Report on activities related to loggerhead turtle conservation

Prepared by: Dr. Joanna Alfaro-Shigueto & Dr. Jeffrey C. Mangel
ProDelphinus, Lima, Peru
www.prodelphinus.org

Introduction

ProDelphinus, an NGO based in Lima, Peru, conducts research related to the interactions of threatened and endangered marine fauna (sea turtles, seabirds, marine mammals, sharks) with Peruvian small-scale longline and gillnet fisheries. That research is based largely around an onboard and shore-based observer program that has operated out of multiple Peru fishing ports since 2000 and has provided a platform for the research on loggerhead sea turtles summarized below. Research activities directed at loggerhead sea turtles commenced with confirmation of the species in the region by Alfaro-Shigueto et al. (2004). ProDelphinus and collaborating researchers have conducted a variety of studies of loggerhead turtles focused on fisheries interactions (quantification of bycatch) and in-water ecology (demography, movements, foraging). In addition to those studies summarized below, ProDelphinus has also conducted surveys of fishermen at 43 ports in Ecuador, Peru and Chile to assess and characterize sea turtle bycatch at a regional level.

Ongoing research by ProDelphinus related to loggerhead turtle conservation include onboard and shore-based observer monitoring of small-scale gillnet and longline fisheries, sea turtle bycatch mitigation experiments with small-scale gillnets, a high frequency radio communication program with at-sea fishing vessels to promote sea turtle information sharing and safe release, and marine conservation workshops in fishing communities.

Fisheries bycatch

- Alfaro-Shigueto, J., J.C. Mangel, F. Bernedo, P.H. Dutton, J.A. Seminoff & B.J. Godley. 2011. Small scale fisheries of Peru: a major sink for marine turtles in the Pacific. Journal of Applied Ecology 48: 1432-1440.

1. Over the last few decades, evidence of marine vertebrate bycatch has been collected for a range of industrial fisheries. It has recently been acknowledged that large impacts may also result from similar interactions with small-scale fisheries (SSF) due largely to their diffuse effort and large number of vessels in operation. Marine mammals, seabirds, turtles as well as some shark species have been reported as being impacted by SSF worldwide.
2. From 2000 to 2007, we used both shore-based and onboard observer programs from three SSF ports in Peru to assess the impact on marine turtles of small-scale longline, bottom set nets and driftnet fisheries.
3. We reported a total of 807 sea turtles captured, 91.8% of which were released alive. For these three sites alone, we estimated ca. 5900 turtles captured annually (3200 loggerhead turtles *Caretta caretta*, 2400 green turtles *Chelonia mydas*, 240 olive ridleys *Lepidochelys olivacea* and 70 leatherback turtles *Dermochelys coriacea*).

4. SSF in Peru are widespread and numerous (>100 ports, >9500 vessels, >37 000 fishers), and our observed effort constituted ca. 1% of longline and net deployments. We suggest that the number of turtles captured per year is likely to be in the tens of thousands. Thus, the impacts of Peruvian SSF have the potential to severely impact sea turtles in the Pacific especially green, loggerhead and leatherback turtles.
5. Implications of the human use of turtle products as ‘marine bushmeat’ are also raised as an important issue. Although such utilization is illegal, it is difficult to foresee how it can be managed without addressing the constraints to the livelihoods of those depending almost entirely on coastal resources.
6. Syntheses and applications. Our analysis demonstrates that, despite logistical challenges, it is feasible to estimate the bycatch per unit of effort in SSF by combining methods that account for fishing effort and bycatch, such as using onboard and shore-based observers. We highlight sea turtle bycatch in SSF in the southeast Pacific as a major conservation concern but also suggest possible paths for mitigation.

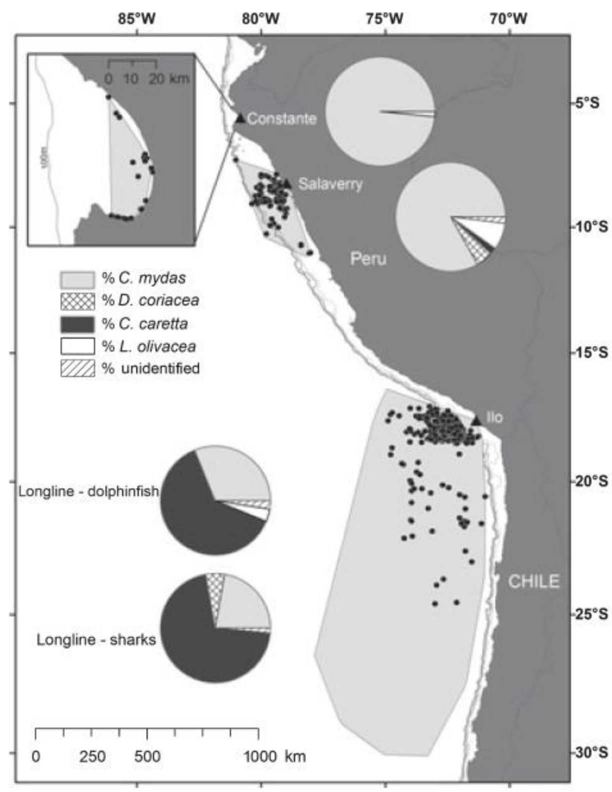

Fig. 1. Fisheries sampled (N to S): Constante (bottom set nets), Salaverry (driftnets) and Ilo (longlines). Fishing areas are indicated by polygons and represent each of the grounds used by each fishery based on set locations (represented by dots). Species composition of turtle bycatch for each fishery indicated in a pie chart.

Table 2. Turtles captured. Summary of status and fate (live/dead, retained/released) and mode of capture (H: hooked, E: entangled, H/E: both) of the turtle bycatch observed (*n*), per species by fishery. Proportion of bycatch-positive sets for that species (set +) and mean bycatch per unit of effort (BPUE) per set are then used to calculate mean annual estimates (numbers caught, released, retained, dead) using multi-annual shore-based data (Table 1). Mortality per fishery obtained from animals dead at capture and those retained alive. Note: a small proportion of turtles were not identified to species in driftnets ($n = 3$), longline for dolphinfish ($n = 11$) and longlines for sharks ($n = 3$)

		Fate (%)				Capture									
		Live		Dead		Mode (%)									
	Species (*n*)	Retain	Release	Retain	Discard	H	E	H/E	Set+	BPUE per set	Mean Catch	Released	Live Retain	Dead	Mortality
Bottom set net	*Chelonia mydas* (65)	29	60	11	–	–	100	–	0·564	2·78 ± 1·8	321 (239–395)	193 (143–237)	94 (70–116)	35 (26–43)	129
	Lepidochelys olivacea (1)	100	–	–	–	–	100	–	0·026	1	47 (25–61)	0	47 (25–61)	0	47
Driftnet	*C. mydas* (90)	10	81	6	3	–	100	–	0·213	1·15 ± 0·2	881 (868–903)	723 (712–741)	88 (78–89)	79 (78–81)	167
	L. olivacea (7)	14	72	14	–	–	100	–	0·017	1	60 (55–63)	43 (40–45)	9 (8–9)	9 (8–9)	18
	Caretta caretta (1)	–	–	100	–	–	100	–	0·003	1	15 (10–22)	0	0	15 (5–15)	15
	Dermochelys coriacea (5)	20	80	–	–	–	100	–	0·012	1	40 (37–44)	32 (30–35)	8 (7–9)	0	8
Longline (dolphin fish)	*C. mydas* (135)	–	100	–	–	54	41	4	0·155	1·3 ± 0·2	1061 (801–1313)	1061 (801–1313)	0	0	0
	L. olivacea (16)	–	94	–	6	56	44	–	0·026	1	133 (116–158)	125	0	8 (7–10)	8
	C. caretta (272)	–	100	–	–	52	46	2	0·391	1·42 ± 0·2	2613 (2104–3066)	2613 (2104–3066)	0	0	0
	D. coriacea (1)	–	100	–	–	–	100	–	0·002	1	6 (3–9)	6 (3–9)	0	0	0
Longline (shark)	*C. mydas* (44)	–	98	2	–	45	52	2	0·055	1·14 ± 0·1	131 (100–163)	128 (98–159)	0	3 (2–4)	3
	L. olivacea (2)	–	100	–	–	50	50	–	0·003	1	7 (5–9)	7 (5–9)	0	0	0
	C. caretta (140)	–	100	–	–	33	66	1	0·155	1·23 ± 0·2	589 (545–646)	589 (545–646)	0	0	0
	D. coriacea (11)	–	100	–	–	27	55	18	0·015	1	26 (24–27)	26 (24–27)	0	0	0
Totals		–	–	–	–	–	–	–	–	–	5930	5546	246	149	395

- Alfaro-Shigueto, J., J.C. Mangel, P.H. Dutton, J.A. Seminoff & B.J. Godley. 2012. Trading information for conservation: a novel use of radio broadcasting to reduce sea turtle bycatch. Oryx 46(3): 332-339.

Bycatch of non-target animals in small-scale fisheries poses a major threat to seabirds and marine mammals and turtles. This is also a problem for small-scale fisheries in Peru because of the magnitude of these fisheries and the important marine biodiversity in Peruvian waters. Here we describe how we implemented a novel approach to mitigate bycatch impacts on marine turtles in Peru. We used high-frequency (HF) two-way radio communication to exchange information with fishers. We sought data that would afford insights into fishing patterns and levels of turtle bycatch so that we could identify areas of high-density bycatch in real time and warn other fishers. In return we provided oceanographic and atmospheric information useful for the fishers. Radio communication also served as a platform to promote the use of safe handling and release techniques for incidentally caught animals. During the 24 months of the programme we communicated with over 200 vessels and with 200–1,400 fishers, who used primarily longlines, gillnets, jiggers, purse seiners and trawlers. Our findings suggest that HF radio communication is a useful tool (low cost and widely used by fishers, with extensive spatial coverage), helps build links with fishers that potentially reduces fishery impacts on marine turtles, and can also provide information on poorly documented fisheries and the relevant bycatch data associated with small-scale fishing practices.

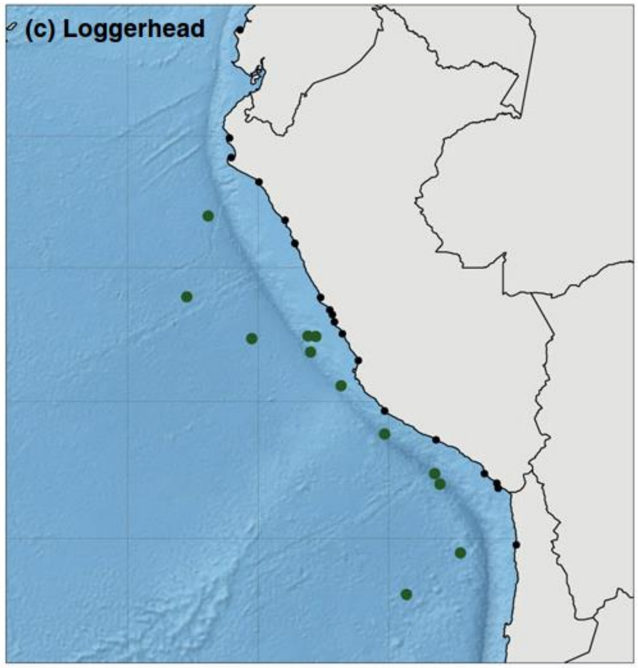

FIG. 4 Locations of interactions with (a) green *Chelonia mydas* (n = 45), (b) leatherback *Dermochelys coriacea* (n = 27), (c) loggerhead *Caretta caretta* (n = 14) and olive ridley marine turtles *Lepidochelys olivacea* (n = 3) reported by the small-scale fishing vessels with which we made contact. The locations of the 18 ports of origin (Fig. 3) of the fishing vessels are indicated but only Callao is labelled, for reference. The location of the continental shelf is indicated.

<u>Demography</u>

- Alfaro-Shigueto, J., J. Mangel, J. Seminoff & P. Dutton. 2008. Demography of loggerhead turtles *Caretta caretta* in the southeastern Pacific Ocean: fisheries-based observations and implications for management. Endangered Species Research 5(2-3): 129-135.

Since 2000 we have used artisanal fishing operations as an opportunistic platform for in-water studies of marine megafauna, including sea turtles. We present data on loggerhead turtles *Caretta caretta* incidentally captured by artisanal longline and gillnet fisheries activities operating from 7 ports along the coast of Peru. Data on location, body size and apparent maturity class of loggerheads were gathered. A total of 323 loggerhead turtle captures were recorded between latitudes 13 and 22° S in waters from 46.5 to 637.1 km off shore. Curved carapace length (CCL) ranged from 35.9 to 86.3 cm (mean ± SD = 57.2 ± 9.18 cm, n = 307), which equated to a predominance of juvenile turtles. The substantial fishing effort of the fisheries sampled (63 083 gillnet and 11 316 longline trips yr^{-1}) underscores the importance of mitigating fisheries impacts on loggerheads in the southeastern Pacific. We recommend that regional research and conservation work quantitatively document and, where possible, reduce impacts to loggerheads in the southeastern Pacific foraging area.

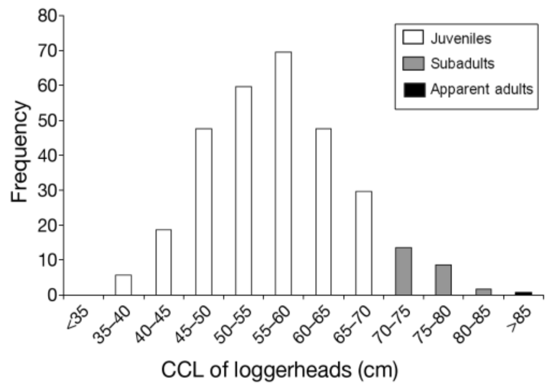

Fig. 2. *Caretta caretta*. Curved carapace length (CCL) distribution of loggerhead turtles incidentally caught in Peru (n = 307), showing the cut offs for every 5 cm of CCL, between the 3 size classes (n = 307): juveniles (<70 cm), subadults (70 to 85 cm), and apparent adults (>85 cm). Categories are based upon CCL and not internal analysis of gonads (as in Heppell et al. 1996). Size classes were adopted from values from figures for CCL and maturity stage class presented in Limpus & Limpus (2003b)

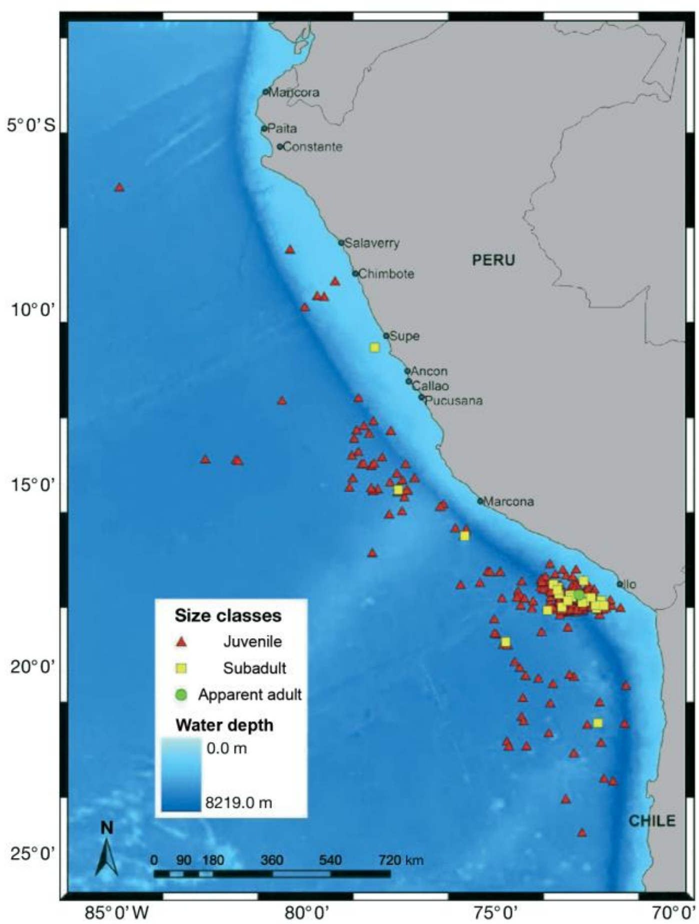

Fig. 1. *Caretta caretta*. At-sea locations of loggerhead turtles captured off Peru (n = 299). Loggerhead turtles were grouped by curved carapace length size classes: juveniles (<70 cm), subadult (70 to 85 cm) and apparent adults (>85 cm)

At-sea movements

- Mangel, J. C., J. Alfaro-Shigueto, M. J. Witt, P. H. Dutton, J. A. Seminoff & B. J. Godley. 2011. Post-capture movements of loggerhead turtles in the southeastern Pacific Ocean assessed by satellite tracking. Marine Ecology Progress Series 433: 261-272.

The post-capture movements made by loggerhead sea turtles *Caretta caretta* in the southeastern Pacific Ocean were monitored from 2003 to 2007. Fourteen loggerhead turtles were fitted with satellite transmitters and released off the coast of Peru. All turtles were juveniles (curved carapace length range: 40.5 to 68.5 cm) incidentally captured by small-scale longline fishing vessels from southern or central Peru. Track durations were highly variable (mean ± SD: 143 ± 90 d; range: 8 to 297 d) with no clear signs of immediate post-release mortality. Upon release, all turtles moved offshore beyond the continental shelf. Eight of 11 turtles tracked for >60 d had final displacements of <750 km, suggesting that loggerhead turtles often maintain extended residency in these waters and that this area is an important foraging zone for loggerhead turtles of southwest Pacific origin. Satellite tracks also showed a substantial overlap of areas used by turtles with known Peruvian longline fishing effort. Turtles spent 75% of their time within the area fished by this fleet (based upon observed sets). This suggests that turtles are vulnerable to fishery interactions and that bycatch mitigation measures should be employed to minimize fishery impacts on loggerhead turtles. The loggerhead turtles tracked during this study spent ca. 51% of their time in Peruvian waters, 39% in international waters and 9% in Chilean waters, which emphasizes the need for a multinational approach to sea turtle conservation and fisheries management in the region.

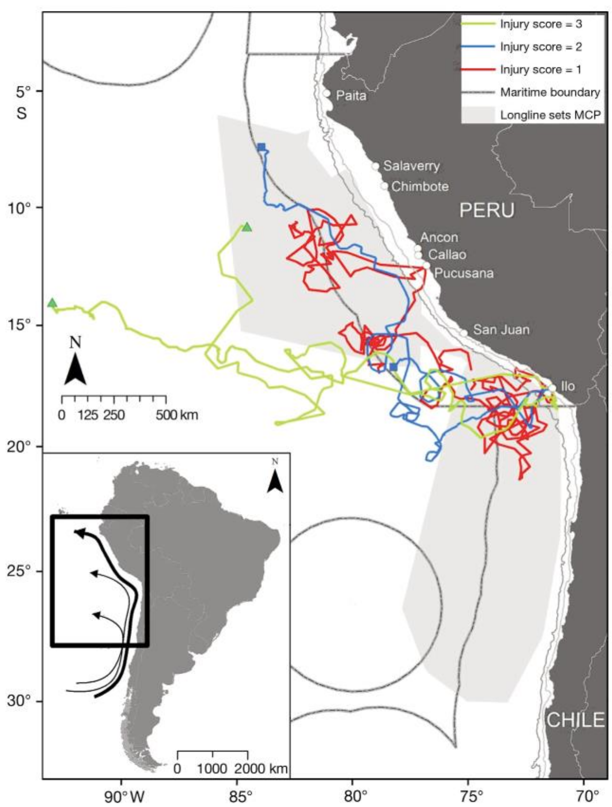

Fig. 1. *Caretta caretta*. All turtle track locations (turtles tracked for 60+ d) by level of injury and showing a polygon of longline fishing effort monitored from 8 ports (242 trips, 1771 sets) collected by fisheries observers from 2000 to 2007 (Alfaro-Shigueto et al. 2008). Color shading of tracks indicates injury scores. Red: injury score 1 (n = 7); blue: injury score 2 (n = 4); green = injury score 3 (n = 3). The termination points of tracks of injury scores 2 and 3 are also marked with colored squares and triangles, respectively. Tracked loggerhead positions were within fishing area boundaries from 75 ± 33% of the time (range, 13 to 100%) (500 and 2000 m bathymetric contours are also shown). Inset shows the predominant current patterns (arrows) of the southeastern Pacific Ocean. MCP: minimum convex polygon

3 point injury scale:

- **Level 1** referred to turtles with external injuries only (including those that were only entangled)
- **Level 2** indicated minor injuries to the mouth cavity or lower mandible
- **Level 3** indicated more severe injuries including turtles deeply hooked in the esophagus or soft palate.

Foraging ecology

- Pajuelo, M., K. Bjorndal, J. Alfaro-Shigueto, J. Mangel, J.A. Seminoff & A.B. Bolten. 2010. Stable isotope dichotomy in loggerhead turtles reveals Pacific-Atlantic oceanographic differences. Marine Ecology Progress Series 417: 277-285.

Denitrification and nitrogen-fixation processes in the marine environment have been intensively studied, particularly how these processes affect the nitrogen stable-isotope signature (δ15N) of inorganic nutrients and organisms at the base of the food web. However, the assumption that these δ15N differences at the base of food webs are reflected in higher trophic-level organisms has not been widely investigated. In the present study, we evaluated whether an ocean-basin δ15N variation was evident in oceanic juvenile loggerhead turtles *Caretta caretta* by analyzing their stable-isotope signatures in the Pacific and Atlantic oceans. Skin samples from oceanic juvenile loggerheads were collected from Peruvian waters in the southeast Pacific and from waters around the Azores Archipelago in the northeast Atlantic and analyzed for δ15N and carbon stable-isotope signature (δ13C). Our results showed that turtles in the 2 ocean regions have mean δ13C signatures of –16.3 and –16.7‰, which reflects the oceanic feeding behavior of these loggerhead populations. However, the δ15N signatures in Pacific loggerheads are significantly higher (mean ± SD = 17.1 ± 0.9‰) than those of Atlantic loggerheads (7.6 ± 0.5‰). This inter-ocean difference in δ15N values was also observed in organisms at the base of the food web in the 2 study areas. The δ15N at the base of the food web, which is determined by the predominant process of the nitrogen cycle in each ocean region, is subsequently transferred to higher trophic levels. Stable isotope signatures in high trophic-level organisms, such as oceanic-stage sea turtles, can reveal differences in oceanographic processes.

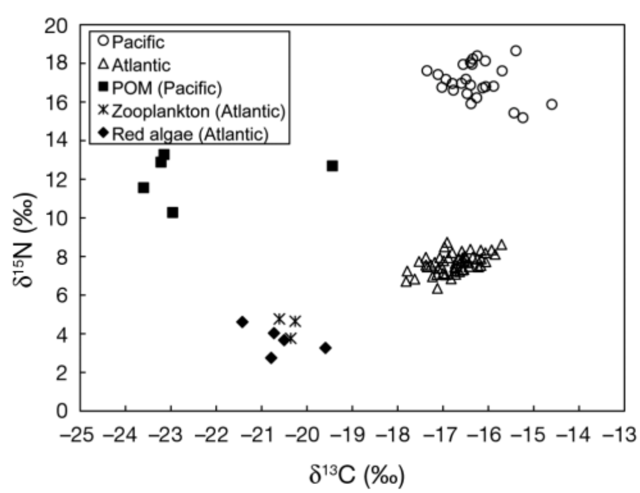

Fig. 3. *Caretta caretta*. Stable-isotope ratios of nitrogen (δ^{15}N) and carbon (δ^{13}C) of skin samples from juvenile loggerheads off southern Peru in the southeast Pacific (○) and in Azorean waters in the northeast Atlantic (△). Particulate organic matter (POM) values off southern Peru and red algae and zooplankton samples from Azorean waters are also shown

Literature related to loggerhead turtles in the southeastern Pacific Ocean

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Alfaro Shigueto, J., Dutton, P., Mangel, J. and Diana Vega. 2004. First confirmed occurrence of loggerhead turtles *Caretta caretta* in Peru. Marine Turtle Newsletter 103: 7-11.

Alfaro Shigueto, J., Mangel, J.C., Seminoff, J.A., Dutton, P.H. 2008. Demography of loggerhead turtles *Caretta caretta* in the southeastern Pacific Ocean: fisheries-based observations and implications for management. Endangered Species Research 5: 14-21.

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Boyle, M.C., Fitz-Simmons, N.N., Limpus, C.J., Kelez, S., Velez-Zuazo, X. & Waycott, M. 2009. Evidence for transoceanic migrations by loggerhead sea turtles in the southern Pacific Ocean. Proceedings of the Royal Society B 276: 1993–1999.

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Largacha, E., Parrales, M., Rendon, L., Velasquez, V., Orozco, M. & Hall, M. 2005. Working with the Ecuadorian fishing community to reduce the mortality of sea turtles in longlines: the first year March 2004 – March 2005. Report to the World Wild Fund, pp 66.

Mangel, J.C., Alfaro-Shigueto, J., Witt, M.J., Dutton, P.H., Seminoff, J.A. & Godley, B.J. 2011 press. Post-capture movements of loggerhead turtles in the southeastern Pacific assessed by satellite tracking. Marine Ecology Progress Series 433: 261-272.

Pajuelo, M., Bjorndal, K., Alfaro-Shigueto, J., Seminoff, J.A., Mangel, J.C., and Bolten, A.B. 2010. Stable isotope variation in loggerhead turtles reveals Pacific-Atlantic oceanographic differences. Marine Ecology Progress Series 417: 277–285.