Progress of the REMMOA aerial surveys conducted in the French EEZ and adjacent waters: contrasted cetacean habitats in the southwest Indian Ocean.

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REMMOA stands for *REcensements des Mammifères marins et autre Mégafaune pélagique par Observation Aérienne* (Census of marine mammals and other pelagic megafauna by aerial survey)

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ABSTRACT

The French Agency for marine protected areas (*Agence des aires marines protégées*; AAMP) decided to conduct a series of surveys from 2008 onwards following a standardized methodology that would allow comparisons within and between regions as well as temporally, for the identification of hotspots of abundance and diversity and the establishment of a future monitoring scheme of cetacean and other pelagic megafauna across the French EEZ. The general study areas of the REMMOA surveys include all sectors of the French EEZ in the tropical Atlantic (French Caribbean and Guiana), southwestern Indian (Reunion Island, Mayotte and the Scattered Islands) and south Pacific oceans (French Polynesia, New Caledonia, Wallis and Futuna). The objective of this paper is to present the analysis of the Southwestern Indian Ocean survey with a focus on comparing cetacean and other pelagic megafauna communities in areas characterized by contrasted oceanographic conditions. The SW Indian Ocean survey was conducted from December 2009 to April 2010. Total effort deployed in the six areas amounted to 84,000 km. A total of 1,274 sightings of cetaceans were collected on effort, including 17 different taxa. In addition to this, 8 sightings of the sirenian *Dugong dugon* were collected, as well as over 22,343 seabird, 586 turtle and 338 elasmobranch sightings. Relative densities were estimated for six groups of cetaceans and for seabirds, sea turtles and elasmobranchs. Southern and central Mozambique Channel was characterized by the dominance of large *delphininae*, with a maximum density encountered in the central part of the channel (27.3 $x10^{-2}$ ind.km^{-2}, CV=23%). *Delphininae* relative density peaked around the Seychelles Plateau (32.6 $x10^{-2}$ ind.km^{-2}, CV=29%). The northern Mozambique Channel was dominated by *globicephalinae* and was also favorable to beaked whales (D=0.52 $x10^{-2}$ ind.km^{-2}, CV=43%). Northeast of Madagascar and around La Reunion and Mauritius Islands densities were very low in general, except for deep divers. In the near future the priority is to conduct the same kind of analyses on French Polynesia data and complete the first series of REMMOA surveys in the South West Pacific Ocean between November 2012 and March 2013. The long term objectives of the REMMOA surveys is to establish an initial situation of cetaceans and other pelagic megafauna diversity and relative abundance and to build up a monitoring strategy to be implemented from this point onwards. When the series of surveys is completed, it is planned to hold a workshop that would examine the statistical properties of the complete data set and infer recommendations for monitoring strategies. In this exercise, expertise from the marine mammal, seabird and fish scientific communities would be most welcome and the outcomes of this work extremely useful for all stakeholders and managers in charge of monitoring cetaceans across the tropics.

INTRODUCTION

The distribution of hotspots of diversity or abundance of cetaceans and other pelagic megafauna (sirenians, birds, turtles, large teleosts and elasmobranchs) is considered as a key element of knowledge for the design and implementation of a marine biodiversity conservation strategy for three main reasons. Firstly, these species are intrinsically vulnerable because of their generally large size, high trophic level, low natural adult mortality and low fecundity; because of these characteristics most of these species are exposed to many anthropogenic pressures and have a limited capacity to recover from highly degraded situations; they are therefore listed in a number of national, regional or international agreements for marine conservation. Secondly, it is also considered that conservation strategies tailored for these highly mobile species would be beneficial to ecosystems and lower trophic levels over large areas or networks of areas, a consequence colloquially named the umbrella effect of top predators. Thirdly, these species form one of the few components of pelagic biodiversity that can be readily seen from the surface of the ocean and therefore be surveyed across large oceanic regions; it is therefore expected that their species assemblages would reveal some of the major properties of the underlying ecosystems, a characteristics referred to as the indicator value of cetaceans and other marine megafauna.

In order to establish a baseline map of cetaceans and other pelagic megafauna across the French EEZ and a reference situation for future monitoring of these areas, the *Agence des aires marines protégées* (AAMP; Agency for Marine Protected Areas) decided to conduct a series of surveys from 2008 onwards following a standardized methodology that would allow comparisons within and between regions as well as temporally, for the sake of the identification of hotspots of abundance and diversity and the establishment of a future monitoring scheme (Table 1). The emphasis is clearly given to mapping diversity and density of pelagic top predators rather than focusing on one particular taxonomic group. The rationales for developing such multi-target surveys are twofold: firstly the cost-effectiveness of one multi-target survey compared to several single-target ones and secondly the capacity of multi-target surveys to inform on a broader array of ecosystem compartments and properties. Challenges related with this choice are also multiple and include compromises in survey and protocol designs, complexity in analyzing data sets and interpreting the ecological significance of observed distribution patterns of pelagic megafauna.

Additionally, considering the fragmented nature of the French EEZ, notably compared to the spatial scale that is relevant for the species of interest, the implementation of these surveys at regional scale by collaboration with neighboring countries is encouraged. The general spatial extent of the REMMOA project include all regions of the French EEZ in the tropical Atlantic (French Caribbean and Guiana; Van Canneyt et al., 2009 and 2010), southwest Indian (Reunion Island, Mayotte and the Scattered Islands; Laran et al., 2012), western South Pacific (New-Caledonia, Wallis and Futuna) and central south Pacific oceans (French Polynesia) oceans (Figure 1). Where appropriate and possible, EEZ of neighbouring countries are considered as well in a collaborative approach; this was particularly the case in the southwest Indian Ocean (see below). These large regions that are defined both on ecological and political grounds generally contains contrasted ecosystems. For instance, the eastern Caribbean-Guiana Plateau region can be split into the oligotrophic Lesser Antilles and the productive Guiana Plateau under the influence of massive fresh water inputs (Mannocci et al., in review). In the southwest Indian Ocean, the Mozambique Channel, the Seychelles Plateau and the Mascarene Islands are three ecosystems characterized by intense eddy activity and continental input, by active up-welling and by oligotrophic waters respectively (this work). In the central south Pacific, the Tubuai and the Gambier are two areas surrounded by extreme oligotrophic waters, whereas the Marquises located to the north of the region show much higher productivity due to their relative proximity to the eastern tropical Pacific system.

This work analyzes the pelagic megafauna communities living in the southwest Indian Ocean with a particular focus on the comparison on cetacean distribution and patterns of relative density between the contrasted ecosystems that can be found across the whole region. The other objective of this paper is to present these recent analyses of the SW Indian Ocean survey data as an example of the on-going analytical work for the whole REMMOA survey series. This paper is a follow-up of the two previous up-dates (SC/62/E14 and SC/63/WP3).

MATERIALS AND METHODS

General design and time line of the REMMOA surveys

Sampling is organised at three hierarchical spatial levels: regions (the 4 regions listed above and shown in figure 1), areas (up to six areas per region representing regional habitat diversity) and general bathymetric strata (shelf, slope, oceanic). For each regional survey, the time line extents over more than 4 years, necessary for planning and conducting the survey, analysing the data and disseminating the results (Table 1). All surveys are run in parallel but start at intervals of 1-2 years.

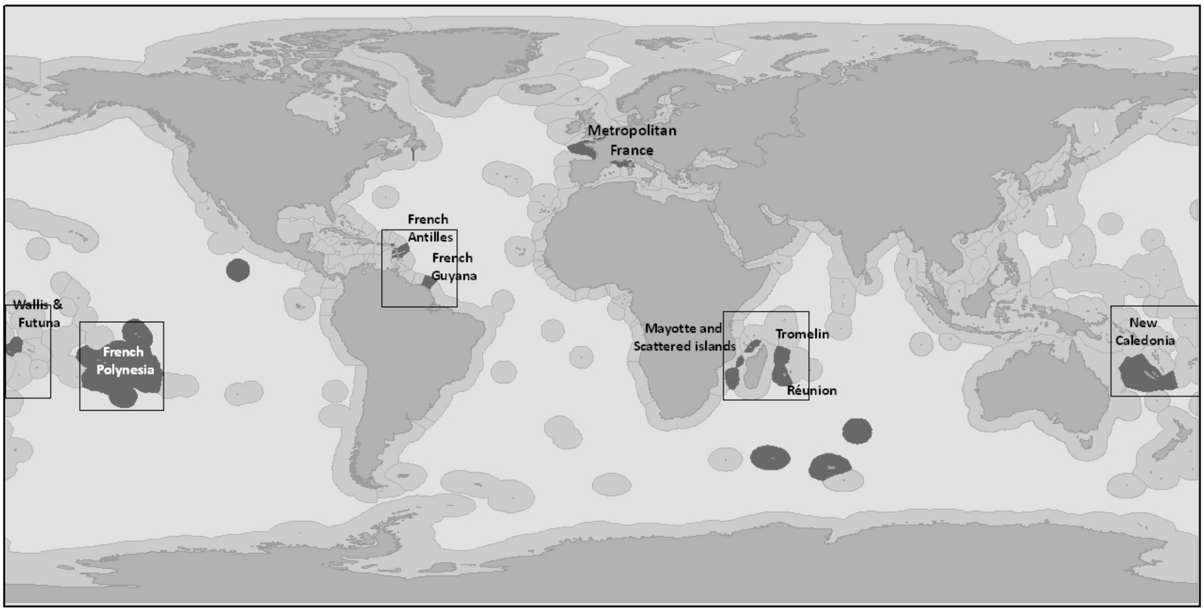

Figure 1: The French Economic Exclusive Zone (in dark grey) stretches across all three oceans from approximately 50°N to 50°S and is generally highly fragmented. Tropical regions of interest to the REMMOA surveys are the eastern Caribbean/Guiana Plateau, the southwest Indian Ocean, the western South Pacific Ocean, and the central South Pacific Ocean.

Table 1: Time line of the REMMOA phase I survey series (dark grey: done; light grey: underway).

Actions	Regions					Design of REMMOA-II monitoring strategy
	Caribbean & Guiana (local)	Southwest Indian Ocean (regional)	French Polynesia (regional)	Western South Pacific Ocean (regional)	Caribbean & Guiana (regional)	
Planning	2007-8	2008-9	2009-10	2010-12	2013	2013-14
Survey	2008	2009-10	2011	2012-13	2014	
Analysis	2009-12	2010-12	2012	2013-14	2015-2016	
Dissemination	2010-12	2012-13	2012-13	2014-15	2015-16	

The second REMMOA survey was conducted in the southwest Indian Ocean from December 2009 to April 2010. This survey was designed and implemented regionally under the framework provided by the Indian Ocean Commission (IOC), which includes Comoros, Madagascar, Mauritius, Reunion Island (France) and the Seychelles; the combined EEZ of all these countries represent a study region of approximately 5,000,000 km². Six areas were determined in order to 1) sample all representative pelagic ecosystems in the region, 2) involve the five countries of IOC, 3) cover most of the French EEZ, 4) and have access to airfields with appropriate refuelling and maintenance capacity. Total effort deployed in the six areas amounted to 90,000km or 500h (Table 2; Figure 2).

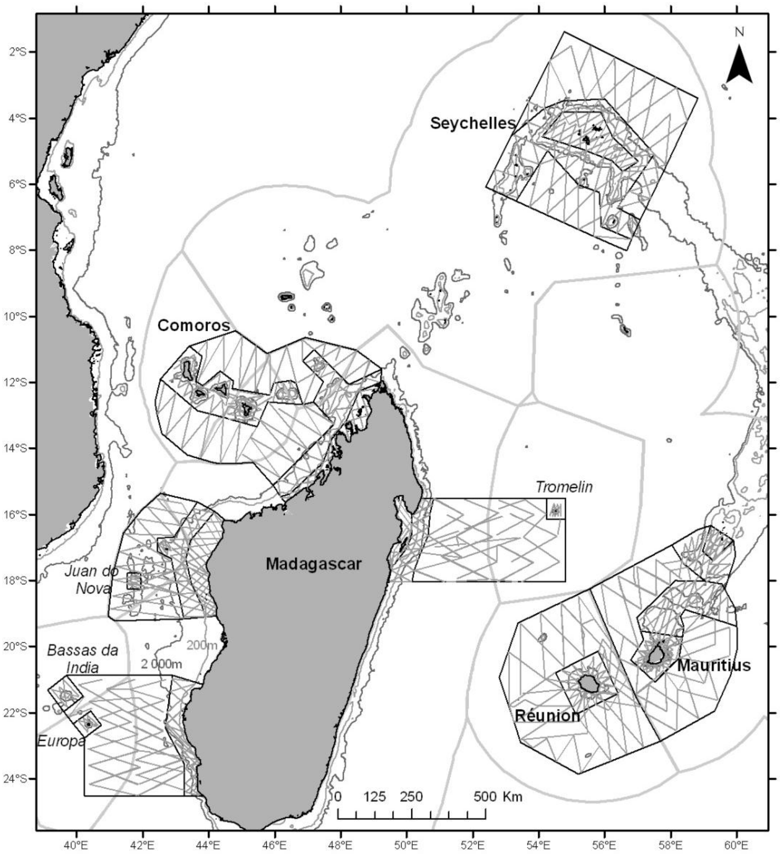

Figure 2. Study area and transect of effort conducted in all surveyed areas across the southwest Indian Ocean from December 2009-April 2010.

Data acquisition

The survey followed the general SCANS methodology (Hiby and Lovell, 1998) adapted to aircrafts (SC/62/E14 and SC/63/WP3). Briefly, a zigzag track layout was used and transects were sampled at a target altitude of 180 m and ground speed of 90 nm.h^{-1} (167 km.h^{-1}). Survey platforms were high-wing, double-engine aircrafts fitted with bubble windows (Britten Norman BN-2). The survey was conducted in the summer season in order to avoid the trade wind winter season; doing this, we could not adequately survey migratory large whales. Survey crew typically consisted in four members: two trained observers, one navigator, and one additional crew member off duty. All crew members rotated every 2 hours on these four positions to minimize loss of attention due to tiredness.

Data collected included taxon, group size, angle to survey track measured with an inclinometer for all sightings of marine mammals, large fish and vessels, allowing line transect data analyses. For seabirds and macro-debris, sightings were collected in strip-transect mode using a 200m band width on both sides of the survey track in order to minimize disruption of observers' attention from the main target species (cetaceans) in areas of high seabird or trash densities. Parameters collected on board included sea-state, turbidity, glare, subjective condition relative to small delphinids and cloud coverage.

Table 2. Effort expressed as distance flown (in km; refers to transect line flown in effort), covered area (in km²; refers to boxes shown in figure 2) and duration (in days; refers to total duration between first and last transect for any given spatial unit sampled) per area and stratum.

Areas	Strata	Distance flown		Sampled area		Survey duration	
		Per stratum	Total	Per stratum	Total	Per stratum	Total
Comoros -NW Madagascar	Neretic	2 258	15 198	18 344	275 636	10	20
	Slope	6 292		85 362		20	
	Oceanic	6 648		171 930		19	

W Madagascar	Neretic	2 445	9 776	22 234	123 680	19	19
	Slope	3 329		27 414		19	
	Oceanic	4 002		74 032		19	
SW Madagascar	Slope	3 549	9 785	33 664	152 763	14	14
	Oceanic	6 236		119 099		14	
NE Madagascar	Neretic	1 647	10 432	8 440	153 238	10	12
	Slope	2 624		20 580		10	
	Oceanic	6 161		124 218		11	
Mauritius	Neretic	909	14 046	6 250	216 717	11	26
	Slope	6 861		72 578		26	
	Oceanic	6 276		137 889		26	
La Reunion	Slope	2 687	10 041	20 822	189 794	13	20
	Oceanic	7 354		168 972		20	
Seychelles		2 783	14 448	28 913	293 903	10	10
	Slope	4 658		97 713		10	
	Oceanic	7 007		167 277		10	
Total			**83 726**		**1 405 731**	**121**	

General analytical procedure

Encounter rates (sighting. km^{-1}) of marine mammals, seabirds and sea turtles were mapped in all sampled areas across study region. A grid of 60x60km was overlaid and number of sighting and effort calculated in each cell by using extension for ArcGis 9.3 with projection UTM 39S. No correction for sighting-condition-related biases was done.

For relative density estimate, only data collected in 'good' or 'moderate' condition were considered (Beaufort scale <4). Detection curve and effective strip half-width (ESW) of each species or group of species were determined using the Multiple-Covariate Distance Sampling (MCDS) option with *Distance sampling* (Thomas et al., 2010). Subjective conditions, glare, sea state and group size were retained as covariates when significant. Models (with no covariate or with one or more covariates to be included in the detection function) minimizing the *Akaike* information criterion (AIC) were selected.

Conventional Distance Sampling (CDS) was preferred when no covariate model was selected, and density in each stratum was estimated by:

$$\hat{D} = \frac{n \cdot \bar{E}_{(s)}}{2 \cdot L \cdot ESW}$$

Where, *n* is the number of primary sightings, *L* is the total distance flown in effort and $\bar{E}_{(s)}$ the mean estimated pod size. The variance associated to D combines encounter rate, detection function and mean group size variances. We used the coefficient of variation (CV; see section 3.6 in Buckland et al., 2001).

When models with covariates were selected, multiple covariate distance sampling (MCDS) was preferred (Marques & Buckland, 2004) and ESW became a function of the covariate.

$$\hat{D} = \frac{1}{2 \cdot L} \cdot \sum_{i=1}^{n} s_i \cdot \hat{f}(0|\underline{z}_i)$$

Where $\hat{f}(0|\underline{z}_i)$ is the estimated probability density function of the observed perpendicular distances x, evaluated at x= 0, considering f as function of covariates (z).

School size was averaged by bathymetric stratum or by area depending of the number of available sightings (Laran *et al*, 2012 for details). No correction for either availability or perception biases was made.

Preferential habitats were then predicted using DSM (Density Surface Modeling) of Distance sampling (Hedley & Buckland, 2004). Continuous survey tracks conducted under similar condition (environmental and observers) were split into 10-km segments. Significant covariates were selected among physiographic and geographic covariates (depth, slope, latitude, longitude, distances to coast and to main bathymetric contours) and oceanographic covariates obtained from remote sensing data. Sea Surface Temperature (SST) and Chlorophyll (Chl *a*) concentration were provided by AquaMODIS at 4 km and 32 day resolution; gradients of SST and Chl *a* as well as net primary production were computed using Wimsoft (Kahru, 2010). All covariates were processed with ArcGIS 9.3 and associated to the center of each segment. General Additive Models were used to establish relationships between covariates and densities of main taxa within surveyed areas and ultimately to predict densities across the entire region.

RESULTS

Description of available data

In the southwest Indian Ocean, detection conditions were excellent in all areas of the Mozambique Channel and the Seychelles Plateau, intermediate in the northeast of Madagascar and suboptimal around Reunion and Mauritius. Over the six surveyed areas of the SW Indian Ocean, 1,274 sightings of cetaceans were collected on effort including 17 different taxa (Table 3). In addition, 22,343 sightings of seabirds, 586 of sea turtles and 338 of Elasmobranchs were also collected on effort.

Table 3. Cetacean sightings collected on effort

Categories	Taxa	Number of sightings
Small delphininae	*Stenella attenuata*	2
	Stenella longirostris	16
	Stenella or *Delphinus* spp.	205
Large delphininae	*Tursiops truncatus*	259
	Sousa chinensis	9
	Lagenodelphis hosei	1
	Tursiops spp. or *S. chinensis* or *L. hosei*	213
Globicephalinae	*Globicephala macrorhynchus*	27
	Pseudorca crassidens	54
	Globicephala or *Pseudorca*	22
	Peponocephala electra	75
	Feresa attenuata	1
	Peponocephala or *Feresa*	33
	Grampus griseus	62
Deep divers	*Ziphius cavirostris*	33
	Mesoplodon densirostris	4
	Indopacetus pacificus	3
	unidentified beaked whale	25
	Physeter macrocephalus	46
	Kogia spp.	30
Others	unidentified delphinids	54
	Balaenoptera spp.	17
	B. acutorostrata/bonaerensis	4
	Unidentified cetaceans	30
	Dugong dugon	8

Encounter rates

Marine mammal, seabird, sea turtle and elasmobranch encounter rates showed extensive variations across the region (figure 3). Highest values were found in the Mozambique Channel and the Seychelles Plateau for all categories. Among cetaceans, small *delphininae*, large *delphininae, globicephalinae* and deep divers may differ in distributions (figure 4). Large delphininae display highest encounter rates in the central and southern Mozambique Channel and in the Seychelles; whereas the distribution pattern of deep divers is less contrasted between areas.

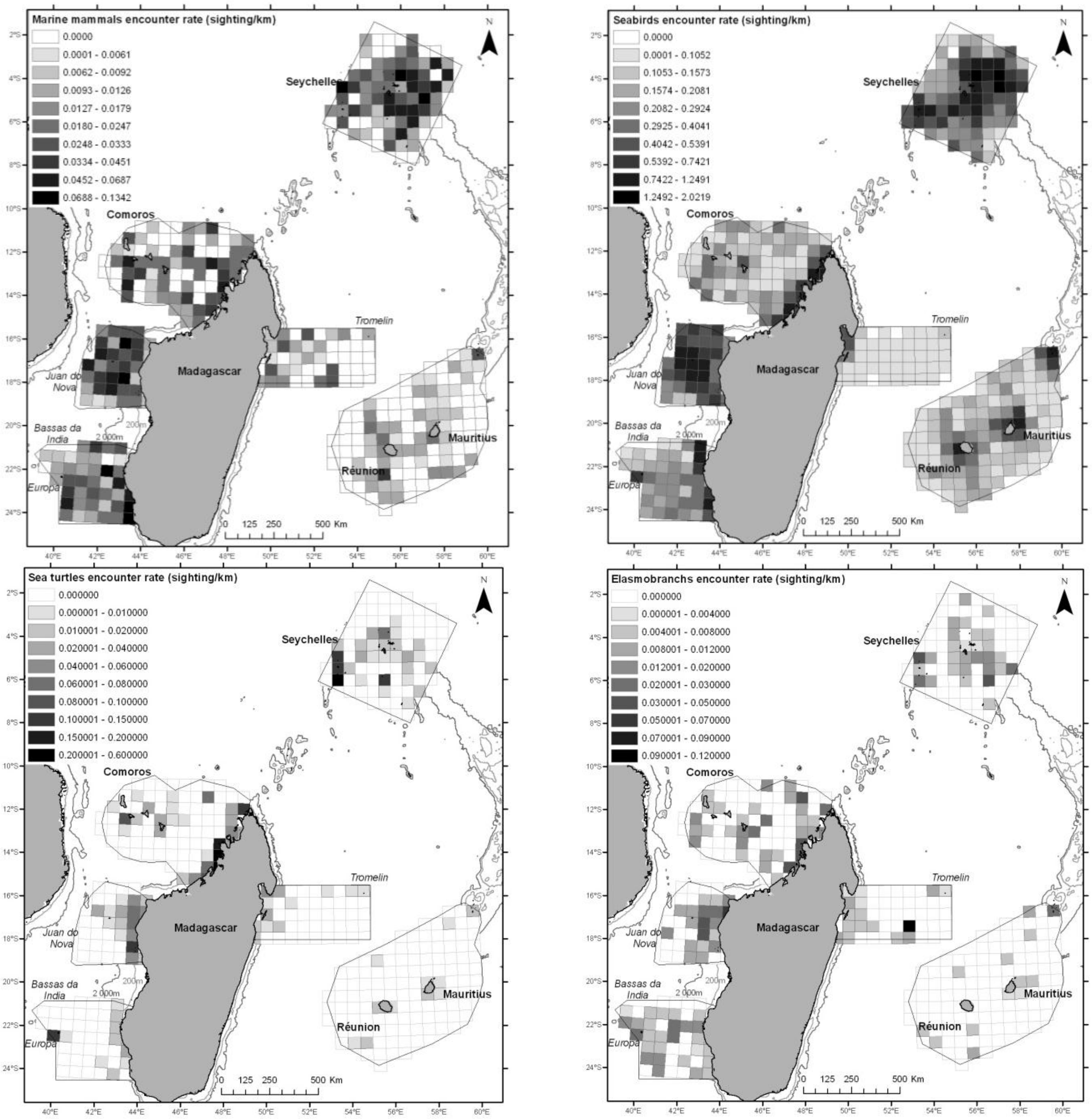

Figure 3. Spatial variation of encounter rate for pooled marine mammals, seabirds, sea turtles and elasmobranchs. All 60x60 km cells shown on the maps received over 50 km of effort.

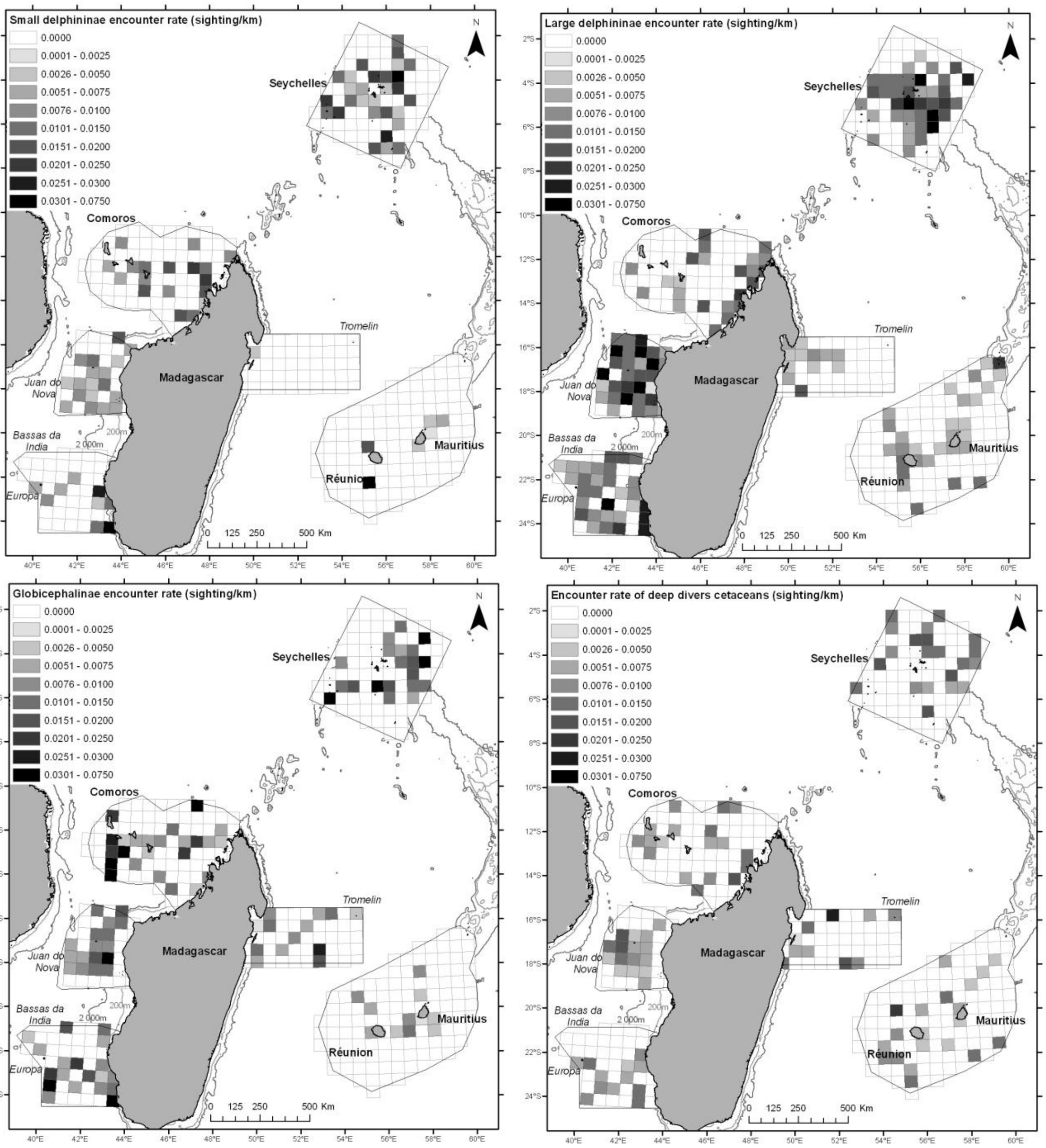

Figure 4. Spatial variation of encounter rate for pooled small *delphininae*, large *delphininae*, *globicephalinae* and deep divers. All 60x60 km cells shown on the maps received over 50 km of effort.

Relative densities

Detection functions were estimated for the main groups of cetaceans and other megafauna with sufficient data (figure 5). Effective strip widths (ESW) and associated coefficient of variation (CV) varies largely between targets.

Relative density estimates vary between sectors and groups of species (figure 6).

The southern to central Mozambique Channel is characterized by high densities of large *delphininae*, mainly bottlenose dolphins. Maximum density is found in the central channel (W Madagascar: D=27.3 x10^{-2} ind.km^{-2}, CV=23%), almost twice higher than in the southern channel (SW Madagascar, D=17.0 x10^{-2} ind.km^{-2}, CV=28%). Densities of small *delphininae* peaked in the central Mozambique Channel (D=19.4 x10^{-2} ind.km^{-2}, CV=27%) and, more importantly, over the Seychelles Plateau (D=32.6 x10^{-2} ind.km^{-2}, CV=29%). The northern Mozambique Channel is dominated by *globicephalinae*, mainly *Peponocephala electra* (D= 35.4 x10^{-2} ind.km^{-2}, CV=33%); this area also appears to be quite favorable for beaked whales (D=0.52 x10^{-2} ind.km^{-2}, CV=43%).

Northeast of Madagascar and around La Reunion and Mauritius Islands, densities are comparatively very low for all taxonomic groups. However, all deep divers do not show significant differences in densities between surveyed areas.

The Seychelles Plateau is characterized by higher densities of small delphininae, sperm-whale and *Kogia* spp compared to the other areas.

For total seabirds, higher densities were found in the south of the Mozambique Channel (figure 6), whereas for turtle and elasmobranchs minimum density was around La Reunion and Mauritius Islands.

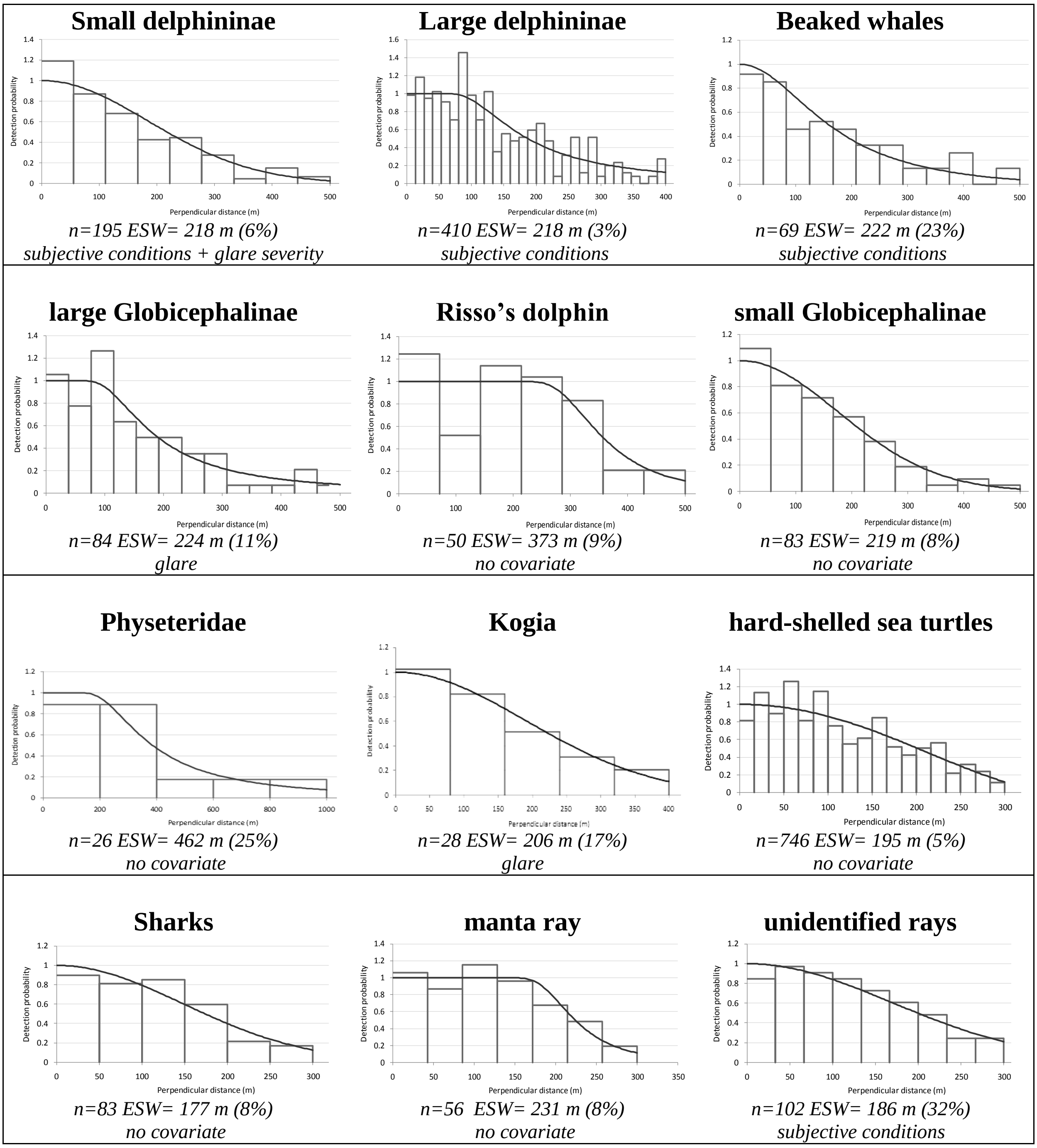

Figure 5. Detection functions for the main groups of cetaceans, turtles and elasmobranchs. Numbers of sightings after truncation (*n*), effective strip widths (ESW), coefficients of variation and significant covariates associated to the detection function are given.

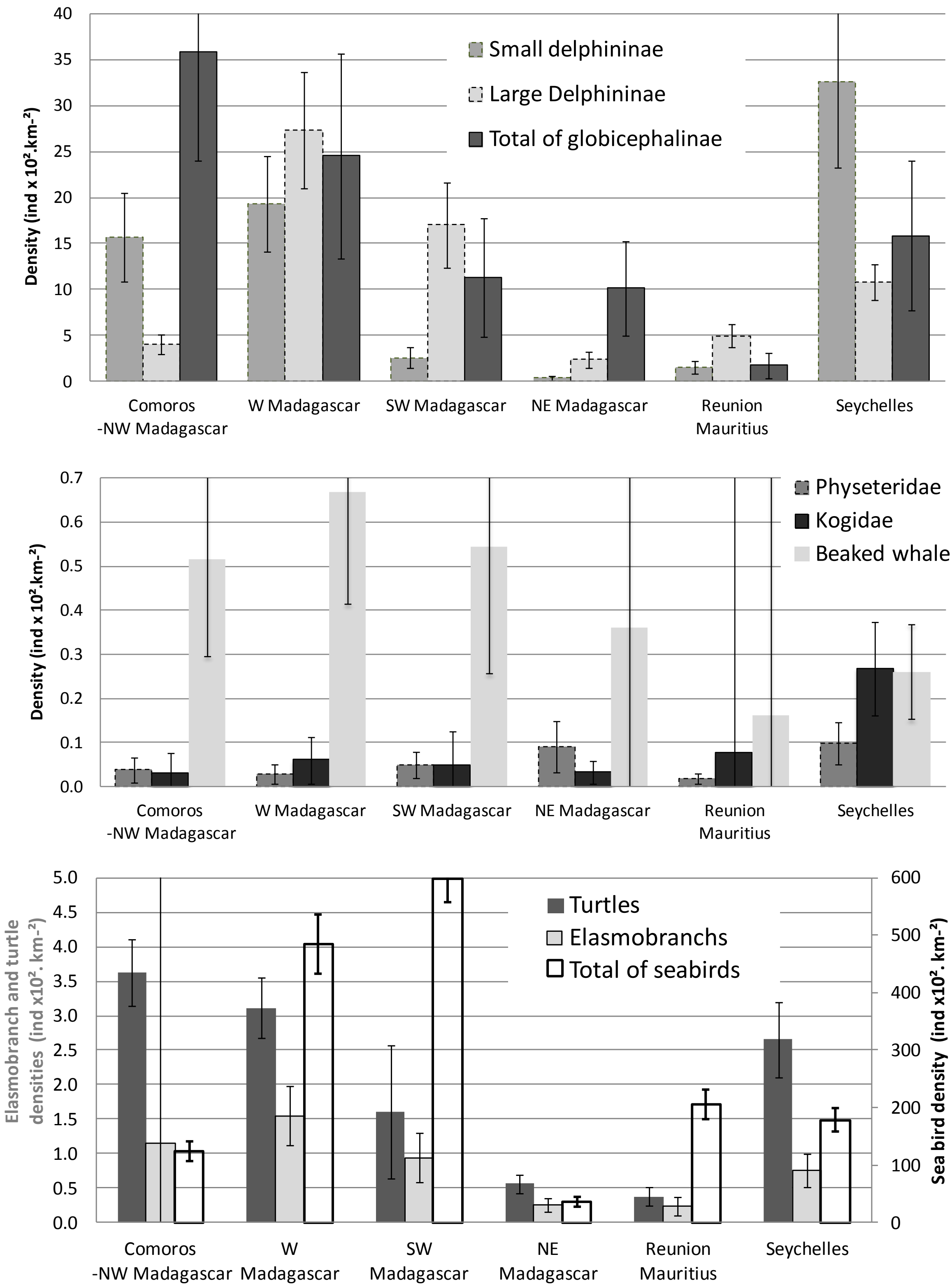

Figure 6. Relative densities (in individuals x $10^2.km^{-2}$) estimated for small and large *delphininae*, total of *globicephalinae* (including Risso's dolphin, top), *Physeteridae*, *Kogidae* , beaked whale (center) and turtles, total elasmobranchs and total seabirds (down). Error bars represent standard error of estimates.

Habitat modeling

Models of density surface were obtained for seven groups of cetaceans: small *delphininae* (29% of the deviance explained), large *delphininae* (19%), small *globicephalinae* (25%), Risso's dolphin (49%), large *globicephalinae* (29%), beaked whales (20%) and *Physteroidea* (*Kogidae* and *Physeteridae;* 33%). As examples, only the small delphininae and the Risso's dolphin models are described below.

The best model for density of small *delphininae* selected longitude, latitude, depth, distance to the 200 m contour, gradient of chlorophyll, sea surface temperature (*p=0.000*), then slope and primary production (*p=0.001*) as significant covariates. It explained 29% of the deviance. Prediction was produced for the whole region with the environmental conditions as of December 2009 (figure 7 left). For the Risso's dolphin the best model selected longitude, latitude, depth, slope, distance to the 2 000 m contour, gradient of chlorophyll, primary production and sea surface temperature (*p=0.000*), then chlorophyll with a time lag of 2 months (*p=0.01*) as significant covariates. This model explained 49% of the deviance (figure 7 right).

Predictions for the seven cetacean taxa were then made for the whole region and pooled together. This prediction clearly highlighted the importance of the Mozambique Channel and the Seychelles Plateau for cetaceans (Figure 8).

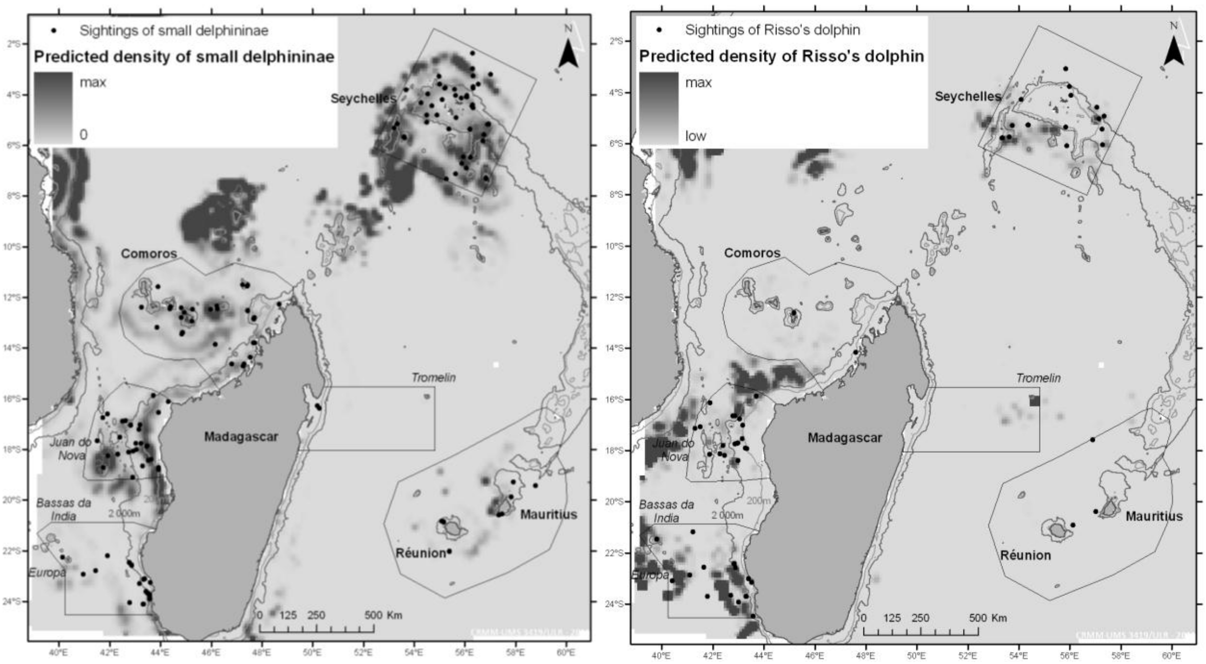

Figure 7. Predicted density distributions and sightings for small *delphininae* (left) and Risso's dolphin (right) with environmental conditions as of December 2009.

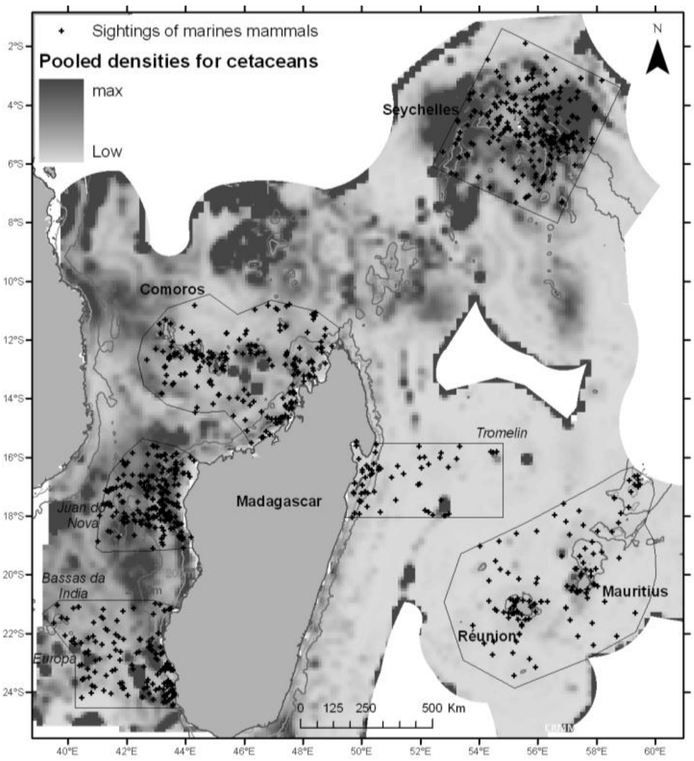

Figure 8: Pooled predicted density distribution pooled for seven cetacean taxa: small *delphininae*, large *delphininae,* small *globicephalinae,* Risso's dolphin, large *globicephalinae,* beaked whales and *Physteroidea* (*Kogidae* and *Physeteridae*) with environmental conditions as of December 2009.

DISCUSSION AND PERSPECTIVES

General

Regarding the choice of the survey platform, aircrafts *versus* ships, the advantages and limitations of both types are well known. Vessels allow a higher proportion of sightings to be identified at species level; thanks to their higher passenger capacity, they also allow double platform methodology to be implemented and therefore the detection probability on track line to be estimated; finally, because of their much longer autonomy, logistic constraints on survey design are lower. Their drawbacks include the limited flexibility of vessel utilization during survey period which generally precludes quick reaction to changing weather and sea conditions, hence resulting in a lower rate of platform usage in optimal detection conditions; ships generate positive and negative interaction biases with the survey target species (either cetaceans or birds) which imply species-specific analyses; because of limited steaming speed, several ships are needed to cover extended survey areas if sufficient spatial resolution is needed for modelling; finally cost and carbon print per unit effort (km surveyed in effort) are higher. For aircrafts, the higher flexibility of utilization allows an optimal rate of platform usage under good detection conditions; there is no evidence of survey target species reaction to survey platform (this may be different with a helicopter); extended areas can be surveyed in a limited amount of time; costs and carbon print are lower per unit effort flown (km surveyed in effort). Several limitations to surveying from the air are well known and include the heavier logistic constraints placed on survey design (aircrafts are 'central-place' survey platforms); higher number of sightings that cannot be identified to species; difficulty to implement the double platform methodology and hence to estimate detection probability on survey track. In the case of the REMMOA survey series, cost related issues were key elements of the decision because of the vast geographical span of the project, which made a series of ship surveys too expensive. Some of the aircraft-specific limitations can be mitigated.

Distribution patterns in the SW Indian Ocean

The southwest Indian Ocean is an oceanographically contrasted region where three broad systems can be recognized: the Seychelles, the Mascarene Islands and the Mozambique Channel, that belong to three distinct Large Marine Ecosystems (the Indian monsoon gyre, the East African coastal and the Indian south subtropical gyre provinces respectively) as defined by Longhurst (1998) largely on the basis on oceanographic processes. Marine Ecoregions Of the World (MEOW) is another system of bioregionalization that incorporates more biological element and focus on shelf habitats (Spalding et al., 2007). In this latter context, the whole study

region of the present paper belongs to one single province called the Western Indian Ocean and our surveyed areas belong to several of its marine ecoregions: Seychelles, Cargados Carajos-Tromelin, Mascarene Islands and Western to Northern Madagascar.
The preliminary analyses conducted on the REMMOA data set tend to fit well within these bioregionalization systems. In particular encounter rates, relative densities and prediction of preferred habitats all concur to oppose areas of the Mozambique Channel and the Seychelles characterized by generally higher values with areas of the Mascarenes characterized by much lower values in general. A closer look at the data would suggest that not all cetaceans, and by extension pelagic megafauna, would respond similarly to differences in oceanographic processes between areas. In particular, it appears that deep divers may be more equally distributed between areas suggesting that they would be less sensitive to the oceanographic parameters classically used to describe surface marine productivity. To develop further these analyses and better interpret the causal relationship underlying the variety top predator distribution patterns, data on the distribution of their prey would be essential. However, direct measurements of prey field or prey densities in the different water layers of interest to cetaceans are unlikely to be available in the southwest Indian Ocean in a near future. SEAPODYM is a model initially developed for investigating spatial population dynamics of tuna under the influence of both fishing and environmental effects (Lehodey, 2004 a, b; Lehodey and Senina, 2009). This model allows prediction of both temporal and spatial distribution of secondary consumers in oceanic ecosystems at various water depths and therefore has the potential to provide additional covariates of direct interest to top predator ecology.

Perspectives
In the near future the immediate priority is to complete the first series of REMMOA surveys. The next REMMOA aerial survey is planned in the southwest Pacific Ocean between November 2012 and March 2013, and the eastern Caribbean/Guiana plateau region is planned to be surveyed regionally later on (Table 1). Lessons drawn from the first steps are extremely useful for the continuation of the project. In the southwest Pacific, the French EEZ (2,040,000 km²) is split into two sub-units: the large New Caledonia and the smaller Wallis and Futuna area that are located some 15° longitude apart.

The long term objectives of the REMMOA surveys is to establish an initial situation of cetacean and other pelagic megafauna diversity and relative abundance and to build up a monitoring strategy to be implemented from this point onwards. In 2013-2014 a workshop is planned to be hold in order to examine the statistical properties of the complete data set and infer recommendations for monitoring strategies in the future. In this exercise, expertise from the marine mammal, seabird and fish scientific communities would be most welcome and the outcomes of this work extremely useful for all stakeholders and managers in charge of monitoring cetaceans across the tropics.

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