CO-OCURRENCE OF CETACEAN INDICATOR SPECIES OF UPWELLING MODIFIED WATERS AND TROPICAL WARM WATERS OFF OSA PENINSULA, COSTA RICA

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ABSTRACT: Osa Conservation Area is regarded as the region with highest biodiversity in Costa Rica. In terms of marine fauna this locations offers a great variety of complex coastal and marine ecosystem that support an equally impressive amount of marine species, among them, more than 11 species of cetaceans. The aim of this contribution is to determine the correlation of oceanographic parameters and fauna composition, distribution and abundance of cetacean species in the study area. Including biological data of typical upwelling modified waters (UMW) species, co-ocurring with typical warm tropical waters cetaceans (WTW). Data collection was achieved through platform of opportunity (on commercial cetacean watching vessels), and cover three zones during 2001 - 2006 sampling season: Drake bay, the west coast of Osa Peninsula and Southwest of Caño Island. Sighting data included photographic and geographic coordinates (GPS) records as well as abundance estimations during encounters. Spatial distributions correlated with bathymetry, slope and temperature were analyzed through a GIS, but also using a diversity index to compare the variation of cetacean diversity in correlation with those oceanographic features. *Stenella attenuata*, *Tursiops truncatus* and *Megaptera novaeangliae* dominated the neritic range, although major groups of spotted and bottlenose dolphins are consistent with locations of oceanic like features. An important abundance and an increase in species diversity were observed in transitional areas between the coastal and oceanic waters, with greater occurrence of oceanic dolphins and overlap of indicator species such as Delphinus dephis (UMW) - Stenella longirostris (WTW). This investigation gathered baseline information at a regional scale that could sustain conservation and management initiatives.

INTRODUCTION:

- Osa Conservation Area is the region with highest biodiversity in Costa Rica. In terms of marine fauna this locations offers a great variety of complex coastal and marine ecosystem that support an equally impressive amount of marine species, among them, 12 species of cetaceans.
- The use of landscape units for the evaluation, monitoring and conservation of the diversity of species allows for the integral analysis of complex systems. It is on the landscape level that human activity (contamination, degradation, change and fragmentation of ecosystems) has effects that often elude ecological analysis carried out on a local scale
- The alpha diversity of an indicator group (cetaceans) reflects the number of species that use a given environment or resource. Beta diversity represents the response of the organisms to spatial heterogeneity.
- The aim of this contribution is to determine the correlation of oceanographic parameters and fauna composition, distribution and abundance of cetacean species in the study area.

MATERIALS AND METHODS

Data collection through platform of opportunity (on commercial cetacean watching vessels), and cover three zones during 2001 - 2006 sampling season: Drake bay, the west coast of Osa Peninsula (Corcovado N. P.) and Southwest of Caño Island: Sighting data + geographic coordinates (GPS) + school size

Spatial distributions correlated with bathymetry, slope and temperature analyzed through a GIS + diversity index to compare the variation of cetacean diversity. To correct for bias due uneven efforts, only cells (1min X 1min) with very similar to equal efective observation time (3.2 hours) were analyzed.

Simpson diversity: clear perception of species dominance through a probability value.
The estimates on tables 1 – 4 are only relative abundance indices generated by non-systematic efforts.
Alpha (Species Richness) and Beta diversity using Whittaker's modified index: $\beta = \Sigma\{[(S/a)-1]/(N-1)\}$

- Oceanographic parameters were analyzed with a succession of SST monthly mean maps (the AVHRR Oceans Pathfinder 5 SST data were obtained through the online PO.DAAC Ocean ESIP Tool (POET) at the Physical Oceanography Distributed Active Archive Center(PO.DAAC), NASA Jet Propulsion Laboratory, Pasadena,CA. http://podaac.jpl.nasa.gov/poet)
- Variation of the seasonal upwelling system a Wind Speed interanual monthly variation in the Papagayo Upwelling area was calculated (from QuickSCAT, obtained from CERSAT, at IFREMER, Plouzané (France))

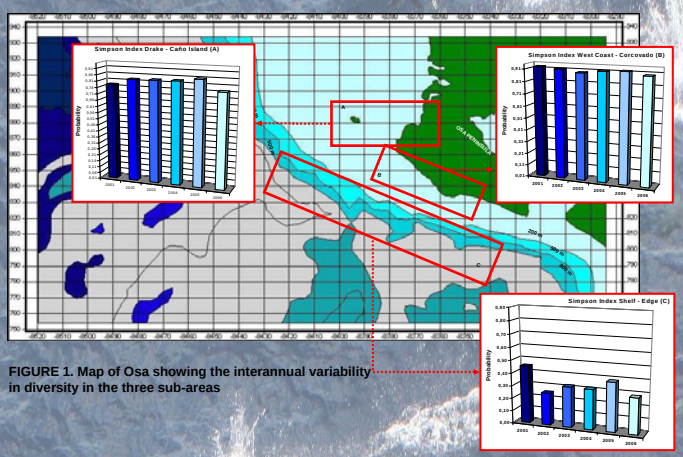


FIGURE 1. Map of Osa showing the interannual variability in diversity in the three sub-areas

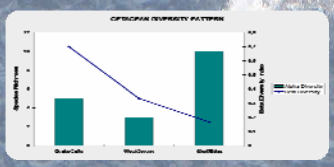


FIGURE 2. Graph of Diversity (Alpha + Beta) Pattern

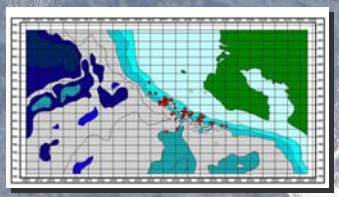


FIGURE 3. Spatial overlap of *D. delphis* (red solid dots) and *S l. centroamericana* (white dots) at the shelf edge.

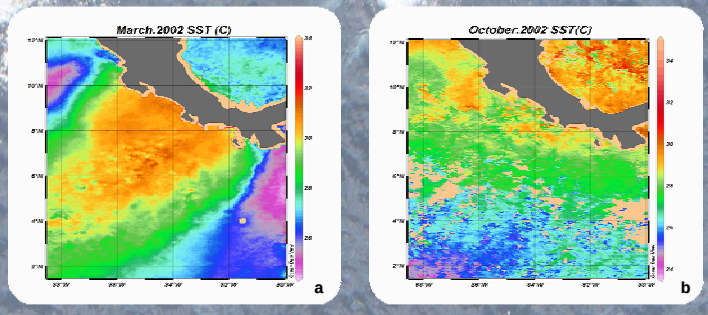
DISCUSION:

Cetacean Diversity Pattern off Osa Peninsula

- ***Stenella attenuata***, ***Tursiops truncatus*** and ***Megaptera novaeangliae*** have an important presence within the neritic range. An important abundance and an increase in species diversity were observed in transitional areas between the coastal and oceanic waters (Shelf Edge). This is illustrated by the probability' distribution of observing two cetaceans of the same species in this location. It contrasts with the dominance of high probability values within the neritic habitat, due to the importance of pantropical spotted dolphins abundance over coastal waters. The difference in the number of species (Beta Diversity) between the three sites, also diminishes considerably towards the transition habitat.
- Interannual variability in the distribution of Simpson Indices over the shelf edge habitat could be affected by intensity in upwelling events. When the upwelling (wind jet generated) is quantified, years with longer periods of strong winds have a stronger upwelling season than the others, and could trigger higher local diversity. However, it does not imply a great influence on the species richness, since the rate of change in the number of species at a given site varies greatly over longer periods of time owing to emigration, the local extinction of some species and the arrival of others previously not present (Arellano and Halfter, 2003).

Cetacean Indicator Species:

There is a greater occurrence of oceanic dolphins in the transition habitat of the shelf edge, with an overlap of indicator species such as Delphinus dephis (common of Upwelling Modified Waters) and - Stenella longirostris centroamericana (tipically a Warm Tropical Water species). This could be related with a key stability of such area within two important thermal fronts, one on the north (near Papagayo Gulf) and the other on the south border (near Panama Gulf), these two systems originated by a seasonal wind jet system (McCreary et al., 1989), create an special area (a small Warm Pool surrounded by the thermal fronts), plus the fact that underwater topography could act out as a retention basin. Therefore, this greater transitional ecosystem becomes sort of an oasis were indicator species converge.



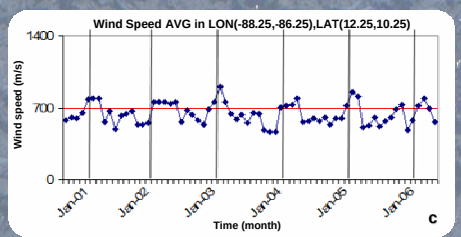


FIGURE 4. SST maps of Osa Oceanographic System, showing the upwelling and warm pool seasonal system: a) March 2002 b)October 2002. c) Interanual wind speed variation on the North Upwelling Area (Papagayo wind jet area)

CONCLUSION:

This research has shown the importance of the transition ecosystem (shelf edge off Osa Peninsula) as a diversity hot spot for cetaceans. There is an ongoing plan to establish a new MPA of neritic dominance that will integrate the existing protected areas. A MPA status to be granted in this key transitional habitat will enhance conectivity between key habitats. Ongoing research in the area is heading towards a more systematic approach, determining critical habitat as a tool for conservation of important species such as the endemic *S. l. Centroamericana*.

Literature cited:

1) Arellano L. and G. Halffter. 2003, Gamma diversity: derived from and a determinant of alpha diversity and beta diversity. An analysis of three tropical landscapes. *Acta Zoologica Mexicana* 90: 27-76. 2) Ballance, L.T., Pitman, R.L., Fiedler, P.C. (2006) Oceanographic influences on seabirds and cetaceans of the eastern tropical Pacific: A review. Progress in Oceanography, 69:360–390. 3) Harrison, S., S. J. Ross & J. H. Lawton. 1992. Beta diversity on geographic gradients in Britain. *J. Anim. Ecol.*, 61:151-158. 4) McCreary Jr., J.P., Lee, H.S., Enfield, D.B., 1989. The response of the coastal ocean to strong offshore winds; with application to circulations in the Gulfs of Tehuantepec and Papagayo. *Journal of Marine Research* 47, 81–109.

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