development in order to overcome adverse environmental conditions.

Unfortunately, a higher percentage of eggs are now failing at early embryonic stages due to inundation by sprinklers. The affected clutches during the 1999 nesting season had hatching success rates of less than 13%. Out of the 48 marked loggerhead nests used in a ghost crab study, 6% were "watered" daily by sprinkler systems at either single-family homes or hotels. Post-emergent nest evaluations of those 6% revealed that 74% of the total number of eggs failed at early embryonic stages. Such failures will only continue as land development does unless corrective measures are taken. In the meantime, further observations and research are required in order to document this new cause of embryonic death and quantify the total contribution to egg failure over several seasons. Additional research needs to be completed on the influence of other anthropogenic factors on egg mortality as well so that effective conservation practices can be put in place.

The data presented here were meant to provide useful information for other researchers and conservationists who are interested in beach hatcheries or protection of our natural beaches worldwide. While further investigations are needed, this research does contribute to a greater understanding of the most critical life history stage in threatened and endangered marine turtles.

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TRANSPACIFIC MIGRATION ALONG OCEANIC FRONTS BY LOGGERHEAD TURTLES RELEASED FROM SEA WORLD SAN DIEGO

Denise M. Parker[1], Peter Dutton [2], Scott Eckert [3], Donald R. Kobayashi [4], Jeffrey J. Polovina [4], Donna Dutton [5], and George H. Balazs [4]

[1] Joint Institute for Marine and Atmospheric Research, 8604 La Jolla Shores Dr., La Jolla, CA USA 92037
[2] National Marine Fisheries Service, Southwest Fisheries Science Center, 8604 La Jolla Shores Dr., P.O. Box 271, La Jolla, CA USA 92038
[3] Hubbs-Sea World Research Institute, 2595 Ingraham St., San Diego, CA USA 92109
[4] National Marine Fisheries Service, Southwest Fisheries Science Center, Honolulu Laboratory, 2570 Dole Street, Honolulu, HI USA 96822-2396
[5] Ocean Planet Research, Inc., 12368 Rue Fountainbleau, San Diego, CA USA 92131

INTRODUCTION

Loggerhead turtles (*Caretta caretta*) are a highly migratory circumglobal species. Major nesting areas for loggerheads in the Pacific Ocean are located in Japan and Australia. Pacific loggerheads make transoceanic migrations from nesting beaches through pelagic developmental habitat to feeding areas offshore of the western coast of Mexico. This is based on evidence from genetic stock analysis from juvenile loggerheads captured in the high seas driftnet, the Hawaii-based longline fishery in the North Pacific, and those found feeding off Baja California, all of which were of Japanese origin (Bowen et al. 1995, Dutton et al. 1998). Recently, the frontal areas in the North Pacific have been documented as developmental habitat and probable feeding areas for juvenile and sub-adult loggerheads (Polovina et al. 2000). The present study follows the tracks of two loggerheads released from Hubbs-Sea World San Diego after over 20 years of captivity.

METHODS

Two loggerheads were held in captivity for over 20 years as part of a sea turtle display at Sea World San Diego. The turtles were measured at 77 and 80 cm curved carapace length. They were assumed to be female based on their size and short tail length. Genetic mtDNA analysis showed that the turtles were of Japanese origin. ST-10 Telonics satellite transmitters were attached to the carapace of each turtle using polyester resin and fiberglass cloth (Balazs et al. 1996, Figure 1). One ST-10 (ID 22130) had a duty cycle of two hours on, four hours off, but was modified with a different battery configuration, and the transmitter antenna was placed facing posterior on the carapace. The other ST-10 (ID 22131) was not modified, and the transmitter antenna was facing toward the head on the carapace. ID 22131 had a duty cycle of two hours on, four hours off and four - 2/3-A batteries. Both turtles were released together approximately 5 miles offshore of San Diego, California. Locational data from the transmitters were collected and relayed by Argos Service, Inc. Sea surface temperatures encountered during the turtles migrations were extrapolated using temperature data from Advanced Very High Resolution Radiometer (AVHRR) satellites.

RESULTS

After release, both turtles headed west across the Pacific Ocean. Loggerhead ID 22130 traveled 3300 km at an average speed of 1.8 km/hr over a two month period before the transmissions ceased. The other loggerhead (ID 22131) traveled 8300 km at an average speed of 1.5 km/hr over a six month period. Both turtles traveled mainly along a 19 °C isotherm (Figure 2).

DISCUSSION

Earlier theories regarding the migration of juvenile loggerheads assumed that they traveled with prevailing currents rather than actively swimming against them (Bowen et al. 1995, Hays and Marsh 1997, Musick and Limpus 1997, Figure 3). Recent data have shown that loggerheads moving towards Japan swim along the northern side of the subtropical gyre against weak geostrophic currents which are along the edge of thermal fronts (Balazs et al. 2000, Nichols et al. 2000, Polovina et al. 2000). Work done by Balazs et al. (2000) and Polovina et al. (2000) focused mainly on juvenile and sub-adult turtles captured in the Hawaii-based longline fishery. Although adult-sized loggerheads are not usually found in the feeding areas off Baja California, Mexico, the two captive adult loggerheads which were released demonstrated similar migration patterns to that of the immature wild turtles by swimming along the northern side of the subtropical gyre following a front defined by a 19 °C isotherm. The movement of the two captive loggerhead turtles along this thermal front suggests that this is an innate behavior and that these fronts may be used as a navigational aid in loggerhead transoceanic migrations. Pelagic thermal fronts also provide a rich source of food such as the pelagic prey items *Janthina* spp., *Velella velella*, and *Lepas* spp., known pelagic food sources for loggerheads (Parker et al. In Press). Many other factors are likely also involved in the migration of these animals and research should be continued on this subject. In conclusion, thermal fronts are important developmental habitat and migratory routes for loggerheads in the Pacific Ocean.

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Figure 1. Attaching satellite transmitter (ID 22130) with polyester resin and fiberglass cloth.

Figure 2. Satellite tracks of captive released loggerhead turtles over sea surface temperature data.

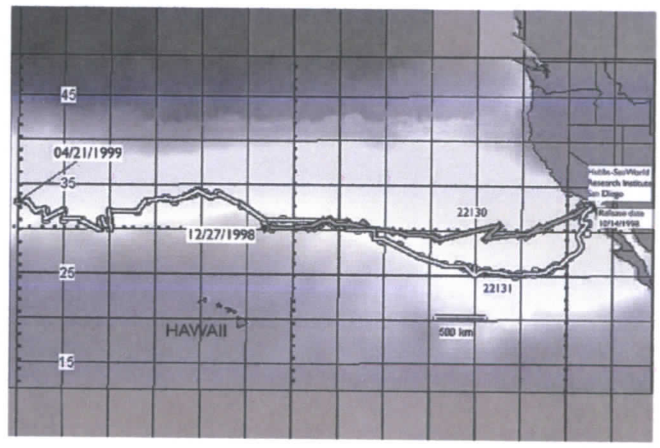

Figure 3. Distribution of loggerhead mtDNA haplotypes in Pacific nesting areas, North Pacific driftnet fisheries, and Baja California feeding grounds (modified from Bowen et al. 1995).