need to explore alternative methods that can provide affordable and reliable abundance data (Anadon et al., 2009a).

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Local ecological knowledge (LEK) refers to the understanding and insights developed by local communities about their surrounding environment, including plants, animals, ecosystems, and natural resources (Aswani et al., 2018; Lin et al., 2019). Despite the considerable potential for error and bias in the collection, interpretation, and quantification of LEK, it is increasingly seen as an important source of data to guide evidence-based conservation decision-making (Turvey et al., 2015; Pan et al., 2016; Liu et al., 2019; Griffiths et al., 2021; Nuez, 2023). Engaging with rural and indigenous communities to understand their LEK represents a relatively inexpensive approach for collecting comparative data across large areas (Danielsen et al., 2005; Liu et al., 2016; Lin et al., 2019), especially for rare or cryptic species which are otherwise difficult to study using standard field survey methods (Turvey et al., 2015; Braga-Pereira et al., 2022). Although LEK has been widely used to analyse population trends in many vertebrates (Giglio et al., 2015; Figus et al., 2017; Gray et al., 2017; Early-Capistrán et al., 2020; Lin et al., 2024a), few studies have investigated its ability to estimate animal abundances. Anadon et al. (2009b) compared abundance estimates from interviews with standard distance sampling data, showing that LEK could provide high-quality and low-cost information about the absolute abundance of a terrestrial tortoise species. Turvey et al. (2013) reported good agreement between data from interviews and boat-based surveys for the Yangtze finless porpoise (*Neophocaena asiaeorientalis asiaeorientalis*). Braga-Pereira et al. (2022) also found that LEK-based methods and line-transect surveys provided congruent estimates of wildlife relative abundance in tropical forests, concluding that a combination of local and scientific knowledge was a useful conservation tool. However, the application, limitations, and biases of using this body of knowledge to estimate animal abundances remain untested in marine species. As marine environments and terrestrial ecosystems pose major differences in key ecological parameters such as species distributions, movements, and detectability, it is essential to examine the usefulness of LEK for investigating abundance of marine species.

One possible way to investigate whether LEK can provide an estimate of animal abundance is to ask respondents about the number of individual animals encountered per unit area over a defined period of time, and then compare these data with information obtained from standard field-based techniques (e.g., by using regression equations; Anadon et al., 2009a; Anadon et al., 2009b). However, this approach is not suitable in marine animal research due to the lack of spatial reference points at sea, making it challenging for respondents to pinpoint sighting locations accurately. Additionally, variable surfacing behaviour of marine megafaunal species can make it difficult for untrained respondents to estimate group size, further impacting the accuracy of abundance estimation. The reliability of LEK for marine species abundance must thus be assessed through indirect methods, such as by calculating metrics based upon the proportion of respondents reporting sightings (Turvey et al., 2013) or sighting frequencies (Braga-Pereira et al., 2022). However, it remains unclear whether such indirect abundance indices can be used to establish accurate regression models for predicting the abundance of target marine species.

The Indo-Pacific humpback dolphin (*Sousa chinensis,* referred to as the humpback dolphin hereafter) is a small odontocete found from China to the Indo-Malay Archipelago and around the coastal rim of the Indian Ocean as far west as the Orissa coast of India (Jefferson et al., 2015; Jefferson et al., 2017). Humpback dolphins generally inhabit shallow waters within 20 km of shore in water depths of 20–30 m (Jefferson et al., 2017; Lin et al., 2022a). This habitat overlaps with intense human activities, making the species under severe threat from anthropogenic disturbances (Chen et al., 2023; Song et al., 2025). It is currently assessed as Vulnerable on the IUCN Red List (Jefferson et al., 2017) and has been listed as a Grade 1 National Key Protected Animal by the Chinese State Council since 1988 (Wang, 2012). Although the entire population size of humpback dolphins was roughly estimated to be more than 10000 individuals (Jefferson et al., 2017), robust abundance estimates were mainly avaliable for several populations in China, with around a total of 5000 individuals were estimated (Liu et al., 2023). It is the most well-studied marine mammal species in Chinese waters, with field surveys conducted systematically in all its known habitats during the past two decades. Abundance estimates are available for all humpback dolphin populations in China, and photo identification comparisons show that all of these populations are isolated, as no individuals have been identified in multiple populations (Liu et al., 2023). The availability of abundance information derived from standard field surveys for these isolated populations makes this a perfect model marine species to test the reliability of LEK data for estimating abundance.

In this study, we selected humpback dolphin as a case study to evaluate whether LEK can provide extensive reliable data in estimating the abundance of a marine animal. To achieve this goal, we evaluated the information content of LEK by comparing it with existing data obtained from standard cetacean field surveys, and explored the performance of four indirect LEK-based indices to assess absolute and relative abundance patterns and their potential to act as indicators in population monitoring programs.

2. Materials and methods

2.1. Study area

An interview survey of marine resource users in fishing communities was conducted across four Chinese maritime provinces (Hainan, Guangxi, Guangdong, and Fujian), which encompass the entire distribution of humpback dolphins in mainland Chinese waters (Jefferson et al., 2017; Liu et al., 2023, Fig. 1). We conducted interviews in 22 municipalities (between 18°15′N-109°30′E and 26°02′N-119°19′E) and sampled 66 fishing communities through representative sampling in relation to coastline length and numbers of registered fishing families. Survey communities were grouped into 10 city groupings from north to south: Fuzhou, Xiamen, Shantou, Zhuhai (including Jiangmen and Zhongshan), Yangjiang, Zhanjiang, Qinzhou (including Beihai and Fangchenggang), northern Hainan (Changjiang, Chengmai, Danzhou, and Lingao), eastern Hainan (Lingshui, Qionghai, Wanning, and Wenchang), and southwest Hainan (Dongfang, Ledong, and Sanya) based on geographic location and sample size. These groupings are associated with different humpback dolphin populations (Fig. 1). Although the humpback dolphins in the Pearl River Estuary and Moyang River Estuary are considered to represent a single population (Li et al., 2019), we separated them into two locations because of the distance between them.

2.2. Survey design and implementation

Interviews were conducted between 15 July and 13 August 2019 by four researchers and 21 volunteers. Volunteers were mainly students studying marine biology or ecology who were recruited from local universities and received training in humpback dolphin identification and interview methods before conducting interviews. Prior to the survey, we consulted the China Fishery Statistical Yearbook to obtain provincial-level data on the total number of operational fishing vessels and fishermen. Based on this information, a sampling rate of approximately 1 % was applied to estimate target sample size for each province (Lin et al., 2023). However, practical implementation during fieldwork introduced variability, with actual samples occasionally exceeding or falling short of projected numbers due to real-time logistical constraints. An actual number of 41–105 interviews were conducted per city grouping to satisfy the assumption that the total number of interviews in each location should be sufficient to capture potential variation in responses for each question. Respondents were only interviewed if they were professional fishers and had lived in the survey location for most of their lives. Fishers are expected to have a rich knowledge of local marine resources and environments, which can be utilized by decision-makers, and typically conduct regular fishing activities in locations likely to be

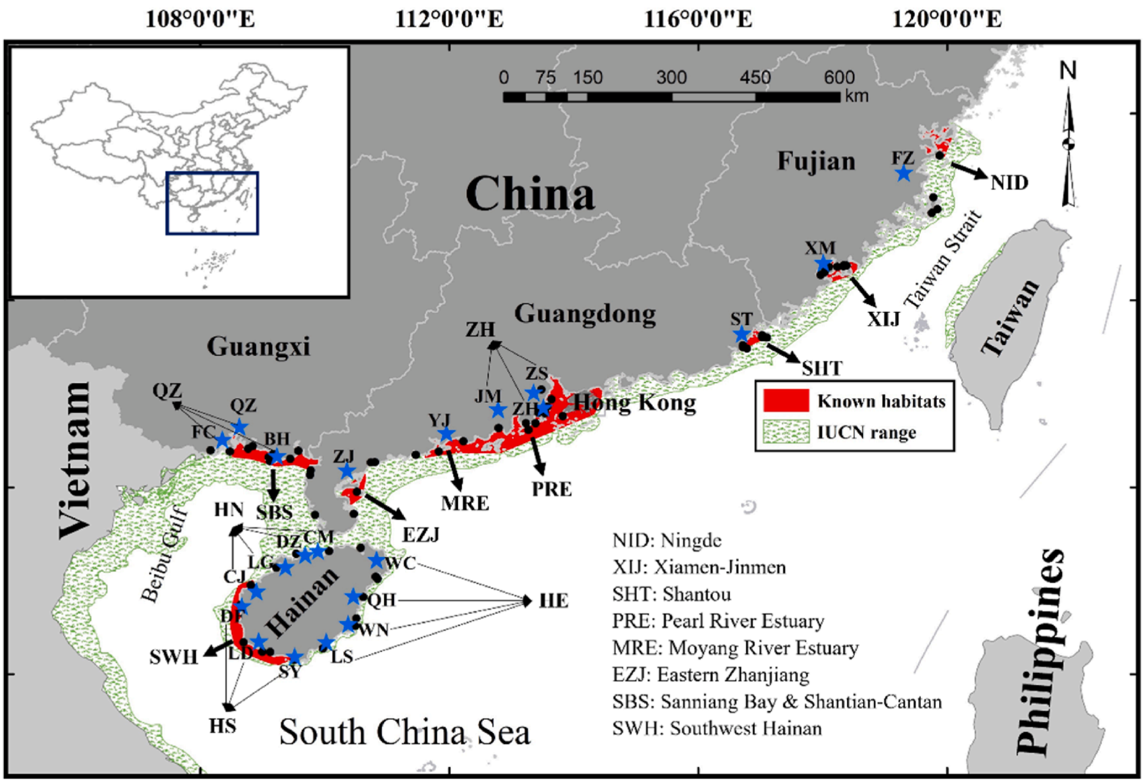

Fig. 1. Map of 22 surveyed cities (blue stars) and 66 fishing communities (black circles) across four Chinese maritime provinces. Some adjacent cities with small interview samples have been combined for analysis. FZ: Fuzhou, XM: Xiamen, ST: Shantou, ZH: (Zhuhai, ZS: Zhongshan, JM: Jiangmen), YJ: Yangjiang, ZJ: Zhanjiang, QZ: (Qinzhou, BH: Beihai, FC: Fangchenggang), HN: (CM: Chengmai, LG: Lingao, DZ: Danzhou, CJ: Changjiang), HE: (WC: Wenchang, QH: Qionghai, LS: Lingshui, WN: Wanning), HS: (SY: Sanya, DF: Dongfang, LD: Ledong).

inhabited by humpback dolphins. Sex and ethnicity were not used as selection criteria to avoid bias, but people below the age of 18 were not interviewed, and only one respondent was interviewed per household or boat to ensure independence of responses. Respondents did not receive any monetary or other rewards, though sometimes a cigarette was offered to build rapport before the interview. In some cases, fishermen declined to participate due to the lack of payment, so we moved on to the next respondent. Respondents were selected opportunistically by walking through each fishing community and interviewing people who were available, with some respondents who were known to have good LEK introduced to us by local community heads through targeted “snowball sampling”.

Interviews were conducted mainly in Mandarin using a standard questionnaire that took approximately 45 min to complete, following a methodological protocol previously applied to research on marine mammals in the South China Sea (Liu et al., 2019; Lin et al., 2022b). The questionnaire contained a combination of multiple choice, short free-response, and multi-part questions. The first section collected background information about respondent age, education, and fishing experience (how many years ago they started fishing and how many days per year they typically spent fishing). Respondents were then shown colour photographs of humpback dolphins taken from different angles, and were asked about their encounter experience and knowledge of the species. If respondents stated that they had encountered humpback dolphins, they were asked to provide further ecological and morphological details to confirm accurate recognition, together with information on timing and location of their most recent sighting, sighting frequency, and number of sightings in the previous five years. Any self-reported encounter with a dolphin group regardless of spatial aggregation or behaviour was recorded as a single “sighting”. We further asked about whether there had been changes in populations during their fishing career (yes/no), and if so, whether the changes resulted in an increase or decrease in the population, as well as the magnitude of these changes (significant/moderate/minimal) and reasons. Finally, we inquired whether this species had disappeared from any areas where it used to be found (yes/no/don't know). We implemented two strategic measures to ensure the acquired knowledge reflected fishermen's first-hand experiences: anchoring questions to personal lived experience (e.g., “Do you think that the population of this species has changed since you first became a fisherman?”), and incorporating spatial precision through location-specific prompts (e.g., “Has this species disappeared from any areas where it used to be found?”). See more details about the design of interview survey methods in Lin et al. 2023 and Lin et al., 2024a.

2.3. Data analysis

All available published literature on humpback dolphin distribution and abundance in mainland Chinese waters from 1990 onwards was systematically reviewed. Midpoints were used if available abundance data represented value ranges, and mean values were used if multiple records were available for the same population. Absolute abundance estimates for each location were normalised to a common scale with the function of (y-min(y))/(max(y)-min(y)) prior to modelling to remove biases associated with scaling. In addition to using absolute abundance as a predictor, we also calculated a relative abundance rank (AR) based upon abundance relative to the largest humpback dolphin population in the world (the Pearl River estuary population). We used quantile classification to divide the absolute abundance of continuous variables into five levels (very low, low, medium, high, very high; Brewer and Pickle, 2002), with each level including two locations (ranging from 1 in eastern and northern Hainan to 5 in Zhanjiang and Zhuhai; Table S1).

Four indirect indices were calculated based on LEK data: (1) encounter rate (ER)—the proportion of respondents who reported at least one dolphin sighting divided by the total number of respondents; (2) encounter rate in the past decade (ED)—the number of respondents who reported sightings during the past 10 years divided by total the number of respondents; (3) sighting frequency (SF)—qualitative reported sighting frequencies converted into numerical values for analysis (none = 0, once = 1, rarely = 2, sometimes = 3, often = 4, very often = 5), revised from Braga-Pereira et al. (2022); and (4) mean annual sightings in the past five years (AS). We used linear models to examine the relationships between these indices and published humpback dolphin abundance data (Anadon et al., 2009b). We also evaluated the effectiveness of LEK in assessing population trends and threat factors for humpback dolphins. We investigated responses about perceived dolphin population change and habitat loss using multivariate generalized linear models (GLMs). Multivariate GLMs were constructed with logit link and binomial error structure, and included boat length, number of years of fishing experience, and interview locality (city grouping) as fixed effects. During model construction, Fuzhou was used as the randomly selected reference city for investigating spatial patterns of response variation. We used Shapiro-Wilk tests to assess whether boat length and number of fishing years satisfied the assumption of a normal distribution; both parameters were not normally distributed ($p < 0.001$), so we used nonparametric Kruskal-Wallis tests to investigate differences among city groupings. All analyses were conducted in R 4.1.1 (R Development Core Team, 2021).

3. Results

3.1. *Geographical population abundance of humpback dolphins*

Based on existing data, the coastal waters of eight of the 10 surveyed city groupings contain known resident humpback dolphin populations; the only regions lacking populations are northern and eastern Hainan (Table S1). The largest population is in Zhuhai (2582 individuals), following by Zhanjiang (993), Yangjiang (528), Qinzhou (314), southern Hainan (200), Xiamen (68), Fuzhou (20), and Shantou (19). Based on interview data, the highest humpback dolphin encounter rates were reported from Xiamen (96.88 % of respondents) and Zhuhai (96.15 %), following by Qinzhou (82.65 %), Shantou (82.09 %), Zhanjiang (79.45 %), and Yangjiang (75.61 %), and the lowest rates were reported in northern (46.91 %) and eastern (29.52 %) Hainan. The highest encounter rates in the past decade were reported from Xiamen (79.69 %) and Zhuhai (75.64 %), and the lowest rates were reported in eastern (15.24 %) and northern Hainan (13.58 %). The highest sighting frequencies were reported from Zhuhai (3.51), Xiamen (3.27), Shantou (2.88), and Qinzhou (2.79), and the lowest frequency was reported from eastern Hainan (0.62). The highest mean annual sightings in the past five years were reported from Zhuhai (30.4 times per year), following by Zhanjiang (21.2) and Qinzhou (19.2), with the lowest levels reported from southern (5.2), eastern (4.4), and northern (1.4) Hainan (Fig. 2, Table S2).

Linear regressions showed that interview-based sighting data were correlated with abundance rank but not with absolute abundance of humpback dolphins, and mean annual sightings had a better performance than the other indexes (Fig. 2). All four indices predicted abundance rank, accounting for >50 % of variation in all models, with the most variation explained by mean annual sightings (AR $= -0.69 + 5.19\times$ER, $R^2 = 0.56$, $p = 0.012$; AR $= 0.56 + 4.88\times$ED, $R^2 = 0.55$, $p = 0.015$; AR $= 0.37 + 1.16\times$SF, $R^2 = 0.53$, $p = 0.018$; AR $= 1.22 + 0.14\times$AS, $R^2 = 0.68$, $p = 0.003$). Conversely, 26 % of variation in absolute abundance across 10 city groupings was explained by encounter rate, 25 % by encounter rate in the past decade, 29 % by sighting frequency, and 66 % by mean annual sightings, with a significant regression coefficient only with mean annual sightings ($p = 0.004$, Fig. S1). However, Zhuhai (an outlier value) had an effect on the regression, with only 39 % of variation in absolute abundance ($p = 0.073$) explained if this value was removed. The abundance indices can be used to establish a classification system for the abundance of humpback dolphin populations in mainland Chinese waters (Table 1). The presence of humpback dolphins only occur in city groupings where the proportion of respondent encounters exceeded 49 %, with a minimum of 28 % of respondents having encountered the species within the last 10 years, a sighting frequency of ≥1.35, and a minimum of 3 sightings per year.

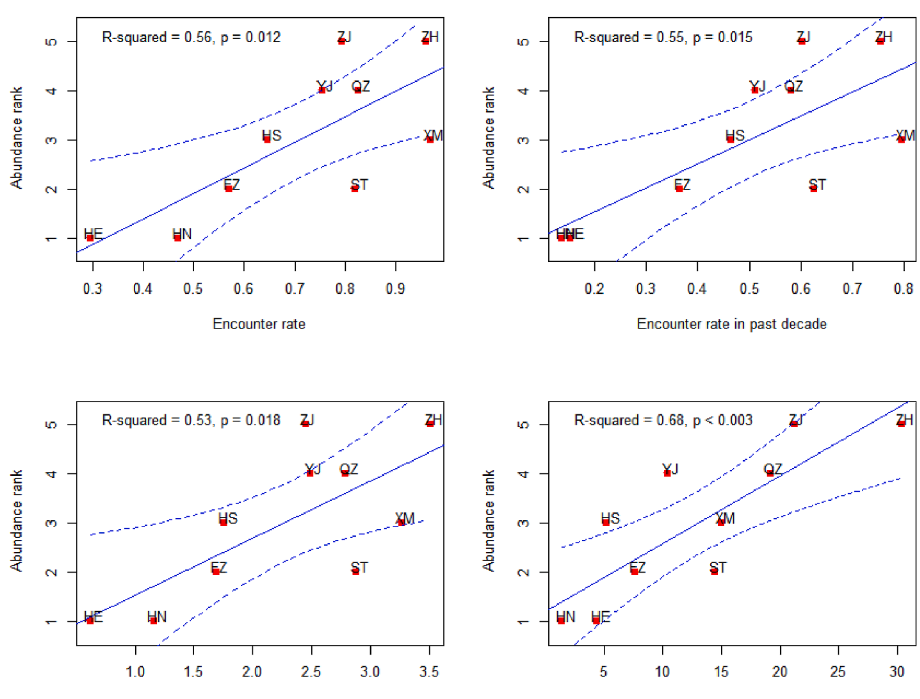

Fig. 2. Regression of abundance rank with encounter rate, encounter rate in the past decade, sighting frequency, and mean annual sightings in the past five years for 10 surveyed cities. Dotted lines show 95 % confidence intervals.

Table 1
Abundance classes of Indo-Pacific humpback dolphins in mainland Chinese waters, compared with absolute abundances from standard field surveys and with indirect abundance indices obtained from interviews with fishers. AA, absolute abundance; ER, encounter rate; ED, encounter rate in the past decade; SF, sighting frequency; AS, mean annual sightings in the past five years.

Abundance class	Field survey	Interviews			
	AA	ER	ED	SF	AS
Very low (1)	0–19	0–60 %	0–39 %	0–1.81	0–8
Low (2)	19–68	60 %–71 %	39 %–50 %	1.81–2.26	8–13
Medium (3)	68–313	71 %–82 %	50 %–61 %	2.26–2.71	13–18
High (4)	313–993	82 %–93 %	61 %–72 %	2.71–3.17	18–23
Very high (5)	993–2536	93 %–100 %	72 %–100 %	3.17–5.00	>23

3.2. Population trends and threats

A total of 269 respondents (64.66 %) reported that they thought humpback dolphin population size had changed since they had first started fishing. The highest proportion of fishers who reported a population change was in Xiamen ($n = 39$, 82.98 %) and the lowest proportion was in eastern Hainan ($n = 12$, 46.15 %) (Table 2). Of these respondents, 233 (86.62 %) reported that dolphin populations had decreased, with at least 85 % of respondents in eight city groupings reporting declines; however, 55.17 % of respondents in Shantou and 20.51 % of respondents in Xiamen reported increases. When asked about the level of decline, 76.39 % of respondents believed that it was severe. GLMs showed that, compared to the reference city of Fuzhou, fewer respondents believed that dolphin population size had changed in eastern Hainan ($p = 0.049$), and fewer respondents believed that population size had decreased in Shantou ($p < 0.001$) and Xiamen ($p = 0.012$, Table 3). GLMs showed that respondents who had more years of fishing experience were more likely to report dolphin population declines ($p = 0.019$) but not describe declines as severe ($p = 0.188$). The main threat factors identified by fishers as being responsible for humpback dolphin declines were water pollution (36.08 %), habitat destruction (25.95 %), overfishing (20.89 %), and bycatch (10.13 %). Only 21.43 % of respondents reported that habitat loss for humpback dolphins had occurred since they had first started fishing, with the highest value of 30 % of respondents reporting this in Yangjiang (Table 2).

4. Discussion

The extensive resources required by field-based marine survey methods, in terms of time and funding, have limited their application in many systematic biodiversity assessments and population monitoring programmes. Developing alternative low-cost, time-saving methods that can still create large-scale datasets, for example through surveying the information contained in LEK, is thus a key priority for ecological research (Anadon et al., 2009b). Although the LEK data that we collected does not correlate with independently-derived absolute abundance data for humpback dolphins, our results demonstrate that data on relative abundance ranks collected through community interviews show congruent spatial patterns with data from field-based surveys. High-resolution spatial patterns of abundance ranks indicated by various indices derived from respondents' sightings of dolphins closely matched data obtained from line transect and mark-recapture methods, with mean annual sightings in particular able to predict almost 70 % of the observed variation in relative dolphin abundance. Higher sighting histories, frequencies, and rates were reported from regions with larger resident humpback dolphin populations (e.g., Zhuhai, Qinzhou, Zhanjiang, and Yangjiang), in contrast to reports from regions with small or no dolphin populations (e.g., Fuzhou and northern and eastern Hainan).

To our knowledge this is the first time that interview data have been shown to provide accurate quantitative information on patterns of marine mammal relative abundance. Although previous studies have used LEK to collect extensive data on abundance estimates for terrestrial animals (Anadon et al., 2009b; Braga-Pereira et al., 2022) and freshwater cetaceans (Turvey et al., 2013), our study goes further to demonstrate the useful application of LEK in marine ecosystems, specifically in a priority marine region containing 85 of the world's 90 cetacean species (Jefferson et al., 2015). Marine cetacean survey techniques typically involve boat-based surveys and passive acoustic monitoring, the logistic and financial restrictions of which limit their regular use and thus their ability to detect population trends (Turvey et al., 2013). In contrast, community interviews to collect LEK of marine resource-users offer a cost-effective method of gathering data over large geographical areas (Moore et al., 2010) and enable the acquisition of both historical and up-to-date information about target species. We therefore propose that interview-based data collection of LEK can serve as a valuable alternative monitoring technique to assess the relative abundance and population trends of marine cetaceans and other distinctive marine megafaunal species. This approach may be particularly suitable for regions with limited resources for conducting regular field-based surveys or with a lack of long-term monitoring plans, as it can help identify potential aggregation and foraging habitats of cetaceans, thereby guiding targeted follow-up surveys or passive acoustic monitoring efforts.

Our results agree with Anadon et al. (2009a) that predicting absolute animal abundances using community interviews remains challenging with LEK data. Only 25–29 % of the variation in humpback dolphin absolute abundance can be explained by interview-based encounter history and sighting frequency metrics, similar to the predictive ability

Table 2
Informant responses when asked if they thought dolphin population size had changed, whether this was a decrease, if the decrease was substantial, and whether dolphin habitat loss had occurred during their lifetime of fishing. See Fig. 1 for full names of abbreviated cities.

City	informers	Responding Informers (%)	Population size change			Habitat Loss Yes (%)
			Yes (%)	Decrease (%)	Very much (%)	
FZ	93	38 (40.86)	25 (65.79)	24 (96.00)	20 (83.33)	8 (24.24)
XM	64	47 (73.44)	39 (82.98)	31 (79.49)	17 (54.84)	8 (19.05)
ST	67	46 (68.66)	29 (63.04)	13 (44.83)	10 (76.92)	6 (17.14)
ZH	78	61 (78.21)	45 (73.77)	42 (93.33)	30 (71.43)	15 (29.41)
YJ	41	23 (56.10)	14 (60.87)	14 (100)	12 (85.71)	6 (30.00)
ZJ	73	45 (61.64)	23 (51.11)	20 (86.96)	17 (85.00)	6 (15.38)
QZ	98	62 (63.27)	41 (66.13)	39 (95.12)	28 (71.79)	12 (26.09)
HN	81	26 (32.10)	17 (65.38)	17 (100)	15 (88.24)	6 (26.09)
HS	88	42 (47.73)	24 (57.14)	22 (91.67)	22 (100)	6 (16.22)
HE	105	26 (24.76)	12 (46.15)	11 (91.67)	7 (63.64)	2 (8.33)
Total	788	416 (52.79)	269 (64.66)	233 (86.62)	178 (76.39)	75 (21.43)

Table 3
Final multivariate generalized linear models (GLMs) investigating informant responses when asked about dolphin population size change and habitat loss. Fuzhou represents the randomly selected reference city.

Predictor	Estimate	SE	*z*-value	*P*-value
1. *Did population size change happen?*				
Intercept	0.762	0.106	7.185	**<0.001**
Boat length	−0.003	0.002	−1.839	0.067
Fishing year	<0.001	0.002	0.136	0.892
Xiamen	0.122	0.107	1.144	0.253
Shantou	−0.060	0.107	−0.561	0.575
Zhuhai	0.025	0.103	0.249	0.804
Yangjiang	−0.068	0.125	−0.541	0.589
Zhanjiang	−0.202	0.109	−1.849	0.065
Qinzhou	−0.042	0.100	−0.418	0.676
Northern Hainan	−0.060	0.124	−0.480	0.631
Southwest Hainan	−0.151	0.112	−1.352	0.177
Eastern Hainan	−0.242	0.122	−1.976	0.049*
2. *If change happened, was it an increase or a decrease?*				
Intercept	0.953	0.090	10.629	**<0.001**
Boat length	−0.003	0.002	−1.619	0.107
Fishing year	0.003	0.001	2.356	**0.019**
Xiamen	−0.210	0.083	−2.527	**0.012**
Shantou	−0.540	0.087	−6.185	**<0.001**
Zhuhai	−0.078	0.082	−0.958	0.339
Yangjiang	0.030	0.103	0.297	0.767
Zhanjiang	−0.152	0.095	−1.597	0.112
Qinzhou	−0.039	0.083	−0.467	0.641
Northern Hainan	−0.017	0.101	−0.169	0.866
Southwest Hainan	−0.106	0.095	−1.118	0.264
Eastern Hainan	−0.086	0.110	−0.780	0.436
3. *If a decrease happened, was it substantial?*				
Intercept	0.743	0.118	6.304	**<0.001**
Boat length	0.002	0.002	0.747	0.456
Fishing year	0.002	0.002	1.320	0.188
Xiamen	0.029	0.111	0.265	0.791
Shantou	−0.062	0.135	−0.461	0.646
Zhuhai	−0.104	0.106	−0.983	0.327
Yangjiang	−0.002	0.127	−0.012	0.990
Zhanjiang	0.051	0.126	0.405	0.686
Qinzhou	−0.109	0.107	−1.022	0.308
Northern Hainan	0.097	0.130	0.745	0.457
Southwest Hainan	0.164	0.124	1.324	0.187
Eastern Hainan	−0.147	0.147	−0.995	0.321
4. *Did habitat loss happen?*				
Intercept	0.265	0.103	2.565	**0.011**
Boat length	−0.002	0.002	−0.909	0.364
Fishing year	0.002	0.002	0.903	0.367
Xiamen	−0.094	0.104	−0.900	0.369
Shantou	−0.098	0.105	−0.933	0.351
Zhuhai	0.018	0.101	0.179	0.858
Yangjiang	0.039	0.118	0.329	0.743
Zhanjiang	−0.115	0.105	−1.093	0.275
Qinzhou	−0.006	0.099	−0.066	0.948
Northern Hainan	−0.020	0.117	−0.173	0.863
Southwest Hainan	−0.124	0.107	−1.163	0.246
Eastern Hainan	−0.190	0.115	−1.662	0.097

of the abundance models in Anadon et al. (2009a). Although reported mean annual sightings performed somewhat better in our analyses, this pattern is driven by the outlier value of Zhuhai, which supports the world's largest humpback dolphin population (Liu et al., 2023). Data noise and bias potentially associated with respondent recall, ability to identify target species, dolphin distribution patterns, movement and surfacing behaviour, and/or survey location distributions, may all contribute to the inability to predict dolphin absolute abundance using LEK as a data source. For example, humpback dolphins are known to have larger home ranges in some parts of our survey area (e.g., southwest Hainan; Lin et al., 2022a), potentially leading to underestimation of local abundance by respondents. Survey locations were selected based on representative sampling of fishing communities, but these locations do not align neatly with the distribution of local humpback dolphin populations. The relationship between absolute abundance estimates obtained from field surveys and true population abundances is also not always certain, especially in Hainan where abundance estimation models have not yet been investigated, and in Zhanjiang where dolphin absolute abundance estimates remain controversial (Liu et al., 2023).

By combining our different abundance indices, we developed a classification system for the relative abundance of humpback dolphin populations in mainland Chinese waters, and identified threshold values of these indices that were associated with the local occurrence of resident humpback dolphin populations (Table 1, Fig. 2). Resident populations of humpback dolphins were identified only in city groupings where the proportion of respondent encounters exceeded 49 %, with at least 28 % of respondents having seen the species within the last 10 years, a sighting frequency of ≥1.35, and a minimum of 3 sightings per year. This could be due to fishers with larger vessels operating in the area of humpback dolphins; occasional strandings and sightings of some vagrant individuals venturing outside of their usual range (Liu et al., 2023); or habitat loss and population declines resulting in the absence of resident populations in some historically inhabited areas. This approach thus allows the use of LEK to identify both hotspot and absence regions for target marine mammal species based upon low cost and short duration interviews. Although we cannot estimate absolute dolphin abundance in these regions, rapid identification of the distribution of top abundance classes can support future conservation and research, such as selection of passive acoustic monitoring sites. If transferrable to other marine mammal species, this approach is particularly useful given the broad distribution and migratory behaviour of many cetaceans (Jefferson et al., 2015). However, we recognise that the reliability of this abundance classification system requires further verification for other cetaceans, as the near-shore distribution and morphological distinctiveness of humpback dolphins might make an LEK-based approach more applicable compared to other species.

Other than in Shantou, most respondents reported severe humpback dolphin population declines across the survey region. As the dolphin population in Shantou contains fewer than 20 individuals (Lin et al., 2024b), perceptions about the recent status of this local population might fail to recognise the longer-term declines that led to its currently reduced size. Due to the lack of long-term monitoring data, evidence of serious humpback dolphin population declines are only available for Qinzhou and Zhuhai, which is consistent with our interview results. Based on life-table analysis using data from stranded animals, humpback dolphins are experiencing a continuous decline of 2.5 % per annum in the Zhuhai region (Pearl River Estuary), with the population likely to drop below a sustainable demographic threshold within two generations and to lose 74 % of current individuals within three generations, matching an IUCN status assessment of Endangered or Critically Endangered (Huang et al., 2012; Karczmarski et al., 2016). Similar patterns have been demonstrated for the Qinzhou region (Sanniang Bay and Shantian-Caotan) (Lin et al., 2022c). These results confirm that interview-based sighting histories can be used to identify cetacean population trends (Turvey et al., 2012, 2015; Gray et al., 2017), and suggest that other humpback dolphin populations in mainland Chinese waters that lack direct field survey data might also be in serious decline. More seriously, GLMs showed that respondents who had more years of fishing experience were more likely to report declines, indicating population declines are possibly resulting in a shifting baseline syndrome, whereby the history of humpback dolphin declines is lost in the younger generations.

Our respondents considered that water pollution, habitat destruction, overfishing, and bycatch were the main factors responsible for humpback dolphin population declines. These proposed threat factors are consistent with known threats to the species in mainland Chinese waters. Water pollution from industrial, agricultural, and domestic sources, which introduces contaminants such as heavy metals and persistent organic pollutants into coastal waters, are known to result in health issues including compromised immune systems, reproductive problems, and increased mortality rates in humpback dolphins (Gui et al., 2017; Sanganyado et al., 2018). Coastal development and construction have led to the degradation and loss of critical dolphin habitat, disrupting their feeding and breeding patterns (Huang et al., 2012; Jefferson et al., 2017). Coastal fisheries have led directly to dolphin injury and death through bycatch, and indirectly to malnutrition and reduced reproductive success through prey base depletion (Slooten et al., 2013). These results indicate that fishers can identify many of the key humpback dolphin threats, indicating that interview surveys can be used to assess the impact of human activities on marine cetaceans. However, it is also important to recognise that some other known threats, e.g., increased maritime traffic and underwater noise pollution (Liu et al., 2017; Sun et al., 2022), were underreported by respondents, which may due to a lack of experience or professional knowledge. In addition, only 21 % of our respondents reported that habitat loss had occurred for humpback dolphins, despite the extensive loss of natural habitat in regions including Xiamen Bay, the Beibu Gulf, and the Pearl River Estuary since the 1970s (Wang et al., 2017, 2022; Wu et al., 2017), and the habitat loss associated with the modification of shallow marine wetlands for aquaculture that has occurred in Zhanjiang and the Beibu Gulf (Lin et al., 2022a). One possible reason for this discrepancy is that fishers might consider modified shallow coastal waters as suitable humpback dolphin habitat, possibly due to an incomplete understanding of the species' distribution. These findings indicate that our current interview structure is less able to assess the severity of this threat to humpback dolphins.

Our findings can be used to provide several recommendations for humpback dolphin conservation and for future LEK surveys. Given the severe declines observed in all humpback dolphin populations in mainland Chinese waters, urgent and comprehensive conservation planning is necessary. Conservation efforts should focus on controlling bycatch, habitat destruction, overfishing, and marine pollution. Our research suggests that quantitative abundance metrics such as mean annual sightings offer a more accurate reflection of dolphin abundance compared to qualitative data (yes/no encounter responses) or ordinal data (sighting frequencies). This finding is likely to reflect the fact that the mean annual sightings metric captures data across a relatively long time-window, increasing the likelihood of capturing records even in locations where dolphins are only infrequently or seasonally present, and also allows for greater numerical response variation compared to some other metrics. When using community interviews to investigate animal abundance, it is thus advisable to use questions that can capture similarly variable quantitative metrics (Turvey et al., 2013). Finally, it is essential for spatial survey design to be based upon the target species' distribution; overestimates of local dolphin abundance were reported from Shantou and Xiamen, possibly due to over-sampling of fishing communities in relation to local dolphin distribution, and it is thus essential to ensure that fishers have similar likelihood of experiencing dolphins across the survey region in order to ensure accuracy and reliability of collected data.

5. Conclusions

Overall, our findings provide strong support for considering LEK as a valuable tool for understanding the relative abundance and identifying potential habitats of marine cetaceans, especially near-shore species that occur in regions that also experience extensive fishing effort. Our results demonstrate the reliability of LEK in monitoring mid-to long-term population trends and identifying at least some potential threat factors. We thus recommend that future research should explore additional applications of LEK for establishing conservation baselines in marine systems. As there have been occasional recent stranding records of humpback dolphins north of Fujian (Liu et al., 2023), we propose that questionnaire surveys should also be conducted further north to assess whether additional populations might occur outside the species' known range. It is also essential to evaluate the feasibility of using our relative abundance framework to assess the status and distribution of other *Sousa* species and other cetaceans. The applicability of indirect abundance indices should be investigated for other cetacean species to improve comparability across different species and regions.

CRediT authorship contribution statement

Mingli Lin: Writing – original draft, Supervision, Investigation, Formal analysis, Conceptualization, Funding acquisition, Methodology, Project administration, Data curation, Writing – review & editing. **Mingming Liu:** Software, Writing – original draft, Investigation, Conceptualization. **Heidi Ma:** Methodology, Visualization, Writing – review & editing, Validation, Formal analysis. **Yuanyuan Li:** Data curation, Conceptualization. **Zirui You:** Data curation. **Yifei Cai:** Data curation. **Samuel T. Turvey:** Resources, Methodology, Conceptualization, Supervision, Writing – review & editing, Project administration. **Songhai Li:** Writing – review & editing, Resources, Supervision, Funding acquisition, Project administration.

Ethics statement

This work was performed under an Ethical Statement of the Institute of Deep-sea Science and Engineering, Chinese Academy of Sciences, with the number IDSSE-SYLL-MMMBL-01.

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Declaration of competing interest

The authors declare that they have no competing interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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