Project Report and Summary of Multi-Species Marine Sighting Survey in Golfo Dulce, Costa Rica, January – February 2010

Sponsored by Friends of the Osa, PO Box 5482-03, Puerto Jiménez, Costa Rica.

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INTRODUCTION

Golfo Dulce is a curved tropical fiord-like embayment located along the south Pacific coast of Costa Rica. It is held against the mainland by the Osa Peninsula and four main rivers supply fresh water into the embayment: Rincon, Esquinas, Tigre and Coto Colorado (Fig. 1). The gulf is approximately 50 km in length and 10-15 km wide with an effective sill of about 60 m. Inner basin waters are just over 200 m in depth (Svendsen *et al.* 2006), although the gulf's deepest waters are reported by local fishermen and guides to surpass 300-400 m in the cratered center of Rincon Bay at the most northwesterly point of the gulf. Like the Osa Peninsula, which remains home to many key tropical species—jaguars, scarlet macaws, tapirs and red-backed squirrel monkeys—Golfo Dulce supports an abundance of critical wildlife. Current calculations show a total of 4,745 marine species in Costa Rica's Pacific waters, more than double the number reported from the Caribbean side of the country (Wehrtmann & Cortés 2009).

Fig. 1. Sketch of Costa Rica with zoom of Golfo Dulce showing main rivers and position of two large pueblos, Puerto Jimenez (P.J.) and Golfito.

This pilot project was designed to collect baseline data regarding the marine species that enter or reside in Golfo Dulce during the dry season months of January and February, and to determine spatial distribution for species seen during the study period. I was the principal investigator, and my research assistant and boat captain was Jorge Largaespada. Jorge is Costa Rican and has over 35 years experience living on the Osa Peninsula, working and fishing in Golfo Dulce. He currently works as a guide and was employed for his extensive knowledge of regional fauna. Our survey effort utilized two avenues of data collection, both essential to the findings. First, interviews with local fishermen and tour boat guides garnered preliminary relative abundance data for several flagship marine species. Second, we undertook 30 daily on-water surveys of the gulf, recording our own first-hand sightings.

Escalating pressure on the gulf ecosystem due to established and developing fishing practices, as well as coastal industry and urbanization, has increased the vulnerability of biodiversity in Golfo Dulce and the need for data that may aid discussions about the future of the habitat. In a recent publication about marine biodiversity in Costa Rica, research associate and chapter author Dr. Laura May-Collado recommends a push for additional marine studies across Central America. She writes, "[Costa Rica] is an excellent place to conduct baseline information studies (eg. habitat use, distribution patterns, abundance estimates). There is a need for basic information to support establishment of appropriate conservation and management regulations." This is one such study and, as many details about the embayment's fauna have not been previously published, we have valuable information to share about individual species encountered during our survey, as well as insight into the status of conservation in the gulf region based on communications with the local people.

MATERIALS and METHODS

During preliminary interviews we asked 82 local commercial fishermen, sport-tourist fishermen and tour boat guides ("interviewees") a few brief questions about their work experience in Golfo Dulce with specific

inquiry as to how often they see five key marine species: whales, dolphins, sea turtles, whale sharks, and pelagic sea snakes. Interviewees also had the option to describe where and which species they most often see. Responses were recorded onto interview forms.

For the 30-day on-water survey effort, we recorded our own first-hand marine sightings in Golfo Dulce. Sightings, labeled "S", were numbered in chronological order (S1, S2, S3, etc.). Each sighting comprised all individuals of the same species seen in the same area at the same time. Therefore, a reported sighting could represent a single animal or multiple animals (Examples: S112 = five Bottlenose dolphins, S132 = one Manta ray, S160 = four Green/Black sea turtles).

Fig. 2. Demarkation of survey areas GA1-4. GA5 represents waters outside Golfo Dulce.
GA1 = ↑ Cañaza 8°35'41.18"N, 83°24'2.22"W / Esquinas 8°43'14.73"N, 83°19'53.92"W
GA2 = ↑ PJ 8°32'32.87"N, 83°18'13.73"W / Golfito 8°37'18.06"N, 83°10'55.50"W
GA3 = ↑ Tamales 8°27'7.51"N, 83°16'55.11"W / Pavones 8°25'13.15"N, 83° 6'30.87"W
GA4 = ↑ Matapalo 8°22'27.17"N, 83°17'26.19"W / Pt Banco 8°21'58.70"N, 83° 8'44.05"W
GA5 = ↓GA4 (outside gulf)

Sighting data was collected from a 19-foot panga with a 50 hp Mercury outboard motor. The gulf was divided into four Geographical Areas and labeled GA1-4 with GA5 representing waters outside the embayment (Fig. 2). GA1 and GA4 were smaller in breadth to balance time and fuel consumption, considering distance from the operations base of Puerto Jiménez. Each day we focused on one quadrant, generally employing a rotation of GA1, GA3, GA2, GA4, and traversed the quadrant in a variable pattern attempting to cover as much area as possible. A marine-band radio kept our survey boat in contact with other vessels, often providing information about other boats' sightings around the gulf, although rarely did we deviate from our planned route.

Observation periods typically began just after sunrise and lasted a daily average of 7 hours and 46 minutes, although we did carry out three nighttime surveys. Sightings were logged using Global Positioning System (GPS) and standard data fields were recorded, including time, species, ID reliability (definite/probable/maybe/unconfirmed), group size, proximity to boat, swim direction, behavior and associated fauna. Three cameras were employed to collect photo identification: a Nikon D50 SLR digital camera (with time/date stamp), a small Nikon Coolpix 5200 digital camera with underwater housing, and a Canon GL-1 mini DV prosumer video camera. Daily solar and tidal charts were kept and environmental conditions were logged 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

INTERVIEWS

Of the 82 interviewees polled during this study, 72% (59) were professional fisherman (commercial and/or sport-tourist), 13% (11) worked in non-fishing tourism (boat tours/excursions), and 15% (12) of the subjects did both. Only 2% (2) of the interviewees were female. The average number of work days per week for those polled was 5. The number of years the interviewees had worked in Golfo Dulce ranged from 1-40, but averaged at 12 years.

Overall, interviewees were generous and candid with information. This is noteworthy because the people residing on the shores of Golfo Dulce live "sea to mouth", relying heavily on fauna in the embayment for both livelihood and sustenance. The collective maritime experience of all 82 interviewees was 965 years and their

combined knowledge of endemic and migratory species in Golfo Dulce proved an extraordinary resource of data.

The most easily analyzed aspect of the interviews was the standardized portion, which asked interviewees to estimate how often they see whales, dolphins, sea turtles, whale sharks and yellow pelagic sea snakes in Golfo Dulce. For each of these, they were given the option to answer or circle one of the following choices: Never, Rarely, Occasionally, Frequently, or Always. The reported answers of highest percentage were as follows: 51% of the interviewees reported whales are "occasionally" seen in Golfo Dulce; 68% reported dolphins are "always" seen; 84% of the interviewees reported sea turtles they are either "always" (44%) or "frequently" (40%) seen; whale sharks were reported either "occasionally" or "rarely" by 82% (41% for each); and 44% of interviewees reported yellow pelagic sea snakes were "rarely" seen (Fig. 3).

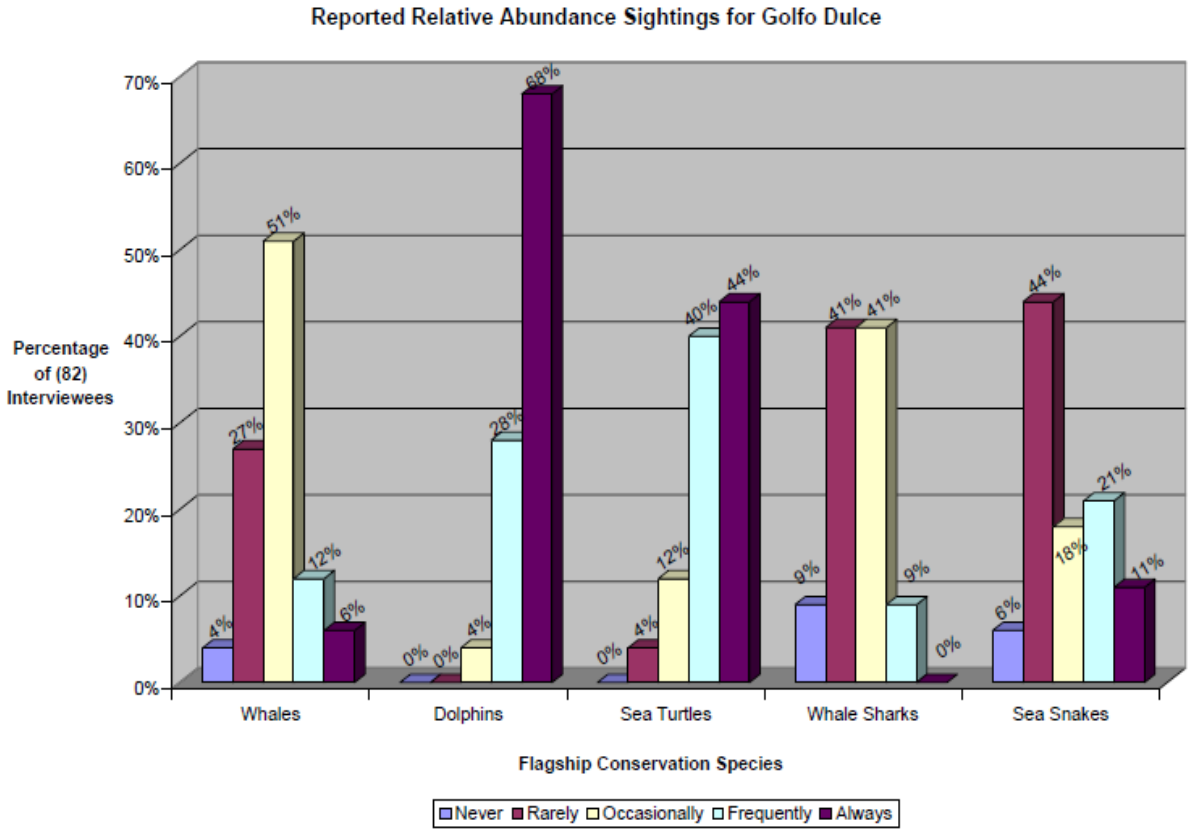

Fig. 3. Graph of interview responses to relative abundance sightings for five marine species in Golfo Dulce.

Written and/or verbally described details provided by interviewees about specific species will be presented alongside our first-hand sighting survey data in the following sections, respectively.

30-DAY SIGHTING SURVEY

A total of 233 observation hours between the dates of January 13th and February 24th, 2010 rendered 234 documented marine sightings. 89% of our observation hours were conducted during daylight hours, the average visibility was greater than 15 km and, for the most part, precipitation was minimal and the water was relatively calm. Our recorded air temperatures averaged 28.6°C and marina sea surface temperatures averaged 30.5°C (Table 1).

Photos and/or video were collected in 76% of all sightings. Dozens of species were seen during the survey period, but those that played most prominently in the study were Humpback whales, *Megaptera novaeangliae*, Bottlenose dolphins, *Turciops truncatus*, Pantropical Spotted dolphins, *Stenella attennata*, Green/Black sea turtles, *Chelonia mydas agassizii*, Olive Ridley sea turtles, *Lepidochelys olivacea*, Hawksbill sea turtles, *Eretmochelys imbricata*, and Yellow-bellied sea snakes, *Pelamis platurus*. The study was marked by a lack of sightings for whale sharks, *Rhinocodon typus*, a species expected inside Golfo Dulce at the time of study.

Table 1. Basic daily environmental data as recorded near the marina of Puerto Jimenez before and after each survey effort. Note: missing temperatures for last three reporting periods are due to a broken thermometer.

					START						END					
Day #	Date	Sunrise	Sunset	High Tide	Time	Air Temp °C	Sea Surf. Temp °C	Wx	BWF	Vis. (km)	Time	Air Temp °C	Sea Surf. Temp °C	Wx	BWF	Vis. (km)
1	13-Jan-10	6:00	17:36	13:54	7:15	30	32	C	2	25+	10:45	32	32	C	3	25+
2	15-Jan-10	6:00	17:37	15:19	5:45	26	28	C	2	25+	14:00	31	30.3	C	4	25+
3	16-Jan-10	6:00	17:37	15:56	5:40	25	30	C	1	25+	14:00	25	31.5	C	2	25+
4	18-Jan-10	6:01	17:37	17:06	6:05	25	30	C	2	15+	14:00	29	31.5	C	3	25+
5	19-Jan-10	6:01	17:38	5:16	5:50	25	29	C	2	5+	14:55	30.5	30.5	C	2	25+
6	20-Jan-10	6:01	17:39	5:52	6:15	26	28.5	C	1	5+	14:15	29	31.5	C	3	15+
7	22-Jan-10	6:01	17:40	7:08	6:05	24.5	28.5	C	2	15+	14:20	33.5	32	C	3	15+
8	23-Jan-10	6:01	17:40	7:51	6:40	25.5	28.5	C	2	5+	12:25	32.5	30	C	2	15+
9	25-Jan-10	6:01	17:41	9:46	6:10	25	29.5	O	2	5+	14:10	32	32	C	3	15+
10	26-Jan-10	6:01	17:42	10:56	9:30	29.5	31.5	C	3	15+	17:35	29	30	O	1	5+
11	27-Jan-10	6:01	17:42	12:05	6:00	24.5	28.5	C	2	5+	13:40	29	32	C	2	15+
12	29-Jan-10	6:01	17:43	14:02	7:30	29	30	X	2	25+	15:25	30.5	31	C	2	25+
13	30-Jan-10	6:01	17:43	14:53	14:10	35	31.5	C	2	25+	23:00	27	30	O	1	5+
14	31-Jan-10	6:01	17:43	15:42	6:00	26	30	C	2	5+	12:25	33	31.5	C	3	25+
15	1-Feb-10	6:01	17:43	4:13	6:30	27	30	C	2	15+	14:05	32.5	32	C	2	25+
16	2-Feb-10	6:01	17:44	17:16	15:00	35	32.5	C	2	25+	0:00	28.5	30	X	1	15+
17	3-Feb-10	6:01	17:44	5:37	6:05	27	30	C	2	15+	11:40	32.5	32	C	3	25+
18	8-Feb-10	6:00	17:46	10:26	6:30	25.5	29	O	2	25+	15:10	30	31.5	C	3	25+
19	9-Feb-10	6:00	17:46	11:38	6:05	25.5	29	R	1	25+	14:10	30.5	31	C	2	25+
20	11-Feb-10	6:00	17:47	13:34	6:55	28	29.5	C	2	15+	14:45	28.5	31	C	2	15+
21	12-Feb-10	5:59	17:47	14:18	6:30	26.5	30	C	3	25+	14:30	31	31.5	C	2	25+
22	13-Feb-10	5:59	17:47	14:55	7:35	28	29.5	O	2	15+	15:30	27.5	30	R	2	5+
23	15-Feb-10	5:59	17:47	3:41	6:00	26	29	C	2	25+	14:05	29	30	R	3	25+
24	16-Feb-10	5:58	17:48	4:16	7:55	28	29.5	X	1	15+	15:05	29.5	32	C	2	25+
25	17-Feb-10	5:58	17:48	4:50	6:50	26	29.5	C	1	5+	14:40	29	31.5	R	2	15+
26	19-Feb-10	5:57	17:48	5:59	7:05	26	30	C	1	5+	15:25	29.5	30.5	C	2	15+
27	20-Feb-10	5:57	17:48	18:54	15:55	29	31	C	2	15+	1:05	28	31	C	1	1+
28	21-Feb-10	5:56	17:48	7:17	6:15	27.5	31	C	1	15+	12:05	29.5	31	C	3	25+
29	23-Feb-10	5:56	17:49	9:12	7:00	28	30	O	4	5+	15:30	-	-	O	2	5+
30	24-Feb-10	5:55	17:49	10:27	6:00	-	-	O	3	15+	14:40	-	-	O	2	15+

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

Presumably a variety of whale species utilize the oceanic waters off the west coast of Central America. Several have been documented near the Osa Peninsula, including Byrde's whale, *Balaenoptera edeni*, Sperm whale, *Physeter macrocephalus*, Orca/Killer whale, *Orcinus orca*, and likely Fin whale, *Balaenoptera physalus* (Calambokidis *et al.* 1999). In January-February 2010, two deep-sea fishermen reported seeing Orcas while on day trips outside the gulf. Toothed whales have been recorded inside Golfo Dulce, including False Killer whale, *Pseudorca crassiddens* (Acevedo-Gutierrez *et al.* 1997) and Pilot whales, *Globicephala macrorhynchus*, which were described as being inside the embayment by at least two interviewees.

Humpback whale, *Megaptera novaeangliae*

Perhaps the most commonly seen whale in Golfo Dulce is the baleen whale, *Megaptera novaeangliae*. Humpback whales arrive during their breeding/birthing seasons, and mothers with young calves commonly migrate up into the gulf for periods of time. Cows are often attended by male escorts. One interviewee told us he watched a female Humpback give birth in a calm bay south of Puerto Jiménez/Puntarenitas in late January, 2004.

The waters in and around Golfo Dulce are unique in that they support Humpbacks from both hemispheres since distribution of whales from the North Pacific Ocean and Southern Ocean overlap in that region (Acevedo & Smultea 1995, Rasmussen *et al.* 2007). Indeed, mitochondrial DNA rendered from biopsy studies suggests migratory cross-over in the eastern Pacific allows genetic exchange between subpopulations (Baker *et al.* 1993). Although Humpbacks may be seen during several months of the year, interviewees seemed to agree that more southern hemisphere Humpbacks utilize the gulf (peak season August-October) than do individuals from the northern hemisphere (most commonly seen in January and February).

We documented two first-hand whale sightings during our survey effort, representing five individuals, all Humpbacks. One Mother with a young calf (Mother-Calf, S108) was logged at 11:40 on January 31, 2010. The pair was seen more than mid-way into Golfo Dulce at 8°35'0.79"N, 83°14'28.61"W. The calf, which had fairly white pectoral flippers, was surfacing tightly aside the cow as they calmly traveled a heading of 360°, swimming further into the embayment. Photos and video were collected.

Our second whale sighting began at 08:46 on February 15, 2010, when we recorded a group of two adult Humpbacks and one calf (Mother-Calf-Escort, S166) at 8°20'32.52"N, 83° 8'38.88"W, approximately 1.5 km off the coast of Punta Banco, just outside the mouth of Golfo Dulce. Upon arriving, we found the group passing the fishing vessel that had notified us via radio of the whales' presence. The calf was repeatedly breaking away from the adults to breach and roll. Photos and video were taken as the threesome traveled a heading of 120° along the coast toward Panama, and we left the group at 8°20'6.96"N, 83° 7'30.12"W. The exact location of this sighting was especially significant because it occurred at the proposed site for a Yellowfin tuna farm (see section "Conservation in Golfo Dulce").

During January and February 2010, we received five supplementary reports of Humpback whales seen inside Golfo Dulce by interviewees on days different than our first-hand sightings (January 8, 18, 21, 25, 29). Those reported sightings are also included on our sighting map for Humpbacks (Fig 4). Four of the five additional sightings were reported to us by at least two separate people, increasing confidence in the reliability of those accounts.

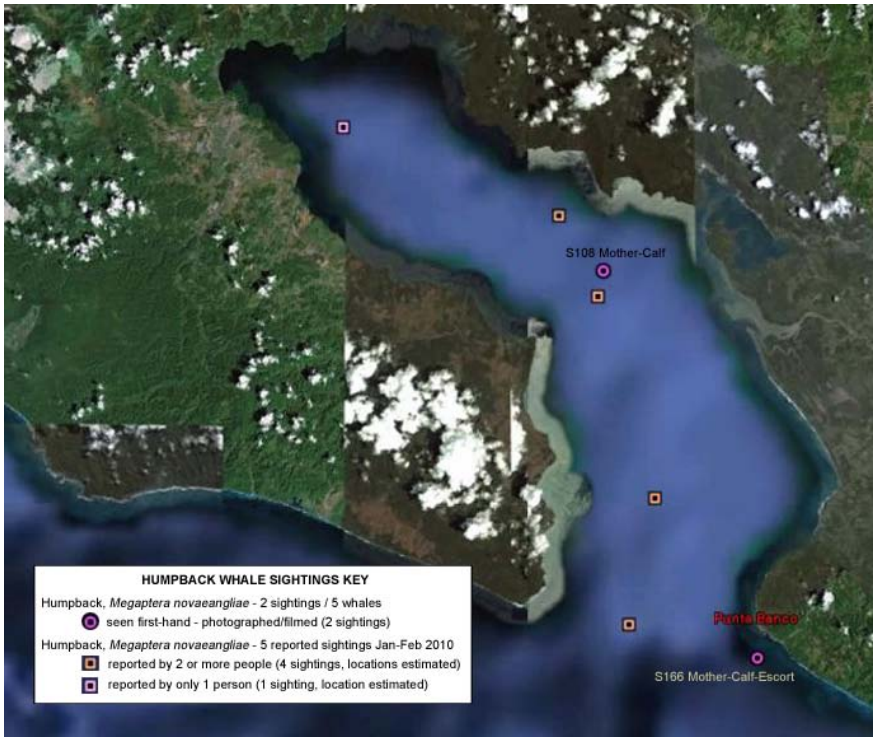

Fig. 4. GPS points for first-hand Humpback whale sightings (Mother-Calf, S108, 31 January), (Mother-Calf-Escort, S166, 15 February), and estimated location points for reported sightings in January-February 2010. Punta Banco is marked for reference.

Other researchers, based in Drake Bay and working under an alliance of Oceanic Society Research Expeditions, Exploritas and Cascadia Research Collective, were actively photo-identifying Humpback whales in the South Pacific waters of Costa Rica during part of our survey period, though that team did not enter Golfo Dulce. In their two weeks of shipboard surveys, they reported encountering 56 Humpback whales, identifying 13 individuals and matching eight whales to historical catalog (Calambokidis *et al.* 2010).

DOLPHINS

Dolphins were seen every day except one of the 30 we spent on the water (February 19, 2010). Observed behavior was mostly feeding and/or traveling. Two species of dolphin were confirmed inside Golfo Dulce by our survey: Bottlenose dolphin, *Turciops truncatus* and Pantropical Spotted dolphin, *Stenella attennata.* We documented a total of 81 first-hand dolphin sightings, representing approximately 1400 dolphins. Of our dolphin sightings, 63% (51 sightings, ~150 dolphins) were Bottlenose and 31% (25 sightings, ~1250 dolphins) were Pantropical Spotted dolphins. The species was unconfirmed for only 6% (5) of our sightings (Fig 5).

Some interviewees reported historically seeing other species of dolphin inside the gulf, including Spinner dolphin, *Stenella longirostris*, and Short-beaked common dolphin, *Delphinus delphis*.

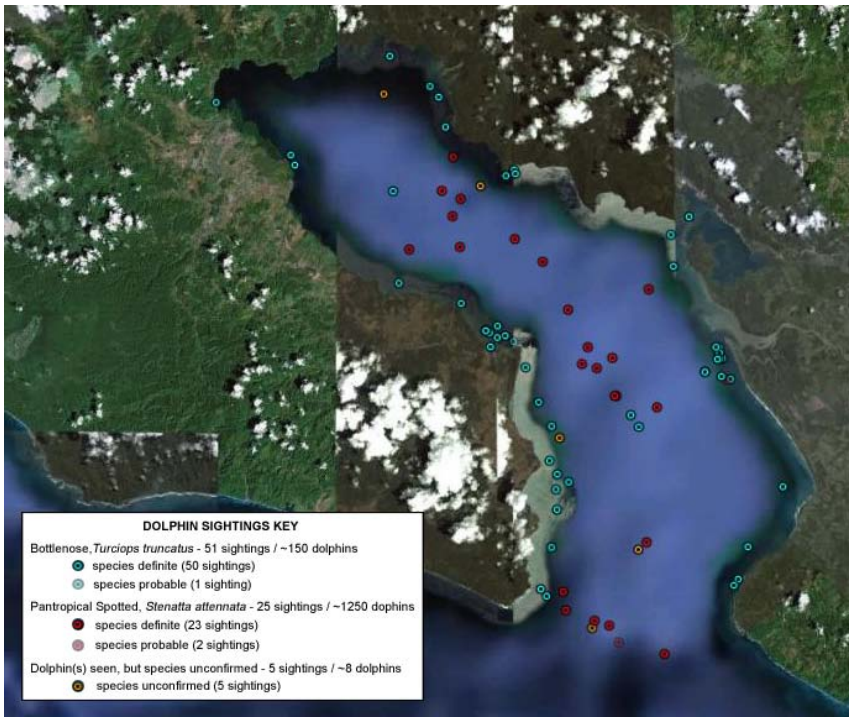

Fig. 5. GPS points for first-hand dolphin sightings, which represent approximately 1400 dolphins. Notice that Bottlenose dolphin sightings (blue) were generally more coastal than Pantropical Spotted dolphin sightings (red).

Bottlenose dolphin, *Turciops truncatus*

Bottlenose dolphins appear to be residents of Golfo Dulce. In concurrence with another study, this species tended to be seen more coastally, often near river outlets (Acevedo-Gutiérrez, & Burkhart 1998), with sightings occurring most frequently in GA2-3. We usually recorded Bottlenose dolphin swimming alone or groups of 2-3 individuals, but larger congregations of 7-15 were occasionally sighted.

Normally considered a playful and interactive cetacean species (Shirihai & Jarrett 2006), the Bottlenose dolphins in Golfo Dulce were inclined to behave more timidly than the Pantropical Spotted dolphins, keeping distance from approaching vessels, especially when in smaller numbers. However, certain individuals and, more likely, the larger groups sometimes approached our boat to bowride.

Photo-identification

We were able to capture photographs in 84% of our Bottlenose dolphin sightings. In several cases, those photos allowed us to identify individuals. Using natural skin markings, scars and the distinctive shapes of dorsals and tail flukes, at least 40 individual dolphins were distinguished. Both left and right dorsolateral images were garnered for 22 of the recognizable individuals. Photo compilations of individuals were labeled with "B" plus a number and, in a few cases, given a "name" for ease of recollection (Appendix).

Fig. 6. GPS points of sightings for B13 "Dorsal S", including dates, sighting numbers and, in parentheses, the other individuals confirmed at those sightings.

By identifying individuals and mapping the GPS coordinates of their sightings, some insight was gleaned into the movement of Bottlenose dolphins within the gulf. Multiple sightings were confirmed for 18 dolphins (B1, B2, B3, B7, B8, B9, B10, B11, B12, B13, B14, B16, B18, B19, B27, B28, B37 and B39). For some, their general location changed relatively little from sighting to sighting while others traveled extensively within the interior of the embayment during the sighting survey.

For example, B12, also referred to as “Dorsal A”, was seen five times. Four of those sightings occurred in the same general area, near the mouth of Rio Coto, and the other sighting was logged approximately 25 km away at S30, where ten or more Bottlenose had converged into a large feeding group. Conversely, dolphin B13, referred to as “Dorsal S”, also sighted five times, was never seen twice in the same area. That dolphin was recorded along both coasts, with GPS locations spanning over 37 km and stretching almost the entire length of the gulf (Fig. 6).

Possible Skin Disease in Resident Bottlenose Dolphins

Seven Bottlenose dolphins were identified with marked skin lesions, which appear to be symptoms of disease rather than natural skin coloring or the result of direct injury. In four of the dolphins, B8/“Notchpox”, B13/“Dorsal S”, B16 and B16, the grey spot-like lesions have tattooed sections of the dorsal, body and/or flukes (Fig. 7). Three other bottlenose dolphins appear to have similar skin disruptions B14/“PinkSpot” (who also had a large scar from a previous injury), B40 and B44, but the extent and exact appearance of their lesions are less clear due to the distance at which they were photographed.

Fig. 7. Skin lesions similar to these were seen on several Bottlenose dolphins inside Golfo Dulce.

A variety of unusual skin lesions have be described in *Turciops truncatus* (Wilson *et al.* 1997) and several cutaneous diseases are recognized in scientific and medical literature (Merck & Co. 2008), including dolphin pox (Geraci *et al.* 1979) and candidiasis (Nakeeb *et al.* 1977). Poxvirus has been reported in free-ranging Bottlenose dolphins and results in stippling blemishes. In the active phase, lesions tend to be light grey with dark borders. Candidiasis is more common in captive populations and normally appears around bodily orifices.

The cause of the lesions in the Golfo Dulce population of Bottlenose dolphins is yet unknown; a diagnosis could not be determined solely on our survey photographs, and personal communications with a few veterinarians and researchers familiar with skin disease in dolphins suggest the lesions are atypical of either of the aforementioned diseases (Nakeeb, S.; Reif, J.; Mason S., per. com. 2010). Therefore, an entirely different causal agent may be at play. A skin biopsy from an affected area allowing culture and histopathology would be necessary to determine any underlying microbiology. Important questions remain as to whether skin lesions seen on the Bottlenose dolphins in Golfo Dulce are self-limiting or chronic, pathogenic or benign, and/or whether they are linked to any compromised immunity, issues of stress, illness and/or environmental degradation, which could decrease reproduction or longevity.

Pantropical Spotted dolphin, *Stenella attennata*

Spotted dolphins appear to be migratory in Golfo Dulce. This species is distinguishable from *Turciops* by its smaller size, distinctly falcate dorsal, and tendency toward larger group size. The average group seen during our survey varied from 5-60 individuals; however we also recorded five sightings of large scattered herds estimated to include 100-500 individuals. Spotted dolphins were most often seen in the deeper middle waters, traveling or feeding as they moved into or out of the gulf. Although sightings ranged fairly evenly across GA2-4, we had no confirmed Spotted dolphin sightings in GA1. The reason(s) this species was not observed in the most northerly reaches of the embayment remains unclear.

These gregarious cetaceans were frequently seen making high, playful leaps above the water. They regularly engaged our boat and other passing vessels, approaching to bowride and wake surf. The most unique sighting of Spotted dolphins occurred on the morning of February 17, when we watched a feeding group of about 50 Spotted dolphins swimming in a unique formation—a clearly defined counterclockwise circle with an approximate diameter of 25 m.

SEA TURTLES

Sea turtle tracks and nests are commonly found along the shores of Golfo Dulce and four species of sea turtle are reported by interviewees to enter or reside in Golfo Dulce: the “Pacific Black” Green sea turtle

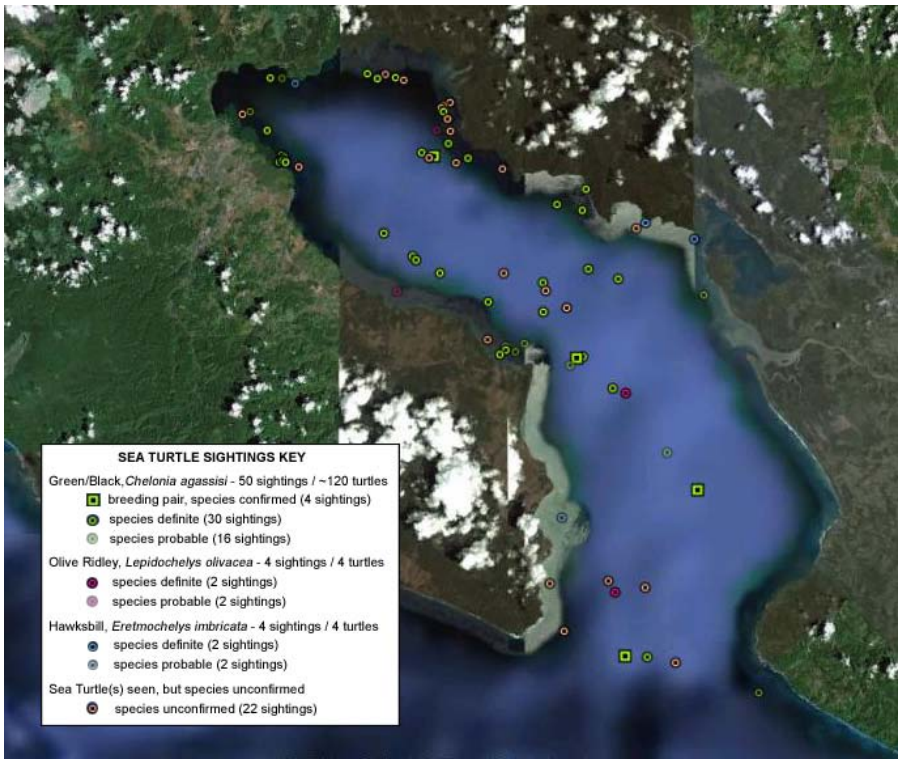

Fig. 8. GPS points for first-hand sea turtle sightings, representing approximately 225 turtles, including Green/Black, Olive Ridley and Hawksbill. Green squares symbolize sightings of Green/Black breeding pairs, which were documented in all four quadrants of Golfo Dulce.

(Green/Black), *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*

Many fishermen with several years experience in Golfo Dulce commented on the decline in numbers of sea turtles seen these days, saying the drop is at least 30%.

During our 30-day marine sighting survey, there were only two days did we not see sea turtles (February 2 and 17, 2010). In total, we documented 80 first-hand sea turtle sightings, representing approximately 225 sea turtles. Of those, 62.5% (50 sightings, ~120 turtles) were Green/Black sea turtles, 5% (4) sightings/turtles were Olive Ridley, and 5% (4) sightings/turtles were Hawksbills. In 27.5% (22) of the sightings, we were unable to confirm the species of the turtle(s) we saw (Fig.8-9). Overall, more sea turtle sightings (48% of the total) were recorded in GA2 than the other quadrants, suggesting that is an essential section of the embayment for their natural activities.

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

There is no doubt that biological differences divide the Pacific Black sea turtle from other Green sea turtles; yet, whether *C. agassizii* should be considered a separate species or a subspecies of *C. mydas* remains a debate of scientific nomenclature beyond the scope of this study. Interviewees overwhelmingly referred to this specimen as Green sea turtle (*tortuga verde*). To ensure understanding, this report shall refer to the species as Green/Black with the scientific name cited as *Chelonia mydas agassizii*.

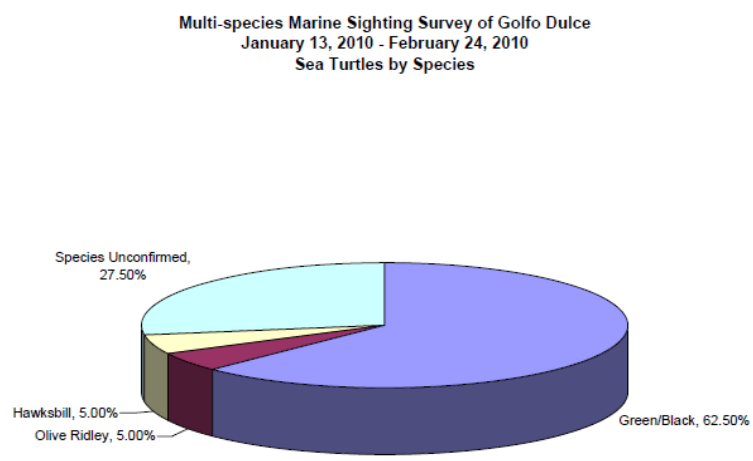

Fig. 9. Green/Black sea turtles were markedly seen more frequently than other species during the study period.

Golfo Dulce appears to be a significant breeding, feeding and nesting area for endangered Green/Black sea turtles with large numbers utilizing the embayment in the dry season. The number of Green/Black sea turtles we encountered during our first-hand sighting survey was considerably higher than expected based on pre-project communications with local sea turtle organizations. In

fact, discovering such a large population of Green/Black sea turtles in Golfo Dulce was one of our most important findings. This species, by far the most frequently seen, was mostly observed in the upper regions of the gulf (76% of sightings occurred in GA1-2), usually resting at the sea surface; however, we documented four breeding pairs of Green/Black sea turtles—one pair in each quadrant—demonstrating that the area of use for this species is widespread. We also discovered a unique spot where turtle grass prolifically grew and multiple sea turtles were consistently seen. One day at that location, we were able to document an estimated 40 individuals at one sighting, all within an area approximately 400 m squared. Interviewees confirmed Green/Black sea turtles are the predominant species inside the gulf during the dry season.

Olive Ridley sea turtle, *Lepidochelys olivacea*

Interviewees who were questioned during our study reported more Olive Ridleys inside Golfo Dulce during the rainy season, July to December, the period coinciding with that species known nesting season. Although our survey took place during the dry season, we did log four first-hand Olive Ridley sightings, representing four turtles. Two were recorded in GA2, one in GA3, plus a large individual calmly approached our boat in GA4. No Olive Ridley sea turtles were recorded in GA1.

Several conservation organizations, including Friends of the Osa, run sea turtle conservation programs on or near the Osa Peninsula. Such programs are designed to integrate preservation, research and educational outreach on behalf of Costa Rica's sizeable population of sea turtles. Most of the field work is done in the rainy season along the Pacific side of the peninsula, and the chief documented species is the Olive Ridley sea turtle, with lesser numbers of Green/Black sea turtles (Retana Jiménez, G. per. com. 2008).

Hawksbill sea turtle, *Eretmochelys imbricat*a

In preliminary interviews, the Hawksbill, locally called *carey*, was often described as "the little turtle". This was confusing at first, since the Olive Ridley is published as the smallest species of sea turtle inhabiting Costa Rican waters (Devaux & De Wetter 2000). Nevertheless, locals insisted the smallest sea turtle is the *carey* and, during our subsequent on-water survey, the Hawksbill sea turtles found inside Golfo Dulce were unquestionably the smallest species seen. More studies are necessary to explain this size discrepancy. Rather than stunted growth, it is possible the species is simply more residential than others, which might increase the odds of juveniles and sub-adults being observed within the habitat.

We recorded four Hawksbill sightings, accounting for four individual sea turtles. All of the turtles were seen fairly close to the shoreline. One was sighted in GA1 near Punta Estrella at the northern tip of the gulf, two were near the bay of Golfito in GA2 and GA3, and one was spotted along the southwestern beaches of Tamales on the border of GA3/GA4. The distance between locations suggests this species inhabits an extensive range around the embayment.

Leatherback sea turtle, *Dermochelys coriacea*

It is of special interest to note that five of our interviewees reported multiple historic sightings of Leatherbacks, *Dermochelys coriacea,* inside Golfo Dulce, especially near the embayment's southeastern shores of Pavones. One reported sighting occurred less than a month prior to our study, in December 2009. The critically endangered Pacific Leatherback sea turtle does have several principal nesting beaches in Costa Rica; whether that species enters Golfo Dulce for reasons of reproduction is yet unknown. Many species of jellyfish, a food source for Leatherbacks, were seen in Golfo Dulce waters during our first-hand sighting surveys.

WHALE SHARKS

Whale sharks, *Rhinocodon typus*, are seasonal visitors to Golfo Dulce. Normally seen singly or in small numbers, historical aggregations of around twenty individuals were reported to us during interviews. Members of this species are generally described as swimming close to the coast and remaining in the embayment for several days at a time.

Although the major months for migratory whale sharks to arrive in the gulf are proposed to be January and February, the height of the dry season, none were seen first-hand nor reported to us during our survey. The absence of whale sharks may have been related to water temperature. One published study on whale shark movement in a different coastal environment showed the species using waters up to 28°C (Gunn *et al.* 1999). Our average recorded sea surface temperature, taken near the marina at Puerto Jiménez, was 30.5°C (Highest

32.5°C/Lowest 28°C). One day during our study, a sport-tourist fisherman told us that his deep water thermometer showed 28.9°C, more than a degree higher than what he normally sees at that time of year.

Finally, we did receive a post-project report about a whale shark in Golfo Dulce, which came via email on March 22, 2010. The fish was seen by a local tour boat guide, who had been an interviewee during the survey.

PELAGIC SEA SNAKES

The Yellow-bellied sea snake, *Pelamis platurus*, a pelagic serpent found in the Indian and Pacific oceans, is the only sea snake in Costa Rica. The species regularly exhibits counter-shading, displaying black on top and yellow beneath, with bands or spots marking the flat, paddle-like tail; however, color patterns are variable and all-yellow specimens can be seen in Golfo Dulce (Roegiers & McCuen 2001). We documented 38 pelagic sea snakes during our sighting survey, including individuals of both normal and xanthic coloration. The ecology of the latter is still under investigation.

OTHER SPECIES

We saw many other marine (and rainforest) animals during our survey. Several were officially documented, most were not. The following short list of marine species is provided to reveal a broader portrait of Golfo Dulce.

American crocodile, *Crocodylus acutus* and **Caiman, *Caiman crocodylus***

American crocodiles and Caiman crocodiles inhabit the brackish waters and mangrove roots in the main rivers and smaller tributaries that feed Golfo Dulce. First-hand sightings of numerous individuals of both species were noted one night in an estuary near Puerto Jiménez called Platanares, and five American crocodiles were sighted and logged on a nighttime survey of Rio Esquinas.

Birds and Fish

We saw an assortment of marine birds and fish too extensive to record or recite. However, most common among Aves, we noted Brown boobies, Magnificent frigates, Osprey, Brown pelicans (including a nesting spot with upwards of 100 pelicans), several species of herons, gulls, terns, swallows, and dozens of wading and estuary birds. For fish we saw sharks, Manta rays, Flying fish, Needlefish, Roosterfish, Parrotfish, tuna, bonitas, ballyhoo, snappers, jacks, saboles, sardines, mullets, a variety of rays, eels, puffers, and a plethora of species specific to coral reefs.

Invertebrates

We observed several Portuguese Man-of-wars, mainly in drifts, as well as an array of sea jellies, sea stars, corals, crabs, oysters, conches and other mollusks.

CONSERVATION IN GOLFO DULCE

Recording 234 sightings in 233 observation hours equates to around one sighting per hour and, honestly, we expected to see more marine fauna during our survey. A large portion of interviewees shared sincere concerns that marine life is waning in Golfo Dulce, with some fishermen estimating overall wildlife numbers to have declined 30-40% within their lifetimes. In speaking with those fishermen and other local citizens around Golfo Dulce, conservation is a prime and pressing issue. Many people are actively seeking ways to better care for the region's unique biodiversity, proffering both ethical and economic reasoning.

Billfish, including marlin and sailfish, once prevalent across the region are now rarely, if ever, seen inside Golfo Dulce; however, they are still fished in Pacific waters outside the gulf, so populations, given the chance, could notionally rebound. Historic numbers of sea turtles, corals, sharks and schooling fish have clearly gone down, yet they do continue to exist in the embayment. Significant numbers of sea turtles still utilize the gulf. Some coral reefs show extensive bleaching, but we saw at least one reef that appeared to exhibit new coral growth. Although only two sharks were logged during our survey, one Tiger shark and another believed to be a Bull shark, both looked to be of breeding size and could likely reproduce. We did not observe any large tuna within the gulf but we did see several sizeable schools of juveniles as well as immature snapper and jack. These markers of enduring wildlife inspire hope and it is critical that immediate conservation measures be successfully employed to allow diminishing populations of endemic and migratory species to recover to sustainable levels.

Yellowfin Tuna Farm at Punta Banco

A tuna farm, the very first to raise Yellowfin, has been permitted but not yet constructed near the mouth of Golfo Dulce, just beyond the southeastern shores of Punta Banco. As the project would surely impact local communities, we anticipated mixed opinions among interviewees regarding its development. To our surprise, we

uncovered *only* opposition, which turned out to be both unanimous and antagonistic. Every interviewee, without exception, was fervently against the tuna farm, fearing loss of resources that would directly impact his or her livelihood.

Should this planned commercial "experiment" move forward, the gulf may prove less conducive to traditional fishing practices, and pollutants may reduce international travel to Costa Rica for surfing, sport fishing and eco-travel, creating long-term changes in national and local industry. Underwater cages will not only consume space, encroaching on existing wildlife and blocking entrance to calm mineral-rich gulf waters, but organic waste produced by captive fish is likely to alter water quality, potentially damaging the delicate tropical fiord ecosystem. Endangered sea turtlings hatched on nearby beaches may be drawn to the cage marker lights and fall prey to hungry farm tuna and a wide array of species may be affected by entanglement and introduced disease.

Without exception, every sea-faring species that migrates into or out of Golfo Dulce as part of its natural life process—sea turtles, whale sharks, dolphins, Humpbacks, many fish—must funnel through the relatively narrow channel adjacent to Punta Banco. Any impingement in or near the mouth of the gulf could have grave effects on the health and vitality of the whole embayment.

Trash from Golfito

On several days, while traversing the gulf, we incidentally noted tremendous amounts of floating human debris drifting from the bay of Golfito, including bottles, plastic bags, drink containers, shoes, cans, and other miscellaneous items (Fig. 10). While bits and pieces of trash were occasionally seen throughout Golfo Dulce, the amount of rubbish streaming from Golfito was far and above anything seen elsewhere in the embayment, suggesting the majority of solid pollution in gulf waters derives from Golfito and reflecting a poor waste management system in that community.

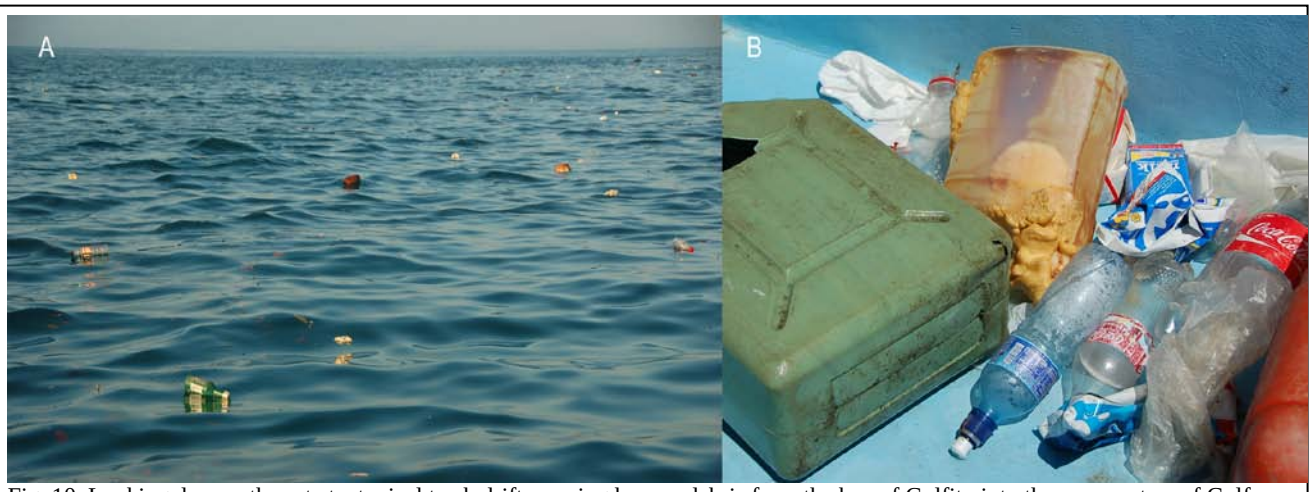

Fig. 10. Looking due southwest at a typical trash drift carrying human debris from the bay of Golfito into the open waters of Golfo Dulce (8A). A few of the trash items gathered into the survey boat (8B).

Two interviewees spoke candidly about the water quality in the Port of Golfito, telling us the floating pollution is just the proverbial tip of the iceberg. They said they would never swim in nor eat fish from those waters because of toxicity caused by chemicals and sewage from Golfito. Indeed, the area has the highest levels of polychlorinated biphenyls (PCB) in all of Golfo Dulce. With concentrations ranging up to 15.7 µg/g dw sediment, contamination is greater than expected based on the pristine appearance of the surrounding landscape (Spongberg 2004). We made two designated trips all the way into the bay of Golfito, spending at least 1 hr each time, yet no significant sightings of wildlife occurred beyond the mouth, and the inner waters appeared to be largely uninhabited.

Fishermen Initiatives

The conservation effort of local fishermen around Golfo Dulce was impressive. Overall, fishermen were adamant about the need to improve their fisheries for long-term sustainability, and several initiatives created or supported by local fishermen are worth mentioning here.

While doing interviews in La Palma, we were shown plans to establish new protections for a coastal strip of land and water along that segment of the gulf. The project, spearheaded by the local fishermen's association, is designed to safeguard swaths of mangrove habitat in order to support naturally occurring fisheries, which could help maintain local communities into the future.

We also had opportunity to attend the January 2010 fishermen's meeting in Golfito, where many topics of conservation were discussed. Large-scale commercial long-lining and shrimp trawling methods are no longer permitted in Golfo Dulce but small local permits for those activities remain in circulation. Sport/tourism fishing and other types of local commercial fishing are also in practice. Despite other disagreements among fishermen from those varying practices, many leaders spoke intensely about the need to unify, to work together toward better sustainability, which would benefit everyone in the gulf. The meeting was disrupted by the unexpected entrance of families from the *pueblo* of Sierpe. Dozens of sign-carrying marchers arrived to protest a construction project likely to cause damage to their wetlands. The group had traveled considerable distance to show their environmental concern.

Three interviewees also expressed unsolicited concern about a previously proposed plan to build a larger marina in the vicinity of Puerto Jiménez/Puntarenitas. That bay is fed by the river Platanares and its naturally occurring estuary supports many endemic species, including a litany of fish and birds, plus Caiman and American crocodiles. We also sighted many dolphins and sea turtles around that area during our study. We were told the campaign for the new marina was defeated due to strong opposition from the community, which cited potential for ecological damage.

CONCLUSIONS

Golfo Dulce remains a locale of intense biological interest and through sound research and protective strategies it may continue to be one of Costa Rica's most important and vibrant marine habitats. Further studies are required to more fully understand the ecology of this unique embayment. While data analysis did not allow precise population estimates for the species studied, it is hoped the information secured by this pilot sighting survey expands knowledge about which species utilize Golfo Dulce and which areas they frequent, providing some framework for future researchers seeking to investigate individual species with greater precision.

We also hope this baseline data will support new and improved measures of *in situ* conservation. Though overall wildlife populations seem to be in decline, public desire for conscientious stewardship of remaining biodiversity and environmental resources increases the potential to attain ecological stability in Golfo Dulce. International support, strong national environmental policy and local enforcement regulations are all required to guarantee the protection of Golfo Dulce through prudent eco-management.

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APPENDIX

Photographic compilations for several (not all) of the individually identified Bottlenose dolphins sighted inside Golfo Dulce during our marine sighting survey. Not shown in chronological order.

B1 was confirmed at three sightings (S24, S30, S215).

B2 “Esquinas” was confirmed at two sightings, both times with her calf (S148, S161).

B3 was confirmed at only one sighting (S61).

B4 was confirmed at two sightings (S36, S130).

B5 was confirmed at only one sighting (S187).

B6 “Arrow” was confirmed at only one sighting (S112).

B24 was only confirmed at one sighting S234

B9 was confirmed at two sightings (S41, S126).

B23 was only confirmed at one sighing (S55)

B10 “Split-Bent” (broken dorsal) and B11 “Scrape” were seen at two sightings, both times paired (S30, S61).

B12 “Dorsal A” was the first dolphin we identified, easily recognized by the severed dorsal. This dolphin was confirmed at five sightings (S20, S22, S30, S86, S212).

B13 “Dorsal S” was confirmed at five sightings (S30, S86, S127, S165*, S226); Figure 5 shows the GPS locations of those sighting within the gulf.

B8 “Notchpox” was confirmed at four sightings (S74, S127, S165*, 226). B8 was commonly seen with B13 “Dorsal S”.

*seen with B21, calf (photo below).

B21, a young calf, was confirmed at only one sighting (S165. It was with only two adults, B8 “Notchpox” and B13 “Dorsal S”. The calf was extremely playful and broke away from the adults several times to swirl around the boat.

B14 “Pink Spot” was confirmed at two sightings (S74, S225).

B15 was only confirmed at one sighting (S187).

B16 was confirmed at three sightings (S5, S129*, S142*)

*with B39, possibly an older calf (maybe at S5, too).

B17 was confirmed at only one sighting (S154).

B27 was confirmed at two sightings S180, S222

B18 “Shark” (triangular dorsal) and B19 “Nub” were confirmed at two sightings (S112, S222).

B20 was confirmed at only one sighting (S30).

B7 was confirmed at two sighting (S86, S211). Both times it readily approached the boat.

B25 “Barnacle” was confirmed at only one sighting (S59)

B26 was confirmed at only one sighting (S30).

B37 was confirmed at two sightings (S20, S86)