Distribution and abundance of *Delphinus delphis* off the Southern Pacific Coast of Costa Rica

Marc Fernández[1,2] and Lenin Oviedo [1,3,4]

1) Fundación Vida Marina, Drake Bay, Costa Rica. 2) CIRN/FCT and Departamento de Biologia, Universidade dos Açores (UAC), Portugal. 3) Proyecto Delphinus, Margarita Island, Venezuela. 4) Proyecto Golfo de la Ballena - Biotrópica, Caracas, Venezuela.

ABSTRACT

Short beaked common dolphin in the ETP is closely associated with one of the meso-scale physical features of the region: the Costa Rica Dome and has been termed as an indicator species for upwelling modified waters. The Southern Pacific coast off Osa Peninsula is a complex and rich marine ecosystem, cetaceans occurring within the marine habitats off Osa Peninsula, are an indication of ecosystem complexity, prey availability and overall of ecosystem health. This contribution is a preliminary spatial analysis on the distribution and abundance of common dolphins off the southern Pacific coast of Costa Rica during 2001 - 2006. Sightings records from 2001 - 2006 (n= 42) of short beaked common dolphin, were pooled together analyzed through descriptive statistic and incorporated into a GIS (ArcGIS 9.2). Spatial predictive models were constructed through a Gaussian Kriging Interpolation. While spatial distribution at a macro scale showed a relative proximity to the coast, the distribution of the common dolphin' APUE, and the predictive density model evidenced a particular spatial trend beyond the 200 m isobath, with an apparent absence in shelf waters. The clear distribution pattern off the shelf edge could be interpreted in association to preferred prey availability. Geographic distance and divergence between upwelling modified habitats within this region could potentially induce conditions that result in particularities in distribution patterns, potentialy related with the intensity of the jet winds responsible to the formation of thermal fronts. Further data analysis related with the latter hypothesis is in progress.

KEYWORDS: PACIFIC OCEAN; DISTRIBUTION; ABUNDANCE ESTIMATE; NORTHERN HEMISPHERE; EASTERN TROPICAL PACIFIC; MODELLING, ECOSYSTEM, HABITAT.

INTRODUCTION

Short-beaked common dolphin *Delphinus delphis* is a representative species from the Eastern Tropical Pacific (ETP). The most recent abundance estimate for 2006 determined the species as the most abundant dolphins in the region; about 3.13 million, according to Gerrodette *et al*. (2008). Short beaked common dolphin in the ETP is closely associated with one of the meso-scale physical features of the region: the Costa Rica Dome and has been termed as an indicator species for upwelling modified waters (Reilly, 1990; Balance *et al*., 2006). Based on distribution paucity and intrinsic biological factors such as differences in asymptotic length of adult animals, and contrast in breeding seasonality, three stocks for management purposes, have been identify in the ETP: northern, central, and southern respectively.

Fernandez *et al*. (2007) argued that common dolphin seasonal presence off Osa Peninsula could not only be influenced by the Costa Rica Dome (CDR), but by the key stability of an area within two important thermal

fronts, one in the north (near Papagayo Gulf) and the other in the south border (near Panama Gulf). These two systems originated by a seasonal wind jet regime (McCreary et al., 1989), create a special small warm pool area, surrounded by the thermal fronts and that benefits from the retention basin effect induced by the underwater topography. The warm pool oasis would promote the overlap of species such as *D. dephis* (common to upwelling modified waters, as mentioned above) and *Stenella longirostris centroamericana* (typically a warm tropical water species).

The Southern Pacific coast off Osa Peninsula is a complex and rich marine ecosystem, cetaceans occurring within the marine habitats off Osa Peninsula, are an indication of ecosystem complexity, prey availability and overall of ecosystem health. This contribution is a preliminary spatial analysis on the distribution and abundance of common dolphins off the southern Pacific coast of Costa Rica during 2001 - 2006. The potential environmental attributes that might have an incidence on the species distribution, in the relatively close to shore marine habitat are discuss. The ultimate goal of this paper is to identify patterns of distribution and abundance within the transitional-oceanic ecosystem, as important aspects to build up a solid baseline for management and conservation.

MATERIALS AND METHODS

Study area

The Osa Peninsula is the southern-most portion of Costa Rica's Pacific Coast (Figure 1). The study area was framed by a polygon limited east by the shorelines of Terraba-Sierpe River System, Drake Bay and Corcovado National Park to Punta Salsipuedes, continuing south following the meridian 83° 35'W. The northern and southern limits were represented by the parallels 08°55'N, and 8°12'N respectively, while the western-most limit of the study area was located at 84°10'W. Overall the whole polygon covered an approximated area of 4800 Km^2. This area is the target location of whalewatching boats (the platform of observation), and is characterized by a great portion of shelf waters, that progressively shrinks southward along the western coast of the Peninsula. Within shelf waters the most remarkable topographic unit is *Isla del Caño*.

Cetacean sightings

Opportunistic data collection on cetacean populations on the Southern Pacific coast of Costa Rica has been carried out aboard whale-watching vessels since 1998 by Fundación Vida Marina, resulting in an extensive data-base of more than eleven species. Sightings records from 2001 - 2006 (n= 42) of short beaked common dolphin, were pooled together analyzed through descriptive statistic and incorporated into a GIS (ArcGIS 9.2). All records yielded information on date, time, group size, behavior, detectability conditions (Beaufort scale ≤ 2), geographic coordinates, and effort corrected (monthly average time invested during searches) relative abundance and sighting indices (APUE and SPUE respectively).

Spatial analysis

Spatial distributions were predicted using the effort corrected APUE and the geographical coordinates of each record as input parameters, interpolated in a 3.6 × 3.6 km grid. The spatial predictive models were achieved through a Gaussian Kriging Interpolation, generating thematic maps using the geo-statistical analysis tool of ArcGIS 9.2 .Differences on APUE values were assessed using the Kruskal Wallis Test, assuming a non parametric distribution (Zar, 1996), and plotted on a map, log normalized and clumped by classes of standard deviation.

RESULTS

Common dolphin's occurrence and distribution

From all the odontocetes species observed in the Southern Pacific region of Costa Rica during 2001 - 2008 (table 1), *D. delphis* is ranked four in SPUE, after the sightings of coastal pantropical spotted dolphins (*Stenella attenuata graffmani*), bottlenose dolphins (*Tursiops truncatus*), spinner dolphin (*S. l.*

centroamericana). However, the trend in abundance (APUE), shown in figure 2, established the importance in terms of biomass of short-beaked common dolphins, only top by central American spinner. Five classes of APUE has been differentiated and detailed in table 2. Differences between classes were statistically significant (Kruskal Wallis, X^2:36.75, DF: 4, $p < 0.05$).

Common dolphin´s APUE seemed to be associated with two factors: 1) a seasonal pattern, due to the temporal distribution of the records; 95% of the observations were collected during dry season months (December - April) 2) distribution associated with bathymetry privileged major depths beyond the transitional habitat, with a possible absence on shelf waters (Figure 3). The predicted spatial trend in distribution would concord with the latter; a major density would be expected along the shelf edge forming a wide banded area that progressively decreased towards shelf domains and further off shore. Higher density would also be localized aside areas with steep slope as shown in figure 4.

DISCUSSION

Short-beaked common dolphin off Osa Peninsula would be included into the Central ETP stock (Perrin *et al*. 1985, Dizon *et al*., 1994). Within this stock, dolphins inhabiting the maritime transitional-oceanic habitat in the study area could be defined as off the CDR subpopulation (classified as subpopulation "C", according to Danil and Chiver, 2006). Furthermore, Danil and Shiver (2006) established that the "C" subpopulation is found closer to shore (86.4 n miles) than their conspecific of subgroups "A" and "B", a trend observed in the common dolphin's distribution of the sampled analyzed off Osa Peninsula, where the farthest distance to the coast was less that 25 n miles. Although there is a relative proximity to the coast, the distribution of the common dolphin' APUE, and the predictive density model evidenced a particular spatial trend beyond the 200 m isobath, with an apparent absence in shelf waters. The clear distribution pattern off the shelf edge could be interpreted in association to preferred prey availability, and indirectly by small and meso-scale oceanographic variables. Olson and Waters (2003) reported that mesopelagic fish represent over 50% of the diet of oceanic (mesopelagic) dolphins (*D. delphis* included within this functional group). Mesopelagic prey would be encountered in major density in waters off the continental shelf, where small scale micro-upwelling linked to the shelf edge topography, would promote a stronger vertical migration, with high concentration of the Deep Scattering Layer in shallower waters.

If the occurrence of short-beaked common dolphin is defined by a seasonal pattern, as suggested by the temporal distribution of the records analyzed here, the marked increase in APUE within the high density band in opposite directions, might be linked to the increase in intensity of the wind jets in Gulf of Papagayo and Gulf of Panama, emphasizing the border effects created by the respective thermal fronts and also increasing the possibility of incoming eddies from the adjacent upwellings (mostly from the southern one), creating an input of upwelling modified waters on the area. Geographic distance and divergence between upwelling modified habitats within this region could potentially induce conditions that result in fine scale population structure and distribution pattern, currently not recognized, but important to be considered within management and conservation schemes, along with the fact that common dolphins have been the third most impacted small odontocete species in the tuna fishery operation in the ETP. Further data analysis related with the latter hypothesis is in progress.

The non systematic nature of the data collected here might represent a caveat in this contribution. Specifically with the fact that apparent seasonal trend could be an artifact of the seasonal effort and range of the whale watching platform use in data collection.

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Table 1. Common name of all the odontocetes species reported in this study, with details on average SPUE (± Standard Deviation)

Common name	Scientific name	Sightings (SPUE)
Coastal pantropical spotted dolphins	*Stenella attenuata graffmani*	5.96 (± 2.32)
Bottlenose dolphin	*Tursiops truncatus*	1.55 (±0.72)
Central American spinner dolphin	*Stenella longirostris centroamericana*	1.12 (±0.68)
Short-beaked common dolphin	*Delphinus delphis*	1.04 (±0.67)
Short-finned pilot whale	*Globicephala macrorhynchus*	0.73 (±0.42)
Risso's dolphin	*Grampus griseus*	0.66 (±0.29)
False killer whale	*Pseudorca crassidens*	0.66 (±0.42)
Rough-toothed dolphin	*Steno bredanensis*	0.58 (±0.24)
Killer whale	*Orcinus orca*	0.56 (±0.31)

Table 2. Relative abundance of short-beaked common dolphin in the study area.

APUE Classes	Relative Abundance	Confidence Interval (CI 95%)
Very High	275.70	195.51 - 418.97
High	133.23	121.60 - 145.62
Medium	74.89	69.57 - 80.12
Low	44.65	42.19 - 52.74
Very Low	16.06	6.85 - 23.98

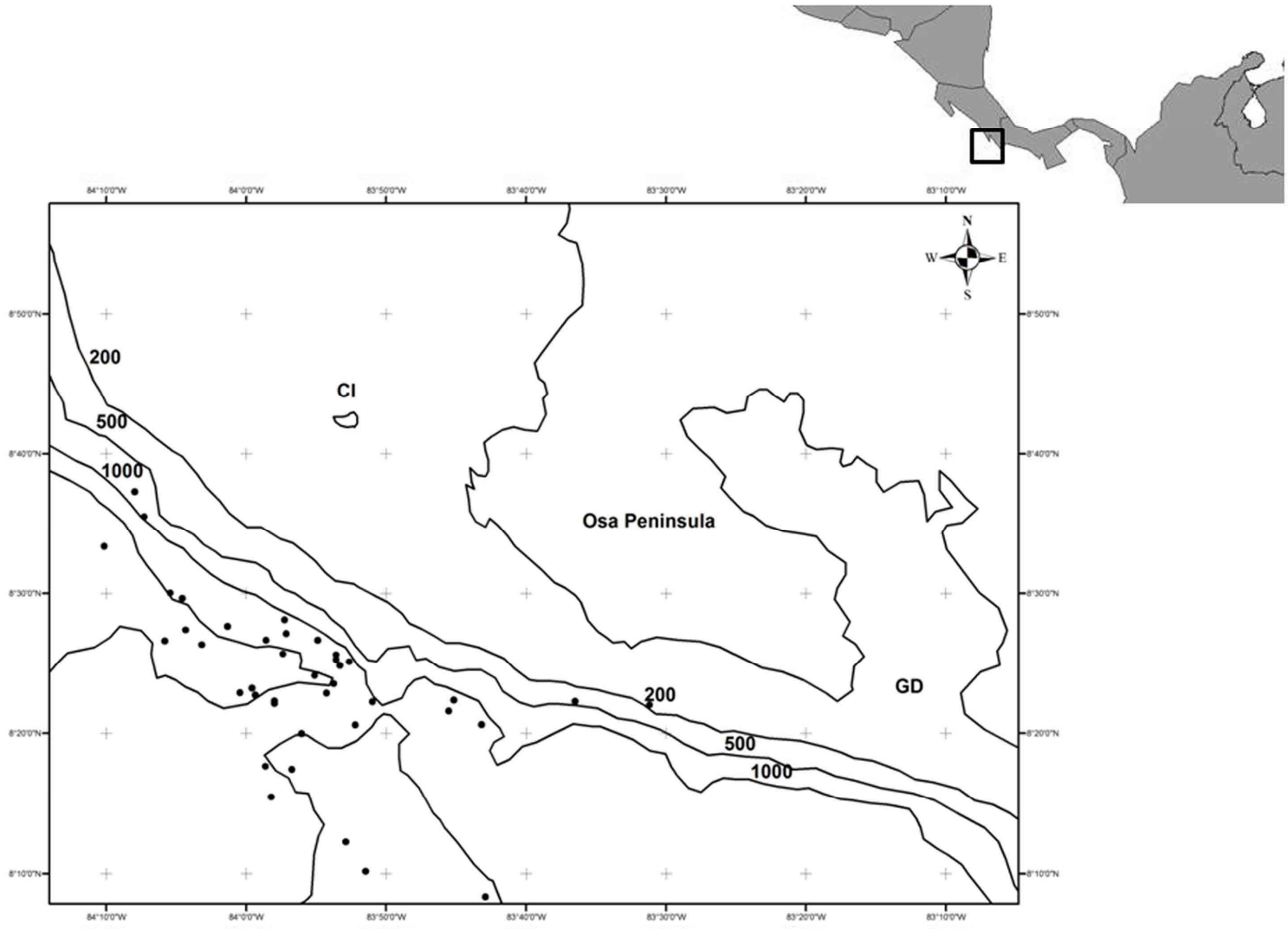

Figure 1. Study area and sighting distribution of short-beaked common dolphin off Osa Peninsula, Costa Rica.

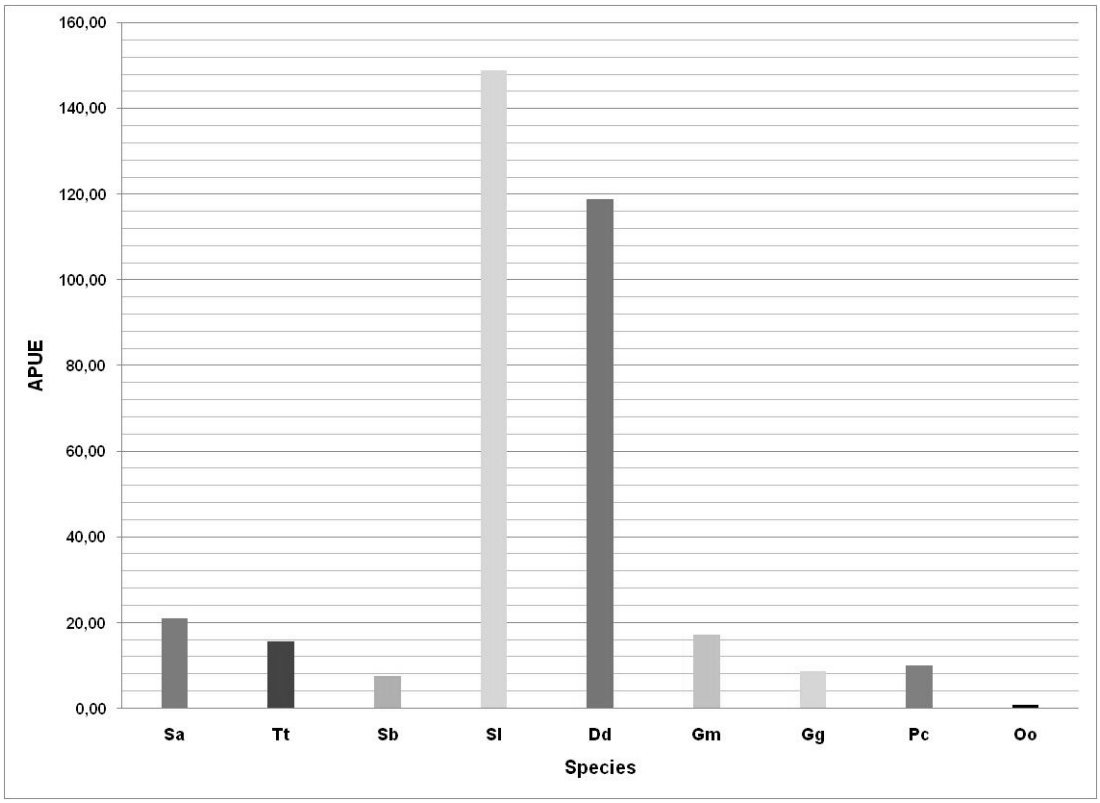

Figure 2. Abundance per unit of effort (APUE) of the odontocetes species assessed in this study off the Southern Pacific Coast of Costa Rica, during 2001 - 2006: coastal pantropical spotted dolphin (Sa), bottlenose dolphin (Tt), rough-toothed dolphin (Sb), Central American spinner dolphin (Sl), short-beaked common dolphin (Dd), short-finned pilot whale (Gm), Risso's dolphin (Gg), false killer whale (Pc) and killer whale (Oo).

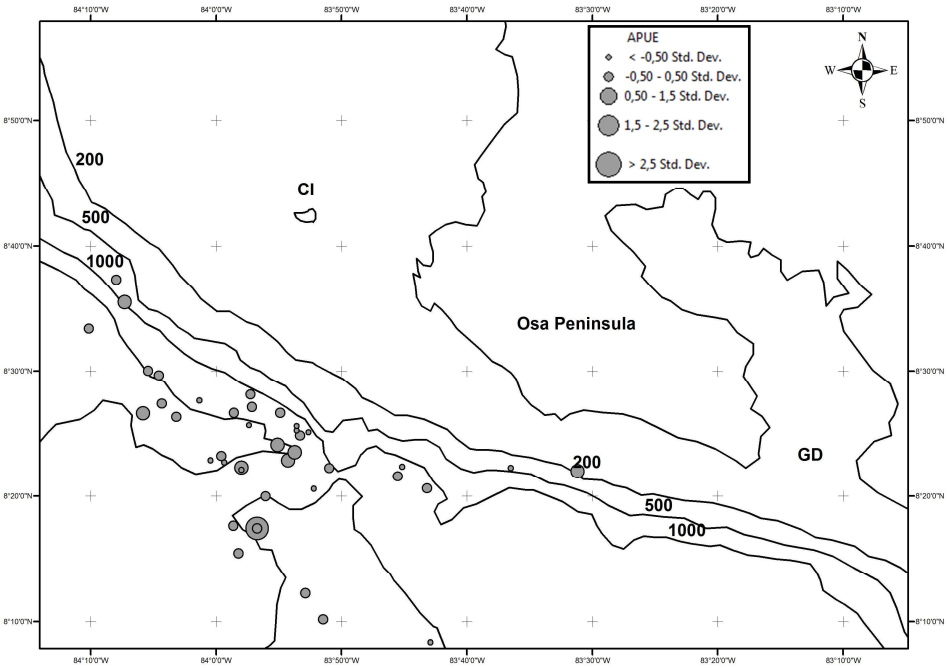

Figure 3. Distribution of effort corrected APUE of *D. delphis* in the study area. Classes were grouped by means of the standard deviation. CI= Caño Island, GD= Golfo Dulce.

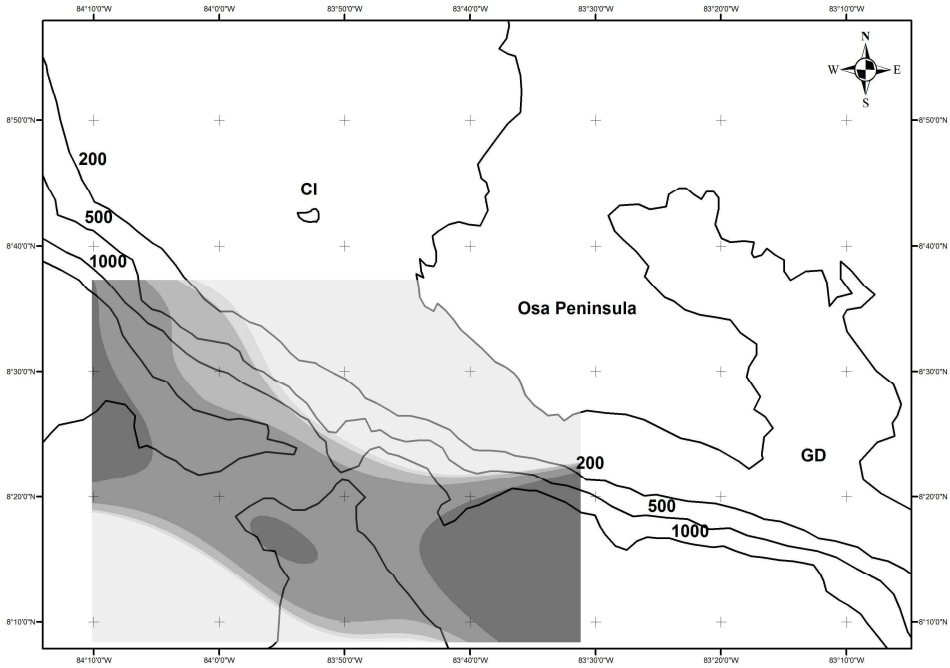

Figure 4. Predicted density (generated from effort corrected APUE) of common dolphin off the Osa Peninsula, including Caño Island (CI) and Golfo Dulce (GD). Densities scale from the lowest values is shown in light gray to the highest values shown in dark gray.