Can local ecological knowledge provide meaningful information on coastal cetacean diversity? A case study from the northern South China Sea

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Running Head: Can local ecological knowledge reveal cetacean diversity?

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Abstract Identifying and evaluating potentially suitable tools to assess the status of cetaceans in coastal waters with high levels of anthropogenic threat represents a first step towards effective cetacean conservation management. Local ecological knowledge (LEK) can often provide more extensive information on focal species and biological resources than is available from standard ecological surveys, and is increasingly recognized as an important source of data for conservation research and management, but it has rarely been used as a tool to assess the status of cetaceans. We investigated the efficacy of using LEK from local fishers combined with stranding records to characterise the diversity and distribution of coastal cetaceans in the northern South China Sea, a region with high historical levels of cetacean abundance and diversity but which is experiencing intensifying anthropogenic pressures. Fishers were unable to identify most regionally occurring cetaceans to species level. However, we were able to determine the distributions of eight categories of cetaceans that were observed by fishers, and a previously unknown population of Indo-Pacific humpback dolphin reported from the coastal waters of Hainan that was later confirmed through boat-based surveys. The number of sightings of different cetacean categories reported by fishers has a significant positive linear relationship with independent data on numbers of stranded cetaceans, validating the accuracy of our respondent data and indicating that LEK can provide useful, quantitative information on abundance rankings of different cetacean categories.

Keywords: Hainan; Indo-Pacific humpback dolphin; questionnaire survey; South China Sea; traditional ecological knowledge.

1. Introduction

Cetacean populations are increasingly recognised to be showing declines across the globe (Taylor et al., 2007; Schipper et al., 2008). Cetacean declines are often detected through observed contractions in species' geographic ranges, which are associated with regional population extirpation (Channell and Lomolino, 2000; Mace et al., 2008). However, standardised cetacean monitoring data are unavailable for many regions, including some ecologically important coastal areas, due to limited resources (time, funding and manpower) available to conduct quantitative boat-based surveys (Aragones et al., 1997; Richman et al., 2014). This data limitation therefore makes estimation of cetacean status or geographic distribution difficult or impossible for these regions, hindering identification of possible range change through time.

Visual surveying and acoustic monitoring constitute the two main traditional cetacean ecological research methods. Precise data about cetacean species occurrence and group size can be collected through visual observation, and distance sampling and photo-identification can be further used to estimate abundance (Buckland et al., 1993; Fearnbach et al., 2012). Acoustic data can also be collected in the field using hydrophones, and used to determine species occurrence, distribution and even abundance (Mellinger et al., 2007; Li et al., 2010). However, visual and acoustic monitoring are time-consuming and associated with high financial and labour costs (Aragones et al., 1997; Richman et al., 2014), and these disadvantages can limit their use in long-term or large-scale studies.

45 Alternative sources of data on coastal cetacean status and diversity may also be
46 available to inform scientific understanding and conservation planning, notably from
47 untrained local marine resource users who utilise the same environments as cetaceans.
48 Local ecological knowledge (LEK) represents experiential knowledge from such
49 resource users that is derived from their lived interactions with the local environment
50 (Inglis 1993; Berkes et al. 2000; Newing, 2011). Over the last 30 years, LEK has
51 increasingly been recognized as a potentially useful tool for addressing diverse
52 questions on ecological and applied conservation issues (Johannes et al., 2000; Olsson
53 and Folke 2001). In particular, LEK is often able to provide useful information about
54 the status of target species and ecological resources (Newing, 2011; Sousa et al., 2013;
55 Ziembicki et al., 2013; Turvey et al., 2014; Marin et al., 2017), and thus represents a
56 potential management tool for marine protected areas and wider marine biodiversity
57 (Gerhardinger et al., 2009; Sanchez-Carnero et al., 2016). Questionnaire surveys to
58 collect LEK from fishers have been suggested as a potentially effective and
59 economical method for assessing cetacean status and diversity across wide geographic
60 areas, especially for rare or elusive species that may otherwise be difficult to study or
61 monitor, and this approach can also provide both historical and recent data with a
62 single collection effort (Turvey et al., 2010). LEK has so far been demonstrated to
63 represent an important tool for studying population declines and extinction patterns in
64 freshwater cetaceans (Turvey et al., 2010, 2012), folk classification of cetaceans by
65 fishers (Souza and Begossi, 2007), fishers' perceptions of dolphin-fisheries

66 interactions (Goetz et al., 2014; Gonzalvo et al., 2014), and patterns of bycatch in
67 multiple cetacean species (Lopez et al., 2003; Liu et al., 2016).

68 However, there is considerable potential for error and bias in the collection,
69 interpretation and quantification of LEK data, which can prevent its straightforward
70 use for providing baselines on cetacean diversity and distribution (Turvey et al., 2014;
71 Caruso et al., 2016). Although extensive data on local cetacean status can often be
72 provided in systems where few or only single species are present (e.g. freshwater
73 systems), or where researchers are primarily interested in LEK associated with
74 specific easily identifiable target species, accurate LEK data on broader patterns of
75 regional cetacean species composition in marine environments may be difficult to
76 obtain if untrained local observers are unable to distinguish effectively between
77 morphologically or ecologically similar species. Using approximated or qualitative
78 data collected during interview surveys to develop quantitative estimates of cetacean
79 abundance or to map species distributions across large marine areas is also a major
80 challenge. It is therefore necessary to evaluate the extent to which the use of interview
81 surveys to collect LEK can provide meaningful information on different aspects of
82 cetacean status in high-diversity marine environments, and whether it is possible to
83 validate the quality of LEK datasets.

84 The South China Sea (SCS), an area of over 3.5 million km^2 that extends from the
85 Strait of Malacca in the southwest to the Strait of Taiwan in the northeast, is a
86 geographic region with high historical levels of cetacean abundance and diversity
87 (Wang, 2011). Data on the regional status of most cetacean species in the SCS is

88 restricted to sporadic stranding records (Hao et al., 2011; Wang, 2011), with scientific
89 surveys conducted in coastal waters for only a few species, most notably the Indo-
90 Pacific humpback dolphin *Sousa chinensis* (Wang et al., 2007; Zhou et al., 2007;
91 Huang et al., 2012; Jutapruet et al., 2015). However, rapid human population growth
92 and economic development in countries bordering the SCS has intensified pressure on
93 coastal cetacean populations through a wide range of anthropogenic factors, including
94 direct mortality caused by targeted exploitation, fisheries bycatch and vessel
95 collisions, and indirect effects such as habitat destruction, prey depletion, and
96 chemical and noise pollution (Wang and Han, 2007; Marcotte et al., 2015). It is
97 therefore extremely important to establish an improved baseline on the diversity and
98 distribution of coastal cetaceans in the SCS, both to allow assessment of species status
99 for current conservation planning, and to act as a baseline against which to evaluate
100 potential future declines. In order to address this knowledge gap, we conducted a
101 large-scale interview survey of marine resource users in the northern SCS and
102 compared LEK data on cetaceans obtained from this survey with independent data
103 that we collected on cetacean strandings for the same region, to investigate the extent
104 to which fishers' LEK can be used to characterise cetacean status and map cetacean
105 diversity and distributions in a high-diversity and highly threatened marine
106 environment.
107

108 ## 2. Materials and methods

109 *2.1 Fisher survey*

We conducted a large-scale questionnaire-based interview survey around the coast of Hainan Island, which covers an area of 35,400 km^2 and is separated from mainland China by the Qiongzhou Strait and from Vietnam by Beibu Bay (Fig. 1). Spatial sampling design was based on information about fishing activities around Hainan (e.g. number and location of fishing ports, number of registered fishing boats/families in each region) provided by the China Fishery Statistical Yearbook (The People's Republic of China Ministry of Agriculture, 2012) and Bureau of Ocean and Fishery of Hainan Province. Sixteen big ports across ten cities: Changjiang, Dongfang, Haikou, Ledong, Lingao, Lingshui, Qionghai, Sanya, Wanning and Wenchang were selected to almost equally cover the whole island and to reflect the current distribution of fishing vessels (Fig. 1). As we aimed for the same amount of interviews, we interviewed 20-60 adult fishers in each survey site. Age, sex and ethnicity were not used as selection criteria, to avoid bias. Respondents were only selected for interview if they were professional fishers, they practising fishing as their main source of economic income, and they were born on Hainan or had lived on Hainan for most of their lives. These resource users typically conducted regular fishing activities with respect to both timing and location(s) likely to be inhabited by marine mammals, making them more likely to be familiar with local coastal cetacean populations.

LEK data were collected using a standard questionnaire that took approximately 30 minutes to complete, based on the combined qualitative and quantitative interview techniques described by Chambers (1992) and developed for conservation research in Chinese fishing communities by Turvey et al. (2010, 2012). The questionnaire

132 included a combination of multiple choice, short free response, and multi-part
133 questions (Appendix A). We first asked respondents a series of questions about their
134 age, education, fishing gear, fishing area and boat length, how many years ago they
135 started fishing, how many days per year they typically spent fishing, and their
136 perception of the present status of the SCS ecosystem and its fisheries. We then
137 showed them an illustrated handbook including 35 cetacean species that are
138 potentially present in the SCS (Wang, 2011), and asked them to identify the species
139 that they encountered when fishing, together with information on the timing, location,
140 and frequency of sightings. Initial interviews showed that identification of cetacean
141 sightings to species level generally proved difficult for local fishers, and so we
142 grouped the 35 cetacean species in the illustrated handbook into eight categories
143 (Table 1). We used a grid map of the northern SCS (grid size = longitude 0.5 degree ×
144 latitude 0.5 degree, approximately 55 km × 50 km) to help respondents locate their
145 cetacean sightings.

146 Questionnaire surveys were conducted between 30 November and 21 December
147 2013. Interviews were conducted by both cetacean researchers and trained volunteers.
148 All respondents were interviewed on a one-to-one basis in relaxed, informal settings.
149 Only one person per fishing vessel was interviewed to ensure that interview data were
150 independent. All respondents were informed at the outset about the study's general
151 aims (i.e. collecting LEK data to understand status of cetacean populations) and
152 assured them that data would be kept anonymously; we only conducted interviews
153 following verbal consent of participants. Research design was approved by the

154 Research Ethics Committee of the Institute of Deep-Sea Science and Engineering,
155 Chinese Academy of Sciences (permit no.: SIDSSE-SYLL-MMMBL-01).
156
157 *2.2 Stranding records*
158 We also collected all available cetacean stranding records from the northern SCS,
159 including the coastal areas of Fujian, Guangdong, Guangxi, Hainan, Hong Kong,
160 Macau and Taiwan, for the period 2000-2014. Stranding records were collected from
161 local news reports (local newspapers, television or internet) and scientific publications
162 (papers and books), and from the integrated cetacean stranding rescue and record
163 systems for Taiwan and Hong Kong provided by the Taiwan Cetacean Society and
164 Ocean Park Hong Kong, respectively. For each stranding case, we recorded the
165 species identity, number of individuals involved, associated photographic/video
166 documentation, stranding date, locality and data source (Appendix B). Species
167 identity was typically confirmed (or revised if reported inaccurately) on the basis of
168 photographs or videos associated with news reports or publications; when the
169 cetacean involved in a stranding event could not be accurately identified from
170 available images, it was recorded as "unidentified stranded species". All cetacean
171 common and scientific names presented here follow Berta (2015).
172
173 *2.3 Data analysis*
174 We calculated the mean encounter rate (± standard error) for each cetacean
175 category in each survey grid cell to reflect the abundance rankings of cetacean

176 categories. Encounter rate was calculated as the total number of sightings for a
177 cetacean category in a specific grid cell divided by the total number of fishers
178 reporting that they fished in that grid cell, expressed as a percentage.

179 All data were analysed in R version 3.2.4 (R Core Team, 2016). We used chi-
180 squared tests to assess whether respondent sighting rate varied between the five west
181 coast counties (Changjiang, Dongfang, Haikou, Ledong, Lingao) and the five east
182 coast counties (Lingshui, Qionghai, Sanya, Wanning, Wenchang), and we conducted
183 analysis of variance (ANOVA) followed by Tukey HSD multiple contrasts to test for
184 significant differences between the ten counties in boat length (representing an
185 indicator of fishing in coastal or offshore waters by respondents) and number of years
186 that respondents have practised fishing. We then used a multivariate GLM model with
187 logit link and a binomial error structure to investigate whether boat length or fishing
188 effort affected the likelihood of respondents having seen cetaceans.

189 We used the stranding data to assess cetacean species composition and to validate
190 the accuracy of our respondent data for ranking the relative abundances of different
191 cetacean categories in the SCS. We assessed available stranding data for Taiwan,
192 Hong Kong and other Chinese provinces separately, due to the different origin and
193 quality of data from these three regions. We calculated the total number of strandings
194 for each cetacean category, and then compared these stranding data with fishers'
195 cetacean encounter rates using regression analysis.

196

197 ## 3. Results

198 *3.1 Overview of fisher survey data*

199 A total of 510 fishers were interviewed in Hainan: Changjiang (n = 63), Dongfang
200 (n = 49), Haikou (n = 48), Ledong (n = 58), Lingao (n = 55), Lingshui (n = 62),
201 Qionghai (n = 41), Sanya (n = 54), Wanning (n = 31), Wenchang (n = 49). Mean
202 respondent age was 42 ± 13 years, 98% of respondents were men, fishing experience
203 began at 17 ± 5 years old, and 80% of respondents were educated to middle school
204 level. Respondents used two categories of fishing vessels: small vessels (11 ± 4
205 meters, mean ± SD, n = 314) which generally fish within c. 50 km of ports, and large
206 vessels (27 ± 6 meters, mean ± SD, n = 196) which trawl or purse within c. 200 km of
207 ports. Significant differences in boat length were present between sites ($F = 24.95$, d.f.
208 = 9, $p < 0.001$), with Dongfang, Lingao and Wenchang having larger boats, and
209 Haikou and Wanning having smaller boats (Fig. 2). Mean number of years that
210 respondents had practised fishing was 23 ± 12 years, with Tukey HSD multiple
211 contrasts showing no differences between any sites (all $p > 0.05$). Respondents spent
212 about half of each year at sea (177 days per year ± 57, mean ± SD) and ranged across
213 76 grid cells, so can be considered likely to be extremely knowledgeable about
214 biological resources in the SCS.

215

216 *3.2 Cetacean distribution*

217 Overall, 93% of our respondent sample reported cetacean sightings, representing all
218 eight cetacean categories: other dolphins (82% of respondents), Indo-Pacific
219 humpback dolphin (30%), Indo-Pacific finless porpoise *Neophocaena phocaenoides*

220 (29%), baleen whales (19%), black whales (18%), beaked whales (4%), sperm whale
221 (4%) and grey whale (1%). The five most frequently reported cetacean categories are
222 shown in Figure 3. All respondents in Ledong and Qionghai reported cetacean
223 sightings, followed in percentage of reported sightings by Lingshui (98%), Wanning
224 (97%), Wenchang (96%), Changjiang (81%) and Haikou (79%). The five east coast
225 counties had significantly higher levels of overall reported sightings compared with
226 the five west coast counties ($\chi 2 = 7.61$, d.f. = 1, $p = 0.006$).

227 The highest level of Indo-Pacific humpback dolphin sightings was reported from
228 Ledong (88% of respondents), following by Sanya (61%) and Wenchang (47%); these
229 three sites had significantly higher levels than Changjiang (10%) and other sites (all <
230 25%, $p < 0.001$). The highest level of Indo-Pacific finless porpoise sightings was
231 reported from Dongfang (55%) and the lowest level was reported from Wanning (6%),
232 with a significant difference in sighting levels between east coast counties (39%) and
233 west coast counties (19%) ($\chi 2 = 23.80$, d.f. = 1, $p < 0.001$). For black whales,
234 Wanning and Wenchang had the same highest levels of reported sightings (27%) and
235 Sanya had the lowest (6%), with no difference between east coast and west coast
236 counties ($\chi 2 = 1.46$, d.f. = 1, $p = 0.227$). For other dolphins, Lingshui had the highest
237 level of reported sightings (97%) and Haikou had the lowest (60%), with a significant
238 difference in levels between east coast counties (91%) and west coast counties (73%)
239 ($\chi 2 = 25.80$, d.f. = 1, $p < 0.001$). For baleen whales, Qionghai had the highest level of
240 reported sightings (37%), whereas no respondents from Dongfang reported sightings,

241 and east coast counties (30%) had significantly higher sighting levels compared with
242 west coast counties (11%) ($\chi 2 = 27.81$, d.f. = 1, $p < 0.001$).

243 Respondent sighting experience of cetaceans was statistically correlated with both
244 fishing effort and boat length in GLM analysis. Years spent fishing was a significant
245 predictor of increased respondent likelihood of having seen Indo-Pacific humpback
246 dolphin (effect size = 0.037, SE = 0.010, $p < 0.001$), Indo-Pacific finless porpoise
247 (effect size = 0.041, SE = 0.009, $p < 0.001$), other dolphins (effect size = 0.031, SE =
248 0.011, $p = 0.004$) and baleen whales (effect size = 0.024, SE = 0.010, $p = 0.017$),
249 although it was not significant in predicting likelihood of having seen black whales (p
250 $= 0.474$) or "all species" ($p = 0.082$). Increased boat length was a significant predictor
251 of increased respondent likelihood of having seen other dolphins (effect size = 0.063,
252 SE = 0.011, $p = 0.004$), but did not predict any other cetacean categories (all $p > 0.05$).

253 The distributions of reported encounter rates for the four most frequently seen
254 cetacean categories show marked spatial variation (Fig. 4): Indo-Pacific humpback
255 dolphin were reportedly encountered mainly around the Pearl River estuary, Sanniang
256 Bay, Leizhou Bay, and in the southwest coastal waters of Hainan; Indo-Pacific finless
257 porpoise were encountered mainly in the Changhua River estuary on the west coast of
258 Hainan; and other dolphins and baleen whales were instead more commonly
259 encountered along the east coast of Hainan.

260 Changes to the regional status of cetaceans over time in the SCS were revealed by
261 both respondent perceptions and last-sighting records. For dolphin species (adult
262 length < 4 m, with no recognizable spray column), nearly half of respondents

263 considered that abundance had decreased, and very few thought that they had
264 increased (increase: 8%; decrease: 49%; no change: 12%; don't know: 26%; no
265 response = 5%). Respondents had similar perceptions about whale species (adult
266 length > 4 m, with recognizable spray column), with substantially more respondents
267 again considering that abundance had decreased (increase: 2%; decrease: 28%; no
268 change: 4%; don't know: 42%; no response = 24%). A total of 445 cetacean last-
269 sighting records were collected (Changjiang, n = 47; Dongfang, n = 44; Haikou, n =
270 27; Ledong, n = 58; Lingao, n = 47; Lingshui, n = 59; Qionghai, n = 40; Sanya, n = 47;
271 Wanning, n = 29; Wenchang, n = 47). Most cetacean last-sighting records dated after
272 2010 (61%, n = 272), with only 25 records from before 1990, 33 records from
273 between 1990-2000, and 115 records from between 2001-2010 (Fig. 5). For most
274 counties, more than 60% of last-sighting records dated from after 2010, but more
275 respondents in Changjiang (19%), Haikou (30%) and Lingao (43%) had not seen
276 cetaceans during this period.
277
278 *3.3 Cetacean species composition and abundance rankings of cetacean categories*
279 In total, information for 1621 stranded cetacean individuals in 1367 separate
280 stranding events between 2000-2014 was compiled for analysis (Table 3). For all
281 administrative regions excluding Taiwan and Hong Kong, 249 stranded cetacean
282 individuals from 193 stranding events (an average of 17.8 events/year) were
283 documented, including 63 in Fujian, 58 in Guangdong, 50 in Hainan, 19 in Guangxi
284 and three in Macau; the data include six identifiable baleen whale species, 19

identifiable toothed whale or dolphin species, and 10 baleen whale and five toothed whale or dolphin individuals that could not be identified to species level. Pantropical spotted dolphin *Stenella attenuata* (21 events, 67 individuals), Indo-Pacific finless porpoise (30 events, 30 individuals), and Indo-Pacific humpback dolphin (25 events, 26 individuals) were the most commonly stranded odontocetes across this area; long-beaked and short-beaked common dolphin *Delphinus capensis* and *D. delphis*, melon-headed whale *Peponocephala electra*, pygmy killer whale *Feresa attenuata*, and Cuvier's beaked whale *Ziphius cavirostris* were also each recorded once. Bryde's whale *Balaenoptera edeni* (13 events, 13 individuals) was the most commonly stranded baleen whale species, and blue whale *B. musculus* and gray whale *Eschrichtius robustus* were each recorded once. For Hong Kong, 448 stranding events involving 450 cetacean individuals were documented during the same period. These data mainly involved Indo-Pacific finless porpoise (275 individuals, 61% of strandings) and Indo-Pacific humpback dolphin (145 individuals, 32% of strandings). For Taiwan, there were 726 stranding events involving 922 cetacean individuals; the most frequently stranded species was Indo-Pacific finless porpoise (129 events, 136 individuals), followed by dwarf sperm whale *Kogia simus* (71 events, 81 individuals), common bottlenose dolphin *Tursiops truncatus* (54 events, 54 individuals), Risso's dolphin *Grampus griseus* (50 events, 55 individuals) and Pantropical spotted dolphin (48 events, 68 individuals). Twelve stranded Indo-Pacific humpback dolphin were recorded from Taiwan during this period.

306 Linear regression analyses show significant positive correlations between the
307 percentage of interviewed fishers who reported sightings of each cetacean category
308 and the total number of stranded cetacean individuals representing the corresponding
309 cetacean category for data from Taiwan ($R^2 = 0.863$, $Y = 0.106X + 0.500$, $p < 0.001$),
310 Chinese provinces excluding Taiwan and Hong Kong ($R^2 = 0.970$, $Y = 0.137X +$
311 0.111, $p < 0.001$), and the total combined dataset ($R^2 = 0.803$, $Y = 0.136X + 0.125$, p
312 $= 0.003$), although no linear relationship was observed for data from Hong Kong
313 alone (Fig. 6).
314

315 # 4. Discussion

316 *4.1 Species distributions*

317 Using LEK to quantify the distribution of cetaceans presents several potential
318 challenges. Fishers are often unable to identify species accurately, so that there can be
319 uncertainty over the identity of species associated with reported sighting locations.
320 Fishers generally visit fixed fishing areas, meaning that LEK data may violate
321 sampling assumptions that are required to analyse survey effort. Error and bias may
322 also occur between actual and remembered sighting locations and dates, and fishers
323 may only be able to provide a general sighting region when the same species have
324 been observed on more than one occasion. Despite these potential limitations,
325 however, by grouping similar species into categories, we have been able to use LEK
326 data to determine spatial distribution patterns for the four most frequently encountered
327 cetacean categories in the northern SCS (Figs 3 and 4). For example, our results show

that Indo-Pacific humpback dolphin and Indo-Pacific finless porpoise are mainly distributed in the west coastal waters of Hainan, whereas other dolphins and baleen whales are mainly encountered off the island's east coast close to deeper open ocean waters, suggesting that water depth is likely to play an important role in cetacean species distribution in the SCS.

Our results show that increasing boat length is a significant predictor of whether respondents have seen other dolphins, and there are significant differences in boat length between counties. These two facts together suggest that variation in the reported spatial data for other dolphins might partly be caused by different patterns of fishing activity/effort by respondents in different parts of Hainan, rather than reflecting actual ecological variation in dolphin populations. However, the usefulness of LEK for generating accurate maps of the distribution of some easily identifiable cetacean species is demonstrated by data for Indo-Pacific humpback dolphin. Jefferson (2000) hypothesized that there were about eight populations of humpback dolphins in Chinese waters, but there were no records of humpback dolphins from the waters around Hainan (Jefferson et al., 2008; Chen et al., 2009; Chen et al., 2011). Interestingly however, our interview survey revealed high encounter rates of this species reported by fishers around the southwest coastal waters of Hainan. Following our 2013 fisher survey, humpback dolphins were then recorded for the first time near Hainan in October 2014 during a boat-based field survey (Li et al., 2016) and a stranded individual was also collected in February 2015, confirming the presence of

this species in the coastal waters of Hainan and providing further independent verification of the general accuracy of fishers' knowledge of cetaceans in the SCS.

4.2 Species composition

Our study indicates that LEK is unlikely to be able to provide accurate information on coastal cetacean species richness in a diverse marine system. When we asked fishers to identify cetacean species they had seen from an illustrated handbook, they often found it difficult to do so, frequently using phrases such as "it looked like this species", "maybe this one", and "this sort of dolphin". Respondents were generally only able to confidently distinguish species that differed markedly in skin colour, dorsal fin or other unique morphology, and/or body length. As such, we were only able to gather estimates of cetacean abundance rankings and distribution in this study when species were grouped into categories.

Our study demonstrates that the potential limitations of LEK in determining the species composition of a diverse regional cetacean fauna can be addressed by the use of stranding records, which can often be sourced through a variety of information channels. Our stranding records database for the SCS contains 29 species of cetaceans, including six baleen whales and 23 odontocetes. This number is slightly lower than the SCS cetacean fauna reported by Wang (2011) and Jefferson et al. (2008), who reported between 30 and 32 regionally occurring species, respectively. This slight discrepancy may reflect different reasons. Some stranded animals were unidentifiable to species level due to the preservational state of carcasses or photo quality, and the

371 mean number of recorded annual stranding events is low (14 events combined across
372 several other Chinese provinces, compared with 32 and 52 events in Hong Kong and
373 Taiwan, respectively), which probably reflects under-reporting. Using the database
374 established as part of this survey, a new online database for marine mammal stranding
375 records for Hainan was created in July 2015 (http://www.cetacean.csdb.cn/). This
376 database will provide more precise information on regional cetacean diversity and
377 abundance in the future. Alternately, this difference may reflect a recent decline in
378 cetacean biodiversity. Regional anthropogenic pressure on cetaceans may have
379 already caused some species to decline and even disappear. For example, in the 1920s
380 the blue whale was subject to commercial whaling in the southern waters of Taiwan,
381 but it has now almost disappeared, and more than 10 humpback whales *Megaptera*
382 *novaeangliae* were fished from 1957 to 1958 in Guangdong, but this is now a rare
383 species in the SCS (Wang, 2011).
384
385 *4.3 Abundance rankings of cetacean categories*
386 LEK has been used to estimate both relative abundance patterns (Beaidreai and
387 Levin, 2014) and sometimes also absolute abundance levels (Anadón et al., 2009). It
388 is difficult or impossible to obtain absolute abundance data for cetacean species using
389 LEK, as untrained fishers may be unlikely to be able to count or estimate the number
390 of individuals in cetacean groups with high accuracy (Anadón et al., 2009). However,
391 the abundance rankings for some easily identifiable cetacean species or categories
392 were estimated in this study using the percentage of sightings reported for different

393 categories by fishers. Our results suggest that small dolphins are encountered more
394 frequently in the SCS in contrast to larger beaked whales and baleen whales (Figs 2
395 and 3). This suggestion is supported by independent stranding records from Hong
396 Kong and Taiwan showing that delphinids and phocaenids are the main stranded
397 species, suggesting that small dolphins are the most abundant coastal cetacean species
398 in the northern SCS. Furthermore, we demonstrate that across our entire study area
399 except for Hong Kong, levels of reported cetacean sightings correlate statistically with
400 the independent measure of cetacean abundance represented by stranding records.
401 This correlation provides crucial validation of the general accuracy of our regional
402 cetacean LEK dataset, and confirms that LEK can provide accurate abundance
403 ranking information about cetaceans. Although overall levels of reported cetacean
404 sightings do not correlate statistically with independent stranding records around
405 Hong Kong, Indo-Pacific finless porpoise and Indo-Pacific humpback dolphinboth
406 had relatively high observed regional stranding rates, were both widely reported from
407 this region by respondents in our study, and are known to be relatively abundant
408 compared with other cetacean species based on independent survey data (Wang,
409 2011).

410 This validation suggests that other, non-verified quantitative LEK data obtained
411 from our study on the regional status of cetaceans in the northern SCS may also be
412 accurate. Analysis of last-sighting data from the ten surveyed counties around Hainan
413 showed that more respondents in Haikou, Lingao and Changjiang had not seen
414 cetaceans in recent years, indicating that cetaceans in waters off these three northwest

415 counties might have been affected more substantially by increasing anthropogenic
416 pressure in marine areas close to mainland China. In particular, data for this region on
417 respondent perceptions of cetacean declines and the long time period since many
418 respondents have observed cetaceans together raise concerns about the local status of
419 cetacean populations, and regional cetacean population trends should be investigated
420 further through future field surveys.
421
422 *4.4 Conservation and whale-watching*
423 Rapid economic growth in China and other Southeast Asian countries, along with
424 rising anthropogenic pressures such as fishing, eutrophication, habitat destruction and
425 shipping (Ng and Tan, 2000; Pitcher et al., 2000), have direct negative ecological
426 impacts on cetaceans (Nowacek et al., 2007; Williams et al., 2008; Baird et al., 2015).
427 However, other than the studies of Ng and Leung (2003), the impacts of these
428 anthropogenic pressures on coastal cetaceans in the SCS have so far been the focus of
429 little research. The findings of our study should be used to establish a conservation
430 framework for cetaceans in the northern SCS. This aim could be achieved through the
431 delineation of marine protected areas (MPAs) in locations where cetaceans occur in
432 relatively high abundance, and our LEK and field data are currently being used to
433 inform potential establishment of an MPA for Indo-Pacific humpback dolphin in
434 coastal waters off southwest Hainan.
435 Cetacean-watching tourism may be an alternative to a local fishing-based economy
436 around parts of Hainan. Cetacean-watching is commonly presented as a benign

437 method for enhancing public attitudes toward the marine environment, and it is
438 increasingly popular in cetacean-rich western countries including Canada, the United
439 States and Australia (Hoyt, 2001). Hainan is experiencing economic growth and
440 tourism development, and cetacean-watching has the potential to be a new source of
441 revenue. However, this type of tourism activity is currently only available in the
442 northern SCS on the east coast of Taiwan and in Sanniang Bay, Guangxi (Tseng et al.,
443 2011; Chen et al., 2016). Although cetacean-watching needs to be well regulated, this
444 study provides important information to aid its potential establishment in Hainan. Our
445 results indicate that there is potential for cetacean-watching for Indo-Pacific
446 humpback dolphin and Indo-Pacific finless porpoise in southwest Hainan, and
447 possibly for baleen whales and other dolphins in eastern Hainan.
448

449 ## 5. Conclusion

450 Although interview data on fishers' LEK are likely to be both incomplete and
451 biased, our study shows that such data can still provide quantitative information on
452 both diversity and distribution for several coastal cetacean species or categories, such
453 as Indo-Pacific humpback dolphin in the northern SCS. Interview surveys therefore
454 represent an effective, rapid survey method for obtaining information on key
455 parameters of cetacean ecology across large geographic regions, especially for regions
456 where traditional cetacean field surveys have rarely been conducted.

457 As LEK and stranding data are now demonstrated to constitute a good indicator of
458 regional cetacean status, there is a need to establish a cetacean database for the whole

of the SCS, ideally also including data from boat-based and/or plane-based visual surveys and boat-based acoustic surveys, to provide more accurate information about species composition, abundance and distribution. Understanding the relationship between cetacean distribution patterns and environmental factors is becoming increasingly important in the changing ecosystem of the SCS, and this region also requires a novel policy framework that should include ecological information together with analysis of the current and future ecosystem services associated with regional cetacean presence.

Acknowledgements

We express our thanks to Ocean Park Conservation Foundation Hong Kong for providing stranding data from Hong Kong, and the Blue Ribbon Ocean Conservation Society of Sanya for their help in recruiting volunteers. We are also grateful to Wang Renyi, Xu Xiqian, Deng Hualan, Gou Lifang, Wu Jianjun, Zuo Chen, Lai Wenyi, and many other volunteers for their assistance with the questionnaire survey. This research was financially supported by the National Natural Science Foundation of China (41422604, 41306169, 41406182), the "Hundred Talents Programme" of the Chinese Academy of Sciences (SIDSSE-BR-315 201201, Y410012), the Knowledge Innovation Programme of the Chinese Academy of Sciences (SIDSSE-316 201210), the Science and Technology Cooperation Project of Sanya City and the Chinese Academy of Sciences (2013YD75), the Marine Development by Science and Technology Project of Hainan Province (XH201423), the Advanced Project in Young

Talent of the Sanya Institute of Deep-Sea Science and Engineering, Chinese Academy of Sciences (SIDSSE-QN-201304), a Major Science and Technology Project in Hainan Province (grant no. ZDKJ2016009-1-1), and Ocean Park Conservation Foundation Hong Kong (MM03-1415, MM02-1516).

Appendix A. Fishermen survey questionnaire (English version).

Appendix B. Stranding data.

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648

650 **Table 1.** Categories of cetaceans likely to be present in the South China Sea, that
651 were used in our questionnaires. Some species were listed individually as they are
652 easily identifiable due to distinctive skin colour or head morphology, or absence of
653 dorsal fin.

Group categories	Code	Common name	Latin name
Indo-Pacific finless porpoise	NPH	Indo-Pacific finless porpoise	*Neophocaena phocaenoides*
Indo-Pacific humpback dolphin	SCH	Indo-Pacific humpback dolphin	*Sousa chinensis*
Grey whale	ERO	Grey whale	*Eschrichtius robustus*
Sperm whale	PMA	Sperm whale	*Physeter macrocephalus*
Black whales	BLW	Killer whale	*Orcinus orca*
		Short-finned pilot whale	*Globicephala macrorhynchus*
		Pygmy killer whale	*Feresa attenuata*
		Melon-headed whale	*Peponocephala electra*
		False killer whale	*Pseudorca crassidens*
Beaked whales	BEW	Cuvier's beaked whale	*Ziphius cavirostris*
		Longman's beaked whale	*Indopacetus pacificus*
		Blainville's beaked whale	*Mesoplodon densirostris*
		Ginkgo-toothed beaked whale	*Mesoplodon ginkgodens*
Other dolphins	OTD		
Other baleen whales	BAW		

654

655

656 **Table 2.** Final multivariate generalized linear models (GLMs) investigating

657 respondent sighting experience of cetaceans around Hainan.

Predictor	Estimate	SE	z-value	P-value
1. Indo-Pacific humpback dolphin				
Intercept	-3.353	0.553	-6.062	<0.001
Haikou	0.386	0.623	0.619	0.536
Lingao	0.951	0.553	1.720	0.086
Dongfang	1.073	0.573	1.872	0.061
Ledong	4.329	0.596	7.262	<0.001
Sanya	2.674	0.524	5.105	<0.001
Lingshui	0.806	0.550	1.465	0.143
Wanning	-0.958	1.110	-0.863	0.388
Qionghai	0.287	0.647	0.444	0.657
Wenchang	2.017	0.551	3.660	<0.001
Boat length	0.011	0.014	0.740	0.459
Fishing year	0.037	0.010	3.838	<0.001
2. Indo-Pacific finless porpoise				
Intercept	-1.447	0.409	-3.538	<0.001
Haikou	-0.114	0.424	-0.268	0.789
Lingao	0.136	0.415	0.328	0.743
Dongfang	1.108	0.422	2.626	0.009
Ledong	-0.082	0.393	-0.209	0.834
Sanya	-0.622	0.431	-1.444	0.149
Lingshui	-0.855	0.434	-1.969	0.049
Wanning	-2.006	0.787	-2.547	0.011
Qionghai	-1.430	0.556	-2.575	0.010
Wenchang	-0.270	0.455	-0.594	0.553
Boat length	-0.011	0.014	0.749	0.454
Fishing year	0.041	0.009	4.699	<0.001
3. Black whales				
Intercept	-1.873	0.520	-3.600	<0.001
Haikou	0.449	0.564	0.796	0.426
Lingao	1.057	0.523	2.021	0.043
Dongfang	0.586	0.557	1.052	0.293
Ledong	-0.276	0.617	-0.447	0.655
Sanya	-0.725	0.719	-1.009	0.313
Lingshui	1.099	0.492	2.232	0.026
Wanning	0.391	0.639	0.612	0.541
Qionghai	0.954	0.542	1.761	0.078
Wenchang	1.107	0.542	2.042	0.041
Boat length	-0.003	0.015	-0.193	0.847
Fishing year	-0.007	0.010	-0.715	0.474

Predictor	Estimate	SE	z-value	P-value
4. Other dolphins				
Intercept	-0.556	0.489	-1.136	0.256
Haikou	-0.309	0.435	-0.710	0.478
Lingao	0.502	0.544	0.923	0.356
Dongfang	-0.523	0.468	-1.116	0.265
Ledong	-0.228	0.414	-0.551	0.582
Sanya	0.121	0.460	0.262	0.793
Lingshui	2.399	0.781	3.073	0.002
Wanning	1.664	0.694	2.398	0.017
Qionghai	2.002	0.789	2.538	0.011
Wenchang	1.045	0.693	1.508	0.132
Boat length	0.063	0.021	3.065	0.002
Fishing year	0.031	0.011	2.889	0.004
5. Baleen whales				
Intercept	-3.978	0.688	-5.785	<0.001
Haikou	0.993	0.763	1.301	0.193
Lingao	1.180	0.703	1.679	0.093
Dongfang	-14.686	557.456	-0.026	0.979
Ledong	1.571	0.682	2.303	0.021
Sanya	1.449	0.691	2.098	0.036
Lingshui	2.136	0.658	3.247	0.001
Wanning	2.498	0.715	3.492	<0.001
Qionghai	2.461	0.678	3.632	<0.001
Wenchang	1.962	0.687	2.854	0.004
Boat length	0.025	0.014	1.798	0.072
Fishing year	0.024	0.010	2.381	0.017
6. All cetacean species				
Intercept	0.303	0.618	0.491	0.624
Haikou	0.124	0.506	0.244	0.807
Lingao	1.054	0.703	1.499	0.134
Dongfang	0.803	0.649	1.237	0.216
Ledong	18.147	1404.010	0.013	0.990
Sanya	0.718	0.575	1.249	0.212
Lingshui	2.699	1.060	2.546	0.011
Wanning	2.282	1.084	2.105	0.035
Qionghai	18.138	1661.241	0.011	0.991
Wenchang	1.306	0.832	1.570	0.116
Boat length	0.039	0.028	1.403	0.161
Fishing year	0.026	0.015	1.740	0.082

658 Changjiang represents the randomly selected reference county.

660 **Table 3.** Stranding information for cetaceans in Hainan, Guangdong, Guangxi, Fujian,

661 Macao (collectively "Other Provinces"), Hong Kong and Taiwan between 2000–2014.

662 T = stranding events; NM = number of individuals.

Common name	Scientific name	Other Provinces		Hong Kong		Taiwan	
		T	NM	T	NM	T	NM
Grey whale	*Eschrichtius robustus*	1	1	0	0	0	0
Common minke whale	*Balaenoptera acutorostrata*	5	5	0	0	4	4
Bryde's whale	*Balaenoptera edeni*	13	13	1	1	1	1
Blue whale	*Balaenoptera musculus*	1	1	0	0	0	0
Omura's whale	*Balaenoptera omurai*	4	4	1	1	5	5
Humpback whale	*Megaptera novaeangliae*	3	3	0	0	1	1
Long-beaked common dolphin	*Delphinus capensis*	1	1	1	1	5	5
Short-beaked common dolphin	*Delphinus delphis*	1	1	0	0	3	3
Pygmy killer whale	*Feresa attenuata*	1	2	0	0	32	37
False killer whale	*Pseudorca crassidens*	3	4	2	2	16	16
Short-finned pilot whale	*Globicephala macrorhynchus*	9	9	0	0	22	30
Risso's dolphin	*Grampus griseus*	13	14	1	1	50	55
Fraser's dolphin	*Lagenodelphis hosei*	0	0	0	0	44	45
Melon-headed whale	*Peponocephala electra*	1	1	0	0	9	17
Indo-Pacific humpback dolphin	*Sousa chinensis*	25	26	144	145	10	12
Pantropical spotted dolphin	*Stenella attenuata*	21	67	1	1	48	68
Striped dolphin	*Stenella coeruleoalba*	0	0	2	2	7	8
Rough-toothed dolphin	*Steno bredanensis*	3	3	3	3	35	44
Spinner dolphin	*Stenella longirostris*	7	8	0	0	9	9
Indo-Pacific bottlenose dolphin	*Tursiops aduncus*	10	13	1	1	13	14
Common bottlenose dolphin	*Tursiops truncatus*	6	6	4	4	54	54
Sperm whale	*Physeter macrocephalus*	4	4	1	1	5	5
Pygmy sperm whale	*Kogia breviceps*	9	9	2	2	31	140
Dwarf sperm whale	*Kogia simus*	4	4	0	0	71	81
Longman's beaked whale	*Indopacetus pacificus*	0	0	0	0	2	3
Blainville's beaked whale	*Mesoplodon densirostris*	3	4	0	0	17	17
Ginkgo-toothed beaked whale	*Mesoplodon ginkgodens*	0	0	0	0	11	14
Cuvier's beaked whale	*Ziphius cavirostris*	1	1	0	0	12	12
Indo-Pacific finless porpoise	*Neophocaena phocaenoides*	30	30	274	275	129	136
Unidentified toothed whales	-	4	5	6	6	4	4
Unidentified baleen whales	-	10	10	4	4	76	82
Total		193	249	448	450	726	922

663

664

665 # FIGURE LEGENDS

666 **Fig. 1.** Survey sites in Hainan (names inside indicate survey counties; names outside
667 indicate interview localities).

668

669 **Fig. 2.** Boxplot of respondent boat length and fishing effort. The same letter indicates
670 no significance between counties, while different letters indicate significant
671 differences ($P < 0.05$). No significant differences were observed in fishing effort
672 between sites with Tukey HSD multiple contrasts. CJ: Changjiang, DF: Dongfang,
673 HK: Haikou, LD: Ledong, LG: Lingao, LS: Lingshui, QH: Qionghai, SY: Sanya, WC:
674 Wenchang, WN: Wanning.

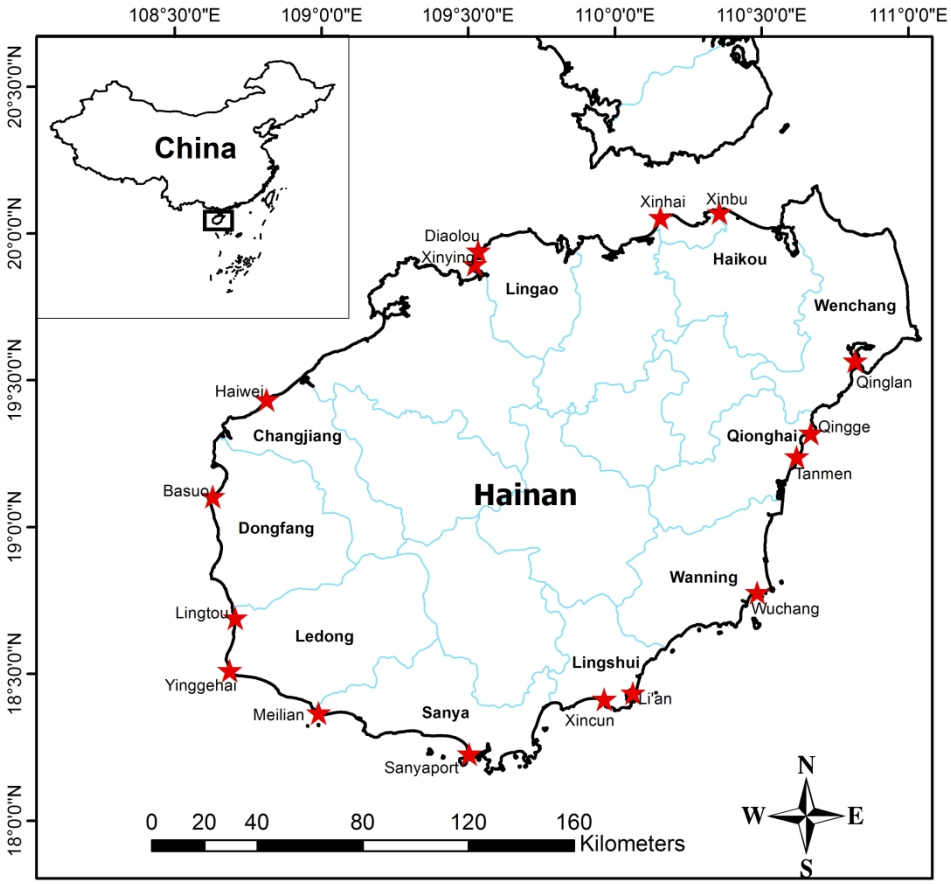
675

676 **Fig. 3.** Proportion of respondents who reported sightings of different cetacean
677 categories (BAW: baleen whales, BLW: black whales, NPH: Indo-Pacific finless
678 porpoise, OTD: other dolphins, SCH: Indo-Pacific humpback dolphin). CJ:
679 Changjiang, DF: Dongfang, HK: Haikou, LD: Ledong, LG: Lingao, LS: Lingshui,
680 QH: Qionghai, SY: Sanya, WC: Wenchang, WN: Wanning. Asterisks indicate
681 counties with significantly lower awareness/experience levels than Changjiang; stars
682 indicate counties with significantly higher levels.

683

684 **Fig. 4.** Distribution maps of encounter rate (i.e. proportion of respondents who
685 reported sightings of specific cetacean categories against the total number of
686 respondents fishing in each grid cell) for four cetacean categories (a): Indo-Pacific

687 humpback dolphin, (b): Indo-Pacific finless porpoise, (c): baleen whales, (d): other
688 dolphins.
689
690 **Fig. 5.** Frequency distributions for cetacean last-sighting records across 10 counties in
691 Hainan for the period 1980–2013.
692
693 **Fig. 6.** Linear regression of respondent encounter rate of different cetacean categories
694 against number of reported strandings for different geographic regions around the
695 SCS (BAW, baleen whales; BEW, beaked whales; BLW, black whales; ERO, grey
696 whale; NPH, Indo-Pacific finless porpoise; OTD, other dolphins; PMA, sperm whale;
697 SCH, Indo-Pacific humpback dolphin).



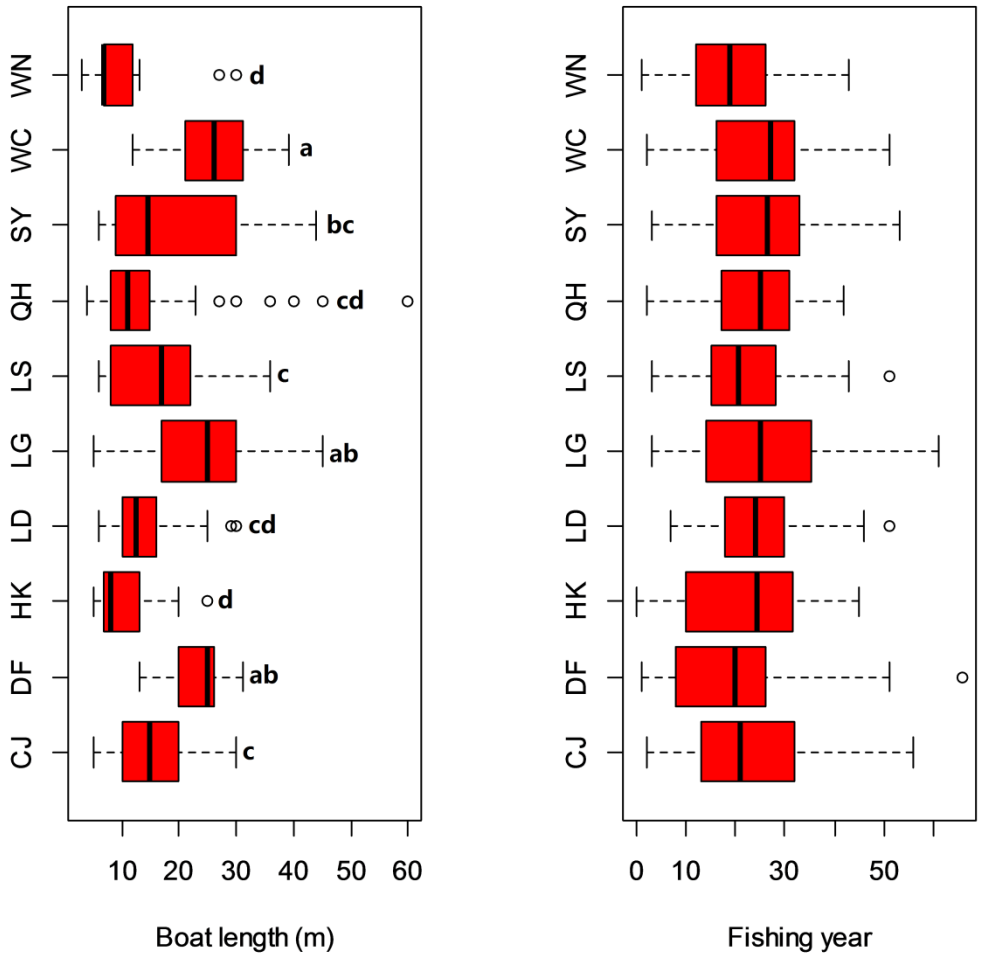
699

700 **Fig. 1**

701

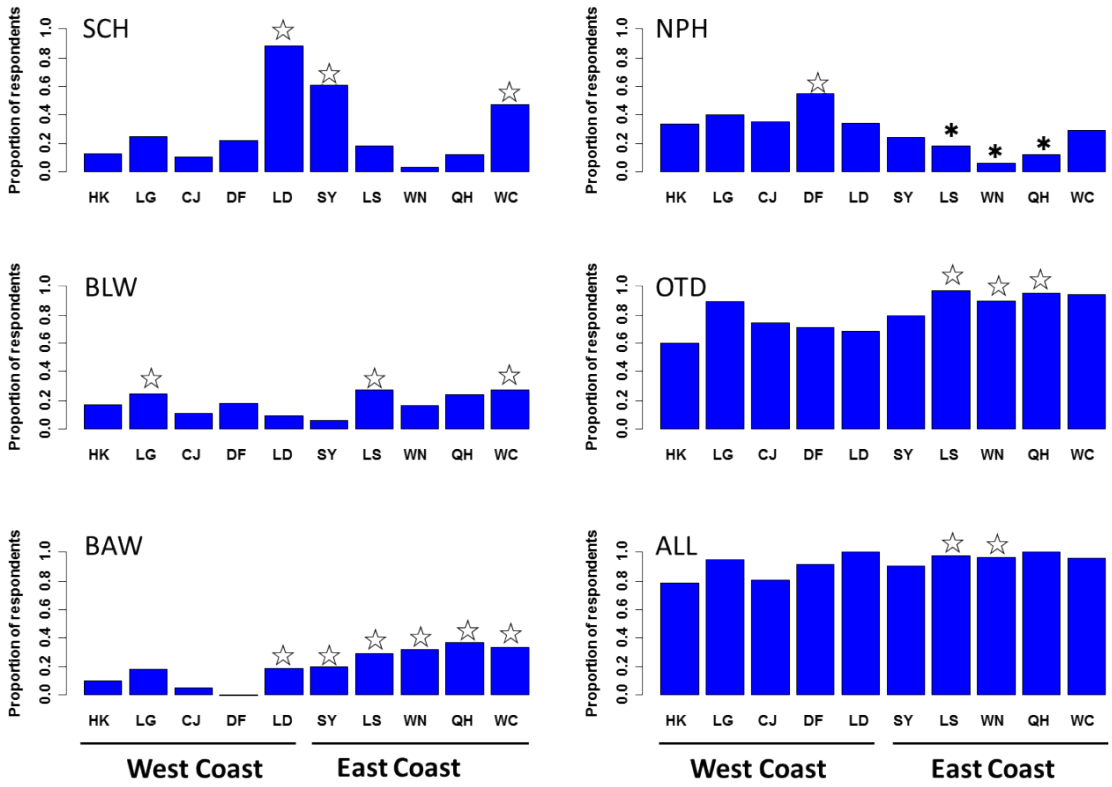
702

703


WN
WC
SY
QH
LS
LG
LD
HK
DF
CJ
d
a
bc
cd
c
ab
cd
d
ab
c
10
20
30
40
50
60
Boat length (m)
0
10
30
50
Fishing year

704

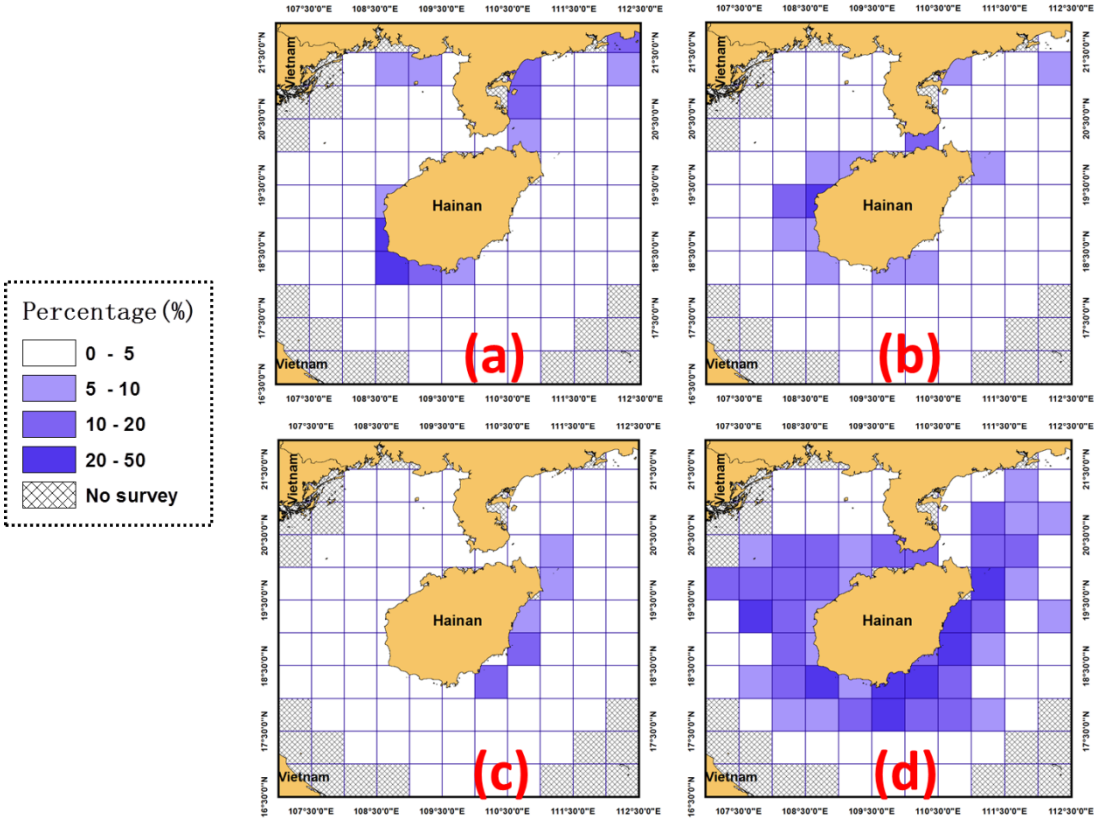
705 **Fig. 2**



707

708 **Fig. 3**

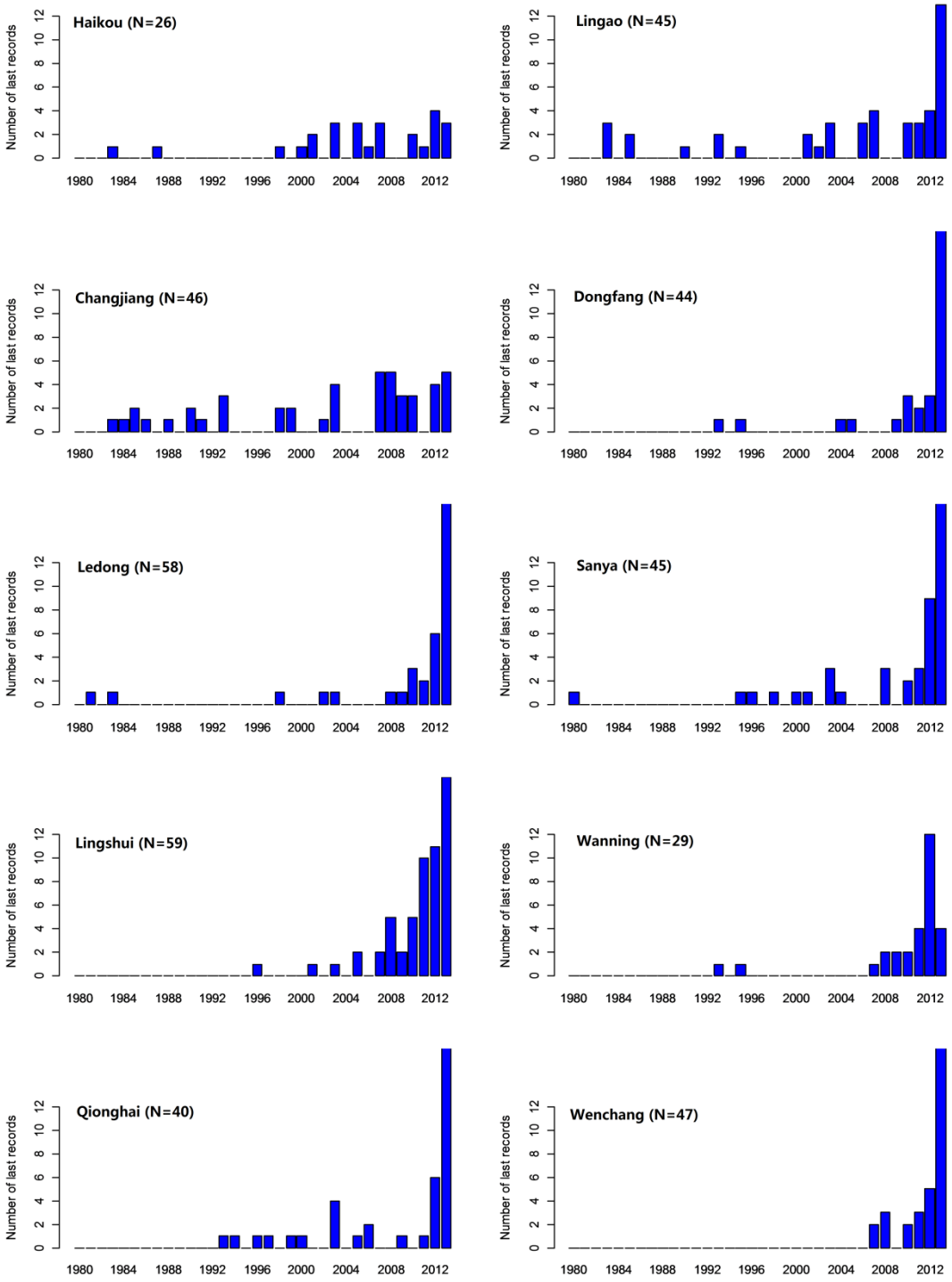
709



710

711 **Fig. 4**

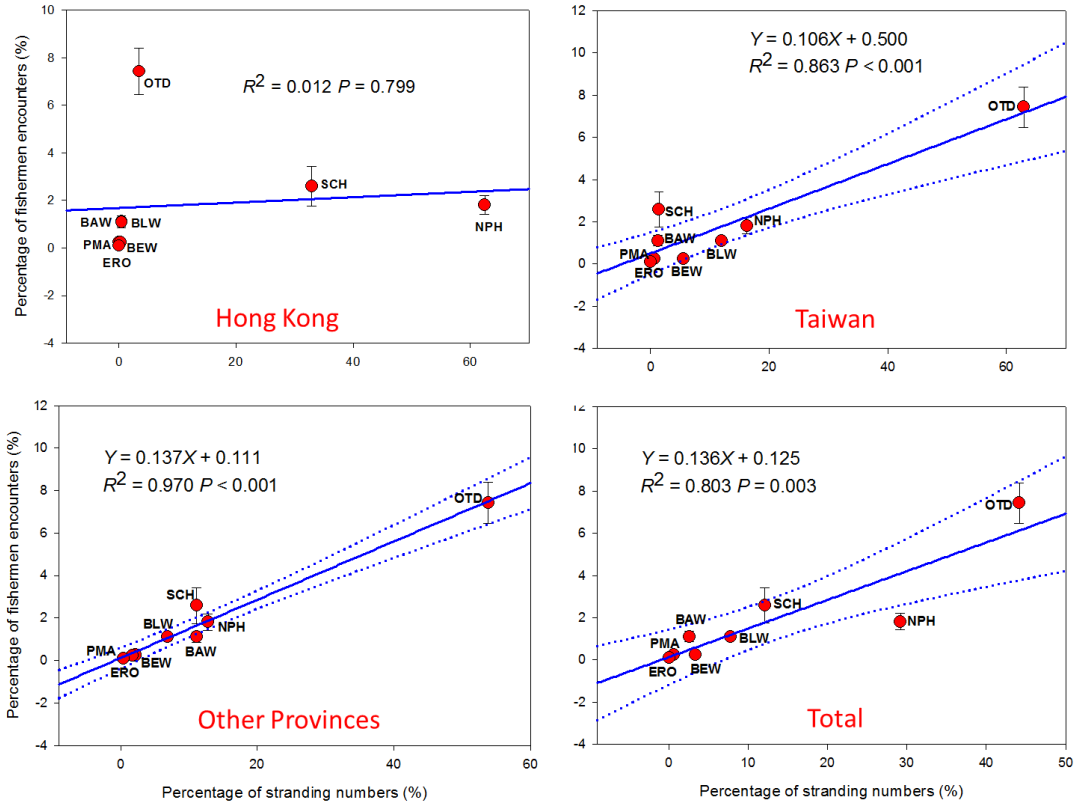
712



713

714 **Fig. 5**

715



716

717 **Fig. 6**

718

719

Appendices A. Fishermen survey questionnaire (English version)

DATE:_____ LOCATION:_____ INTERVIEWER:_____

We undertaking an opinion survey related to fishers' local ecological knowledge on cetacean species. The outcome of the survey will be published in a peer-reviewed journal but will remain anonymous. Would you consent to participate in this study and answer questions related to this subject?

☐ **Yes** ☐ **No**

A: FISHERY AND CETACEANS

1) How old are you? _____

Gender _____

Nationality _____

What is your education level?

☐ University/College ☐ Senior mid school

☐ Junior mid school ☐ Elementary school

☐ Illiterate ☐ Other level (Please describe: _____)

2) You have engaged in fishing from _____ years old to _____ years old

3) Which months do you fish at sea each year? _____

4) How long is your vessel? _____

5) Which fishing gears have you used recently? _____

☐ 1. Drift gillnets ☐ 2. Fixed gillnets

☐ 3. Trawls ☐ 4. Purse nets

☐ 5. Light-trapping ☐ 6. Electric-fishing

☐ 7. Hooking ☐ 8. Long-line

☐ 9. Stow nets ☐ 10. Bomb-fishing

☐ 11. Other fishing gears or methods (Please describe: _____)

6) Please identify your target fish species (A-V) with the help of photographs of commercial fishes in the South China Sea; please list and describe if you mainly catch other species such as crustaceans or cephalopods.

☐ A. *Engraulis* spp. (Anchoveta)

☐ B. *Pampus* spp. (Butterfish)

☐ C. *Pagrosomus* spp. (Sea bream)

☐ D. *Pseudosciaena* spp. (Croaker)

☐ E. *Trichiurus* spp. (Ribbonfish)

☐ F. *Etrumeus* spp. (Herring)

☐ G. *Muraenesox* spp. (Conger)

☐ H. *Argyrosomus* spp. (White croaker)

☐ I. *Nibea* ssp. (Yellow croaker)

☐ J. *Nemipterus* spp. (Nemipterus)

☐ K. *Decapterus* spp. (Scad)

☐ L. *Scombermorus* spp. (Horse mackerel)

☐ M. *Thunnus* spp. (Tuna)

☐ N. *Trachurus* spp. (Mackerel)

☐ O. Cynoglossidae spp. (Tonguefish)

☐ P. *Collichthys* spp. (Croaker)

☐ Q. *Branchiostegus* spp. (Tilefish)

☐ R. *Sardinella* spp. (Sardine)

☐ S. *Mugil* spp. (Mullet)

☐ T. *Navodon* spp. (Filefish)

☐ U. *Epinephelus* spp. (Grouper)

☐ V. *Pneumatophorus* spp. (Chub mackerel)

☐ Other species (Please describe and list: _____)

7) How many days do you devote to fishing on average every year?

_____

8) Where do you typically engage in fishing?

_____(Please write down the grid numbers)

9) How have fishery resources changed during your fishing career?

a) Fishing catch

☐ Increase ☐ Decrease ☐ Unchanged

b) Number of fishing vessels

☐ Increase ☐ Decrease ☐ Unchanged

10) Recent incidental catch of cetaceans:

a) Which fishing gears or methods? _____
b) Which species? _____
c) How many? _____
d) Where? _____ (Write down the grid numbers)
e) When? _____

11) If you have incidentally caught a cetacean, please describe its status:

☐ Dead ☐ Alive but injured ☐ Alive and not injured

☐ Other status (Please describe: _____)

12) Have you ever seen or heard that cetaceans were hit by propellers of fishing vessels?

☐ Ever seen ☐ Ever heard

☐ Never seen ☐ Never heard

If you have you ever seen or heard:

a) When did it happen? _____
b) Which species? _____
c) Where? _____ (Please write down the grid numbers)

13) Relationship between fishing gears and cetaceans:

a) Which fishing gear is able to catch cetaceans most easily? _____

b) How many cetaceans do you know this gear has caught? _____
c) Which other gears can also catch cetaceans? _____

B: DISTRIBUTION AND QUANTITY OF DOLPHINS

(Adult length <4m, typically without column of spray)

14) Please identify and list all dolphin species you have seen
(Identify species with the help of the illustrated handbook, without any prompting or influence from colleagues present)

a) Which dolphin species have you seen most frequently? _____
b) Which dolphin species have you seen in the greatest numbers?
_____

15) During which months is it easiest to see dolphins in your fishing area?
During which months is it more difficult to see dolphins in your fishing area?

16) Where do you see dolphins most frequently?
_____ (Please write down the grid numbers)

17) About the largest size of dolphin group you have ever seen.
a) When? _____
b) Where? _____ (Please write down the grid numbers)

18) How has the amount of dolphins changed during your fishing career?

☐ Increase ☐ Decrease ☐ Unchanged ☐ Do not know

19) About your recent sighting(s) of stranded dolphin(s):
a) Which species? _____
b) How many? _____
c) When? _____
d) Where? _____ (Please write down the grid numbers)

20) Have you ever seen Indo-Pacific humpback dolphins?

☐ Yes ☐ No

a) When? _____
b) Where? _____ (Please write down the grid numbers)
c) How many? _____

21) Have you ever seen finless porpoises?

☐ Yes ☐ No

a) When? _____
b) Where? _____ (Please write down the grid numbers)
c) How many? _____

C: DISTRIBUTION AND QUANTITY OF WHALES

(Adult length >4m, with recognizable spray column)

22) Please identify and list all whale species you have seen
(Identify species with the help of the illustrated handbook, without any prompting or influence from colleagues present)

23) Which whale species have you seen most frequently? _____

24) Describe recent sightings of whales at sea (not including stranded cetaceans):
a) Which species? _____
b) When? _____
c) Where? _____ (Please write down the grid numbers)

25) About the largest group size of whales you have ever seen?
_____
a) Which species? _____
b) How many? _____
c) When? _____
c) Where? _____ (Please write down the grid numbers)

26) Have you ever seen or heard of stranded whale(s): ☐ Yes ☐ No

a) Which species? _____
b) How many? _____
c) When? _____
d) Where? _____ (Please write down the grid numbers)

27) How has the number of whales changed during your fishing career?

☐ Increase ☐ Decrease ☐ No change ☐ Not sure

D: PERCEPTIONS OF CETACEANS AND FISHERY

28) Average family income per month:

☐ <2000 RMB ☐ 2000-4000 RMB ☐ 4000-6000 RMB

☐ 6000-8000 RMB ☐ 8000-10000 RMB ☐ >10000 RMB

29) Do you think fishing is a good profession? ☐ Yes ☐ No

Do you hope that your children work as fishers? ☐ Yes ☐ No

30) How often do you talk about cetaceans with other fishers?

☐ Frequently ☐ Sometimes ☐ Occasionally ☐ Never

31) What topics do you discuss when you talk about cetaceans?

☐ Sighting cetaceans at sea ☐ Cetaceans hurt by vessels or nets

☐ Too many fish eaten by cetaceans ☐ Stranding events

☐ Other topics (Describe: _____)

32) Have you ever eaten dolphin or whale meat? ☐ Yes ☐ No

When have you recently eaten it? _____

33) Have you ever sold cetaceans? ☐ Yes ☐ No

a) ☐ Dead ☐ Alive

b) How much? _____
c) When? _____
d) Purposes of the buyer: _____

34) Do you think cetaceans play an important role in the marine ecosystem?

☐ Yes ☐ No ☐ Not sure

35) Do you think cetaceans should be protected?

☐ Yes ☐ No ☐ Not sure

36) Will fishery resources increase cetaceans are removed?

☐ Yes ☐ No ☐ Not sure

37) Why have marine fishery resources decreased in your opinion?

☐ Increase of advanced fishing methods and gears

☐ Increased number of marine fishers

☐ Fishery resources consumed by cetaceans

☐ Increasing water pollution

☐ Other reasons (Please describe: _____)

38) Why have cetacean populations decreased?

☐ Reduction of food resources due to overfishing

☐ Increased collision risk from increasing vessel traffic

☐ Increased water pollution

☐ Other reasons (Please describe: _____)

39) How do you deal with stranded cetaceans?

☐ Free ☐ Sell ☐ Eat

☐ Inform local fisheries administration ☐ Ignore

☐ Other choices (Please describe: _____)

40) How do you deal with entangled cetaceans?

☐ Free alive ☐ Discard dead ☐ Sell

☐ Inform local fisheries administration ☐ Eat

☐ Other choices (Please describe: _____)

41) Do you think cetaceans are national protected animals in China?

☐ Yes ☐ No ☐ Not sure

42) Do you think that hunting or selling cetaceans is illegal?

☐ Yes ☐ No ☐ Not sure

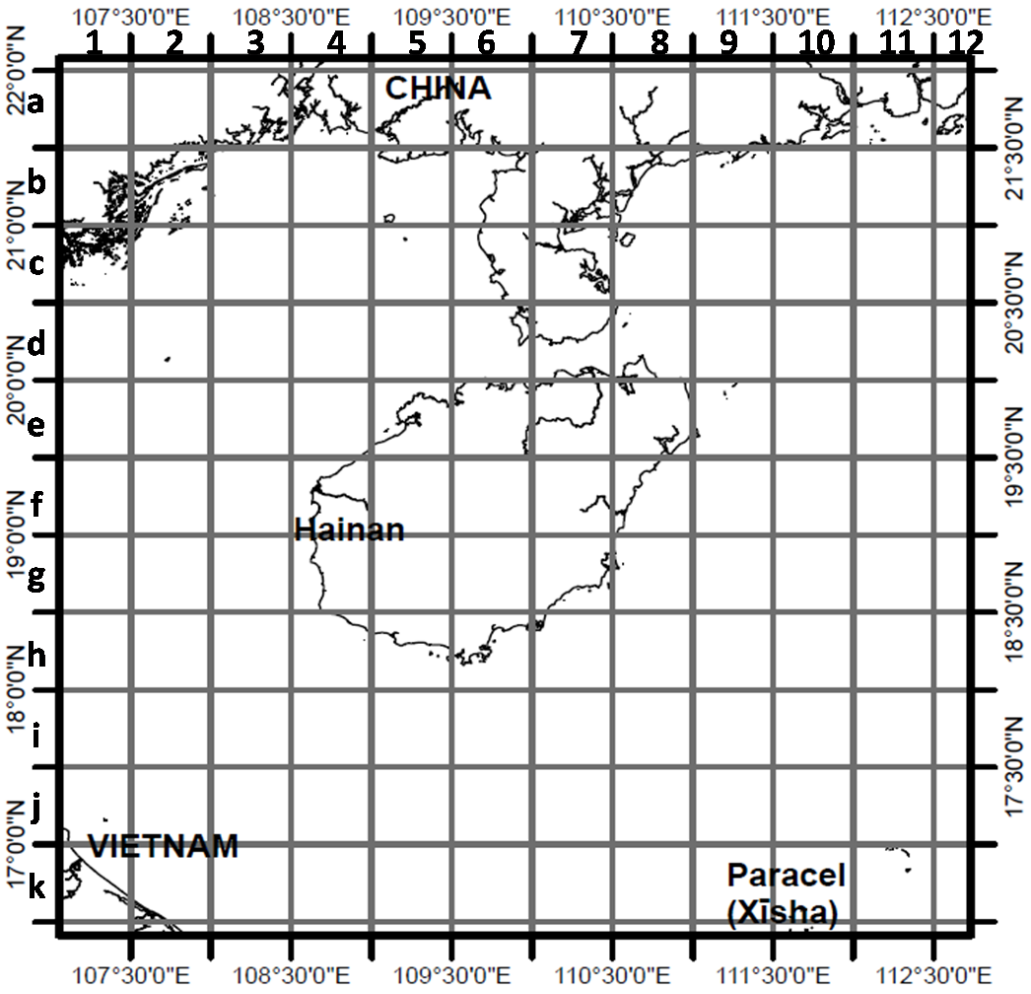


Figure S1 Grid map of Hainan and adjacent waters

1). Please write down grid numbers according to the format "Letter + Number" (e.g., b4).

2). Please record names or geographic locations on the map of other areas in the South China Sea that you have mentioned (e.g., Nansha, Xisha).

SPACE FOR OTHER USEFUL OR ADDITIONAL INFORMATION: