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Marine Science Review – 328

Sea turtles

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In this review:

O/A denotes an open access article or journal

A. Recent articles – no abstract

Fuentes, M.M.P.B. and Hamann, M. **A rebuttal to the claim natural beaches confer fitness benefits to nesting marine turtles.** *Biology Letters* 5(2): 266-267, 2009.

Pike, D.A. **Natural beaches produce more hatchling marine turtles than developed beaches, despite regional differences in hatching success [*invited reply*].** *Biology Letters* 5(2): 268-269, 2009.

Clements, R., Foo, R., Othman, S., Rahman, U., Mustafa, S.R.S., and Zulkifli, R. **Islam, turtle conservation, and coastal communities.** *Conservation Biology* 23(3): 516-517, 2009.

B. Recent publications available online

Conant, T.A. *et al.* 2009. ***Loggerhead sea turtle (Caretta caretta) 2009 status review under the U.S. Endangered Species Act.*** Report of the Loggerhead Biological Review Team to the National Marine Fisheries Service, August 2009. 222 pages.

Available at: http://www.nmfs.noaa.gov/pr/pdfs/statusreviews/loggerheadturtle2009.pdf

Notes: This status review concludes that all loggerhead turtle distinct population segments (DPSs), of which there are considered to be 9 globally, have the potential to decline in the future. Although some DPSs are indicating increasing trends at nesting beaches (Southwest Indian Ocean and South Atlantic Ocean), available information about anthropogenic threats to juveniles and adults in neritic and oceanic environments indicate possible unsustainable additional mortalities. According to the threat matrix analysis used, the potential for future decline is greatest for the North Indian Ocean, Northwest Atlantic Ocean, Northeast Atlantic Ocean, Mediterranean Sea, and South Atlantic Ocean DPSs.

C. Recent articles with abstracts

Witherington, B., Kubilis, P., Brost, B., and Meylan, A. **Decreasing annual nest counts in a globally important loggerhead sea turtle population.** *Ecological Applications* 19(1): 30-54, 2009.

Notes: The loggerhead sea turtle (*Caretta caretta*) nests on sand beaches, has both oceanic and neritic life stages, and migrates internationally. We analyzed an 18-year time series of Index Nesting Beach Survey (Index) nest-count data to describe spatial and temporal trends in loggerhead nesting on Florida (USA) beaches. The Index data were highly resolved: 368 fixed zones (mean length 0.88 km) were surveyed daily during annual 109-day survey seasons. Spatial and seasonal coverage averaged 69% of estimated total nesting by loggerheads in the state. We carried out trend analyses on both annual survey-region nest-count totals (N = 18) and annual zone-level nest densities (N = 18 x 368 = 6624). In both analyses, negative binomial regression models were used to fit restricted cubic spline curves to aggregated nest counts. Between 1989 and 2006, loggerhead nest counts on Florida Index beaches increased and then declined, with a net decrease over the 18-year period. This pattern was evident in both a trend model of annual survey-region nest-count totals and a mixed-effect, "single-region" trend model of annual zone-level nest densities that took into account both spatial and temporal correlation between counts. We also saw this pattern in a zone-level model that allowed trend line shapes to vary between six coastal subregions. Annual mean zone-level nest density declined significantly (-28%; 95% CI: -34% to -21%) between 1989 and 2006 and declined steeply (-43%; 95% CI: -48% to -39%) during 1998-2006. Rates of change in annual mean nest density varied more between coastal subregions during the "mostly increasing" period prior to 1998 than during the "steeply declining" period after 1998. The excellent fits (observed vs. expected count $R^2 > 0.91$) of the mixed-effect zone-level models confirmed the presence of strong, positive, within-zone autocorrelation ($R > 0.93$) between annual counts, indicating a remarkable year-to-year consistency in the longshore spatial distribution of nests over the survey region. We argue that the decline in annual loggerhead nest counts in peninsular Florida can best be explained by a decline in the number of adult female loggerheads in the population. Causes of this decline are explored.

Santidrian Tomillo, P.S., Saba, V.S., Piedra, R., Palkdino, F.V., and Spotila, J.R. **Effects of illegal harvest of eggs on the population decline of leatherback turtles in Las Baulas Marine National Park, Costa Rica.** *Conservation Biology* 22(5): 1216-1224, 2008.

Notes: Within 19 years the nesting population of leatherback turtles (*Dermochelys coriacea*) at Parque Nacional Marino Las Baulas declined from 1500 turtles nesting per year to about 100. We analyzed the effects of fishery bycatch and illegal harvesting (poaching) of eggs on this population. We modeled the population response to different levels of egg harvest (90, 75, 50, and 25%) and the effect of eradicating poaching at different times during the population decline. We compared effects of 90% poaching with those of 20% adult mortality because both of these processes were present in the population at Las Baulas. There was a stepwise decline in number of nesting turtles at all levels of egg harvest. Extirpation times for different levels of poaching ranged from 45 to 282 years. The nesting population declined more slowly and survived longer with 20% adult mortality (146 years) than it did with 90% poaching (45 years). Time that elapsed until poaching stopped determined the average population size at which the population stabilized, ranging from 90 to 420 nesting turtles. Our model predicted that saving clutches lost naturally would restore the populatin when adult mortality rates were low and would contribute more to population recovery when there were short remigration intervals between nesting seasons and a large proporation of natural loss of clutches. Because the model indicated that poaching was the most important cause of the leatherback decline at Las Baulas, protecting nests on the beach and protecting the beach from development are critical for survival of this population. Nevertheless, the model predicted that current high mortality rates of adults will prevent population recovery. Therefore, protection of the beach habitat and nests must be continued and fishery bycatch must be reduced to save this population.

Mazaris, A.D., Matsinos, G., and Pantis, J.D. **Evaluating the impacts of coastal squeeze on sea turtle nesting.** *Ocean and Coastal Management* 52(2): 139-145, 2009.

Notes: Recent studies have provided theoretical and empirical evidence about the importance of hatchling production for sea turtle population dynamics. Therefore, understanding the effect of nesting habitat loss as a factor leading to hatchling reduction is essential in order to establish conservation plans for the recovery of sea turtle populations. In the present study, we developed a method to quantify habitat loss and link it with hatchling production. We used data for loggerhead sea turtles (*Caretta caretta*) collected at Sekania nesting beach, western Greece, to describe biological and behavioral attributes of nesting individuals. Spatial characteristics of the nesting site were analyzed and alternative scenarios of habitat loss were examined. We then used circle-packing technique to evaluate the impact of an increasingly reduced available nesting area on the spatial distribution of nests. An increased number of nests within the study site resulted in density-dependent processes regulating

hatchling production. Under the different scenarios, we evaluated the risk of the laying nests exceeding the estimated carrying capacity of the nesting beach. Our results clearly demonstrated the need to apply direct and efficient conservation measures at Sekania nesting site to minimize further habitat loss from human-related processes and a rising sea level. The approach developed evaluates the effect of habitat loss upon nesting by linking it with quantifiable processes (density dependence), providing a conservation tool to guide planning decisions towards the conservation of the sea turtle population.

Pike, D.A. **Natural beaches confer fitness benefits to nesting marine turtles.** *Biology Letters* 4(6): 704-706, 2008.

Notes: Coastal ecosystems provide vital linkages between aquatic and terrestrial habitats and thus support extremely high levels of biodiversity. However, coastlines also contain the highest densities of human development anywhere on the planet and are favoured destinations for tourists, creating a situation where the potential for negative effects on coastal species is extremely high. I gathered data on marine turtle reproductive output from the literature to determine whether coastal development negatively influences offspring production. Female loggerhead (*Caretta caretta*) and green turtles (*Chelonia mydas*) nesting on natural beaches (as opposed to beaches with permanent development) produce significantly more hatchling turtles per nest; all else being equal, females that successfully produce more offspring will have higher fitness than conspecifics producing fewer offspring. Thus, female marine turtles nesting on natural beaches probably have higher fitness than turtles nesting on developed beaches. Consequently, populations nesting on natural beaches may be able to recover more quickly from the historic population declines that have plagued marine turtles, and some species may recover more quickly than others.

Daley, B., Griggs, P., and Marsh, H. **Exploiting marine wildlife in Queensland: the commercial dugong and marine turtle fisheries, 1847-1969.** *Australian Economic History Review* 48(3): 227-265, 2008.

Notes: The historical exploitation of marine resources in Queensland has only been partially documented. In particular, the history of the commercial fishing of dugongs and marine turtles has received comparatively little scholarly attention. Since European settlement in Queensland, various human activities have exploited these resources. We present documentary and oral history evidence of the scale of those industries. Based on extensive archival and oral history research, we argue that diverse fishing practices occurred and that the sustained exploitation of dugongs, green turtles, and hawksbill turtles led to observable declines in the numbers of these animals - now species of conservation concern.

Boyle, M.C., FitzSimmons, N.N., Limpus, C.J., Kelez, S., Velez-Zuazo, X., and Waycott, M. **Evidence for transoceanic migrations by loggerhead sea turtles in the southern Pacific Ocean.** *Proceedings of the Royal Society of London [B]* 276(1664): 1993-1999, 2009.

Notes: Post-hatchling loggerhead turtles (*Caretta caretta*) in the northern Pacific and northern Atlantic Oceans undertake transoceanic developmental migrations. Similar migratory behaviour is hypothesized in the South Pacific Ocean as post-hatchling loggerhead turtles are observed in Peruvian fisheries, yet no loggerhead rookeries occur along the coast of South America. This hypothesis was supported by analyses of the size-class distribution of 123 post-hatchling turtles in the South Pacific and genetic analysis of mtDNA haplotypes of 103 nesting females in the southwest Pacific, 19 post-hatchlings stranded on the southeastern Australian beaches and 22 post-hatchlings caught by Peruvian longline fisheries. Only two haplotypes (CCP1 93% and CCP5 7%) were observed across all samples, and there were no significant differences in haplotype frequencies between the southwest Pacific rookeries and the post-hatchlings. By contrast, the predominant CCP1 haplotype is rarely observed in North Pacific rookeries and haplotype frequencies were strongly differentiated between the two regions (F_{st}=0.82; p =<0.00001). These results suggest that post-hatchling loggerhead turtles emerging from the southwest Pacific rookeries are undertaking transoceanic migrations to the southeastern Pacific Ocean, thus emphasizing the need for a broader focus on juvenile mortality throughout the South Pacific to develop effective conservation strategies.

Brock, K.A., Reece, J.S., and Ehrhart, L.M. **The effects of artificial beach nourishment on marine turtles: differences between Loggerhead and Green turtles.** *Restoration Ecology* 17(2): 297-307, 2009.

Notes: Marine turtle reproductive success is correlated with the stability and quality of the nesting environment. Female marine turtles show fidelity to nesting beaches, making artificial beach nourishment practices directly relevant to their recovery. We evaluated the impacts of artificial beach nourishment on Loggerhead (*Caretta caretta*) and Green turtles (*Chelonia mydas*) between artificially nourished and nonnourished beaches. We observed reduced nesting success (ratio of nesting emergences to emergences not resulting in nest deposition) for both species. This negative effect lasted for one season in Loggerheads and for at least one season in Green turtles. Physical attributes of the fill sand did not impede nesting attempts. We argue that the decrease in nesting success resulted from an altered beach profile not favorable for nest deposition, which subsequently improved in later seasons as the beach equilibrated to a more natural slope. We observed a 52.2% decrease in reproductive output (hatchlings km^{-1} yr^{-1}) for Loggerheads one year postnourishment, with a 44.1% increase observed the two seasons postnourishment. In Green turtles, a 0.8% reduction was observed the first season postnourishment, despite a 13% increase in the nonnourished area. The reduction in reproductive output in both cases was primarily a consequence of decreased nesting success, lowering nest numbers. These results reveal stronger negative effects of beach nourishment on Loggerheads compared to Green turtles and the importance of minimizing excessive nonnesting emergences associated with artificial beach nourishment. Nourished areas also experienced more than 600% increase in the number of Loggerhead hatchlings disoriented by artificial lighting over two years postnourishment.

Kelle, L., Gratiot, N., and de Thoisy, B. **Olive ridley turtle *Lepidochelys olivacea* in French Guiana: back from the brink of regional extirpation?** *Oryx* 43(2): 243-246, 2009.

Notes: The estimated number of olive ridley marine turtles *Lepidochelys olivacea* nesting annually in 2002-2007 in French Guiana was 1,716-3,257, the highest ever recorded in the country and similar to nesting numbers recorded in neighbouring Suriname c. 40 years ago, where the species has now severely declined. A shift of nesting females from Suriname to French Guiana beaches and improvement of nationwide marine turtle monitoring appear to be the most plausible explanations for the current high level of nesting recorded in French Guiana. The species' nesting status in French Guiana therefore appears less critical than previously documented but ongoing threats suggest the need to reinforce regional conservation efforts in the West Atlantic.

Hulin, V., Delmas, V., Girondot, M., Godfrey, M.H., and Guillon, J.M. **Temperature-dependent sex determination and global change: are some species at greater risk?** *Oecologia* 160(3): 493-506, 2009.

Notes: In species with temperature-dependent sex determination (TSD), global climate change may result in a strong sex ratio bias that could lead to extinction. The relationship between sex ratio and egg incubation at constant temperature in TSD species is characterized by two parameters: the pivotal temperature (P) and the transitional range of temperature that produces both sexes (TRT). Here, we show that the proportion of nests producing both sexes is positively correlated to the width of the TRT by a correlative approach from sex ratio data collected in the literature and by simulations of TSD using a mechanistic model. From our analyses, we predict that species with a larger TRT should be more likely to evolve in response to new thermal conditions, thus putting them at lower risk to global change.

Orós, J., González-Díaz, O.M., and Monagas, P. **High levels of polychlorinated biphenyls in tissues of Atlantic turtles stranded in the Canary Islands, Spain.** *Chemosphere* 74(3): 473-478, 2009.

Notes: Polychlorinated biphenyls (PCBs 28, 31, 52, 101, 138, 153, 180, and 209) were measured in tissue samples (liver and fat) from 30 loggerhead turtles *Caretta caretta*, 1 green turtle *Chelonia mydas*, and 1 leatherback *Dermochelys coriacea* stranded on the coasts of the Canary Islands, trying to establish a possible relation between PCB concentrations and the lesions and causes of death. Tissues from these turtles contained higher levels of PCBs than those reported in turtles from other geographical regions. ∑PCB concentrations (1980 ± 5320 ng g^{-1} wet wt.) in the liver of loggerheads were higher than in the adipose tissue (450 ± 1700 ng g^{-1} wet wt.). Concentrations of PCB 209 in the liver (1200 ± 3120 ng g^{-1} wet wt.) of loggerheads and in the

liver (530 ng g^{-1} wet wt.) and adipose tissue (500 ng g^{-1} wet wt.) of the leatherback were remarkable. Frequencies of detection of PCB 209 in the liver (15.5%) and adipose tissue (31%) were also remarkable. Cachexia was detected in 7 turtles (22%) and septicemia was diagnosed in 10 turtles (31%). Statistically, a positive correlation was detected between ∑PCBs concentration and cachexia. Poor physical condition, cachexia and/or septicaemia could explain the high levels of PCBs and tissue distribution. However, no histological lesions exclusively attributed to the acute effects of PCBs were described. The most prevalent histological lesions were ulcerative and purulent oesophagitis, purulent dermatitis, necrotizing enteritis, and granulomatous pneumonia. The bacteria most frequently isolated were *Escherichia coli, Staphylococcus* sp., and *Aeromonas* sp. Although immunosupression as a result of PCBs pollution has been described previously, other factors in this study, such as incidental fishing, nutritional status, and exposition to different micro-organisms, make it difficult to establish a clear association between PCB concentrations and causes of death.

Mrosovsky, N., Ryan, G.D., and James, M.C. **Leatherback turtles: The menace of plastic.** *Marine Pollution Bulletin* 58(2): 287-289, 2009.

Notes: The leatherback, *Dermochelys coriacea*, is a large sea turtle that feeds primarily on jellyfish. Floating plastic garbage could be mistaken for such prey. Autopsy records of 408 leatherback turtles, spanning 123 years (1885-2007), were studied for the presence or absence of plastic in the GI tract. Plastic was reported in 34% of these cases. If only cases from our first report (1968) of plastic were considered, the figure was 37%. Blockage of the gut by plastic was mentioned in some accounts. These findings are discussed in the context of removal of top predators from poorly understood food chains.

Al-Bahry, S., Mahmoud, I., Elshafie, A., Al-Harthy, A., Al-Ghafri, S., Al-Amri, I., and Alkindi, A. **Bacterial flora and antibiotic resistance from eggs of green turtles *Chelonia mydas*: An indication of polluted effluents.** *Marine Pollution Bulletin* 58(5): 720-725, 2009.

Notes: Sea turtles migrate to various habitats where they can be exposed to different pollutants. Bacteria were collected from turtle eggs and their resistance to antibiotics was used as pollutant bio-indicators of contaminated effluents. Eggs were collected randomly from turtles when they were laying their eggs. A total of 90 eggs were collected and placed into sterile plastic bags (3 eggs/turtle) during June-December of 2003. The bacteria located in the eggshell, albumen and yolk were examined, and 42% of the eggs were contaminated with 10 genera of bacteria. *Pseudomonas* spp. were the most frequent isolates. The albumen was found to be the part of the egg to be the least contaminated by bacterial infection. Bacterial isolates tested with 14 antibiotics showed variations in resistance. Resistance to ampicillin was the highest. The presence of antibiotic resistant bacteria in eggs indicates that the green turtle populations were subjected to polluted effluents during some of their migratory routes and feeding habitats. Scanning electron microscopy revealed that *Salmonella typhimurium* penetrated all eggshell layers.

Fonseca, L.G., Murillo, G.A., Guadamuz, L., Spinola, R.M., and Valverde, R.A. **Downward but stable trend in the abundance of arribada olive ridley sea turtles (*Lepidochelys olivacea*) at Nancite Beach, Costa Rica (1971-2007).** *Chelonian Conservation and Biology* 8(1): 19-27, 2009.

Notes: Although the olive ridley sea turtle (*Lepidochelys olivacea*) is the most abundant sea turtle in the world, the species has exhibited a significant decrease in the size of arribadas at Nancite Beach, Costa Rica, since its discovery in 1970. In the present study, we compiled data on number of nesting females per arribada from previous authors for the period 1971-1997 and collected new data using a total count methodology and a strip transect method for the arribadas during 1999-2007. We used generalized additive models to assess the trend of arribada size for the period 1971-2007. Our data indicate a significant reduction of 42%, 84%, and 90% in the number of nesting females per arribada in the periods 1971-1984, 1971-1992, and 1971-2007, respectively. Although we could not determine the specific reasons for this attrition we speculate that this decline may be driven by embryo-associated mortality due to a poor nest microenvironment in this beach. Our data confirm that the Nancite arribada population has undergone a significant decrease over the past 36 years but that the population currently appears to be at a stable low point. In addition, our data show that hatchling production may be increasing at this beach, which

suggests the possibility that this population may recover over a few decades. The significant attrition observed in this study underscores the ephemeral nature of arribada populations in general and the need for the continued monitoring of the Nancite population.

Pike, D.A. **Do green turtles modify their nesting seasons in response to environmental temperatures?** *Chelonian Conservation and Biology* 8(1): 43-47, 2009.

Notes: Recent evidence suggests that higher sea-surface temperatures are affecting nesting patterns in loggerhead turtles (*Caretta caretta*), specifically by causing nesting to begin earlier in years with higher oceanic temperatures. I tested whether a sympatrically nesting species (*Chelonia mydas*) also shows the same pattern and found that green turtle seasonal nesting patterns at Canaveral National Seashore, Florida, were unrelated to environmental temperatures at the nesting beach; although, the date of the first nest predicted the magnitude of the nesting season (nesting earlier in the year led to higher numbers of nests). Although the reasons for differences in loggerhead and green turtles remain unclear, these results indicate that the timing of loggerhead turtle nesting may change in a warming environment; whereas, green turtle nesting may remain relatively fixed with regard to temperatures at the nesting beach.

Ferraro, P.J. and Gjertsen, H. **A global review of incentive payments for sea turtle conservation.** *Chelonian Conservation and Biology* 8(1): 48-56, 2009.

Notes: Performance payment conservation approaches are based on a willing buyer-willing seller model. Sellers deliver conservation outcomes in exchange for a negotiated payment in cash or in kind. The use of performance payments to achieve conservation outcomes is increasingly being used as an alternative to traditional regulatory and development-based approaches in low-income nations. Although payments are increasingly common in terrestrial species and ecosystem conservation initiatives, they are rare in marine conservation efforts such as sea turtle protection. This paper describes sea turtle incentive payment initiatives taking place around the world, most of which are found in projects focusing on nesting beach protection. We find that many of these initiatives have achieved substantial results for a very low annual cost. The potential for expanding payment incentive schemes beyond nest protection to reduce bycatch and hunting pressures on juvenile and adult turtles is unknown but should be further explored.

Alfaro-Shigueto, J., Mangel, J., Seminoff, J.A., and Duttone, P.H. **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, 2008. **O/A**

Notes: Since 2000 we have used artisanal fishing operations as an opportunistic platform for inwater 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.

Peckham, S.H., Maldonado-Diaz, D., Koch, V., Mancini, A., Gaos, A., Tinker, M.T., and Nichols, W.J. **High mortality of loggerhead turtles due to bycatch, human consumption and strandings at Baja California Sur, Mexico, 2003 to 2007.** *Endangered Species Research* 5(2-3): 171-183, 2008. **O/A**

Notes: Assessing mortality of long-lived organisms is fundamental for understanding population trends and for implementing

conservation strategies, but doing so for marine megafauna is challenging. Here we assessed anthropogenic mortality of endangered North Pacific loggerhead turtles in the coastal waters of Baja California Sur, Mexico (BCS), through the synthesis of 3 sources: (1) intensive surveys of an index shoreline from 2003 to 2007; (2) bimonthly surveys of additional shorelines and towns for stranded and consumed carcasses from 2006 to 2007; and (3) observations of bycatch by 2 small-scale fishing fleets. Using Monte Carlo simulations we estimate that 1500 to 2950 loggerhead turtles died per year at BCS from 2005 to 2006 due to bycatch in the 2 observed fleets. Actual mortality may be considerably higher due to bycatch in other fisheries, directed hunting for black market trade, and natural factors including predation and disease. From 2003 to 2007 we encountered 2719 loggerhead carcasses on shorelines and in and around towns of BCS. Along the 43 km Playa San Lázaro, 0.25 loggerheads km^{-1} d^{-1} were stranded during summer fishing months over 5 yr, which is among the highest reported stranding rates worldwide. This stranding rate corroborates similarly high observed bycatch rates for local small-scale longline (29 loggerheads 1000 $hooks^{-1}$) and gillnet (1.0 loggerhead km^{-1} of net) fisheries. A significant increase in mean length of 2636 carcasses measured at BCS occurred from 1995 to 2007. Given the endangered status of the North Pacific loggerhead population, conservation action to reduce bycatch and poaching at BCS is urgently needed.

Mancini, A. and Koch, V. **Sea turtle consumption and black market trade in Baja California Sur, Mexico.** *Endangered Species Research* 7(1): 1-10, 2009. **O/A**

Notes: We examined sea turtle consumption and illegal trade in Baja California Sur (BCS) using data from (1) bimonthly surveys at beaches, fishing camps and dumpsites and (2) semi-structured interviews with fishermen. From March 2006 to February 2008, we found the carcasses of 1014 sea turtles; the meat of 461 of these turtles (45.5%) had been consumed. The East Pacific green turtle *Chelonia mydas* was the most sought-after species (77% of total consumed turtles). Consumption is still the main cause of mortality for sea turtles and the greatest threat to them in BCS, affecting mostly juvenile-sized specimens. Sea turtle consumption occurred all year round with a lower number recorded from November to February and an increase thereafter. From 151 interviews we identified 3 areas where turtle meat is consumed but not sold, 4 areas with a local black market and 3 areas providing for a regional and/or international black market. Prices vary from 2-5 USD kg^{-1} (entire turtle sold on the beach) to 4-20 USD kg^{-1} (meat only). Consumption of sea turtle meat is partly related to cultural factors, as it is consumed more frequently during the Christian fasting period of Lent. While trade and consumption have decreased in recent years, there are still several places that supply sea turtle meat to local, regional, and sometimes even international markets. Authority involvement in sea turtle traffic and the lack of law enforcement need to be addressed to improve sea turtle conservation in the region. The use of both qualitative and quantitative data in the present study has helped to gain a better understanding of sea turtle consumption in BCS.

Wallace, B.P. and Saba, V.S. **Environmental and anthropogenic impacts on intra-specific variation in leatherback turtles: opportunities for targeted research and conservation.** *Endangered Species Research* 7(1): 11-21, 2009. **O/A**

Notes: Intra-specific variation in life history traits and/or population trends provides 'natural experiments' to identify causes of observable differences among populations of organisms. Geographically widespread marine species, for example, can experience variation in both environmental and anthropogenic impacts across their ranges that can differentially influence expression of life history traits and population dynamics in separate populations. For example, body size and reproductive output differences among geographically separate, conspecific populations of leatherback turtles *Dermochelys coriacea* have been linked to variations in environmentally driven resource availability, which differentially affect the resilience of leatherback populations to anthropogenic pressures. Specifically, differences in life history traits and population trends among breeding populations of leatherbacks that forage in the eastern Pacific versus Atlantic Ocean reflect the variable nature of resource availability in the eastern Pacific. These environmentally driven life history differences have contributed to divergent population responses to anthropogenic sources of mortality. In this review, we provide a synoptic view of this body of research and conclude with strategic recommendations for future research and conservation initiatives. This approach has implications for other widely distributed marine species with variations in life history traits that make them more susceptible to human-driven population declines.

Hawkes, L.A., Broderick, A.C., Godfrey, M.H., and Godley, B.J. **Climate change and marine turtles.** *Endangered Species Research* 7(2): 137-154, 2009. **O/A**

Notes: Marine turtles occupy a wide range of terrestrial and marine habitats, and many aspects of their life history have been demonstrated to be closely tied to climatic variables such as ambient temperature and storminess. As a group, therefore, marine turtles may be good indicators of climate change effects on coastal and marine habitats. Despite the small number of species in the taxon and a growing body of research in the field, the evidence base to predict resultant impacts of climate change remains relatively poor. We review the data from peer-reviewed publications to assess the likely impacts of climate change on marine turtles and highlight the types of data that would be most useful for an accurate assessment of future effects. The cumulative indications from these previous studies indicate that future research should focus on: (1) climate change effects on key habitats upon which turtles depend; (2) factors that influence nest site selection; (3) the consequences of skewed primary sex ratios; and (4) the effect of climate change on turtles at sea, for example range shifts and dietary breadth. Although it is too early to give detailed management recommendations, careful protection of coastlines along which turtles nest should be considered, as should the protection of beaches that produce male hatchlings, which may be of increased importance in the future. More active management approaches, for example translocation of eggs to suitable yet vacant nesting beaches, may be necessary to consider under worst-case scenarios.

Murray, K.T. Characteristics and magnitude of sea turtle bycatch in US mid-Atlantic gillnet gear. *Endangered Species Research* 8(3): 211-224, 2009. **O/A**

Notes: From 1995 to 2006, US federal fisheries observers deployed aboard commercial fishing vessels in the US mid-Atlantic region documented captures of loggerhead *Caretta caretta*, green *Chelonia mydas*, Kemp's ridley *Lepidochelys kempii*, and leatherback *Dermochelys coriacea* turtles in commercial sink gillnet gear. Data collected by these observers were used to characterize sea turtle bycatch in sink gillnet gear, including the temporal and spatial distribution, fishing characteristics, species composition, and sizes of turtles captured. In addition, these data were used to develop a generalized additive model to evaluate and predict bycatch rates (turtles per metric ton of fish landed) of sea turtles. These rates were then applied to commercial gillnet landings over the same time period to estimate total bycatch of loggerhead turtles. Bycatch rates of loggerheads were correlated with latitude, sea surface temperature, and mesh size. Highest predicted bycatch rates occurred in warm waters of the southern mid-Atlantic, in large-mesh gillnets. From 1995 to 2006, the average annual bycatch estimate of loggerheads was 350 turtles (coefficient of variation = 0.20, 95% CI over the 12 yr period: 234 to 504). Characteristics and magnitude of bycatch can help inform population assessments, while the distribution of bycatch rates can be used to help inform bycatch mitigation options.
