Designing a shipboard line transect survey to estimate cetacean abundance off the Azores archipelago

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Management schemes dedicated to the conservation of wildlife populations rely on the effective monitoring of population size, and this may require the accurate and precise estimation of this parameter. Line transect distance sampling can be an effective approach for estimating abundance. Little information is available regarding cetacean abundance in the Azores. This paper had two aims: 1) to design a line transect shipboard survey to estimate the absolute abundance of the most common cetaceans off the Azores; and 2) to provide a set of potential survey effort scenarios to policy makers and environmental managers. Three survey scenarios are assessed, and one detailed survey design is presented. A total of 8,800 km of survey effort is recommended; at this level the expected coefficient of variation of estimates is less than 0.3 for most species. However, if logistic constraints prevent this, at least 5,000 km of survey effort should be used to achieve minimum sample size requirements; this is estimated to take 36 days of effort. It is also recommended to conduct a pilot survey. This would provide more detailed information that could be used to improve the survey design of what would be the first survey of this magnitude ever to be implemented in the Azores.

Key words: distance sampling, effort scenarios, logistics, methods, statistical robustness

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INTRODUCTION

Many studies of wildlife populations require an estimate of population density, size, or rate of population change. Distance sampling can be an effective approach for estimating such parameters (Buckland et al. 2001). The most widely used type of distance sampling is line transect sampling (Thomas et al. 2010). Here, the observer travels along a line, recording detected objects and the distance from the line to each object detected (hence the name, distance sampling). In the standard methods, all objects on or near the line should be detected, but this method allows a proportion of objects within a certain distance of the line to be missed (Buckland et al. 2001).

Achieving reliable results from a distance sampling survey depends greatly on good survey design. This relies upon two fundamental principles: replication (i.e. multiple lines) and randomization. A large enough number of lines ensures that the variation in the number of objects detected per unit survey effort (encounter rate) can be adequately estimated, as well as that the underlying distribution of distances available for detection can be safely assumed as known. The transect lines should be randomly positioned so that each point within the study area has a known, non-zero probability of being covered by a transect (the "coverage probability") (Thomas et al. 2010). Additionally, obtaining reliable results requires good field methods and data analysis (Thomas et al. 2007).

Survey design encompasses the selection of a target sample size to achieve a desired level of precision for the estimates, and the layout of the transect lines. The best choice for the layout of the lines will depend namely, on the survey region, logistics and efficiency (Buckland et al. 2001). Cetacean surveys generally take place in large study areas and ship time is expensive so continuous zigzag designs are often preferred as it maximizes search effort time and can minimise transit time between transects (Strindberg & Buckland 2004). Spatial stratification can be used to improve precision of estimates; the study area can be divided into blocks that are likely to have similar animal density and/or detection functions (defined as the probability of detecting an object at a given distance from a transect line or point). Another benefit of stratification is that the study area is divided into smaller areas, for which managers may want separate abundance estimates, or which may provide survey blocks of a more manageable size (Thomas et al. 2010).

Other species-specific issues may need to be taken into account during survey design, such as responsive movement of animals to the approaching observer (Buckland et al. 2001), and diving behaviour of the species. Species behaviour will also influence the choice of method to use; sperm whales (*Physeter macrocephalus*), for instance, are unavailable to visual observers as they can dive for an hour or more. However, this species vocalizes during a considerable part of their dive; therefore, acoustic surveys are potentially more valuable for sperm whales than for many other species (Barlow & Taylor 2005).

Most distance sampling surveys are analysed, and many are designed, using the software Distance (Thomas et al. 2010). The design outputs can be useful in determining if a design is feasible, and whether there is sufficient effort to produce enough sightings for reliable analysis. Once a design is chosen, a single realisation can be generated and exported to be used as the survey plan (Thomas et al. 2010).

Despite sometimes denoted as poorly productive, the waters of the Azores contain a high diversity of cetaceans with 23 species confirmed to occur in the area (Steiner et al. 2007). In spring and summer, the most common cetaceans in the Azores are the Atlantic spotted dolphin (*Stenella frontalis*), short-beaked common dolphin (*Delphinus delphis*), bottlenose dolphin (*Tursiops truncatus*), Risso's dolphin (*Grampus griseus*), and the sperm whale (*Physeter macrocephalus*) (Silva et al. 2003). The IUCN Red List of Threatened Species for the Azores lists the spotted, common and bottlenose dolphins as Least Concern, Risso's dolphins as Data Deficient and sperm whales as Vulnerable (Cabral et al. 2005). Additionally, all species are protected under the EU Habitats Directive and bottlenose dolphins are listed in the Annex B-II, requiring the designation of Special Areas of Conservation (DL 49/2005).

Estimates of abundance are missing for most cetaceans in the Azores. With only a few exceptions (e.g. Matthews et al. 2001; Silva et al. 2009), studies carried out in the area do not provide such information, vital to the implementation of management schemes in the Azores. Despite the current international push to get information on cetacean distribution to support marine spatial planning and habitat protection, and the recommendations that Portugal should carry out surveys to estimate cetacean abundance, it has not yet been possible to secure funding to support this research.

This paper had two aims: 1) to design a line transect shipboard survey to estimate the absolute abundance of the most common cetaceans off the Azores; and 2) to provide information on alternative scenarios for policy makers and environmental managers. We provide clear information and important considerations to take in when creating a good survey design. We briefly present the criteria used for choices made along the iterative process of defining the elements of a survey design. Three survey effort scenarios are assessed to illustrate the range of possibilities between statistical robustness and logistic/ management restrictions, and one survey design is presented.

MATERIAL AND METHODS

STUDY AREA

The archipelago of the Azores is composed of nine volcanic islands divided into three groups, extending ca. 600 km along a NW- SE axis (Fig. 1). The Azorean Exclusive Economic Zone (EEZ) comprises 938,000 km^2, ca. 30% of the European EEZ (Santos & Pinho 2005). The islands are separated by deep waters (ca. 2,000 m) with scattered seamounts (Santos et al. 1995). The high bathymetric amplitude is known to influence the local and regional circulation patterns, which in turn influence the distribution of pelagic organisms. There is a high seasonal and inter-annual variability in the oceanographic processes, which in turn influence the overall circulation in the Azores (Seabra et al. 2006).

METHODS AND LOGISTICS

The survey will use mark recapture distance sampling (see Laake & Borchers 2004 for details), with a double platform configuration. The target species for data collection will be spotted, common, bottlenose, and Risso's dolphins as well as sperm whales. In the Azores, spotted and common dolphins are eager bow riders; bottlenose dolphins may also be attracted to vessels whereas Risso's dolphins and sperm whales do not show attraction to vessels (Silva pers. comm.). Data will be collected for all species encountered, provided that this does not compromise data collection for the target species. The nautical survey will use visual detections for the species of dolphins and passive acoustic detections for sperm whales (e.g. Lewis et al. 2007). To give some starting point, it was assumed that 20 days of ship time were available to complete the survey. However, an estimate of the required survey effort for a given precision was expected to be an output of the design process, so the final recommended effort is likely to be substantially different from this.

The research vessel *ARQUIPÉLAGO* is used as a model, as it has the desired specifications; it has a cruising speed of 9.5 knots and maximum speed of 11 knots, it is able to operate for 2,500 km without making landfall, and is able to accommodate six scientists.

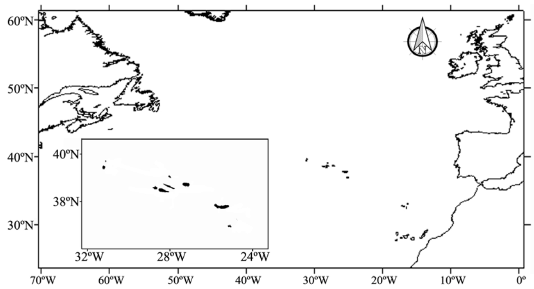

Fig.1. Location of the Azores archipelago in the north Atlantic.

The study area will be defined to be as wide as possible, from a minimum range of 20-30 km around the islands. The areas between the three groups of islands will be included if possible as well as the seamount complex located south to Pico Island. The survey will be conducted some time between June and August, as these are the months with better and more stable sea-state conditions (Windguru 2007). At this time of year, the day length is ca. 14 hours, allowing long days of work. In this period the percentage of days with sea-state below Beaufort 4 is about 80% (Silva pers. comm.).

DEFINITION OF THE SURVEY AREA

The initial area considered to define the extent of the survey was the geographic area defined by Seabra et al. (2005), 258,228 km^2 that enclosed the effort and sightings recorded between 1999 and 2004, in two major projects conducted at the Department of Oceanography and Fisheries of the University of the Azores (DOP/UAç; "Cetamarh" (1999-2004) and POPA (2001-2004). Different shapes and widths for the survey areas were considered, as well as the number of islands included in a survey sub-area. Two buffer zones were tested around the islands, one of 10 nautical miles (nm) (suggested in previous studies) and another of 12 nm (Territorial Sea). All maps were projected in the most appropriate way for the Azores (WGS1984 UTM Zone 26N).

DEFINITION OF THE SURVEY STRATA

Stratification was created to account for geographical gradients, given the underlying management interest. Strata were defined as: 1) seamount complex SE Pico; 2) corridors between island groups; 3) Western group; 4) Central group; and 5) Eastern group of islands. Within these, substrata were created to make the sub-areas more convex, reduce off-effort time (e.g. Thomas et al. 2007), and to maximize the number of transects per strata. Buckland et al. (2001) recommend 10-20 replicates as a minimum and Thomas et al. (2007) reinforce the use of > 15.

DEFINITION OF THE SURVEY PARAMETERS

Initially, the potential precision associated with the choices of survey effort (i.e. line length, L) was investigated using input parameters from previous studies in the Azores (Projects Cetamarh 2000-2004, Golfinicho 2005-2006, LIFE (1999-2000)). These previous findings provided the range of values of encounter rate (ER); a range of plausible coefficient of variation (CV) and sample size (n) was used.

The total line length (L) required in a main survey was determined using the formula proposed by Buckland et al. (2001), based on a pilot study. Given a target CV, cv_t , where

$$\left[cv(\hat{D})\right] = \frac{s\hat{e}(\hat{D})}{\hat{D}};$$

let n_0 be the number of animals (or clusters) counted in a pilot survey, and the total line length from pilot survey, then

$$L = \frac{b}{\left[cv_t(\hat{D})\right]^2} x \frac{L_0}{n_0}$$

where,

$$b \approx \frac{\text{var}(n)}{n} + \frac{n.\text{var}\left[\hat{f}(0)\right]}{\left[\hat{f}(0)\right]^2}$$

n being the number of animals (or clusters) and f(0) the probability density function of detected distances from the line, at zero distance. For simplicity and lacking better information, b=3 is used, following the suggestion of Buckland et al. (2001).

Lastly, survey effort scenarios were generated using R (version 2.5.1) (R Development Core Team 2007). From these, three survey effort options were chosen aiming to inform project managers; one illustrating a scenario where the resulting abundance estimates are robust, another illustrating a more feasible scenario incorporating cost-benefit aspects, and a third illustrating a trade-off of statistical robustness and logistic/ management restrictions.

DEFINITION OF THE SURVEY DESIGN

An equal spaced zigzag line was chosen to create the survey design in the present study (Strindberg & Buckland 2004). A survey design was generated using Distance 6 (Thomas et al. 2010) for survey option with smaller effort, using a 2 km strip width and a coverage grid with points 2 km apart (9,817 points in total). The survey region was approximated by a convex hull.

Effort was determined by line spacing, and proportional effort was allocated to each substratum. 5,000 simulations were run to examine the coverage probability (i.e. assess how even it is), and a minimum of 15 lines per stratum was ensured. Additionally, on effort time needed to perform this survey was compared with the time allocated initially to perform the survey (20 days), to assess the feasibility of the survey design.

RESULTS

DEFINITION OF THE SURVEY AREA AND STRATA

Oval regions were preferred, islands were grouped per group (Eastern, Central, Western), and 12 nm buffers were created (Fig. 2). Within the five strata initially defined to account for geographical gradients, a total of 16 substrata were created. The survey area, strata and substrata characteristics are summarized in Table 1. Total survey area is ca. 39,300 km^2, and the proportion of the total area represented by substratum ranged from 2% (corridor SMi-SMa) to 12.7% (seamounts_S).

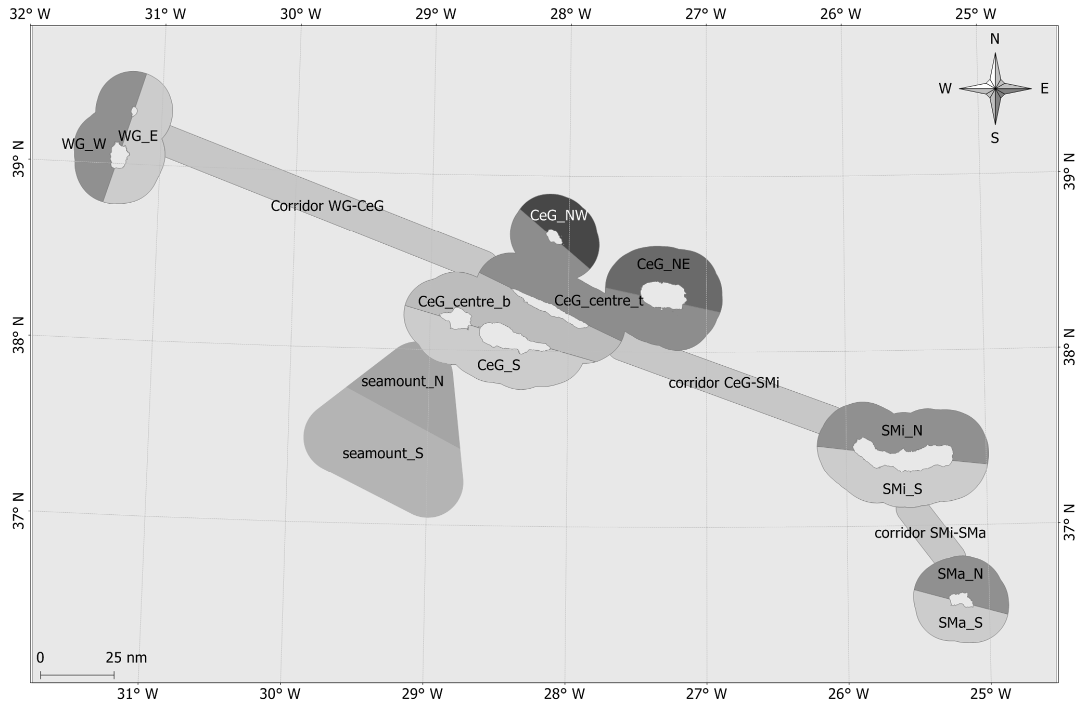

Fig. 2. Map of the survey area showing the 16 substrata with respective label.

Table 1. Characteristics of each stratum and substratum defined for the survey design; % refers to total area.

Strata	Substrata	ID	Label	Area (km^2)	% of area
Seamount	Seamount complex North	1	seamounts_N	2,480.2	6.31
	Seamount complex South	2	seamounts_S	4,997.0	12.71
			sum	7,477.2	19.01
Corridors	Corridor Western Group to Central Group	3	corridor WG-CeG	4,244.5	10.79
	Corridor Central Group to S. Miguel island	4	corridor CeG-Smi	2,656.8	6.76
	Corridor S. Miguel island to S. Maria island	5	corridor SMi-SMa	797.1	2.03
			sum	7,698.4	19.58
Western Group	Western Group West	6	WG_W	1,878.6	4.78
	Western Group East	7	WG_E	1,854.9	4.72
			sum	3,733.5	9.49
Central Group	Cental Group Northwest	8	CeG_ NW	1,207.4	3.07
	Cental Group Northeast	9	CeG_ NE	1,817.4	4.62
	Cental Group centre-top	10	CeG_centre_t	4,370.7	11.11
	Cental Group centre-bottom	11	CeG_centre_b	2,882.5	7.33
	Cental Group South	12	CeG_S	2,615.0	6.65
			sum	12,893.0	32.79
Eastern Group	S. Miguel island North	13	SMi_N	2,624.9	6.68
	S. Miguel island South	14	SMi_S	2,355.2	5.99
	S. Maria island North	15	SMa_N	1,306.9	3.32
	S. Maria island South	16	SMa_S	1,234.9	3.14
			sum	7,522.0	19.13
	Survey area	1	survey area	39,316.9	

DEFINITION OF THE SURVEY PARAMETERS

The survey effort scenarios showed 8,250 km were necessary to get CV≤0.3 for all species except sperm whales, and 17,600 km provided CV=0.36 for these whales and CV≤0.2 for the remaining species. In order to obtain CV=0.2, the amount of effort required for each species ranged from ca. 6,000 km for spotted dolphins and ca. 57,500 km for sperm whales. Regarding sample size, L needed to provide n=60 differed greatly, varying between 4,850 km for spotted dolphins, and ca. 46,500 km for sperm whales.

Given these results, further analysis for the survey design aimed for CV≈0.2 (set by the authors to illustrate good statistical robustness) and n≈60 (practical minimum suggested by Buckland et al. 2001); the ER used for each target species corresponded to mean values recorded in the Azores from June to August. Further, sperm whales were left out from the decision-making process given its abundance estimates will not depend on visual sightings (and therefore on the available visual-based ER, but on an acoustic-based ER).

Table 2. Summary of the three survey design options defined, coefficient of variation (CV) and sample size (n) obtained per species. ER (mean number of animals recorded per 100 km, for June to August). Codes used for cetacean species: DDE – short-beaked common dolphin; GGR – Risso's dolphin; PMA – sperm whale; SFR – Atlantic spotted dolphin; TTR – bottlenose dolphin.

		Option 1		**Option 2**		**Option 3**	
		L=5,000km		L=17,600km		L=8,800km	
Sps	**ER**	**CV**	**n**	**CV**	**n**	**CV**	**n**
DDE	0.8	0.3	39.9	0.2	140.5	0.2	70.2
GGR	0.4	0.4	20.3	0.2	71.4	0.3	35.7
SFR	1.3	0.2	62.3	0.1	219.3	0.2	109.7
TTR	0.8	0.3	38.1	0.2	134.2	0.2	67.1
PMA	0.1	0.7	6.5	0.4	23.0	0.5	11.5

Lastly, three survey effort options were chosen, to be presented to project managers: Option 1 – L = 5,000 km: incorporates cost-benefit aspects (based on hypothetical budget) that result in the possible loss of robustness of one of the target species; it generates CV≈0.3 for all target species except for Risso's dolphins; Option 2 – L=17,600 km: defined as the minimum L that would provide CV at least equal to 0.2; Option 3 – L=8,800 km: defined as half the Option 2, representing a trade-off of statistical robustness and logistic/ management restrictions. Table 2 summarizes the values considered in the three survey effort options. Despite not being used for decision making, the corresponding values for sperm whales are also shown.

DEFINITION OF THE SURVEY DESIGN

A survey design was generated for the survey option with smaller effort (Option 1, L=5,000 km). Designs were not generated for the two other effort options given the minimum number (i.e. ≥15 lines) of line transects per stratum was already achieved in Option 1. The coverage probability generated was quite even (mean 0.49, range < 0.001 to 0.76, SE=0.05). The angle of the zigzag lines per substratum varied between 70° and 175° to the x-axis (Table 3). Line spacing (mean spacing for each substratum) ranged between 7.96 km (seamounts_S) and 8.72 km (corridor SMi-SMa), and the overall mean used in the survey design was 8.32 km. The mean total on effort line length generated for the survey design was 4,956.4 km. The number of transect lines per substratum ranged from 5 (corridor SMi-SMa) and 28 (corridor OcG-CeG) and all strata had at least 20 lines.

Twenty nine (29.7) days of effort would be needed to complete the survey when L=5,000 km, sailing at 9 knots with 10 h work per day; number of days needed to survey each stratum would range from 2.8 to 9.7 (Western and Central group, respectively). A survey plan resulting from a single realization of the chosen survey design is shown in Figure 3. This gave a total line length of 4,968.2 km with 156 km off-effort (3.14% of the total line length).

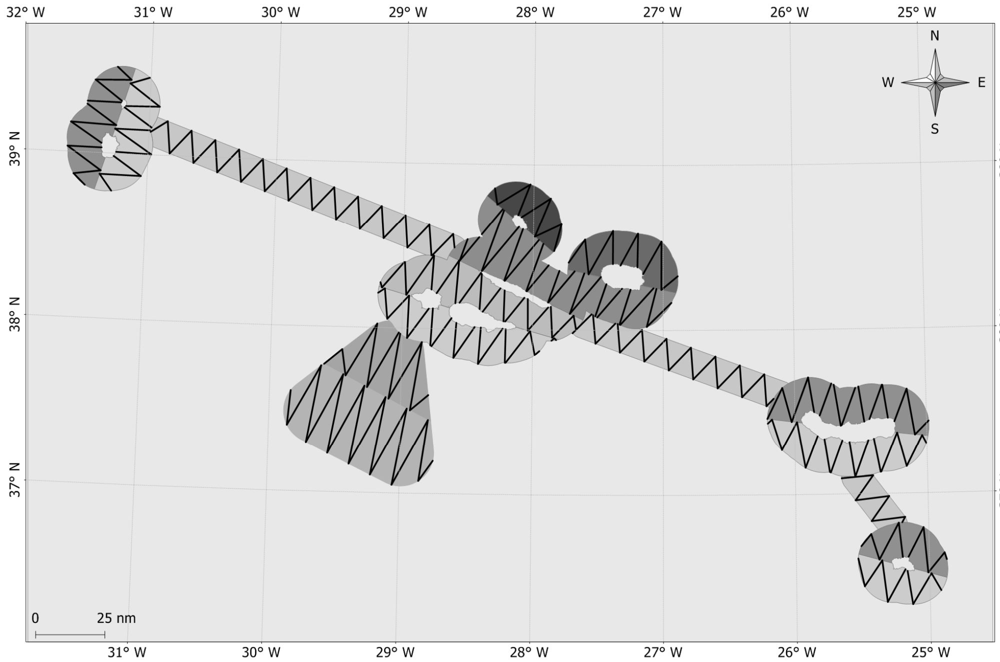

Fig. 3. Survey plan generated from a single realization of the survey design.

Table 3. Survey design summary. Transect length and number of samples (i.e. transect lines) are means; minimum and maximum in brackets. Survey days refer to proportion of a total 20 days available and the number of days required when travelling at 9 knots.

	DESIGN				**# survey**	
Substrata label	**DA angle (°)**	**Spacing (Km)**	**On effort trackline L (Km)**	**# samplers**	**from 20 days**	**at 9 knots**
seamounts_N	160	8.07	307.5 (288.2 - 313.9)	9.8 (8 -10)	1.3	1.8
seamounts_S	160	7.96	611.6 (602.7 - 621.8)	13.4 (13 - 14)	2.5	3.7
			sum	23.2 (21 - 24)	3.8	5.5
corridor OcG-CeG	160	8.55	554.26 (543.6 - 565.5)	27.1 (26 - 28)	2.2	3.3
corridor CeG-Smi	160	8.70	346.4 (333.2 - 358.0)	18.1 (17 - 19)	1.4	2.1
corridor SMi-SMa	120	8.72	101.5 (87.8 - 115.7)	6.00 (5 - 7)	0.4	0.6
			sum	51.2 (48 - 54)	4.0	6.0
OcG_W	70	8.01	239.6 (223.4 - 250.2)	10.9 (10 - 12)	1.0	1.4
OcG_E	70	8.00	235.6 (215.7 - 248.9)	10.9 (10 - 12)	0.9	1.4
			sum	21.9 (20 - 24)	1.9	2.8
CeG_ NW	140	8.29	154.5 (141.9 - 165.2)	7.6 (7 - 8)	0.6	0.9
CeG_ NE	165	8.28	227.0 (207.5 - 249.3)	9.6 (9 - 10)	0.9	1.4
CeG_centre_t	150	8.16	533.8 (511.9 - 547.3)	18.1 (17 - 19)	2.2	3.2
CeG_centre_b	160	8.46	365.5 (355.5 - 371.5)	16.9 (16 - 17)	1.5	2.2
CeG_S	160	8.42	330.5 (316.8 - 341.8)	15.3 (14 - 16)	1.3	2.0
			sum	67.5 (63 - 70)	6.5	9.7
SMi_N	175	8.29	328.2 (318.8 - 348.1)	13.7 (13 - 14)	1.3	2.0
SMi_S	175	8.41	296.2 (313.8 - 348.1)	13.5 (12 - 14)	1.2	1.8
SMa_N	170	8.42	166.2 (157.3 - 180.5)	7.9 (7 - 8)	0.7	1.0
SMa_S	170	8.48	157.7 (148.2 - 166.9)	7.8 (7 - 8)	0.6	0.9
	overal mean	8.32	*sum*	42.9 (39 - 44)	3.8	5.7
		Total	4,956.4 (4,729.6 - 5,151.5)	206.7 (191 - 216)	20.0	29.7

DISCUSSION

Three options for double platform survey effort were presented to guide project managers in the implementation of a shipboard survey design in the Azores. All these excluded sperm whales (*P. macrocephalus*) from the target species, given its estimation will be based on acoustic detections, for which there are no previous encounter rates (ER) available for the Azores. Option 1 illustrated a scenario based on a hypothetical budget, with the expected cost of losing precision in the estimates and possibly not allowing adequate estimates for one target species (Risso's dolphins, *G. griseus*, the species with lowest ER). Option 2 illustrated a scenario where the expected CV values are low and sample sizes are large. Despite the statistical robustness, however, this may be an excessive financial investment for a first survey. Option 3 illustrated the trade-off between statistical robustness and logistic/management restrictions. Given money is a severe constraint in the process of planning a design, and adding the fact this would be the first survey of this magnitude ever to be implemented in the Azores, Option 3 (L=8,800 km) is the one recommended.

It may be that funds are not available to survey even the lowest effort scenario we considered. In this case, consideration could be given to undertaking a multi-year survey, with different areas surveyed in different years (see below). Alternatively, a design with fewer strata might be used, so that fewer lines are required to achieve >15 per stratum. However, since density is expected to differ between the strata suggested here, this strategy will likely lead to greatly increased variance. It will also lead to few observations for fitting the detection function for many species.

All scenarios generated (double platform survey efforts), may nonetheless, be biased. ER values were derived from previous single-platform surveys, with a large proportion of sightings that were not identified to species level, and low height of the observation platform (Silva pers. comm.). A double platform translates in practical terms as having more observers searching for cetaceans, and a (second) higher platform of observation, increasing the probability of detecting the animals. The use of Mark Recapture Distance Sampling will provide the baseline of accurate information for future double-platform surveys in the Azores. It is important to stress that a small pilot survey should precede the main survey designed here, in order to refine field protocols and other practical matters, as well as potentially provide better estimates of encounter rate for use in planning the main survey. In the absence of a pilot survey, the main survey will likely become a pilot survey (Buckland et al. 2001).

The information collected will be a single snapshot in time. Nevertheless, if repeated every four or five years, it could be possible to detect trends in the populations of targeted species (e.g. Taylor & Gerrodette 1993). This would also mean one could increase the number of available detections for each species over the years, which would improve the modelling of detection functions, allowing to increase a posteriori the precision of estimates obtained even for the first survey.

Reinforcing the underlying management purposes of this work, the study area was created using a 12 nm buffer around the strata of interest, as this comprise the Azorean Territorial Sea. Although there is insufficient data to define substrata by a biological gradient (e.g. insufficient data on costal populations), it is well known that there are differences between geographical regions. Silva et al. (2003) reported that cetaceans were not seen equally in all three groups of islands (Eastern, Central and Western), possibly due to differences in the abundance or diversity of food resources. Seamounts in the Azores may act as feeding stations for some visitor species as marine mammals, as they may localize pelagic prey (Morato et al. 2008). Further, corridors between islands were considered to illustrate an off-shore habitat, but might nonetheless be different when compared to other off-shore areas not between islands.

Sixteen substrata were created. This improved the survey design by allowing a better adjustment of the non-convex survey region, providing short transect length off-effort and thus maximizing time on-effort (Thomas et al. 2007). The transect line width is very small compared to the transect length, so that overlap and other edge effects are likely negligible (Strindberg & Buckland 2004;

Thomas et al. 2007). The equally spaced zigzag used generated even close-to coverage probabilities along the study area, and one essential requirement for a good survey design, randomization, was fulfilled (Buckland et al. 2001). Few points had low coverage probability, possibly derived by the survey algorithm itself. This unevenness may not affect the precision with which animal abundance is estimated (Rexstad 2007). Furthermore, a minimum of 20 transect lines were allocated to all strata, fulfilling a second essential requirement for a good survey design, replication (Buckland et al. 2001).

Even though the survey design generated for the survey option with smaller effort has little off-effort time, the number of days at sea allocated initially for the survey (20 days) was not sufficient. To complete the total 5,000 km transect in 20 days with 10 hours of work, the average survey speed would have to be 13.4 knots and this is an excessive survey speed. More days should therefore be attributed to implement the survey. The time on effort needed to perform this survey at 9 knots was 29.7 days, and 20% (i.e. 6 days) should be added to account for bad weather (Silva, pers. comm.). Therefore, approximately 36 days should be allocated so that the smaller effort survey option can be conducted. Accounting for the example of the large scale European survey SCANS II (average work days of 6.5 h; Macleod pers. comm.) and considering days with 8 h of work, one would need 37.2 days to survey the area, supporting the recom-mendation above.

The uses of alternative methods to estimate the abundance of cetaceans should also be assessed, such as passive acoustic, aerial line transects, or perhaps mark-recapture for some species (see Borchers et al. 2002; Evans & Hammond 2004 & Mellinger et al. 2007 for reviews). These may be particularly effective for some species, such as sperm whales, not well catered for in the design suggested here. The possibility to conduct the survey in more than one year, with only few strata surveyed at each time (mosaic survey) could also be considered. A power analysis could be performed allowing the evaluation of population trends over time (Taylor & Gerrodette 1993). The ultimate objective of these surveys would be to obtain estimates which can be used for the management of cetacean populations, and being able to detect changes in abundance over time is a fundamental requirement for adequate manage-ment.

CONCLUDING REMARKS

If logistic constraints persist and it is not possible to opt for the intermediate effort option proposed (8,800 km), at least 36 days should be allocated to allow a feasible implementation of the survey option with smaller effort (5,000 km). Not being possible to allocate more survey effort, Risso's dolphins could be removed from the target species given this was the species levelling the minimum survey effort required to obtain good precision levels. Careful consideration should also be given to the field methods, as poor methods can destroy an otherwise well-designed survey. Data analysis should also be carefully performed, although unlike survey design and field methods, this can be re-done if improved methods come to light, so it is less critical to get it right the first time. It is highly recommended to conduct a pilot survey. This would enable field methods to be refined, as well as providing more detailed information that could be used to improve the survey design (e.g. number of substrata in the survey area, existence of biological gradients in the strata, survey effort based on adequate ER).

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