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Daniel Gonzalez-Socoloske
Andrews University, gonzalezd@andrews.edu

James P. Reid

Carlos Espinoza-Marin

Kherson E. Ruiz

Kenneth E. Glander

See next page for additional authors

Authors
Daniel Gonzalez-Socoloske, James P. Reid, Carlos Espinoza-Marin, Kherson E. Ruiz, Kenneth E. Glander, and Leon David Olivera-Gomez

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First successful capture and satellite tracking of a West Indian manatee (*Trichechus manatus*) in Panama: feasibility of capture and telemetry techniques

Daniel Gonzalez-Socoloske[†, ‡, *], Leon D. Olivera-Gómez[§], James P. Reid[¶], Carlos Espinoza-Marin[#], Kherson E. Ruiz[$] and Kenneth E. Glander[†]

[†]University Program in Ecology, Duke University, PO Box 90329, Durham, NC 27708, USA
[‡]Present Address: Dept. of Biology, Andrews University, Price Hall Rm 236, 4280 Administration Dr., Berrien Springs, MI 49103, USA
[§]División Académica de Ciencias Biológicas, Universidad Juárez Autónoma de Tabasco, Carretera Villahermosa-Cardenas Km 0.5, C.P. 86150, Villahermosa, Tabasco, Mexico
[¶]Sirenia Project, Southeast Ecological Science Center, US Geological Survey, 7920 NW 71st Street, Gainesville, FL 32653, USA
[#]Fundación Trichechus, Apdo. 245-3015, San Rafael de Heredia, Costa Rica
[$]Asociación de Amigos y Vecinos de la Costa y la Naturaleza (AAMVECONA), Apartado Postal No.0103-00099, Changuinola, Bocas del Toro, Panama
*Corresponding author, email: gonzalezd@andrews.edu

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Here we report the results of a multi-national and multi-institutional collaboration resulting in the first successful capture and satellite tracking of a West Indian manatee in southern Central America.

All extant sirenians, manatees and dugongs, are currently listed as vulnerable by the International Union for Conservation of Nature (IUCN) mostly due to anthropogenic causes such as collision with boats, habitat loss, poaching, and entanglement in fishnets (IUCN, 2012). The West Indian manatee, *Trichechus manatus*, ranges from Florida to northeastern Brazil (Marsh *et al.*, 2012; Self-Sullivan and Mignucci-Giannoni, 2012), however, throughout much of the species' range information regarding their behavioral ecology is limited or lacking (Deutsch *et al.*, 2008). Manatees can be very shy and cryptic, especially in areas where they are hunted (Jiménez, 2002) or heavily disturbed by humans (Miksis-Olds *et al.*, 2007), such as in Mexico, Central America, and South America. Excluding Belize, manatee research in Central America has been limited to habitat descriptions (Klein, 1979; Smethurst and Nietschmann, 1999; Jiménez, 2002) and distribution studies (Rathbun *et al.*, 1983; Mou Sue *et al.*, 1990; Reynolds *et al.*, 1995; Smethurst and Nietschmann, 1999; Jiménez, 2005; Gonzalez-Socoloske *et al.*, 2011). No genetic studies have been conducted of manatees in Central America south of Belize (Garcia-Rodriguez *et al.*, 1998; Vianna *et al.*, 2006), with the exception of one location in western Panama (Muschett, 2008). It is currently unknown how important the Central American countries south of Belize are as a link between manatee populations in the north (Belize and Mexico) and populations in South America. Therefore, apart from knowing where manatees are found, it is important to understand how manatees are using these habitats and if they are moving between countries or distinct population centers.

Previously used methods to study manatee movement include photo identification (Reid *et al.*, 1991; Beck and Reid, 1995; Beck and Clark, 2012) and telemetry studies (Deutsch *et al.*, 2003; Flamm *et al.*, 2005; Marmontel *et al.*, 2012). While the use of photo identification has been successfully used for decades in Florida to document manatee residence and movements among specific sites, its use is limited to locations where manatees with distinctive features (*e.g.* scars resulting from boat collisions) can be observed (Beck and Clark, 2012). These marks are seldom seen in wild manatee populations outside of Florida, making that technique for individual identification unfeasible. The use of radio tagging techniques to understand movement patterns has been successfully implemented on wild West Indian manatees in Florida (Deutsch *et al.*, 2003; Flamm *et al.*, 2005), Mexico and Belize (Castelblanco-Martínez *et al.*, 2013), Puerto Rico[1] (Lefebvre *et al.*, 2000), and Brazil[2] (Reid, unpub. data). However, most West Indian manatee captures outside of Florida have occurred in marine or brackish waters where visual observation of manatees was possible. The capture technique involves sighting manatees from a raised platform

[1]Reid, J.P., Bonde, R.K., Easton, D.E. and Kochman, H.I. (1994) *1993 Annual report on the radio telemetry of manatees in Puerto Rico.* National Biological Survey, Gainesville, FL. 24 pp.
[2]Normande, I.C., Attademo, F.L.N., Viana Jr, P.C. and Savaget, P.V. (2014) MA2-Área de vida e utilização do habitat por peixes-boi marinhos *Trichechus manatus* (Sirenia: Trichechidae) na Bacia Potiguar, Brasil. Pages 770-701 *in* Libro de resúmenes, *IV Congreso Colombiano de Zoologia,* 1-5 December 2014, Cartagena de Índias, Colombia.

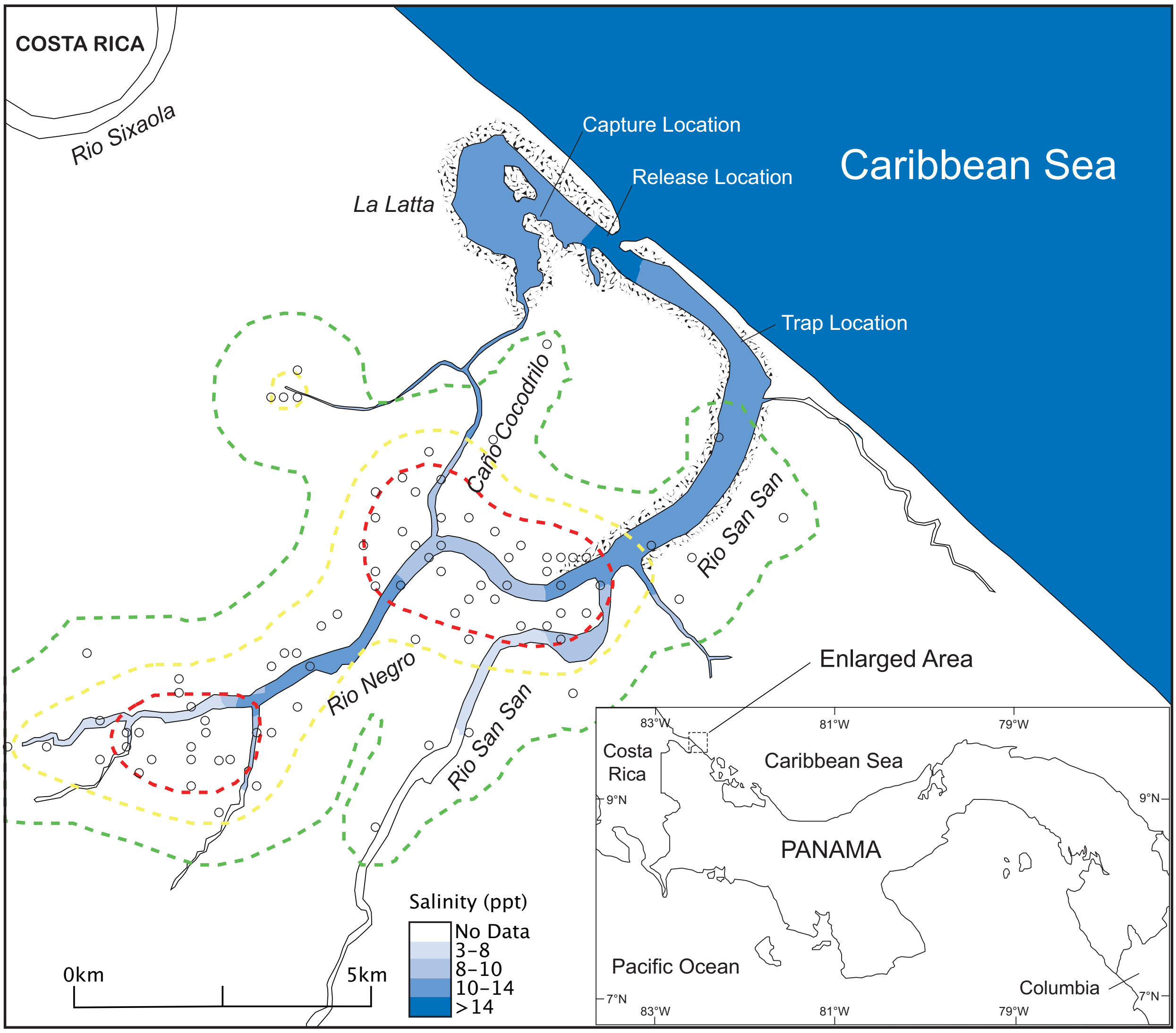

Figure 1. Location of study site within San San Pond Sak, Panama, showing surface salinity and shore areas dominated by red and white mangrove (thatch texture). Kernel densities of Argos location classes 2-3 (n=92) shown with dashed lines, 50% (inner red perimeters), 75% (middle yellow perimeters), and 90% (outer green perimeter). PTT locations indicated by open circles.

on a boat (or with aerial detection) and then following the target individual until it can be safely encircled with a net (Marmontel *et al.*, 2012). However, this capture technique is limited to the ability to detect manatees visually, which is very difficult in dark water habitats (*i.e.* turbid or tannin-stained rivers and lakes). For example, in 2005 a weeklong manatee capture effort was organized by one of the authors (CE-M) in Tortuguero National Park, Costa Rica, but was unsuccessful due to the difficulty of detecting manatees in the turbid riverine habitat. Seasonally flooding forests and mangrove habitats pose an additional complication by increasing the potential for the radio tags to snag on benthic or near-shore structures and prematurely breaking off. This possibility puts into question the feasibility of using conventional telemetry techniques in these types of habitats. The objectives of this study were to (1) develop and test an alternative manatee capture technique for dark water habitats to permit radio tagging studies, and (2) assess whether telemetry techniques are feasible in a mangrove habitat to determine manatee movement patterns and habitat use.

The study area selected was the Wetlands of International Importance San San Pond Sak[3] (SSPS; 09°30'48.86"N, 82°30'28.84"W) in northern Panama (Figure 1). We selected this site based on previous manatee sightings reported by Mou Sue *et al.* (1990) and more recent sightings by several of the authors (KE in 2006-07, CE-M in 2006, DG-S in 2007) and because the local non-government organization (NGO) working in the area developed a way to bait manatees, facilitating the possibility of capturing manatees by attracting them to specific areas.

[3]Known officially as Humedal de Importancia Internacional San San Pond Sak and Ramsar Wetlands of International Importance number 611.

The protected area SSPS (20025ha) was established on 2 August 1994 (Resolución de Junta Directiva 020-94) primarily to preserve the wetland habitat for migrating birds and diverse flora[4]. Several local NGOs have been working in the area to protect nesting sea turtles and other fauna. The protected area SSPS is located within the province of Bocas del Toro near the northern border with Costa Rica (Figure 1). The eastern and western limits of the protected area are bordered by the Sixaola and Changuinola rivers, respectively. Surface water salinity (salinity meter HQ40d, Hach, USA) in the San San and Negro rivers gradually decreased as distance from the river mouth increased, ranging from 32.60 to 3.47ppt (mean = 10.40 ± 5.14 SD; n=28; Figure 1). Upriver, shore vegetation was dominated by *Hibiscus* sp., mangrove fern (*Acrostichum aureum*) and various shore grasses. Downriver, where salinity levels were the highest, shore vegetation was dominated by red (*Rhizophora mangle*) and white (*Laguncularia racemosa*) mangrove forests (Figure 1). Tidal influence was minimal, and floating vegetation was only found far upriver where salinity levels were low. No submerged vegetation was observed.

We employed two different capture techniques that took advantage of the ability to bait manatees to strategic capture locations. The first was to make a rectangular trap (4x2m) using long mangrove sticks stuck into the bottom substrate, similar in design to manatee traps used in West Africa[5] (Kouadio, 2012). One end of the trap faced the edge of the river lined with *R. mangle* roots, while the other faced out towards the river. Water depth increased towards the river channel and averaged 2m. A vertical slide door was constructed on the river side, which was held up in the open position by a metal pin. The pin was attached to a rope, which was connected to a small bunch of bananas on the near-shore end of the trap. When sufficient pressure was placed on the rope (by tugging on the banana bunch), the pin would come out and the vertical slide door would fall, resulting in complete closure of the trap. Banana leaves were attached to nearby mangrove branches adjacent to the trap in an attempt to attract more manatees to the area. We were unsuccessful in luring a manatee into the trap, in spite of manatees consuming all of the nearby banana leaves. Several times the trap door was found closed with no manatee inside. However, there were small bite marks on the bananas that were out of the water, suggesting that they were possibly raided by one of the capuchin monkey (*Cebus capuchinus*) troops occupying the area. Had more days been allocated to this method and the bait placed completely underwater (to avoid being manipulated by primates or other arboreal animals), this method may have been successful.

The other technique attempted was to bait manatees with banana leaves into a small shallow cove (60x40m) lined by mangroves in a section called La Latta (Figure 1). A lookout was placed atop the mangrove trees overlooking the shallow cove with radio communication to the rest of the capture team. Once two or more manatees were feeding on the banana leaves, the lookout radioed the nearby capture boat to quickly close the entrance to the small cove by deploying a large net with a small mesh so that manatees could not get entangled. Once the entrance was sealed off and the manatees were contained in the area, a smaller net with a larger mesh was used to encircle and restrain individual manatees. This capture technique was employed from 28 January to 2 February 2008, during which manatees were successfully enclosed in the cove four different times. Each time, 1-3 manatees were contained, even though the lookout reported between 2-8 manatees feeding at the bait station, indicating that a substantial number of manatees were able to escape the cove before it was enclosed or were able to go under the large net. In one instance, two large manatees were enclosed and while one put tension on the net by pushing against it (thereby lowering the top portion), the other manatee escaped over the net. Only one manatee was captured during the four attempts.

On 31 January 2008, a 210cm female manatee was captured and adapted with a caudal peduncle belt and a tethered floating Argos satellite tag (PTT) with an integrated VHF transmitter (ST-14, Telonics, Inc., Mesa, AZ). The manatee was assessed as having a good body condition (*i.e.* no visible scars, adequate weight and proportions, no lesions or skin defects, etc.). To conserve battery life, the PTT tag had an on/off duty cycle of two hours on, three off, two on, four off, two on, six off; which constituted activity time hours between 05:00-07:00, 10:00-12:00, 16:00-18:00, and 21:00-23:00 hours local time (GMT -5). The tag design developed in Florida was used, which contains weak links built into both the belt and tether as a safety measure so that the manatee could break free should the tag become entangled (Deutsch *et al.*, 1998; Marmontel *et al.*, 2012).

A total of 224 locations were obtained in 46 days during deployment on the manatee from 1 February to 17 March 2008 (Table 1). Sixty-six percent (147 of 224) of the locations were of Argos classes 1, 2 or 3, meaning that locations were obtained when four or more messages were received, and thus are of higher location accuracy than classes A, B or 0. Location accuracies for class 1, 2, and 3 are estimated at better than 1500m, 500m, and 250m radius, respectively[6].

In spite of being released at the mouth of the San San River and initially heading out to the Caribbean Sea, all locations of class 1-3 were situated upriver within Negro River and San San River (Figure 1). The lack of long-range movement to the seagrass beds of Bocas del Toro or nearby Costa

[4]Autoridad Nacional del Ambiente [ANAM] (2004) *Plan de manejo del humedal de importania international San San Pond Sak* [Management plan for the wetlands of international importance San San Pond Sak], Asociación Nacional para la Conservación de la Naturaleza Panama City, Panama.
[5]Powell, J.A. (1996) *The distribution and biology of the West African Manatee* (Trichechus senegalensis, *Link 1795*). Regional Seas Programme, Ocean and Coastal Areas. Nairobi, Kenya, United Nations Environmental Program. 68pp.

[6]Argos (2011) Argos User's Manual. Avaliable at http://www.argos-system.org/manual/. Consulted on July 25, 2011.

Table 1. Summary of PTT locations obtained from a West Indian manatee *Trichechus manatus manatus* in Panama from February 1 to March 17, 2008.

	Argos Classes						
	A	B	0	1	2	3	All
Locations	19 (8%)	36 (16%)	22 (10%)	55 (25%)	56 (25%)	36 (16%)	224
Daily Ave. ± SD	0.4 ± 0.7	0.8 ± 0.9	0.5 ± 0.7	1.2 ± 1.0	1.2 ± 0.9	1.2 ± 0.9	4.9 ± 1.8
Daily Range	0-2	0-3	0-3	0-4	0-3	0-3	1-11

Rica (*e.g.* Gandoca-Manzanillo Wildlife Refuge) could be because manatees use marine waters more frequently during environmental conditions or seasons not sampled in this study. Our preliminary survey of the vegetation available to manatees in SSPS included the presence of various shore grasses (*Panicum* sp., *Axonopus* sp., and *Brachiaria* sp.) and small amounts of floating vegetation (*Pistia stratiotes* and *Nymphoides* sp.), as well as red mangrove (*Rhizophora mangle*), all of which have been reported as manatee food in other locations (Best, 1981; Spiegelberger and Ganslosser, 2005; Marsh *et al.*, 2012), indicating that the need for marine sources of food may be minimal.

Habitat use was determined by kernel density estimates (50%, 75%, and 90%) of the most accurate locations (classes 2 and 3; n=92) using GIS software (ArcView 3.2 ESRI, Redlands, CA). It appears that this manatee utilized two core areas – the junction of the Negro River and Caño Cocodrilo and where the San San River joins the Negro River (Figure 1). Salinity in these areas ranged from 8-12ppt and the dominant shore vegetation in these areas was *Rhizophora mangle*, *Laguncularia racemosa*, and *Acrostichum aureum*, with almost no shore grasses.

The protected area SSPS appears to provide ample forage, protection, and freshwater thus allowing for high site fidelity, however this could not be confirmed due to our small sample size. Future studies consisting of a larger sample size are needed to evaluate this hypothesis. A genetic study from fecal samples of manatees collected within SSPS found only one mtDNA haplotye 'J' (Muschett, 2008), which has also been identified as haplotype 'J01' in Mexico (Nourisson *et al.*, 2011), Belize (Hunter *et al.*, 2010), Colombia, and Venezuela in lower frequencies (Vianna *et al.*, 2006). Neighboring Colombia has the highest reported haplotype diversity for the West Indian manatee (Garcia-Rodriguez *et al.*, 1998; Vianna *et al.*, 2006), allowing for the possibility of more haplotypes in Panama. The low haplotype diversity in manatees in SSPS reported by Muschett (2008) was based on 43 floating fecal samples and should be viewed with caution because the authors did not test for the unique number of individuals. Therefore the fecal samples may represent only a few individuals, especially because they were all collected from only one location within SSPS by one of the local residents[7].

The baiting technique was very effective in this dark water habitat and allowed us to attempt many captures in a relatively short amount of time. There appeared to be no negative effects on the manatees from the capture attempts because they always returned to the capture site shortly after we replenished the site with additional banana leaves. Banana plantations surround SSPS and it is common for discarded banana leaves to wash down the river, thus habituating manatees to their presence as a food source. Using banana leaves as bait may not be effective in areas where manatees have not been exposed to them, however other preferred food items could be used use such as cassava leaves used by manatee hunters in West Africa[8]. Based on the success of the tag attachment and the quality of the locations, we conclude that the protected area SSPS is an adequate site for future manatee radio tracking studies and that the riverine and mangrove habitat there does not impede the use of the traditional belt, tether, and floating tag technology for monitoring manatees.

Although small in area, SSPS may have the highest concentration of manatees in Panama. More research needs to be conducted in SSPS in order to understand the extent of the use of this protected area by manatees. Future tagging studies may reveal the importance of nearby seagrass beds and the possible interchange between manatee populations in neighboring Costa Rica. Our study demonstrates the feasibility of both capturing manatees, via the baiting technique, and implementing traditional radio tagging techniques in dark brackish and riverine habitats. The implications extend beyond the specific site and species used in this study, since these dark water habitats exist elsewhere for both West Indian (specifically the Antillean subspecies, *T. m. manatus*) and West African (*T. senegalensis*) manatees and represent a substantial and critical portion of the remaining available habitat for both taxa.

[7]S. Herrera, pers. comm., 2 February 2008

[8]J. Powell, pers. comm., 25 November 2011

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