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Occurrence of Loggerhead Sea Turtles (*Caretta caretta*) in the Gulf of California, México: Evidence of Life-History Variation in the Pacific Ocean

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Loggerhead turtles, *Caretta caretta*, are highly migratory and use a wide range of broadly separated localities and habitats during their lifetime. In the Pacific, most loggerheads carry out an extensive developmental migration, traveling from nesting areas in Japan and Australia to distant developmental and foraging habitats in the eastern Pacific (Bowen 1995; Bowen et al. 1995; Uchida and Teruya 1988; P. Dutton, unpubl. data). After spending years foraging in the eastern Pacific, these turtles return to their natal nesting beaches for reproduction (Nichols et al. 2000; Resendiz et al. 1998) and remain in the western Pacific for the remainder of their life cycle (Hatase et al. 2002; Kamezaki et al. 1997; Sakamoto et al. 1997). At least some loggerhead turtles, however, apparently do not undertake trans-Pacific migrations and instead remain in the western Pacific for their entire life cycle (Limpus et al. 1994).

Loggerhead sea turtles in the Pacific are adversely impacted by a variety of activities including incidental capture in commercial fisheries, boat strikes, debris ingestion, and intentional harvest (Gardner and Nichols 2001; Suganuma 2002; Wetherall 1996). These have contributed, at least in part, to declines in annual nesting populations in Japan (Suganuma 2002) and Australia (Limpus and Couper 1994; Limpus and Reimer 1994). These reductions have prompted calls for increased research and protection (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998). However, the development of appropriate management strategies has been hindered by the paucity of data on the biology of loggerhead turtles.

Knowledge of regional size-class distributions of loggerhead turtles can help determine the importance of different marine habitats for various life stages, and provide insights into the geographic variability in life history patterns (Bjorndal et al. 2000; Bolten, *in press*; Witzell 2002). An important component of this understanding is the size at which juveniles depart the oceanic zone (i.e., seafloor depth > 200 m; Lalli and Parsons 1993) and recruit to neritic foraging habitats (i.e., seafloor depth ≤ 200 m; Lalli and Parsons 1993). Size-at-recruitment to the neritic zone is an important element in the development of sea turtle population models (Bjorndal et al. 2000; Bolten, *in press*; Crouse et al. 1987) but is poorly understood in the Pacific: current knowledge is based solely on Limpus et al. (1994) who report a neritic recruitment size of 70 cm curved carapace length in Australia based on in-water research. However, the vast size and substantial variation in coastal bathymetry of the Pacific (Briggs 1974) combined with potential life-history differences between Japanese and Australian nesting stocks suggest that the size-at-recruitment for loggerhead sea turtles in Australia may not be representative of the entire Pacific. In the Atlantic, for example, some loggerheads may recruit to neritic habitats at substantially smaller sizes (starting at 25.0 cm curved carapace length along the US Atlantic coast; Musick and Limpus 1997). The purpose of this report is to present information on the size of loggerhead sea turtles in neritic habitats of the Gulf of California. This will provide researchers with a small data set with which to compare demographic data from other locations in the Pacific Ocean.

From 1996 to 2002 we documented the presence of loggerhead turtles at two study areas in the central Gulf of California: Bahía de los Angeles (BLA) and the Infiernillo Channel (CIN), along the coasts of Baja California and Sonora, México, respectively (Fig. 1). These areas are neritic feeding grounds for green turtles, *Chelonia mydas* (Cliffton et al. 1982; Seminoff 2000), and the large abundance of invertebrate fauna (Brusca 1980) suggest they are potential foraging areas for loggerhead turtles. Efforts to document loggerhead turtle presence included: (1) in-water capture of live turtles (2) beach surveys for dead carcasses, and (3) documentation of turtle consumption in human coastal communities.

We attempted to capture loggerhead turtles with entanglement nets (100 m x 8 m, mesh size = 50 cm stretched) placed along the shallow perimeter of each study area. Distance from shore and water depth of netting sites ranged from 50 m to 500 m, and 2 m to 27 m, respectively. Nets were set during both day and night and monitored regularly. Turtles were removed immediately upon capture and held captive up to 24 h. We calculated catch per unit effort (CPUE) with each unit effort equaling the deployment of one 100-m net for 24 h. At BLA and CIN we recorded straight carapace length (SCL; ± 0.1 cm) and curved carapace length (CCL; ± 0.1 cm), respectively, from the nuchal notch to the posterior-most portion of the rear marginals. We converted all CCL measurements to SCL using the conversion equation: CCL = 1.388 + (1.053) SCL (Bjorndal et al. 2000). Prior to release each turtle was double tagged with Inconel tags (Style 681; National Band and Tag Company, Newport, Kentucky); one tag in the first large proximal scale of each front flipper.

To quantify the occurrence of deceased loggerheads we conducted beach surveys along coastal perimeters of each study area. Each survey of the Infiernillo Channel coast covered 16 km of coastline. Surveys were conducted quarterly in March, June, September, and December, 1999–2001 (N = 12). At Bahía de los Angeles each survey encompassed 5 km of shoreline, and surveys were performed monthly from June to September, 1996–2002 (N = 26). In addition, we searched fish camps and refuse dumps near

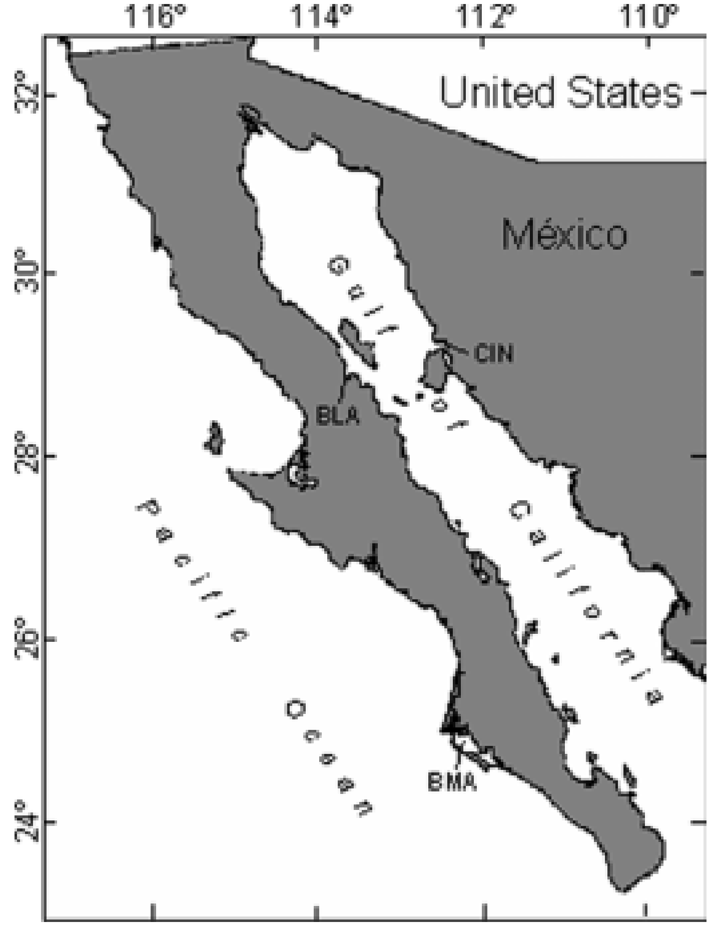

FIG. 1. Map of northwestern México showing Bahía de los Angeles (BLA) and Infiernillo Channel (CIN) regions in the Gulf of California, and Bahía Magdalena (BMA) along the Pacific coast of the Baja California peninsula.

each study site once each year ($N_{BLA} = 7$; $N_{CIN} = 3$). Data were recorded on each sea turtle carcass found, following Gardner and Nichols (2001). Measurements followed the same procedure as that for live-captured turtles. We described presence of external abnormalities, carried out necropsies when possible (Work 2000), and recorded cause of death when known. After each carcass was examined, it was marked with all-weather spray paint or collected to avoid duplicate counting.

We recorded a total of 15 loggerhead turtles during this study: 10 (seven live-captured, two floating dead, and one at a dumpsite) at BLA and five (all at dumpsites) at CIN. Mean straight carapace length of loggerhead turtles was 61.9 (SE = 2.1; range = 43.5–92.7 cm). There was no difference in the mean SCL between the two sites ($t = 0.35$; $P = 0.73$), nor was there a difference in the mean SCL of live and deceased turtles ($t = 0.54$; $P = 0.29$). A summary of the size and manner of collection for each turtle is presented in Table 1.

We could not determine the cause of death for the six loggerheads found at dumpsites; however, the fact that all had meat removed and were actively discarded suggests human consumption was likely. For the two loggerhead turtles encountered floating near BLA, mortality may have been from incidental capture in local fisheries: gillnets are commonly utilized in the region for harvest of a variety of finfish species (JAS, pers. obs.). We saw no evidence of contact with oil or tar, no turtles had boat collision or propeller damage, and necropsies of these turtles revealed that both had full stomachs at the time of death.

Overall, the seven live-captured loggerheads from BLA represent 3.2% of all live-captured sea turtles (including *Chelonia mydas*, *Eretmochelys imbricata*, and *Lepidochelys olivacea*) at that area over the same time period (Seminoff 2000). The CPUE for the seven live turtles captured at BLA was 0.014, or one loggerhead capture every 1699 h of netting effort. At CIN, no live loggerhead turtles were captured despite 624 h of netting effort. The eight dead loggerhead turtles represent 6.6% of all deceased turtles found at the two areas (Seminoff 2000; Seminoff, unpubl. data).

We are unaware of the habitats from which deceased turtles originated, but the capture of live turtles provides useful information on the distribution of loggerheads. In the Gulf of California some loggerhead turtles apparently shift from the oceanic juvenile phase to the neritic juvenile phase at a size that is smaller than that reported for populations in the western Pacific Ocean. While Limpus et al. (1994) report settlement sizes starting at 65.2 cm SCL (70.0 cm CCL) in the southern Great Barrier Reef of Australia, the smallest live loggerhead turtle encountered during this study measured 43.5 cm SCL. Olguin-Mena (1990) and Resendiz et al. (1999) reported minimum sizes of 37 cm SCL and 29.9 cm SCL, respectively, for loggerheads in similar habitats within the Gulf of California. Based on these data, the sizes at which some loggerheads recruit to neritic habitats in the Gulf of California appear more similar to those for loggerheads along the US Atlantic coast (25-46 cm CCL; Bjorndal et al. 2001; Musick and Limpus 1997).

Although the mechanisms of dispersal into the Gulf of California are unclear, our study illustrates the potential variability of loggerhead life-history in the Pacific Ocean. The factors that contribute to apparent differences in neritic recruitment size are poorly understood and caution should be exercised in formulating theo-

TABLE 1. Summary of *Caretta caretta* recorded from the Gulf of California 1996 to 2001. Disposition codes include: L – live captured; F – floating in water; D – found dead at dumpsite.

Date	Size (cm SCL)	Disposition
	Bahía de los Angeles	
1 January 1996	47.7	F
4 September 1997	69.4	L
31 October 1997	49.7	L
22 August 1998	75.4	F
4 February 1999	92.7	L
6 September 1999	43.5	L
19 September 1999	63.0	L
26 June 2001	61.1	L
2 August 2001	57.7	D
2 July 2002	67.4	L
	Infiernillo Channel	
1 June 2000	49.0	D
18 June 2000	67.1	D
7 March 2001	63.3	D
9 March 2001	60.9	D
4 June 2001	61.2	D

TABLE 2. Comparison of size data for loggerhead turtles (*Caretta caretta*) in the Gulf of California and Pacific coast of the Baja California Peninsula, México.

Site	Gulf of California[a]	Pacific Coast of Baja California[b]	Pacific Coast of Baja California[b]
Mean SCL ± SE	61.9 ± 2.1	58.5 ± 11.1	46.9 ± 1.3
Range (cm)	43.5 – 92.7	26.6 – 83.4	32 – 58
N	15	180	39

[a] this study.
[b] Data from Gardner and Nichols (2001). Data are for stranded turtles only. Mean is reported with Standard Deviation.
[c] Data from Ramirez Cruz et al. (1991). Data are for live-captured turtles.

ries about neritic recruitment patterns based on the few studies that have occurred to date. Moreover, as reported for Atlantic loggerheads by Witzell (2002), the shift from pelagic to coastal habitats may be flexible. Some immature turtles may remain in the pelagic habitat longer than hypothesized, and some may move back and forth between pelagic and coastal foraging habitats. These variable data underscore the need for additional comparative studies of intrinsic and environmental effects on loggerhead turtles to assess their relative influence on habitat preference.

Considering that most sea turtles attain maturity at or near mean nesting size (Chaloupka and Musick 1997), the size range in this study (43.5–92.7 cm SCL) is indicative of a population consisting primarily of juveniles and sub-adults. All but one turtle encountered during this study was smaller than the mean nesting size in Japan (89.0 cm SCL; Uchida and Nishiwaki 1982). A preponderance of juvenile sizes has also been reported for loggerheads along the Pacific Coast of Baja California (Nichols 2002; Olguin-Mena 1990; Ramirez Cruz et al. 1991). These findings are consistent with the prevailing life-history model that depicts the eastern Pacific as an important juvenile developmental habitat (Bowen et al. 1995).

The mean size of loggerheads examined in this study (61.9 ± 2.1 cm SCL) is significantly larger than that reported by Ramirez Cruz et al. (1991) for live loggerheads from the Pacific coast of the Baja California Peninsula ($t = 6.029$, $P < 0.0001$; Table 2; Fig. 1). Moreover, the maximum SCL in this study (92.7 cm) is larger than that reported for both live (58 cm; Ramirez Cruz et al. 1991) and stranded (83.4 cm; Gardner and Nichols 2001) loggerhead turtles from the Pacific. Consistent with our results, Márquez (1969) reported that the larger of two loggerheads found in the Gulf measured 92.0 cm SCL. Although the greater size of loggerheads in the Gulf of California relative to the Pacific coast of the Baja California peninsula may be because of small sample sizes, we believe this difference might result from the semi-enclosed nature of the Gulf of California. Perhaps the Baja California peninsula acts as a land barrier, delaying the westward journey of loggerheads in the Gulf of California. Nichols et al. (2000) reported that a loggerhead turtle returning to Japan from Baja California maintained a westward bearing regardless of surface current patterns. If bearing-specific homing is characteristic of all Pacific loggerheads, then return movements of individuals in the Gulf of California, that must first move south to depart the Gulf, might be delayed relative to those of loggerheads on the west side of the Baja California peninsula that have an unimpeded westbound route. We encourage additional studies to substantiate the comparatively large mean size observed in this study. Moreover, satellite telemetry might be a useful tool to investigate this 'peninsular barrier' hypothesis and establish the route taken by loggerheads as they depart the Gulf of California.

The low capture per unit effort in this study suggests that the Gulf of California may not provide critical habitat for loggerhead turtles in the eastern Pacific. Nevertheless, given consideration of the recent population decline for Pacific loggerheads, the Gulf region should be included as a target area for efforts to protect this endangered marine species.

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The Gender of the Genus *Scinax* Wagler, 1830 (Anura, Hylidae)

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Johann Georg Wagler (1800–1832), German naturalist with a special interest in herpetology and ornithology, produced major treatises in his short life (Adler 1989). Among them, his "Natürliches System der Amphibien" (1830) is a comprehensive classification, in which the first 129 pages were dedicated to mammals and birds, and the remainder to the "Amphibia" (reptiles included). Higher taxa (order, family, genus) were diagnosed, species were listed with synonymies (some also diagnosed), and footnotes with comments on identification and etymology of the names are provided (Vanzolini 1977).

In this work, Wagler proposed the generic name "*Scinax*, Schnellfrosch" (= "*Scinax*, quick frog") with the following diagnosis, freely translated from Latin: "Similar to preceding [*Phyllomedusa*]; body somewhat long; head narrow and snout somewhat long; fingers slender, cylindrical, ending in globulous disc, without webbing; foot half webbed, except the free first toe. (Throat in not inflatable vesicle.) America." The species included in the new genus were *Hyla aurata* Wied-Neuwied, *Hyla variolosa* Spix, and *Hyla bipunctata* Spix. *Hyla variolosa*, currently a junior synonym of *Hyla punctata* (Schneider), was also placed as a species belonging to the genus *Auletris* Wagler. In a footnote, the