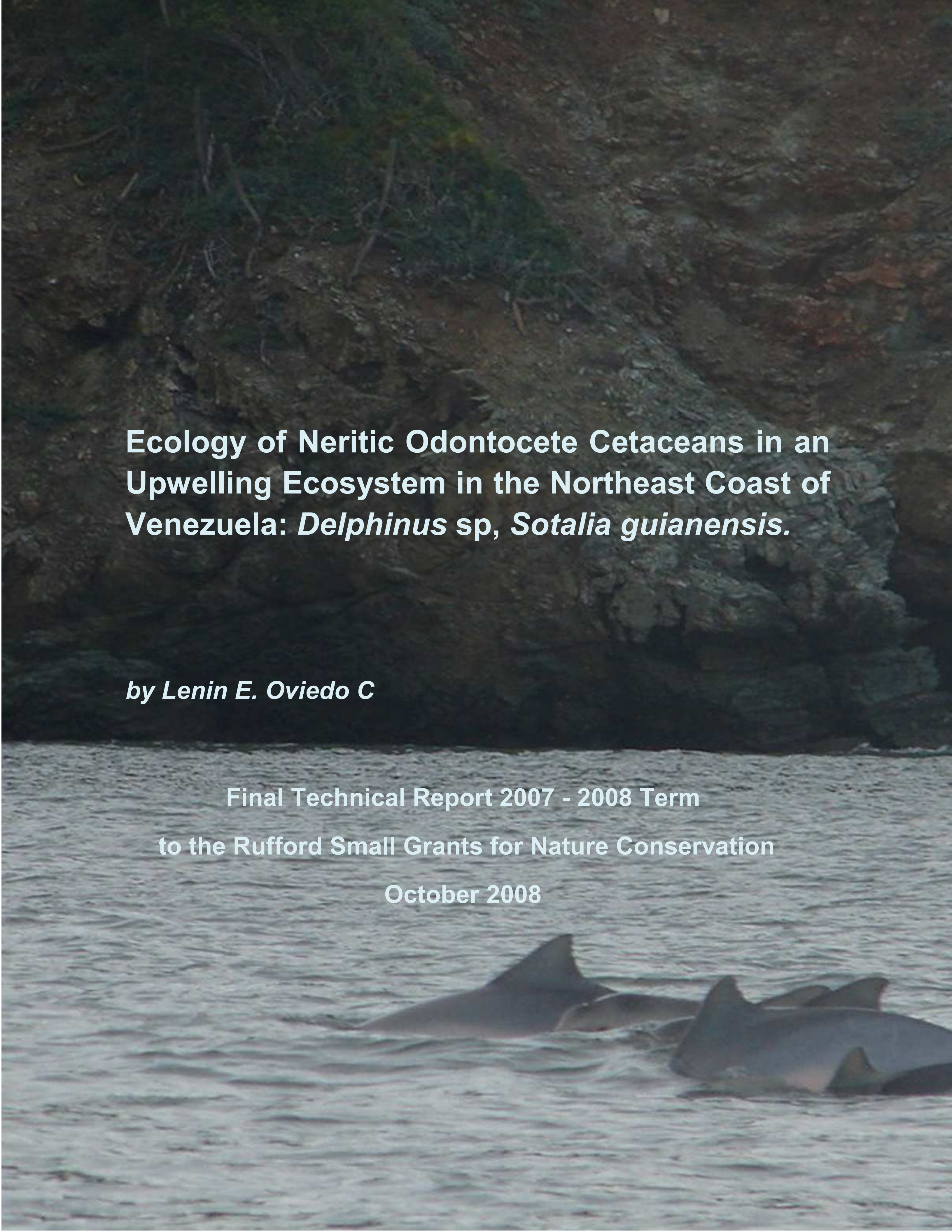

Ecology of Neritic Odontocete Cetaceans in an Upwelling Ecosystem in the Northeast Coast of Venezuela: *Delphinus* sp, *Sotalia guianensis.*

by Lenin E. Oviedo C

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Abstract: The northeast coast of Venezuela host a great diversity of megafauna, particularly related with high water productivity due to coastal upwelling. This area is mainly characterized by the existence of big sardine schools among other species. This would explain why the area supports a wide range of marine top predators, including cetaceans. The current status of cetacean populations in the northeast coast of Venezuela is uncertain, at least from a quantitative point of view, mainly because research efforts are novel. There are still many gaps of information in cetacean biology to establish a solid base-line useful in management decision. The latter is especially true for those coastal species with a restricted range in the area, exposed to pervasive threats, such as habitat degradation linked to coastal development and fishery over-exploitation. For instance, there are not sound estimates of the distribution, abundance and habitat use of tucuxi and common dolphins in the northeast coast of the country and their key areas for survival. This contribution deals with the results obtained in the first year of intensive survey for both species, exploring how dolphins are using the physical habitat and the possible determinants of their distribution within the coast of northeastern Venezuela. Tucuxi dolphin is locally a discrete population with a restricted range. Foraging has been the most important behavioral state in the activity budget. Information on habitat use of tucuxi dolphins evidences a relevant trend towards a localized critical foraging habitat and a non homogeneous use of the coastal environment. The behavior budget will establish the baseline reference for any future impact assessment. Common dolphins are widely dispersed over the whole northeast basin, including the research area. Affiliation of common dolphin foraging bouts to a specific locale at the shelf edge, among with the fact that travelling increases with distance from the 100 m isobaths, could suggest migration towards localized foraging areas. Common dolphin' sardines consumption should not have a strong effect that could develop into competition with fisheries. But potentiality of a trophic cascade is a possible risk for this predator. Further data collection is recommended, increasing the scope into the dispersal pattern of the local tucuxi population (immigration and emigration data). In the case of *Delphinus* sp. efforts should be focalized in the continuity of behavior sampling and diet determination pair with the progression of the systematic line transects estimations.

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1) INTRODUCTION

The northeast coast of Venezuela host a great diversity of megafauna, particularly related with high water productivity due to coastal upwelling. This area is mainly characterized by the existence of big sardine schools (*Sardinella aurita*) among other species (Mendoza *et al*. 2003, Guzman *et al*. 1999, Cardenas 1997). This would explain why the area supports a wide range of marine top predators, including cetaceans.

Acevedo (2007) detailed the distribution of 11 species of marine cetaceans, among them *Delphinus sp*, and *Sotalia fluviatilis* as important species within shelf and coastal habitats. Over 50% of the cetaceans (35 species) reported in the South Caribbean Sea occur at the northeastern region of Venezuela (Acevedo 2001; Oviedo and Silva 2001; Oviedo and Silva 2005; Oviedo *et al*. 2005, Romero *et al*. 2001). An area of conservation importance that guarantees their protection does not exist (Acevedo *et al.* 2003; Rodriguez and Rojas-Suárez, 1998), even though some of them are considered threatened, or would be so soon due to anthropogenic activities like oil and gas production facilities and commercial shipping traffic.

The current status of cetacean populations in the northeast coast of Venezuela is uncertain, at least from a quantitative point of view, mainly because research efforts are novel, therefore, comparison with historical records or estimates are not possible. There are still many gaps of information in cetacean biology to establish a solid base-line useful in management decision. Coastal species with a restricted range in the area, are exposed to pervasive threats as habitat degradation linked to coastal development and fishery over-exploitation, the latter situation is added to biological information scantly documented. For instance, there are not sound estimates of the distribution, abundance and habitat use of tucuxi and common dolphins in the northeast coast of the country and their key areas for survival. Just recently some abundance estimates as those of *Tursiops truncatus* in the northeast coast of Margarita Island are being published (Oviedo and Silva, 2005).

Acevedo *et al* (2007) identified and termed the southern coast of Margarita Island and the northern coast of Araya Peninsula as a key area for the conservation of odontocetes cetaceans, particularly for common and tucuxi dolphins. The complex underwater relief, together with the enhanced productivity due to up-welling processes, promotes the occurrence of dolphin's populations.

Within the region bounded by the 100 m isobath inside the Cariaco Basin, the upwelling seasonal plume covered a surface area that ranged between 0 and $1X10^3$ km^2 from August to October, and which then typically extended over an area greater than $12X10^3 km^2$ in March (Muller Karger *et al*. 2004). This would have a direct effect on the distribution of the main cetacean prey: spanish sardines (*S. aurita*). There seems to be just one stock of *S. aurita* in the basin, since there is no genetic differentiation of local aggregations throughout the northeast coast of Venezuela (De Donato *et al*. 2005). Therefore species as *Delphinus* sp. should disperse over this greater area of complex topography, upwelling influence and sardines abundance. The affiliation of common dolphin with uneven underwater topography has been described in other latitudes (Hui, 1979).

Determination of critical habitat is the keystone to proposed designation of any special management status in any specific locations of their habitat. Hence, the ultimate goal of this project is to determine what portions of the shelf habitat in the northeast coast of Venezuela represent feeding areas, reproductive areas and nursery for tucuxi and common dolphins.

This report deals with the results obtained in the first year of intensive survey for both species, and contributes to the available knowledge on coastal dolphins' ecology in Venezuela, in particular, by exploring how dolphins are using the physical habitat and the possible determinants of their distribution within the coast of northeastern Venezuela. The results obtained here highlight two important relationships between occurrence and environment. First there is clear evidence that dolphins are not evenly distributed throughout the environment of the study area; and second, the location of animals during feeding bouts concentrate in a discrete area, giving insight of a potential *critical feeding habitat*.

1.2 Rationale and Problem

1.2.a Cetacean habitat and resources: The northeast coast of Venezuela is a key area in terms of biodiversity in the Greater Caribbean ecoregion, as mentioned before the prey abundance is particularly characterized by the local occurrence of small pelagic such as sardines associated with habitat productivity. A trend in coastal development, have resulted in an increased in boat traffic and corresponding noise pollution that is actually not regulated considering technical arguments related with habitat dynamic.

Global climate change has also had a strong influence in the northeast coast habitat, there have been a documented steady decreased in the wind force since 2004, resulting in a weak upwelling that has affected the larval energy intake of the cetacean' potential prey, sardines (Varela 2008). Therefore, the sardine fishery has equally decrease since 2003, reaching a critical point on 2005. Another added effect related to the lack of wind force is the replacement of the phytoplankton community, diatoms has been replaced by smaller less nutritious components such as microflagellates, coccolithophorids and dinoflagellates (Varela 2008).

Prey depletion has been an influential factor for cetacean population decreased (particularly common dolphins) in locations within the Mediterranean basin (Bearzi *et al.* 2005, 2006). The degradation of the food web has been documented, where the current situation of exploitation of marine resources could lead to additional species loss (Coll et al., 2008).

1.2.b Common dolphins as predators: There is no quantitative information of the role of common dolphin as key predator in the productive environment of the northeastern coast of Venezuela. The amount of energy extracted from the system by predation of the key resource; sardines, can only be estimates with proper biological parameters of key predators. Common dolphins are probably the most representative predator species within the whole basin. The baseline on the species diet is non-existent; hence there is no insight of how important other prey items, such as Mycthophids would be. In terms of predators' stock structure, identity and population estimates are another latent issue, the species occurring in the basin could be a local morphotype that requires genetic assessment (Esteves & Oviedo, 2005; Esteves & Oviedo 2007a). All the existing relative abundance estimates have been obtained through platform of opportunities, and the result are no solid estimations with use in stock management.

1.2.c Tucuxi dolphins as coastal environmental sentinels: Coastal species with a restricted range in the area, such as tucuxi dolphins are particularly exposed to pervasive threats such as habitat degradation linked to coastal development. There are not sound estimates of the population size distribution and conservation status of tucuxi dolphins in the northeast coast of the country and what the key areas for the species survival are. Determination of critical habitat is the keystone to proposed designation of any special management status in any specific locations of their habitat. Hence, determining what portions of the shelf habitat in the northeast coast of Venezuela represent feeding areas, reproductive areas and nursery for tucuxi dolphins should be a priority. Especially, if considered the fact that tucuxi's population is so small and seemed to have a quite restricted range that could be locally relictual (Oviedo *et al.* 2004).

1.3 Aims and Objetives

This project aims to produce biological information on critical habitat, behaviour, acoustic and feeding habits and abundance of two important representative species in the northeast coast of Venezuela: a) *Delphinus* sp and b) *Sotalia guianensis.* The ultimate goal of this project is to integrate species-based information into an ecosystem level approach, that will widen the understanding of key processes in key marine habitat and foster development of more effective policy making and management.

The general objective of this project is to produce information on the ecology of coastal odontocetes: common dolphin (*Delphinus* sp.) and tucuxi (*Sotalia guianensis*) that will serve as baseline information to sustain ecological approaches useful in management initiatives.

The specific objectives are:

- To characterize the habitat of *Delphinus sp* and *S. guianensis* in the study area
- To describe the main ethological and acoustic characteristics of *Delphinus sp* and *S. guianensis* in the study area within the context of habitat use
- To determine the relative abundance of the populations of *Delphinus sp* and *S. guianensis* in the study area
- To establish the trophic impact of *Delphinus* sp predation and its effects on local fisheries

2) MATERIALS AND METHODS

2.1 Tucuxi dolphins

The study area comprised the bays and coves from Guaca Bay (10°40'-63°24'/10°40'-63°25') to Guaraguao Bay (10°40'-63°28'/10°40'-63°29'), about 39 (38.86) Km^2 of shallow marine areas, and rocky - sandy coastline located in the north coast of Paria Peninsula (Figure 1).

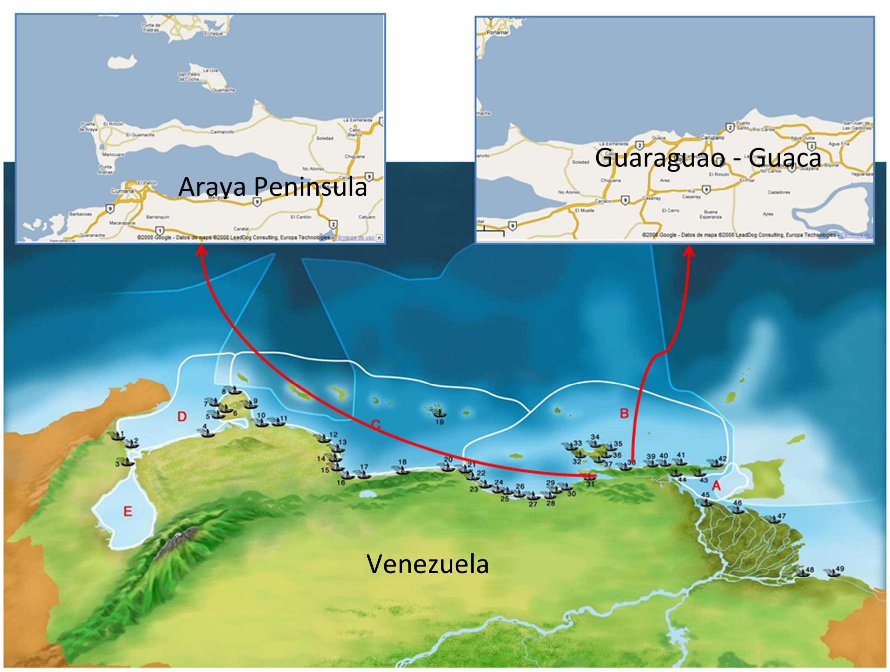

Figure 1. Details of the research areas in the northeast coast of Venezuela

Research method implied systematic small boat surveys: Ethological - sampling centered in areas of significant presence, documented previously (Oviedo *et al*., 2004; Esteves & Oviedo, 2007). Behavior sampling was undertaken through group follow protocol and scan-sampling: every two minute, with a five minute interval (Altman, 1974; Mann, 1999). Behavioral state were described through a standardized behavioral key, following Schneider (1999) and García and Dawson (2003) approach, based of the preliminary observations of Oviedo *et al.,* (2004), and the behaviors reported in Daura Jorge *et al*. (2005).

The estimation of the relative abundance was achieved by the association of a unit of effort (APUE) and the modification of the relative abundance estimation by means of the *waiting distance* (Henrys, 2005). The latter requires the determination of the distance between encounters (li), including that from the departure point, this element is associated to a fixed detection distance (μ= 500 m). The fixed detection distance is modified to be adapted to group follow protocol, due to the need of close range behavioral observations. The result between the association of the waiting distance and the detection distance is an effective detection area (li2μ), this area is included into a density coefficient ($D = ns/as$), in order to calculate a relative abundance number closely related with the surveyed area ($ns = Dxli2\mu$). That population number is then extrapolated to the whole study area. A non parametric bootstraps (95%, 10000 repetitions) allows the determination of a confidence interval (CI).

Habitat characterization was accomplished through the correlation between spatial distribution of the dolphin's sightings and two kinds of eco-geographical variables (Gregr & Trites 2001, Hirzel *et.al.* 2001, 2002): a) continuous variable: bathymetry, b) categorical variables: slope. A grid of 1,8 Km by 1,8 Km cells was established in a GIS of the study area. The relationship between underwater topography and spatial distribution of dolphins was given by the slope index (Oviedo *et al.,* 2005) modified from Mignucci-Giannoni (1998). The slope index was calculated according to Acevedo (2007), including the categories for slope classes. Variables mentioned before are known to be relevant in the distribution of cetaceans (Compton 2004), and of great importance for *Sotalia* along the distribution range of the species in the Southern Atlantic coast of Brazil (Wedekin, 2007).

Each cell was characterized by dolphin use intensity, through quantification of observation time in two minutes terms during group follow. Therefore, dolphin time spent in a specific cell was calculated. A modified coefficient of Area Use (Garrafo *et al*., 2007) was estimated as:

AU= # 2 *min intervals* $cell_x$/*Total # 2 min intervals in the sampling*.

Dolphins' activity in each cell was quantified using an activity index AI (Karczmarski *et al.,* 2000). This index was used to represent the time the animals were engaged in a particular activity within a particular cell:

$IA = t_x / T$.

Where t_x is the time spent in activity X; according with the behavior budget of the cell, and T is the total time (as in the AU index, this estimate was adapted to fit the follow protocol, in order to use the 2 min terms).

The basic indices of the Ecological Niche Factor Analysis (ENFA) developed by Hirzel *et al*. (2002), were calculated for *S. guianensis*, with the variant of being calculated individually for each eco-geographical variable considered. To asses the bathymetry, maximum depth (Zmax) was considered per each cell, while the Slope Index (as a proportion to one) was the input data for slope:

Marginality; M = μP- μSg / 1.96XθP

Tolerance; Tol= θSg/θP

In the estimation of *marginality*, μP is the global mean of the study area, per each factor in each cell, μSg is the mean of the distribution of *S. guianensis*, per each factor in each cell. θP is the global dispersion of the data, given by the standard deviation, and θSg is the dispersion in dolphins' specific distributions in each environmental factor. These indices evaluate if the average environmental conditions associated with a particular distribution pattern, differ from the global environmental conditions of the study area. Hence a *Marginality* value closer to one expresses a distribution of values associated with a particular environmental factor and separated from the global conditions. To ease the interpretation of specialization, the *Tolerance* coefficient; which is the inverse of the specialization, is given as it is an indicator of the species' niche breadth.

2.2 Common dolphins

Common dolphin assessment was centered in the north coast of Araya Peninsula, including the southern and west coast of Cubagua Island, however initial preliminary surveys (n=10) focusing in the species were done off the coast of Carupano (between the southeast coast Margarita Island and the mainland). This region has a complex submarine topography due to the presence of Margarita, Coche and Cubagua Islands. An upwelling area is located north of Araya Peninsula; its intensity is highly influenced by the seasonal variations associated with the annual cycles of trade winds. The polygon that limits the sampling area (576 Km^2) comprises approximately 60% (>340 Km^2) of shelf habitat and 40 % (>230 Km^2) of transitional areas within the shelf break.

Two boat survey' routes were followed with different departure points: a) from Araya Peninsula (from El Rincon community) towards the west coast of Cubagua and back to the west side of the Peninsula. All these surveys were intended to cover ethological sampling and were done during the months of January - February. b) From Margarita Island towards Cubagua and the northwest coast of Araya Peninsula. This route was covered during abundance and ethological sampling from March to June. Behavior sampling followed the same protocol and methods described before, while abundance estimations followed the line transect methodology.

A grid of 1,8 Km by 1,8 Km cells was established in a GIS of the study area. Data analysis intended to follow the same procedures applied to *S. guianensis*, however, due to the nature of the data collected on *Delphinus* sp, a preliminary cluster analysis by square Euclidian distance was used, centered in one eco-geographical variable: a reference isobath (100 m) as the marker for the transitional area (shelf break). Statistical significance of sub-samples was assessed by Kruskal Wallis test (Zar, 1996).

Data for relative abundance analysis obtained by line transect, is insufficient at this stage of the project for a solid estimation. Relative abundance analysis was alternatively processed through the relative abundance indices per unit of efforts (APUE) and by means of the *waiting distance* estimation explained elsewhere in this report.

3) RESULTS

3.1 Field efforts

Field efforts comprised 76 field surveys: 12 in coastal habitat for *S. guianensis* assessment, plus 64 surveys distributed in shelf and transitional habitat for the evaluation of *Delphinus* spp. The average accumulated time spent searching for dolphins is about 315,61 (+/- 92.97) hours. With an overall encounter rate of 62 %. The highest encountered rate is from the coastal sampling on tucuxi dolphins with 90%, common dolphin encounter rate is 60%.

3.2 Tucuxi dolphins

The important presence of *S. guianensis* within the study area is particularly clear with the high encounter rate mentioned before. That encounter index is restricted to the coastal extension between Guaraguao Bay to the west, and Guaca Bay to the east. The relative abundance estimates per unit of effort and by the waiting distance (Table 1), were significantly different (Kruskal Wallis Test; p= 0,038; K: 4.31, X^2: 4.31; GL:1).

Four behavioral states were recorded during group follow: foraging, travelling, milling and socializing. From all four, foraging was the dominant behavioral state with 75% of the time (254 min: 127 observation terms of 2 min, at conditions ≤ Beaufort 2) during group follow invested in foraging bouts. Travelling and milling had a lesser occurrence, as illustrated in figure 2.

In terms of area use, cells corresponding with the coastline were mainly used (Fig. 3). Dolphins were never recorded in cells beyond 2 km from the coast. The eastern side of Guaraguao Bay (cell #10) concentrated most of the records from the group follow (AU> 0.77), Playa Colorada (cell#8) also had a high level of usage (AU=0.14). In the eastern sector of Guaraguao Bay, the most important activity corresponded with foraging (IA: 0.82), traveling was second (IA: 0.10). At Playa Colorada, the most relevant activity was travelling (IA: 0.56), followed by milling and foraging (IA: 0.25, and 0.19 respectively).

For the estimation of *marginality* and *tolerance*, only foraging bouts were considered, due to the dominance of this state in the behavioral budget of *S. guianensis*. Details on the value of the central tendencies and dispersions of the eco-geographical variables are given in Table 2. The marginality and tolerance values for maximum depths (Table 3) indicate a weak divergence of the local conditions of bathymetry in the study area, with the realized niche where foraging bouts occurred. The trend is the same for slope. The average slope of the study area is poorly differentiated with the slope corresponding to the foraging niche, according to the value of the *marginality* (0,29). While slope classes different to that of the foraging niche are scantily tolerated (0,37)

3.3 Common dolphins

Relative abundance of common dolphins (Table 5) is 4,89 dolphins (CI95%: 3,87 - 5,99) per unit of effort, and 125 individuals with a corresponding average waiting distance of 23,60 Km (CI95%: 19,49 - 27,65). Differences between estimates were statistically significant (*Kruskal Wallis,* X^2*:40,43 GL: 1, p <0,05*).

The density of animal within the shelf habitat is 0,22 approximately 59,65 % (465,27) of all the individuals recorded occurred within the shelf area. The average group size was 25,16 (+/-17,40) dolphins, containing approximately 86% adult, 11% juveniles and 3% calves. The cluster analysis (Figure 4) revealed four group size classes: *very big groups*

(> 60 individuals), *big groups* (20 - 40 individuals), *medium size groups* (9 - 16) and *small* groups (4 - 5 individuals). The average distance to the 100 m isobaths of all the sightings was 4,37 km. The cluster analysis established three classes of distance (Figure 5): *far* (12,4 - 10,2 Km), *medium* (5,2 - 8,2 Km) *and close* (0 - 4 Km), differences between them were statistically significant (*Kruskal Wallis,* X^2*:23,65 GL: 1, p <0,05*).

Additionally an estimation of biomass consumption was done, using the density calculated with the relative abundance by the *waiting distance* extrapolated to 13908 km^2; the whole area extension assessed in the last fishery biomass prospection (Molinet *et al*., 2008), and then incorporated to the expression: *IB (Ingested Biomass)=* $0{,}123M^{0{,}80}$; following the approach of Read & Brownstein (2003). To comply with the latter, the sardines consumption estimation in the diet (60%) suggested by Naveira (1996) has been paired together with the non published data of common dolphin' total length (Proyecto Delphinus' data-base in stranding), which resulted in an average estimated weight of 98 Kg -1.98 m dolphin (Kumar,2003: linear model for inshore dolphins' weight calculation), the resulted estimate of sardines biomass consumption for common dolphins is 5.58 ton/Km^2/year.

In an attempt to produce a comparison between previous unpublished estimates and the results presented here, figure 6 compare the estimations generated in 2003 (Quevedo, 2004), 2005 (Orlando, 2005) and those listed in this report (2008a - 2008b) using a homogenized average unit of effort (5,87 hours). Among all estimates, the one generated during March - June 2008 (2008b), is notably higher than 2003, 2005 and 2008a. The relative abundance of 2003 and 2008a present similar values. The index corresponding with 2005 is the lowest relative abundance estimate in the area.

Big size groups dominates the whole study area, they are likely to be frequent near the shelf edge, much more that medium size and smaller groups. Only three behavioral states were recorded during sampling: foraging, travelling and socializing. Foraging bouts seemed to be directly proportional to distances closer to the shelf edge, with 50% of the recorded foraging bouts located at distances equal or lower than 4 Km (Figure 7).

The opposite trends is observed with travelling groups of dolphins, the occurrence of travelling bouts seemed to be directly associated with an increase distance from the shelf edge. Both traits are supported statistically (*Kruskal Wallis,* X^2*:25,23 GL: 1, p* <*0,05*).

In terms of behavior by group size classes, small and very big groups were only recorded while travelling. On the other hand foraging was quite common with big groups of dolphins, more than with medium size schools. Details of behavior records distribution are provided in figures 8 and 9.

4) DISCUSSION

4.1 Tucuxi dolphins' relative abundance and habitat use

The indices pertaining relative abundance reported in table 1 are an accurate expression of the field observations, where group size of tucuxi dolphins schools was approximately lower than 50 animals. Some evidences of individual dolphins re-sighted previously as far as May 2003 (Oviedo *et al*. 2004), seemed to suggest that the animals observed might be a discrete stable population unit.

Differences between the two estimates could be linked to the fact that the waiting distance estimate constrains effectively the spatial and time variables associated with particularities of the sampling methods, in this case a sampling within an ethological context. However if the APUE estimate is modified using the same total number of dolphins recorded (265), and the unit of effort is transformed into minutes instead of hours, the new relative abundance estimate (265/2440= 0,11) can be compare with the estimations of tucuxi dolphins inhabiting the Paraty Bay in Rio de Janeiro, Brazil: 0,12 (Lodi, 2003), Paraty Bay and the present study area share some parallel environmental characteristics, such a similar bathymetry; with 10 m as the deepest isobaths, an a similar extension (< 11 Km). However, seasonality affecting the ecology of the species is not an observed trend in Guaraguao - Guaca area, as opposed to Paraty Bay, this is clearly due to latitudinal differences.

The population of *S. guianensis* assessed in this contribution is a discrete and extremely localized population unit where two possible scenarios can be theorized:

a) There is a possibility that the population observed is a relict of a major one widely distributed all along the Venezuelan coast, this could be supported by documented historical records of stranding and sightings (Acevedo, 2001, 2007 & Romero *et al*., 2001) and the physical barriers implicated in the ecological distribution of tucuxi dolphins (Acevedo, 2007). If that is the case, habitat degradation promoted by coastal development, and probably competition could have trigger the decrease in population to the actual numbers. This implies a pervasive risk of reduction in the breeding population (mature individuals) leading to reduced survival, partly due to a reduce likelihood of finding a potential mate without risk of inbreeding (Allee effect).

b) The population of tucuxi dolphins recorded in the study area, could be part of a metapopulation, in that case any local extinction will be balance by re-colonization of nearby population units. However the occurrence of the species has not been documented further east in the north coast of the Paria Peninsula, but in the Paria Gulf.

Behavior sampling allowed a clear definition of key activities of relevant value for day to day survival, and the spatial location associated with them. Dolphins engaged in particular activities were not evenly distributed in the coastal habitat of the study area. Therefore, a clear trend of differential use of certain coves and bays was documented. Guaraguao Bay and Playa Colorada concentrated not only most of the sightings, but also the records of the most important behavior bouts, foraging and travelling. Based on the activity indices, Playa Colorada was used as a transit area to the most important foraging location; the eastern portion of Guaraguao Bay

The physiographic features of Guaraguao bay might provide advantage in the process of prey capture. For instance, most of the events of cooperative foraging were observed in the eastern section of the bay, where dolphins used the rocky coastline as a contention barrier. The slope in this part of the study area is 60%, categorized as high slope, according to Acevedo (2007). However, even though the marginality and tolerance indices defined accurately the macro-habitat for *S. guianensis* (shallow bathymetry and steep slope), they fail to establish any diversification towards a microhabitat. Wedekin (2007) explains this trend, considering the fact that the same eco-geographical variables important at a macro-scale, might be dominant at the micro-habitat level.

In the north coast of Paria Peninsula, areas with steep slopes were expected to concentrate the foraging bouts of dolphins; those areas of high sea-floor relief are often related to upwelling. In the study area, the upwelling seasonal plume covered a surface area that ranged between 0 and $1X10^3$ km^2 from August to October, and which then typically extended over an area greater than $12X10^3 km^2$ in March (Muller Karger *et al*. 2004). In the present study, an important trend toward steeper slopes where dolphins foraged was observed. For species of cetacean prey, such as small pelagic fish (as the locally abundant *Sardinella aurita*) physiography could play an indirect role through mechanisms such as topographically induced upwelling of nutrients (Hui, 1979; Baumgartner, 1997). The preferential use of areas with steep slope has been shown in studies of other populations of *S. guianensis* (Wedekin, 2007).

Daura Jorge *et al*. (2005), Wedekin, (2007) and Wedekin *et al*. (2007) have documented differential habitat use in *S. guianensis* along the southern Atlantic coast of Brazil, identifying critical habitats within the distribution range of the species. Critical habitat refers to the portions of a cetacean distribution range that have a key particular value for survival and maintaining a healthy population growth. Consequently, areas that are used for foraging, including all aspects of the prey capture process, breeding, including courtship, resting and migration are part of the critical habitat (Hoyt, 2005). An adequate identification of key habitats and core areas where biologically and socially important behaviors concentrate is important in understanding the species' ecology, and the development of an effective conservation and management strategy of any wild animal population (Karczmarski et al. 2000). This contribution makes a special emphasis in the habitat as the fundamental unit in the conservation of biodiversity (Garaffo *et al.*, 2007). Disruption of the coastal habitat, and particularly of the critical foraging habitat, will imply a strong effect on the local population of dolphins, specifically disturbing such relevant behavioral state as foraging. This affectation has important consequences for the energetic budget of the species, especially considering the localized investment in energy intake.

4.2 Common dolphin a predator at risk

Even though four line transect surveys (two in November 2007 - two in March 2008) have been done already, analysis of the data will not yield any useful trend that would allow any conclusive remarks yet. However, information drawn from the APUE and *waiting distance* estimates provides a good insight of the wide distribution of *Delphinus* sp*.* in the northeast coast of Venezuela. The species inhabit any major marine habitat, from shelf waters to transitional areas, and even oceanic habitat such the Cariaco Basin (Acevedo, 2007; Rangel *et al*., 2005). The relative abundance of the species in the study area calculated by the *waiting distance* (125, 28: CI95%125, 28 -125,40)*,* seemed to be more solid and concord with field observations; once again, as in the case of tucuxi dolphins, the statistically significant differences are linkable to a major control of spatial and sampling time variables.

The similarities between values of 2003 - 2008 are important, since the estimation of 2003 coincide with a high level of sardine production, prior to the decline (assuming the production level as a stock quality indicator). On the other hand the 2005 estimation; the lowest of all the relative abundance efforts, coincide with the steady decrease in sardines production. However, 2008 estimation is not only more localized, but a lot more intensive than previous years, so comparison's representativeness could be compromised.

The behavior data processed here corresponded with initial behavioral states (at first encounter with the group of dolphin), and the statistics presented are only an expression of frequencies rather than proportions. Nevertheless, there is an evident overall dominance of travelling groups over foraging and socializing. Though, a clear spatial pattern can be drawn from the clumping of the foraging bouts on two localized areas at the shelf edge (Figure 8 and 9). That pattern is supported by half of the episodes of prey capture and consumption at a close range distance from the limiting isobaths of 100 m.

Acevedo (2007) reported that the slope range for *Delphinus sp* in the northeastern coast is between 0 to 71%, this relationship between foraging and slope is a common trait in cetaceans due to advantages provided in prey capture (Ingram & Rogan 2002, Baumgarther 1997, Wilson *et al.,* 1997). The key fact in this case, is that the latter among with the fact that travelling increases with distance from the 100 m isobaths, could suggest migration towards a localized foraging area. More data is needed on activity patterns and above all on dietary (prey) preferences, in order to sustain the latter hypothesis, in forthcoming sections of this report, limitations are acknowledge and identified. A preliminary identification of foraging areas strengthens the baseline for the determination of critical habitat. This is needed in order to increase management in this important shelf ecosystem.

Common dolphins (*Delphinus sp*) might be a key predator for the main fishery resource of the northeast coast basin (sardines), the estimated biomass consumption should not represent a problem on a total sardines' biomass between 785600 to 941000 tons (Cardenas & Achury, 2002). Nevertheless actual estimations are as low as 11000 tons (Cardenas J, *pers com.*). On the other hand, at this point of the research project, I can only suggest the relevance of *S. aurita* in the diet of common dolphins, first according with observations of foraging dolphins plus anecdotic accounts, and second though the only diet assessment done to two stranded specimens by Naveira (1996). There is strong possibility that Myctophids might play a relevant role as prey items, probably more in the case of common dolphins occurring in oceanic-like environments, such the Cariaco Trench (Rangel *et al*.,2005). An issue of concern is the declining trend of the sardine stock. The affectation of common dolphins in a possible trophic cascade scenario was suggested before (Oviedo, 2005). The actual sardine fishery situation seemed to accelerate the need of understanding how the predator-prey interrelationship between *S. aurita* and common dolphins is set in the study area.

4.3 Limitations

4.3.1 Common dolphin acoustic and behavior sampling: I acknowledge the combined effects of the prevailing environmental conditions and the type of research platform used on the data set. Specifically, in the collection of biological information of *Delphinus sp*: Unfortunately the use of small boats to do acoustic and behavior sampling under and average level of wind force of Beaufort 3, has prevented the collection of proper data to be included in a behavior budget and acoustic analysis, which is the base of the whole evaluation of critical habitat. Therefore, measures of behavioral bouts presented in this report, should be only considered frequencies of initial behavioral states, and not proportion of time invested in particular behavioral activities derivated of an unbiased scan sampling, such as the case of tucuxi dolphins. The same limitations has also complicated the use of acoustic, video and photographic equipment, due to the perennial rocking of the boat, as a matter of fact one of our volunteers lost the project camera overboard during the first sampling trip of 2008, this situation has represent a pervasive risk of equipment lost and adamge. From all the recording (n=12) obtained the signal to noise ratio has been so high, that acoustic features are not possible to isolate and identify.

Another factor that has detrimental effects is the departure point from Margarita Island; we have been working with local fishermen, and the boat hired in “El Ríncon” (Araya Peninsula), that is the one with proper safety conditions is no longer in operation and availability for dolphin survey. Araya Peninsula has been our ideal departure point, since by the time we departure from Margarita and have the first encounter, the environmental conditions degrade. Unfortunately the settings of boats available at the moment in Araya Peninsula are not reliable. The boat used for line transect trips is not cost wise for ethological sampling and acoustic recording, due to the expensive fare (it is a tourist boat), so options has been limited to boats settled in the southern coast of Margarita Island.

The option we have evaluated and decided upon, for the next dolphin sampling campaign, is to establish the departure point at Coche Island, where boats with higher standards in terms of safety (including stability) can be hired at similar cost and guarantee safety for staff and equipment. Also we will constrain more the research area from north to south, in a way that only the portion of southern Cubagua Island will be surveyed, without lost of representativeness in the stratification of the sampling area by habitat. I will have to downgrade the limiting Beaufort conditions to validate future behavioral budgets, assuming that a better more stable platform will improved detectability and settings for acoustic evaluation.

4.3.2 Common dolphin trophic impact: There is no sound determination of *Delphinus* sp. diet in the northeastern coast of Venezuela, we admit that inferences on trophic impact presented here, are based on one evaluation of stomach content in 1996 (Naveira 1996), Pauly (1998) also provides a dietary account, but local particularities are not detailed. The main limitation in this aspect of the research reported here is the delay in granting proper permits by the environmental government agency in charge. To handle and collect biological samples such as stomach content of stranded dolphins, a permit to do so issue by the government is required; otherwise the information can not be published. The delay has to do with a frequent change of person in office responsible for it. Now, the need for stomach content and diet determination is even more crucial since we might be facing a sardine stock collapse, so we have been promised to be provided of the permits once again.

5) CONCLUSIONS AND RECOMMENDATIONS

This report has shown a positive gain in baseline knowledge of coastal and neritic cetacean species (*S. guianensis* and *Delphinus sp.*). Results presented here on abundance, behavior and habitat use are providing a strong support for a much needed conservation strategy and management implementation.

Information on habitat use of tucuxi dolphins evidences a relevant trend towards a localized critical foraging habitat and a non homogeneous use of the coastal environment. Also the behavior budget will establish the reference for any future impact assessment, whether related with an increase on boat traffic (as an outcome of tourism) or habitat degradation.

The results on common dolphins are giving preliminary insight of several important ecological aspects, but the information requires strengthening by a continuity of data collection under a sampling design adapted to the wider distribution of this dolphin in the study area, and the prevailing environmental conditions related with the sightings.

Further data collection is recommended, increasing the scope into the dispersal pattern of the local tucuxi population (immigration and emigration data). Acoustic assessment of tucuxi dolphin is schedule to begin by mid November. In the case of *Delphinus sp.* efforts should be focalized in the continuity of behavior - acoustic sampling and diet determination, pair with the progression of the systematic line transects estimations.

6) **FINANCIAL REPORT**

The project counted with the support of three funding organization: *WDCS*, *Rufford Project* and *Iniciativas de Especies Amenazadas (IEA, Provita - CI)*. Funding received from Rufford accounted for 64,5% of all grant money awarded.

Money was invested in the acquisition of an acoustic recording equipment (appendix 1a) and field surveys (boat trips: appendix 1b), as stated in the proposal' budget. However cost of planned boat surveys notably increase from the one presented in the proposal budget, due to extension of the sampling area and the need to use a better platform: the 100$ fee correspond with a small zodiac, which was an excellent platform for coastal survey (and actually used in the preliminaries of common dolphin survey off Carupano's coast), but not suitable for major extension further away of the coast line.

All ethological sampling boat surveys from October 2007 on *Delphinus* sp. and two abundance survey (line transect) from the 2nd and 4th of November were supported by Rufford's funding. The detail below provides all the expenses report with the corresponding amount in Venezuelan currency (BsF) and in US $. The official (fixed) exchange rate is 2,15 Bs / 1 US $.

Receipt No	Date	Concept	Amount (BsF)	Amount (US $)
D001	22/10/2007	Dolphin Survey Route Carupano	215	100
D002	23/10/2007	Dolphin Survey Route Carupano	215	100
D003	24/10/2007	Dolphin Survey Route Carupano	215	100
D004	25/10/2007	Dolphin Survey Route Carupano	215	100
D005	26/10/2007	Dolphin Survey Route Carupano	215	100
D006	27/10/2007	Dolphin Survey Route Carupano	215	100
D007	28/10/2007	Dolphin Survey Route Carupano	215	100
D008	29/10/2007	Dolphin Survey Route Carupano	215	100
D009	30/10/2007	Dolphin Survey Route Carupano	215	100
D010	31/10/2007	Dolphin Survey Route Carupano	215	100
D011	02/11/2007	Dolphin Survey Route (Mar -Cub-Ar)	1075	500
D012	04/11/2007	Dolphin Survey Route (Mar -Cub-Ar)	1075	500
D013	23/01/2008	Dolphin Survey Route (Ar - Cub)	430	200
D014	24/01/2008	Dolphin Survey Route (Ar - Cub)	430	200
D015	25/01/2008	Dolphin Survey Route (Ar - Cub)	430	200
D016	26/01/2008	Dolphin Survey Route (Ar - Cub)	430	200
D017	27/01/2008	Dolphin Survey Route (Ar - Cub)	430	200
D018	28/01/2008	Dolphin Survey Route (Ar - Cub)	430	200
D042	19/04/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
D043	22/04/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
D044	23/04/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
D045	24/04/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200

D046	25/04/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
D047	26/04/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
D048	27/04/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
D049	02/05/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
D050	04/05/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
D051	05/05/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
D052	12/05/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
D053	14/05/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
D054	19/05/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
D055	25/05/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
D056	26/05/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
D057	29/05/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
D058	01/06/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
D059	02/06/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
D060	03/06/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
D061	04/06/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
D062	05/06/2008	Dolphin Survey Route (Mar -Cub-Ar)	430	200
Total			**15910**	**7400**

See appendix 1b for copies of supports

6.1 Outcomes of the Project

Thanks to the funding provided by Rufford, the project was able to intensify field work on systematic surveys specifically set for dolphin research. Prior efforts were conditioned to platform of opportunity.

The results provided in this report are already scheduled to be presented in a scientific meeting (VII congress of SOLAMAC: 13 - 17 October, Uruguay), and right after presentations, they will conform technical articles to be submitted to per review journals (two Venezuelan Journals and one International).

Data on sightings are provided in an open access GIS (Google Earth Platform) since they are going to be used for training of volunteers and students working within the frame of the project in forthcoming training sessions (January 20th - 26th). And they are made available to MINAB, The government environmental agency.

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TABLES AND FIGURES

Table 1. Relative abundance of *Sotalia guianensis* in the study area

Estimation Method	**Relative Abundance**	**Confidence Interval (CI 95%)**
(APUE)	**25**	**11 – 50**
(Waiting Distance)	**109,12**	**109,12 – 109,19**

Table 2. Results of the slope and bathymetry analysis for *S. guianensis* in Paria Peninsula

Bathymetry analysis and Slope Index	
Research Area	12 celdas
Average Slope Index (μSIOs)	0,50
SD Slope Index (θSIOs)	0,19
Average Maximum Depth (μZmaxOs)	8
SD Maximum Depth (θZmaxOs)	1,86
S. guianensis	
Average Slope Index (μSISg)	0,60
SD Slope Index (θSISg)	0.07
Average Maximum Depth (μZmaxSg)	7,09
SD Maximum Depth (θZmaxSg)	0,68

The slope index is relative to 1 as maximum, bathymetry is given in (m).

Table 3. Marginality and Tolerance of *S. guianensis* in Paria Peninsula

	Marginality	Tolerance
Bathymetry (Zmax)		
S. guianensis	0,25	0,37
Slope (Sl)		
S. guianensis	0,29	0,37

Table 4. Area Use (AU) and Activity Index (IA) of *S. guianensis* in Paria Peninsula

Cell	**Area Use (AU)**	**Activity Index (IA)**			
		Foraging	**Travelling**	**Milling**	**Socializing**
1	0,03	1	0	0	0
2	0,05	1	0	0	0
3	0,00	0	0	0	0
4	0,03	1	0	0	0
5	0,00	0	0	0	0
6	0,00	0	0	0	0
7	0,00	0	0	0	0
8	0,14	0,19	0,56	0,25	0
9	0,00	0	0	0	0
10	0,75	0,82	0,10	0,03	0,05
11	0,00	0	0	0	0
12	0,00	0	0	0	0

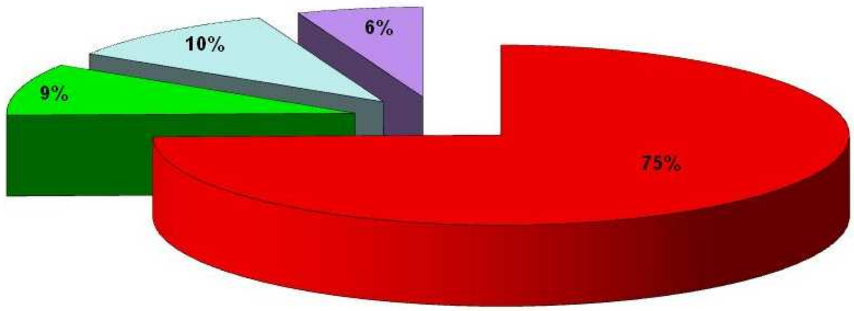

Figure 2. Behavior budget of *S. guianensis* in Paria Peninsula: Foraging (red), Travelling (green), Milling (light blue) and Socializing (purple).

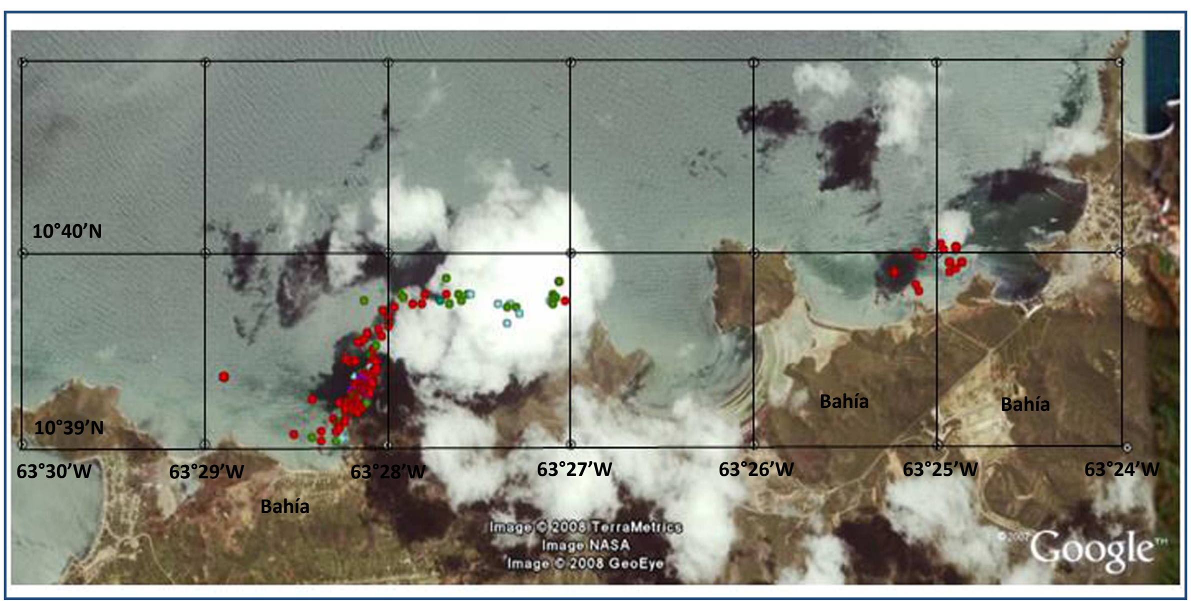

Figure 3. Distribution of behavior records during group follow protocol of *S. guianensis* in Paria Peninsula: Foraging (red), Travelling (green), Milling (light blue) and Socializing (purple).

Table 5. Relative abundance of *Delphinus* sp. in the study area

Estimation Method	Relative Abundance	Confidence Interval (CI 95%)
(APUE)	**4,89**	**3,87 – 5,99**
(Waiting Distance)	**125, 28**	**125,28 – 125,40**

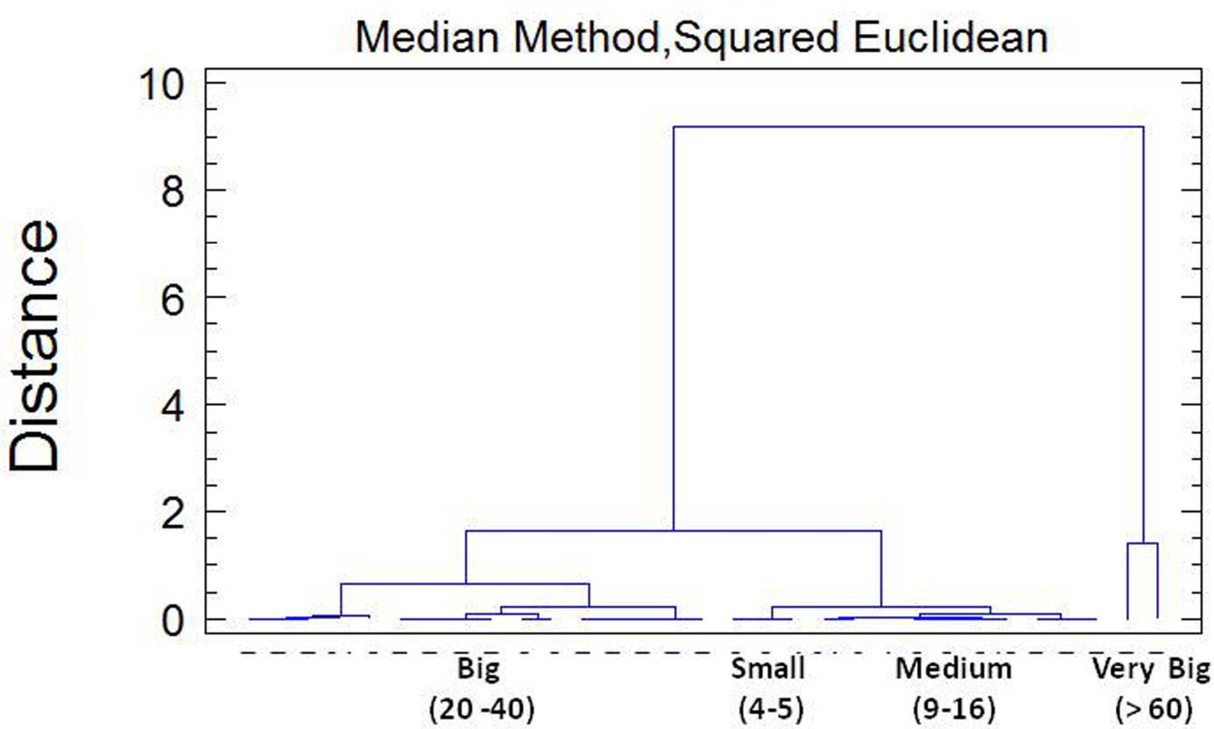

Figure 4. Cluster analysis group size of *Delphinus* sp. in the study area

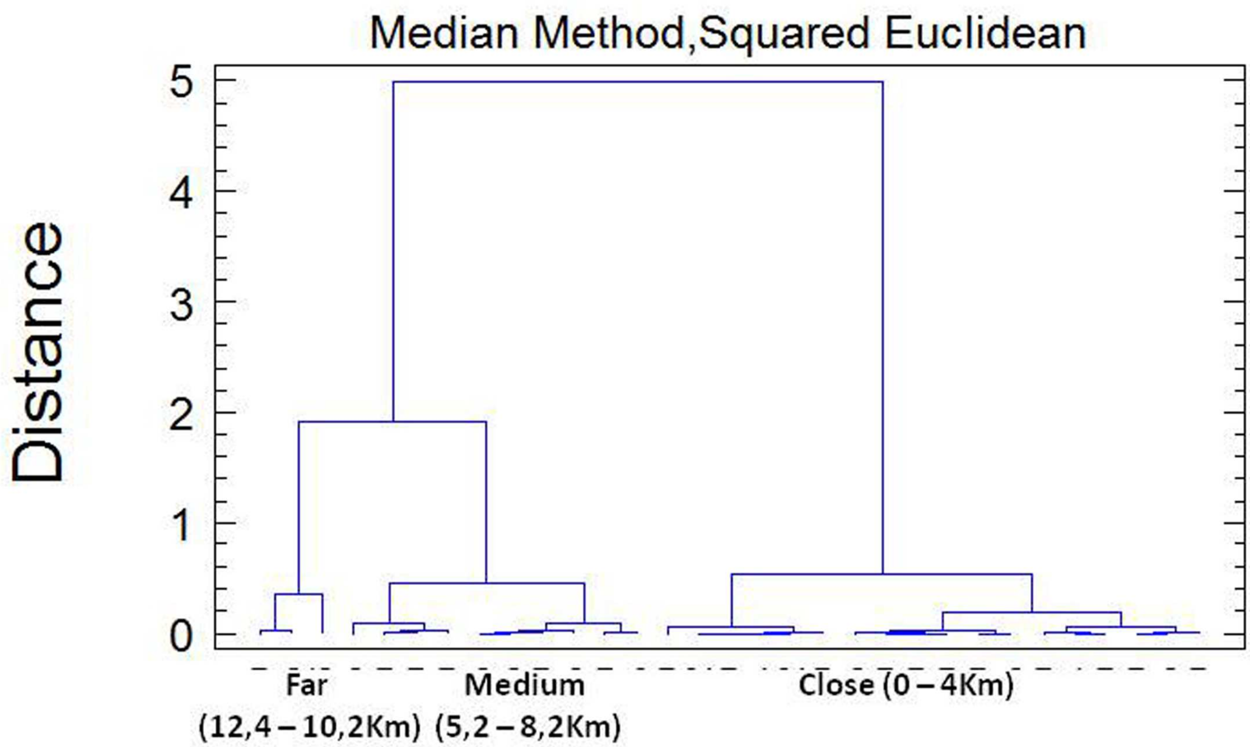

Figure 5. Cluster analysis of distance to 100 m isobath, *Delphinus* sp. in the study area

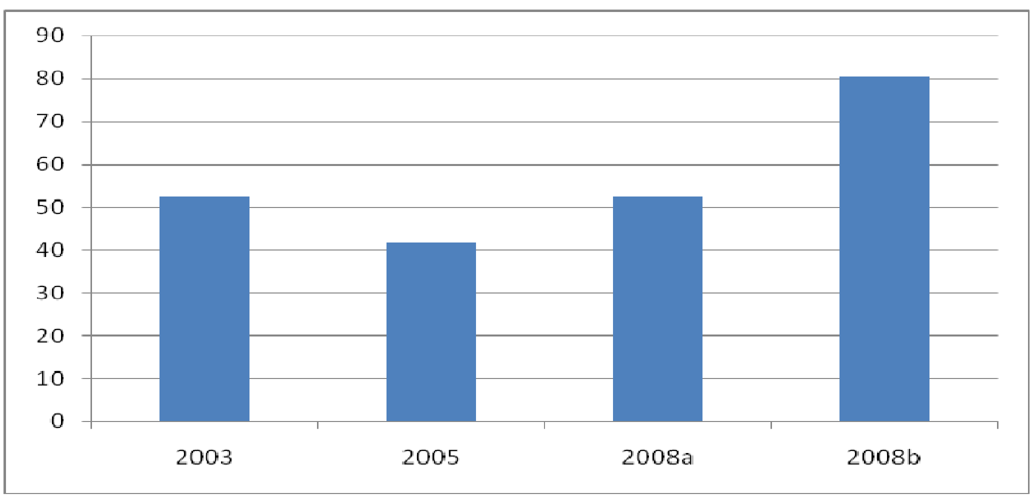

Figure 6. Relative abundance (APUE) of *Delphinus* sp. in the study area. X axis is given in number of dolphins per unit of effort (5,87 hours).

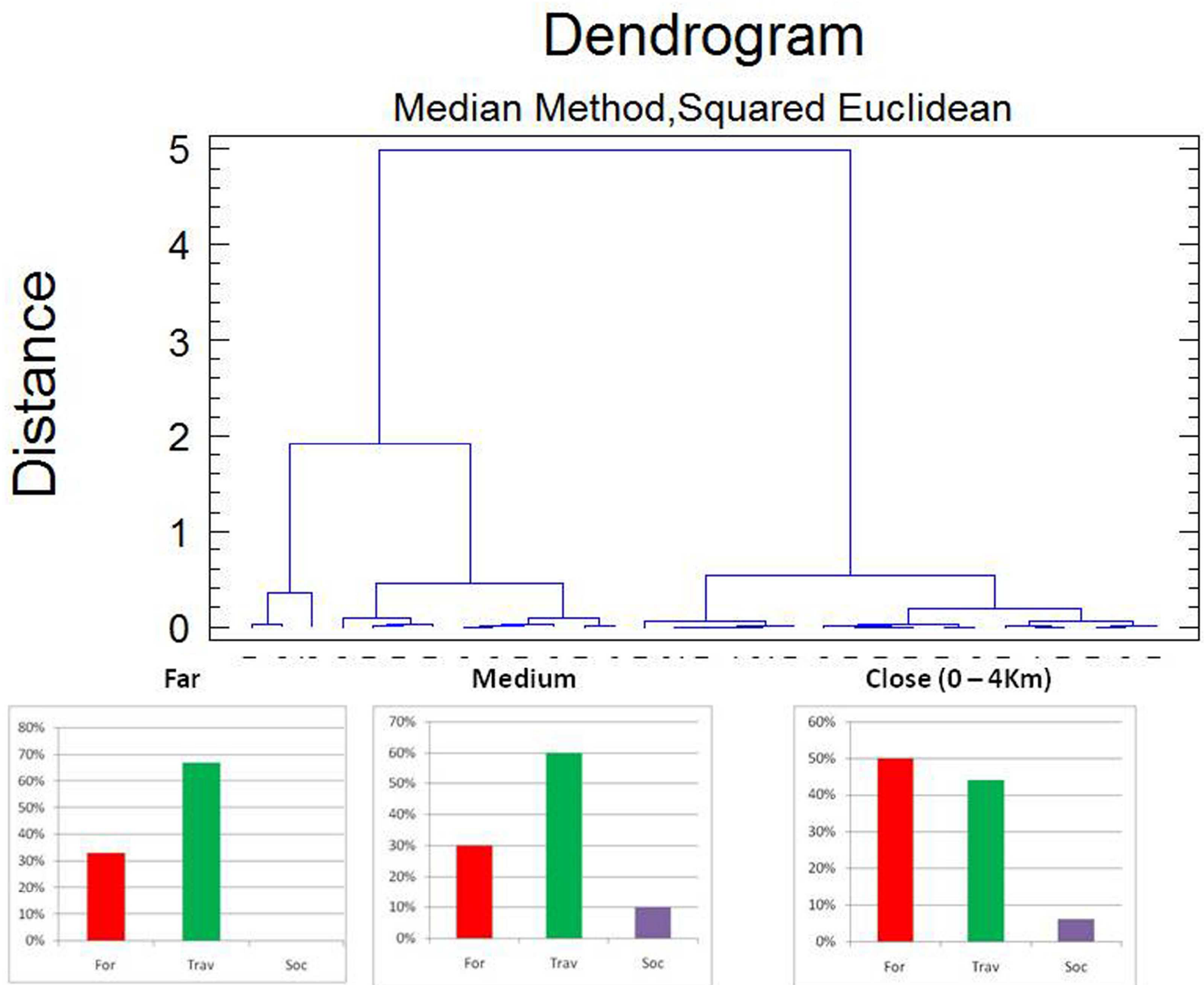

Figure 7. Cluster analysis of frequency of behavior bouts of *Delphinus* sp by distance to the 100 m isobaths: Foraging (red), Travelling (green), Socializing (purple).

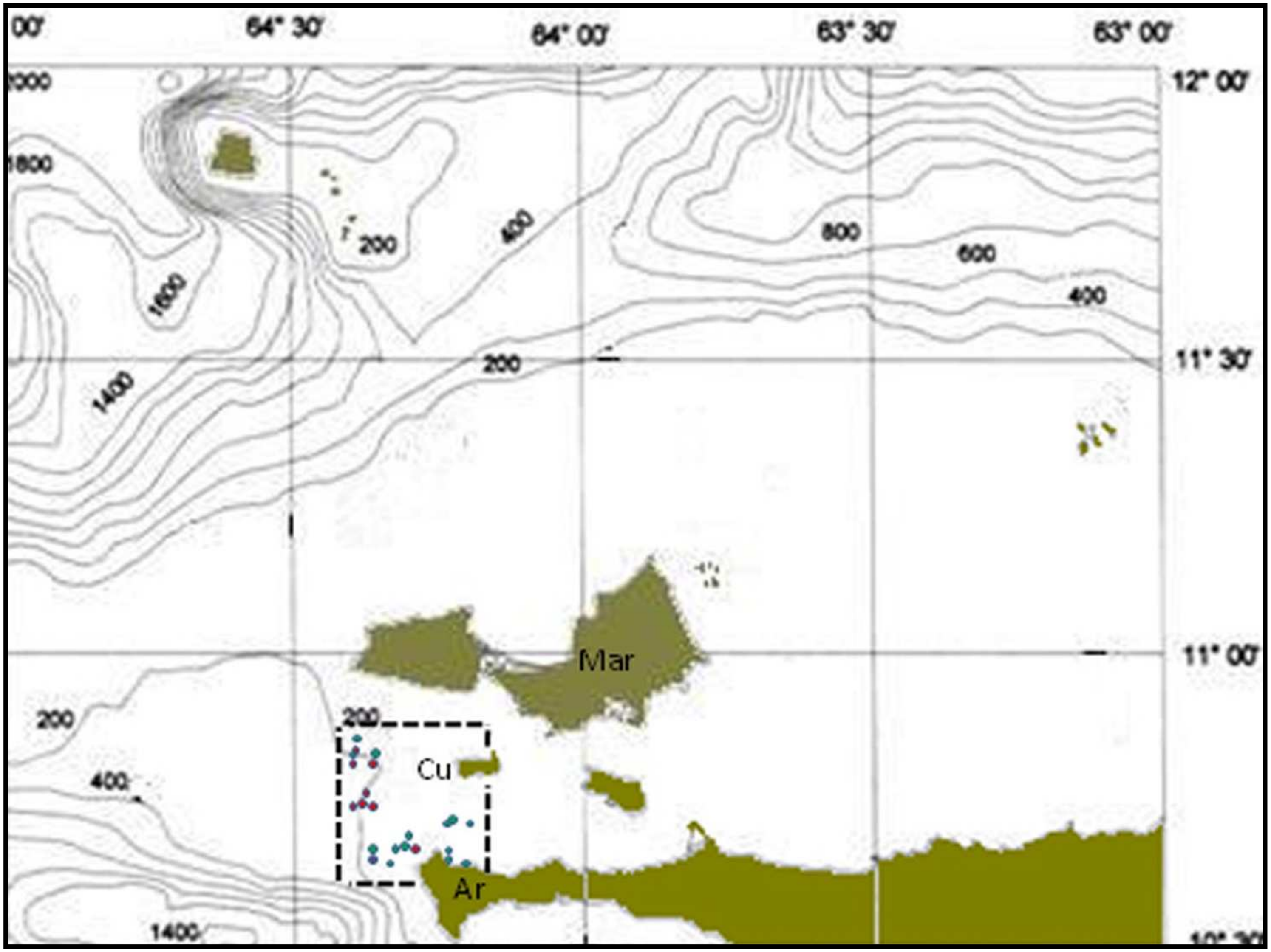

Figure 8. Distribution of behavior records during initial sightings of *Delphinus* sp: Foraging (red), Travelling (green) and Socializing (purple). Cu (Cubagua Island). Mar (Margarita Island) and Ar (Araya Peninsula).

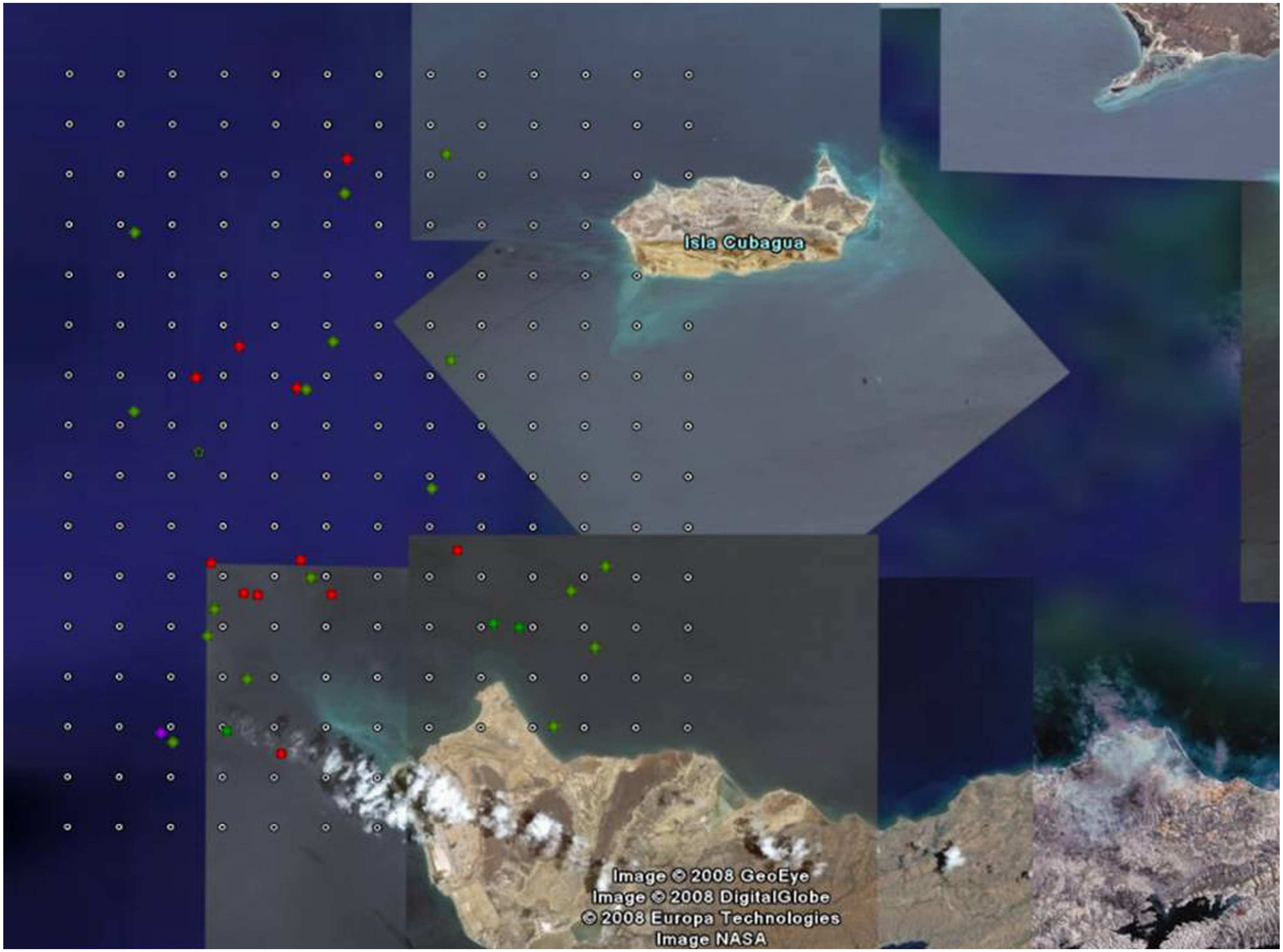

Figure 9. Distribution of behavior records during initial sightings of *Delphinus* sp: Foraging (red), Travelling (green) and Socializing (purple).