THE BLUE WHALE, *BALAENOPTERA MUSCULUS:* AN ENDANGERED SPECIES THRIVING ON THE COSTA RICA DOME

Preliminary research regarding the blue whale's presence on the Costa Rica Dome indicates that this area likely fulfills several scientific criteria adopted by the Convention on Biological Diversity (CBD) to identify ecologically and biologically significant areas (EBSAs); especially, importance for threatened, endangered or declining species and/or habitats.

Prepared by Erich Hoyt[1]

Introduction

The blue whale, *Balaenoptera musculus,* is the largest animal ever to have lived, and a true resident of the world ocean (Yochem and Leatherwood, 1985; Sears and Perrin, 2008). Distribution includes the deep sea and open ocean ecosystems across all ocean basins except the Mediterranean and the Baltic seas. The idea that such a wide-ranging "global" animal has specific place-based habitat needs is only fairly recent – at most two decades old. Pioneer blue whale scientist Richard Sears was the first to discover (using photo-identification of individual blue whales) that the same blue whales were returning year after year to feed in the waters of the north shore of the St. Lawrence River and Gulf in Canada (Sears et al, 1990). The same proved to be true off California and in the waters of the Gulf of California east of Baja California, Mexico, as well as in the limited locations where blue whales have been studied around the world (for a recent review, see Sears and Perrin, 2008; Reilly et al, 2008). Being able to identify individual blue whales, to establish their relative abundance and thus to predict their habitat is the first step toward understanding their habitat needs.

The blue whale is classified as an "endangered" species on the IUCN Red List but may in fact meet the criterion for "critically endangered" (Reilly et al, 2008). In the early to middle decades of the 20th Century, the blue whale was whaled so heavily (more than 300,000 alone taken from the Antarctic and sub-Antarctic) that current rough estimates of the world population range from only 10,000 to an optimistic 25,000, corresponding to about 3-11% of the 1911 population size (Reilly et al, 2008). Abundance estimates for the eastern North Pacific population – some of which are using the Costa Rica Dome located on the high seas of the eastern North Pacific at around 9˚N 90˚W (mean position) – are 3000 animals (CV = 0.14) by line-transect methods and 2000 animals by capture-recapture (photo-identification) (Calambokidis and Barlow, 2004). In the pre-20th Century world with several hundred thousand blue whales, there were likely considerably more habitats used by blue whales; it becomes even more important therefore to conserve for research the known habitats that remain in terms of any possible recovery of this species.

In 1994, Bruce Mate and his colleagues radio-tagged 10 blue whales off California, one of which travelled some 5,400 mi (8,668 km) to the Costa Rica Dome (Mate et al, 1999). The tags allowed tracking by satellite for 5.1 to 78.1 days. During the period that tags lasted, four whales were tracked along the Baja California coast, two of which passed Cabo San Lucas before the tags stopped transmitting, and one of which was followed for the maximum period and reached the Costa Rica Dome.

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[1] Senior Research Fellow, WDCS, the Whale and Dolphin Conservation Society and Head, Critical Habitats Programme, WDCS; member, IUCN SSC Cetacean Specialist Group

In two 2-3 week periods in January and March 1999, an expedition led by the Cascadia Research Collective to the Costa Rica Dome investigated the large number of blue whales on the Dome. The study area covered 8˚-11˚N latitude and 90˚-100˚W longitude: more than 100,000 mi^2 (260,000 km^2) the rough area where blue whales had been reported in the past corresponding to the Costa Rica Dome and the area slightly west. Some 24 sightings of 28 blue whales were made during 1300 nmi of cruising. Of 13 blue whales photographically identified, 8 of them matched individuals known from off California (Calambokidis, pers. comm. from unpublished logbook 1999). In addition, all the recordings matched known calls from northeastern Pacific blue whales.

Subsequent work on the Costa Rica Dome, including a cruise in January 2008 reported in National Geographic Magazine in which 54 sightings of a total of 87 blue whales were reported (Calambokidis, pers. comm., from unpublished logbook notes 2008; Brower, 2009), has suggested some important facts about blue whales and their residence on the Costa Rica Dome.

- Blue whales are found year-round on the Costa Rica Dome (Reilly and Thayer, 1990). It will soon be possible to find out through the technique of photo-identification of individual blue whales if some of these are the same individuals spending the whole year or if other whales are migrating in and out during the year (Sears et al, 1990). It has been suggested that at least some blue whales may be coming from the southern hemisphere (e.g., off Chile), migrating across the Equator to the Costa Rica Dome (IWC Chairs Report 2008).
- Blue whales are feeding here during winter (based on observation and collection of fecal material and feeding behavior documented on suction-cup attached tags corresponding to the detected krill layer, Calambokidis, pers. comm, from unpublished logbook notes 2008; Brower, 2009). Along with the observations of blue whales feeding in the Gulf of California and off the west coast of Baja California in winter and early spring, this indicates blue whales do not fast over the winter, as do other baleen whales. Using photo-ID matches researchers have shown that even feeding blue whales known to have migrated from California are also feeding on the Costa Rica Dome. Thus, unlike other known baleen whale species, these blue whales are feeding year-round. This rewrites what was "known" about blue whales. The common understanding of baleen whales is that they spend 4-6 months of the year feeding, and the rest of the year travelling and on the mating and calving grounds where they do not feed. This is based largely on what we know about gray, humpback and other baleen whales and was assumed to be true of blues as well. However, blue whales have been seen routinely feeding on the Dome indicating that this is a productive area that is probably of critical importance to the eastern Pacific blue whale population (stock).
- There is evidence that some blue whales on the Costa Rica Dome are also calving and/or raising calves. A mother and young calf were observed on two occasions on the Dome although the overall proportion of mothers and calves was low. Some level of calving is likely occurring on the Dome although this may not be an exclusive calving area.
- There is evidence of mating on the Costa Rica Dome. Frequent active groups of three and four whales were observed on the Dome at a much higher rate than is seen off California suggesting that this is likely an area where mating could be occurring.

What is emerging is a much broader scale picture of the blue whale in the eastern North Pacific with the Costa Rica Dome having a central importance for this endangered, charismatic species, (There are also known habitats off California in the four large national marine sanctuaries within the US EEZ, with some movements to offshore British Columbia waters and México (Calambokidis and Barlow, 2004) and as yet some other unknown areas.). Of the roughly ten locations where blue whales are being studied today, the eastern North Pacific has the largest abundance (2,000-3,000 individuals) and is generally considered the healthiest. The species itself may depend on the health of this population, and its habitat, including the Costa Rica Dome.

What is the Costa Rica Dome?

The Costa Rica Dome is a shoaling of the generally strong, shallow thermocline of the eastern tropical Pacific Ocean (Fiedler 2002). This upwelling of cold, nutrient-rich waters occurs due to the confluence of currents west of the Isthmus of Darien. It varies in size and position throughout the year but the mean position is near 9˚N 90˚W. It is a distinct and highly productive biological habitat where phytoplankton and zooplankton biomass is higher than in surrounding tropical waters (Fiedler 2002). (See Figure 1).

Satellite data as well as field measurements, including the presence of numerous feeding blue whales, support the hypothesis that the Costa Rica Dome is an area of high productivity. Enhanced chlorophyll levels (associated with relatively higher biomass of phytoplankton and high nutrient levels) are visible in satellite imagery (examples are snapshots from animations at http://svs.gsfc.nasa.gov/vis/a000000/a003500/a003544/index.html). It is important to note that the Costa Rica Dome itself cannot be seen or measured by satellite, only through ship-board CTD measurements taken at various depths.

Figure 1.

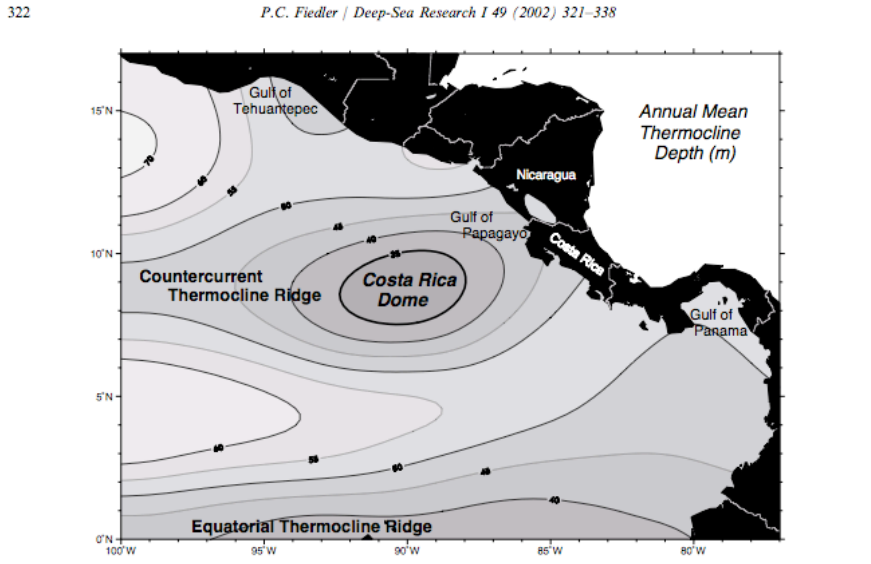

Fig. 1. Annual mean thermocline depth (20°C isotherm depth) in the region of the Costa Rica Dome. Data from World Ocean Database 1998 (Conkright et al., 1999).

Considerations in measures to protect the Costa Rica Dome

The changing size and position of the dome (Figure 2) make static protection somewhat problematic. Complicating matters is the fact that the dome and the areas with high chlorophyll concentration do not always coincide (Figure 3). However, the changes in the dome are seasonally predictable. As Fiedler (2002) says, "a seasonally predictable, strong and shallow thermocline makes the Costa Rica Dome a distinct biological habitat." Thus, despite the contraction and expansion in size and the variability of the location, the predictability could allow for seasonal boundary changes that would accommodate this.

There is also evidence of blue whale shifts in distribution even over the limited timeframe of a month. What is not known is whether blue whales follow the precise or even approximate shifts in size and position of the Costa Rica Dome throughout the year. Collection of year-round data and comparison to existing data for the Dome and blue whale distribution would clarify this. However, the strong hypothesis would have to be that the blue whales would be found in the most productive areas in and around the Dome.

Figures 2 and *3:*

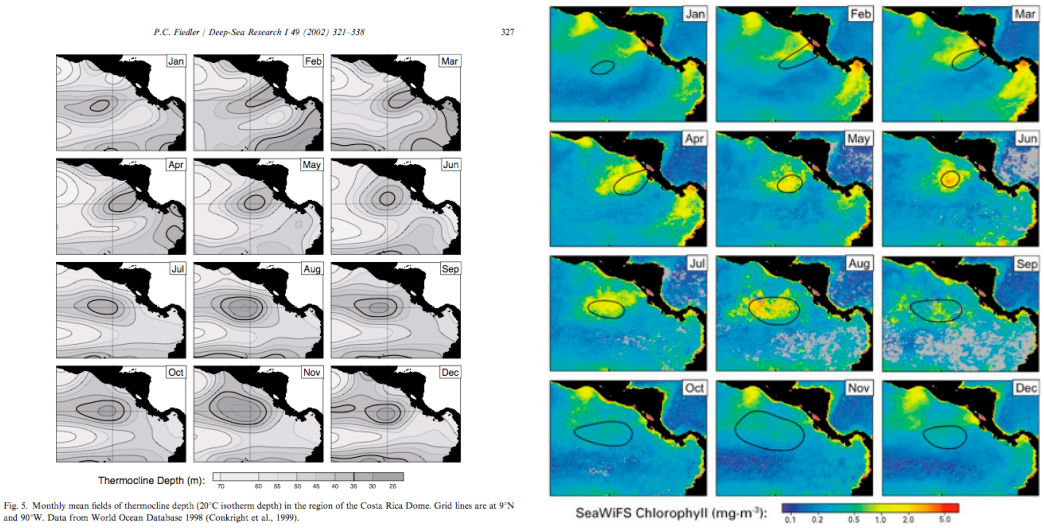

Fig. 5. Monthly mean fields of thermocline depth (20°C isotherm depth) in the region of the Costa Rica Dome. Grid lines are at 9°N and 90°W. Data from World Ocean Database 1998 (Conkright et al., 1999).

Scientific criteria determining that the Costa Rica Dome is ecologically and biologically significant as blue whale habitat

Based on what we now know about blue whales on the Costa Rica Dome, we believe that it fulfills the scientific criteria for ecologically and biologically significant areas (EBSA) as prime blue whale habitat in the following categories/ for the following reasons:

1. Uniqueness or rarity
   • Taking a global perspective of blue whales, this is a rare and possibly unique habitat where the whales spend the entire year feeding as well as mating and calving.
   • Loss of the Costa Rica Dome through overfishing or other threats could mean the disappearance of this population of blue whales currently known to be increasing, or could displace or marginalize them.

• In terms of the habitat, the thermocline conditions that create a predictable dome appear unique for this part of the tropical world ocean. Even on a global scale, these conditions could be considered "rare": There is a western Pacific Dome called the Mindanao Dome; the other tropical thermal domes occur in the eastern Atlantic – the Guinea Dome and Angola Dome (Fiedler, 2002).

2. Special importance for life history stages of species
   All life history stages for the blue whale can be found in this single area — but we should also note the potential importance of connectivity in terms of the known connections that blue whales from the Costa Rica Dome have with protected habitat off central and southern California and México (Gulf of California) (from photo-ID matches and radio tagging with satellite-acquired locations) and the value of MPA networks in terms of protecting wide-ranging animals.

3. Importance for threatened, endangered or declining species and/or habitats
   Blue whales are endangered (IUCN Red List) and the Costa Rica Dome habitat may be essential to their survival and possible recovery. Note that the eastern North Pacific blue whale population (one of only two population stocks in the North Pacific) is the only one in the world that has been shown to be recovering, so the hope for the recovery of blue whales in the North Pacific and worldwide depends on this eastern North Pacific, with the Costa Rica Dome as a critically important component. **This is arguably the most applicable of the CBD EBSA criteria, as regards blue whale use of the Costa Rica Dome habitat.**

4. Vulnerability, Fragility, Sensitivity, or Slow recovery
   Blue whales are presumed to have low population birth rates as do other whales, but the details have not been defined. They are known to reach sexual maturity at 5-15 years old, typically 8-10 years for both sexes (Sears and Perrin 2008). Females give birth every 2-3 years after a 10-12 month gestation period. Infant mortality (to age 1) is unknown but the demands on the mother must be considerable to take care of a 6-7 m calf (at birth) weighing 2-3 tons that must put on 90 kilos (200 pounds) a day before it is weaned at about 8 months (Sears and Perrin 2008). It may be that the Costa Rica Dome is an important area for blue whales precisely because it is both a warmer water tropical calving and nursing ground as well as, crucially, a place where new mothers can continue feeding.

5. Biological productivity
   An area such as the Costa Rica Dome that can consistently support a large number of feeding blue whales is, almost by definition, extraordinarily productive. The krill and other zooplankton largely eaten by whales, are important food sources for fish and other marine organisms, and crucial to maintaining the food chain that supports apex predators such as killer whales, seabirds, sharks, tuna and other fish.

6. Biological diversity
   There is evidence from cruises that many other apex predators are found here, but overall biological diversity is yet to be uncovered. In terms of cetaceans,

cruises have encountered mainly pantropical spotted dolphins, *Stenella attenuata*; bottlenose dolphins, *Tursiops truncatus;* common dolphins, *Delphinus* spp; spinner dolphins, *Stenella longisrostris;* with odd sightings of Bryde's whales, *Balaenoptera edeni*; killer whales, *Orcinus orca;* rough-toothed dolphins, *Steno bredanensis;* Cuvier's beaked whales, *Ziphius cavirostris,* as well as other beaked whales; pilot whales, *Globicephala* spp; Risso's dolphins, *Grampus griseus;* striped dolphins, *Stenella coeruleoalba;* and various unidentified dolphins and whales (see 2 examples in Figure 4). The biodiversity needs to be studied further.

Figure 4.

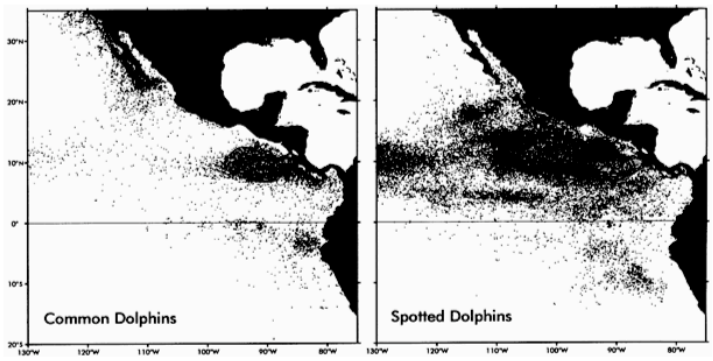

Fig. 15. Sighting locations of common dolphins (*Delphinus delphis*) and spotted dolphins (*Stenella attenuata*) from research and tuna vessels in the NOAA/NMFS/SWFSC sightings database (1971–1999). Monthly positions of the Costa Rica Dome (35 m thermocline depth contour, thin lines) from Fig. 5.

7. Naturalness
   This needs to be evaluated further in view of fishing activities in the area in recent decades.

Conclusion

The Costa Rica Dome presents challenges due to its seasonal movements and its position sometimes completely on the high seas and sometimes including national waters of five Central American countries. But the opportunity to create a vital protected habitat for one of the most charismatic species on Earth, the great blue whale, is more than sufficient reason to seek to resolve the difficulties.

According to Reilly et al (2008), based on their evaluation of the world's blue whales for the most recent update to the IUCN Red List, the International Whaling Commission granted protection to blue whales in 1966, and no blue whales have been recorded as deliberately caught since 1978. The species remains on Appendix I of both CITES and CMS and is classified as Endangered. The IUCN Red List evaluation further notes that "local measures may be required to protect the habitat of specific local populations in order to ensure their long-term viability in the face of increasing human impacts". The Costa Rica Dome is a strong example of the need for such local measures, and would be something that would help build the network of MPAs that are already helping to focus research and conservation work on the blue whale through the four National Marine Sanctuaries off California and MPAs in the Gulf of California, México.

Please note that this assessment is largely based on the importance of this habitat for a single endangered species. On the two cruises noted above, other cetacean species were found. The importance of this area for endangered blue whales and other apex

predators, and the productivity of this ecosystem clearly indicate the merit of a full investigation of biological and ecological criteria as applied to the entire ecosystem.

The process engaged by WDCS to make a preliminary identification of the critical habitat for blue whales covering the Costa Rica Dome is described in Figures 5-8 below.

Acknowledgements

Thanks to John Calambokidis for helpful information and sharing preliminary information from log reports. I am very grateful for comments and corrections from Jeff Ardron, Kristina Gjerde and Jason Roberts. Thanks also to Nicolas Entrup. The maps in figures 1-4 and figure 7 were extracted from Fiedler (2002). The remaining maps are rough, working maps as well as original maps prepared for this project by Lesley Frampton with background research by Calvin Frampton. The blue whale photograph of mother and calf is by Lucy Molleson.

Sources of Data

A number of oceanographic cruises have been undertaken, at least two of which have focused on blue whales (Brower, 2009; Calambokidis pers. corres. from unpublished logs for 1999 and 2008).

Reilly and Thayer (1990) compiled blue whale sightings from NMFS research vessels and by biologists aboard commercial tuna fishing vessels between 1975 and 1988.

Mate et al (1999) and reported in Brower (2009) has done extensive satellite tracking of blue whales over a period of years which has shown that some blue whales travel from California to Mexican Pacific waters and on to the Costa Rica Dome.

Calambokidis's work (see various papers below) has focused on photo-identification, biopsy and acoustics, and has succeeded in matching blue whale photos taken in a long-standing study off California with Costa Rica Dome photos. Acoustics has further shown that all the eastern North Pacific whales are part of the same stock or population.

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Photograph of blue whale mother and calf. Lucy Molleson/ WDCS, the Whale and Dolphin Conservation Society.

Figures 5-13 illustrate WDCS (Whale and Dolphin Conservation Society) process to identify draft potential boundaries for blue whale habitat at the Costa Rica Dome:

P. 510 "Blue Whales" - National Geographic

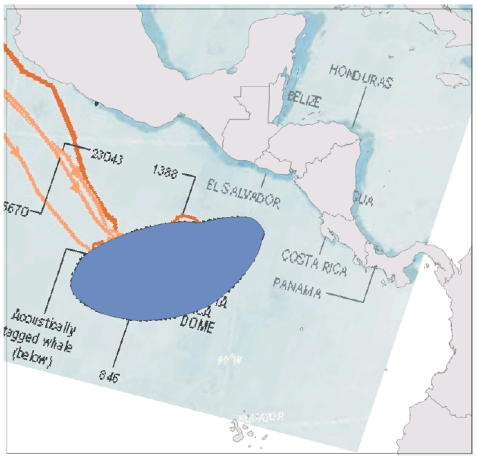
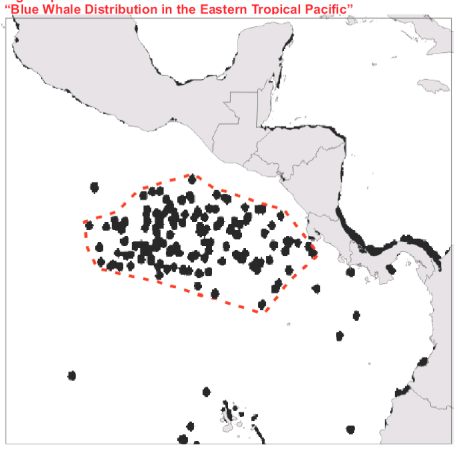


Fig. 1 Spatial Distribution of Blue Whales
"Blue Whale Distribution in the Eastern Tropical Pacific"



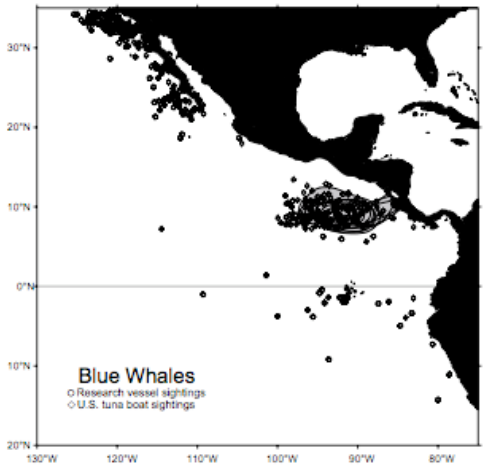
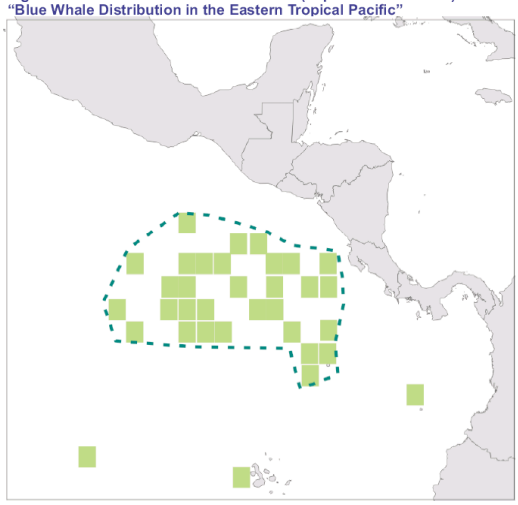


Fig. 14. Sighting locations of blue whales (*Balaenoptera musculus*) from research vessels (1976–1999, $n = 327$) and US tuna boats (1971–1990, $n = 191$) in the NOAA/NMFS/SWFSC sightings database. Monthly positions of the Costa Rica Dome (35 m thermocline depth contour, thin lines) from Fig. 5.

Fig.3 Relative Abundance of Blue Whales (4 quarters combined)
"Blue Whale Distribution in the Eastern Tropical Pacific"



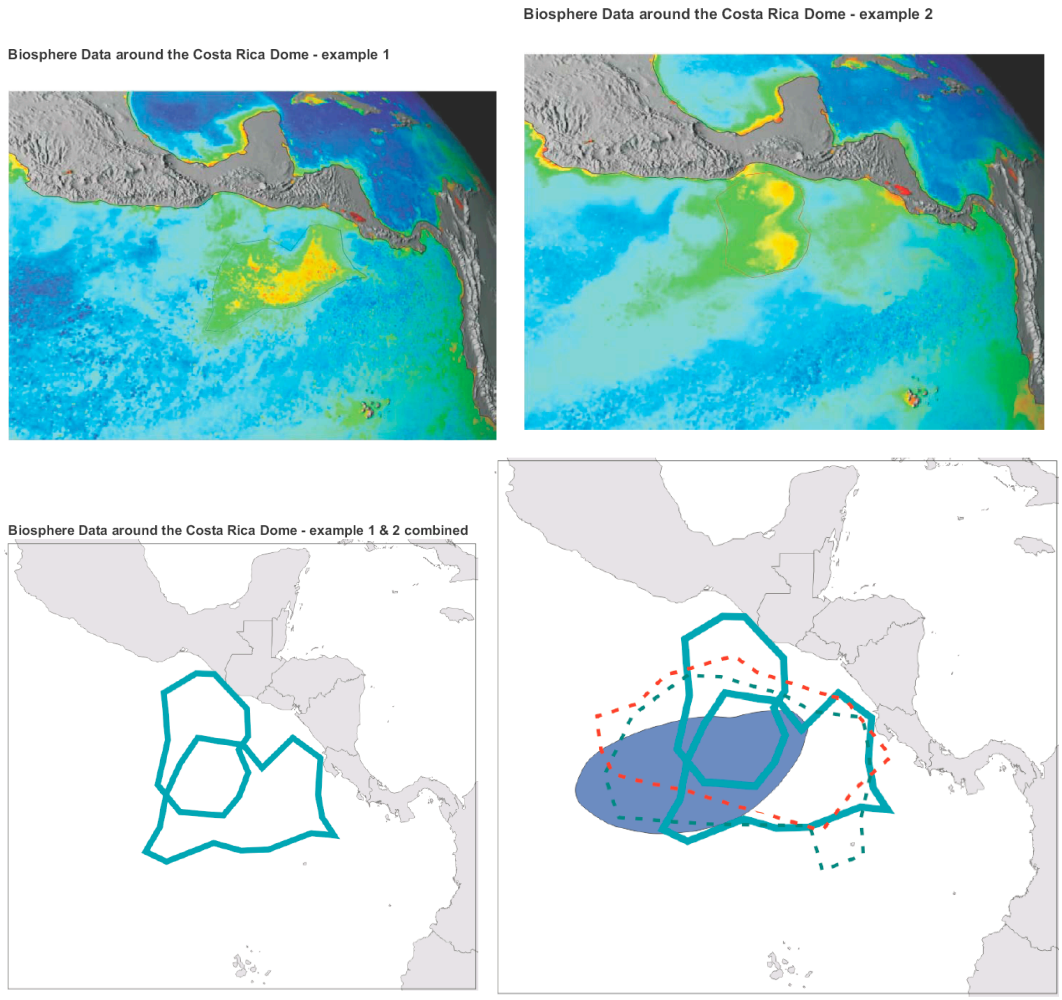
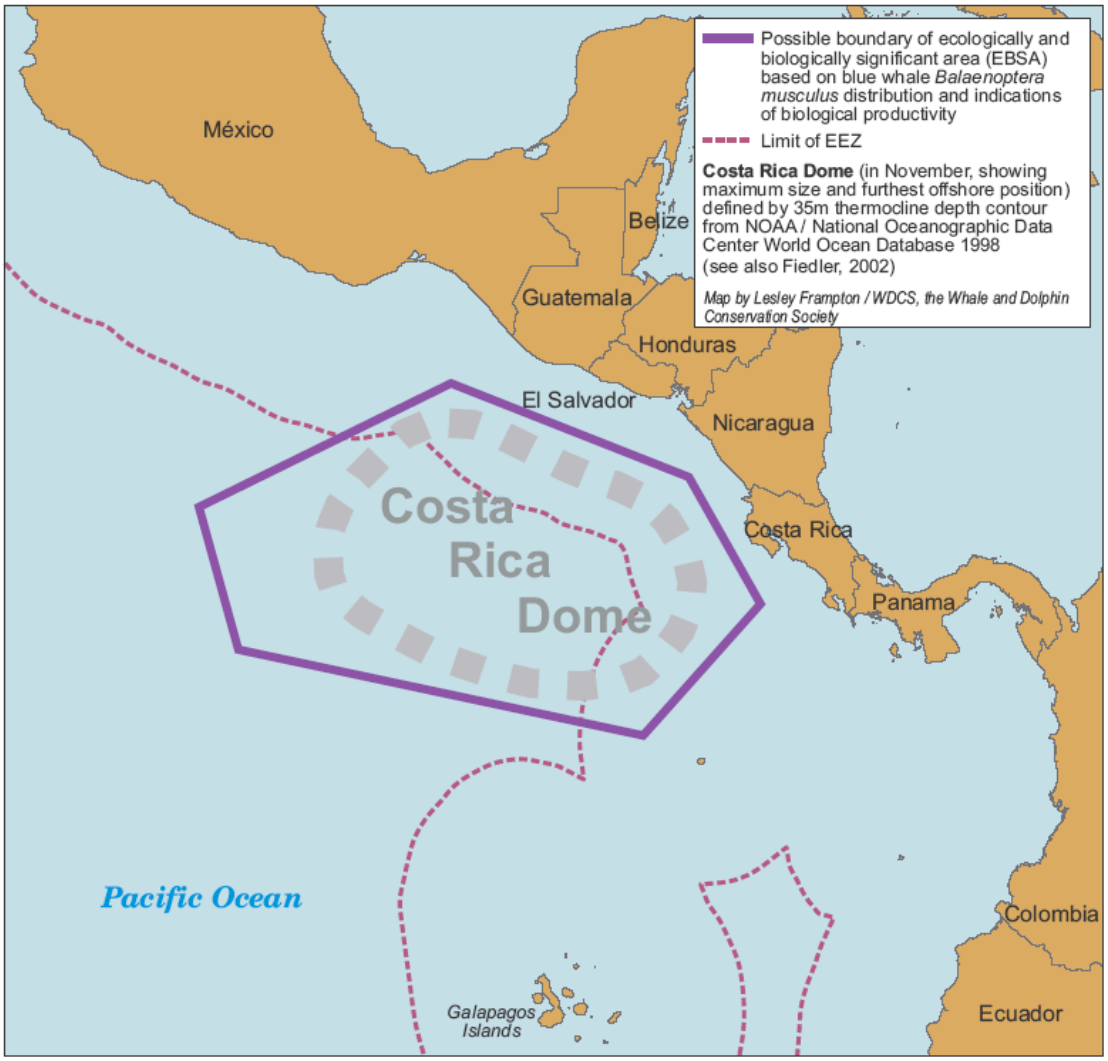


Figure 13. Initial WDCS proposed boundary based on blue whale distribution and biological productivity. EEZ shows that this area would be a potential high seas as well as transboundary EBSA including some of the EEZ of Costa Rica, Nicaragua, Honduras, El Salvador, Guatemala and México. Map by Lesley Frampton/ WDCS, the Whale and Dolphin Conservation Society.


Possible boundary of ecologically and biologically significant area (EBSA) based on blue whale *Balaenoptera musculus* distribution and indications of biological productivity
Limit of EEZ
Costa Rica Dome (in November, showing maximum size and furthest offshore position) defined by 35m thermocline depth contour from NOAA / National Oceanographic Data Center World Ocean Database 1998 (see also Fiedler, 2002)
Map by Lesley Frampton / WDCS, the Whale and Dolphin Conservation Society
México
Belize
Guatemala
Honduras
El Salvador
Nicaragua
Costa Rica
Panama
Colombia
Ecuador
Costa Rica Dome
Pacific Ocean
Galapagos Islands