

Distribution and abundance of the West Indian manatee

(*Trichechus manatus*) in the Panama Canal

Giselle Muschett^{1,2} and Juliana A. Vianna²

¹ Department of Biological Sciences, Macquarie University, NSW 2109, Australia,
giselle.muschett@students.mq.edu.au

² Facultad de Agronomía e Ingeniería Forestal, Pontificia Universidad Católica de Chile.
Ave. Vicuña Mackena 4860, Santiago, Chile, jvianna@uc.cl

The West Indian manatee (*Trichechus manatus*) is threatened throughout its distribution, and is categorized as vulnerable by IUCN (Lefebvre 2001, IUCN 2007). The number of mature individuals is currently estimated at less than 10,000 and is expected to decline at a rate of at least 10% over the next 20 years as a result of both habitat loss and anthropogenic factors (Deutsch *et al.* 2008). While the West Indian manatee is the most widespread of all existing sirenians, some populations are estimated at fewer than 10 individuals (Deutsch *et al.* 2008, Quintana-Rizzo and Reynolds 2010). In addition, in most Central American countries reliable information on manatee distribution and conservation status is missing and there is need to assess these remnant populations to guide future management strategies.

In Panama, there has been little recent manatee research (Muschett *et al.* 2009, Lefebvre 2001). There are two known resident manatee populations in the country, one

26 in Bocas del Toro, on the Northern Caribbean Coast, and the other in Lake Gatun, in
 27 the Panama Canal Watershed (Fig. 1) (Mou-Sue *et al.* 1990, Lefebvre 2001). The origin
 28 of this second population is unclear, and whether manatees in the Chagres River
 29 survived the construction of the Panama Canal remains unknown (Mou-Sue *et al.* 1990,
 30 MacLaren 1967). However, in 1964 one Amazonian manatee *T. inunguis* from Peru and
 31 nine West Indian manatees *T. manatus* from Bocas del Toro were introduced into an
 32 enclosure in Lake Gatun as part of an aquatic vegetation control program for the
 33 Panama Canal. Some years later these manatees either escaped or were released into
 34 the lake (MacLaren 1967). Since then manatee sightings have been common, as have
 35 vessel collisions and deaths from underwater detonations for dredging (Schad *et al.*
 36 1981, Hernández 1982). However, an aerial survey carried out years later spotted only
 37 one manatee in the lake (Mou-Sue *et al.* 1990). To date the actual number of manatee
 38 in Lake Gatun remains undetermined. The annual number of deaths is also unknown
 39 and there are unconfirmed reports of hunting by local people (Lefebvre *et al.* 2001).

40

41 The net result of these circumstances is that there is a pressing need to gather
 42 information on the current state of this population. In this study we provide preliminary
 43 information on the number of the West Indian manatees in Lake Gatun and document
 44 possible human threats to manatees in the main body of water within the Panama
 45 Canal. Located in central Panama (09°09'N 75°51'W) and covering 430km² (Fig. 2),
 46 Gatun is an artificial freshwater lake created in 1906 when the Chagres River was
 47 impounded to build the Panama Canal. The typical vegetation in the lake includes
 48 *Eichhornia crassipes*, *Pistia stratiotes*, *Pontederia rotundifolia* and *Hydrilla verticillata*,
 49 all of which are part of the manatee's diet (Jimenez-Perez 2000, TLBG *et al.* 2002).

50

We conducted interviews with local people in order to determine their perception of and association with manatees. Interview questionnaires were modified from Lima (1997) and Luna (2001) (see Annex 1). Similar to the methodology used by Motonya-Ospina *et al.* (2001), we also reviewed information from the captain's logs of the Panama Canal Authority (ACP) Aquatic Vegetation Control Unit and the Smithsonian Tropical Research Institute (STRI) Game Warden reports which contained detailed information on the removal of deceased manatees and allowed us to assess the number of recorded manatee carcasses sighted in the lake. Finally, we conducted aquatic (boat-based) surveys and aerial surveys to locate and assess the numbers of manatees in Lake Gatun. We plotted each manatee sighting from each of the different sources on a map using ArcView GIS 3.2 (ESRI, Inc. 2002). We analyzed the proportion of interviews that yielded manatee sightings as well as any grouping in the location of sightings. To simplify analyses, we divided the lake into six sectors: I) Culebra Cut South II) Culebra Cut North III) Chagres River, IV) Barro Colorado, V) Northeast and VI) West (Fig. 2).

We conducted interviews between March and July 2007. Interviews focused on employees of the Gamboa Rainforest Resort, Barro Colorado Nature Monument game wardens, private boat operators, and several Divisions of the ACP since they spend the majority of their working hours (day and night) on the lake. We were not able to conduct interviews with members of local agricultural communities located on the Western sector of the lake due to difficult access. Forty-four interviews were conducted between March and June 2007. Interviewees ranged in age from 27 to 56 years, with a mean of 42 years. Only two of the individuals interviewed had never seen a manatee, and thus the effective number of interviews was 42. These 42 interviews yielded 59 manatee sightings; 63% (37) corresponded to recent manatee sightings (< 3 years), and 22%

(13) were historical sightings. Sightings concentrated on Culebra Cut North, Sector II (26%) and Barro Colorado, Sector IV (24%) (Fig. 2). We were not able to conduct interviews with members of local agricultural communities located on the Western sector of the lake due to difficult access.

Only one respondent admitted to hunting a manatee, while 21% (9) of respondents knew of the existing legislation prohibiting hunting of manatees. Of these 78% (6) of which corresponded to the STRI game wardens. 21% (9) recalled seeing females with calves, but there was no specific time of the year when respondents saw calves more often. Interviewees also commonly saw manatees alone (42%) or in pairs (36%); while only 5% reported seeing groups of three or more. Finally, 64% (27) of respondents had seen at least one dead manatee in the lake; 26% (7) speculated they deaths were the result of detonations during dredging activities in Culebra Cut, while 37% (10) attributed deaths to collisions with boats.

A total of 32 Captain's logs was reviewed, which recorded 19 manatee deaths over the 14 years from 1995 to 2008. The largest number of deaths in one year ($n = 4$) was registered in 2007. No deaths were recorded during 1998 or 2003. No deaths were reported in February, August, or September of any year. Thirteen deaths (76%) were registered in Culebra Cut (Fig. 2), but the Aquatic Vegetation Control Unit only surveys Culebra Cut, Chagres River and the Tabernilla region (Sectors I, II and IV), so these results must be treated with caution.

Boat-based surveys were carried out 3m long fiberglass boat with a 25hp outboard engine on five different occasions from January to June 2007. Due to difficult access

boat-based surveys were only carried out in Sectors II, III and IV. Only two manatees were seen from the boat during the surveys: one in the Chagres River (Sector III) and west of Barro Colorado Island (Sector IV) (Fig. 2).

Aerial surveys were carried out in a Robinson R44 helicopter, flying at an average altitude of 150m and speed of 180km/h (following Lefebvre *et al.* 1995). Restrictions regarding aerial space over the Panama Canal locks required these areas to be flown above 200m. Each flight originated in Marcos A. Gelabert National Airport, Panama City (8.9733° N, 79.5556° W). Aerial surveys were conducted on 10 January 2008, 14 January 2008 and 10 October 2008 (Table 1). All flights were carried out in the early morning to reduce the effect of glare (Marsh and Sinclair 1989). For the aerial surveys Sectors I to VI were flown on 10 January, Sectors I, II, III and V were flown on 14 January 2008, and sectors IV and V on 10 October 2008. The beginning and end of each transect was marked using a GPS (Fig. 2). During each flight, each time a manatee was spotted from the air an observer recorded the transect number, number of individuals seen, if they were in a group (a visually distinct “clumping” of individuals) and the presence of calves (individuals of approximately less than 2m in close proximity to or accompanying a larger individual) (Morales-Vela *et al.* 2000).

During the 10 January 2008 aerial survey, 10 manatees (8 adults + 2 calves) were sighted in 1:30 h of survey time. During the 14 January 2008 survey only two manatees (both adults) were sighted in 45 min. During 10 October 2008, 16 manatees (12 adults + 4 calves) were sighted in 1:10hrs. Sightings were made in the Northeast (Sector V) and Barro Colorado (Sector IV) sectors (Fig. 2). There were no sightings of manatees in the Western sector (Sector VI), or either sections of Culebra Cut (Sectors I and II).

126

127 Our study, while preliminary, is the first to assess the distribution and conservation
128 status of the West Indian manatee population in Panama Canal in over 20 years. Our
129 results show that there are at least 16 individuals in Lake Gatun and that at least some of
130 them are reproducing as evidenced by the sighting of females with young. While 16
131 manatees is still very few, it is more than what has previously been reported (Mou-Sue
132 *et al.*, 1990). Our study also shows the first evidence of manatees reproducing in the
133 Panama Canal.

134

135 The 59 manatee sightings obtained through interviews are similar to those obtained by
136 Schad *et al.* (1981). However, we cannot rule out that some sightings were of the same
137 individual and may merely be evidence of a small number of manatees using habitat
138 near areas frequented by humans. For example, Reports in Culebra Cut (Sectors I and
139 II) accounted for more than 40% of the manatee sightings. Culebra is arguably the
140 busiest section of the Panama Canal. A mere 152m across, the Cut is bustling with
141 activity 24 hours a day, not only due to large shipping vessels (up to 45 a day) but the
142 almost non-stop dredging activity, as well as tourism operators. Manatees could be
143 using the upper portion of Culebra cut to transit to and from the Chagres river and the
144 lake proper. As such, these sightings do not necessarily indicate the level of habitat use
145 or a higher than expected number of manatees in the area. Indeed, there was no
146 apparent correlation between areas of low boat traffic and high sightings of manatees
147 with any of the methods used in this study.

148

149 Interviews with residents in the less congested Western sector of the lake would help
150 off-set this potential bias, but we were unable to interview local farmers and fishermen

in this sector of the lake due to difficult access. Past studies have faced a similar challenge (Schad *et al.* 1981, Mou-Sue *et al.* 1990). Future studies would do well to include local communities in this area.

An apparent lack of hunting is encouraging, and is contrary to what has been found in other parts of Panama (Mou-Sue *et al.* 1990), and in the remainder of Central and South America (Reynolds *et al.* 1995, Auil 1998, Luna 2001, Montoya-Ospina 2001, Jimenez 2002). However, it might be that manatees are not yet abundant enough to be a regular source of protein for locals. Results of interviews from communities in the western sector of the lake would go a long way to determining whether or not this is indeed the case. In contrast to studies carried out in Guyana, Brazil and Costa Rica (Reynolds *et al.* 1995, Jimenez-Perez 1998, Luna 2001, de Thoisy *et al.* 2003) few respondents knew of the legislation that prohibits the hunting of manatees (Legislative Assembly 1995). This lack of knowledge needs to be addressed and the legislation needs to be made known to the public at large if manatees are to be protected in the long term.

The 19 reported manatee mortalities from 1995 to 2008 have no accurate cause of death however, manatee mortality in the lake has previously been attributed to collisions with trans-oceanic vessels or under water detonations due to dredging activities in the Canal (Schad *et al.* 1980, Hernández 1982). What the deaths recorded in the captain's logs and game warden's reports do reveal that manatees have been consistently present in the lake during those 14 years. A death rate of approximately one manatee per year may not seem high, but considering the small number of

manatees in the lake it is cause for concern. Our study represents the first time this type of methodology was used to assess manatee mortality in Panama.

Contrary to what has been found in other studies (LaCommare *et al.* 2012), we only sighted two manatees during boat-based surveys. This is discouraging, as boat-based surveys have proven to be a cost-effective method of monitoring manatee populations in other areas of Central America (LaCommare *et al.* 2012). However, boat-based surveys work best in clear waters and would be of lesser value in the deeper and more turbid waters of Lake Gatun, particularly during the rainy season.

In our study, the highest number of manatees sighted during a single survey, and thus least likely to count individuals twice, was 16. When we consider that aerial surveys tend to underestimate the number of manatees present (Marsh and Sinclair 1989, Lefebvre *et al.* 1995, Edwards *et al.* 2007), and that three aerial surveys are of limited utility in such a large area with dispersed manatees, there may be upwards of 20 – 25 individuals in the lake. Of course, this is still a very small number. By comparison, in Belize and Mexico counts can reach more than 200 individuals (Morales-Vela *et al.* 2000). More locally, in Bocas del Toro Mou-Sue *et al.* (1990) sighted a maximum of 70 manatees, while in Tampa Bay, Florida a single survey can yield 192 sightings (Wright *et al.* 2002) and more recent counts report close to 2000 manatees (see <http://myfwc.com/research/manatee/research/population-monitoring/synoptic-surveys/>).

However, both Vianna *et al.* (2006) and Tucker *et al.* (2012) found low genetic diversity in the endangered Florida manatee. Their findings suggest that a large population size should not be taken as the main indicator of overall health. In fact, as a “bridge”

between Central and South America the preservation of Panama manatees could prove to be relevant to the overall genetic health of manatees in the region (Castelblanco-Martinez *et al.* 2012). We recommend future studies consider assessing the genetic variability of manatees in Panama.

While we did not see any fishing with nets or poles, we did see large expanses of cattle ranching, agricultural and forest crops were clearly visible amongst the small communities that border the Western sector. It is tempting to speculate that the almost permanent human presence at the lake edge may be altering manatee distribution as suggested by Castelblanco-Martinez *et al.* (2012). However, the relatively common sightings of manatees in Culebra Cut could be an indication that at least some manatees are accustomed to human presence and substantial activity. Indeed, the manatee sighted during the complimentary aerial survey of the lake by Mou-Sue *et al.* (1990) was in this western sector.

The increased agricultural activity in that sector did not alter water clarity during aerial surveys, but turbidity was a factor during the October 2008 survey (Table 1). Water turbidity due to run-off from agricultural lands carried into the lake could have affected visibility. In addition to the Chagres some 20 smaller rivers empty into the lake, which make the water in the lake turbid during the rainy season (from April to November). Reynolds *et al.* (1995) found that in Costa Rica aerial surveys during the rainy season are not a productive way to survey manatees. Turbidity undoubtedly limits the visibility of manatees from the air (Marsh and Sinclair 1989, Lefebvre *et al.* 1995, Edwards *et al.* 2007). Marsh and Sinclair (1989), Lefebvre *et al.* (1995) and Edwards *et al.* (2007) discussed the problems of aerial surveys for the estimation of population sizes and

trends. These results highlight the importance of using a variety of methods to assess population status of cryptic species (Hines *et al.* 2008). We recommend not only more intense aerial surveys in the future, but also assessments using side-scan sonar which has been proven highly effective to detect manatees, particularly in turbid waters (Gonzalez-Socoloske *et al.* 2009).

In conclusion, the number of manatees present in the Panama Canal, while still quite small, is slightly higher than previously thought and we now have evidence that they are reproducing in the lake. However, there is a relative high number of deaths which is cause for concern. While hunting does not appear to be an immediate threat, the impact of large transoceanic vessels and underwater detonations for dredging on the manatees in lake Gatun would need to be assessed. A manatee carcasses recovery program needs to be instated in order to perform proper necropsies to determine accurate causes of death and to recover biological samples from the deceased animals, such as the protocol described by Bonde *et al.* (1983, 2012). We also recommend further, more detailed surveys in order to understand population trends and habitat use.

Acknowledgements

This work was funded by Wildlife Trust Alliance and The Rufford Foundation's Small Grants for Nature Conservation. We wish to thank the Aquatic Vegetation Control Unit of the ACP, the Gamboa Rainforest Resort, STRI and the BCI Game Wardens. Special thanks to Isis Tejada, Karla Aparicio, Daniel Muschett, Milton Clark, Ana Salazar, Apolonio Vásquez, Oris Acevedo, Belkys Jimenez and Narkis Morales for their invaluable assistance.

Literature Cited

- Auil, N. 1998. Belize Manatee Recovery Plan. Sustainable development and management of biologically diverse coastal resources – Belize Project No. BZE/92/G31. Belize Coastal Zone Management Project – United Nations Development Program. 67pp.
- Bonde, R. K., A. A. Mignucci-Giannoni and G. D. Bossart. 2012. Sirenian pathology and mortality assessment. Pages 148-156 in E. Hines, J. Reynolds, L. Aragones, A. A. Mignucci-Giannoni and M. Marmontel (eds.) Sirenian conservation issues and strategies in developing countries. University of Florida Press, Gainesville, Florida, USA.
- Bonde, R. K., T. J. O'Shea and C. A. Beck. 1983. Manual of procedures for the salvage and necropsy of carcasses of the West Indian manatee (*Trichechus manatus*). National Technical Information Service, Springfield, VA, USA. 175pp.
- Castelblanco-Martínez, D. N., N. C. Nourisson, E. Quintana-Rizzo, J. Padilla-Saldivar, J. J. Schmitter-Soto. 2012. Potential effects of human pressure and habitat fragmentation on population viability of the Antillean manatee *Trichechus manatus manatus*: a predictive model. *Endangered Species Research* 18:129-145.
- Deutsch, C. J., C. Self-Sullivan and A. Mignucci-Giannoni. 2008. *Trichechus manatus*. The IUCN Red List of Threatened Species. Version 2014.2. www.iucnredlist.org. [Accessed 11 August 2014].
- de Thoisy, B., T. Spiegelberger, S. Rousseau, G. Talvy, I. Vogel and J. C. Vié. 2003. Distribution, habitat, and conservation status of the West Indian manatee *Trichechus manatus* in French Guiana. *Oryx* 37:431-436.

273 Edwards, H. H., K. H. Pollock, B. B. Ackerman, J. E. Reynolds III and J. A. Powell.
 274 2007. Estimation of detection probability in manatee aerial surveys at a winter
 275 aggregation site. *Journal of Wildlife Management* 71:2052-2060.

276 Gonzalez-Socoloske D., L. D. Olivera-Gomez and R. E. Ford. 2009. Detection of free-
 277 ranging West Indian manatees (*Trichechus manatus*) using side-scan sonar.
 278 *Endangered Species Research* 8:249-257.

279 Hernández, F. 1982. En peligro de extinción manatíes en aguas del Canal. Spillway del
 280 Canal de Panamá. Page 3. Panama Canal Authority Periodic Publication.
 281 Panama.

282 Hines, E., K. Adulyanukosol, P. Somany, L. Sam Ath, N. Cox, P. Boonyanate and N.
 283 Xuan Hoa. 2008. Conservation needs of the dugong *Dugong dugon* in
 284 Cambodia and Phu Quoc Island, Vietnam. *Oryx* 42:113-121.

285 IUCN 2007. IUCN Red List of Threatened Species. <http://www.iucnredlist.org>.
 286 [Accessed 6 march 2008].

287 Jiménez-Pérez, I. 1998. Ecología y conservación del manatí (*Trichechus manatus*, L.)
 288 en el noreste de Costa Rica. Base de datos de los humedales del noreste de
 289 Costa Rica asociada a un sistema de información geográfica. MSc. Thesis.
 290 Universidad Nacional de Costa Rica. Heredia, Costa Rica. 140pp.

291 Jiménez-Pérez, I. 2000. Los manatíes del Río San Juan y los canales de Tortuguero.
 292 Proyecto Río San Juan Amigos de la Tierra. San José, Costa Rica. 120pp.

293 Jiménez, I. 2002. Heavy poaching in prime habitat: the conservation status of the West
 294 Indian manatee in Nicaragua. *Oryx* 36:272-278.

295 LaCommare, K. S., S. Brault, C. Self-Sullivan and E. M. Hines. 2012. Trend detection in
 296 a boat-based method for monitoring sirenians: Antillean manatee case study.
 297 *Biological Conservation* 152:169-177.

298 Lefebvre, L. W., B. B. Ackerman, K. M. Portier and K. H. Pollock. 1995. Aerial surveys
299 as a technique for estimating trends in manatee population size – problems and
300 prospects. Pages 63-74 in T. J. O’Shea, B. B. Ackerman and H. F. Percival,
301 eds. Population biology of the Florida manatee National Biological Service
302 Information and Technology Report I. Florida, USA.

303 Lefebvre, L. W., M. M. Marmontel, J. P. Reid, G. B. Rathbun and D. P. Domning. 2001.
304 Status and biogeography of the West-Indian manatee. Pages 425-464 in C.
305 Woods and F. E. Sergile, eds. Biogeography of the West Indies: past, present,
306 and future, second edition. CRC Press LLC, Boca Raton, Florida, USA.

307 Legislative Assembly (Asamblea Nacional). 1995. Por la cual se establecen la
308 legislación de vida silvestre en la República de Panamá y se dictan otras
309 disposiciones. Gaceta Oficial No. 22801. Panamá, República de Panamá.

310 Lima, R. 1997. Peixe-bois marinho (*Trichechus manatus*): distribuição, status de
311 conservação e aspectos tradicionais ao longo do litoral nordeste do Brasil. MSc.
312 Thesis. Univerisdad Federal de Pernambuco, Recife, Brasil. 80pp.

313 Luna, F. 2001. Distribuição, status de conservação e aspectos tradicionais do peixe-boi
314 marinho (*Trichechus manatus manatus*) no litoral norte do Brasil. MSc. Thesis.
315 Universidade Federal de Pernambuco, Recife, Brasil. 122pp.

316 MacLaren, J. P. 1967. Manatees as a naturalistic biological mosquito control method.
317 Mosquito News 27:387-393.

318 Marsh, H., and D. F. Sinclair. 1989. Correcting for visibility bias in strip transect aerial
319 surveys of aquatic fauna. Journal of Wildlife Management 53:1017-1024.

320 Montoya-Ospina, R.A., D. Caicedo-Herrera, S. L. Millán-Sánchez, A. A. Mignucci-
321 Giannoni and L .W. Lefebvre. 2001. Status and distribution of the West Indian

322 manatee, *Trichechus manatus manatus*, in Colombia. Biological Conservation
323 102:117-129.

324 Morales-Vela, B., D. Olivera-Gómez, J. E. Reynolds III and G. B. Rathbun. 2000.
325 Distribution and habitat use by manatees (*Trichechus manatus manatus*) in
326 Belize and Chetumal Bay, Mexico. Biological Conservation 95:67-75.

327 Mou Sue, L., D. Chen, R. K. Bonde and T. J. O'Shea. 1990. Distribution and status of
328 manatees (*Trichechus manatus*) in Panama. Marine Mammal Science 6:234-
329 241.

330 Muschett, G., C. Bonacic and J. Vianna. 2009. A noninvasive sampling method for
331 genetic analysis of the West Indian manatee (*Trichechus manatus*). Marine
332 Mammal Science 25:955-963.

333 Quintana-Rizzo E and J. E. I. Reynolds. 2010. Regional management plan for the West
334 Indian manatee (*Trichechus manatus*). CEP Tech Rep. United Nations
335 Environment Programme, Kingston.

336 Reynolds III, J. E., W. A. Szelistowski and M. A. León. 1995. Status and conservation of
337 manatees *Trichechus manatus manatus* in Costa Rica. Biological Conservation
338 71:193-196.

339 Schad, R. C., G. Montgomery and D. Chancellor. 1981. La distribución y frecuencia del
340 manatí en el lago Gatún y en el Canal de Panamá. ConCiencia 8:1-4.

341 TLBG (The Louis Berger Group), UP (Universidad de Panamá) and STRI (Smithsonian
342 Tropical Reserach Institute). 2002. Informe Final de la Región Occidental de la
343 Cuenca del Canal. Informe Técnico. Panamá, República de Panamá. 179pp.

344 Tucker, K., M. Hunter, R. Bonde, *et al.* 2012. Low genetic diversity and minimal
345 population substructure in the endangered Florida manatee: implications for
346 conservation. Journal of Mammalogy 9:1504-1511.

347 Vianna, J. A., R. K. Bonde, S. Caballero, *et al.* 2006. Phylogeography, phylogeny and
 348 hybridization in trichechid sirenians: implications for manatee conservation.
 349 Molecular Ecology 15:433-447.

350 Wright, I. E., J. E. Reynolds III, B. B. Ackerman, L. I. Ward, B. L. Weigle and W. A.
 351 Szelistowski. 2002. Trends in manatee (*Trichechus manatus latirostris*) counts
 352 and habitat use in Tampa Bay, 1987-1994: Implications for conservation.
 353 Marine Mammal Science 18:259-274.

354 **Table 1** Weather conditions, water clarity, duration and number of manatees sighted
 355 during the three aerial surveys, Lake Gatun, Panama Canal, Panama.

Date	Weather Conditions	Water clarity	Duration of survey	No. of manatees	No. of calves	No. of groups
10 Jan 2007	Good*	Clear	1.5 h	10	2	1
14 Jan 2007	Poor*	Clear	45 min	2	-	1
10 Oct 2008	Fair*	Turbid	1.1 h	16	4	2

356 *as defined by Ackerman (1995) and Hodgson *et al.* (2007).

357

Figure. 1 Location of the two known resident populations of West Indian manatees (*Trichechus manatus*) in Panama; Bocas del Toro and Lake Gatun.

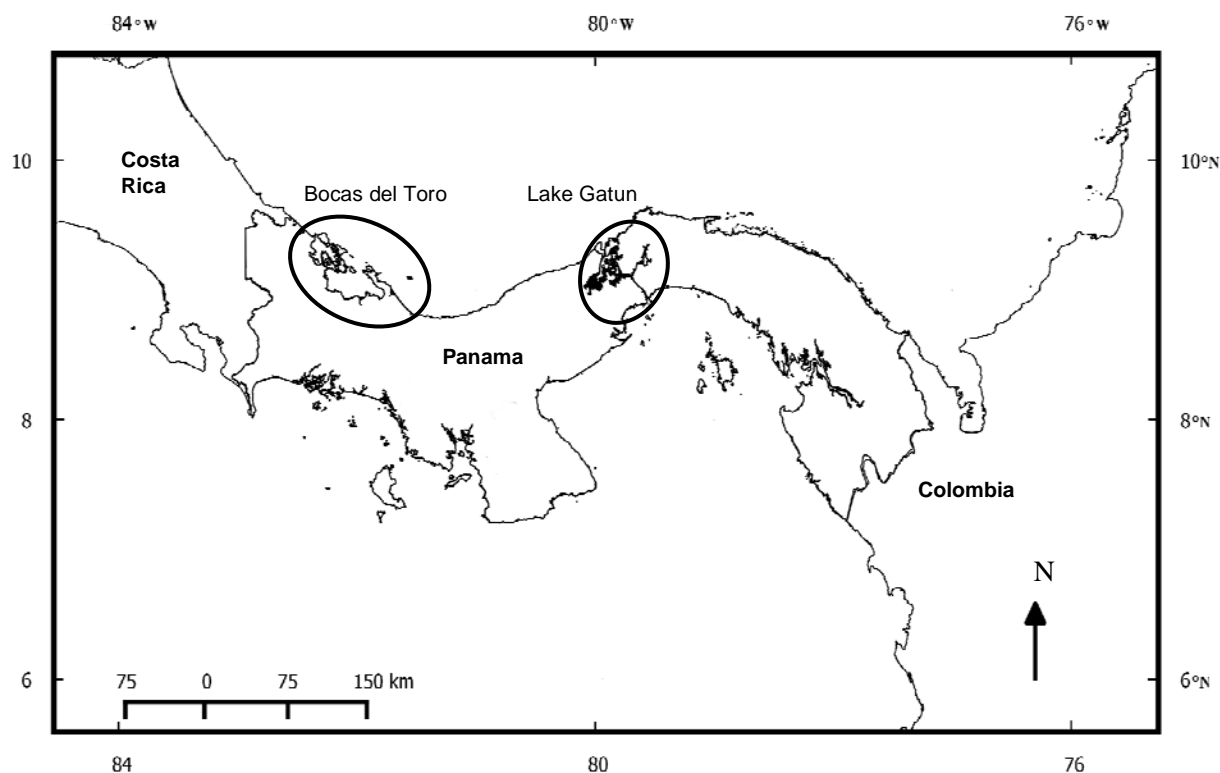
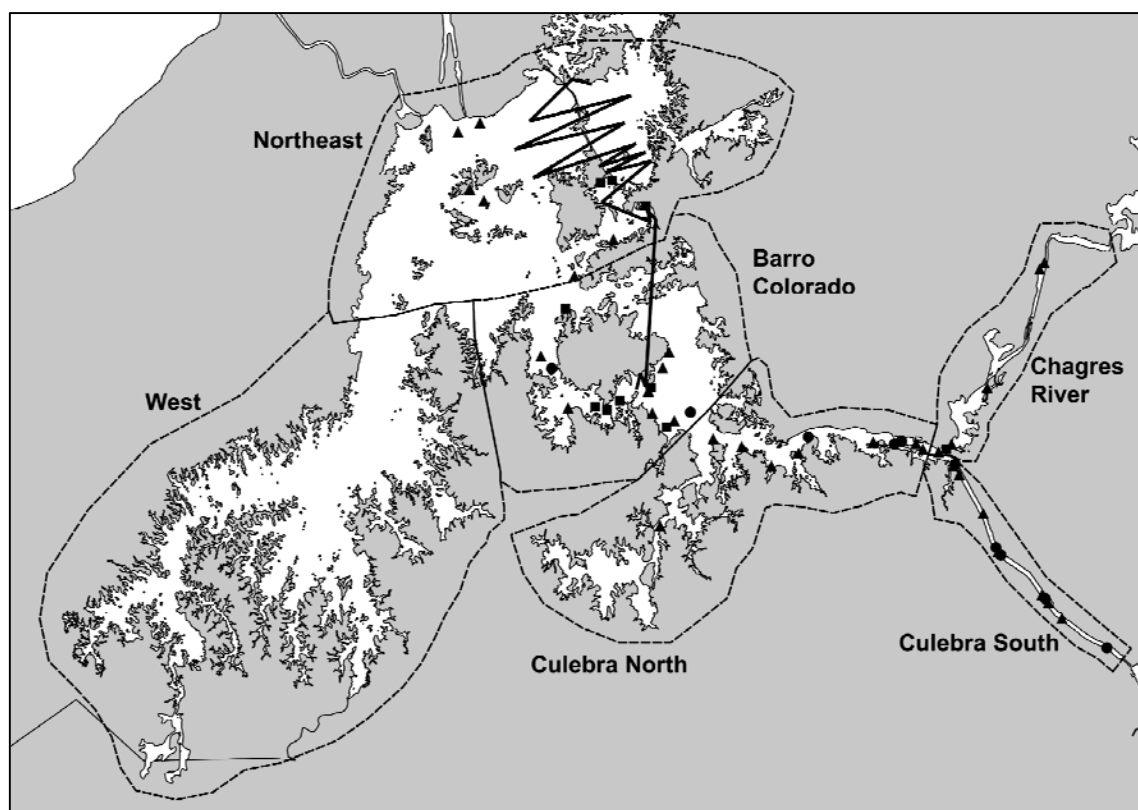


Figure. 2 Lake Gatun was divided into six sectors for this study; Sector I Culebra South, Sector II Culebra North, Sector III Chagres River, Sector IV Barro Colorado, Sector V Northeast, Sector VI West. Triangles indicate manatee sightings through interviews, circles indicate sightings from official documents, and squares indicate sightings from boat-based and aerial surveys. Black line indicates transects flown during aerial survey, 10 October 2008.



Annex 1 Sample of survey questions (translated from Spanish) applied to personnel of the Gamboa Game Forest Resort, the Panama Canal Authority (ACP), the Smithsonian Tropical Institute (STRI), and private boat operators between March and July 2007 to determine their knowledge of manatees in Lake Gatun, Panama Canal. Questionnaire modified from Lima (1997) and Luna (2001).

Date: _____ Survey number: _____
 Name: _____ Age: _____
 Occupation: _____ Organization: _____
 Department: _____ Location: _____
 Time employed _____ (months, years)
 Please tick ():
 Have you ever seen a manatee? () yes () no
 Where did you first see one? _____
 Do you remember when? () yes _____ () no
 Can you describe a manatee? _____
 Have you seen a manatee more than once? () yes () no
 When was the last time you saw a manatee? _____
 Where have you seen them most often? _____
 - or mark the locations where you have manatees them on the map provided
 What was the manatee(s) doing?
 () feeding () traveling () breathing at the surface () other _____
 Is there a time of the year when manatees are more common?
 () dry season () rainy season () don't know
 Have you seen more than one manatee together in a group? () yes () no
 - what is the largest number of manatees you have seen in a group?
 largest number (_____) smallest number (_____)
 Have you seen females with calves? () yes () no
 - when did you see them? _____

- 411 Have you seen a dead manatee? () yes () no
412 - do you know the cause of death? _____
413 Have you ever hunted a manatee? () yes () no
414 - how is the hunt carried out? _____
415 Do you know of the laws that prohibit hunting of manatees? () yes () no