Non-lethal boat scars on manatees in Belize as a tool for evaluation of a Marine Protected Area – Preliminary Results

CARYN SELF-SULLIVAN[1, 2, 3]
[1]*Department of Wildlife and Fisheries Sciences, Mail Stop 2258, Texas A&M Univ., College Station, TX 22843-2258 USA*
[2]*Hugh Parkey Foundation for Marine Awareness and Education, Belize City, Belize, Central America*
[3]*Sirenian International, Inc., 200 Stonewall Drive, Fredericksburg, VA 22401-2110 USA*

ABSTRACT

To evaluate the effectiveness of a Marine Protected Area (MPA) as a conservation strategy for an endangered species, it is important to know to what extent the population is using the MPA. In the Wider Caribbean Region, the use of MPAs is driven by the SPAW Protocol of the Cartagena Convention. Belize has been a leader in implementing goals set forth in the SPAW Protocol, including establishment of MPAs targeted towards the Antillean manatee, *Trichechus manatus manatus*. However, evaluation of the effectiveness of this conservation strategy for protecting endangered manatees in Belize is lacking. As part of a long-term study (1999-2006), I used underwater video techniques to capture images of manatees encountered in the Drowned Cayes area near Belize City. Non-lethal boat scars were detected on 103 of the 233 manatee images captured on video. Due to this relatively high number of individually identifiable animals in the area, a database of known manatees is being developed and analyzed to determine the parameters of the manatee population using Swallow Caye Wildlife Sanctuary (SCWS) and the Drowned Cayes. SCWS is a MPA established in the Drowned Cayes area in 2002, and the only MPA in the vicinity of Belize City where manatee mortality due to boat collisions is high. If manatees previously hit by boats have learned to seek shelter within SCWS, I would expect the proportion of scarred animals to be higher within the boundaries of the MPA. To date, the probability of capturing a scarred manatee within the boundaries of SCWS (probability =0.44, n=43 events, 19 scarred) is equal (G2=0.00) to the probability of capturing a scarred manatee outside SCWS (probability=0.44, n=190 events, 84 scarred). Continuation of this study is necessary to determine the parameters of the manatee population using SCWS and to evaluate the effectiveness of this MPA.

KEY WORDS: *Trichechus manatus manatus*, watercraft collision, Swallow Caye Wildlife Sanctuary

Cicatrices no Letales de Embarcaciones en Manatíes de Belice como Herramienta para la Evaluación de un Área Marina Protegida

Para evaluar la efectividad de un Área Marina Protegida (AMP) como estrategia de conservación para una especie en peligro, es importante conocer hasta qué punto la población esta utilizando el AMP. En la Región del Gran Caribe, el uso de AMPs es impulsado por el protocolo SPAW de la Convención de Cartagena. Belice ha sido un líder en la implementación de las metas establecidas por el Protocolo SPAW, incluyendo el establecimiento de AMPs dirigidas hacia el Manatí Antillano, *Trichechus manatus manatus*. Sin embargo, hace falta una evaluación de la efectividad de esta estrategia de conservación para la protección de manatíes en peligro en Belice. Como parte de un estudio a largo plazo (1999-2006), he utilizado técnicas de video subacuático para capturar imágenes de manatíes avistados en el área de los Drowned Cayes cerca de la Ciudad de Belice. Cicatrices no letales de embarcaciones fueron detectadas en 103 de las 233 imágenes de manatíes capturados en video. Debido a este número relativamente alto de animales identificables individualmente en el área, se está desarrollando y analizando una base de datos de manatíes conocidos para determinar los parámetros de la población de manatíes que utiliza el Swallow Caye Wildlife Sanctuay (SCWS) y los Drowned Cayes. El SCWS es un AMP establecida en el área de los Drowned Cayes en el 2002, y es la única AMP en las cercanías de la Ciudad de Belice, donde la mortalidad de manatíes debido a colisiones con embarcaciones es alta. Si los manatíes previamente embestidos por embarcaciones han aprendido a buscar refugio dentro del SCWS, se esperaría una mayor proporción de animales con cicatrices dentro de los límites del AMP. Hasta la fecha, la probabilidad de capturar un manatí con cicatrices dentro de los límites del SCWS (probabilidad =0.44, n=43 eventos, 19 con cicatrices) es igual (G2=0.00) a la probabilidad de capturar un manatí con cicatrices fuera del SCWS (probabilidad=0.44, n =190 eventos, 84 con cicatrices). Es necesario continuar este estudio para determinar los parámetros de la población de manatíes que utiliza el SCWS y para evaluar la efectividad de esta AMP.

PALABRAS CLAVES: *Trichechus manatus manatus*, colisión con embarcaciones, Swallow Caye Wildlife Sanctuary

INTRODUCTION

The conservation and management of endangered species often includes legislation that creates a protected area (Shrader-Frechette and McCoy 1993). However, targeted species do not necessarily remain confined to their protected areas (see Siex and Struhsaker 1999 and Wittemyer 2001 for examples). The optimal protected area for conservation of marine mammals would encompass the popula-

tion's year-round distribution (Reeves 2000). For most marine species this is unrealistic due to political, social, and economic constraints. One promising alternative is a system of protected areas created by identifying and protecting essential areas, activity centers, travel corridors, resources for expansion, and the ecosystem that supports the former through a variety of mechanisms (Packard and Wetterqvist 1986, Soulé and Simberloff 1986, Noss 1996, von Zharen 1998, 1999). However, it is necessary to have a reasonable understanding of the endangered species' distribution, ecology, life history, and behavior (Soulé and Simberloff 1986, Noss 1996, Channell and Lomolino 2000) to determine: (1) what areas should be protected and when; (2) the boundaries and connectivity necessary to make the protected areas effective conservation tools; and (3) how the protected area will be integrated with human needs. In reality, most Marine Protected Area boundaries have been defined through a "complex mix of aesthetics, opportunism, a little science, and a large helping of compromise" (Roberts 2000). On the other hand, Roberts argues that opportunism informed by a little science can help reach conservation goals, and to delay the establishment of protected areas until we know all we should is a greater risk.

In the Wider Caribbean Region, the use of protected areas and protected species legislation has been driven by the Protocol on Specially Protected Areas and Wildlife (SPAW), one of four protocols of the Cartagena Convention aimed at marine conservation in the region (Freestone 1991). Belize has been a leader in implementing goals set forth in the SPAW Protocol, including establishment of protected areas and programs targeted towards species of priority concern, especially the Antillean manatee, *Trichechus manatus manatus* (Gibson 1995, Auil 1998). Wildlife Sanctuaries, one of several types of MPAs in Belize, have been established specifically for the protection of Antillean manatees in Corozal Bay, Southern Lagoon, and around Swallow Caye—the focal point for manatee ecotours originating from Belize City, Caye Caulker, and San Pedro. The boundary for Swallow Caye Wildlife Sanctuary was selected based on local knowledge and opportunism, with emphasis on socio-economic-political concerns and less than optimal input from the scientific community. However, with scientific monitoring and evaluation of these sanctuaries and other known manatee habitat within the Belize Barrier Reef Lagoon System, we have a beginning for the alternative described above.

Similar to the situation in Florida, watercraft collision has been identified as a leading cause of manatee mortality in Belize. With an exponential increase in cruise ship tourism since 2001 (Belize Tourism Board 2006), the local perception has been that more manatees are being injured or killed by boats due to an increase in boating activity, especially near Belize City. According to the Belize Marine Mammal Stranding Network, there was an increasing trend in boat-related mortality from 1996 to 2003 (Auil and Valentine 2003, 2006). In Florida, most adult manatees can be individually identified by unique scar patterns, a result of non-lethal collisions with boats (Hartman 1979, Beck et al. 1982, Beck and Reid 1995). An analysis of propeller wounds on living and dead Florida manatees suggested that larger watercraft are responsible for most boat related mortality and that manatees probably survive strikes by boats with smaller propellers (Beck et al. 1982), such as those used by many tour operators near Belize City. If a significant proportion of manatees in Belize can be identified by non-lethal boat scars, this may be one way of assessing the relationship between increases in tourism activities, non-lethal watercraft collisions with manatees, and the use of protected areas by previously injured manatees.

As part of a long-term study on the distribution, ecology, and behavior of Antillean manatees using the Drowned Cayes area near Belize City, I looked at the effects of space and time on the likelihood of encountering a boat-scarred manatee. My objectives were to (1) determine the likelihood of encountering a boat-scarred manatee given a manatee was encountered; (2) determine whether boat-scarred manatees were more likely to be encountered inside or outside the boundaries of Swallow Caye Wildlife Sanctuary (SCWS); and (3) determine if there was an increase in the likelihood of encountering a boat-scarred manatee related to the increase in cruise ship tourism from 1999 to 2005. If the likelihood of encountering a boat-scarred manatee is high, then techniques used to study the Florida manatee population may be useful in the Drowned Cayes area of Belize. If SCWS provided a preferred refuge for manatees previously struck by a boat then I would expect to see a higher likelihood of encountering boat-scarred manatees within the boundary of SCWS. Alternatively, if the entire Drowned Cayes area provided a refuge for manatees previously struck by a boat, then I would expect to encounter boat scarred manatees equally distributed within the study area. If there has been an increase in non-lethal boat strikes since 2001, then I would expect to see an increase in the likelihood of encountering a scarred manatee over time.

METHODS

In Florida, during the winter months, manatees aggregate at warm water effluents and rest at the surface to warm themselves. This enables scientists to capture images of individuals from either a fixed or floating platform without entering the water. In the Drowned Cayes area of Belize, manatees neither aggregate in large groups, nor do they rest at the surface, making it more difficult to identify and/or capture images of individuals from surface. From 1999 to 2005 I used underwater video techniques to capture images of manatees opportunistically encountered during boat surveys and point scans in the Drowned Cayes study area. The Drowned Cayes area is classified as marine, with an average salinity of 35 PPT and extremely lim-

ited sources of fresh water (unpublished data). The area includes a labyrinth of mangrove islands, surrounded by seagrass beds, and intersected by deep (4-9 m) and shallow (1-3 m) channels locally known as bogues (Ford 1991). The features of this system provide a unique juxtaposition of manatee resources, including feeding areas, resting areas, social and nursery areas, and travel corridors in a marine habitat where site specific studies are lacking.

Definitions

I define boat-scar as any visible markings representative of fresh, recent, healing, or healed wounds (Beck et al. 1982) most likely resulting from a watercraft collision. Lacerations due to propellers and skegs leave distinctive scars, which are easily detected prior to complete healing and re-pigmentation of the skin. In this paper, the word 'scar' refers to a boat-scar as distinct from other types of scars or natural markings that may be found on manatees; the word 'capture' refers to video captures as distinct from physical captures of manatees. Re-pigmented scars and scars on animals encrusted with sediment, algae, and/or barnacles, are more difficult to detect using underwater video techniques. As a result, I have most likely underestimated the probability of capturing a scarred manatee. However, I assumed that the probability of capturing a manatee using underwater video techniques was not affected by whether or not the animal was scarred; and detecting a scar, given a scar is present, is equal across all categories used for analysis in this chapter.

Underwater Video Capture Methods

When a manatee was encountered, I determined whether conditions were optimum for capturing its image based on behavior of the animal, water clarity, and time available to devote to the capture. If all three of these conditions were optimal for a successful capture, I entered the water with mask, snorkel, fins, and camera, and maneuvered cautiously towards the animal. The capture event continued until one of 3 events occurred: (1) I had recorded images of the animal's paddle, trunk, and face, and determined its sex; (2) the animal moved away from the area; or (3) conditions became less than optimal for recording (e.g., low visibility due to angle of sun or disturbance of substrate, low battery, or tape end).

Data Reduction and Analysis

Video data were reviewed using a Toshiba Satellite M35X-S349 computer with 15-inch screen and Adobe Premiere 6.0 software, which enabled slow-motion and frame-by-frame playback. Re-captures were rare (unpublished data) and each capture was recorded as an event without regard to individual identity of the manatee. In the case of replicate captures of the same animal on the same day only one capture was included as an event (n=1). Log-likelihood ratio tests (G2) were used to determine whether the probability of capturing a scarred manatee differed

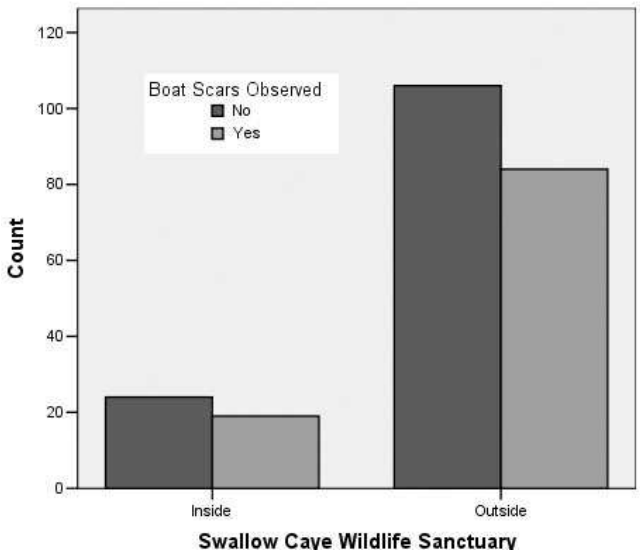

Figure 1. Distribution of opportunistic capture events (Count) by inside or outside the boundaries of Swallow Caye Wildlife Sanctuary split by unscarred (light bars) and scarred (dark bars) manatees. There was no significant difference in the likelihood of encountering a scarred manatee inside or outside the sanctuary. The low sample size inside the sanctuary is representative of the proportion of the study area that lies within the sanctuary boundaries.

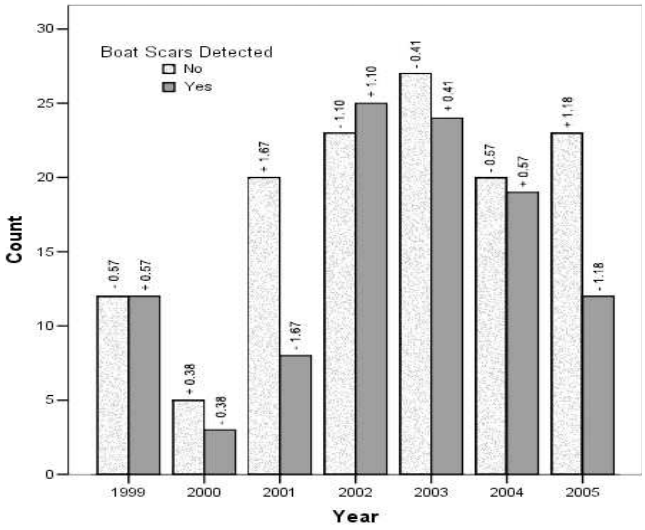

Figure 2. Distribution of opportunistic capture events (Count) by year split by unscarred (light bars) and scarred (dark bars) manatees. The exponential increase in cruise ship activity occurred between the 2001 and 2002 field seasons (Chapter I). Although there appeared to be an increase in the likelihood of capturing a scarred manatee between 2001 and 2002 (Self-Sullivan and LaCommare 2003), analysis of the data over an extended number of years indicated that this is neither significant nor a trend within the Drowned Cayes study area (G2 = 6.48, z-scores are shown above bars).

from what was expected by chance.

RESULTS

Scars were detected in 103 of the 233 events analyzed resulting in the overall probability of capturing a scarred manatee, given a manatee was captured, of 0.44. Probability in this context is defined as a simple probability (i.e., percentage) of scarred animals captured during all events (Bakeman and Gottman 1986). The probability of capturing a scarred manatee inside SCWS (probability = 0.44, n = 43 events, 19 scarred) was equal (G2 = 0.00) to the probability of capturing a scarred manatee outside SCWS (probability = 0.44, n = 190 events, 84 scarred, Figure 1).

To determine if the likelihood of capturing a scarred manatee changed with time, I examined the capture events by year. Years 1999-2001 had low cruise ship activity; years 2002-2005 had high cruise ship activity, with an exponential increase each year beginning in 2002. Preliminary analysis had indicated an increasing trend in the likelihood of capturing a scarred manatee from 1999-2002 (Self-Sullivan and LaCommare 2003). However, additional data collected during 2003-2005, contradicted the trend (Figure 2). Final analysis indicated that the likelihood of capturing a scarred manatee was variable and not significantly associated with SCWS or year.

DISCUSSION

Given that 44% of the manatees captured on video were scarred by boats, the lack of relationship between the likelihood of capturing a scarred manatee and increased cruise ship activity is surprising and contradicts both local perception and preliminary analysis. Indeed, I was quite surprised to see no significant increase in the likelihood of capturing a scarred manatee over time. Cruise ship tourism, as defined as the number of passengers leaving the cruise ship during a one-day Port of Call in Belize City, increased by 564% between 2001 and 2002. This exponential increase continued in 2003 (+80%), 2004 (+ 48%). Cruise ships anchor offshore between Belize City and the Drowned Cayes study area for a 6-8 hour Port of Call. Up to 12,000 passengers per day disembark the cruise ship via tender and tour boats for water and land based activities, which has dramatically increased the boat traffic in the Belize City area over the course of this study. However, on only one occasion was a manatee in the Drowned Cayes area captured with a fresh (pink) boat scar. In all other events the scarring appeared to be healing (white) or healed (gray) (Beck et al. 1982). The rate of healing is most likely variable depending on the original depth of the wound and extent of tissue damage, the general condition of the animal and environmental factors such as water temperature (G. Bossart, personal communication). Perhaps the individual manatees that use the Drowned Cayes area have learned to avoid the high traffic areas used by the cruise ship tender and tour boats. Alternatively, perhaps manatees struck by boats use some other area until their wounds are healed.

The proportion of manatees carrying significant boat scars in Belize was somewhat surprising considering the relatively low number of boats using the Drowned Cayes study area. This might indicate that animals use this area as part of a larger habitat, including the high traffic areas in the Belize River, Haulover Creek, and along the mainland near Belize City. On a positive note, the ability of researchers in Florida to identify individual manatees by boat-scarring has enabled significant population oriented research resulting in a better understanding of the Florida subspecies (Langtimm et al. 1998, Koelsch 2001, Kendall et al. 2003, Langtimm and Beck 2003, Kendall et al. 2004, Langtimm et al. 2004). To evaluate the effectiveness of a Marine Protected Area as a conservation strategy for an endangered species, it is important to know to what extent the population using the MPA is open or closed. If the population is relatively closed, then it can be assumed that the MPA provides some protection beyond other conservation strategies because it is protecting an entire population, which may serve as a source for recruitment outside the MPA. Indeed this is just such the argument for MPAs used to protect and enhance commercial fisheries species. However, if the population using the area is relatively open and individuals do not tend to stay within the MPA, then how do we know whether it is providing additional protection?

Analysis of manatee boat scars indicated that the probability of capturing a scarred manatee in SCWS and nearby habitat was relatively high and equal, enabling the possibility of long-term photographic capture-recapture methods to further analyze the population. The equal distribution of scarred manatees within the study area indicates no preference for SCWS over the larger Drowned Cayes area, indicating that the entire area may currently be used as a refuge from increasing boat traffic near Belize City. Preliminary capture-recapture analysis of the events indicate a low number of recaptures (unpublished data), which is indicative of an open population. This hypothesis is supported by data collected in collaboration with other manatee researchers in Belize. For example, one male manatee, captured in the Drowned Cayes during the May 2004 Wildlife Trust Capture Event, spent most of his time west and north of the study area during the seven months immediately post-capture (Auil et al., unpublished data). This same animal also made at least one trip outside the Belize Barrier Reef Lagoon System, traveling east to Turneffe Atoll and back, during the tracking period. Another male manatee, originally photo-identified at Basil Jones cut (northern Ambergris Caye) in 1994-95, was resighted at Gallows' Reef in 1999 (Self-Sullivan et al, 2003).

The most recent IUCN Red List assessment of the Antillean manatees (*T. m. manatus*) suggested human activities, such as habitat degradation, poaching, incidental take, watercraft collision, and human disturbance, are an increasing threat to survival of the sub-species in the Wider Caribbean Region (Self-Sullivan and Mignucci-Giannoni 2006).

In 14 of the 21 countries assessed, "Protected Area" was reported as an important conservation strategy for protecting manatees and their habitat. However, monitoring of the effectiveness of these protected areas is lacking. I proposed that photo-id methods, using boat-based surveys and under-water video techniques, may provide an inexpensive mechanism for monitoring the effectiveness of manatee sanctuaries, especially in developing nations with limited resources. If individual manatees are subject to non-lethal boat strikes throughout the Wider Caribbean Region, these methods can use used to build a regional catalog of individuals, the first step towards understanding how these elusive and endangered creatures use the sanctuaries and whether they move long distances between sanctuaries and other manatee habitat systems within the region.

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