

1 **Distribution and abundance of the West Indian manatee**
2 **(*Trichechus manatus*) in the Panama Canal**

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12

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

23

24 In Panama, there has been little recent manatee research (Muschett *et al.* 2009,
25 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

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

65

66 We conducted interviews between March and July 2007. Interviews focused on
67 employees of the Gamboa Rainforest Resort, Barro Colorado Nature Monument game
68 wardens, private boat operators, and several Divisions of the ACP since they spend the
69 majority of their working hours (day and night) on the lake. We were not able to conduct
70 interviews with members of local agricultural communities located on the Western
71 sector of the lake due to difficult access. Forty-four interviews were conducted between
72 March and June 2007. Interviewees ranged in age from 27 to 56 years, with a mean of
73 42 years. Only two of the individuals interviewed had never seen a manatee, and thus
74 the effective number of interviews was 42. These 42 interviews yielded 59 manatee
75 sightings; 63% (37) corresponded to recent manatee sightings (< 3 years), and 22%

76 (13) were historical sightings. Sightings concentrated on Culebra Cut North, Sector II
77 (26%) and Barro Colorado, Sector IV (24%) (Fig. 2). We were not able to conduct
78 interviews with members of local agricultural communities located on the Western
79 sector of the lake due to difficult access.

80

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

90

91 A total of 32 Captain's logs was reviewed, which recorded 19 manatee deaths over the
92 14 years from 1995 to 2008. The largest number of deaths in one year ($n = 4$) was
93 registered in 2007. No deaths were recorded during 1998 or 2003. No deaths were
94 reported in February, August, or September of any year. Thirteen deaths (76%) were
95 registered in Culebra Cut (Fig. 2), but the Aquatic Vegetation Control Unit only surveys
96 Culebra Cut, Chagres River and the Tabernilla region (Sectors I, II and IV), so these
97 results must be treated with caution.

98

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

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

104

105 Aerial surveys were carried out in a Robinson R44 helicopter, flying at an average
106 altitude of 150m and speed of 180km/h (following Lefebvre *et al.* 1995). Restrictions
107 regarding aerial space over the Panama Canal locks required these areas to be flown
108 above 200m. Each flight originated in Marcos A. Gelabert National Airport, Panama City
109 (8.9733° N, 79.5556° W). Aerial surveys were conducted on 10 January 2008, 14
110 January 2008 and 10 October 2008 (Table 1). All flights were carried out in the early
111 morning to reduce the effect of glare (Marsh and Sinclair 1989). For the aerial surveys
112 Sectors I to VI were flown on 10 January, Sectors I, II, III and V were flown on 14
113 January 2008, and sectors IV and V on 10 October 2008. The beginning and end of
114 each transect was marked using a GPS (Fig. 2). During each flight, each time a
115 manatee was spotted from the air an observer recorded the transect number, number of
116 individuals seen, if they were in a group (a visually distinct “clumping” of individuals)
117 and the presence of calves (individuals of approximately less than 2m in close proximity
118 to or accompanying a larger individual) (Morales-Vela *et al.* 2000).

119

120 During the 10 January 2008 aerial survey, 10 manatees (8 adults + 2 calves) were
121 sighted in 1:30 h of survey time. During the 14 January 2008 survey only two manatees
122 (both adults) were sighted in 45 min. During 10 October 2008, 16 manatees (12 adults
123 + 4 calves) were sighted in 1:10hrs. Sightings were made in the Northeast (Sector V)
124 and Barro Colorado (Sector IV) sectors (Fig. 2). There were no sightings of manatees in
125 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

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

154

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

167

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

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

177

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

184

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

196

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

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

204

205 While we did not see any fishing with nets or poles, we did see large expanses of cattle
206 ranching, agricultural and forest crops were clearly visible amongst the small
207 communities that border the Western sector. It is tempting to speculate that the almost
208 permanent human presence at the lake edge may be altering manatee distribution as
209 suggested by Castelblanco-Martinez *et al.* (2012). However, the relatively common
210 sightings of manatees in Culebra Cut could be an indication that at least some
211 manatees are accustomed to human presence and substantial activity. Indeed, the
212 manatee sighted during the complimentary aerial survey of the lake by Mou-Sue *et al.*
213 (1990) was in this western sector.

214

215 The increased agricultural activity in that sector did not alter water clarity during aerial
216 surveys, but turbidity was a factor during the October 2008 survey (Table 1). Water
217 turbidity due to run-off from agricultural lands carried into the lake could have affected
218 visibility. In addition to the Chagres some 20 smaller rivers empty into the lake, which
219 make the water in the lake turbid during the rainy season (from April to November).
220 Reynolds *et al.* (1995) found that in Costa Rica aerial surveys during the rainy season
221 are not a productive way to survey manatees. Turbidity undoubtedly limits the visibility
222 of manatees from the air (Marsh and Sinclair 1989, Lefebvre *et al.* 1995, Edwards *et al.*
223 2007). Marsh and Sinclair (1989), Lefebvre *et al.* (1995) and Edwards *et al.* (2007)
224 discussed the problems of aerial surveys for the estimation of population sizes and

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

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

240

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

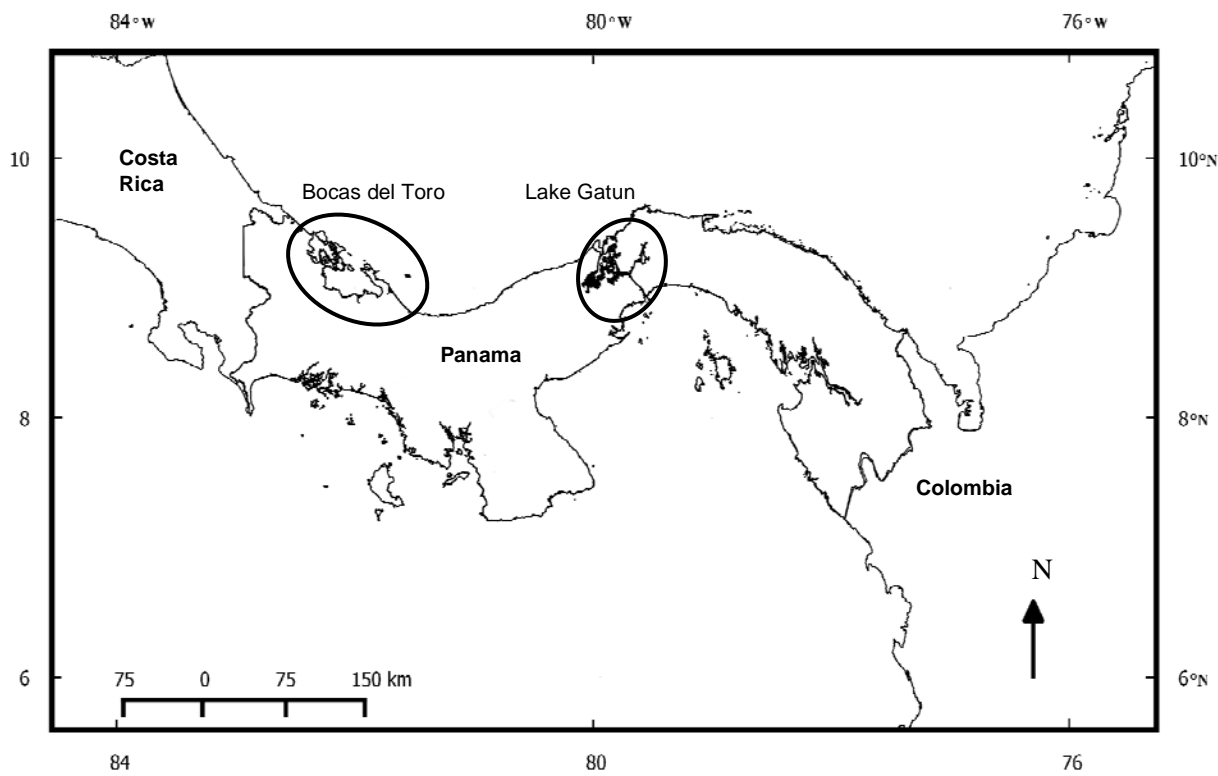
Date	Weather Conditions	Water clarity	Duration of survey	No. of manatees	No. of calves	No. of groups
10 Jan 2007	Good*	Clear	1.5 h	10	2	1
14 Jan 2007	Poor*	Clear	45 min	2	-	1
10 Oct 2008	Fair*	Turbid	1.1 h	16	4	2

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

357

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

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361

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

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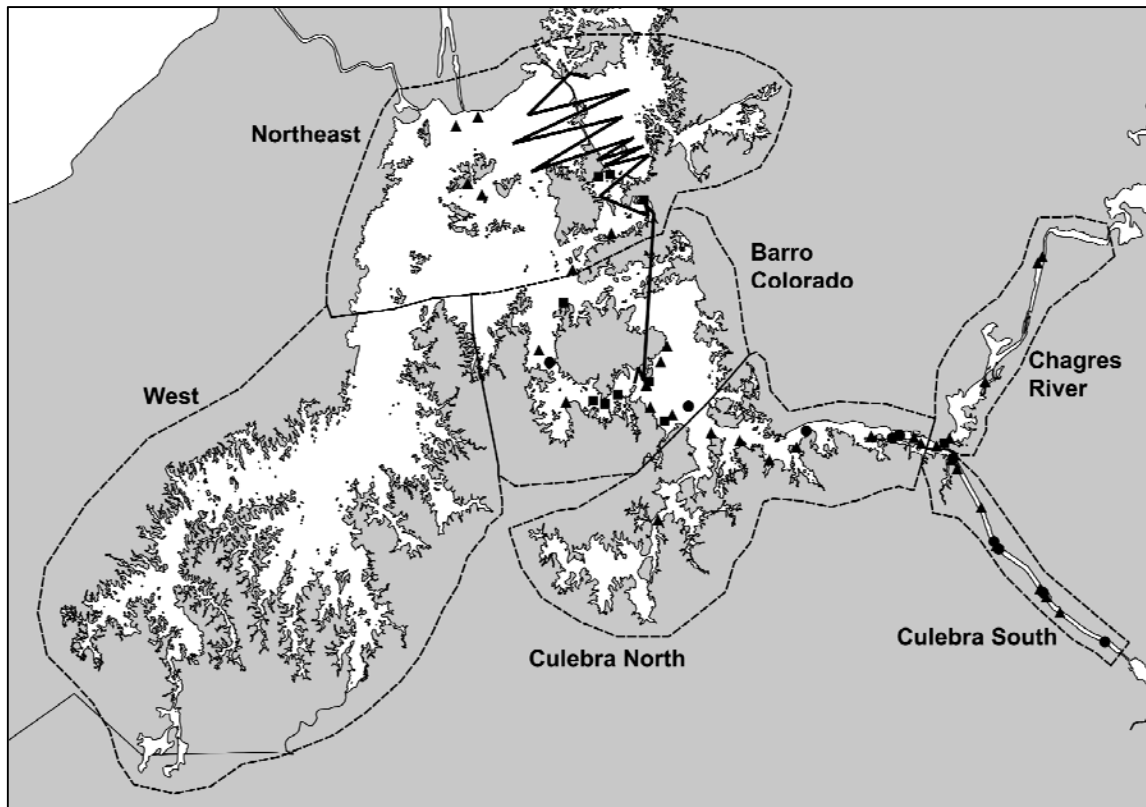
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382 **Annex 1** Sample of survey questions (translated from Spanish) applied to personnel of
383 the Gamboa Game Forest Resort, the Panama Canal Authority (ACP), the Smithsonian
384 Tropical Institute (STRI), and private boat operators between March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

387
388 Date: _____ Survey number: _____

389 Name: _____ Age: _____

390 Occupation: _____ Organization: _____

391 Department: _____ Location: _____

392 Time employed _____ (months, years)

393 Please tick ():

394 Have you ever seen a manatee? () yes () no

395 Where did you first see one? _____

396 Do you remember when? () yes _____ () no

397 Can you describe a manatee? _____

398 Have you seen a manatee more than once? () yes () no

399 When was the last time you saw a manatee? _____

400 Where have you seen them most often? _____

401 - or mark the locations where you have manatees them on the map provided

402 What was the manatee(s) doing?

403 () feeding () traveling () breathing at the surface () other _____

404 Is there a time of the year when manatees are more common?

405 () dry season () rainy season () don't know

406 Have you seen more than one manatee together in a group? () yes () no

407 - what is the largest number of manatees you have seen in a group?

408 largest number (_____) smallest number (_____)

409 Have you seen females with calves? () yes () no

410 - 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