# Cetacean-fishery interactions in Galicia (NW Spain): results and management implications of a face-to-face interview survey with local fishers

**Sabine Goetz [1,2], Fiona L. Read [2,3], M. Begoña Santos [2], C. Pita[1,4] and Graham J. Pierce [1, 5]**

1 Centro de Estudos do ambiente e do mar (CESAM), Universidade de Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal

2 Centro Oceanográfico de Vigo, Instituto Español de Oceanografía (IEO), Subida a Radio Faro 50, 36390 Vigo (Pontevedra), Spain

3 Instituto de Investigaciones Marinas (C.S.I.C.), Eduardo Cabello 6, 36208 Vigo (Pontevedra), Spain

4 eGEO, Geography and Regional Planning Research Centre, Faculdade Ciências Sociais e Humanas, Universidade Nova de Lisboa, Portugal

5 School of Biological Sciences, University of Aberdeen, Zoology Building, Tillydrone Avenue, Aberdeen AB24 2TZ, UK

Corresponding author address:
Centro de Estudos do Ambiente e do Mar (CESAM)
Universidade de Aveiro, Campus Universitário de Santiago

3810-193 Aveiro, Portugal
Tel. +351 234370200; fax. **+ 351 23470985**
E-mail address: sa.goetz@web.de

## Abstract

Galicia (NW Spain) is an important fishing region with a high potential for cetacean-fishery interactions Cetacean depredation on catch and damage to fishing gear can potentially lead to substantial economic loss for fishers, while cetacean bycatch raises conservation concerns. With the aim to gather information on the types and scale of interactions and to suggest possible management strategies, we conducted face-to-face interviews with fishers in local fishing harbours, in particular to identify specific problematic interactions and to quantify the level of economic loss and bycatch rates associated with these interactions. We found that cetacean-fishery interactions are frequent, although damage to catch and fishing gear by cetaceans was mostly reported as small. Nevertheless, substantial economic loss can result from common bottlenose dolphins (*Tursiops truncatus*) damaging coastal gillnets and from short-beaked common dolphins (*Delphinus delphis*) scattering fish in purse seine fisheries. Cetacean bycatch mortality was reported to be highest for trawls and set gillnets, and probably exceeds sustainable levels for local common and bottlenose dolphin populations. Although interview data may be biased due to the perceptions of interviewees, and therefore should be interpreted with care, the methodology allowed us to cover multiple sites and fisheries within a reasonable time-frame. Minimising cetacean-fishery interactions requires the implementation of case-specific management strategies with the active participation of fishers. For set gillnet and purse seine fisheries, the use of acoustic deterrent devices (pingers) may prevent cetaceans from approaching and getting trapped in the nets. For trawl fisheries, where bycatch appears to be particularly high at night in water depths of 100 - 300 m, possible solutions include the implementation of time/area closures and the relocation of some fishing effort to deeper waters.

Keywords: cetacean-fishery interactions, depredation, dolphin bycatch, interview survey, fishers' opinions, fisher participation

## 1. Introduction

Cetacean-fishery interactions remain a cause for concern, with cetacean bycatch being considered a serious threat to cetacean populations world-wide, particularly if threatened species are affected (IWC, 1994). In addition, damage to fishing gear and loss of catch (although the latter is difficult to prove) can potentially lead to substantial economic loss for fishers, especially in areas with acute conflict. Although interactions can be beneficial for some fisheries, for instance in purse seining where the presence of dolphins is used as a cue to detect fish concentrations (e.g. Allen, 1985), the majority of reports describe adverse effects, i.e. catch loss and gear damage through cetacean depredation (Bearzi *et al.*, 2011; Brotons *et al.*, 2008a; Gazo *et al.*, 2008; Gilman *et al.*, 2006; Lauriano *et al.*, 2004; Rocklin *et al.*, 2009; Silva *et al.*, 2011) and scattering of fish (Wise *et al.*, 2007). In Mediterranean waters, Bearzi *et al.* (2011) estimated the mean economic loss of artisanal trammel net fishers as € 2561 per year and Brotons *et al.* (2008a) calculated that trammel net fishers may lose around 5.3% of their total catch value due to interactions with cetaceans.

Galicia (41º48' - 43º47' N), situated in the northwest corner of the Iberian Peninsula (Figure 1), is the most important Spanish fishing region, accounting for almost half of the Spanish fleet and landings in 2010-2011 (Galician Institute for Statistics, 2013; Spanish Ministry of Agriculture, Food and Environment, 2013). Cetacean-fishery interactions are frequently observed in the region, involving a large variety of gears and cetacean species (Aguilar, 1997; Fernández *et al*., 2011a, 2011b; Fernández Contreras *et al*., 2010; López *et al*., 2003; Pierce *et al*., 2010). The short-beaked common dolphin (*Delphinus delphis*) is the most abundant and frequently sighted cetacean species in the area, followed by the common bottlenose dolphin (*Tursiops truncatus*), which mainly inhabits the coastal inlets (rías) of South Galicia. Other frequently sighted species include long-finned pilot whales (*Globicephala melas*), striped dolphins (*Stenella coeruleoalba*), harbour porpoises (*Phocoena phocoena*), Risso's dolphins (*Grampus griseus*) and other large toothed and baleen whales (López *et al*., 2002, 2004; Pierce *et al*., 2010; Spyrakos *et al*., 2011).

López *et al.* (2003) suggested that the bycatch mortality of common and bottlenose dolphins in Galician waters almost certainly substantially exceeds the maximum bycatch mortality rate (1.7% of the best available population estimate) recommended by ASCOBANS[1]. Catch loss and gear damage due to interactions with cetaceans have also been reported in the area (Aguilar, 1997; López *et al*., 2003) although, to date, no detailed assessment of the extent and negative effects on fisheries has been carried out.

Cetacean conservation on the one hand and the interests of fishers on the other provide a classic example of a user-environment conflict (Proelss *et al*., 2011), that requires a

---

[1] ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas), United Nations Environment Programme, New York, 17 March 1992

holistic management approach in order to find an acceptable solution for all parties involved. The first important step for an effective management strategy is the clear identification of specific problematic interactions, i.e. fisheries and/or marine areas in which interactions are most prevalent, and the cetacean species that are most involved.

We conducted a face-to-face interview survey to collect data on the experiences and opinions of fishers. Apart from making use of fishers' ecological knowledge (FEK) , the co-operation with fishers in scientific research also allows for the establishment of partnerships between scientists and fishers - which is thought to increase data quality, create buy-in among stakeholders and facilitate fishers' support for future management strategies (Johnson and van Densen, 2007).

As explained above, previous studies of cetacean-fishery interactions in Galician waters mainly focussed on the assessment of cetacean bycatch, while adverse effects on fisheries received little attention. Therefore the main objective of our interview survey was to obtain a holistic view on cetacean-fishery interactions by assessing all types of interactions ("positive" and "negative") as observed by Galician fishers, determining the types of gears and cetacean species most involved, and fishing areas (geographical location, water depth and distance to coast) where these interactions mainly occur. We further wanted to quantify the economic loss and bycatch rates associated with cetacean-fishery interactions and identify which mitigation methods were being applied by fishers. Finally, based on the results, we suggest possible management and mitigation strategies for specific cases.

## 2. Methods

### 2.1. Study area and local fisheries

Galicia's coastline (about 1200 km in length) is characterized by a series of large, coastal inlets (rías) (Fariña *et al*., 1997) the size and orientation of which affects the frequency and intensity of the seasonal upwelling events which boost this area's productivity. The four Southern rías are much larger and oriented towards the SW, while the Northern rías are smaller and more exposed to the oceanic influence, displaying a variety of orientations (Figueiras *et al*., 2002; ICES, 2011a). Due to these differences, which also condition the human exploitation of the rías, we have divided our study area into two sub-areas (North and South Galicia), Punta Queixal (5 km north of the town of Muros) representing the geographic border between the North and South Galician coasts (Fernández *et al*., 2011a) (Figure 1).

There are 128 fishing harbours along the Galician coast, with Vigo, Ribeira, A Coruña, Burela and Celeiro being the most important in terms of landings (Galician Ministry of Fisheries, 2013). In 2011, the Galician fleet comprised 4734 boats of which the majority (87.6%) fishes with "minor gears" (small-scale fisheries involving vessels < 12 m) such as pots, artisanal longlines and a large variety of artisanal gillnets (trammel nets, single panel bottom-set gillnets and driftnets), targeting fish, cephalopods, crustaceans and bivalves in coastal waters. A substantial proportion (26.3%) of the small-scale fishing fleet is also engaged in shellfish harvesting (with hand- and boat dredges, rakes or manual collection). Most small-scale fishing boats are polyvalent, i.e. they shift between gears depending on the season.

Littoral, medium- to large-scale fisheries (vessel length ≥ 12 m) only account for 12.4% of the Galician fleet. These vessels target shoaling pelagic and demersal species with purse seines, bottom trawls, longlines and large bottom-set gillnets mainly in Galician waters, but also off Asturias, Cantabria, the Basque Country and outside Spanish waters (in the latter case, < 5% of the Galician fleet) (Galician Ministry of Fisheries, 2010, 2013).

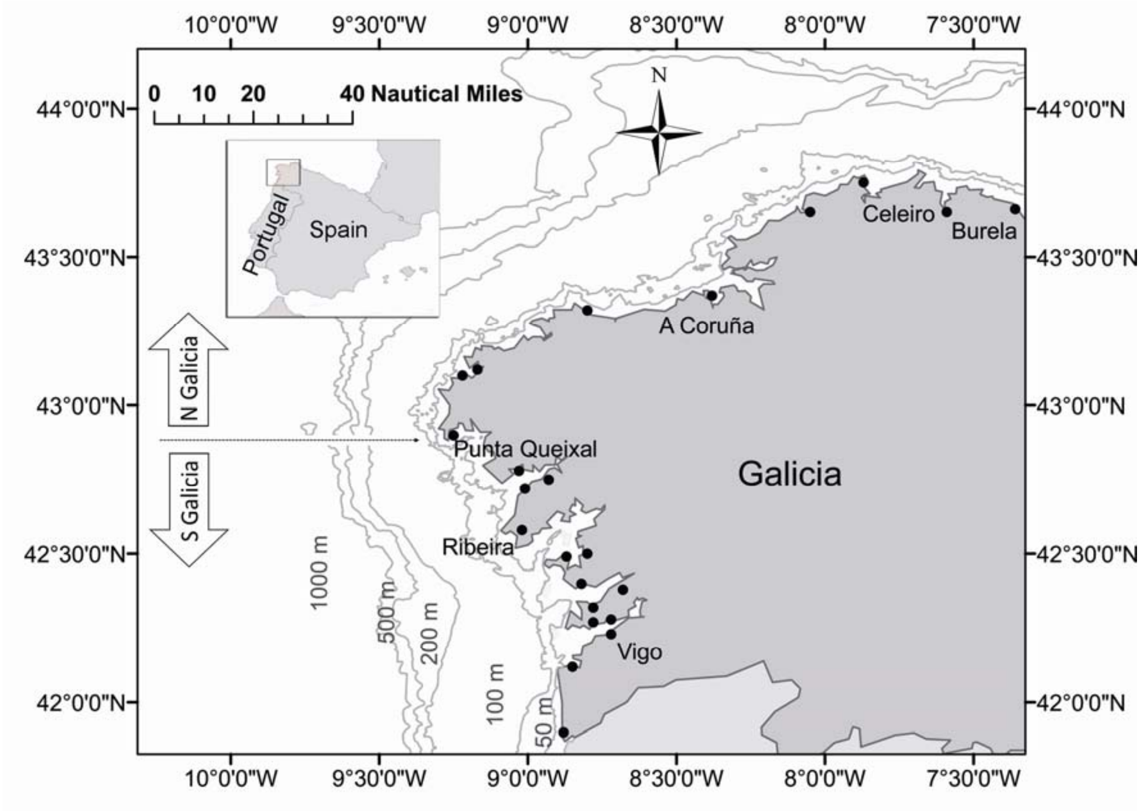

Figure 1. Map of the study area (Galicia, NW Spain). *Black dots* indicate harbours where interviews were conducted.

### 2.2. Interview survey

Interview surveys are increasingly applied in ecology due to being an effective methodology to sample multiple sites and (in the present context) multiple types of fisheries in a comparatively time- and cost-effective way (Moore *et al*., 2010; White *et* *al*., 2005), that would not be possible otherwise. Furthermore, interviews offer the possibility to obtain valuable insights into the characteristics of local fisheries and their interactions with the marine environment (Johannes *et al*., 2000), including preliminary data on bycatch rates (e.g. López *et al*., 2003; Moore *et al*., 2010).

We conducted a face-to-face interview survey in Galician fishing harbours, applying a stratified sampling procedure, with strata based on the type of fishing gear (seven strata, see Tables 1,2). This sampling approach was selected because fishers operating the same gear were assumed to experience similar types of interactions with cetaceans. Fisheries operating outside Spanish waters were not included in order to delimit the study area. Shellfish harvesters operating manual dredges and rakes were also excluded since interactions with cetaceans were assumed to be unlikely. To get a representative sample of Galician fisheries we aimed for a proportional sample, i.e. the sample size (number of vessels) for each stratum being proportional to the overall composition of the sampled fleet. Many harbours in Galicia specialize in certain fishing gears, especially the smaller harbours. Therefore, in order to get sufficient samples for each stratum, we selected harbours (the primary sampling units) according to their representativeness for a certain fishing gear (thus selecting 23 out of 128 harbours) and then sampled boats (secondary sampling units) opportunistically, i.e. we targeted all fishers present and available for interviewing, within the selected harbours (Lauriano *et al*., 2009). In order to maximize the number of interviews for each sampling day, timing of interviewing was adjusted to the seasonal and daily routine of the fisheries sampled.

We designed a structured questionnaire[2] mainly composed of closed-ended questions, making sure all possible answers were covered and allowing for the answer “don’t know”, following White *et al*. (2005). Since we were also interested in fishers’ opinions and suggestions we included some open-ended questions. In order to optimize response rates, we began with “easier”, more general, questions, and asked more difficult and open-ended questions towards the end of the interview. The interviews took 15-20 minutes and were conducted face-to-face by two interviewers who surveyed fishers - if possible the skippers of the vessels – simultaneously, but separately, in the pre-selected harbours. Only professionally active fishers were interviewed. All interviews were kept anonymous and we assured interviewees that all personal data would be treated as confidential. Prior to the implementation of the survey, the questionnaire was pre-tested, first conducting the interview with colleagues and then with a small number of fishers (n = 20). Unclear or ambiguous wording was corrected and sequence of questions was adjusted to improve clarity and flow. The survey collected information about: the interviewee’s profile (to determine level of experience), characterization of the fishing activity (gears used, main fishing grounds, target species and amount of catch), attitude towards cetaceans (positive, negative, neutral), cetacean sightings (sighted species), occurrence of positive and negative interactions with cetaceans and non-cetacean species, consequences of these interactions for fisheries (description and level of damage, including catch loss through depredation and scattering of fish, gear damage and associated economic loss) and cetaceans (level of bycatch), mitigation measures employed and suggestions for solutions to avoid interactions. To obtain an overview of cetacean-fishery interactions that also accounts for potential seasonal variations, we

---

[2] The questionnaire form used for this article can be found as an online Appendix

asked fishers to describe their general experience of such interactions or, in the case of questions that included the estimation of numbers (e.g. catch loss, gear damage and cetacean bycatch), to relate their observations to the last 1-2 years, rather than reporting specific events during their last fishing trip. Catch loss was quantified as the % of total catch lost per depredation/scattering event. Economic loss associated with catch loss/gear damage was quantified as the amount of money (in €) lost per year and bycatch as the number of cetaceans (by species) caught per year (Table 1). When asking about cetacean sightings during the interview, we provided an identification catalogue with colour photographs taken in the area, not labelled with species names, and asked fishers to point to the species seen and indicate the name. Incorrect identification of cetaceans in the catalogue was noted by the interviewer in the questionnaire and all species-related information given in the respective interview was excluded from further analysis.

In order to identify the main local fishing grounds, we provided a nautical map for fishers to indicate the approximate geographic location of their usual fishing grounds. At the end of each interview, we asked fishers to give us their general opinion about the factors which most influence the occurrence/level of cetacean interactions with Galician fisheries. In addition, fishers' narratives (e.g. comments and anecdotes) were recorded, when possible. This qualitative information was collected in order to complement and corroborate the results obtained by the quantitative data analysis.

### 2.3. Data analysis

In order to simplify the dataset and to avoid digit preference, the answers to some questions were grouped into categories (Table 1). If a respondent indicated a range of values, we used the mid-point value. To obtain comparable values for the economic loss associated with catch loss and gear damage for each fishery, we converted the reported monetary loss into the % of gross income (estimated from mean catch volume based on the market price of the main target species) lost per vessel/year. Boats were assigned to North or South Galicia according to the geographical location of their main fishing grounds.

To check the reliability of answers we compared the answers for the most important questions (e.g. proportion of interviewees that report negative interactions with cetaceans) collected by one interviewer with the answers collected by the other interviewer. Any significant differences might indicate that our results are biased by an interviewer effect, i.e. unintended influence of the interviewee by the interviewer. We also analysed whether the interviewees' work experience and function on-board of the vessel had a significant effect on their ability to correctly identify the cetacean species displayed in the catalogue.

Since some interviewees operated more than one type of fishing gear, we recorded multiple responses by the same interviewee for all gear–related questions (e.g. occurrence/consequences of interactions with cetaceans and other species, mitigation measures employed) and analysed these responses separately. For analysis that did not include gear type or other gear-related variables (e.g. interviewee's profile, cetacean sightings, factors influencing interactions and suggestions for solution), only one response per interviewee was included.

Since the final number of interviews per stratum (i.e. type of fishing gear) was not exactly in proportion to the relative fleets' sizes, for the purpose of summary statistics, we weighted the strata, adjusting their relative proportion in the sample to their actual proportions in the surveyed fleet (Table 2). For statistical modelling, gear-type is an explanatory variable and no weighting was necessary.

Generalized linear models (GLM) were used in order to determine which factors are most influential on the frequency of occurrence of cetacean-fisheries interactions, the extent of associated economic loss and the choice of mitigation methods employed (Cameron and Trivedi, 1998; Chambers and Hastie, 1992; White *et al*., 2005). All response variables were binary and a binomial distribution was used with the logit link function if the dataset contained more ones than zeros and the cloglog link function otherwise. We ran a GLM with all relevant covariates, also including interaction terms between variables, using a backward selection procedure. At each step, non-significant variables were dropped (F-Test) and the model was re-run, until all remaining covariates were significant. All variables included in the analysis are listed in Table 1. The variable "harbour" was included into the model to account for any variability between harbours that was independent of gear type. We then validated the final model, checking if the assumptions of homogeneity and independence of residuals were met, also checking for the existence of influential data points. For categorical covariates with more than two categories we created dummy variables, in order to investigate which categories of the covariate are significantly different from each other, and applied a Bonferroni correction for multiple comparisons.

A rough estimation of fishery-related cetacean mortality in Galician waters was derived by extrapolating the average annual number of dead animals reported by the fisheries with highest bycatch in the current interview dataset (i.e. trawls, trammel nets and single panel bottom-set gillnets) to the entire Galician trawl and set gillnet fleets, accounting for the proportion of each fleet that reports to have bycatch.

Statistical analysis was performed using SPSS Statistics 19 (IBM) and, for modelling, Brodgar 2.7.2 (Highland Statistics Ltd.).

Table 1. List of variables used in the analysis with their description and categories.

| | Variables | Description and categories |
|---|---|---|
| Interviewee profile & fishery data | harbour | names of all fishing harbours where interviews were conducted |
| | fisher work experience | low (< 5 years), intermediate, high (≥ 30 years) |
| | function on board of vessel | skipper, crew member |
| | fishing gear | pair- and otter trawls[1], purse seines[1], surface driftnets[1], single panel bottom-set gillnets ("betas"[1], "volantas"[2], "rascos"[2])*, bottom-set tra nets, i.e. three panels ("trasmallos"[1], "miños"[1])*, bottom longlines[1], |
| | target species | European hake (*Merluccius merluccius*), European conger (*Conger conger*), other large demersal fish, blue whiting (*Micromesistius poutassou*), shoaling pelagic species, i.e. sardine (*Sardina pilchardu* horse mackerel (*Trachurus* spp), Atlantic mackerel (*Scomber scomb* molluscs (cephalopods & bivalves), crustaceans |
| | type of fishery | vessel length in m: small-scale (< 12m), medium- to large- scale (≥1 |
| | mean catch volume | in kilogram/haul: low (< 100 kg), intermediate, high (≥ 500 kg) |
| | mean water depth | in metres: shallow (< 50 m), intermediate, deep (≥ 100 m) |
| | mean distance to coast | in nautical miles: nearshore (< 12 nm), offshore (≥ 12 nm) |
| | main fishing grounds | North Galicia (N-Galicia), South Galicia (S-Galicia) |
| Cetacean sightings & fishers' attitudes | cetacean sightings (individuals or groups) | common dolphin, bottlenose dolphin, striped dolphin, long-finned pi whale, harbour porpoise, Risso's dolphin, killer whale, sperm whale, baleen whales |
| | attitude towards cetaceans | negative, neutral, positive |

| | | |
|---|---|---|
| Interactions | positive interactions | cetaceans indicate fish schools |
| | negative interactions | catch damage/loss (depredation & scattering of fish) and gear damag cetaceans and non-cetacean species, cetacean bycatch |
| | approach gear | cetaceans approach gear (or not) |
| | catch (%) loss | % of catch lost per vessel/interaction event: low (< 10%), intermedia high (≥ 50%) |
| | economic (€) loss | % of gross income lost per vessel/year: minimal (< 10%), significant 10%) |
| | bycatch | occurrence and number of animals caught per vessel/year: minimal ( low (2-10), intermediate (11-30), high (> 30) |
| Mitigation | mitigation measures | change of fishing area, scare cetaceans away, wait until cetaceans lea use of pingers, reduce fishing time, other |

*different net dimension, mesh size and soak time

[1] small-scale/artisanal fisheries

[2] medium- to large-scale fisheries

## 3. Results

Between May 2008 and August 2010 we conducted 283 interviews (accounting for 283 vessels) in 23 harbours along the Galician coast, covering around 6.3% of the Galician fleet operating in national waters (4450 vessels; Galician Ministry of Fisheries, 2013). If considering only the fleet of interest (excluding shellfish harvesters), interviews covered 11.6% of vessels (from a total of 3267). Including multiple responses given by the interviewees who operated more than one type of gear, the total sample size was 330. (Table 2). The response rate was high (97%) with only a few fishers (n = 8) refusing to take part in the survey because they had no time for the interview. There were no significant differences in answers for the most important questions between the two interviewers, suggesting that interviewer effect was negligible. The factor "harbour" was not significant in any of the GLMs, which indicates that our sampling procedure did not introduce notable bias into our data and that there were no differences between harbours not captured by other variables already included in the analysis (e.g. gear type, fishing area).

### 3.1. Characteristics of the sampled fleet

Fishers interviewed were almost exclusively males (99.3%), between 19 – 65 years of age and had a mean working experience of 25 years (SD = 11.45). The majority (90.7%) reported family links to fisheries. Most fishers interviewed were skippers (73.6%), the remainder being crew members (26.4%).

Gillnets were the fishing gear most frequently used (trammel nets 22.7%, single panel gillnets 15.8% and driftnets 3%), followed by pots (21.8%), purse seines (17.6%), trawls (otter-trawl 6% and pair-trawl 5.5%) and longlines (7.6%). 63.2% of our interviewees were fishing in South Galician waters, 30.3% in North Galicia and the remaining 6.5% along the Asturian, Cantabrian and Basque Country coasts.

High catches (≥ 500 kg/haul) were mostly reported by trawl fishers (blue whiting, large demersal fish and shoaling pelagic species mainly in deep offshore waters) and purse seiners (shoaling pelagic species in nearshore waters). Fishers operating longlines and single panel bottom-set gillnets mostly targeted hake, conger and other large demersal fish in nearshore waters and achieved low to intermediate catches (< 500kg). , Trammel nets, pots and driftnets were mostly set in shallow waters (< 50 m), achieving small catches (< 100 kg); the former two targeted cephalopods, crustaceans and large demersal fish, while the latter caught exclusively shoaling pelagic fish (Table 2).

Table 2. Composition and detailed description of the surveyed fleet (excluding vessels fishing outside Spanish waters and shellfish harvesters) and sample, including the number of vessels and percentages of vessels associated with each type of fishery (stratum), and the weighting factors applied in descriptive analysis. Moreover the characteristics of each type of fishery are summarized for the sample. The percentage of surveyed vessels within each category is indicated. (SPBG – single panel bottom-set gillnet).

|  | Type of fishing gear |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  | Trawl | Purse seine | SPBG | Trammel net | Driftnet | Longline | Pot | **Total** |
| surveyed fleet (N) |  |  |  |  |  |  |  |  |
| number of vessels | 84 | 158 | 343 | 701 | 148 | 762 | 1071 | **3267**<br>334 |
| % | 2.6 | 4.8 | 10.5 | 21.5 | 4.5 | 23.3 | 32.8 |  |
| sample (n) |  |  |  |  |  |  |  |  |
| number of interviews | 38 | 58 | 52 | 75 | 10 | 25 | 72 | **330** |
| % | 11.5 | 17.6 | 15.8 | 22.7 | 3.0 | 7.6 | 21.8 |  |
| weighting factor | 0.22 | 0.28 | 0.67 | 0.94 | 1.49 | 3.08 | 1.50 |  |
| type of fishery (vessel length): |  |  |  |  |  |  |  |  |
| small-scale (< 12 m) |  | 6% | 60% | 80% | 100% | 60% | 87% |  |
| medium- to large-scale (≥ 12 m) | 100% | 94% | 40% | 20% |  | 40% | 13% |  |
| mean water depth: |  |  |  |  |  |  |  |  |
| shallow (< 50 m) |  | 63% | 43% | 68% | 92% | 56% | 78% |  |
| intermediate |  | 31% | 26% | 29% | 8% | 12% | 19% |  |
| deep (≥ 100 m) | 100% | 6% | 31% | 3% |  | 32% | 3% |  |
| mean distance to coast: |  |  |  |  |  |  |  |  |
| nearshore (< 12 nm) | 11% | 100% | 79% | 96% | 100% | 84% | 100% |  |
| offshore (≥ 12 nm) | 89% |  | 21% | 4% |  | 16% |  |  |
| main target species: |  |  |  |  |  |  |  |  |
| European hake | 11% |  | 43% | 1% |  | 23% |  |  |
| European conger |  |  |  |  |  | 48% |  |  |
| other large demersal fish | 22% |  | 54% | 69% | 7% | 29% |  |  |
| blue whiting | 34% |  |  |  |  |  |  |  |
| shoaling pelagic fish | 33% | 100% |  |  | 93% |  |  |  |
| molluscs |  |  |  | 17% |  |  | 81% |  |
| crustaceans |  |  | 3% | 13% |  |  | 19% |  |
| mean catch volume: |  |  |  |  |  |  |  |  |
| low (< 100 kg) |  |  | 50% | 85% | 59% | 29% | 86% |  |
| intermediate | 12% | 13% | 38% | 12% | 33% | 63% | 14% |  |
| high (≥ 500 kg) | 88% | 87% | 12% | 3% | 8% | 8% |  |  |

### 3.2. Cetacean sightings: species composition and fishers' attitudes towards cetaceans

Based on weighted interview data, the cetacean species most frequently sighted were bottlenose dolphins (40.1% of sightings) and common dolphins (35.4%), followed by non-identified cetaceans (10.8%), harbour porpoises (5.2%), long-finned pilot whales (5%), and striped dolphins (1.8%). Risso's dolphins, sperm whales (*Physeter macrocephalus*), killer whales (*Orcinus orca*) and baleen whales were also occasionally sighted (all < 1%).

The majority (73.5%) of fishers were able to identify the common cetacean species correctly, independent of their work experience or their function on-board of the vessel (no significant differences were detected).

Fishers' attitudes towards cetaceans were mostly neutral (70.6%); they reported that animals do not disturb fishing operations, at least not with their gears, although they acknowledged that they may be problematic for other gears. Negative opinions about cetaceans (17.4% of respondents) were significantly related to catch- and gear damage (Table 3). Fishers with a positive opinion (12%) frequently replied that they like to see cetaceans, because "they break their routine" and that "their presence indicates the presence of fish schools".

Table 3. GLM results: All response variables followed a binomial distribution (yes/no). Results displayed are as follows: nominal explanatory variables included in the final model, their significance based on $\chi^2$ tests, with p-value (the significantly different

categories of each explanatory variable are specified in the text of sections 3.3 and 3.4), the degrees of freedom (d.f.), the number of observations (n) and the overall percentage of deviance explained (%dev) by the model.

Abbreviations: Common dolphin (DDE), bottlenose dolphin (TTR), cetaceans (cet) and non-cetacean species (non-cet). For a detailed description of variables see Table 1.

| **Response variables** | **Explanatory variables** | $\chi^2$ | **p** | **d.f.** | **n** | **%dev** |
|---|---|---|---|---|---|---|
| **negative attitude towards cetaceans** | catch and gear damage by cetaceans | 104.23 | < 0.0001 | 1 | 330 | 27.4 |
| **positive interactions** | target species | 33.91 | < 0.0001 | 6 | 285 | 24.9 |
| | water depth | 9.33 | 0.0049 | 2 | | |
| | presence of DDE | 3.07 | 0.0798 | 1 | | |
| **cetaceans approach gear** | gear damage | 27.22 | < 0.0001 | 1 | 313 | 30.2 |
| | catch damage | 7.18 | 0.0074 | 1 | | |
| **cetacean catch damage** | main fishing grounds | 16.98 | < 0.0001 | 1 | 267 | 31 |
| | target species | 63.39 | < 0.0001 | 6 | | |
| catch damage by DDE | catch volume | 8.85 | 0.0119 | 2 | 58 | 20.9 |
| | water depth | 6.25 | 0.0439 | 2 | | |
| catch damage by TTR | catch volume | 21.45 | < 0.0001 | 2 | 58 | 26.8 |
| high catch (%) loss (cet) | catch volume | 36.62 | < 0.0001 | 2 | 77 | 34.7 |
| **non-cetacean catch damage** | catch volume | 6.31 | 0.0426 | 2 | 232 | 15.6 |
| catch damage by cephalopods | target species | 20.13 | 0.0012 | 5 | 53 | 30.5 |
| | water depth | 12.66 | 0.0018 | 2 | | |
| catch damage by sharks | target species | 12.98 | 0.0235 | 5 | 53 | 46.1 |
| | water depth | 7.22 | 0.027 | 2 | | |
| high catch (%) loss (non-cet) | catch damage by crustaceans | 25.61 | 0.0202 | 1 | 58 | 22.8 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **cetacean gear damage** | fishing gear | 80.48 | < 0.0001 | 6 | 229 | 29.3 |
| gear damage by TTR | fishing gear | 16.13 | 0.0028 | 6 | 66 | 17.7 |
| gear damage by DDE | fishing gear | 14.66 | 0.0119 | 6 | 89 | 12.4 |
| significant economic (€) loss (cet) | gear damage by TTR | 4.5 | 0.034 | 1 | 73 | 5.98 |
| **non-cetacean gear damage** | | | | | | |
| gear damage by crustaceans | fishing gear | 15.09 | 0.0099 | 6 | 32 | 41.9 |
| significant economic (€) loss (non-cet) | gear damage by crustaceans | 7.99 | 0.0047 | 1 | 29 | 40.8 |
| | gear damage by conger | 4.84 | 0.0278 | 1 | | |
| **cetacean bycatch (yes/no)** | fishing gear | 62.99 | < 0.0001 | 6 | 235 | 30.5 |
| | water depth | 18.59 | < 0.0001 | 2 | | |
| bycatch of DDE | fishing gear | 11.41 | 0.0483 | 6 | 83 | 10.5 |
| bycatch of TTR | type of fishery | 12.04 | 0.0005 | 1 | 83 | 17.5 |
| **mitigation measures (yes/no)** | gear damage | 21.16 | < 0.0001 | 1 | 316 | 46.1 |
| | fishing gear | 35 | < 0.0001 | 6 | | |
| | catch damage | 13.69 | 0.0002 | 1 | | |

## 3.3. Interactions

Based on weighted data, slightly over one-third (38.6%) of fishers reported having interactions with cetaceans, the majority (83.5%) being classified as negative.

Positive interactions were mostly associated with common dolphins, primarily because dolphins were associated with presence of schools of pelagic species in intermediate water depth (Table 3).

Negative interactions comprised damage/loss of catch (depredation and scattering of fish; 42.2%), gear damage (34.3%) and cetacean bycatch (23.5). In contrast, only 0.5% of fishers considered bycatch to be their most serious cetacean-related problem.

Fishers reported damage to catch and gear caused by cetaceans (52.3% of damage events), but also by other animals (47.7%), such as bony fish (conger), elasmobranchs (blue shark, *Prionace glauca*; shortfin mako, *Isurus oxyrinchus*), cephalopods (common octopus, *Octopus vulgaris*; European squid, *Loligo vulgaris*; common cuttlefish *Sepia officinalis),* crustaceans (green crab, *Carcinus maenas*; parasitic isopods *Cymothoa spp.*; lobster, *Homarus* spp), starfish and seagulls (Figure 2a,b).

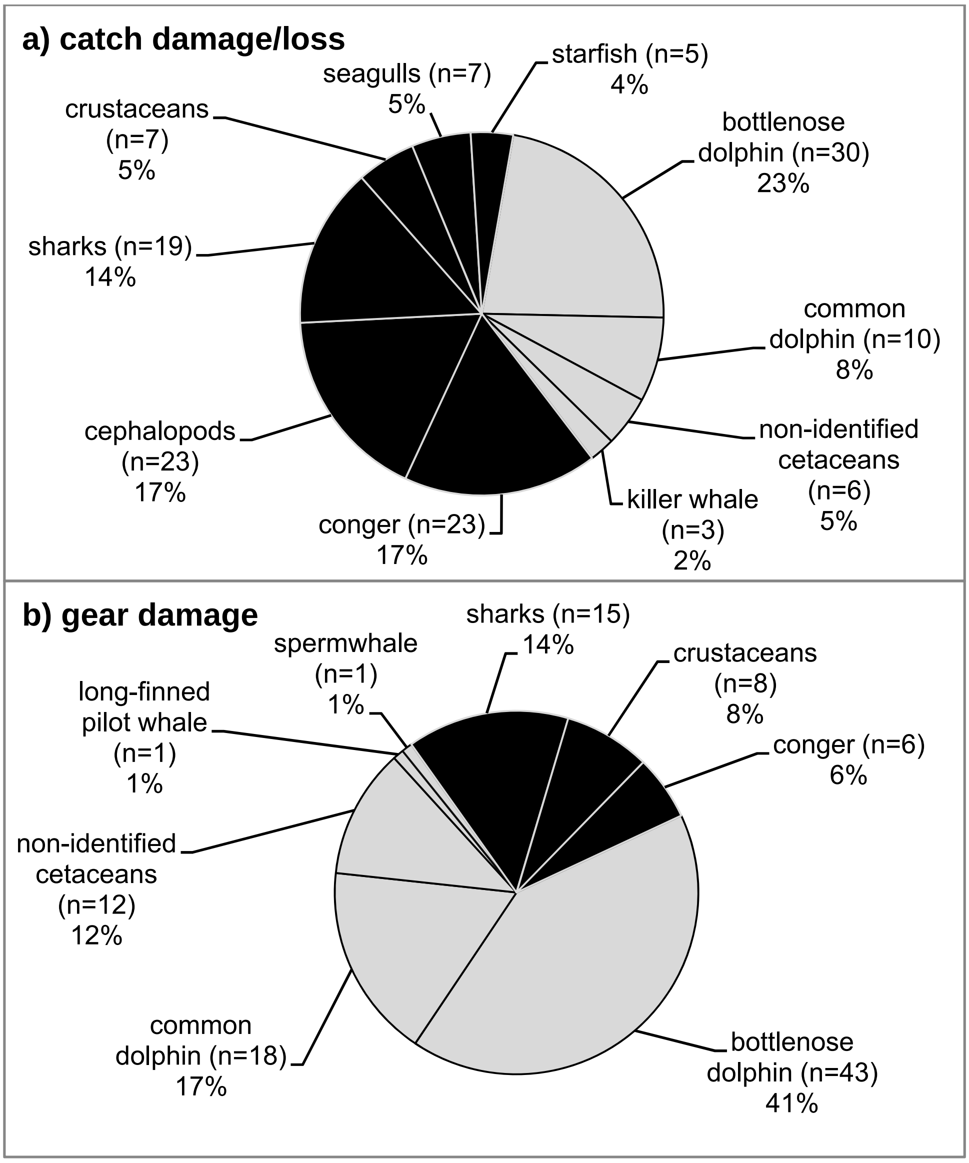

Figure 2. Contribution of cetacean (*grey*) and non-cetacean species (*black*) to **a)** catch damage/loss and **b)** gear damage, as reported by interviewees (in %).

Cetaceans as well as non-cetacean species were described to feed on catch or bait trapped in the gear (depredation). Fishers reported being able to identify which group was responsible for depredation, either through direct observation or based on the nature of the damage. They mentioned that cetaceans normally tear the body of the fish, leaving characteristic bite marks and often just the fish head in the nets, whereas sharks typically bite the fish in half leaving clean borders. The presence of several small bites on the fish body indicate depredation by conger, cephalopods and crustaceans. While the latter frequently bite small holes into the nets during feeding, cetaceans and sharks may tear medium-sized to large holes into the nets when they remove fish. Fishers reported that large sections of the nets may also be torn if cetaceans accidentally get entangled in static nets. In purse seine fisheries, cetaceans were frequently observed to scatter fish before the net was pursed, while in trawl fisheries they occasionally twisted the gear, resulting in catch loss.

The reported contribution of cetaceans (mainly bottlenose dolphin, followed by common dolphin) to catch damage/loss was considerably lower than the contribution of non-cetacean species (conger, cephalopods, sharks and crustaceans) (36.8% and 63.2%, respectively; Figure 2a), while damage to gear was reported as being more frequently caused by cetaceans than by non-cetacean species (72.1% and 27.9%, respectively; Figure 2b). Cetaceans were sighted close to the gear in the majority of cases when catch damage/loss (89.6% of cases) and gear damage (90%) occurred (Table 3). Longlines and pots were the only gears that were not affected by any type of interactions with cetaceans.

Significantly higher rates of catch damage/loss caused by cetaceans were reported by fishers operating in South Galicia and targeting shoaling pelagic species (Table 3).

Bottlenose dolphin was the main species associated with depredation on catch (61.4% of all reported depredation events), preying primarily on small catches, while common dolphin was reported to be most likely to scatter fish (50% of scattering events) in intermediate water depth, predominantly interfering with fisheries achieving large catches (Table 3).

The reported occurrence of gear damage by cetaceans was significantly higher for artisanal driftnets (100% of the driftnet users reported gear damage; n=15) than for all other gears. Single panel bottom-set gillnets also had a relatively high proportion of damage by cetaceans (54.3% of single panel bottom-set gillnet users), while there were no reports of damage to pots (Table 3).

Damage to gear caused by bottlenose dolphin was observed mainly in driftnets and set gillnets, while common dolphin caused net damage mostly in trawls and purse seines (Table 3).

Catch loss per vessel/interaction event was classified as low (<10% of total catch) by 42.6% of the fishers who had reported catch damage. 41.9% of interviewees reported high catch loss (≥50% of total catch), frequently mentioning that it is not unusual to lose the whole catch when cetaceans interfere with the fishing operation. This was significantly linked to fisheries with high catches (Table 3). Purse seine fishers estimated that losing the whole catch during a fishing operation is equivalent to a monetary loss of 3500 - 6000 Euros per event.

The annual economic loss associated with catch damage caused by cetaceans was, however, mostly (77.7% of catch damage reports) reported to be minimal (< 10% of gross income) (Figure 3). In only 22.3% of cases, economic loss was reported to be significant (≥ 10% of gross income), over half (57.1%) of these cases relating to catches of shoaling pelagic species.

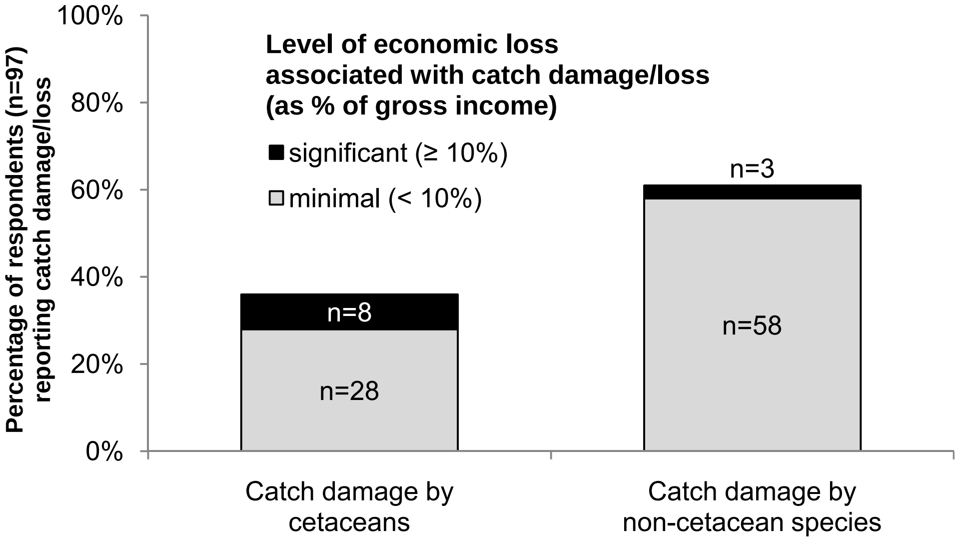

Figure 3. The contribution (in %) of cetaceans and non-cetacean species to catch damage/loss (a total of 97 interviewees reported catch damage). The level of economic loss (as % of gross income lost per vessel/year) associated with cetacean and non-cetacean catch damage is also illustrated, *grey* referring to minimal (<10%) and *black* referring to significant (≥10%) economic loss.

Economic loss associated with gear damage by cetaceans was mainly reported to be minimal (72.9% of gear damage reports; Figure 4). Significant economic loss (27.1%) was strongly related to gear damage by bottlenose dolphins (Table 3). Although fishing gear was not significant in our model, high economic loss was a lot more common in coastal gillnets (93.8% of cases) than other gears.

Depredation by non-cetacean species was reported to be mainly associated with low catches, octopus mostly preying on catches of crustaceans in deep waters and sharks preying on hake in intermediate water depth, while gear damage was mainly associated with crustaceans damaging pots (Table 3).

Economic loss associated with depredation and gear damage by non-cetacean species was reported to be significant in only 4.9% (n=3) and 12.9% (n=4) of interaction events with these species, respectively (Figures 3,4). The main non-cetacean species causing significant catch and gear damage were conger (44.4% of these cases) and crustaceans (33.3%; Table 3), cephalopods (21.1%) and starfish (10.5%).

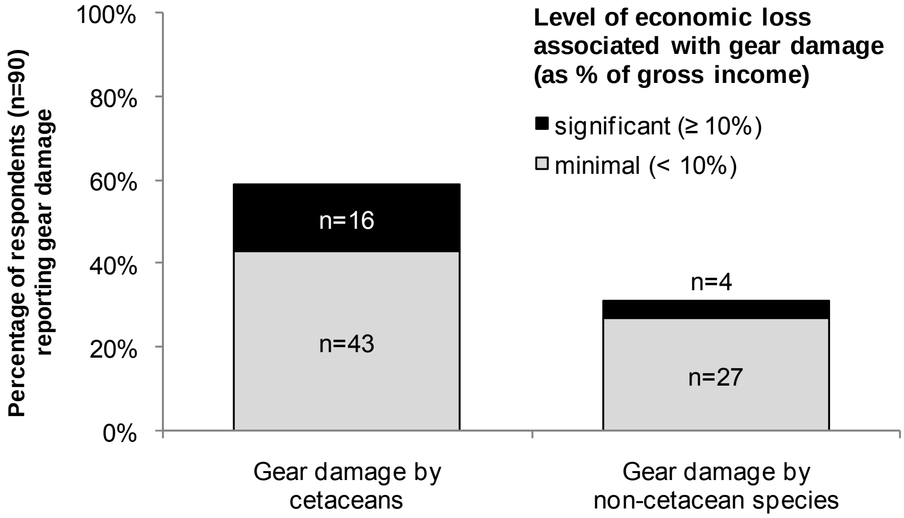

Figure 4. The contribution (in %) of cetaceans and non-cetacean species to gear damage (a total of 90 interviewees reported gear damage). The level of economic loss (as % of gross income lost per vessel/year) associated with cetacean and non-cetacean gear damage is also illustrated, *grey* referring to minimal (<10%) and *black* referring to significant (≥10%) economic loss.

## Estimated versus perceived loss

At the end of each interview, fishers who reported suffering catch and/or gear damage by cetaceans were asked if they perceived this damage as problematic, i.e. significant for their activity, 62.5% of fishers answered “yes”. This percentage markedly exceeds the proportion of interviewees whom we estimated to suffer significant economic loss.

## Cetacean bycatch

One-fifth (20.2%) of fishers reported incidental bycatch of cetaceans, mainly in trawls, purse seines, trammel nets (trasmallos and miños) and single panel bottom-set gillnets (betas and volantas), identifying common dolphin as the species most frequently bycaught (53.3%), followed by non-identified cetaceans (23.3%) and bottlenose dolphin (18.3%). Pilot whale, striped dolphin and harbour porpoise represented only 5.1% of bycatch reported during interviews (based on weighted data). Almost half (49%) of the interviewees who reported cetacean bycatch, declared that they catch fewer than 10 animals per year, 44.4% had minimal bycatch (≤ 1 animal/year) and only 6.6% said that bycatch was high (> 30 animals/year). In our model, the probability of cetacean bycatch was highest for trawls, purse seines and trammel nets, and generally increased with increasing water depth (Table 3). Cetacean bycatch reported by trawlers (mainly of common dolphins) was concentrated in waters of 100 - 300 m depth, while for trammel nets and purse seines bycatch mainly occurred in shallower waters (< 100m). Bycatch in single panel bottom-set gillnets occurred mainly between 50 – 300 m without any clear trend (Figure 5). Bycatch of bottlenose dolphins was significantly related to small-scale fisheries (Table 3). According to fishers, animals encircled in purse seines usually survived, either by escaping unaided or being helped to escape by the lowering of the corkline.

Of those fishers reporting any bycatch, trawl fishers reported catching 12 animals per year on average, and fishers operating fixed gillnets reported catching two (trasmallos and volantas) or three (miños and betas) animals per year on average. To estimate total bycatch by the whole Galician trawl and set gillnet fleets, we first calculated the number of boats within each sector which would have bycatch (68.4% of 84 trawls, 30% of 363 trasmallos, 54.5% of 39 volantas, 52.4% of 338 miños and 25% of 301 betas), and then multiplied these numbers with the average annual bycatch number of each sector. Summing up all products, this would give a total estimate of 1707 cetaceans killed by Galician fisheries each year (159 common dolphins, 136 bottlenose dolphins, 73 long-finned pilot whales, 40 harbour porpoises and 1299 non-identified cetaceans).

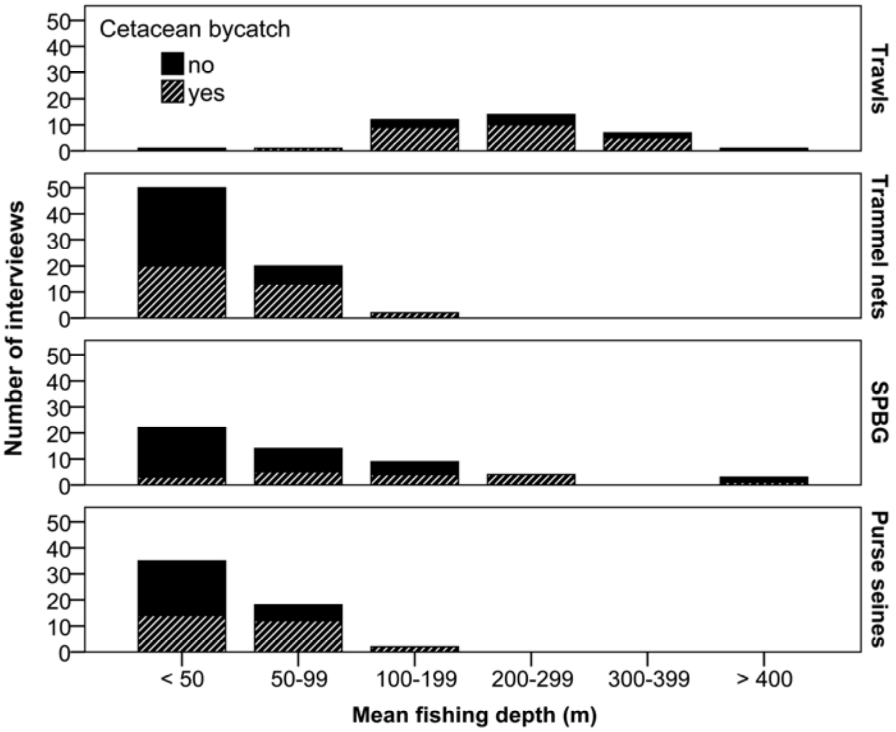

Figure 5. Reported depth distribution (mean fishing depth in m) of fishing activity and occurrence of cetacean bycatch for trawls, set gillnets (trammel nets and single panel bottom-set gillnets - SPBG) and purse seines. The bars represent the number of interviews in each depth category. The proportions of interviews reporting cetacean

bycatch are highlighted with diagonal white stripes, while the proportions of interviews with no bycatch reports are highlighted in black.

### 3.4. Mitigation measures

Almost half (42.6%; weighted percentage) of the interviewees who reported negative interactions also reported the application of mitigation. The main measure was to navigate to alternative fishing grounds away from the cetaceans (44.4% of fishers that used mitigation measures). Another strategy was scaring the cetaceans away from the vessel (28.8%), for instance by making noise, using firecrackers, throwing stones at the animals or hosing them with seawater. Some fishers mentioned that they postpone the fishing operation until the cetaceans leave the area (16.4%) and very few interviewees reported that they reduce the fishing/soak time (7.1%) or use pingers (3.3%) to avoid interactions.

Mitigation measures were used significantly more frequently by fishers suffering gear and catch damage, compared to those suffering no damage, particularly by those using driftnets and purse seines (Table 3), and when scattering of fish was reported as the main problem.

### 3.5. Influential factors and fishers' suggestions for solutions

When asking fishers about the most important factors influencing the amount of interactions with cetaceans, they indicated that the type of fishing gear used was the most influential factor (56.6%). Gillnets were identified as the most problematic gear. Another factor frequently indicated was the catch target species (22%), namely when fishing for shoaling pelagic species. 8.1% of interviewees believed that season was also an important factor, with interactions occurring more frequently in summer and spring and 6.8% mentioned that fishing area may be influential, interactions occurring more frequently nearshore than offshore. Other factors mentioned (< 5 %, in each case) included fishing time/duration, weather, water depth, cetacean behaviour, moon cycle and resource availability.

Relatively few fishers (15.7%) provided suggestions about how to solve the problem of cetacean-fisheries interactions. Suggestions included measures to benefit fisheries and cetaceans in approximately equal proportions. The former ranged from deterring cetaceans from approaching the gear (for instance with acoustic deterrent devices) and financial compensation, to a few rather extreme suggestions, namely the hunting and deliberate killing of cetaceans reduce the local population.

Measures to benefit cetaceans mainly comprised the prohibition of fishing gears with high bycatch levels, a large-scale reduction of fishing effort and the establishment of cetacean conservation areas, where fishing is restricted. The need for alternative "cetacean friendly" fishing methods and more environmental education was also emphasized.

## 4. Discussion

### 4.1. Cetacean species sighted and their interactions with fisheries

Quantitative analysis as well as qualitative information provided by Galician fishers suggests that the occurrence/level of cetaceans' interactions is primarily influenced by the type of fishing gear, target species and fishing area. Coastal demersal gillnet fisheries and purse seine fisheries for shoaling pelagic species are the main fisheries affected by catch/gear damage, while offshore trawling causes the highest cetacean bycatch mortality.

The cetacean species sighted by the respondents and their relative frequency of occurrence are consistent with those previously described by other authors for the North West Iberian Peninsula using a variety of methods, including sightings from vessels and from the coast, and interviews (Aguilar, 1997; López *et al*., 2002, 2003, 2004; Pierce *et al*., 2010; Spyrakos *et al*., 2011).

As in several similar studies, bottlenose dolphin was reported to be the species most strongly associated with depredation and gear damage, particularly for set gillnets (Aguilar, 1997; Bearzi *et al*., 2011; Brotons *et al*., 2008a; Lauriano *et al*., 2004, 2009; López *et al*., 2004; Rocklin *et al*., 2009). Common dolphins were also frequently mentioned to interact with the fishing activity, but primarily with purse seines.

Although the report of interaction frequency was generally high in our survey, the majority of interviewees had a neutral or positive attitude towards cetaceans and the economic loss resulting from negative interactions was mainly classified as low. This contrasts with the perception of fishers affected by catch loss and gear damage who mostly classified cetacean-fishery interactions as “problematic”. This discrepancy between the estimated and the perceived impact of cetacean-fishery interactions, which was also observed by Silva *et al*. (2011) and Wise *et al*. (2007), may be linked to the fact that fishers who frequently experience negative interactions with cetaceans might tend to exaggerate the real economic impact in order to draw attention to their situation or may perceive the interviews as an opportunity to influence decision-making with respect to governmental monetary compensations for catch loss and gear damage (Bearzi *et al*. 2011). In contrast, cetacean bycatch that was reported by almost one-quarter of fishers, was rarely considered a serious problem, most likely because (apart from occasional gear damage) bycatch did not have a direct negative impact on fishers' profit and/or because fishers may be afraid of the implementation of bycatch reduction measures that restrict their activity.

However, there were two circumstances where dolphins were reported to have a significant negative impact on fisheries: interactions between purse seiners and common dolphins and interactions between bottlenose dolphins and coastal gillnets. Purse seine fisheries target sardine, one of the main prey species of common dolphins in Galician waters (Méndez Fernández *et al*., 2012; Santos *et al*., 2013). They frequently use observations of dolphins as a cue for the presence of a large fish school, although, in contrast, some interviewees indicated that if dolphins are in an area, they avoid it. Fishers reported that dolphins cause scattering or sinking of entire fish schools, frequently leading to the complete loss of the catch for the affected haul. Such occurrences are plausible and are probably directly linked to the fish school's awareness of the presence of a predator (Wise *et al*., 2007). Nevertheless, due to the low frequency of interactions and stable catch rates, Wise *et al*. (2007) concluded that small cetaceans are not harmful to purse seine fisheries in Portuguese waters. Our study, however, indicates that catch may be significantly reduced if cetaceans interact during purse seining. In fishing areas with high dolphin abundance such interactions are likely to occur and associated economic losses may therefore be substantial.

Gear damage by bottlenose dolphins in particular was considered to be a problem for fishers who target shoaling pelagic species with artisanal surface driftnets and hake and other large demersal fish with single panel bottom-gillnets inside the South Galician rías. Both types of fish are important in the diet of bottlenose dolphins (Santos *et al*., 2007). As the dolphins attempt to remove fish trapped in the nets, they frequently tear large holes in the net (Brotons *et al*., 2008a). Fishers also indicated that dolphins sometimes get entangled in the gear and damage larger sections of the net. Fishers mentioned that net repair is too expensive and that they usually continue using the damaged gear (which becomes ineffective, reducing catch) until the end of the fishing season before replacing it.

In contrast, fishers reported that depredation on catch by bottlenose dolphins occurred less frequently than gear damage by the same species in set net fisheries. This may indicate that dolphins mainly prey on fish in the water column and only occasionally take fish from nets as an additional food source, which was also hypothesized by Rocklin *et al*. (2009).

It was not only cetaceans that were reported to interact with fisheries: damage of catch by crustaceans, cephalopods, conger and sharks was more frequently reported than damage by dolphins in coastal small-scale net fisheries. Cephalopods were mentioned to consume all the shellfish from gillnets and pots and leave only the shells, while crustaceans and conger were reported to cause significant monetary loss (although only occasionally). It is therefore important to note that non-cetacean predators can also contribute substantially to catch loss and gear damage (Bearzi *et al*., 2011; Rocklin *et al*., 2009). The types of catch and gear damage described by our interviewees were consistent with those reported by similar studies (Brotons *et al.*, 2008a; Gazo *et al.* 2008; Gönerer and Özdemir, 2012; Secchi and Vaske, 1998) and we are therefore confident that fishers were able to identify types of damage correctly. However, it is possible that, since dolphins were more visible to fishers than other predatory species, some damage to catch and gear attributed to dolphins may be caused by other species. Seasonal or spatial variation in fish abundance or catchability, as well as oceanographic conditions, may be also responsible for reduced catches (Lauriano *et al.*, 2004). Gear damage may also arise when the nets get caught on the seafloor or collect marine debris, as mentioned by some interviewees.

Galician fishers also reported occurrence of cetacean bycatch, which was classified as particularly high for trawls, purse seines and trammel nets, mainly affecting common dolphins. This is consistent with the findings of Aguilar (1997), Fernández Contreras *et al.* (2010) and López *et al.* (2003) for the same area. The high bycatch frequency of common dolphins in trawl nets is probably linked to the fact that pair-trawlers off Galicia usually operate in water depths between 125 and 700 m, mainly targeting blue whiting, horse mackerel, Atlantic mackerel and hake (Fernández Contreras *et al.*, 2010), which overlaps with both important prey species of common dolphins and the range of water depths over which the species occur (López *et al.*, 2004; Pierce *et al.*, 2010; Santos et al., 2013). Purse seines can be considered to have a low impact on cetacean mortality due to the high survival rate of encircled dolphins (Aguilar, 1997; Hamer *et al.*, 2008; Wise *et al.*, 2007).

In contrast, bottlenose dolphins and harbour porpoises, due to their generally more coastal distribution in Galician waters (López *et al.*, 2004; Pierce *et al.*, 2010), are more likely to interact with set gillnets. Nevertheless, the reported bycatch rate of these species was relatively low when compared to common dolphins in trawls. Buscaino *et al*. (2009) and Cox *et al*. (2003) both pointed out that bottlenose dolphins frequently interact with gillnets, but rarely get entangled.

Although the bycatch rates reported by Galician fishers may seem to be moderate (mostly < 10 animals per year), it has to be considered that coastal gillnet fisheries make up a large proportion of the Galician fleet and that the sum of animals killed by this fishery may actually be considerable. Our preliminary estimate of fishery-related cetacean mortality for trawls and set gillnets is 1707 animals per year (of which 159 are common and 136 bottlenose dolphins); see Read *et al*., In Prep, for a more detailed examination of likely bycatch rates based on the interview data. This total estimate is almost double that derived by López *et al*. (2003), who estimated that 917 cetaceans (trawls and gillnets being responsible for 90.3% of bycatch, i.e. 828 cetaceans) are killed by fisheries in Galician waters each year (including approximately 690 common and 48 bottlenose dolphins in trawls and gillnets only), based on interview data from the late 1990s. It is however difficult to compare the two sets of figures due to the much higher proportion of non-identified cetaceans in the present dataset. In addition, survey designs, including detailed content of the questionnaires, were different.

Based on results from the SCANS II survey (SCANS-II, 2008), Santos *et al.* (submitted) estimated that the common dolphin population in Galicia and adjacent Northern Spanish waters was around 7050, which compares to an estimate of 8140 for Galicia, from opportunistic surveys, used by López *et al.* (2003). Similarly, using SCANS II results, the bottlenose dolphin population of the North West Iberian Peninsula, excluding animals in the coastal rías, is probably around 3000; López *et al.*

(2003) quoted a figure of 660 animals for Galician waters including the rías. Even selecting the smallest bycatch estimates and the largest population size estimates from these given above, the annual bycatch rates for common dolphin (159/8140 or 2.0%) and bottlenose dolphin (48/3000 or 1.6%) are close to the limit of 1.7% recommended by ASCOBANS, and other combinations of these figures would yield annual bycatch rates of over 10% for common dolphins and over 20% for bottlenose dolphins. Moreover, analysis of stranded animals in Galicia suggests that fishery-related mortality rates of harbour porpoise may be unsustainable (Read *et al*., 2012).

Based on the present study, there is cause for concern in the case of both common and bottlenose dolphins. Given the limitations of interviews as a means to collect reliable quantitative data, we believe that a new study of cetacean bycatch in Galicia, based on on-board observation, is urgently needed.

### 4.2. Mitigation measures and possible management strategies

Interviewees frequently mentioned that "interactions are natural and we have to accept them" and the majority offered no suggestions about solutions. Nevertheless, a number of fishers provided constructive, feasible ideas.

Avoidance of fishing areas where dolphins are present was the most frequently mentioned strategy for all types of fisheries. However, due to the substantial overlap between cetacean feeding areas and preferred fishing grounds, the avoidance strategy obviously has its limitations. Technical solutions, such as acoustic deterrent devices, were mentioned by a few affected fishers.

In our study we were able to identify three specific problematic cetacean-fishery interactions, each of which is likely to need a case-specific management strategy. For set gillnets, which are mostly used inside the South Galician rías, the goals are to reduce bycatch of bottlenose dolphins as well as damage to gear, while in purse seine fisheries common dolphins need to be deterred from approaching the nets in order to avoid scattering of fish. The use of pingers, which are low-intensity acoustic signal generators emitting mid to high frequency sounds, designed to prevent small cetaceans from approaching fishing gear (Reeves *et al*., 2001), represent a possible solution, at least for static gears. The devices can be relatively easily attached to nets, although operational issues have been reported, including pinger breakages and interference with fishing operations (e.g. Northridge, 2011; Dawson *et al*., 2013). Numerous trials showed that pingers can be effective in reducing damage caused by, and bycatch rates of, bottlenose dolphins (e.g. Brotons *et al*., 2008b; Buscaino *et al*., 2009; Gazo *et al*., 2008; Gönerer and Özdemir, 2012; Leeney *et al*., 2007; Read and Waples, 2009) and common dolphins (Barlow and Cameron, 2003; Carretta and Barlow, 2011), although there are also studies that could not demonstrate any obvious aversive reactions of common dolphins to pinger sounds (e.g. Berrow *et al*., 2008; Sagarminaga *et al*., 2006). McPherson *et al.*, (2004) reported that pingers are not effective in reducing bottlenose dolphin entanglement in gillnets and that the dolphins sometimes behaved aggressively toward pingers, repeatedly attacking them. All of the above-mentioned trials were based on fixed gears. For mobile gears like trawls, the high level of associated noise means that pingers are unlikely to be effective: additional noise is unlikely to enhance detection of the gear (thus permitting avoidance) or act as a deterrent. Operation of a purse seine is perhaps not as noisy as trawling but in addition to the main vessel, motor launches may be deployed to help herd the fish into the net (e.g. ICCAT, 2008) so pingers may not be effective.

Even in the case of static gear, the long-term effectiveness of pingers is still controversial since especially bottlenose dolphins may potentially habituate to the pinger sounds and consequently start to ignore them or even become attracted to them (e.g. Cox *et al*., 2003; Northridge *et al.*, 2003). For common dolphins, however, no such effect was detected by Caretta and Barlow (2011), who conducted a long-term study over 19 years. The likelihood of habituation may be minimized by using responsive pingers that only activate when receiving cetacean clicks (Leeney *et al*., 2007) or by periodically modifying pinger emission frequencies (Gazo *et al*., 2008). Furthermore it is essential to ensure that the signal does not affect the fishery target species in order to avoid negative impacts on catch rates. Since pingers are relatively expensive and may not be affordable for small-scale fishers, governmental subsidies for the acquisition of pingers could be needed.

The possibility of avoiding fishing grounds with high cetacean abundance should be explored. Although it may not be viable if dolphins favour the areas with highest fish abundance, there may be differences between species and size classes targeted by fisheries and those preferred by dolphins which would permit some spatial separation.

For trawl fisheries, the mitigation of dolphin bycatch is the main objective. There are certain operational factors that can influence bycatch: incidental capture is more likely to occur in shallow waters (< 300m) and during nocturnal fishing (Fernández Contreras *et al*., 2010; López *et al*., 2003; Morizur *et al*., 1999). Interviewees reported that most dolphins were captured in water depths between 100 and 300 m. Time/area closures can be effective when patterns of bycatch are predictable in time and space (Murray *et al.*, 2000), and therefore the relocation of some trawling effort to waters deeper than 300 m and imposition of limits on trawling in waters shallower than 250m, as suggested by Fernández Contreras *et al.* (2010), combined with a reduction of nocturnal trawling (López *et al.*, 2003) could dramatically reduce cetacean bycatch in Galicia. However, since few of the fishers interviewed fished in deeper waters, we cannot be sure that cetacean bycatch rates of trawlers in deeper waters would be lower. The impact of any measures designed to reduce bycatch clearly needs to be monitored, preferably using on-board observers.

### 4.3. The suitability of interview surveys to assess cetacean-fishery interaction

Our qualitative research results are in accordance with quantitative findings for the area (Aguilar, 1997; Fernández Contreras *et al.* 2010; López *et al.*, 2002, 2003, 2004; Pierce *et al.*, 2010; Spyrakos *et al.*, 2011), showing that fishers' ecological knowledge can serve as a useful data source that may also be valuable for wildlife management (Johannes *et al.*, 2000). Nevertheless, information based on reports from fishers (like all interview data) may be potentially influenced by the opinions, perceptions and personal interests of the interviewees (Bearzi *et al.*, 2011). Therefore the damage and bycatch rates indicated by our interviewees should be interpreted with care as economic loss may be overestimated, while bycatch rates are likely to be underreported by fishers.

Nevertheless, interview surveys can be particularly useful where extensive scientific studies may be impractical or financially unfeasible (Johannes, 1998), as it is the case for cetacean-fishery interactions that usually occur in remote locations over a wide geographic area. Interview surveys are clearly less costly and time-consuming than on-board sampling and allow for a wide geographic coverage and sampling of multiple gears at the same time (White *et al.*, 2005). In our study we covered more than 5% of the fishing fleet of interest, which is in accordance with the minimum sample size recommended for interview surveys by Czaja and Blair (2005). Furthermore, by applying a stratified sampling strategy (Moore *et al.*, 2010; White *et al.*, 2005), we ensured the sample was reasonably representative of the entire Galician fleet, covering all types of fisheries operating in coastal and offshore waters that are possibly affected by interactions with cetaceans.

The assessment of cetacean-fishery interactions only by on-board observers would be financially and logistically unfeasible. Based on a fleet size of 3267 vessels fishing 5 days a week, around 42 610 observer days, would be needed every year to monitor 5% of the fleet activity, i.e. requiring 163 full-time observers. Clearly, this is a maximum estimate (some vessels probably fish fewer days per week or only during certain seasons) and observations could be focused on those fishing activities most likely to generate interactions with cetaceans. López *et al.* (2003) estimated that a minimum of between 500 and 2000 observer trips per year would be needed to quantify cetacean bycatch in Galician fisheries. Nevertheless, the need for additional data sources is apparent. For routine monitoring, some combination of vessel-based observations by trained observers in a small fraction of the fleet, interview surveys and (as recently trialled in several studies, see ICES, 2011b) on-board video cameras may provide the best solution.

We chose face-to-face interviews because, in contrast to telephone or postal surveys, they create more confidence between interviewer and respondents, allowing for good quality of recorded responses, a high response rate and, consequently low non-response bias (i.e. difference in the answers of respondents from the potential answers of those who did not answer; Czaja and Blair, 2005; Lien *et al*., 1994; White *et al*., 2005). A common point of criticism of this methodology is the interviewer effect, i.e. the unintended influence on the interviewee through the interviewer (Czaja and Blair, 2005). In our survey we did not detect such an effect.

## 5. Conclusions

The data derived from our interview survey indicate that cetacean-fishery interactions are frequent in Galicia, although negative consequences for fishers and cetacean bycatch levels were mostly classified by fishers as low to moderate. Nevertheless some interactions may lead to serious conservation and/or economic problems. Our preliminary calculations suggest that bycatch rates for both common dolphin and bottlenose dolphin are likely to be unsustainable. It is therefore essential to improve the situation of affected fisheries and cetacean populations through the implementation of appropriate management plans, the success of which largely depends on fishers' willingness to cooperate, apart from legal enforcement and monitoring (Campbell and Cornwell, 2008). There are many cases where cetacean bycatch levels have been successfully reduced with the direct co-operation of fishers (IWC, 1994). Fishers have expertise with fishing gears and should therefore be involved in the creation and trial of new gear technologies. Their active participation into dolphin watching activities, as well as the promotion of eco-labelling of fish and fishery products could even help to improve earnings (e.g. Salomon *et al*., 2011). If the large scale use of pingers is considered as a management option, long-term scientific trials need to be conducted to determine which type of pinger is most effective and least likely to cause habituation in dolphins. It could also prove useful to put cameras on nets to verify the cetacean species that cause damage to gear, at what point during fishing activities bycatch occurs, and how many fish are actually removed or damaged, in order to direct research and mitigation measures on a more species- and gear-specific basis.

## Supplementary material

The following supplementary material is available at ICESJMS online: Questionnaire form used for the interview survey (translated into English).

## Acknowledgements

We wish to express our gratitude to all Galician fishers that took part in the survey for sharing their time and information with us. We would also like to thank Baltasar Patiño, for logistical support, Juan Santos and Edward Morgan, for assisting with the interviews and Julio Martínez Portela for suggestions on the manuscript.

The study was funded by the EC projects MEXC-CT-2006-042337 and MEST-CT-2005-020501), the German Academic Exchange Service (DAAD) and the Fundação para a Ciência e a Tecnologia (FCT). MBS participation was part of the EU FP7 grant MYFISH (no. 289257) and the LOTOFPEL project (Plan Nacional de I + D + I, CTM 2010-16053).

848

**References:**

Aguilar, A. 1997. Inventario de los cetáceos de las águas atlánticas peninsulares: aplicación de la directiva 92/43/CEE. Memoria Final. Departamento de Biología Animal (Vert.), Facultad de Biología, Universitat de Barcelona. 189 pp.

Allen, R. L. 1985. Dolphins and the purse-seine fishery for yellowfin tuna. *In* Marine Mammals and Fisheries, pp 236-252. Ed by J. H. Beddington, R. J. H. Beverton, and D.M. Lavigne. George Allen & Unwin, London. 376 pp.

Barlow, J., and Cameron, G. A. 2003. Field experiments show that acoustic pingers reduce marine mammal bycatch in the California drift gill net fishery. Marine Mammal Science 19: 265-283.

Bearzi, G., Bonizzoni, S., and Gonzalvo, J. 2011. Dolphins and coastal fisheries within a Marine Protected Area: mismatch between dolphin occurrence and reported depredation. Aquatic Conservation: Marine and Freshwater Ecosystems 21: 261-267.

Berrow, S., Cosgrove, R., Leeney, R. H., Obrien, J., Mcgrath, D., Dalgard, J., and Gall, Y. L. 2008. Effect of acoustic deterrents on the behaviour of common dolphins *(Delphinus delphis*. Journal of Cetacean Research and Management 10: 227−233.

Brotons, J. M, Grau, A. M, and Rendell, L. 2008a. Estimating the impact of interactions between bottlenose dolphins and artisanal fisheries around the Balearic Islands. Marine Mammal Science 24: 112–127.

Brotons, J. M., Munilla, Z., Grau, A. M., and Rendell, L. 2008b. Do pingers reduce interactions between bottlenose dolphins and nets around the Balearic Islands? Endangered Species Research 5: 1-8.

Buscaino, G., Buffa, G., Sará, G., Bellante, A., Tonello, A. J. Jr., Sliva Hardt, F. A., Cremer, M. J., *et al*. 2009. Pinger affects fish catch efficiency and damage to bottom gill nets related to bottlenose dolphins. Fisheries Science 75: 537–544.

Cameron, A. C., and Trivedi, P. K. 1998. Regression Analysis of Count Data. Cambridge University Press, Cambridge, UK. 436 pp.

Campbell, L. M., and Cornwell, M.L. 2008. Human dimensions of bycatch reduction technology: current assumptions and directions for future research. Endangered Species Research 5: 325-334.

Carretta, J. V., and Barlow, J. 2011. Long-term effectiveness, failure rates, and "dinner bell" properties of acoustic pingers in a gillnet fishery. Marine Technology Society Journal 45: 7-19.

Chambers, J. M., and Hastie, T. 1992. Statistical Models in S. Chapman and Hall, London. 624 pp.

Cox, T. M., Read, A. J., Swanner, D., Urian, K., and Waples, D. 2003. Behavioral responses of bottlenose dolphins, *Tursiops truncatus*, to gillnets and acoustic alarms. Biological Conservation 115: 203-212.

Czaja, R., and Blair, J. 2005. Designing surveys: a guide to decisions and procedures, 2nd edn, Pine Forge Press. 320 pp.

Dawson, S. M., Northridge, S., Waples, D., and Read, A. J. 2013. To ping or not to ping: the use of active acoustic devices in mitigating interactions between small cetaceans and gillnet fisheries. Endangered Species Research 19: 202-221.

Fariña, A. C., Freire, J., and González Gurriarán, E. 1997. Demersal fish assemblages in the Galician continental shelf and upper slope (NW Spain): spatial structure and long-term changes. Estuarine and Coastal Shelf Science 44: 435–454.

Fernández, R., Garcia Tiscar, S., Santos, M. B., López, A., Martinez Cedeira, J. A., Newton, J., and Pierce, G. J. 2011a. Stable isotope analysis in two sympatric populations of bottlenose dolphins *Tursiops truncatus*: evidence of resource partitioning? Marine Biology 158: 1043–1055.

Fernández, R., Santos, M. B., Pierce, G. J., Llavona, A., López, A., Silva, M. A., Ferreira, M., *et al*. 2011b. Fine-scale genetic structure of bottlenose dolphins, *Tursiops truncatus*, in Atlantic coastal waters of the Iberian Peninsula. Hydrobiologia 670: 111–125.

Fernández Contreras, M. M., Cardona, L., Lockyer, C. H., and Aguilar, A. 2010. Incidental bycatch of short-beaked common dolphins (*Delphinus delphis*) by pair trawlers off Spain. ICES Journal of Marine Science 67: 1732–1738.

Figueiras, F. G., Labarta, U., and Fernández Reiriz, J. M. 2002. Coastal upwelling, primary production and mussel growth in the Rías Baixas of Galicia. Hydrobiologia 484: 121–131.

Galician Institute for Statistics [Instituto Galego de Estatística]. 2013. Online statistics. http://www.ige.eu.

Galician Ministry of Fisheries [Xunta de Galicia, Consellería do Mar]. 2010. Comunicación sobre el océano atlántico. 39 pp.

Galician Ministry of Fisheries [Xunta de Galicia, Consellería do Mar]. 2013. Online statistics. www.pescadegalicia.com; http://www.portosdegalicia.es/es/portos-de-galicia.html

Gazo, M., Gonzalvo,J., and Aguilar, A., 2008. Pingers as deterrents of bottlenose dolphins interacting with trammel nets. Fisheries Research 92: 70-75.

Gilman, E. , Brothers, N., McPherson, G., and Dalzell, P. 2006. A review of cetacean interactions with longline gear. Journal of Cetacean Research and Management 8: 215–223.

Gönener, S., and Özdemir, S. 2012. Investigation of the interaction between bottom gillnet fishery (Sinop, Black Sea) and bottlenose dolphins (*Tursiops truncatus*) in terms of economy. Turkish Journal of Fisheries and Aquatic Sciences 12: 115-126.

Hamer, D., Ward, T., and McGarvey, R. 2008. Measurement, management and mitigation of operational interactions between the South Australian sardine fishery and short-beaked common dolphins (*Delphinus delphis*). Biological Conservation 141: 2865-2878.

ICCAT. 2008. ICCAT Manual. International Commission for the Conservation of Atlantic Tuna**.** Available at http://www.iccat.int/en/ICCATManual.htm

ICES [International Council for the Exploration of the Sea]. 2011a. Report of the Working Group on Integrated Assessments of the North Sea (WGINOSE). Hamburg, Germany. ICES CM 2011/SSGRSP:02. 69 pp.

ICES [International Council for the Exploration of the Sea]. 2011b. Report of the Joint NAMMCO/ICES Workshop on observation schemes for bycatch of mammals and birds (WKOSBOMB). ICES, Denmark. ICES CM 2010/ACOM: 33. 40 pp.

IWC [International Whaling Commission]. 1994. Report of the Workshop on mortality of cetaceans in passive fishing nets and traps. Report of the International Whaling Commission, Special Issue 15: 70-71.

Johannes, R. E. 1998. The case for data-less marine resource management: examples from tropical nearshore fisheries. Trends in Ecology and Evolution 13:243-246.

Johannes, R. E., Freeman, M. M. R., and Hamilton, R. J. 2000. Ignore fishers' knowledge and miss the boat. Fish and Fisheries 1: 257-271.

Johnson, T. R., and van Densen, W. L. T. 2007. Benefits and organization of cooperative research for fisheries management. ICES Journal of Marine Science 64: 834–840.

Lauriano, G., Fortuna, C. M., Moltedo, G., and Notarbartolo Di Sciara, G. 2004. Interactions between common bottlenose dolphins (*Tursiops truncatus*) and the artisanal fishery in Asinara Island National Park (Sardinia): assessment of catch damage and economic loss. Journal of Cetacean Research and Management 6: 165-173.

Lauriano, G., Caramanna, L., Scarnó, M., and Andaloro, F., 2009. An overview of dolphin depredation in Italian artisanal fisheries. Journal of the Marine Biological Association of the United Kingdom 89: 921–929.

Leeney, R. H., Berrow, S., McGrath, D., and Cosgrove., R. 2007. Effects of pingers on the behaviour of bottlenose dolphins. Journal of the Marine Biological Association of the United Kingdom 87: 129-133.

Lien, J., Stenson, G. B., Carver, S., and Chardine, J. 1994. How many did you catch? The effect of methodology on by-catch reports obtained from fishermen. *In* Gillnets and cetaceans, Reports of the International Whaling Commission, Special Issue 15, pp. 535-540. Ed by W. F. Perrin, G. P., Donovan, and J. Barlow. 629 pp.

López, A., Santos, M. B., Pierce, G. J., González, A. F., Valeiras, X., and Guerra, A. 2002. Trends in strandings and by-catch of marine mammals in north-west Spain during the 1990s. Journal of the Marine Biological Association of the United Kingdom 82: 513–521.

López, A., Pierce, G. J., Santos, M. B., Gracia, J., and Guerra, A. 2003. Fishery by-catches of marine mammals in Galician waters: Results from on-board observations and an interview survey of fishermen. Biological Conservation 111: 25–40.

López, A., Pierce, G. J., Valeiras, X., Santos, M. B., and Guerra, A. 2004. Distribution patterns of small cetaceans in Galician waters. Journal of the Marine Biological Association of the United Kingdom 84: 283–294.

McPherson, G. R., Ballam, D., Stapley, J., Peverell, S., Cato, D. H., Gribble, N., Claque, C., *et al*. 2004. Acoustic alarms to reduce marine mammal bycatch from gillnets in Queensland waters: optimising the alarm type and spacing. Proceedings of Acoustics 2: 1−6.

Méndez Fernández, P., Bustamante, P., Bode, A., Chouvelon, T., Ferreira, M., López, A., Pierce, G.J., *et al*. 2012. Foraging ecology of five toothed whale species in the Northwest Iberian Peninsula, inferred using carbon and nitrogen isotope ratios. Journal of Experimental Marine Biology and Ecology 413: 150-158.

Moore, J. E., Cox, T. M., Lewison, R. L., Read, A. J., Bjorkland, R., McDonald, S. L., Crowder, L. B., *et al*. 2010. An interview-based approach to assess marine mammal and sea turtle captures in artisanal fisheries. Biological Conservation 143: 795-805.

Morizur, Y., Berrow, S. D., Tregenza, N. J. C., Couperus, A. S., and Pouvreau, S. 1999. Incidental catches of marine-mammals in pelagic trawl fisheries of the northeast Atlantic. Fisheries Research 41: 297-307.

Murray, K. T., Read, A. J., and Solow, A. R. 2000. The use of time/area closures to reduce bycatches of harbour porpoises: lessons from the Gulf of Maine sink gillnet fishery. Journal of Cetacean Research and Management 2: 135-141.

Northridge, S., Vernicos, D., and Raitsos-Exarchopolous, D. 2003. Net depredation by bottlenose dolphins in the Aegean: first attempts to quantify and to minimise the problem. IWC SC/55/SM25, International Whaling Commission, Cambridge.

Northridge, S. 2011. An overview of the state of bycatch monitoring and mitigation measures being implemented in European fisheries. Paper SC/63/SM21 presented to IWC Scientific Committee, Tromso, Norway. 8 pp.

Pierce, G. J., Caldas, M., Cedeira, J., Santos, M. B., Llavona, A., Covelo, P., Martinez, G., *et al*. 2010. Trends in cetacean sightings along the Galician coast, north-western Spain, 2003–2007, and inferences about cetacean habitat preferences. Journal of the Marine Biological Association of the United Kingdom 90: 1547-1560.

Proelss, A., Krivickaite, M., Gilles, A., Herr, H., and Siebert, U. 2011. Protection of Cetaceans in European Waters-A Case Study on Bottom-Set Gillnet Fisheries within Marine Protected Areas. The International Journal of Marine and Coastal Law 26: 5–45.

Read, A. J., and Waples, D. 2009. A pilot study to test the efficacy of pingers as a deterrent to bottlenose dolphins in the Spanish mackerel gillnet fishery. Final Report.

Bycatch Reduction of Marine Mammals in Mid-Atlantic Fisheries Project 08-DMM-02 North Carolina Sea Grant Programme. 25 pp.

Read, F. L., Santos, M. B., González, A. F., López, A., Ferreira, M., Vingada, J., and Pierce, G. J. 2012. Understanding harbour porpoise (*Phocoena phocoena*) and fishery interactions in the north-west Iberian Peninsula. Final report to ASCOBANS (SSFA/ASCOBANS/2010/4). 40 pp.

Reeves, R. R., Read, A. J., and Notarbartolo di Sciara, G. 2001. Report of the workshop on interactions between dolphins and fisheries in the Mediterranean: evaluation of mitigation alternatives. Instituto Centrale per la Ricerca Applicata al Mare (ICRAM), Rome, Italy. 44 pp.

Rocklin, D., Santoni, M. C., Culioli, J. M., Tomasini, J. A., Pelletier, D., and Mouillot, D. 2009. Changes in the catch composition of artisanal fisheries attributable to dolphin depredation in a Mediterranean marine reserve. ICES Journal of Marine Science 66: 699-707.

Sagarminaga, R., Cañadas, A., and Brotons, J. M. 2006. Initiatives about fisheries−cetaceans interactions in Spanish Mediterranean waters. IWC SC/58/SM13, International Whaling Commission, Cambridge. 3 pp.

Salomon, A. K., Gaichas, S., Jensen, O. P., Agostini, V. N., Sloan, N. A., Rice, J., McClanahan, T., *et al*. 2011. Bridging the divide between fisheries and marine conservation science. Bulletin of Marine Science 87: 251-274.

Santos, M. B., Fernández, R., López, A., Martínez, J. A., and Pierce, G. J. 2007. Variability in the diet of bottlenose dolphin, *Tursiops truncatus*, in Galician waters, NW Spain, 1990–2005. Journal of the Marine Biological Association of the United Kingdom 87: 231–242.

Santos, M. B., German, I., Correia, D., Read, F. L., Martínez, J. A., Caldas, M., López, A., *et al*. 2013. Long-term variation in common dolphin diet in relation to prey abundance. Marine Ecology Progress Series 481: 249-268.

Santos, M. B., Saavedra, C., and Pierce, G. J. Quantifying the predation on sardine and hake by cetaceans in the Atlantic waters of the Iberian Peninsula. Submitted to Deep Sea Research II.

SCANS II. 2008. Small Cetaceans in the European Atlantic and North Sea (SCANS-II). Final report to the European Commission under project LIFE04NAT/GB/000245. University of St Andrews, Fife, Scotland, U.K. 54 pp. Available at http://biology.st-andrews.ac.uk/scans2/.

Secchi, E. R. and Vaske Jr., T. 1998. Killer whale (*Orcinus orca*) sightings and depredation on tuna and swordfish longline catches in Southern Brazil. Aquatic Mammals 24: 117-122.

.

Silva M., Machete, M., Reis, D., Santos, M., Prieto, R., Dâmaso, C., Pereira, J. and Santos, R. 2011. A review of interactions between cetaceans and fisheries in the Azores. Aquatic Conservation: Marine and Freshwater Ecosystems 21: 17–27.

Spanish Ministry of Agriculture, Food and Environment [Ministerio de Agricultura, Alimentación y Medio Ambiente]. 2013. Online fisheries statistics. http://www.magrama.gob.es/es/pesca/estadisticas/.

Spyrakos, E., Santos Diniz, T. C., Martinez Iglesias, G., Torres Palenzuela, J. M., and Pierce, G.J. 2011. Spatiotemporal patterns of marine mammal distribution in coastal waters of Galicia, NW Spain. Hydrobiologia 670: 87–109.

White, P. C. L, Jennings, N., Renwick, A. R., and Barker, N. H. L. 2005. Questionnaires in ecology: a review of past use and recommendations for best practice. Journal of Applied Ecology 42: 421-430.

Wise, L., Ferreira, M., Silva, M., Sequeira, M., and Silva, A. 2007. Interactions between small cetaceans and the purse-seine fishery in western Portuguese waters. Scientia Marina 71: 405-412.

bycatch are highlighted with diagonal white stripes, while the proportions of interviews with no bycatch reports are highlighted in black.

# SIGHTINGS/ INTERACTIONS OF CETACEANS WITH FISHERIES

**interview code** ☐

**Date** _________ **Harbour**_______________ **Interviewer**______________

This questionnaire is designed to find out a few things about your job, fisheries in Galicia in general and the interactions of cetaceans (dolphins, porpoises and whales) with these fisheries. Please answer the questions truthfully. There are no right or wrong answers.

This work is for statistical purposes only. All information will be treated confidentially and will not be distributed to a third party

(*please fill in the relevant box or tick one or more answers*)

**1. What is your function on board of the vessel?**

☐ skipper ☐ sailor ☐ mechanic ☐ other______________

**2. What kind of fishing gear do you use?**

☐ pair trawl _________________________
☐ otter trawl _________________________
☐ bottom longline ____________________
☐ surface longline ____________________
☐ gillnets (*specify type*) _______________
☐ purse seine _______________________
☐ pots _____________________________
☐ other ____________________________

**3. What length/tonnage/crew has the vessel ?**
(*indicate just one)*

☐ meters ☐ tons ☐ crew members

**4. In which area are you fishing?**

**Fishing area**

☐ inside the rías

☐ outside of rías

**Sub-area**

☐ 1 Ría Ribadeo - Estaca de Bares
☐ 2 Estaca de Bares - Pta. Segaño (S ría Ferrol)
☐ 3 Pta. Segaño - Cabo Fisterra
☐ 4 Cabo Fisterra - Cabo Corrubedo
☐ 5 Cabo Corrubedo - Cabo Home
☐ 6 Cabo Home - Río Miño
☐ other _____________________

**Mean distance to coast (m/nm):** __________

**Mean water depth (m/fathoms):** __________

**5. What time do you leave for fishing?**

☐

**6. What time do you return to the harbour?**

☐

**7. Which are your main target species ?**

**Fish**

- ☐ Abadexo
- ☐ Acedía
- ☐ Agulla
- ☐ Alavanco
- ☐ Anchoa/Bocareu
- ☐ Anguía
- ☐ Barbada
- ☐ Bertorella
- ☐ Besugo/Ollomol/Pancho
- ☐ Boga
- ☐ Bolo
- ☐ Bonito
- ☐ Burro
- ☐ Cabalón
- ☐ Cabra
- ☐ Cabracho
- ☐ Castañeta
- ☐ Cazón
- ☐ Choupa/Pancha
- ☐ Congro
- ☐ Coruxo
- ☐ Doncella
- ☐ Dourada
- ☐ Escacho
- ☐ Escarapote
- ☐ Escolar
- ☐ Faneca
- ☐ Fodón
- ☐ Fogoneiro
- ☐ Gata
- ☐ Linguado
- ☐ Lirio
- ☐ Maragota/Pinto
- ☐ Marraxo
- ☐ Maruca
- ☐ Melga
- ☐ Mero
- ☐ Muxo
- ☐ Palometa roja
- ☐ Peixe espada
- ☐ Peixe pao
- ☐ Peixe sabre
- ☐ Peixe sapo
- ☐ Pescada(illa)/Merluza
- ☐ Piarda
- ☐ Prago
- ☐ Quenlla
- ☐ Raia
- ☐ Rapante
- ☐ Robaliza
- ☐ Rodaballo
- ☐ Saboga
- ☐ Salmón
- ☐ Salmonete
- ☐ Sanmartiño
- ☐ Sardiña
- ☐ Sargo
- ☐ Serrán
- ☐ Solla
- ☐ Xarda/Cabala/Rincha
- ☐ Xuliana
- ☐ Xurelo
- ☐ mixture
- ☐ ____________

**Bivalves**

- ☐ Ameixa
- ☐ Berberecho
- ☐ Cadelucha
- ☐ Carneiro
- ☐ Centola
- ☐ Cornicha
- ☐ Longueirón
- ☐ Mexillón
- ☐ Navalla
- ☐ Ostra
- ☐ Rabioso
- ☐ Reló
- ☐ Vieira
- ☐ Volandeira

**Cephalopods**

- ☐ Cabezón
- ☐ Choco
- ☐ Chopiño
- ☐ Lura
- ☐ Polbo
- ☐ Pota
- ☐ Puntilla

**Crustaceans**

- ☐ Boi
- ☐ Camarón
- ☐ Cigala
- ☐ Lagosta
- ☐ Lumbrigante
- ☐ Nécora
- ☐ Percebe

**Other**

- ☐ __________
- ☐ __________
- ☐ __________
- ☐ __________
- ☐ __________
- ☐ __________
- ☐ __________

**8. What is your average catch ?** ☐ don’t know

☐ **per haul** ☐ **per trip** ☐ **last trip**

*(indicate just one; if average catch cannot be estimated, indicate amount of catch for last trip)*

**total** in kg (tons) _________ in crates________

*(for each target species)*

________________ in kg (tons)_________ in crates________

________________ in kg (tons)_________ in crates________

________________ in kg (tons)_________ in crates________

-> weight of each crate (kg) ___________

**9. Do you usually see dolphins and whales in your fishing area?**

☐ yes ☐ no *-> if answer is no, go to question **36***

**10. What kind of dolphins and whales do you see and how many? Do you see them frequently?** don't know ☐

*(pres = present; N° = number of individuals; freq = frequent; rare)*

| | **pres** | **N°** | **freq** | **rare** | | **pres** | **N°** | **freq** | **rare** |
|---|---|---|---|---|---|---|---|---|---|
| non-identified (NI) dolphins | ☐ | ☐ | ☐ | ☐ | long-finned pilot whale | ☐ | ☐ | ☐ | ☐ |
| common dolphin | ☐ | ☐ | ☐ | ☐ | sperm whale | ☐ | ☐ | ☐ | ☐ |
| bottlenose dolphin | ☐ | ☐ | ☐ | ☐ | killer whale | ☐ | ☐ | ☐ | ☐ |
| striped dolphin | ☐ | ☐ | ☐ | ☐ | baleen whales | ☐ | ☐ | ☐ | ☐ |
| Risso's dolphin | ☐ | ☐ | ☐ | ☐ | other ________________ | ☐ | ☐ | ☐ | ☐ |
| harbour porpoise | ☐ | ☐ | ☐ | ☐ | | ☐ | ☐ | ☐ | ☐ |

**ID correct?** ☐ yes ☐ no

*(Write down other common species names used by local fishers)*

______________________________________________________________________

**11.Do you think the number of dolphins/whales in the area has….during the last 5 years?**

☐ increased ☐ decreased ☐ been constant ☐ don't know

**12. What are your general feelings about dolphins/whales?**

☐ positive ☐ negative ☐ neutral ☐ don't know

Why?______________________________________________________________________

**13. Do you use the presence of dolphins/whales to locate fish?**

☐ yes ☐ no ☐ don't know

**14. Are the dolphins/whales seen in close proximity to the gear during fishing operation??**

☐ yes ☐ no ☐ don't know

**15. If yes, which species ?** ☐ don't know

☐ NI dolphins
☐ common dolphin
☐ bottlenose dolphin
☐ striped dolphin
☐ Risso's dolphin
☐ harbour porpoise
☐ long-finned pilot whale
☐ sperm whale
☐ killer whale
☐ baleen whales
☐ other _____________

**16. Do the dolphins/whales and/or other animals consume catch ?** ☐ don’t know

☐ yes ☐ dolphins/whales -> *go to question* ***17***
☐ other animals -> *go to question* ***18***
☐ no -> *if answer is no/don’t know, go to question* ***21***

**17. Which species of dolphins/whales?** ☐ don’t know

☐ NI dolphins
☐ common dolphin
☐ bottlenose dolphin
☐ striped dolphin
☐ Risso’s dolphin
☐ harbour porpoise
☐ long-finned pilot whale
☐ sperm whale
☐ killer whale
☐ baleen whales
☐ other ____________

**18. Which other animals?** ☐ don’t know

__________________________________________________________

**19. Can you estimate the proportion of catch damaged/consumed?**

☐ no ☐ yes % of catch per trip (by dolphins/whales) ☐
% of catch per trip (other animals) ☐
☐ there is none

**20. Can you estimate the economic loss associated with this catch damage/loss?**

☐ no ☐ yes by dolphins/whales ☐ per ☐ trip ☐ year
by other animals ☐ per ☐ trip ☐ year
☐ there is none

**21. Do the dolphins/whales and/or other animals cause damage in the gear?** ☐ don’t know

☐ yes ☐ dolphins/whales -> *go to question* ***22***
☐ other animals -> *go to question* ***23***
☐ no -> *if answer is no/don’t know, go to question* ***27***

**22. Which species of dolphins/whales?** ☐ don’t know

☐ NI dolphins
☐ common dolphin
☐ bottlenose dolphin
☐ striped dolphin
☐ Risso’s dolphin
☐ harbour porpoise
☐ long-finned pilot whale
☐ sperm whale
☐ killer whale
☐ baleen whales
☐ other ____________

**23. Which other animals** ☐ don’t know

__________________________________________________________

**24. What kind of damage do the dolphins/whales cause?** ☐ don't know

**25. What kind of damage do other animals cause?** ☐ don't know

**26. Can you estimate the economic loss associated with this gear damage?**

☐ no ☐ yes by dolphins/whales ☐ per ☐ trip ☐ year

☐ there is none by other animals ☐ per ☐ trip ☐ year

**27. Are dolphins/whales accidentally bycaught?**

☐ yes ☐ no ☐ don't know -> *if answer is no/don't know, go to question* ***34***

**28. Which species of dolphins/whales and how many** ☐ don't know

| | month | year | | month | year | | month | year | | month | year |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NI dolphins | ☐ | ☐ | striped dolphin | ☐ | ☐ | long-finned pilot whale | ☐ | ☐ | baleen whales | ☐ | ☐ |
| common dolphin | ☐ | ☐ | Risso's dolphin | ☐ | ☐ | sperm whale | ☐ | ☐ | other | ☐ | ☐ |
| bottlenose dolphin | ☐ | ☐ | harbour porpoise | ☐ | ☐ | killer whale | ☐ | ☐ | ____________ | | |

**29. Are animals bycaught usually dead or alive when you haul the gear?**

☐ alive ☐ dead ☐ don't know -> *if answer is dead go to question* ***31***

**30. Do they survive?**

☐ yes ☐ no ☐ don't know

**31. What do you do with the carcasses?** ☐ don't know

☐ bring them back to the harbour ☐ throw them back into the sea ☐ other_______________

**32. Do you think the amount interactions with dolphins/whales has…during the last 5 years?**

☐ increased

☐ decreased

☐ been constant

☐ don't know

**33. Is there a season with more bycatch?**

☐ yes ☐ no ☐ don't know -> *if answer is no/don't know, go to question* ***34***

**Which season?**_____________________________________________________________

**34. Do you take any measures to avoid interactions(damage to catch/gear and bycatch) with dolphins/whales?**

☐ yes ☐ no -> *if answer is no, go to question* ***36***

**35. What type of measures?**

☐ acoustic devices *(specify)*_______________________________________________________
☐ navigate to alternative fishing grounds away from the dolphins/whales
☐ postpone the fishing operation until the dolphins/whales leave the area
☐ reduce the fishing/soak time
☐ scare the cetaceans away from the vessel *(specify)* __________________________________
☐ other *(specify)* __________________________________________________________

**36. In your opinion, what are the main problems with dolphins/whales and fisheries? (Fill in 3 boxes according to their importance: 1 – most important, 3- least important)**

☐ don't know
☐ there are no problems
☐ the dolphins/whales damage the gear
☐ the dolphins/whales damage the catch
☐ the dolphins/whales cause additional costs, e.g. fuel costs from changing fishing grounds
☐ the dolphins/whales scatter the fish
☐ the dolphins/whales eat too many fish, i.e. competition for resources
☐ there is too much bycatch of dolphins/whales
☐ other *(specify)* ___________________________________________________________

**37. In your opinion, what are the most important factors influencing the amount of interactions (damage to catch/gear and bycatch) with dolphins/whales?**

☐ don't know
☐ there are no factors
☐ fishing time, e.g. day or night/duration
☐ catch target species
☐ fishing area
☐ water depth
☐ season
☐ type of fishing gear
☐ weather
☐ behaviour of dolphins/whales
☐ other *(specify)*___________________________________________________________

**39. What are your suggestions to reduce conflicts between dolphins/whales and fisheries?**

☐

## Some personal information……

**How old are you? ____ How many years of working experience do you have? ____**

**Do you have family links with fisheries?** ☐ yes ☐ no

☐ **male** ☐ **female**

## Comments: