Chapter 12
Ecology and Conservation of Cetaceans of Costa Rica and Panama

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Abstract The cetacean species richness of Costa Rica and Panama represents about 36% of the species described worldwide. Within the economical coastal waters of these countries bottlenose dolphins, the pantropical spotted dolphins, the Guiana dolphin, and humpback whales are the most commonly observed. Their high sight fidelity and predictability has resulted in a rapid increase on the whale-watching industry, perhaps second to incidental mortality, when unregulated whale-watching can negatively affect coastal cetacean populations. In this Chapter, we provide a summary of

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the state of knowledge of the ecology and conservation status of the cetaceans of Costa Rica and Panama. Along this line, we describe the consensus of our small scientific community on what relates to future scientific research and conservation.

The cetacean species richness of Costa Rica and Panama represents about 36% of the species described worldwide. The dolphin family, Delphinidae is the most diverse group of cetaceans in these countries, with some species having year-round resident populations in coastal habitats like the bottlenose dolphins (*Tursiops truncatus*), the pantropical spotted dolphins (*Stenella attenuata),* and the Guiana dolphin (*Sotalia guianensis*). Other dolphin species are found primarily in oceanic and neritic waters like the rough-toothed dolphins (*Steno bredanensis*), striped dolphins (*Stenella coeruleoalba*), spinner dolphins (*S. longirostris*), and common dolphins (*Delphinus delphis*) (Rodriguez-Fonseca 2001; May-Collado et al. 2005). Among baleen whales, the humpback whale (*Megaptera novaeangliae*) is by far the most common species, and both Costa Rica and Panama possess important habitats used by these whales during their breeding season (Steiger et al. 1991; Calambokidis et al. 2000; Rasmussen et al. 2007, 2012).

The economic value of cetaceans in Costa Rica and Panama has increased in the past 20 years particularly due to whale watching activities, an activity that has become highly profitable across Latin America (Hoyt and Iñiguez 2008). Profitable whale watching can mutually benefit humans and wild animal populations, resulting in successful conservation. However, high observation intensities may nevertheless negatively affect animals. In Costa Rica and Panama whale watching is boat-based, and cetaceans are exposed daily to various levels of engine noise, which has been shown to elicit avoidance behaviors and stress, and mask important acoustic signals. For example bottlenose dolphins of Bocas del Toro, Panama, are exposed daily to high levels of underwater noise associated with dolphin-watching boats. In response, these dolphins modify their communicative signal frequency and duration presumably to decrease signal masking (e.g., May-Collado and Wartzok 2008, 2015; May-Collado and Quinones-Lebron 2014). Although cetaceans have evolved ways to compensate for masking by natural ambient noise, noise from human activities represent a new challenge that these animals may not be able to circumvent. The only option may be to avoid contact with these noises in which case noise acts

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much like other pollutants in rendering habitats unsuitable. Because of the potentially harmful effects of noise, the International Whaling Commission (1995) and International Fund for Animal Welfare (1996) have recognized boat-based whale watching as potentially detrimental to cetaceans and their environment and have developed guidelines in an attempt to reduce the impact of the industry.

In Costa Rica, several coastal communities have become economically dependent on whale-watching activities. For instance the communities of Sierpe, Uvita, and Drake located in the South Pacific coast of Costa Rica specialize in taking tourists to observe humpback whales that arrived from the southern hemisphere from August to November. In Panama, whale watching activities occur near Isla Contadora, Archipelago de Las Perlas, and Isla Iguana to name a few areas off the Pacific coast, but the most active whale watching activities in Panama occurs in the Archipelago of Bocas del Toro, located in north Caribbean coast of Panama, where resident bottlenose dolphins are the main target (May-Collado et al. 2012, 2014, 2015). While both countries have developed regulations for whale watching operators to reduce the impact of the activity, these guidelines emphasize the regulation of distance at which boats can approach the animals. However there is growing evidence that engine and propeller noise are the main causes of disturbance (e.g., Morisaka et al. 2005; Nowacek et al. 2001; May-Collado and Wartzok 2008), highlighting the importance of designing experiments that allow to measure noise levels and incorporate this information into local regulations (IWC 1995; IFAW 1996).

Despite their economic value, some cetaceans remain affected by incidental mortality in artisanal fisheries and purse-seine tuna fishery in Costa Rican waters. In Costa Rica dolphin estimates of annual mortality rates due to artisanal fisheries is about 9.5% of the population size for all small cetaceans combined (Palacios and Gerrodette 1996). Anthropogenic mortality rates should not exceed 1–2% of population size, based on the low reproductive rate of cetaceans (Perrin et al. 1994; IWC 1996). In addition, anecdotal information indicates the direct killing of small dolphins for shark bait in both the Pacific and Caribbean coast of Costa Rica, and it has been documented in Guatemala as well by Quintana-Rizzo (2014). The frequency of these incidents and the number of animals being killed is unknown at this moment.

Historically, whaling in Panamanian waters occurred between 1883 and 1886. The *Gay Head*, a commercial whaling vessel from New Bedford, visited the Gulf of Panama three times, capturing and processing a total of 50 humpback whales (Best 2008). This is the first reference of the presence of commercial whaling in the coast of Panama. In addition, the *Olympic Challenger*, a Norwegian factory vessel registered in Panama, was proved to be involve in "pirate whaling" (Birnie 1985) in Panamanian waters.

The impact of both historical and current killing of cetaceans is unknown largely because it occurs far from the coast and under great secrecy. However, this is a source of mortality that needs to be addressed and taken into account in future models along with incidental mortality to better assess the impact of these activities in the local cetacean populations.

In this Chapter we will provide a summary of the state of knowledge of the ecology and conservation status of the cetaceans of Costa Rica and Panama. Along this line, we will identify what our small scientific community considers are the most important threats to these animals and their habitat, highlighting recommendations for their conservation.

12.1 Pacific Coast

The list of cetacean species for the Pacific coast of Costa Rica includes about 28 species. However, information about the ecology and conservation status for most of these species remains unknown. In the past 20 years research has focused primarily on three coastal species: bottlenose dolphins, spotted dolphins, and humpback whales (e.g., Acevedo-Gutierrez and Burkhart 1998; Cubero-Pardo 1998; Calambokidis et al. 2000; Garcia and Dawson 2003; May-Collado and Morales-Ramirez 2005; May-Collado and Forcada 2012; Herrera-Miranda et al. 2016). We will start providing a general background on what we know so far about these three species.

The coastal subspecies of the spotted dolphin (*Stenella attenuate graffmani*) is one of the 16 dolphin species inhabiting Costa Rican and Panamanian waters (May-Collado et al. 2005; May-Collado 2009) and possibly the most common dolphin off the Pacific coast of both Costa Rica and Panama. In Costa Rica, coastal spotted dolphin are commonly observed throughout the Pacific coast, however most of what we know about these dolphins comes from a handful of locations: Cuajiniquil and Gulf of Papagayo in the north Pacific and from Drake Bay, Osa Peninsula, and Gulf Dulce and Isla del Caño in the south Pacific (e.g., Cubero 1998; Oviedo 2007; Oviedo et al. 2014; May-Collado et al. 2005; Martinez-Fernandes et al. 2011, 2014).

In the north Pacific, coastal spotted dolphins appear to be resident year round (Martinez-Fernandez et al. 2011; May-Collado et al. 2005; May-Collado and Forcada 2012). The gulf is characterized by dry and rainy seasons. During the dry season strong northeast trade winds generate the richest coastal upwelling of the country, and spotted dolphin's abundance seem to be associated to it. May-Collado and Forcada (2012) found that the abundance of coastal spotted dolphins increased linearly with water depth and transparency, and non-linearly with the dissolved oxygen concentration. Also, they found that high variability in the relative dolphin abundance occurred during the dry season, a time where a higher number of spotted dolphin groups were observed primarily in foraging activities (May-Collado and Morales-Ramirez 2005). Therefore seasonal changes in relative abundance for these dolphins probably are associated with food availability. Similar patterns were described for the spotted dolphins of the Gulf Dulce by Cubero-Pardo (1998), but no estimates of relative abundance were made, hindering further comparisons.

There is some evidence that at least some coastal spotted dolphins show high site fidelity (May-Collado 2001). Thus, there is concern about the impact coastal human activities may have on these animals. For instance, Montero-Cordero y Lobo (2010) studied the impact of dolphin watching activities on coastal spotted dolphins that inhabit the waters between Drake Bay and Caño Island. They found that the highest density of dolphin groups accompanied by tour boats was near Caño Island. They also found that when operators did not comply with conduct guidelines, the spotted dolphins responded negative towards the boat, by swimming away. What this study suggest is that even dolphin species that live in large group sizes are affected by intense dolphin watching activities and that negative effects can be minimized if operators comply with regulations.

While coastal spotted dolphins are found along the Pacific coast, bottlenose dolphins do not showed a continuous in their distribution. For instance, bottlenose dolphins are rarely observed in the Gulf of Papagayo and surrounding areas, whereas in the gulfs of Nicoya and Dulce they appear to be more common. In Gulf Dulce spotted and bottlenose partition the gulf by differences in habitat use and physical characteristics of the gulf such as bathymetry and topographic characteristics. For instance, bottlenose dolphins are primarily associated with all major river drainages at the inner basin and sill area of the gulf, likely representing a key critical habitat where they main prey is located (Acevedo and Buckhart 1998; Herrera-Miranda et al. 2016). Dietary information is not available yet, but observations on their feeding behavior suggest bottlenose dolphins feed primarily on demersal fish while coastal spotted dolphins seem to feed mainly on pelagic fish (Oviedo 2007).

May-Collado et al. (2005) distribution maps indicate that the Gulf of Nicoya is potentially an important habitat for spotted and bottlenose dolphins. The gulf and surrounding areas are considered the most important fishing ground in Costa Rica (Vargas 1995). To put this in perspective, between the two main fishing ports (located in Puntarenas and Quepos), just in 2014 they accounted for 7511 tons of fish (including sharks). This is about 62% of total catches in the country for the same period (INCOPESCA 2016). This high productivity likely explains the regular presence of spotted and bottlenose dolphins. In addition, other 13 species of cetaceans, including beaked whales, humpback whales, pilot whales, false killer whales, among others have also been observed in this area (May-Collado et al. 2005; Martinez-Fernandez et al. 2014). While high species richness may be associated to food, Palacios-Alfaro pers. comm. (2016) also suggest that the short distance between coast and continental shelf may also increase the probability of observing deep water species.

Although the Gulf of Nicoya and surrounding areas represent important habitats for cetaceans we still know very little about their population dynamics and interactions with human activities in the area. The Central Pacific coast of Costa Rica has the highest fishing effort in the country, mainly due to artisanal fishing activities that use of bottom lines and gillnets, purse seine, trawling, and long lines at small and medium scales. Serious concerns about the potential impact of the fishery industry in the local cetaceans stems from previous work by Palacios and Gerrodette (1996) who estimated that the Costa Rican cetacean bycatch in gillnets was considerably high in comparison with other Central American countries, such as Panama, and by anecdotal accounts of fisherman witnessing bottlenose dolphin calves being trapped in sardine nets (Jose D. Palacios Alfaro pers. comm. 2016).

An indirect impact of fisheries is creating dependence for resources. For example, Palacios-Alfaro (2007a, b) found that dolphins can potentially change their foraging patterns in areas where shrimp fishing occurrence is high. He observed pantropical spotted dolphins and bottlenose dolphins regularly following trawlers to feed on the discarded demersal and pelagic fish. Some dolphin groups consistently approached trawlers and followed them for up to 11 h, suggesting that at least some dolphins might have develop a dependency on this resource.

The third most common cetacean in the Pacific coast of Costa Rica is the humpback whale. Humpback whales make seasonal migrations from high-latitude feeding grounds to low latitude breeding areas where whales give birth and mate. Costa Rica receives humpback whales from two main feeding grounds: off California-Oregon-Washington in the Eastern North Pacific (northern whales) between December and April (Steiger et al. 1991; Acevedo and Smultea 1995; Calambokidis et al. 2000; Rasmussen et al. 2012) and off Chile and Antarctica between July to November (Acevedo et al. 2007; Rasmussen et al. 2007).

Southern humpback whales have been previously documented off the Pacific coast of Central America during the austral wintering season (Townsend 1935; Acevedo and Smultea 1995; Florez-González et al. 1998; Rasmussen et al. 2007; Best 2008). Central America is unique because it harbors the northernmost breeding area of any southern hemisphere humpback whale population, with whales migrating approximately 8300 km from the feeding areas (Acevedo et al. 2007; Rasmussen et al. 2007). As mentioned before these whales have been linked to feeding areas off Chile and Antarctica (Acevedo et al. 2007; Rasmussen et al. 2007) as well as to adjacent breeding areas off Colombia (Florez-González et al. 1998), and are part of the IWC-designated "Breeding Stock G" (BSG). In Panama, one of the most studied breeding grounds for southern humpback whales is the Gulf of Chiriquí. This gulf lies in the western part of Panama, and is bordered by the Azuero Peninsula to the east, and Punta Burica to the west. Here, humpback whales are frequently sighted, predominantly in shallow waters near island groups and close to shore. Approximately half of the sightings contained calves, many of which were small in size, suggesting the females are calving in these waters or in waters very close by. Similar patterns are found in Costa Rica, where 64% of the sightings between Caño Island and Drake Bay are mothers with calves (Palacios-Alfaro et al. 2014) (Figs. 12.1, 12.2, 12.3, 12.4, 12.5, 12.6, 12.7, 12.8, 12.9, 12.10, 12.11, 12.12, 12.13, 12.14).

Although, research on humpbacks whales in Costa Rica was initially focused on northern whales, over the last years a perceived decrease in the number of these whales is raising concerns among local scientists. For this reason whale-watching activities are now only targeted towards southern whales. According to the National Oceanographic Atmospheric Administration (NOAA) while most humpback whale populations are recovering, the Central American humpback whales remain endangered. Therefore, future research should focus on determining if the number of northern whales breeding in Costa Rica is indeed decreasing, and if so what are the factors responsible for this decrease.

The Gulf of Chiriqui is also an important habitat for six other species of cetacean. The most common dolphin is the spotted dolphin both in number of sightings and abundance, followed by bottlenose dolphins, which are sighted both in estuarine waters and offshore waters near islands. Bryde's whales (*Balaenoptera edeni*) are seen occasionally near the Islas Contreras and the Islas Secas. Less common are false killer whales (*Pseudorca crassidens*), sighted twice near the Islas Secas; one

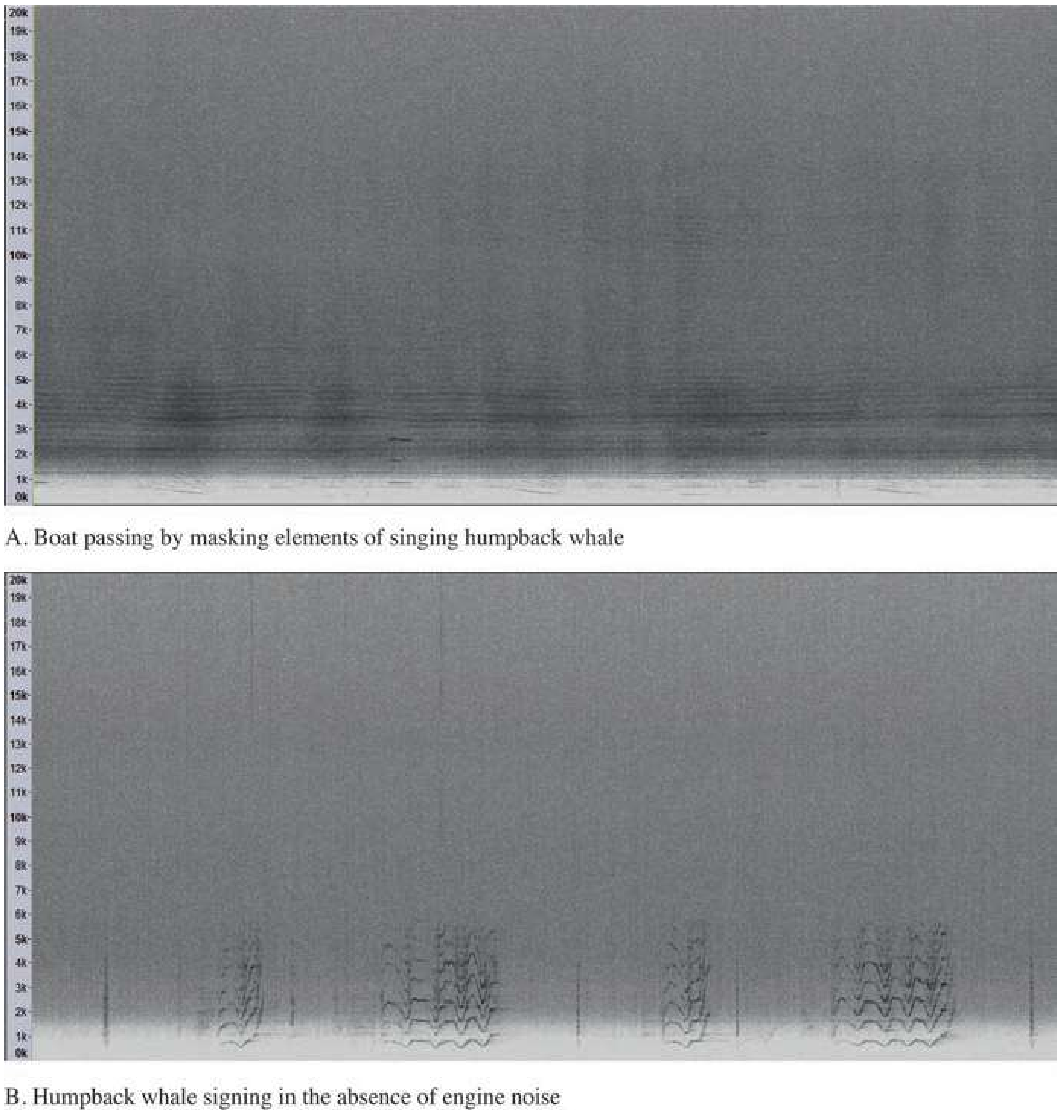

Fig. 12.1 Southern hemisphere humpback whale male singing near Isla del Caño, Costa Rica in 2016. The island, reefs, and humpback whales attract hundreds of tourists to the island each year. Tour operators in Uvita, Drake bay and Sierpe (and likely other locations along the coast) offer tours to the island on daily basis. In this figure we show an example of the noise emitted by a passing boat and its overlap in frequency with some elements of the whale song. These recordings were made using underwater recorders (uRUDAR-mk2 from Cetacean Research Technology) during a pilot project funded by Conservation International Costa Rica (**a**) Boat passing by masking elements of singing humpback whale. (**b**) Humpback whale signing in the absence of engine noise (Credits to Laura J May-Collado, Ana Guzman, and Marco Quesada Alpizar)

minke whale (*Balaenoptera acutorostrata*) sighted near Isla Coiba, and one group of rough toothed dolphins (*Steno bredanensis*) sighted near the Islas Paridas. Other areas were cetacean research is starting to generate information about their occurrence is Isla Iguana, Gulf Montijo, and Islas Perlas.

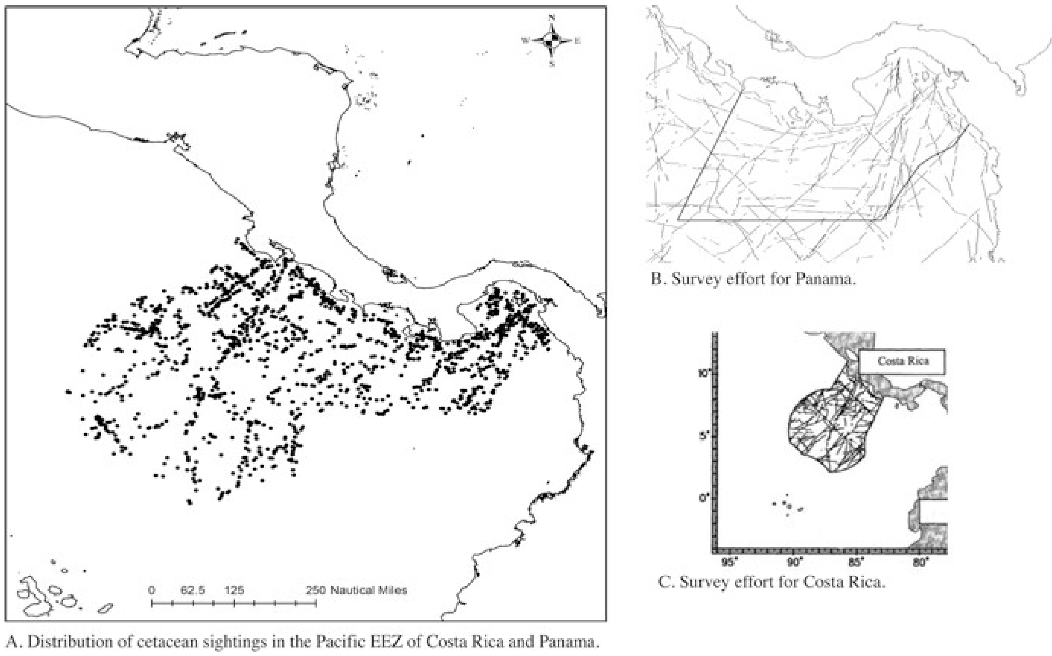

Fig. 12.2 Overall distribution of cetacean sightings during SWFSC-NOAA surveys between 1979 and 2016 in Costa Rica and Panama. (**a**) Distribution of cetacean sightings in the Pacific EEZ of Coasta Rica and Panama. (**b**) Survey effort for Panama. (**c**) Survey effort for Costa Rica (Data provided by Dr. Tim Gerrodette)

Fig. 12.3 Spotted and bottlenose dolphins feeding on fish discharged by shrimp fishing boats in in Central Pacific waters of Costa Rica (Photos by Jose D. Palacios)

12.2 Caribbean Coast

In the Caribbean only nine of the 29 expected species for both Costa Rica and Panama have been confirmed (May-Collado 2009). These species are the pilot whale (*Globicephala macrorhynchus*), killer whales (*Orcinus orca*), false killer whales (*Pseudorca crassidens*), Guiana dolphins, spotted dolphins (*Stenella frontalis*), rough-toothed dolphins, bottlenose dolphins, sperm whales (*Physeter macrocephalus*), and the dwarf sperm whale (*Kogia sima*). This low number of confirmed

Fig. 12.4 Southern humpback whales migrate during the austral wintering season to Panama and Costa Rica and other parts of Central America to breed and give birth (Photo by Kristin Rasmussen)

species is likely the product of the lack of consistent and standard survey efforts in these countries for the Caribbean. The diversity is likely higher as suggested stranding data, where an unidentified beaked whale of the genus *Mesoplodon* and a baleen whale of the genus *Balaenoptera* where documented (see the stranding section).

The most commonly observed cetacean in the Caribbean coast of both Costa Rica and Panama is the bottlenose dolphin. In Costa Rica, bottlenose dolphins have been documented along the entire Caribbean coast, in the north, sightings of bottlenose dolphins have been made in the mouth of the Colorado River, Samay Lagoon, and the Parismina River, in the central Caribbean from the Matina River to the Cieneguita River, and in the south in Gandoca-Manzanillo Wildlife Refuge. In Panama, it is presumed that the only resident population of bottlenose dolphins is located in the Archipelago of Bocas del Toro. However, just like in Costa Rica the Caribbean coast of Panama remains vastly unexplored. Most of what is known about Caribbean bottlenose dolphins comes from a handful of long-term studies in Gandoca-Manzanillo, Costa Rica (Gamboa Poveda and May-Collado 2006; Gamboa-Poveda 2009) and Bocas del Toro, Panama (May-Collado et al. 2012–2015). However, recent efforts in the central Caribbean coast of Costa Rica are changing our perception of bottlenose habitat use and residency. Amador-Caballero, Garita-Alpízar, and Rodríguez-Fonseca surveyed the Central Caribbean between 2015 and 2016. They found that bottlenose dolphins was most commonly foraging in mouth of the river Matina. The coloration of these dolphins suggests that they might transient oceanic animals. Of a total of 74 dolphins photographed between only 7.35% of the animals showed regular use of the area. In this area the second most sighted species was the Atlantic spotted dolphins, which was observed primarily

Fig. 12.5 Cetacean species observed within coastal waters of the Pacific coast of Costa Rica and Panama from top to bottom spinner dolphins (Photo by Monica Gamboa), spotted dolphins (Photo by Laura May-Collado), false killer whales (Photo by Kristin Rasmussen), common dolphins (Photo by Jose David Palacios), Bryde's whale (Photo by Monica Gamboa), killer whale, and rough-toothed dolphins (Photos by Jose David Palacios).

Fig. 12.6 Cetaceans observed in the north Caribbean of Costa Rica and Panama from top to bottom: false killer whales, bottlenose dolphins, and Atlantic spotted dolphins

Fig. 12.7 Guiana dolphin's home range involved the nearshore waters of Gandoca-Manzanillo (Costa Rica) and Changuinola (Panama) where they are regularly expose to illegal nets aimed to trap sea turtles (Photo by Laura J May-Collado and Monica Gamboa-Poveda)

Fig. 12.8 Mixed species interactions of Guiana dolphins and bottlenose dolphins occur daily in Gandoca-Manzanillo. Interactions are particularly intense during social activities where bottlenose dolphins tend to separate and harass one or two Guiana dolphin. The *first photograph* shows a bottlenose dolphin (with the tall and falcate dorsal fin) following three Guiana dolphins (short and triangular dorsal fin) (Photo by Monica Gamboa-Poveda) and the *second photograph* two bottlenose dolphins have already separated a Guiana dolphin from the rest of the group (Photo by Laura J May-Collado)

Fig. 12.9 Bottlenose dolphin of Bocas del Toro belong to the coastal ecotype and are highly isolated from other Caribbean populations including the neighboring dolphins of Gandoca-Manzanillo, Costa Rica located only 35 km north (Photo by Betzi Perez)

in traveling activities and interacting with passing boats. They also observed in two occasion rough-tooted dolphins and false-killer whales highlighting the need for long-term monitoring in the area.

In Gandoca-Manzanillo Wildlife Refuge dolphin sightings are common within and nearby the refuge. Here the majority of the sightings are Guiana dolphins followed by bottlenose dolphins (Gamboa-Poveda 2009). Other species such as the dwarf sperm whale, Atlantic spotted dolphins, and rough-tooted dolphins have been observed occasionally within the refuge (Palacios-Alfaro 2007b). While the bottlenose dolphin is observed throughout the Caribbean coast, the Guiana dolphin

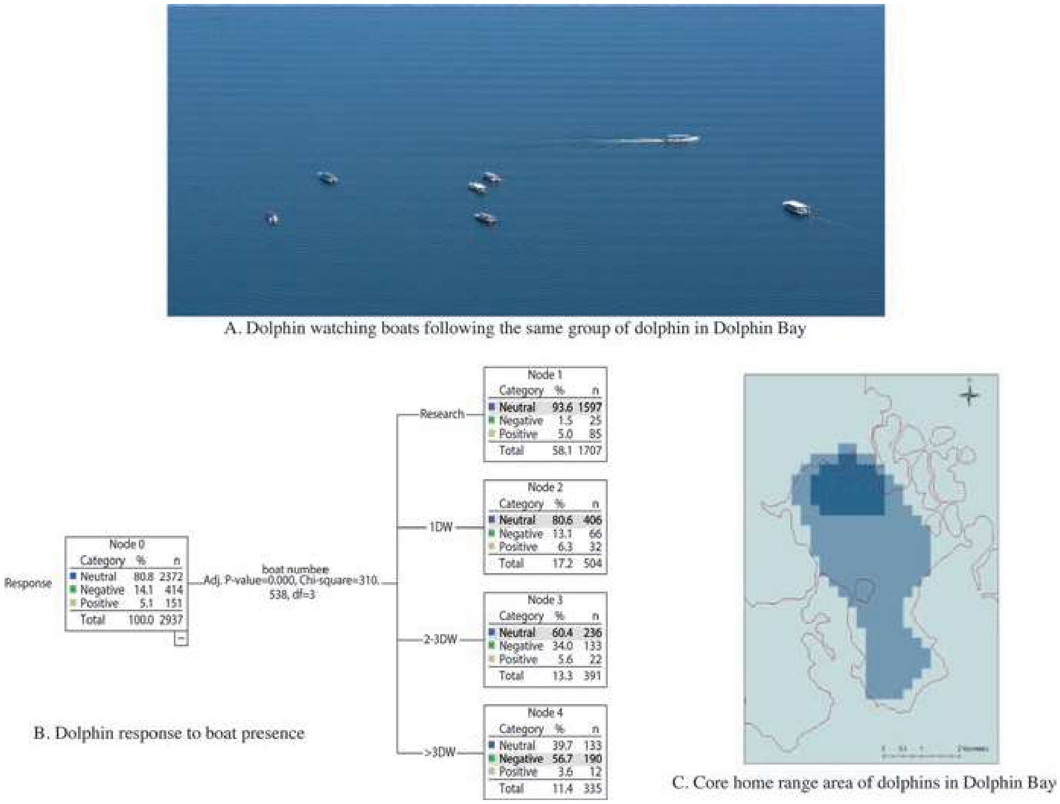

Fig. 12.10 The impact of boat-based dolphin watching in the resident population of bottlenose dolphins in Bocas del Toro. (**a**) highlights the high congregation of boats following the same group of dolphins, (**b**) is A decision tree analysis evaluate of dolphin response (negative, positive, neutral) to number of dolphin watching boats present simultaneously during an encounter (cross validation estimate = 0.311, std. error = 0.013, X2 = 310.5 df = 3, $p < 0.0001$), (**c**) shows the core home range area of dolphins within Dolphin Bay were the majority of encounters with dolphin watching boats occur

appears to be only found in the nearshore waters of Gandoca-Manzanillo and the Changuinola area in the Panamanian side. In both sites, biological productivity is highly influenced by large rivers, in the Costa Rican side by the Sixaola River and in the Panamanian side by the Changuinala River. However, its distribution may had been more ample in the past. For instance, the first documentation of Guiana dolphins for Panama was in Colon, near the Caribbean entrance to the Panama Canal, (Bossenecker 1978) but since this report there has been not sightings of these dolphins in Colon. This highlights the needs for standardized and long-term surveys in the region that can help us understand not only the diversity of cetaceans in it but also the threats to which they may be exposed to.

A special aspect of the dolphins inhabiting Gandoca-Manzanillo is the daily formation of interspecific groups. Gamboa-Poveda (2009) found that the majority of the dolphin groups observed within the refuge belong to the Guiana dolphins (50%), followed by mixed species groups (27.2%) and bottlenose dolphins (22.8%). The mixed groups of Guiana and bottlenose dolphins are observed on daily basis

Fig. 12.11 Adult male striped dolphins with (**a**) Facial scar completely healed, stranded at Camaronal Beach in 2010. (**b**) Ulcerative lesion with active borders, stranded at Tambor Beach, 2011

Fig. 12.12 Adult female dwarf sperm whale with bad body condition at the Pacific exit to the Panama Canal in 2010 (Photos by Lissette Trejos)

Fig. 12.13 Marine mammal specialist and veterinarian Lissette Trejos-Lasso working on a recent stranding of 60 rough-toothed dolphins in the Pacific coast of Panama. Using limited resources Lissette and her support team spent hours rescuing the healthy looking animals and necropsying the deceased

Fig. 12.14 Underwater acoustic recorders used to monitor the acoustic habitat of Cano and Murcielago Island in Costa Rica, both locations are protected areas used by humpback whales and dolphins. The last photograph shows spotted dolphin whistles recorder at 2 a.m. The project is funded and coordinated by Conservation International Costa Rica, and lead by Dr. May-Collado

Table 12.1 List of cetacean species confirmed for both Costa Rica and Panama

	Pacific Coast		Caribbean Coast	
Species	Costa Rica	Panama	Costa Rica	Panama
Balaenoptera edeni	x	x		
Balaenoptera musculus	x			
Balaenoptera physalus	x			
Balaenoptera borealis	x			
Delphinus delphis	x	x		
Feresa attenuata	*x*	x	x	
Globicephala macrorhynchus	x	x		
Grampus griseus	x	x		
Kogia sima	x	x	x	
Lagenodelphis hosei	x			
Megaptera novaeangliae	x	x		
Mesoplodon densirostris	x			
Mesoplodon peruvianus				
Orcinus orca	x	x		
Peponocephala electra	x	x		
Physeter macrocephalus	x	x	x	
Pseudorca crassidens	x	x	x	
Sotalia guianensis			x	x
Stenella attenuata	x	x		
Stenella frontalis			x	x
Stenella coeruleoalba	x	x		
Stenella longirostris	x	x		
Steno bredanensis	x	x	x	x
Tursiops truncatus	x	x	x	x
Ziphius cavirostris	x	x		

primarily during socializing activities (Forestell et al. 1999; Acevedo-Gutierrez et al. 2005; Gamboa-Poveda 2009; May-Collado 2010). Because of the commonality of these social associations and the intermedia morphological characteristics of the dorsal fin of some individuals, Forestell et al. (1999) hypothesized that hybridization between the species might be occurring. However, to this point not genetic study has taken place to determine if such hybrids exist. Another interesting aspect of these mixed species groups, is that sometimes, social interactions between species turned into aggressive interactions. This happens when bottlenose dolphins target one or two Guiana dolphins by separating them from the rest of the group and by chasing them and forcing them into intercourse activities. It is during these antagonistic events that 'hybrid' whistles are produced presumably by the Guiana dolphin as an attempt to match the whistles of its attackers and maybe reduce the intensity of the attack (May-Collado 2010).

Photo-identification work by Gamboa-Poveda (2009) suggested that overall residency rate is low for both dolphin species. Only 14% of Guiana dolphins and 12% of bottlenose dolphins seem to regularly use the refuge. This result is likely biased due to survey effort been limited to the refuge, as shown by recent boat surveys extending from Gandoca to Changuinola. During this recent surveys, Guiana dolphin were observed south the Changuinola River, suggesting that their distribution is larger than previously thought. Interestingly this does not seem to be the case for the bottlenose dolphins from Gandoca-Manzanillo, whose seem to include offshore waters.

Bottlenose dolphins have been documented in several parts of the Caribbean coast of Panama including the Laguna of Chiriquí, but only those from the Archipelago of Bocas del Toro are considered residents. In Bocas del Toro, the population of bottlenose dolphins is small, highly predictable, and it appears to be genetically isolated. Barragan-Barrera et al. (2015) described a unique mtDNA haplotype for this population, not found anywhere else in the Caribbean suggesting some extent of genetic isolation. Microsatellite data also support the isolation of this population even from neighboring Costa Rican bottlenose dolphins. Based on preliminary estimates, the population is considered to be between 80–100 animals, and it seems to be organized into two communities one that has low residency rate (<38.5%) and wider distribution, and a smaller communities that has more restricted movement patterns and higher residency rate (38.5–100%) (May-Collado et al. 2015a).

This small community seems to be restricted in great part to a small semi-enclosed bay called Dolphin Bay, where due to its high predictability it is in constant interactions with dolphin-watching boats. May-Collado et al. (2012) found that the number of boats interacting with these animals has increased exponentially in the Bay; up to 40 boats have been counted to interact with the same group of dolphins within a period of an hour (May-Collado et al. 2015). The increase in the number of boats is correlated with an increase in underwater engine noise and dolphins seem to respond to this noise by modifying their whistles presumably to reduce masking and by switching to avoidance behaviors (Kassamali-Fox et al. 2015; May-Collado and Wartzok 2008 2015, Sitar et al. 2016). Data shows that these dolphins do not respond acoustically in the same way to other watercraft, for example transport and other passing boats that are not directly targeting the animals, rarely elicit changes in their acoustic behavior (May-Collado 2015). Interestingly, interactions with dolphin watching boats vary depending on the animal behavior at the moment of the interaction. For example, foraging dolphins interrupted by dolphin watching boats lower the frequency and increase the duration of their communicative signals but when the animals were socializing not significant changes in the acoustic structure of their signals were noted.

12.3 Cetacean Strandings

In Costa Rica cetacean stranding information is available since 1996. Between 1966 and 1999 a total of 35 stranding events (244 individuals) were recorded. These strandings included predominantly single animals from 13 species of the families Delphinidae, Kogiidae, Physeteridae and Balaenopteridae (Table 12.1) (Rodríguez-Fonseca and Cubero-Pardo 2001). In addition, in 1976 a stranding of 200 individual melon headed whales (*Peponocephala electra*) (~80 died) was reported at Tambor Beach at Cobano, Peninsula of Nicoya in Puntarenas province. During these 33 years, the causes of death in the stranded animals were not determined (Janzen and Wilson 1983). Between 2000 and 2016, 96 stranding events involving 98 individuals were described largely by trained scientists. Most of these strandings (97.9%) consisted of single animals belonging to 16 species within the families Delphinidae, Kogiidae, Physeteridae, Ziphiidae and Balaenopteridae (see Table 12.1). In 2002, another mass stranding was reported at Cedros Beach, 24 kilometers apart from the site of the earlier mass stranding at Tambor Beach in 1976. This time 37 individuals (4 died) of rough-toothed dolphins stranded (Loaiza 2002).

In Costa Rica systematic postmortem examinations started to be performed in 2001, first by the Pathology Department of the School of Veterinary Medicine of the National University of Costa Rica; and later on (after 2009) by the National Veterinary Service of the Ministry of Livestock and Agriculture of the country. Currently, histopathological analyses are routinely performed for each stranding including tissue sections from all organs using standard procedures as described by Kiernan (2003). Since 2001 a total of 70 animal necropsies have been performed in 11 species of odontocetes including, striped dolphins, pantropical spotted dolphins, spinner dolphins, common dolphins, rough-toothed dolphins, bottlenose dolphins, Risso's dolphins, dwarf sperm whale and Cuvier's beaked whale (*Ziphius cavirostris*). All these strandings occurred in the Pacific coasta, to this day only two necropsies have been performed in animals stranded in the Caribbean coast, including one specimen of beaked whale belonging to the genus *Mesoplodon* and one sperm whale. By far the most common stranded species was the striped dolphin that represented 72% of all the specimens analyzed during this period of time. The main cause of death in this species was neurobrucellosis associated with infection caused by *Brucella ceti* (Table 12.2).

Causes of death varied among stranded animals and among species. There is variation in the presence of gastrointestinal parasites, parasitic pneumonias, and skin lesions. For instance, about 32% of stranded striped dolphins presented a localized unilateral or bilateral ulcerative lesion at the level of the mandibular condyle, directly below the eye or slightly frontal or caudal, irregular to oval in shape and with variable levels of chronicity. Some animals presented deep ulcerative lesion with active borders and secondary infection with different species of *Vibrio,* in the other hand other animals presented with completely healed wounds with prominent scar tissue (see figure). Histopathology revealed moderate to severe chronic ulcerative granulomatous dermatitis, negative for special stains intended to demonstrate

Table 12.2 List of cetacean species stranded in Costa Rica and Panama

Common name	Species	Costa Rica	Panama
Orca	*Orcinus orca*	Yes	–
Short finned pilot whale	*Globicephala macrorhynchus*	Yes	–
Melon headed whale	*Peponocephala electra*	Yes	–
False killer whale	*Pseudorca crassidens*	Yes	–
Guiana dolphin	*Sotalia guianensis*	Yes	–
Common dolphin	*Delphinus delphis*	Yes	–
Bottlenose dolphin	*Tursiops truncatus*	Yes	Yes
Spotted dolphin	*Stenella attenuata*	Yes	Yes
Spinner dolphin	*Stenella longirostris*	Yes	–
Striped dolphin	*Stenella coeruleoalba*	Yes	Yes
Rough toothed dolphin	*Steno bredanensis*	Yes	Yes
Risso's dolphin	*Grampus griseus*	Yes	–
Beaked whale	*Mesoplodon spp.*	Yes	–
Cuvier's beaked whale	*Ziphius cavirostris*	Yes	–
Sperm whale	*Physeter macrocephalus*	Yes	Yes
Dwarf sperm whale	*Kogia sima*	Yes	Yes
Fin whale	*Balaenoptera physalus*	Yes	–
Sei whale	*Balaenoptera borealis*	Yes	–
Bryde's whale	*Balaenoptera edeni*	Yes	Yes
Humpback whale	*Megaptera novaeangliae*	Yes	Yes

etiological agents like fungi, protozoans and bacteria. More exhaustive studies are needed to rule out viral agents like herpes and pox virus. These lesions appear to be traumatic in origin but the exact etiology has not been confirmed. There is no tendency for the presentation of these scars and active lesions between gender, age or time of the year of the stranding.

In Costa Rica the incidence of *Brucella ceti* in stranded cetaceans, particularly striped dolphins is considered high. Brucellosis is a zoonotic disease caused by bacteria of the *Brucella* genera. Traditionally, this bacterial disease has been associated in terrestrial animals such as ruminants, with reproductive problems such as abortions, testicular inflammation, lower milk productivity, and partial or complete infertility. Marine brucellosis was first described affecting stranded cetaceans in 1996 in the Scottish coast in United Kingdom (Foster et al. 1996). First, this bacterium was named as *Brucella maris*, then *B. cetaceae* and by 2007, *B. ceti* was recognized as a novel species of the genera affecting cetaceans. In 2004, this bacterial disease was identified as an important causing agent of meningoencephalomyelitis in striped dolphins stranded along the Pacific coast of Costa Rica. Isolation of *B. ceti* was first obtained in the country from a stranded striped dolphin in 2006 from cerebrospinal fluid (CSF), but the presence of this bacterium since then, has been also demonstrated from placenta, umbilical cord, amniotic and allantoic fluids, multiple fetal organs, milk, cardiac valve, atlanto occipital joint fluid, lung and lung nematodes (*Halocercus spp.*) (Hernández-Mora et al. 2008; González-Barrientos et al. 2010; Oliveira et al. 2011; Guzmán- Verri et al. 2012; Hernández-Mora et al. 2013). Serological diagnoses was first described under field and laboratory conditions, using Rose Bengal test as screening assay, (Rapid slide agglutination test, ID VET -France) and confirmed using an indirect ELISA designed for diagnosis of brucellosis in toothed-whales (Hernández-Mora et al. 2009). From 2004 to 2016, six stranded cetacean species in Costa Rica have been described as seropositive for this bacterial disease including striped and spotted dolphins, common dolphins, rough-tooted dolphins, and Cuvier's beaked whale. However, striped dolphins are the only species for which neurobrucellosis was diagnosed as the related cause of death and for which *B. ceti* was isolated (Hernández-Mora et al. 2013).

The most relevant macroscopic findings observed in striped dolphins infected with *B. ceti* include meningeal hyperemia and elevated levels of cerebrospinal fluid, resulting in secondary hydrocephalus in some cases, generalized hyperplastic lymphadenopathy and less frequently valvular endocarditis, placentitis and atlanto-occipital and scapulo-humeral osteoarthritis (González-Barrientos et al. 2010). Central nervous system histopathological lesions observed in striped dolphins with neurobrucellosis consist in a moderate to severe diffuse non-suppurative meningo-encephalomyelitis. These lesions are especially severe on basal structures of the brain like spinal cord, medulla oblongata and pons and less severe in upper regions like the thalamus and cerebral cortex.

Parasites in cetaceans are relatively common and some have been considered a cause of cetacean strandings (Gibson et al. 1998). In 2007, *Taxoplasmosis gondii* was isolated from a stranded striped dolphin found in the Pacific Coast of Costa Rica. This discovery suggest that cetaceans can become infected when this parasite is washed from land to the sea (Dubey and Beattie 1988). In a systematic survey of the parasitic fauna of stranded cetaceans of Costa Rica by Oliveira et al. (2011) it was found that parasites was present primarily in striped dolphins with a prevalence of parasites of 89.5%. Other cetaceans such as bottlenose dolphins, spinner dolphins, pantropical spotted dolphins and Cuvier's beaked whale also presented parasitosis. Fourteen helminth taxa were found and morphologically identified, including six species of cestodes, four nematodes and four digeneans. The nematodes and cestodes were the most prevalent parasite groups (90.9%), followed by the digeneans (22.7%). The most prevalent species were *Anisakis spp*. (90.9%), followed by *Tetrabothrius forsteri* (63.6%), *Halocercus lagenorhynchi* (54.5%) and *Tetraphyllidean plerocercoids* (40.9%). Additionally, *Xenobalanus globicipitis* a commensal crustacean species was also identified (Oliveira et al. 2011).

The pathologies related to the different parasitic infection within these animals include four infected cetaceans with *Anisakis* spp. presented mild gastritis. Moderate to severe granulomatous pneumonia was described in a striped dolphin infected with *Halocercus lagenorhynchi* and spotted and spinner dolphins were infected with *Halocercus* sp. Necrosis, fibrosis and partial destruction of the kidneys was found of Cuvier's beaked whale with *Crassicauda anthonyi,* similar to reported in Australia and Puerto Rico (Robson 1984; Mignucci-Giannoni et al. 1998). Because the related tissue damage demonstrated in crassicaudosis, this is a parasitic disease threatening the health and population recovery of cetaceans (Lambertsen 1992).

In addition to brucellosis and parasites, viruses can be an important cause of cetacean strandings. Among the most important viruses is the cetacean morbillivirus (CeMV) considered as the most pathogenic virus in these animals (Bellière et al. 2011).The reason for this is that CeMV may trigger high mortality events of cetaceans characterized by pneumonia, nonsuppurative meningo-encephalitis and prominent lymphoid cell depletion (Domingo et al. 1992). Strandings caused by CeMV were particularly dramatic between 1990 and 1992 in the Western Mediterranean cetacean species (mainly striped dolphins) and in the east coast of United States from 2010 to 2016 (Colegrove et al. 2016). In Costa Rica CeMV has not been detected yet.

In Panama, regular documentation of cetacean stranding initiated in 2009. In the Panamanian Pacific coast the most common species known to strand are the humpback whale, bottlenose dolphin, pantropical spotted dolphin, and sperm whale. Other species that have stranded include the dwarf sperm whale, false-killer whale, Bryde's whale, striped dolphins and rough-tooted dolphins. Strandings of dwarf sperm whales were associated to parasite infections in kidneys by *Crassicauda anthonyi* and stomach parasites by *Anisakis*, and in the muscle by *Diphilobrotium*. In 2016, a mass stranding of rough-tooted dolphins of 60 animals occurred in the Península of Azuero. The cause is suspected to be zoonotic diseases but not lab analysis were made to confirm it, however, parasite of the genus *Anisakis* where found in their stomach. In the Caribbean coast of Panama, the most common stranded species is the bottlenose dolphin, due primarily to collisions with dolphin-watching boats (Trejos-Lasso and May-Collado 2015). A sperm whale stranded on the Caribbean entrance to the Panama Canal also died due to boat collision (Trejos-Lasso unpublished data).

In recent years, Panamanian scientists have received training courses including one organized by the International Whaling Commission. About 40 people has been trained to assist in cetacean stranding and rescue events. Gear and tools have been donated to attend also whales trapped in fishing nets with the support of the National Coast Guard of Panama, and a protocols are being develop to create a national network that can respond to individual and mass strandings.

12.4 Conservation Threats and Concerns

Conservation efforts to protect cetaceans in Costa Rica and Panama have grown in the past 10 years largely due to increasing economic value of these animals in touristic activities, which consequently prompted the creation of guidelines to protect them. In addition, a number of non-profit organizations have developed workshops and training opportunities for tour operators and coastal communities, encouraging compliance to conduct guidelines. However, *in situ* regulation remains scarce resulting in the 'overuse' of some populations as is the case of the bottlenose dolphins of Bocas del Toro.

In both countries a number of marine protected areas have been created and some expanded. Many of these areas cover a relatively small area given the ranges of most local cetaceans and there is little to non-vigilance to enforce their protection. This is an important issue that needs to be addressed through education of neighboring communities and by funneling more resources for vigilance. In this respect, Panama faces many challenges when it comes to whale watching activities. While lack of compliance in some areas is due to operators limited opportunities for training and education (Sitar et al. 2016) in others operators purposefully ignored regulations, like those that sell tours to swim with humpback whales and dolphins, an activity prohibited in the country.

Although, scientific studies have increased in the past 20 years they remained bias to a few species and limited in space and time. Long-term data such as that of the Gulf of Chiriquí, Bocas del Toro, and the Osa Peninsula have been key to help us asses the demographic trends of these populations as well as any migratory shifts that may occur. Both of these aspects could be affected by climate change, or anthropogenic pressures. For example the Gulf of Chiriquí is an important nursery area for humpback whales with a high proportion of calves seen every year, ensuring that the proper conservation measures are taken will be crucial to the continued recovery of this humpback whale population, as well as the other species seen in these waters.

In Panama, southern humpback whales that travel by the Canal of Panama may be vulnerable to ship collisions. Guzman et al. (2013) using satellite data from adults and calves found that their movement coincides with major commercial maritime routes. In contrasts, humpback whales that use the Gulf of Chiriqui face other more important threats such as entanglement of fishing gear, vessel traffic, pollution and other anthropogenic pressures. Unlike the Gulf of Panama, this area is not used by large vessels transiting through the Panama Canal, so large ship strikes are not considered a major issue (Guzman et al. 2013). However, commercial fishing vessels are found in these waters as well as sport fishing and other pleasure craft, including a small but growing whale-watching industry. In the Osa Peninsula, Costa Rica the non-profit organization Keto has been monitoring touristic activities in the area for over a decade. Their research finds that since diving and whale watching activities were incorporated to local tour offers, the revenue of these communities went up 500%. This rapid economic growth inevitable translates into a larger tourism boat fleet that without control can significantly change the acoustic space of cetaceans.

For this reason the incorporation of acoustic monitoring to current cetacean survey protocols in Costa Rica and Panama can significantly improve population assessments and evaluate the impact of boat traffic. In an ongoing study established by Conservation International Costa Rica, acoustic monitoring is providing novel information about cetacean presence, habitat use, and daily activity, in relation to boat traffic. This type of assessments are key particularly in countries like Costa Rica and Panama where resources are limited. Acoustic monitoring is proven cost efficient methods that ensures large amounts of data of high quality.

In addition to long-term acoustic monitoring, incorporating molecular data to monitoring protocols is urgently needed. The population genetic studies by Barragan-Barrera et al. (2015) in Bocas del Toro, highlights the importance of such information. Her research indicates that this small bottlenose dolphin population is highly isolated form others in the Caribbean, and thus should be treated it as a separate conservation unit, and likely considered threatened in Panama. Another example is the case of coastal spotted dolphins. Escorza-Trevino et al. (2002) genetic work showed significant differences between Costa Rican spotted dolphins and those from the rest of Central America. Molecular data is relevant for conservation and management strategies, especially for cetaceans, which habitat overlaps with important fishing areas and tourism. Finally, we need infrastructure and capacity building for our stranding networks. As described in the stranding section, most strandings are associated with pathogens highlighting the importance of trained scientists, access to laboratories, and novel methods that can provide a better understanding of the causes of death in both countries. Helping to produce conservation policies that reflect cetacean population's health status.

While Costa Rica and Panama are leading the way in marine mammal research and conservation efforts in Central America, the lack of resources and funding can quickly hamper these efforts. Our small scientific community worries about the impact of rapidly growing boat-based whale watching industry and associated noise along our coasts, and how increasing noise levels can affect the soundscape of important habitats such as breeding grounds for migratory whales. We also worry about the lack of estimations of local cetacean mortality in fishing nets and direct killing (for shark bait) and, the effect that global warming will have in tropical habitats. Finally, we worry about the limited sources for funding whether governmental or private that allow us to continue filling up the gaps on the basic ecology of these animals, this information is the basis to make the right decisions on management and policy making.

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