

RAINY SEASON EXTENSION OF THE MULTI-SPECIES MARINE SIGHTING SURVEY IN GOLFO DULCE, COSTA RICA, JULY – AUGUST 2011

Final Report and Comparative Summary

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INTRODUCTION

Golfo Dulce is one of only four tropical fiords in the world (Toft, 2009). Located along the most southwesterly coast of Costa Rica between 8°22' N and 8°45' N, this curved embayment is approximately 50 km in length and 10–15 km wide. It has a deep, occasionally anoxic inner basin reaching 215 m in depth, which is contained by a ~60 m sill (Svendsen *et al.*, 2006). It receives fresh water discharge from four large rivers and several smaller tributaries. The inlet supports an abundance of marine life, including endangered and critically endangered species (Bessesen, 2010; WIDECAST, 2010; 2011).

During the rainy season months of July and August 2011, 25 daily onboard surveys were conducted in Golfo Dulce. This multi-species sighting survey was an extension of a dry season survey undertaken during the months of January and February 2010, which comprised 30 daily onboard surveys and interviews with 82 local fishermen and tour boat guides. Thus, the current study was designed to expand data to include both of Central America's primary seasons. As before, I served as principal investigator and local guide Jorge Largaespada worked as boat captain and research assistant.

Overall objectives were to collect baseline data regarding the types of species that enter or reside in Golfo Dulce; to determine spatial distribution of those species seen during the survey period(s); to compare dry season and rainy season data in order to expose seasonal shifts that might provide broader perspective on the gulf and its biodiversity; and to gain understanding about several focus

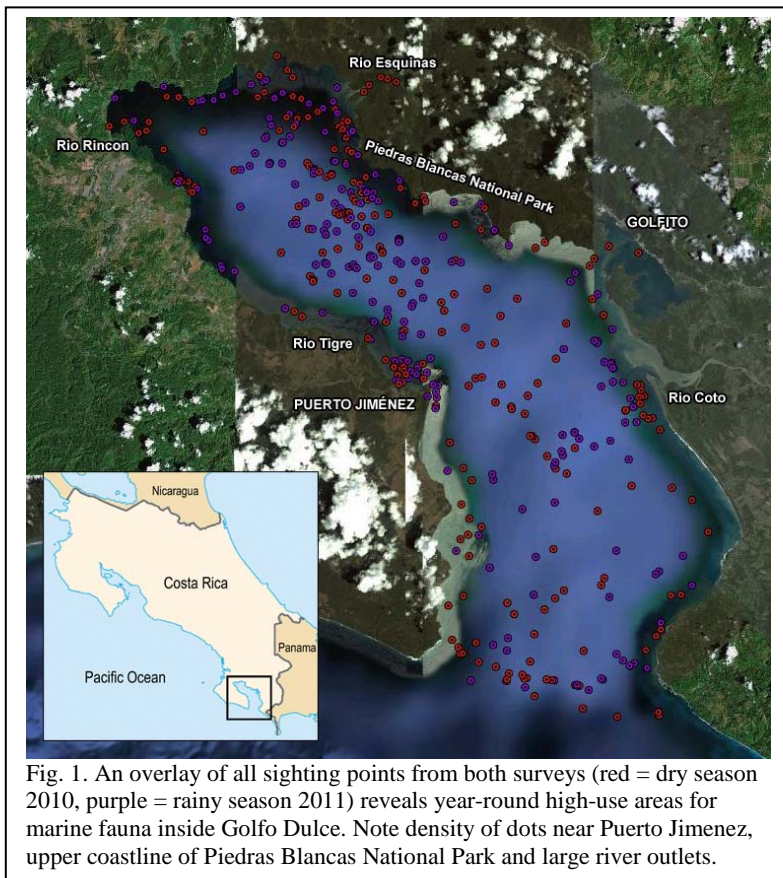


Fig. 1. An overlay of all sighting points from both surveys (red = dry season 2010, purple = rainy season 2011) reveals year-round high-use areas for marine fauna inside Golfo Dulce. Note density of dots near Puerto Jimenez, upper coastline of Piedras Blancas National Park and large river outlets.

conservation species that utilize Golfo Dulce as part of their natural ecology. Mapped sighting points also revealed areas of concentrated bio-density for certain fauna within the gulf (Fig 1).

Here, we mainly distill data from the 2011 rainy season extension survey. However, because cumulative data from both the dry and rainy season surveys will best serve decisions of Marine Spatial Planning, combined data are occasionally presented to show collective results and/or seasonal shifts in habitat use. This report should be considered an extension of the Project Report and Summary of Multi-Species Marine Sighting Survey in Golfo Dulce, Costa Rica, January–February 2010, which offers additional details about the study area and factors affecting *in situ* conservation. It is available in English and Spanish through the author or online at <http://www.osaconservation.org/ScienceReports.html>.

MATERIALS and METHODS

The 2010 study materials and methodology proved viable and were replicated for the rainy season extension survey with the only significant difference being a smaller observation vessel: a 10-foot panga with a 15 hp Mercury outboard motor. Although the lower vantage point may have reduced visibility to some degree, surveying speed and daily distances were not affected. The gulf was divided into four Geographical Areas, GA1-4, highest to lowest latitudes, respectively. We concentrated on one area per day, generally rotated GA1, GA3, GA2, GA4. The full breadth of the focal area was explored in a large loose pattern that ensured time near each coast and in the midwaters. The area outside the embayment, labeled GA5, was not actively surveyed, although occasional sightings were made there while working along the southern border of GA4. Observation periods typically began just after sunrise and lasted an average of 7 hours 40 minutes. Daily travel distance was approximately 65-80 km. Only one nighttime survey was conducted.

Although we focused on whales, dolphins, sea turtles, sea snakes and whale sharks, any sighting of marine fauna deemed significant was logged. Sightings, comprising one or more individuals of the same species in the same area at the same time, were labeled ES for “extension survey” in chronological order (ES1, ES2, ES3, etc.). Recorded data fields included date, time, GPS coordinates, species, ID reliability (definite/probable/maybe/unconfirmed), group size, proximity to boat, swim direction, behavior and associated fauna. Two cameras were employed to collect photo-documentation: a Nikon D50 SLR digital camera (with time/date stamp) and a small Nokia Nuron video camera. Daily solar and tidal charts were kept, and environmental conditions were recorded at the start and end of each observation period, including time, Beauford Wind Force (BWF), air and sea surface temperatures, visibility and prevailing weather.

RESEARCH RESULTS

From 7 July to 25 August 2011, 25 daily on-board sighting surveys rendered 191 observation hours and 224 documented marine sightings. Photos and/or video were collected for 80% of those sightings. Most observation hours (96%) were conducted during daylight hours with average visibility greater than 15 km. Despite being the rainy season, precipitation had minimal impact on survey efforts and the average recorded BWF was actually lower than our dry season average. Recorded air temperatures averaged 27.5°C and marina sea surface temperatures averaged 29°C (Table 1).

Combined seasonal surveys tallied a total of 55 days on the water; 424 observation hours; 458 sightings; and data for over 38 species of marine fauna (Fig. 2). Highlighted species included Humpback whales, *Megaptera novaeangliae*, Bottlenose dolphins, *Turciops truncatus*, Pantropical Spotted dolphins, *Stenella attenuata*, False killer whales, *Pseudorca crassidens*, Green/Black sea turtles,

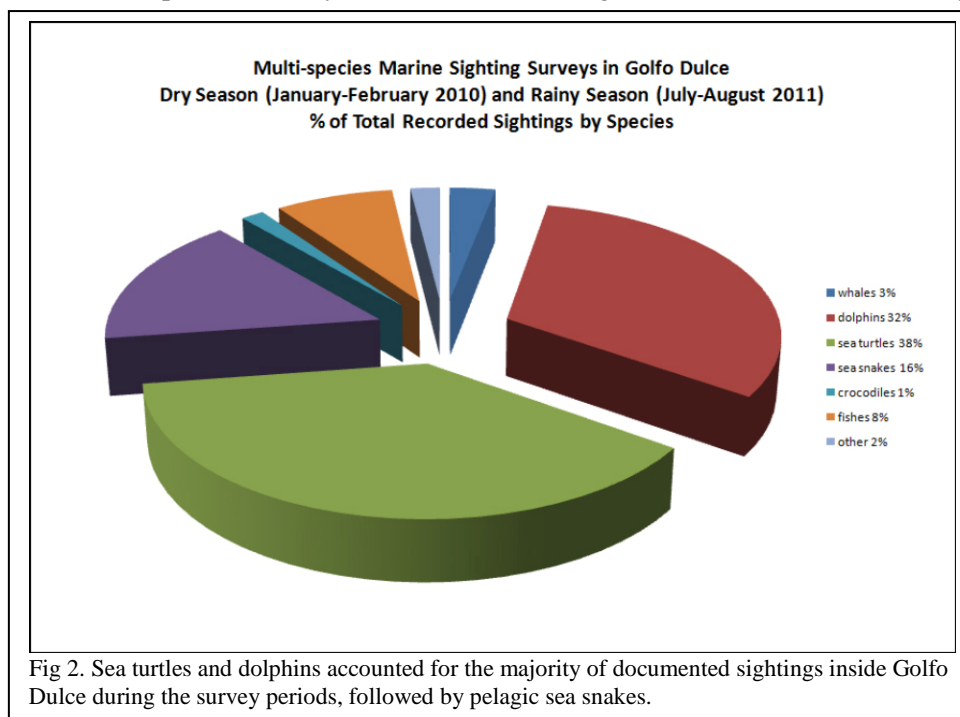


Fig 2. Sea turtles and dolphins accounted for the majority of documented sightings inside Golfo Dulce during the survey periods, followed by pelagic sea snakes.

Chelonia mydas agassizii, Olive Ridley sea turtles, *Lepidochelys olivacea*, Hawksbill sea turtles, *Eretmochelys imbricata*, Pelagic sea snakes, *Pelamis platurus*, Whale sharks, *Rhinocodon typus*, American crocodiles, *Crocodylus acutus*, Tiger shark, *Galeocerdo cuvier*, Bull shark, *Carcharhinus leucas*, Scalloped hammerhead, *Sphyrna lewini*, needlefish, *Tylosurus acus pacificus*, and Brown pelicans, *Pelecanus occidentalis*.

Table 1. At the start and end of each daily observation period, environmental data was recorded near the marina of Puerto Jiménez.

| Day # | Date | Sunrise | Sunset | High Tide | START | | | | | END | | | | | | |
|-------|-----------|---------|--------|-----------|-------|-------------|-------------------|----|-----|-----------|-------|-------------|-------------------|----|-----|-----------|
| | | | | | Time | Air Temp °C | Sea Surf. Temp °C | Wx | BWF | Vis. (km) | Time | Air Temp °C | Sea Surf. Temp °C | Wx | BWF | Vis. (km) |
| E1 | 7-Jul-11 | 5:23 | 18:04 | 7:03 | 6:05 | 27 | 29 | C | 1 | 25+ | 14:05 | 28.5 | 29.5 | O | 2 | 25+ |
| E2 | 9-Jul-11 | 5:24 | 18:04 | 8:52 | 6:00 | 27 | 29.5 | C | 2 | 25+ | 14:50 | 29 | 30 | O | 2 | 25+ |
| E3 | 10-Jul-11 | 5:24 | 18:04 | 9:53 | 6:30 | 27 | 29 | R | 1 | 15+ | 12:40 | 27 | 29 | O | 1 | 25+ |
| E4 | 12-Jul-11 | 5:25 | 18:05 | 12:01 | 8:55 | 28.5 | 28.5 | O | 2 | 15+ | 14:05 | 29 | 30 | O | 3 | 15+ |
| E5 | 14-Jul-11 | 5:25 | 18:04 | 1:41 | 4:45 | 25 | 28 | O | 1 | 1+ | 12:40 | 24.5 | 28 | R | 1 | 1+ |
| E6 | 17-Jul-11 | 5:26 | 18:04 | 4:06 | 5:40 | 24 | 27 | R | 1 | 1+ | 13:40 | 27.5 | 29 | O | 2 | 25+ |
| E7 | 18-Jul-11 | 5:26 | 18:04 | 4:48 | 5:45 | 23.5 | 26.5 | C | 1 | 15+ | 14:10 | 31 | 30 | C | 2 | 25+ |
| E8 | 20-Jul-11 | 5:26 | 18:04 | 18:21 | 15:10 | 27 | 29.5 | O | 1 | 15+ | 0:30 | 28 | 27.5 | C | 1 | 15+ |
| E9 | 21-Jul-11 | 5:27 | 18:04 | 6:47 | 8:40 | 29 | 28.5 | C | 2 | 25+ | 15:35 | 31 | 30 | C | 2 | 25+ |
| E10 | 23-Jul-11 | 5:27 | 18:04 | 8:12 | 4:10 | 24.5 | 28 | C | 2 | 1+ | 11:35 | 31 | 30.5 | C | 1 | 25+ |
| E11 | 24-Jul-11 | 5:27 | 18:04 | 9:00 | 5:00 | 26 | 28.5 | C | 1 | 15+ | 13:05 | 30 | 31 | O | 1 | 15+ |
| E12 | 27-Jul-11 | 5:28 | 18:03 | 11:54 | 7:50 | 30 | 29.5 | C | 1 | 25+ | 15:25 | 30 | 30 | C | 2 | 15+ |
| E13 | 31-Jul-11 | 5:28 | 18:02 | 2:57 | 5:50 | 26 | 27.5 | O | 2 | 15+ | 15:10 | 29.5 | 29 | C | 2 | 15+ |
| E14 | 2-Aug-11 | 5:29 | 18:02 | 4:22 | 6:10 | 26 | 28 | R | 1 | 15+ | 14:35 | 28.5 | 30 | C | 3 | 15+ |
| E15 | 3-Aug-11 | 5:29 | 18:01 | 5:06 | 5:50 | 27 | 28.5 | C | 1 | 15+ | 14:25 | 27.5 | 29 | R | 1 | 25+ |
| E16 | 5-Aug-11 | 5:29 | 18:01 | 6:40 | 6:55 | 28 | 29.5 | C | 1 | 25+ | 15:05 | 29 | 30.5 | C | 2 | 25+ |
| E17 | 7-Aug-11 | 5:29 | 18:00 | 8:29 | 5:05 | 26 | 29.5 | C | 1 | 15+ | 12:20 | 29.5 | 30.5 | O | 2 | 15+ |
| E18 | 8-Aug-11 | 5:29 | 18:00 | 9:30 | 5:40 | 25 | 28.5 | C | 1 | 25+ | 13:15 | 30 | 31 | C | 1 | 25+ |
| E19 | 10-Aug-11 | 5:29 | 17:59 | 11:50 | 7:05 | 30 | 29 | C | 1 | 15+ | 15:15 | 29.5 | 30.5 | R | 1 | 15+ |
| E20 | 12-Aug-11 | 5:30 | 17:58 | 1:30 | 6:45 | 25 | 28 | C | 2 | 15+ | 13:35 | 28 | 30 | O | 2 | 25+ |
| E21 | 13-Aug-11 | 5:30 | 17:58 | 2:19 | 5:30 | 25 | 28 | C | 1 | 15+ | 12:50 | 28.5 | 30 | O | 1 | 15+ |
| E22 | 19-Aug-11 | 5:30 | 17:55 | 6:07 | 5:20 | 25 | 28 | C | 2 | 15+ | 12:20 | 28 | 29.5 | C | 2 | 25+ |
| E23 | 20-Aug-11 | 5:30 | 17:54 | 6:44 | 4:55 | 24.5 | 27 | O | 2 | 1+ | 11:10 | 30 | 30 | O | 2 | 25+ |
| E24 | 22-Aug-11 | 5:30 | 17:53 | 8:12 | 5:15 | 24 | 27 | C | 1 | 25+ | 13:10 | 30 | 31.5 | C | 2 | 25+ |
| E25 | 25-Aug-11 | 5:30 | 17:52 | 11:20 | 5:00 | 23.5 | 27 | O | 1 | 15+ | 11:25 | 26.5 | 28 | R | 2 | 25+ |

KEYS
Weather (Wx): X = Clear C = Clouds O = Overcast W = Wind R = Rain
Beauford Wind Force (BWF): 1 = ripples 2 = small wavelets 3 = smooth wavelets 4 = small wavecaps 5 = moderate wavecaps, some spray

WHALES

As in 2010, Humpback whales, *Megaptera novaeangliae*, were observed inside Golfo Dulce. Photos and/or video were captured in 100% of the rainy season sightings.

Humpback whale, *Megaptera novaeangliae*

Humpback whales annually migrate from colder feeding grounds to warmer equatorial breeding/birthing grounds and the waters around the Osa Peninsula are the only place in the world where a spatial overlap has been documented for Humpbacks from both northern and southern hemispheres (Acevedo & Smultea, 1995; Rasmussen *et al.*, 2007; Oviedo & Solís, 2008). The number of Humpbacks from the North Pacific Ocean generally peaks in Golfo Dulce during January and February (Calambokidis *et al.*, 1999) and their presence was confirmed inside the embayment during those dry season months (Bessesen, 2010). Humpbacks from the Southern Ocean normally arrive in the gulf during July and August and we did also record sightings of the species during the rainy season survey. Although no individual whales were identified or traced to specific wintering grounds, our data presumably corroborate that both Northern Humpbacks and Southern Humpbacks

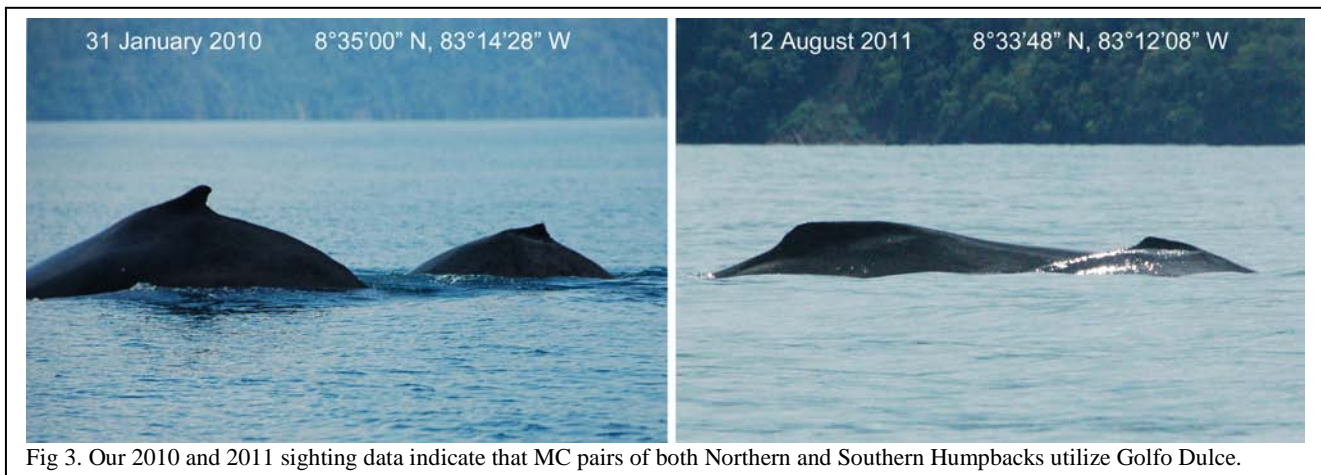


Fig 3. Our 2010 and 2011 sighting data indicate that MC pairs of both Northern and Southern Humpbacks utilize Golfo Dulce.

utilize Golfo Dulce during their breeding/birthing seasons (Fig. 3). In 2010, interviewees stated that more whales can be seen during the rainy season than the dry season. Our bi-seasonal findings concurred, suggesting that more Southern Humpbacks use the gulf than those from the northern hemisphere. (Fig. 4)

We recorded 11 Humpback whale sightings during rainy season survey, representing 20 individuals seen as singletons (S), mother-calf (MC) pairs or mother-calf-escort (MCE) groups. During the study period, we also received 11 supplementary reports of Humpback whale sightings inside Golfo Dulce, which occurred on days that we did not make observations.

Bathymetric conditions around the Osa Peninsula appear conducive for breeding of *M. novaeangliae* (Oviedo & Solís, 2008) and Golfo Dulce may serve as a calving ground and nursery for this rorqual whale. At least two Humpback whale births occurred within the confines of Golfo Dulce during the rainy season study period per reports from first-hand witnesses and separate sightings of lactation were observed (Bessesen, in prep; Marquez-Artavía, per. com.). Other Humpback behaviors included traveling, resting, milling, breaching and spyhopping. Some long localized dive cycles seemed reminiscent of “breath-holding” where whales hang relatively motionless at depth, a behavior personally observed off the west coast of Maui, Hawaii. Unfortunately, poor underwater visibility disallowed verification of subsurface activity in Golfo Dulce.

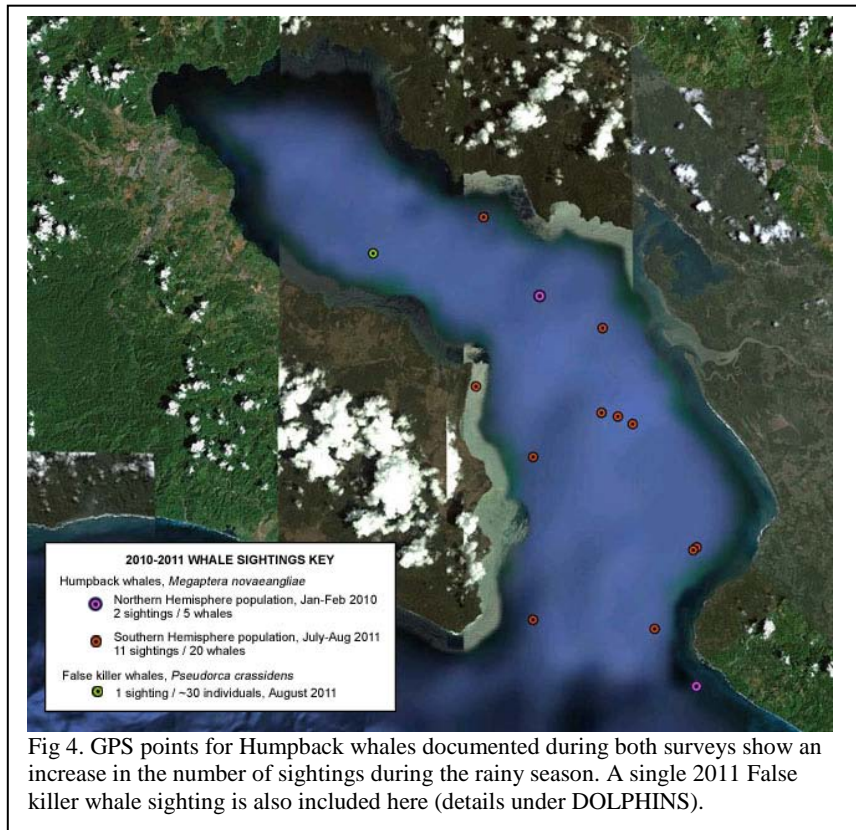


Fig 4. GPS points for Humpback whales documented during both surveys show an increase in the number of sightings during the rainy season. A single 2011 False killer whale sighting is also included here (details under DOLPHINS).

DOLPHINS

Sixty-five dolphin sightings were documented during our rainy season survey, representing approximately 1300 dolphins. Of those sightings, 72% (47 sightings, ~300 dolphins) were Bottlenose dolphins, *Turciops truncatus*, 26% (17 sightings, ~980 dolphins) were Pantropical Spotted dolphins, *Stenella attenuata*, and 2% (1 sighting, ~30 dolphins) were False killer whales, *Pseudorca crassidens*. During both seasonal surveys, Bottlenose dolphins were found more coastally while Spotted dolphins tended to range through the gulf’s deeper waters (Fig. 5A-B). The sympatric existence of these two species appears to be based on non-competing diets as well as habitat partitioning (Acevedo-Gutiérrez & Burkhart, 1998; Oviedo, 2007).

Bottlenose dolphin, *Turciops truncatus*

Bottlenose dolphins remained the most frequently encountered cetacean in Golfo Dulce and were often seen chasing ballyhoo and needlefish at the surface, as well as diving for sardines and other small fish. This species appeared to shift more northerly during the rainy season, although there remained regular sightings near Puerto Jiménez and Rio Coto. The Bottlenose dolphins in Golfo Dulce are generally thought to be residential; however, some movement patterns and the appearance/disappearance of certain individuals over the biseasonal study periods suggest the population may also contain non-residents.

Mating was observed and several MC pairs were recorded, including one newborn calf that was documented within hours of birth traveling with a large, tightly cohesive group. Bottlenose dolphins were commonly found in small groups of 2-3, but appeared to converge into larger congregations of 5-20 more often than during the dry season. The social fission-fusion dynamics were also more conspicuous. In the early morning hours of 12

August, we came upon a semi-scattered herd of at least 40 Bottlenose dolphins, milling and foraging near Golfito Bay. It was the largest group of *T. truncatus* sighted during our surveys.

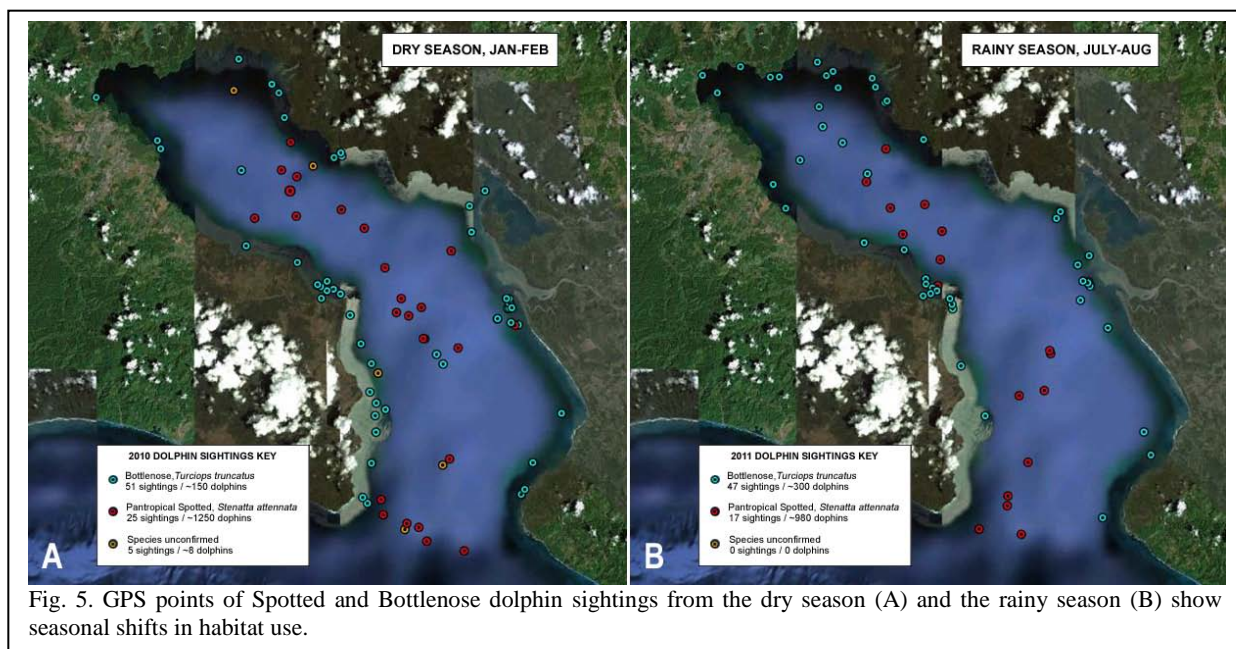


Fig. 5. GPS points of Spotted and Bottlenose dolphin sightings from the dry season (A) and the rainy season (B) show seasonal shifts in habitat use.

Photo-identification of Bottlenose dolphins

To date, we have identified ~80 individual Bottlenose dolphins in Golfo Dulce using photographs of distinctive dorsal shapes, fin cuts, natural skin markings and scars, a technique employed by other biologists in a diverse array of habitats (Würsig & Würsig, 1977; Acevedo, 1991; Maze & Würsig, 1999; Weir *et al.*, 2008). Our original photographic set allowed us to catalog more than 40 individual Bottlenose dolphins and mark movements and social interactions for a few individuals within the gulf (Bessesen, 2010). In 2011, we garnered photographs for 94% of our Bottlenose dolphin sightings, permitting us to roughly double the number of identified dolphins. In addition to distinguishing new individuals, many of the previously cataloged dolphins were photographically recaptured, some several times during the course of the study. This data may allow us to chart associations among dolphins, potentially revealing insight into the prevalence and progression of skin disease within the larger population.

Skin disease in Bottlenose dolphins

Skin lesions have been seen on several Bottlenose dolphins in Golfo Dulce (Fig. 6; Bessesen, 2010; Oviedo, per. com.; Acevedo, per. com). Consulting experts and literature suggest the lesions are characteristic of lobomycosis-like disease, or LLD. Lobomycosis, also known as lacaziosis, is a chronic dermal fungus of emerging concern for cetaceans in many countries (Burdett Hart *et al.*, 2010; Kiszka *et al.*, 2009; Bermudez *et al.*, 2009), which may be associated with chemical or organic pollutants (Van Bressema *et al.*, 2007). Bottlenose dolphins tend to forage around river outlets in Golfo Dulce and it is possible that runoff from human-related activities is causing a decline in water condition. If so, *T. truncatus* may serve as an indicator species for critical environmental issues (Wells *et al.*, 2004). Therefore, studies that address skin disease in dolphins and anthropogenic impacts to water sources around the gulf should be given high priority.

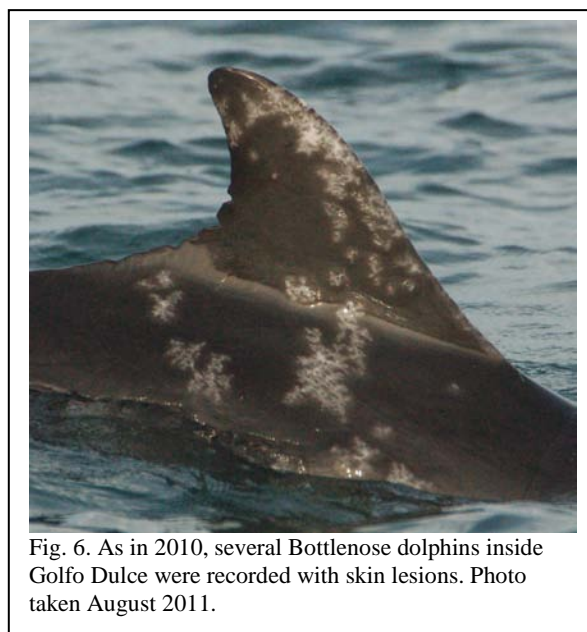


Fig. 6. As in 2010, several Bottlenose dolphins inside Golfo Dulce were recorded with skin lesions. Photo taken August 2011.

Pantropical Spotted dolphin, *Stenella attenuata*

Comparatively speaking, Pantropical Spotted dolphins were seen less frequently and average group size was smaller during the rainy season. Despite documenting four large scattered herds with numbers between 150 and 400 individuals, 59% of our rainy season sightings (10 of 17) were estimated at ≤ 15 individuals. We also noted a substantial increase in the number of MC pairs. Yet, the most significant variance between seasonal findings was behavioral. The Pantropical Spotted dolphins, which were typically playful and interactive in the dry season, tended to keep distance from approaching vessels, especially when in fewer numbers and/or when calves were present. In keeping with our dry season data, this species was never observed in the most northerly quadrant of the embayment.

False killer whale, *Pseudorca crassidens*

A sighting of large delphinids, False killer whales, *Pseudorca crassidens*, was made during the rainy season study period while aboard the vessel of Project Golfo Dulce Wildlife, an institutionalized research initiative that targets habitat assessment based on the ecology of cetaceans and other marine megafauna. An estimated 30 individuals, including adults and at least one calf, were observed traveling and foraging in mid-coastal waters between Sándalo and Playa Blanca in the upper half of the gulf (Fig. 4). This species has previously been recorded inside Golfo Dulce (Acevedo-Gutierrez *et al.*, 1997; Herra-Miranda, per. com) and may be seen in Costa Rica's Pacific waters more frequently during the rainy season than the dry season (Martínez-Fernández *et al.*, 2011).

SEA TURTLES

Four species of sea turtle are known to utilize Golfo Dulce: the "Pacific Black" Green sea turtle, *Chelonia mydas agassizii*, the Olive Ridley sea turtle, *Lepidochelys olivacea*, the Hawksbill sea turtle, *Eretmochel*

imbricate, and the near-extinct Pacific Leatherback sea turtle, *Dermochelys coriacea* (Bessesen, 2010). It is suggested that the intensive use of Costa Rican beaches by sea turtles is due in part to the geographical location of the country's landmass relative to ocean currents (Richard & Hughes, 1972).

During the rainy season survey, we documented 96 sea turtle sightings, representing >200 sea turtles. Of those sightings, 49% (47) were Green/Black sea turtles, 19% (18) were Olive Ridley, and 6% (6) were Hawksbills. In 25% (24) of the sightings, we were unable to confirm the species (Fig.7).

"Pacific Black" Green sea turtle, *Chelonia mydas agassizii*

To retain taxonomic consistency with the previous

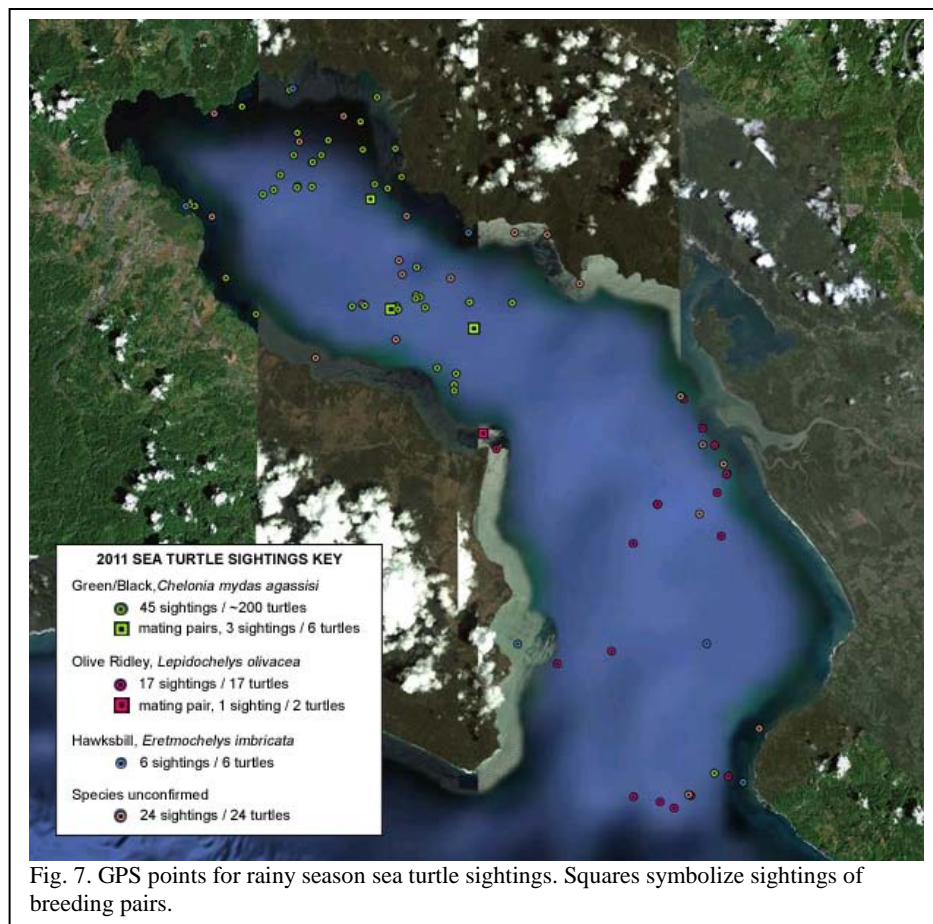


Fig. 7. GPS points for rainy season sea turtle sightings. Squares symbolize sightings of breeding pairs.

report, this species shall be referred to as the Green/Black sea turtle with the scientific name cited as *Chelonia mydas agassizii*. Discovering great numbers of Green/Black sea turtles in Golfo Dulce was one of the most profound findings of 2010. At that time, we also discovered an area of turtle grass where we reliably

encountered this species. In 2011, we once again documented an abundance of Green/Black sea turtles inside the embayment. Mating behavior and use of the sea grass feeding site was recorded; thus, our combined 2010-2011 data show Golfo Dulce to be a year-round breeding and feeding ground for endangered Green/Black sea turtles.

Olive Ridley sea turtle, *Lepidochelys olivacea*

Although some amount of nesting may occur throughout the year, the primary nesting period for Olive Ridley sea turtles in Costa Rica is from July to December (Richard & Hughes, 1972); therefore, an increase in sightings for this species was anticipated for the rainy season survey. Indeed, the numbers and frequency of sightings did rise progressively throughout the study, from 6 sightings of *L. olivacea* in July to 12 sightings in August. In total, 19 Olive Ridley sea turtles were documented, including a mating pair observed on 8 August at 12:55 about 2 km offshore from Puerto Jimenez (Fig. 8). All of the 2011 Olive Ridley sea turtle sightings occurred in lower half of the gulf, as did sightings in 2010, suggesting it is the principal sector for this endangered species within Golfo Dulce.



Fig. 8. Olive ridley sea turtles mating off the shores of Puerto Jimenez.

Hawksbill sea turtle, *Eretmochelys imbricata*

Recent research has confirmed Hawksbill sea turtle nesting in Golfo Dulce on the beaches of Platanares, Sombrero and Punta Banco. Other sites in the embayment, such as Los Mogos, may also support nesting activity (WIDECAS, 2010). This species is listed as *Critically Endangered* by the International Union for Conservation of Nature, IUCN (The Red List, 2011), and data suggest considerable declines threaten imminent extirpation of the Eastern Pacific population (Gaos *et al.*, 2010). We recorded 6 Hawksbill turtles during the rainy season survey, two more than we saw in the dry season. As described in the 2010 report, *E. imbricata* was found close to the shoreline in various locations around Golfo Dulce. We did see at least one Hawksbill sea turtle swimming near a broad stretch of mangroves, which has been described as emerging habitat for the species. (Gaos *et al.*, 2011)

WHALE SHARKS

Whale sharks, *Rhinocodon typus*, aggregate inside Golfo Dulce. Several 2010 interviewees reported historical sightings of more than twenty sharks at a time. The scientific community became aware of this remarkable occurrence only a decade ago and Hanna (2007) suggested a recent reduction in whale shark sightings in Golfo Dulce. IUCN's 2005 assessment of this *Vulnerable* species stated, "...there are now concerns that Whale Shark populations are decreasing in many locations as a result of stock depletion by unregulated fisheries (The Red List, 2011)." Although we did not document any first-hand whale shark sightings during our rainy season survey, 3 sightings of this species were reported to us during the study period. Each shark was described as a juvenile or smaller than adult size, traveling alone inside Golfo Dulce. While overall numbers are perhaps declining, it is clear whale sharks still make use of the embayment.

PELAGIC SEA SNAKES

The **pelagic sea snake, *Pelamis platurus***, is the only sea snake found on the Pacific side of Costa Rica. This species normally displays some variation of black dorsal coloration with yellow-brown ventrolateral surfaces and black posterior spots or bands. However, all-yellow sea snakes have also been observed in Golfo Dulce (Kropach, 1975; Solórzano, 2011). To characterize these two color variations during our dry season survey, we logged typical striated specimens by the common name "Yellow-bellied" and all-yellow or predominantly yellow specimens as "Xanthic". While Yellow-bellied sea snakes were documented near the entrance of the inlet, our 2010 distribution data showed the upper half of Golfo Dulce to be populated exclusively by Xanthic sea snakes (Fig. 9A-B). Furthermore, GPS sighting points showed a spatial gap greater than 21 km separating the two groups. Behavioral discrepancies between Yellow-bellied and Xanthic sea snakes were also noted.

These findings suggest the Xanthic colony is resident and may be genetically disjunct from the broader Pacific population (Bessesen, in press). Despite being the most widely ranging snake in the world (Pickwell & Culotta, 1980), an all-yellow colony of *P. platurus* has never been described elsewhere. In 2010-2011, we logged a total of 68 Xanthic pelagic sea snakes, including several juveniles. It is interesting to note that Xanthic snakes were seen year-round, while Yellow-bellied sea snakes were only seen during the dry season.

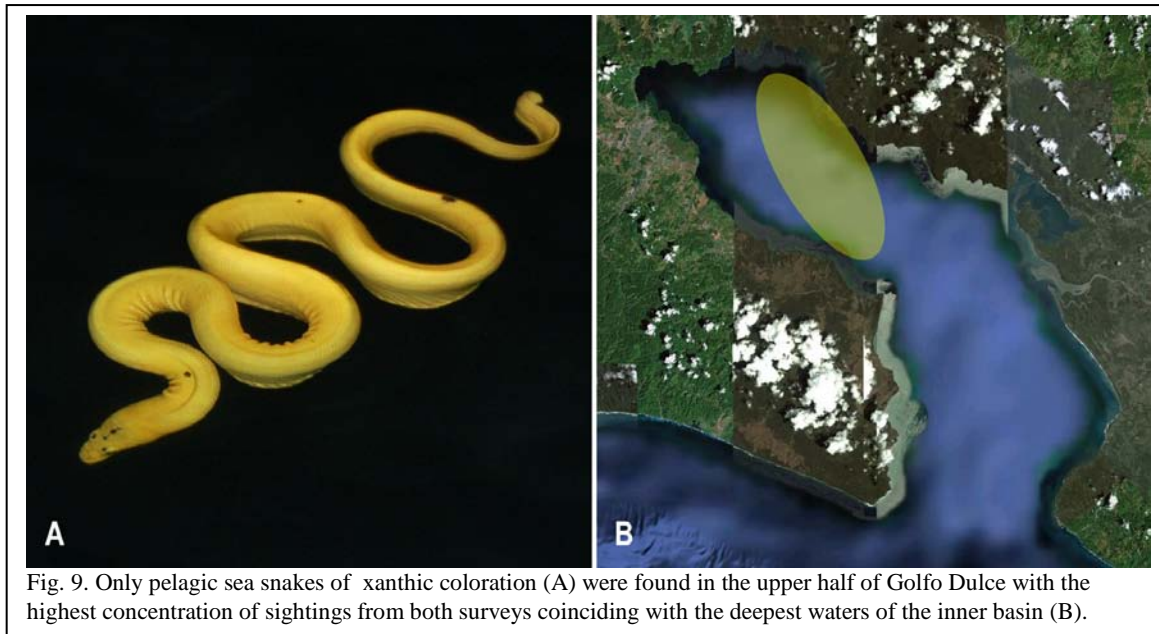


Fig. 9. Only pelagic sea snakes of xanthic coloration (A) were found in the upper half of Golfo Dulce with the highest concentration of sightings from both surveys coinciding with the deepest waters of the inner basin (B).

OTHER SPECIES

Several significant sightings of non-focus species were documented. Here, we share a few which may be of consequence in describing the ecology of Golfo Dulce. We note that during our survey(s) many additional marine animals were seen but not officially logged, including a wide array of birds, fishes and invertebrates (refer to the 2010 report for more detailed lists).

American crocodile, *Crocodylus acutus*

American crocodiles, *Crocodylus acutus*, and Caiman crocodiles, *Caiman crocodylus*, were previously observed in the Golfo Dulce estuaries of Esquinas and Platanares (Bessesen, 2010). These species inhabit the brackish waters and mangrove roots of the Osa region and may be found in all the rivers that feed into Golfo Dulce (Largaespada, per. com.). During the 2011 rainy season survey, 2 American crocodiles were documented in the open waters of Golfo Dulce. One was seen swimming just north of the Puerto Jimenez marina. Although distance disallowed accurate estimation of its length, that individual appeared to be of adult size. The other was a juvenile approximately 1.6 m in length, which was found dead, floating off the mangrove shores above Cañaza (Fig. 11B). A gross visual examination was conducted on-site but no signs of illness or injury were detected and cause of death remains unknown.

Scalloped hammerhead, *Sphyrna lewini*

In 2010-2011, we recorded a total of 5 shark sightings inside Golfo Dulce, representing three species: Tiger shark, *Galeocerdo cuvier*, Bull shark, *Carcharhinus leucas*, and Scalloped hammerhead shark, *Sphyrna lewini* (Fig. 11C). While two of the sharks were relatively large (the Bull and one Tiger), the other three were small and presumed juveniles, including one tiny Scalloped hammerhead found decapitated, most likely with a machete. Our sightings may support claims that Golfo Dulce is a critical habitat for young sharks. With the assistance of local fisherman, Misión Tiburón—a Costa Rican NGO that promotes research, management and conservation of sharks and other marine life—recently identified Golfo Dulce as “an important nursery area for [endangered Scalloped hammerhead sharks]” and is currently tagging *S. lewini* in the embayment (López, per. com.). Several species of ray were also observed during the survey periods (Fig. 11D).

Needlefish, *Tylosurus acus pacificus*

Two species of needlefish are known to spawn inside Golfo Dulce: *Tylosurus crocodilus fodiator* and *Tylosurus acus pacificus*. For *T. acus pacificus*, monthly spawning events take place at thirteen recognized spawning sites in the upper gulf, beginning 5 days after the full moon and continuing for 3 consecutive days (Bernal, 2008). As previously suggested, needlefish appear to be a key food source for the local population of Bottlenose dolphins. On 20 July 2011, we made a special trip to the upper reaches of Golfo Dulce to observe a needlefish spawning event. We arrived at the eastern shore of Mogos Island exactly at sunset (18:04) and 17 minutes before high tide (18:21). Abeam the beach the water surface was white and frothy, marking the presence of needlefish sperm. Several fishermen were standing in the shallows with machetes and employing fishing lines from boats, presumably attempting to capture the amassing fish. While continuing our larger-scale survey throughout the night, needlefish were observed in the area around Mogos Island. When we returned to the same eastern shoreline at on 21 July at 01:20, after the tide had dropped, we documented needlefish eggs, presumably fertilized ovum, strewn along the exposed beach (Fig.10; Fig. 11A).



Fig. 10 *T. acus pacificus* larva hatch at 10-13 days of development and wash back to sea as fry (Bernal, 2008).

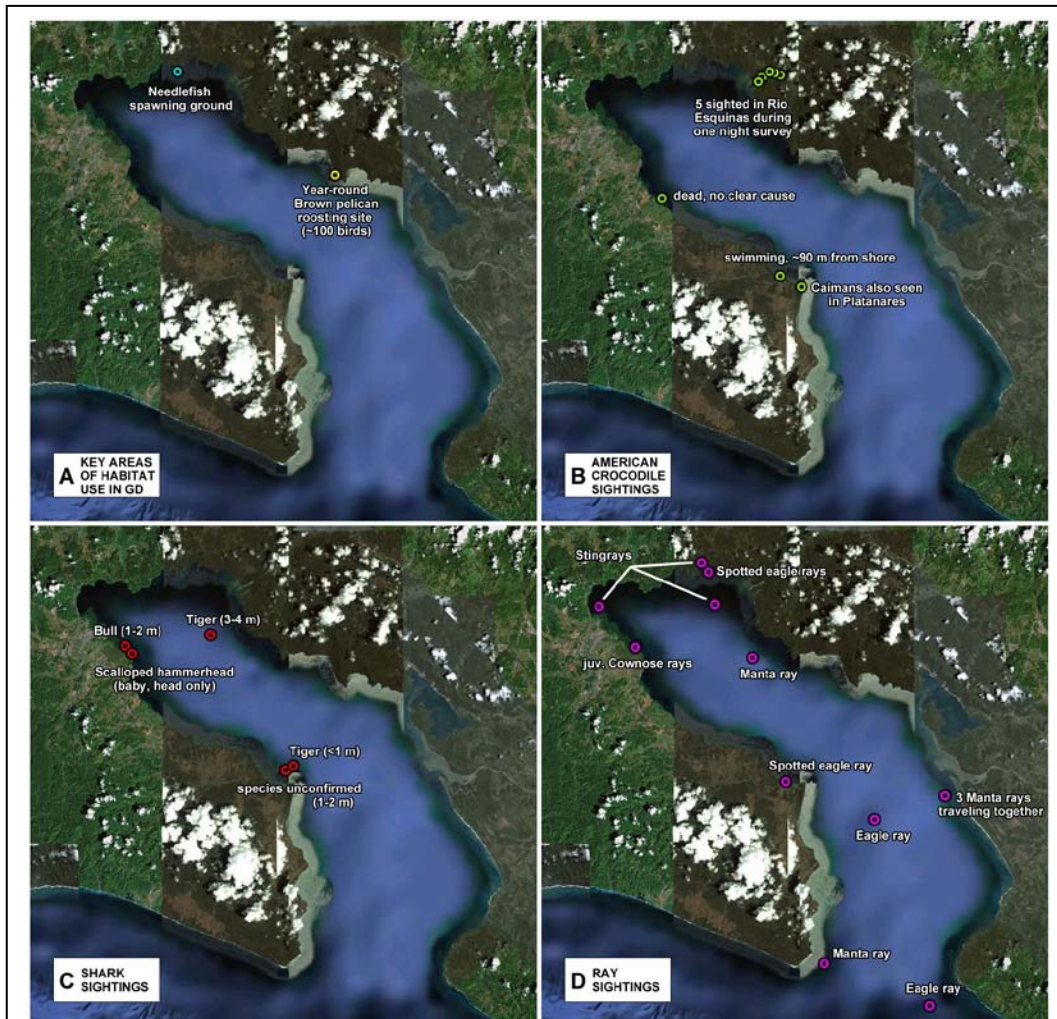


Fig. 11. Along the highest shores of Golfo Dulce, needlefish spawn and pelicans roost (A). Sightings from 2010-2011 also show use of the embayment by several other species of interest, including crocodiles (B), sharks (C) and rays (D).

Brown pelican, *Pelecanus occidentalis*

We have documented a year-round communal roosting area for Brown pelicans, *Pelecanus occidentalis* along the banks of Piedras Blancas National Park in the upper half of Golfo Dulce (Fig. 11A). On 25 January 2010 at 07:58, 82 pelicans were counted among the treetops of a shoreline area stretching approximately 200 m. Others were lifting from their perches and we estimated a total of 100 pelicans in the area. Again on 31 July 2011 we encountered Brown pelicans roosting in same location. The time was 08:32 and 100 pelicans were counted, with a maximum estimate of 150 individuals. While sunrise counts appear indicative of nighttime roosting numbers (Jaques *et al.*, 1996), we arrived slightly late to suggest accurate numbers for this roosting population.

UPDATE ON CONSERVATION IN GOLFO DULCE

Marine Area for Responsible Fisheries

Since our last report, important changes have occurred relating to the management of fisheries inside Golfo Dulce. In October 2010, Instituto Costarricense de Pesca y Acuicultura, INCOPECA, declared Golfo Dulce a Marine Area for Responsible Fishing. This directive delineates zones within the embayment and describes fishing regulations for those zones (La Gaceta, 2010) with the goal of increasing and stabilizing naturally occurring stocks. It should be noted that while conducting the rainy-season survey we observed fishing boats working in unauthorized waters and local fishermen reported limited enforcement of the new laws and suspicions of illicit trawling and long-lining, especially during nighttime hours. Long-term studies of fishery populations will be necessary to determine the efficacy of the Marine Area for Responsible Fishing directive on the ecological sustainability of Golfo Dulce.

Sea turtle hospital in Playa Blanca

Seventeen Olive Ridley sea turtles exhibiting severe illness were discovered along the Osa Peninsula in 2010. The turtles, 4 males and 13 females of varying size, were taken into captivity for evaluation and treatment by WIDECAS (2010), a sea turtle organization working on both the Pacific and Caribbean sides of Costa Rica. Final blood results, diagnosis and recovery statistics show kidney damage and anemia. All the turtles had ectoparasites over their bodies, suggesting they had been floating for weeks at the surface of the Pacific Ocean.

WIDECAS has since opened a sea turtle hospital in the pueblo of Playa Blanca near the upper west banks of Golfo Dulce. The Rescue and Conservation Center is designed to serve sick turtles and assist chelonid research in the area (Chacón, per. com.). WIDECAS is currently involved in a long term research to study some biological and ecological parameters of the newly discovered Green/Black sea turtles at the feeding grounds in Golfo Dulce using a “catch, study and release” technique, which includes net captures, sampling of tissues and attachment of satellite transmitters (Chacón *et al.*, 2011). They are also working with Pacific Hawksbill sea turtles at the same locations. The current study has 195 tagged turtles with just 5% of tags returned (Chacón, per. com.).

Yellowfin Tuna Farm at Punta Banco

Plans to construct a Yellowfin tuna farm near the mouth of Golfo Dulce were officially terminated by the Costa Rican Environmental Secretariat on 7 November 2011 (SETENA, 2011). Since 2004, a foreign interest conglomerate termed Granjas Atuneras de Golfito S. A. has worked toward the development of an aquaculture site off the shores of Punta Banco. The project received environmental permits from the Costa Rican government in 2005 only to be suspended by a Supreme Court order in 2007 ordering the company to conduct a marine current study to address the project’s environmental viability. Though no study was ever performed, the government reapproved the project in 2008 (SETENA, 2008) and when attempts to continue the approval process met strong resistance, the company asked for and received a one-year deferment in 2010.

SETENA’s 2011 resolution ended negotiations with Granjas Atuneras de Golfito S. A., citing a lack of required environmental assessments pertaining to the earlier Supreme Court order, intense community opposition, legal objections by NGOs, and falsification of documents showing support from local community members. The announcement surely came as a relief to many interested parties. However, it has been suggested that “recent free trade agreements with China could provide an economic catalyst for future aquaculture projects” (Bystrom, per. com.). China’s seafood imports have soared in recent years and its trade agreements with Costa Rica allow for the purchase of Costa Rican farm raised tuna (TLC, 2009).

CONCLUSIONS

The 2011 extension survey in Golfo Dulce, Costa Rica illuminated details regarding which fauna utilize the gulf during the rainy season months of July and August. Moreover, the resulting data expanded upon and gave valuable perspective to the dry season findings of 2010, exposing shifts and consistencies in seasonal distribution. While many researchers have undertaken specialized studies of particular species, our goal has been to collect and share data that might provide an overview of the gulf as a dynamic marine habitat through the abundant and varied sea life that symbolizes its ecology. Indeed, we were astounded by the intense biodiversity revealed to us during our research.

Golfo Dulce is a true bio-gem, one of Costa Rica's preeminent riches. Sea turtles—including several hundred Green/Black sea turtles, critically endangered Hawksbill sea turtles, Olive Ridley sea turtles and (reportedly) Pacific Leatherback sea turtles—rest, feed, mate and/or nest in the gulf. A rare xanthic colony of pelagic sea snakes progenerates in the inner basin. Both Northern and Southern Humpback whales enter the inlet to give birth and possibly provide sanctuary for young calves. Whale sharks aggregate in Golfo Dulce. Resident dolphins and other toothed cetaceans breed and raise offspring. Scalloped hammerhead sharks are born there and needlefish spawn. This remarkably vibrant bionetwork appears to play a considerable role in the reproductive success of a multitude of species and the embayment's welfare may impact the broader eastern Pacific ecology. Biologists are currently collecting and publishing data for several flagship conservation species with power to influence environmental policy (Oviedo C. *et al.*, 2009; Artavía *et al.*, 2011; Chacón *et al.*, 2011). Their research results are sure to be both exciting and enlightening.

Vital marine ecosystems around the world are breaking down at alarming rates. Change comes quickly and sound management strategies often come too late to fully preserve the balance that affords sustainability. Golfo Dulce is on the cusp of change. It is true that great strides have already been taken to safeguard this rare tropical fiord and we hope efforts toward prudent stewardship continue to ensure active *in situ* conservation. Yet, as the Osa region grows in popularity and population, competition for resources will undoubtedly intensify. The delicate gulf ecosystem will need to cope with escalating pressures from urbanization, commercial development, special interests, and tourism. Incurred damage could prove irremediable. For that reason and based on the breadth of our research, including numerous local interviews, hundreds of hours of survey data and discussions with leading biologists, it is recommended that Golfo Dulce be considered for designation as a Costa Rican Marine Protected Area (MPA) to secure its future as an internationally recognized natural treasure.

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