LEATHERBACK SEA TURTLE
(DERMOCHELYS CORIACEA)

5-YEAR REVIEW:
SUMMARY AND EVALUATION

NATIONAL MARINE FISHERIES SERVICE
OFFICE OF PROTECTED RESOURCES
SILVER SPRING, MARYLAND
AND
U.S. FISH AND WILDLIFE SERVICE
SOUTHEAST REGION
JACKSONVILLE ECOLOGICAL SERVICES FIELD OFFICE
JACKSONVILLE, FLORIDA

AUGUST 2007

U.S. Department of Commerce
National Oceanic and Atmospheric Administration

NATIONAL MARINE FISHERIES SERVICE

U.S. Department of the Interior

U.S. FISH AND WILDLIFE SERVICE

TABLE OF CONTENTS

1.0 GENERAL INFORMATION.. 1
- 1.1 Reviewers……………………….. 1
- 1.2 Methodology Used to Complete the Review 1
- 1.3 Background 1
  - 1.3.1 FR notice citation announcing initiation of this review……………… 1
  - 1.3.2 Listing history…………………………………………………………. 2
  - 1.3.3 Associated rulemakings……………………………………………….. 2
  - 1.3.4 Review history………………………………………………………… 2
  - 1.3.5 Species' recovery priority number at start of review………………… 3
  - 1.3.6 Recovery plans……………………………………………………….. 3

2.0 REVIEW ANALYSIS.. 3
- 2.1 Application of the 1996 Distinct Population Segment (DPS) Policy............. 3
  - 2.1.1 Is the species under review a vertebrate? 3
  - 2.1.2 Is the species under review listed as a DPS?...................................... 3
  - 2.1.3 Is there relevant new information for this species regarding the application of the DPS policy?.. 3
- 2.2 Recovery Criteria………………………………………………………………. 4
  - 2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?.. 4
- 2.3 Updated Information and Current Species Status.. 8
  - 2.3.1 Biology and Habitat………………………………………………… 8
    - 2.3.1.1 New information on the species' biology and life history…. 8
    - 2.3.1.2 Abundance, population trends, and demographic features… 10
    - 2.3.1.3 Genetics and genetic variation…………….……………….… 22
    - 2.3.1.4 Taxonomic classification…………………...………….……. 26
    - 2.3.1.5 Spatial distribution………………………...……………….. 26
    - 2.3.1.6 Habitat or ecosystem conditions………………...….….…… 31
  - 2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)……………..……………….………….. 32
    - 2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range………………………….. 32
    - 2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes…………………….……. 34
    - 2.3.2.3 Disease or predation……………………………………... 35
    - 2.3.2.4 Inadequacy of existing regulatory mechanisms……………. 35
    - 2.3.2.5 Other natural or manmade factors affecting its continued existence………………………………………… 37
- 2.4 Synthesis……………………………………………………………………. 39

3.0 RESULTS…………………………………………………………...……… 39
- 3.1 Recommended Classification……………………………….……….…… 39
- 3.2 New Recovery Priority Number……………………………….………. 40

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS………………….……… 40

5.0 REFERENCES…………………………………………………………… 41

APPENDIX…………………………………………………………….…… 76

5-YEAR REVIEW
Leatherback Sea Turtle/*Dermochelys coriacea*

1.0 GENERAL INFORMATION

1.1 Reviewers

National Marine Fisheries Service:
Manjula Tiwari - 858-546-5658
Barbara Schroeder - 301-713-2322 (ext. 147)
Therese Conant - 301-713-2322 (ext. 126)

U.S. Fish and Wildlife Service:
Sandy MacPherson - 904-232-2580 (ext. 110)
Earl Possardt - 770-214-9293
Kelly Bibb - 404-679-7132

1.2. Methodology used to complete the review

Dr. Manjula Tiwari of the National Marine Fisheries Service gathered and synthesized information regarding the status of the leatherback sea turtle. This review was subsequently compiled by a team of biologists from the National Marine Fisheries Service's (NMFS) Headquarters Office and the U.S. Fish and Wildlife Service's (FWS) Southeast Regional Office and the Jacksonville Ecological Services Field Office. Our sources include the final rule listing this species under the Act; the recovery plan; peer reviewed scientific publications; unpublished field observations by the Services, State, and other experienced biologists; unpublished survey reports; and notes and communications from other qualified biologists. The draft 5-year review was sent out for peer review to eight academic professionals with expertise on the species and its habitats. Peer reviewers were provided guidance to follow during the review process. Comments received from peer reviewers were incorporated into the 5-year review document (see Appendix). The public notice for this review was published on April 21, 2005, with a 90 day comment period (70 FR 20734). A few comments were received and incorporated as appropriate into the 5-year review.

1.3 Background

1.3.1 FR notice citation announcing initiation of this review

April 21, 2005 (70 FR 20734).

1.3.2 Listing history

Original Listing
FR notice: 35 FR 8491
Date listed: June 2, 1970
Entity listed: Species
Classification: Endangered

1.3.3 Associated rulemakings

Regulations Consolidation Final Rule: 64 FR 14052, March 23, 1999. The purpose of this rule was to make the regulations regarding implementation of the Endangered Species Act of 1973 (ESA) by NMFS for marine species more concise, better organized, and therefore easier for the public to use.

Critical Habitat Designation: 43 FR 43688, September 26, 1978. The purpose of this rule was to designate terrestrial critical habitat for the leatherback turtle as follows: U.S. Virgin Islands – A strip of land 0.2 miles wide (from mean high tide inland) at Sandy Point Beach on the western end of the island of St. Croix beginning at the southwest cape to the south and running 1.2 miles northwest and then northeast along the western and northern shoreline, and from the southwest cape 0.7 miles east along the southern shoreline. 44 FR 17711, March 23, 1979. Critical habitat was designated for waters adjacent to Sandy Point, St. Croix, U.S. Virgin Islands, up to and inclusive of the waters from the hundred fathom curve shoreward to the level of mean high tide.

1.3.4 Review history

Plotkin, P.T. (Editor). 1995. National Marine Fisheries Service and U.S. Fish and Wildlife Service Status Reviews for Sea Turtles Listed under the Endangered Species Act of 1973. National Marine Fisheries Service, Silver Spring, Maryland. 139 pages.
Conclusion: Retain the listing as endangered throughout its range.

Mager, A.M., Jr. 1985. Five-year status reviews of sea turtles listed under the Endangered Species Act of 1973. U.S. Department of Commerce, NOAA, National Marine Fisheries Service, St. Petersburg, Florida. 90 pages.
Conclusion: Retain the listing as endangered throughout its range.

FWS also conducted 5-year reviews for the leatherback in 1985 (50 FR 29901) and in 1991 (56 FR 56882). In these reviews, the status of many species was simultaneously evaluated with no in-depth assessment of the five factors or threats as they pertain to the individual species. The notices stated that FWS was seeking any new or additional information reflecting the necessity of a change in the status of the species under review. The notices indicated that if significant data were available warranting a change in a species' classification, the Service would propose a rule to modify the species' status. No change in the leatherback's listing classification was recommended from these 5-year reviews.

1.3.5 Species' recovery priority number at start of review

National Marine Fisheries Service = 1 (this represents a high magnitude of threat, a high recovery potential, and the presence of conflict with economic activities). U.S. Fish and Wildlife Service (48 FR 43098) = 1 (this represents a monotypic genus with a high degree of threat and a high recovery potential).

1.3.6 Recovery plans

Name of plan: Recovery Plan for Leatherback Turtles (*Dermochelys coriacea*) in the U.S. Caribbean, Atlantic, and Gulf of Mexico
Date issued: April 6, 1992

Name of plan: Recovery Plan for U.S. Pacific Populations of the Leatherback Turtle (*Dermochelys coriacea*)
Date issued: January 12, 1998

Dates of previous plans: Original plan date - September 19, 1984

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate?

Yes.

2.1.2 Is the species under review listed as a DPS?

No.

2.1.3 Is there relevant new information for this species regarding the application of the DPS policy?

Yes. Although the Services believe the current listing is valid based on the best available information, we have preliminary information that indicates an analysis and review of the species should be conducted in the future to determine the application of the DPS policy to the leatherback. Since the species' listing, a substantial amount of information has become available on population structure (through genetic studies) and distribution (through telemetry, tagging, and genetic studies). The Services have not yet fully assembled or analyzed this new information; however, at a minimum, these data appear to indicate a possible separation of populations by ocean basins. To determine the application of the

DPS policy to the leatherback, the Services intend to fully assemble and analyze this new information in accordance with the DPS policy. See Section 2.3 for new information since the last 5-year review and Section 4.0 for additional information.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

No. The "Recovery Plan for Leatherback Turtles (*Dermochelys coriacea*) in the U.S. Caribbean, Atlantic, and Gulf of Mexico" was signed in 1992 and the "Recovery Plan for U.S. Pacific Populations of the Leatherback Turtle (*Dermochelys coriacea*)" was signed in 1998. While not all of the recovery criteria strictly adhere to all elements of the 2004 NMFS Interim Recovery Planning Guidance, they are still a viable measure of the species status. See Section 4.0 for additional information.

The recovery criteria for the two active recovery plans are identified below, along with several key accomplishments:

1992 Recovery Plan for Leatherback Turtles (Dermochelys coriacea) in the U.S. Caribbean, Atlantic, and Gulf of Mexico:

The U.S. population of leatherbacks can be considered for delisting if the following conditions are met:

1. The adult female population increases over the next 25 years, as evidenced by a statistically significant trend in the number of nests at Culebra, Puerto Rico, St. Croix, USVI, and along the east coast of Florida.
   - A Leatherback Turtle Expert Working Group with national and international participants was convened from 2004-2006 to gather and assess the latest, most complete data available on Atlantic leatherback nesting and population information.
   - In Puerto Rico, the main nesting areas are at Fajardo on the main island of Puerto Rico and on the island of Culebra. Between 1978 and 2005, nesting increased in Puerto Rico from a minimum of 9 nests recorded in 1978 and to a minimum of 469-882 nests recorded each year between 2000 and 2005. Annual population growth rate was estimated to be 1.1 with a growth rate interval between 1.04 and 1.12 using nest numbers between 1978 and 2005.
   - In the U.S. Virgin Islands, leatherback nesting on the Sandy Point National Wildlife Refuge on the island of St. Croix has been monitored each nesting season since 1977. Researchers estimated a population growth of approximately 13% per year on Sandy Point from 1994 through 2001. Between 1990 and 2005, the number of nests recorded has ranged from a low of 143 in 1990 to a high of 1,008 in 2001. The average annual growth

rate was calculated as approximately 1.10 (with an estimated interval of 1.07, 1.13) using the number of observed females at Sandy Point, St. Croix, from 1986 to 2004.
  - In Florida, a Statewide Nesting Beach Survey program has documented an increase in leatherback nesting numbers from 98 nests in 1989 to between 800 and 900 nests per season in the early 2000s. Based on the standardized nest counts made at Index Nesting Beach Survey sites surveyed with constant effort over time (1989-2006), there has been a substantial increase in leatherback nesting in Florida since 1989. The estimated annual growth rate was approximately 1.18 with estimated 95% posterior interval of approximately 1.1-1.21.

2. Nesting habitat encompassing at least 75 percent of nesting activity in USVI, Puerto Rico and Florida is in public ownership.
   - Several key properties are in Federal ownership as National Wildlife Refuges in Florida (Archie Carr and Hobe Sound), Puerto Rico (Culebra and Vieques), and the U.S. Virgin Islands (Sandy Point). The extent of nesting activity occurring on properties in protected ownership has not yet been assessed.

3. All priority one tasks have been successfully implemented.
   - Research and monitoring have been conducted in Canada on one of the largest seasonal foraging populations of leatherbacks in the Atlantic (task 121).
   - In cooperation with Canada, threats to leatherback turtles in Canadian waters have been identified and addressed, and contributed to the development of recovery plans for leatherback turtles in Canada (task 121).
   - Nest monitoring and nest protection efforts are ongoing at several National Wildlife Refuges in Florida (Archie Carr and Hobe Sound), Puerto Rico (Culebra and Vieques), and the U.S. Virgin Islands (Sandy Point), as well as on other beaches throughout the species U.S. nesting range (task 212).
   - Regulations requiring year-round use of TEDs by most shrimp trawlers operating in southeastern U.S. waters were required after December 1992 and modifications to improve turtle exclusion have been codified (task 2221).
   - Efforts are ongoing to provide TED outreach and training for various foreign governments (task 2221).

1998 Recovery Plan for U.S. Pacific Populations of the Leatherback Turtle (Dermochelys coriacea):

To consider de-listing, all of the following criteria must be met:

1. All regional stocks that use U.S. waters have been identified to source beaches based on reasonable geographic parameters.

- Stock structure of nesting turtles has been identified using DNA analysis, flipper tagging, and satellite telemetry.
- A mixed stock analysis of leatherback turtles along the California coast has been completed.

2. Each stock must average 5,000 (or a biologically reasonable estimate based on the goal of maintaining a stable population in perpetuity) females estimated to nest annually (FENA) over six years.
   - Efforts to attain this goal are ongoing.

3. Nesting populations at "source beaches" are either stable or increasing over a 25-year monitoring period.
   - Efforts to attain this goal are ongoing.
   - Leatherback turtle population trends have been evaluated, and conservation strategies via stochastic simulation models have been designed and evaluated.
   - Monitoring and protection of leatherbacks nesting in Mexico and Costa Rica is ongoing. Currently, all primary nesting beaches in Mexico are protected (although egg poaching still exists), and secondary nesting beaches are partially protected.
   - Aerial surveys are being conducted to determine abundance of nesting leatherback turtles in Mexico, Papua New Guinea, Indonesia, Solomon Islands, and Latin America.
   - Monitoring and protection of leatherback nesting beaches in the western Pacific, including education of local villagers on the importance of conservation of leatherbacks have been supported. Locations included Papua New Guinea ("no harvest" moratorium set up on Kamiali Beach in 2003; monitoring index beaches and tagging females), Indonesia (ongoing monitoring and protection, tagging, and telemetry), Solomon Islands monitoring), and Vanuatu (monitoring and protection of known leatherback nesting beach; surveying for other possible leatherback nesting beaches).

4. Existing foraging areas are maintained as healthy environments.
   - Efforts to attain this goal are ongoing.

5. Foraging populations are exhibiting statistically significant increases at several key foraging grounds within each stock region.
   - Efforts to attain this goal are ongoing.
   - Monitoring (aerial surveys) for foraging leatherbacks off central and northern California and the Pacific Northwest has been conducted.
   - The distribution and abundance of leatherback turtles within the coastal California ecosystem has been described.

6. All priority #1 tasks have been implemented.
   - The Marshall Islands Sea Turtle-Fisheries Interaction Outreach Education project to build sea turtle conservation and management capacity of the

Marshall Islands Marine Resources Authority has been supported (task 2.1.1.1).
- Satellite tags were attached to turtles in Papua New Guinea, Indonesia, Solomon Islands, and Latin America to gather information regarding migratory movements and pelagic habitat use (task 2.1.2.1).
- National observer programs have been assisted and capacity building has been supported through in-country fishery observer training to improve sea turtle species identification, reporting, handling, and education regarding fishery mitigation techniques in Indonesia, Vietnam, and New Caledonia (task 2.1.4.1).
- An observer program in the Chilean swordfish-directed longline fishery has been supported, and circle hooks and technical support have been provided for experimental testing of modified gear (task 2.1.4.1).
- An observer program in Peru has been supported to document the threat of shark and mahi mahi longline fisheries on leatherback turtles and to document direct harvest (task 2.1.4.1).
- Leatherback interaction rates and mortality rates in U.S. Pacific swordfish directed longline fleets have been reduced by requiring large circle hooks combined with non-squid bait; proper handling of hooked and entangled leatherbacks; and use of disentangling and de-hooking equipment such as dip nets, line cutters, and de-hookers (task 2.1.4.2).
- A capacity building project for the Federated States of Micronesia National Ocean Resources Management Authority and the tuna longline industry to provide training on handling fishery-sea turtle interactions and to provide a foundation for future management activities has been supported (task 2.1.4.2).
- "Best practice technologies" have been promoted in the major longline fleets of the Pacific (task 2.1.4.2).
- A project in Papua New Guinea to mitigate tuna and prawn fisheries interactions with sea turtles and to build the capacity of the National Fisheries Authority has been supported (task 2.1.4.2).
- The efficacy of longline gear technology to reduce sea turtle interactions in Pacific Ocean high seas fisheries has been tested in collaboration with Japan (task 2.1.4.2).
- Turtle interaction rates in the U.S. California/Oregon drift gillnet fisheries for swordfish and thresher shark have been reduced by implementing and enforcing a time/area closure in central and northern California in time/area of high leatherback concentrations (task 2.1.4.2).

7. A management plan designed to maintain sustained populations of turtles is in place.
   - Not yet completed.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

The following sections provide an overview of leatherback research and population trends that have emerged in the past decade since the last 5-year review. This is not meant to be an exhaustive review, rather it aims to provide a comprehensive and updated background on population trends, demography, genetic structuring, and threats so that an appropriate listing classification may be evaluated for populations of the leatherback sea turtle.

2.3.1.1 New information on the species' biology and life history:

This past decade has seen many technological advances and a diversity of research that have allowed us to better understand the biology of leatherbacks, especially away from the nesting beach. With the extensive use of satellite transmitters and other data recorders, a vast body of literature is now available on internesting and post-nesting movements, behavior, physiology, and habitat use, which has been valuable not only for a better understanding of leatherback biology, but also for evaluating their exposure to and the impact of fisheries. Molecular markers (i.e., mitochondrial DNA and microsatellites) have greatly advanced our understanding of the genetic structuring within and among ocean basins, both at the nesting beaches and at foraging grounds (Dutton 1996; Dutton *et al*. 1999, 2002, 2006). Important contributions have been made toward hypothesizing the impact of climate/oceanographic processes on the contrasting population trends observed between the Atlantic and Pacific (see below references). Increased evaluation of bycatch worldwide has provided important insights into the management of this species (see below references). Stable isotopes are also beginning to play an important role in our understanding of leatherback ecology (Godley *et al*. 1998a, Biasatti 2004, Wallace *et al*. 2006b, Paddock *et al*. 2007). Important research is underway to estimate very important demographic parameters such as age at maturity and survival rates (see below references). Furthermore, density-dependent population regulation, a previously unexplored subject in sea turtles, was evaluated in depth on a high-density leatherback nesting beach in French Guiana (Girondot *et al*. 2002, Caut *et al*. 2006a).

Research on many other different aspects of leatherback biology has been conducted in the past decade. Some of the prominent topics covered include:

- anatomy and physiology (Barragan 1996; Paladino *et al*. 1996; Rostal *et al*. 1996, 2001; Penick *et al*. 1998; Davenport 1998; Larese-Casanova and Penick 1998; Southwood *et al*. 1999; Oliver *et* *al*. 2000; Constantino and Salmon 2003; Albright *et al*. 2003; Jones 2004; Wyneken *et al*. 2003; James and Mrosovsky 2004; Maurer-Spurej 2005; Reina *et al*. 2002, 2005; Southwood *et al*. 2005; Bradshaw *et al*. 2007; Garner and Lyle 2007; Hastings *et al*. 2007a, 2007b; Montilla *et al*. 2007);

- age to maturity and survival (Hughes 1996; Rhodin *et al.* 1996; Spotila *et al*. 1996, 2000; Zug and Parham 1996; Dutton *et al*. 2005; Rivalan *et al*. 2005b; Eguchi *et al*. 2006a; Avens and Goshe 2007).
- incubation environment and egg development (Godfrey *et al*. 1997; Juarez *et al*. 1998; Bilinski *et al*. 2001; Billes and Fretey 2001; Noga and Mantai 2003; Kamel and Mrosovsky 2003; Maharaj 2004; Ralph *et al*. 2005; Wallace *et al*. 2004, 2006c; Caut *et al*. 2006b; Marco *et al*. 2006; Gonzalez *et al*. 2006; Conrad *et al*. 2007);
- temperature-dependent sex determination and sexual differentiation (Leslie *et al*. 1996, Binckley *et al*. 1998, Chevalier *et al*. 1999, Herrera *et al*. 2004);
- nest site selection and nesting activity/patterns (Girondot and Fretey 1996, Chevalier *et al*. 2000, Lux *et al*. 2003, Sieg *et al*. 2003, Weishampel *et al*. 2003, Pineda *et al*. 2004, Kamel and Mrosovsky 2004, Nordmoe *et al*. 2004, Clune *et al*. 2006, Nolasco *et al*. 2007);
- hatchling emergence and orientation (Godfrey and Barreto 1995, Kloc *et al*. 1998, Standora *et al*. 2000, Drake and Spotila 2002, Villanueva Mayor 2002, Turnbull 2003);
- rehabilitation (Merigo *et al*. 2006);
- hydrodynamic drag (Hyman and Watson 2006);
- reproductive strategies (Dalton *et al*. 2007);
- research methodologies (McDonald and Dutton 1996, McDonald *et al*. 1996, Eckert *et al*. 1999, Torres 2003, Godfrey and Drif 2002);
- foraging ecology and habitat use (Salmon *et al*. 2004; Desjardin 2005; Eckert 2006; Eckert *et al*. 2006; Harvey *et al*. 2006; Benson *et al.* 2006, in press);
- movement (Ferraroli *et al.* 2004; Hayes *et al.* 2004; James *et al.* 2005a, 2005b; Eckert 2006; Eckert *et al.* 2006; Sale *et al.* 2006);
- management of leatherback populations (Tiwari and Dutton 2006);
- captive rearing of leatherbacks (Jones *et al*. 2007);
- evolution of leatherbacks (Wood *et al*. 1996; Dutton *et al*. 1996, 1999); and
- bycatch (e.g., Moncada and Rodriguez 1996; Cheng and Chen 1997; Duguy *et al*. 1998; Godley *et al*. 1998b; Brito M. 1998; Horikoshi *et al*. 2000; Billes *et al*. 2003; Morisson *et al*. 2003; Dwyer *et al*. 2003; Pinedo and Polacheck 2004; Lewison *et al*. 2004; Kotas *et al*. 2004; Petersen 2005; Eckert and Eckert 2005; James *et al*. 2005a, 2005b; Lee Lum 2006; Marcovaldi *et al*. 2006; Carranza *et al*. 2006; Livingstone and Downie 2005; Gass 2006; Gilman *et al*. 2006; Zeeberg *et al*. 2006; Gallo *et al*. 2006; Fallabrino *et al*. 2000;

Domingo *et al*. 2006; Hamann *et al*. 2006a, 2006b; Laporta *et al*. 2006; Bal *et al*. 2007).

Other research has been directed toward developing tools to determine body mass from morphometric measurements (Georges and Fossette 2006), correct for partial temporal and spatial monitoring effort on nesting beaches (Gratiot *et al*. 2006, Girondot *et al*. 2006), estimate tag loss (Rivalan *et al*. 2005a) and clutch frequency (Rivalan *et al*. 2006a), and analyze multiple satellite telemetry pathways and an animal's navigation ability using state-space models (Mills Flemming *et al*. 2006, Jonsen *et al*. 2006).

Basic nest count data collected consistently over a minimum of 10 consecutive years have been very valuable for better assessing trends in leatherback populations as nesting female and nest count data of less than 10 years have recently been shown to be unsuitable for identifying leatherback population trends (Turtle Expert Working Group 2007). Methodologies to determine nesting numbers on the beach that correct for partial temporal and spatial monitoring effort (Gratiot *et al*. 2006, Girondot *et al*. 2006) and to estimate tag loss (Rivalan *et al*. 2005a) continue to be refined so that population trends can be determined more accurately. Similarly, much effort is being put into determining clutch frequency (Rivalan *et al*. 2006a, Briane *et al*. 2007). Clutch frequency has been difficult to evaluate because of incomplete temporal and/or spatial monitoring and the long-distance movements of leatherbacks within a season (e.g., Stewart *et al*. 2006, Hilterman and Goverse, 2007), and yet it is an essential parameter to estimate the number of females nesting in a season. Therefore, much effort has been expended to determine methodologies -- especially for nesting beaches where survey effort is low and varies among years -- to estimate this value as accurately as possible. Models have been developed to estimate clutch frequency from capture-recapture methodologies (Rivalan *et al*. 2006a) and to determine the distribution of the observed clutch frequency (Briane *et al*. 2007).

2.3.1.2 Abundance, population trends, and demographic features:

2.3.1.2.1 Abundance and population trends:

Pritchard (1982) estimated 115,000 females worldwide, of which 60% nested along the Pacific coast of Mexico. Spotila *et al*. (1996) later estimated that only 34,500 females (with confidence limits of 26,200 to 42,900 females) remained worldwide. However, the most recent population size estimate for the North Atlantic alone is a range of 34,000-94,000 adult leatherbacks (Turtle Expert Working Group 2007). Abundance and population trends (specified by either nesting population or total population where known) are summarized by each ocean basin below.

INDIAN OCEAN AND SOUTHEAST ASIA

Hamann *et al*. (2006a) recently conducted a thorough assessment of leatherbacks in all the countries of the Indian Ocean and Southeast Asia region and identified the following four leatherback nesting sub-regions that may qualify as separate management units due to several factors, including possible independent breeding assemblages and differences in management regimes. Western Pacific countries and Malaysia were included within the Hamann *et al*. (2006a) assessment of the Indian Ocean and Southeast Asia and, although their synthesis is presented here, these countries will be revisited in greater detail under the Pacific section.

Southwest Indian Ocean - South Africa and Mozambique

South African index beaches demonstrated an increase from 10-20 nesting females annually in the 1960s to approximately 100 females annually in the 1990s (Hughes 1996). However, in the past 4 years, numbers have declined to 20 to 40 females nesting annually on the index beaches (Hamann *et al*. 2006a). A recent evaluation of 42 years of nesting data from South Africa found that nesting fluctuations make it difficult to interpret population trends (Nel 2006). In Mozambique, nesting numbers have not been well recorded, but estimates between 1994 and 2004 suggest that approximately 10 females nest per year in southern Mozambique -- no increase in nesting has been observed in Mozambique (Hamann *et al*. 2006a).

Bay of Bengal and Northeastern Indian Ocean - Sri Lanka, Andaman and Nicobar islands (India), Thailand, and Sumatra-Java and other islands of southern Indonesia and Arnhem Island (Australia)

Long-term data sets are not common in the countries of this region. Hamann *et al*. (2006a) summarized the following information from this sub-region: in Sri Lanka the nesting population may consist of 100 to 200 females annually (based on a year of data), whereas in the Andaman and Nicobar islands there are approximately 400 to 600 females nesting per year. Thailand supports about 10 nests per year. In Java, opposite trends are observed in two neighboring rookeries -- Meru Betiri, nesting numbers have declined from 20 females/year in the 1980s to less than five females/year in the early 2000s, whereas at neighboring Alas Perwo the nesting population possibly could have doubled over the same period of time (from 500 eggs annually to 1,000 eggs annually) although clutch frequency data for Alas Perwo are not available. Arnhem Island has not been completely surveyed and known nesting is irregular.

Other Potential Nesting Areas in this Region

For the remaining potential nesting areas in this region, Hamann *et al*. (2006a) summarized the following information. Some nesting has been suspected in the past in Bangladesh, Myanmar, and Somalia, but there are no current nesting accounts. Leatherbacks are rare along the mainland coast of India -- there are only 13 records noted between 1923 and 2003. In countries like Kenya, no nesting has been recorded, but only 50% of the coastline has been surveyed. Rare and anecdotal accounts of leatherback nesting exist in the Philippines. In the Seychelles, there have been two unconfirmed reports of leatherback nesting, but no current reports. Only one leatherback nest has been reported from the Chagos Islands in the 1970s, although since then surveys have not found any evidence of leatherback nesting. Community surveys in Vietnam indicate that nesting numbers have dropped from 500 females per year (= thousands of nests) prior to the 1960s to less than 10 nests annually today (Hamann *et al*. 2006a, 2006b). Only two leatherback clutches have been recorded in Japan after extensive surveys.

PACIFIC OCEAN

A dramatic drop in nesting numbers has been recorded on major nesting beaches in the Pacific, although a sizeable nesting population exists in Papua-Indonesia (Dutton *et al.* 2007, Hitipeuw *et al.* 2007). Spotila *et al*. (2000) have highlighted the dramatic and possible extirpation of leatherbacks from key nesting beaches in the eastern Pacific.

Eastern Pacific

In the eastern Pacific, the major nesting beaches are found in Costa Rica and Mexico. At Playa Grande, Costa Rica, considered the most important nesting beach in the eastern Pacific, numbers have dropped steadily from 1,367 females in 1988-1989 (July-June) to 506 in 1994-1995, and down to 117 by 1998-1999 (Spotila *et al*. 2000). At Parque Nacional Marino Las Baulas, Costa Rica, which consists of Playa Grande and the smaller nesting beaches of Playa Langosta and Playa Ventanas, Santidrián Tomillo *et al*. (2007) analyzed data for the Park as a whole for the first time and reported that leatherback numbers have declined in the past 15 years of monitoring (1988-1989 to 2003-2004) with approximately 1,504 females nesting in 1988-1989 to an average of 188 females nesting in 2000-2001 and 2003-2004.

In Pacific Mexico, Pritchard (1982) conducted an aerial survey of the coastline and derived an estimate of several thousands of nesting females. Monitoring on four primary index beaches for over 20 years (1982-2004) has shown a decline in nest numbers. Tens of thousands of nests were likely laid on the beaches in the 1980s, but during the 2003-2004 season a total of 120 nests was recorded on the four primary index beaches combined (Sarti Martinez *et al*. 2007).

Western Pacific

In the western Pacific, the major nesting beaches in Papua New Guinea, Papua, Indonesia, Solomon Islands, and Vanuatu (Limpus 2002, Dutton *et al*. 2007), consist of approximately 2,700-4,500 breeding females. However, this estimate should be interpreted with caution because it was derived from nest counts, and reliable data on the number of nests per female are not available (Dutton *et al*. 2007).

For a 2-km stretch at Kamiali, Papua New Guinea, also included in the 2004 survey, Benson *et al*. (2007a) counted 415 nests along the 4,516 km flown, with 71% of nests within the Huon Gulf coast. For a 2-km stretch at Kamiali, Papua New Guinea, Benson *et al*. (2007a) reported that between 2000/2001 and 2003/2004 the total number of females estimated to have nested ranged from 41 to 71. Ground surveys at Kamiali recorded a total of approximately 215 nesting events for 1999/2000 through 2003/2004 (Benson *et al*. 2007a). In the past, Quinn and Kojis (1985) had estimated 10 turtles per night from November to January, and Bedding and Lockhart (1989) had estimated 300 annually. This suggests a decline in nesting numbers; however, the results should be viewed with caution as this might be an artifact of sampling inconsistencies.

Long-term data from Indonesia and Papua New Guinea are few. Hamann *et al*. (2006a) estimated that the total nesting population is approximately 1,000 females per year based on recent surveys at both locations. In Papua, Indonesia, the main nesting beaches occur in Jamursba-Medi and Wermon. Nesting numbers have dropped from over 13,000 nests recorded in 1984 at Jamursba-Medi (Bhaskar 1985) to 1,865-3,601 nests recorded between 2001 and 2004, which equates to four nesting seasons. Between 1,788 and 2,881 nests were recorded at Wermon between 2002 and 2004, which equates to two nesting seasons (Hitipeuw *et al*. 2007).

In the Solomon Islands, 150 or more nests have been recorded on at least four beaches, between 20-50 nests on four other beaches, and between 38-65 crawls (i.e., the sea turtle crawls onto the beach, but a nest is not confirmed) on two more beaches (Kinan 2005).

In Vanuatu, recent nesting beach surveys and a review of leatherbacks by Petro *et al*. (2007) indicate that the small nesting populations of leatherbacks on these islands have declined significantly. Leatherbacks nest on many of the islands, but it was estimated that 10-15 females nested on what appeared to be the most important nesting beach. Other potentially good nesting sites need to be thoroughly surveyed.

Information also exists for other nesting rookeries in the western Pacific. In Malaysia, the major nesting rookery at Rantau Bang in Terengganu has collapsed from over 10,000 nests in 1956 to 20 or fewer nests in recent years (Chan and Liew 1996). In southeastern Australia, nesting is sporadic with less than a handful of nests each year (Dobbs 2002). In Fiji, Rupeni *et al*. (2002) estimated nesting by 20-30 individuals.

In eastern Australia, a small nesting site identified in the 1970s is reportedly close to extirpation as no nesting has been recorded since 1996 (Hamann *et al*. 2006a). Nesting is irregular in northern Australia.

ATLANTIC OCEAN

Trends and abundances are provided below for seven leatherback populations or groups of populations identified by the Turtle Expert Working Group (2007) in the Atlantic: Florida, Northern Caribbean, Western Caribbean, Southern Caribbean, West Africa, South Africa, and Brazil. Although some authors have independently presented their analyses of trends, and we have included them in the sections below, the Turtle Expert Working Group (2007) undertook trend analyses (regression and Bayesian) on Atlantic populations with a minimum of 10 years of nesting data and those results are included as well. Overall, an increasing or stable population trend is seen in all regions except the Western Caribbean and West Africa (for the latter, no long-term data are available) (Turtle Expert Working Group 2007).

Florida

In Florida, a Statewide Nesting Beach Survey (SNBS) program has documented an increase in leatherback nesting numbers from 98 nests in 1988 to between 800 and 900 nests per season in the early 2000s (Florida Fish and Wildlife Conservation Commission, unpublished data; Stewart and Johnson 2006). Although the SNBS program provides information on distribution and total abundance statewide, it cannot be used to assess trends because of variable survey effort. Therefore, leatherback nesting trends are best assessed using standardized nest counts made at Index Nesting Beach Survey (INBS) sites surveyed with constant effort over time (1989-2006). An analysis of the INBS data has shown a substantial increase in leatherback nesting in Florida since 1989 (Florida Fish and Wildlife Conservation Commission, unpublished data; Turtle Expert Working Group 2007). The estimated annual growth rate was approximately 1.17 with estimated confidence intervals of approximately 1.1-1.21 (Turtle Expert Working Group 2007).

Northern Caribbean

In Puerto Rico, the main nesting areas are at Fajardo on the main island of Puerto Rico and on the island of Culebra. Between 1978 and 2005, nesting increased in Puerto Rico from a minimum of 9 nests recorded in 1978 and to a minimum of 469-882 nests recorded each year between 2000 and 2005 (R. Martinez, Puerto Rico Department of Natural and Environmental Resources, unpublished data). Annual population growth rate was estimated to be 1.10 with a growth rate confidence interval between 1.04 and 1.12 using nest numbers between 1978 and 2005 (Turtle Expert Working Group 2007).

In the U.S. Virgin Islands, leatherback nesting on the Sandy Point National Wildlife Refuge on the island of St. Croix has been monitored each nesting season since 1977. The Sandy Point National Wildlife Refuge has the most complete and consistent leatherback nesting data set in the Caribbean. Dutton *et al*. (2005) estimated a population growth of approximately 13% per year on Sandy Point from 1994 through 2001. Between 1990 and 2005, the number of nests recorded has ranged from a low of 143 in 1990 to a high of 1,008 in 2001 (Garner *et al.* 2005). The average annual growth rate was calculated as approximately 1.10 with an estimated confidence interval between 1.07 and 1.13) using the number of observed females at Sandy Point, St. Croix, from 1986 to 2004 (Turtle Expert Working Group 2007).

In the British Virgin Islands, annual nest numbers have increased in Tortola from 0-6 nests per year in the late 1980s to 35-65 nests per year in the 2000s. Annual growth rate was estimated to be approximately 1.2 for nests laid between 1994 and 2004 (Hastings 2003, Turtle Expert Working Group 2007).

Western Caribbean

Leatherback nesting along the Caribbean Central American coast takes place between Honduras and Colombia (Troëng *et al*. 2004). Important nesting areas occur in Costa Rica, Panama, and the Gulf of Urabá (Duque *et al.* 2000) and La Playona (municipality of Acandí) in Colombia (Patiño-Martínez *et al*. 2006). A small amount of nesting also occurs in Honduras and Nicaragua (Lagueux and Campbell 2005). In the past 10 years, an increasing number of projects have been initiated to monitor leatherbacks in this region.

In Atlantic Costa Rica, at Tortuguero the number of nests laid annually between 1995 and 2006 was estimated to range from 199 to 1,623; modeling of these data indicated that the nesting population has decreased by 67.8% over this time period (Troëng *et al*. 2007). Troëng *et al*. (2004) found a slight decline in the number of nests at Gandoca between 1995 and 2003, but the confidence intervals were large. Using monitoring data between 1990 and 2004 at Gandoca, at the southernmost end of Caribbean Costa Rica, during which time an average of 582.9 (± 303.3) nests were laid each season, Chacon and Eckert (2007) found that nest numbers have been lower since 2000. The most important nesting area for leatherbacks along the Central Caribbean coast is at Chiriqui Beach in Panama where Ordonez *et al*. (2007) estimated approximately 3,077 leatherback nests and identified 234 individuals on surveys during the 2003 and 2004 nesting seasons. Troëng *et al*. (2004) reported that 5,759-12,893 leatherback nests are deposited annually between the San Juan River mouth (border between Costa Rica and Nicaragua) through Chiriqui Beach, Panama, although this reported trend should be interpreted with caution as it could be an artifact of interannual variation in nest numbers. Nest numbers that were either derived mathematically or observed were used to calculate the population growth rate for Tortuguero, Gandoca, and Pacuare from 1995-2005, and the probability that the population growth rate was >1 was 0.03, suggesting the population was likely not growing (Turtle Expert Working Group 2007).

In the Gulf of Urabá in Colombia, 162 nests were recorded on a 3-km beach during the 1998 season (Duque *et al.* 2000). On La Playona in Colombia (a 3-km area that has been monitored since 1998), an average of 120 new nesting leatherbacks has been tagged every year and an average of 218 nests were laid between 1998 and 2005(note: no data exist for 2000 and 2001; Patiño-Martínez *et al*. 2006). No trend analyses are available in the literature.

Southern Caribbean

Nesting in the Southern Caribbean occurs in Guyana, Suriname, and French Guiana (northern Brazil Guiana Shield) Trinidad, Dominica, and Venezuela. Leatherback studies in the Guianas began in the 1960s, and there is very little mention of leatherback nesting prior to this period in the literature. Leatherback nesting has increased tremendously throughout this region.

Leatherback work in Guyana began in 1965; however, because of the shifting nature of beaches in the region and because of varying sampling methodologies, data collection has not been consistent among years.

Nevertheless, better estimates of nest counts are available between 1988 and 2005 (P. Pritchard, Chelonian Research Institute, unpublished data) and suggest that the population was likely increasing over that period (see Table 11 in Turtle Expert Working Group 2007).

Spotila *et al*. (1996) estimated that over 40% of the world's leatherback population nests in Suriname and French Guiana, although the magnitude of the West African rookery needs to be verified. Prior to the 1990s, population size was not studied in Suriname, but daily nest counts have been conducted since 1969 with varying methodology over the years, and possibly less survey effort in recent years. Hilterman and Goverse (2007) identified 8,462 individual leatherbacks nesting in Suriname between 1999 and 2005. Their estimate of the minimum annual nesting number was between 1,545 and 5,500 females in Suriname. Nesting in French Guiana has been cyclic with nesting varying between approximately 5,029 and 63,294 nests annually between 1967 and 2005 (Turtle Expert Working Group 2007). Rivalan *et al*. (2006b) estimated a population of 2,750-20,000 individuals (males and females of all life stages) from the Maroni (Suriname and French Guiana). They determined that 90-220 individuals were needed to maintain adequate genetic variance for adaptive evolution ("effective population size"). Girondot *et al*. (2007) analyzed 36 years of nesting data from French Guiana and Suriname and found that the population can be classified as stable or slightly increasing. Using nest numbers from 1967-2005, a positive population growth rate was found over the 39-year period for French Guiana and Suriname; the probability that the population was growing was 0.95 (Turtle Expert Working Group 2007).

Trinidad supports an estimated 6,000 leatherbacks nesting annually, which represents more than 80% of the nesting in the insular Caribbean Sea (Fournillier and Eckert 1999, Eckert 2006). Intensive monitoring of the north coast alone between 2000 and 2004 indicated a reliable mean population size of 2,728 (1,949-3,410) nesting females per year; evaluation of past data indicates a significant increase in population size in the last 30 years (Livingstone and Downie 2005). Data on the number of observed nests at Matura Beach in Trinidad (adjusted for number of nesting females) from 1994 to 1999, as well as the actual number of nesting female counts based on tag information for 2000-2005 (excluding 2002), indicated a positive trend over the time period. The probability that the annual growth rate exceeded 1 was 0.81; the Bayesian approach used suggested that the population was likely increasing for the duration of the time series (Turtle Expert Working Group 2007).

In Dominica, the three most important leatherback beaches were patrolled from 22 April-15 December in 2003, from 1 March-30 October in 2004, and from 17 March-30 September in 2005. Seven leatherbacks were encountered and tagged in 2003, 18 in 2004, and 12 in 2005 (Franklin *et al.* 2004, Byrne and Eckert 2006).

In Venezuela, Hernandez *et al*. (2007) encountered 31 females and counted 74 nests between March and August 2001 at Playa Parguito on Margarita Island; no previously published information exists for this beach. Over 200 nests were reported from other parts of Venezuela in 2004 (Mast 2005-2006).

Miscellaneous Caribbean: Based on data from the Wider Caribbean Sea Turtle Conservation Network, according to the Turtle Expert Working Group (2007), there are many locations in the Caribbean that cannot be assigned to a particular population due to lack of nesting surveys and genetic sampling. In the insular Caribbean, 0-25 nests are estimated per year in Antigua, Bahamas, Barbados, Bonaire, Cayman (Grand, Brac, and Little Islands), Cuba, Curaçao, Jamaica, Monserrat, Saba, St. Barthelemy, St. Maarten, St. Martin, and Turks and Caicos. Between 25 and 100 nests are estimated annually in Anguilla, Aruba, Dominica, Guadeloupe, and St. Eustatius. Between 100 and 500 nests are estimated per year in Grenada, St. Kitts and Nevis, St. Lucia, and St. Vincent and the Grenadines (Eckert and Bjorkland 2004). In Martinique, 150-200 nests are estimated to be laid each year. No trend data are available because the time series are too short. These data are summarized by the Turtle Expert Working Group (2007).

Brazil

Thome *et al*. (2007) analyzed nesting in Brazil between 1988-1989 and 2003-2004 and reported 527 nests during that time period although annual numbers varied between 6 in 1993-1994 and 92 in 2002-2003. A 20.4% increase in nesting was observed on average annually between 1995-1996 and 2003-2004. Analyses of data between 1988 and 2003 found an estimated annual growth rate of 1.08 with the estimated 95% confidence interval of 1.04-1.13; the probability of the population increasing was greater than 0.99 (Turtle Expert Working Group 2007).

West Africa

Some nesting has been reported in Mauritania, Senegal, the Bijagos Archipelago of Guinea-Bissau, Turtle Islands and Sherbro Island of Sierra Leone, Liberia, Cote d'Ivoire, Ghana, Togo, Benin, Nigeria, Cameroon, Sao Tome and Principe, continental Equatorial Guinea, Islands of Corisco in the Gulf of Guinea and the Democratic Republic of the Congo, and Angola (summarized in Fretey *et al*. 2007a). A nesting population is found on the island of Bioko (Equatorial Guinea). The number of nests recorded on Bioko for 1996/1997 was 862 and 1,170 in 1997/1998 (Tomas *et al.* 2000). The mean number of nests recorded on five nesting beaches of Bioko in 2000/2001 and 2004/2005 was 3,896 (range=2,127-5,071; Rader *et al*. 2006). In the People's Republic of the Congo, 70 leatherback nests were counted between October and December during the 2003/2004 nesting season along 20 km of beach (Renatura Report 2004), and at least 148 nests were recorded during the 2005/2006 nesting season (Renatura Report 2006).

The most important nesting beach for leatherbacks in the eastern Atlantic lies in Gabon. Billes *et al*. (2000) estimated 30,000 nests along 96.5 km of Mayumba Beach in southern Gabon during the 1999/2000 nesting season. Billes *et al*. (2003) estimated that 6,300 females had nested during the 1999/2000 season and 7,800 females during the 2000/2001 season, although it should be noted that the number of females nesting may be a slight overestimate as clutch frequency may have been underestimated. Furthermore, Sounguet *et al*. (in press) conducted preliminary aerial surveys of 850 km of the Gabon coast in 2003 and estimated that 1,000-1,500 nests were laid on average every night during the peak nesting months and that at least 30,000 nests are laid along the Gabonese coast in a season. Preliminary data from the 2006-2007 collected by the Gabon Sea Turtle Partnership (unpublished data) indicate figures consistent with the 1999-2000 season. However, a steep decline had been noted during the 2003-2004 and 2004-2005 seasons. These estimates highlight the importance of this region and the need to re-evaluate global population size in light of the greater contribution from West Africa. Given the short-term nature of nesting surveys in West Africa, it is not possible to conduct any trend analyses for any of the populations in this region. Interestingly, similar fluctuations have been documented for other nesting beaches in the western Atlantic, such as Gondoca Beach (Chacón-Chaverri and Eckert 2007) and Tortuguero, Costa Rica (Troeng *et al*. 2004).

South Africa

Nesting has not been recorded in Atlantic South Africa. However, South Africa is included under the Atlantic Ocean section, as well as the Indian Ocean and Southeast Asia section, because adults from its nesting population have migrated around the Cape of Good Hope into southeast Atlantic waters (Hughes *et al.* 1998; Luschi *et al.* 2003b, 2006). For the Indian Ocean coast of South Africa, data between 1963 and 1997 indicated an estimated annual growth rate of 1.04 with estimated 95% posterior interval of approximately 1.03-1.05 (Turtle Expert Working Group 2007).

MEDITERRANEAN SEA

Casale *et al*. (2003) reviewed the distribution of leatherbacks in the Mediterranean. Among the 411 individual records of leatherback sightings in the Mediterranean, there were no nesting records. Nesting in the Mediterranean is not known or is believed to be extremely rare.

2.3.1.2.2 Demographic features:

Some demographic features that have received much attention are discussed below.

Age at Maturity

Age at sexual maturity is an important demographic parameter for management purposes and for developing recovery goals. The most sophisticated analyses to date (skeletochronological data based on scleral ossicles) suggest that leatherbacks in the western North Atlantic may not reach maturity until 29 years of age (Avens and Goshe 2007). New data contradict earlier estimates (Pritchard and Trebbau 1984: 2-3 years; Rhodin 1985: 3-6 years; Zug and Parham 1996: average maturity at 13-14 years for females; Dutton *et al*. 2005: 12-14 years for leatherbacks nesting in the U.S. Virgin Islands). Rhodin *et al.* (1996) speculated that extremely rapid growth may be possible because leatherbacks have evolved a mechanism that allows fast penetration of vascular canals into the fast growing cartilaginous matrix of their bones. However, it has not yet been determined if the vascularized cartilage in leatherbacks serves to facilitate rapid growth or affect some other physiological function. Age at maturity remains a very important parameter to be confirmed as it has significant implications for management and recovery of leatherback populations.

Survival

Reliable estimates of survival or mortality at different life history stages are not easily obtained. The annual survival rate for leatherbacks that nested at Playa Grande, Costa Rica, was estimated to be 0.654 for 1993-1994 and 0.65 for those that nested in 1994-1995 (Spotila *et al*. 2000). Rivalan *et al*. (2005b) estimated the mean annual survival rate of leatherbacks in French Guiana to be 0.91. The annual survival rate was approximately 0.893 (confidence interval = 0.87-0.92) for female leatherbacks at St. Croix (Dutton *et al*. 2005). For the St. Croix, U.S. Virgin Islands, population, the average annual juvenile survival rate was estimated to be approximately 0.63, and the total survival rate from hatchling to first year of reproduction for a female hatchling was estimated to be between 0.004 and 0.02, given assumed age at first reproduction between 9 and 13 (Eguchi *et al*. 2006a). Spotila *et al*. (1996) estimated survival in the first year to be 0.0625. The longest observed reproductive lifespan of 18 years has been reported from South Africa (Hughes 1996).

Sex Ratios

Comparison of sex ratios of hatchlings at the nesting beach between Atlantic and some Pacific populations suggests that Pacific populations may be more female biased (Binckley *et al*. 1998) than Atlantic populations (Godfrey *et al*. 1996, Turtle Expert Working Group 2007). However, caution is warranted about making basin wide comparisons. Only one study (Binckley *et al*. 1998) was conducted in the Pacific and sex ratios may widely vary by beach or even clutch. Other studies support a more narrow temperature regime for sex determination in the Atlantic. Chevalier *et al*. (1999) compared temperature-dependent sex determination patterns between the Atlantic (French Guiana) and the Pacific (Playa Grande, Costa Rica) and found that the range of temperatures producing both sexes was significantly narrower for the Atlantic population. An examination of the available database of strandings and in-water sightings from the United States' Atlantic and Gulf of Mexico coasts indicates that 60% were females, and that the proportion of females among adults (57%; >145 cm curved carapace length (CCL) and juveniles (61%; 100-145 cm CCL) was similar for these areas (Turtle Expert Working Group 2007). Although >145 cm CCL is generally believed to be the size cut-off between juvenile and adults, Stewart *et al.* (2007) reviewed published values and found that females as small as 105-125 cm CCL were recorded nesting at various cites (see also Godfrey and Drif 2002). Stewart *et al.* (2007) suggested that smaller females should be considered when studying population dynamics. Assuming the >145 cm CCL cut-off, the proportion of females was greater along the Gulf of Mexico coast than the Atlantic coast. James *et al*. (2007) collected size and sex data from leatherbacks off Nova Scotia from 1999 through 2006. They found the size distribution to consist mainly of large sub-adult and adults (n =152; mean CCL = 148.1 cm) and a significant female biased sex ratio (1.86:1). The proportion of females overall appears to have increased in the strandings since the 1980s, but this pattern is less evident when evaluated by region (i.e., north, south, and Gulf). In the Mediterranean, United Kingdom waters, and along Atlantic France, overall there was no strong female bias among strandings, sightings, and captures, whereas in Atlantic Canada the sex ratio was 69% female for turtles greater than 145 cm CCL (James *et al.* 2007). Brazil also had a female biased sex ratio (Barata *et al.* 2004).

2.3.1.3 Genetics and genetic variation:

The leatherback is unique among sea turtles because it is the only extant survivor of an evolutionary lineage that diverged from other sea turtles 100-150 million years ago (Zangerl 1980). Extinctions during the last Ice Age most likely reduced leatherbacks to a single lineage (Dutton 2004). Although leatherbacks have a deeper evolutionary lineage than other sea turtle species, analysis of genetic data suggest low genetic diversity in the mitochondrial genome (Dutton *et al*. 1999) and a recent global radiation (Bowen and Karl 1996; Dutton *et al*. 1996, 1999). Hypotheses for low genetic diversity include population bottlenecks due to recent extinction, selection pressure that led to the replacement of recent ancestral mitochondrial DNA (mtDNA), and insufficient time to accumulate new mutations at the population level (Dutton *et al*. 1999). However, their probable lower philopatry and ability to disperse extensively and exploit higher-latitude waters because of their thermal tolerance adaptations (Frair *et al*. 1972, Greer *et al*. 1973) is thought to have allowed them to recolonize more rapidly than other chelonids.

Molecular markers commonly used to establish genetic differences among populations are mtDNA and microsatellites, which are polymorphic nuclear markers. Microsatellites, in particular, can provide finer-scale resolution of leatherback population structure. Analyses of mtDNA from 10 nesting populations worldwide indicated shallow divisions both globally and within ocean basins (Dutton *et al*. 1999). The most divergent mtDNA haplotypes occur between the western Atlantic (Florida, Costa Rica, Trinidad, Suriname/French Guiana, St. Croix) and the eastern Pacific (Costa Rica, Mexico) (Dutton *et al*. 1999). Genetic structuring in each of the ocean basins is discussed below.

<u>INDIAN OCEAN</u>

A significant gap in knowledge remains concerning the genetic population structure of leatherback rookeries in the Indian Ocean. Published genotypes only exist for Malaysia, Papua, Indonesia, and South Africa (Dutton *et al*. 1999, 2007). It has been hypothesized that the nesting beaches in Sri Lanka and the Nicobar Islands might be part of a distinct Indian Ocean population (Dutton 2005-2006). Genetic sampling has been recommended from northern and eastern Australia, Andaman and Nicobar islands, Mozambique, Sri Lanka, Sumatra, Java, Thailand, and Vietnam (Dutton *et al*. 1999, 2007).

<u>PACIFIC OCEAN</u>

The rookeries in the eastern Pacific, Mexico, and Costa Rica are indistinguishable but represent a separate population from western

Pacific populations (Papua, Indonesia, Papua New Guinea, and Solomon Islands) (Barragan *et al*. 1998, Barragan and Dutton 2000, Dutton *et al*. 2000b, Dutton 2005-2006). Mitochondrial DNA analyses of samples from the Solomon Islands, Papua, Indonesia, and Papua New Guinea have revealed that these three countries comprise a metapopulation consisting of a single genetic population (Dutton 2006; Dutton *et al*. 2007). The Malaysia nesting population comprises a distinct genetic population, but may be extirpated now with the collapse of this rookery (Chan and Liew 1996, Dutton *et al*. 1999, Dutton 2005-2006).

Genetic work (samples collected from Hawaiian longline and Western U.S. driftnet fisheries) has also shown that leatherbacks from the western Pacific are recorded in the North Pacific (Dutton *et al*. 2000b, 2002a, 2006). The north Pacific foraging grounds essentially comprise animals from the western Pacific nesting population (Dutton *et al*. 1998, 2000b; Dutton 2005-2006), but leatherbacks from the eastern Pacific generally forage in the southern hemisphere in the waters of Peru and Chile (Donoso *et al*. 2000, Dutton 2005-2006). To date, approximately 29% of leatherbacks sampled off Chile (4 out of 14) have been identified to originate from the western Pacific (Donoso *et al*. 2000; Dutton 2005-2006, 2006; P. Dutton, NMFS, unpublished data).

ATLANTIC OCEAN

As previously mentioned, seven leatherback populations or groups of populations have been identified by the Turtle Expert Working Group (2007) in the Atlantic: Florida, Northern Caribbean, Western Caribbean, Southern Caribbean (including northern Brazil), West Africa, South Africa, and southern Brazil. Mitochondrial DNA data originally indicated leatherbacks nesting in Trinidad were distinct from those nesting in French Guiana and Suriname (Dutton *et al*. 1999); however, recent studies based on larger sample sizes indicate genetic homogeneity (P. Dutton, NMFS, unpublished data). Nuclear DNA and the recent mitochondrial DNA data have now identified leatherbacks nesting in French Guiana, Suriname, and Trinidad as one distinct genetic population (Dutton 1995; P. Dutton, NMFS, unpublished data). The Costa Rican population (Tortuguero and Gandoca) also appears to be genetically distinct (Dutton *et al*. 1999; P. Dutton, NMFS, unpublished data). Leatherbacks nesting on St. Croix were significantly different from those from the mainland Caribbean (Dutton *et al*. 1999) suggesting a northern Caribbean population, which may include Culebra Island and Vieques Island, Puerto Rico, and the British Virgin Islands. Recent microsatellite data from St. Croix suggest that first-time nesters may be the offspring of females that nested on St. Croix more than a decade earlier (Dutton *et al*. 2002b, 2005). Preliminary mtDNA results suggest that leatherbacks nesting in Brazil may also be genetically distinct (P.

Dutton, NMFS, unpublished data; Vargas *et al*. 2007). In the eastern Atlantic, West Africa, represented by Gabon, appears to be distinct as does the rookery in South Africa on the Indian Ocean coast (Dutton *et al*. 2003; P. Dutton, NMFS, unpublished data; LaCasella and Dutton 2007).

The populations mentioned above were distinguished primarily based on genetic data. However, it is important to note that some nesting sites have not been sampled (e.g., Guyana, Venezuela, Colombia, and Caribbean islands, such as Grenada and Dominica), so precise boundaries of these populations cannot be drawn. For example, it is not clear where the boundary between the western Caribbean and the southern Caribbean, Guyana, Suriname, and French Guiana/Trinidad, northern Brazil population lies, since nesting beaches in between (Panama, Colombia, and Venezuela) have not yet been surveyed. It is likely that the South American and mainland Caribbean population differentiation is clinal with French Guiana and Costa Rica (Panama/Colombia, etc.) at opposite ends and an overlap (fuzzy boundary) between intermediate sites (P. Dutton, NMFS, personal communication, 2007). Tagging data also blur population boundaries because of movements observed both within and among nesting seasons (Turtle Expert Working Group 2007). For instance, some females from Honduran and Colombian beaches were discovered on beaches in Costa Rica (Troëng *et al*. 2004) suggesting one large rookery along the entire coastline. Four leatherbacks tagged on the beaches of Costa Rica and Panama were later found nesting in Cuba, Florida, St. Croix, and Grenada, thereby weakening the concept of a distinct Western Caribbean leatherback population. A female tagged on St. Croix nested in Dominica, and a leatherback turtle tagged in Costa Rica was later found on a beach in the Indian River Lagoon, Florida (see summaries available in Bräutigam and Eckert 2006 and Turtle Expert Working Group 2007).

Leatherbacks foraging in the waters of the North Atlantic have been shown to be part of the western Atlantic breeding populations (Dutton 2006; Roden *et al*. in press; S. Roden, NMFS, unpublished data).

MEDITERRANEAN SEA

There is no known nesting within the Mediterranean (Casale *et al*. 2003). Leatherbacks found in Mediterranean waters originate from the Atlantic (P. Dutton, NMFS, unpublished data).

SUMMARY

In conclusion, genetic analyses of worldwide nesting assemblages support the natal homing hypothesis, although natal homing in leatherbacks lacks the relative precision observed in other sea turtle species and allows for colonization of new or depleted beaches (Dutton *et al*. 1999). Rivalan *et al*. (2006b) used microsatellites to evaluate whether the lack of nesting records prior to the 1950s in French Guiana and Suriname was the result of a long-term natural population cycle or immigration; neither hypothesis was supported. Although genetic studies failed to detect evidence of a founder effect or bottleneck in French Guiana, Rivalan *et al*. (2006b) suggested immigration might be important to maintaining a regional metapopulation; this requires further investigation. They estimated the effective population to be 90-220 individuals for the French Guiana/Suriname population. Lynch and Lande (1998) have argued that the effective population size for the conservation of an endangered species should range from 500 to 1,000. This indicates the vulnerability of the French Guiana/Suriname population even though large numbers nest annually and also emphasizes the need to preserve smaller populations that may be a source rookery for depleted populations. The evolutionary effective population size calculated from the mtDNA data globally was 45,000 to 60,000 (Dutton *et al*. 1999), whereas Spotila *et al*. (1996) estimated a census size of 26,000 to 43,000 adult females globally.

Furthermore, microsatellites have indicated very infrequent or no multiple paternity within or among successive clutches of a female (Rieder *et al*. 1998, Dutton and Davis 1998, Dutton *et al*. 2000a, Crim *et al*. 2002) suggesting that perhaps females rarely encounter multiple males or that sperm competition may occur (Dutton *et al*. 2000a). Leatherbacks at Playa Grande, Costa Rica, demonstrated some level of polygyny (Crim *et al*. 2002), whereas no polygyny was detected in a Caribbean population (Curtis 1998).

The observed low genetic diversity in leatherbacks and the potential vulnerability of even large populations like French Guiana and Suriname emphasize the need for conservation measures even when populations are stable or increasing. Unique haplotypes contained in breeding assemblages such as St. Croix account for a significant part of the global diversity and are important to conserve and maintain genetic diversity for the species as a whole.

2.3.1.4 Taxonomic classification:

Kingdom: Animalia
Phylum: Chordata
Class: Reptilia
Order: Testudines
Family: Dermochelyidae
Genus: *Dermochelys*
Species: *coriacea*
Common name: Leatherback sea turtle

2.3.1.5 Spatial distribution:

Leatherbacks have the widest distribution of sea turtles, nesting on beaches in the tropics and sub-tropics and foraging into higher-latitude sub-polar waters. They have evolved physiological and anatomical adaptations (Frair *et al*. 1972, Greer *et al*. 1973) that allow them to exploit waters far colder than any other sea turtle species would be capable of surviving. In the Atlantic, they are found as far north as the waters of the North Sea, Barents Sea, Newfoundland, and Labrador (Threlfall 1978, Goff and Lien 1988, Marquez 1990, James *et al*. 2005a) and as far south as Argentina and the Cape of Good Hope, South Africa (Marquez 1990; Hughes *et al*. 1998; Luschi *et al*. 2003b, 2006) and nesting occurs in both the eastern and western Atlantic. In the Pacific, they extend from the waters of British Columbia (McAlpine *et al*. 2004) and the Gulf of Alaska (Hodge and Wing 2000) to the waters of Chile and South Island (New Zealand), and nesting occurs in both the eastern and western Pacific (Marquez 1990, Gill 1997, Brito M. 1998). They also occur throughout the Indian Ocean (Hamann *et al*. 2006a). Although leatherbacks occur in Mediterranean waters, no nesting is known to take place in this region (Casale *et al*. 2003).

Historical descriptions of leatherbacks are rarely found in the accounts of early sailors, and the size of their population before the mid-20th century is speculative. Even for large nesting assemblages like French Guiana and Suriname, nesting records prior to the 1950s are lacking (Rivalan *et al*. 2006b). By the 1960s, several nesting sites were being discovered in the western Atlantic, in Pacific Mexico, and in Malaysia. Soon after, other populations in Pacific Costa Rica and Mexico were identified. It is difficult to explain the lack of published nesting accounts for these large reptiles, but this may result from a lack of publicity by indigenous people or lack of human habitation along leatherback nesting beaches. Today, as described above, nesting beaches are known in all major ocean basins with catastrophic declines observed in the eastern Pacific (Spotila *et al*. 2000) and Malaysia (Chan and Liew 1996).

Important nesting areas in the western Atlantic Ocean occur in Florida (USA); St. Croix, U.S. Virgin Islands; Puerto Rico; Costa Rica; Panama; Colombia; Trinidad and Tobago; Guyana; Suriname; French Guiana; and southern Brazil (Marquez 1990, Spotila *et al*. 1996; Bräutigam and Eckert 2006). Other minor nesting beaches are scattered throughout the Caribbean, Brazil, and Venezuela (Mast 2005-2006, Hernandez *et al*. 2007). In the eastern Atlantic, a globally significant nesting population is concentrated in Gabon, with widely dispersed but fairly regular nesting between Mauritania in the north and Angola in the south (Fretey *et al*. 2007a). In the eastern Pacific, important nesting beaches occur in Mexico and Costa Rica with scattered nesting along the Central American coast (Marquez 1990). Nesting is very rare in the Gulf of California (Seminoff and Dutton 2007). In the western Pacific, the main nesting beaches occur in the Solomon Islands, Papua, Indonesia, and Papua New Guinea (Limpus 2002, Dutton *et al.* 2007). Lesser nesting occurs in Vanuatu (Petro *et al*. 2007), Fiji (Rupeni *et al*. 2002), and southeastern Australia (Dobbs 2002, Hamann *et al*. 2006a) and is very rare in the North Pacific (Eckert 1993). In the Indian Ocean, major nesting beaches occur in South Africa, Sri Lanka, and Andaman and Nicobar islands, with smaller populations in Mozambique, Java, and Malaysia (Hamann *et al*. 2006a). For nesting numbers during the 2004 nesting season from 89 sites around the world, refer to the State of the World's Sea Turtles Report (Mast 2005-2006).

Despite decades of work on sea turtles and the presence of extensive fisheries in all ocean basins, little is known about the dispersal and developmental habitats of hatchling, juvenile, and subadult leatherbacks. Eckert (2002a) summarized the records of nearly 100 sightings of juvenile leatherbacks and found that animals less than 100 cm CCL are generally found in water warmer than 26˚C indicating that the first part of a leatherback's life is spent in tropical waters. In the Gulf of Guinea, a potential developmental habitat may have been identified in the waters of Sao Tome and Principe where accidental capture of four juvenile leatherbacks (17 to 21 cm in carapace length) in March 1994 were reported (Fretey *et al*. 1999). Matings are not commonly observed, but may occur near the nesting beach (Godfrey and Barreto 1998, Reina *et al*. 2005). There appears to be some fidelity to breeding sites by males (James *et al*. 2005b). Females have some degree of natal homing as described in the above genetics section.

With the development and widespread use of satellite telemetry over the past decade, more information is now available on the internesting and post-nesting movements of adult leatherbacks. Internesting movements and/or behavior, as well as data recording methodologies, have been described from several nesting beaches (Eckert *et al*. 1996, 2002b, 2006;

Eckert 2006; Fulton *et al*. 2006; Wallace *et al*. 2005; Reina *et al*. 2005; Eguchi *et al*. 2006b; Myers and Hays 2006; Billes *et al*. 2006b; Hitipeuw *et al*. 2007; Shillinger *et al*. 2006; Benson *et al*. 2007a; Witt *et al*. in press; Fosette *et al*. 2007). Post-nesting movements and oceanic routes and habitat use have been greatly elucidated through satellite telemetry and tend to support genetic studies and traditional tagging data.

In the western Atlantic, widely dispersed post-nesting movements have been elucidated by satellite telemetry (Ferraroli *et al*. 2004, Hays *et al*. 2004, Eckert 2006, Eckert *et al*. 2006, Sale *et al*. 2006; see Turtle Expert Working Group 2007 for summary). Leatherbacks may select foraging areas based on oceanic structures that may concentrate prey (Ferraroli *et al*. 2004, Eckert 2006). Hays *et al*. (2006) demonstrated that during the first year post-nesting leatherbacks generally do not tend to zone in on fixed foraging hotspots, but appear to travel continuously and adjust their foraging behavior and diel activity patterns according to local conditions. Ferraroli *et al*. (2004) found that leatherbacks nesting in French Guiana and Suriname disperse widely throughout the north Atlantic -- there are no corridors -- and into eastern Atlantic waters. Hays *et al*. (2004) also showed that leatherbacks nesting in Grenada disperse widely, sometimes heading north and then perhaps into the eastern Atlantic or directly across the Atlantic into eastern Atlantic waters.

Tag returns and satellite telemetry of turtles from nesting beaches in Caribbean Costa Rica and Panama have revealed that the leatherbacks traveled through the Caribbean and into the Gulf of Mexico and the North Atlantic where some remained close to the Atlantic coast of North America and headed into the waters of Nova Scotia, Canada, or went across the North Atlantic to north of the Azores Islands (Troëng *et al*. 2004, 2007; Evans *et al*. 2007). Post-nesting movements of leatherback turtles tracked from Puerto Rico show wide dispersal into northwest and northeast waters as well, with one leatherback up near North Carolina, USA, and another traveling directly northeast to the Azores (Lutcavage *et al*. 2003). Leatherbacks from Trinidad went across the Atlantic, either through the Flemish Cap or thereabouts or straight across, ending eventually in Mauritanian waters (Eckert 2006). Among leatherbacks fitted with transmitters in Florida, most remained along the North American continental shelf for three seasons and in winter moved off the shelf. Another traveled to the Mauritanian coast and one to the north equatorial Atlantic (Eckert *et al*. 2006). Satellite telemetry work has shown that females as well as males and subadults foraging in the waters of the North Atlantic make return migrations to key feeding areas in the northern latitudes (James *et al*. 2005a). Research has also been conducted on the behavior and diving patterns of these leatherbacks during migration (James *et al*. 2005c, 2006b; Eckert 2006). Canadian waters support the highest densities of leatherbacks in the summer and fall in the North Atlantic (James *et al*. 2006c).

Many leatherbacks fitted with transmitters in Brazil headed south (unpublished data from Projeto Tamar in Turtle Expert Working Group 2007). Leatherbacks have been reported from mid-South Atlantic waters (White and George 2002).

In the eastern Atlantic, captures of leatherbacks from French Guiana, Grenada, and Costa Rica have been reported (Girondot and Fretey 1996, Troëng *et al*. 2004, Hays *et al*. 2004). Billes *et al*. (2006b) found that female leatherbacks tracked from Gabon during the nesting season performed extended movements into waters of neighboring Congo. During their post-nesting migration, these leatherbacks either moved offshore and headed toward the northern hemisphere to areas also shown to be exploited by western Atlantic leatherbacks or remained relatively close to the coast when heading to South Africa. Recent tag returns have shown that leatherbacks nesting in Gabon travel to the waters of Argentina and Brazil (Billes *et al*. 2006a), thereby highlighting the first transatlantic east to west movements, as well as south to the waters of Namibia and South Africa (Fretey *et al*. 2007c). Georges *et al*. (2007) examined movements of satellite-tracked females from Gabon, Grenada, and French Guiana during internesting intervals and after the nesting season. In all locations, the females moved away from beach and travelled hundreds of km between two consecutive nesting events, indicating that leatherbacks disperse broadly during a nesting season. Witt *et al.* (in press) found similar movement patterns in nesting females at Mayumba National Park in Gabon. Internesting data indicate leatherbacks can move from 2,000 to 4,500 km during the entire nesting season. As in the western Atlantic, these animals may be using different foraging grounds or traveling along different routes. A nesting leatherback tagged at Bigisanti Beach, Suriname, in May 1970 was recaptured in the waters of Ghana in April 1971 (Pritchard 1973).

In the Indian Ocean, leatherbacks nesting in South Africa sometimes travel around the Cape of Good Hope into southeast Atlantic waters (Hughes *et al*. 1998; Luschi *et al*. 2003b, 2006). Few data exist on the foraging grounds and migratory corridors of leatherbacks in the Indian Ocean and Southeast Asia region, although leatherbacks have been reported from the waters of 32 of the 44 countries comprising this region (Hamann *et al*. 2006a). Sale *et al*. (2006) describe the diving activity of leatherbacks in the Indian and Atlantic Oceans.

In the western Pacific, satellite telemetry work has demonstrated migrations of leatherbacks nesting in Papua, Indonesia, to the waters of the Philippines and Malaysia, into the Sea of Japan, and across the equatorial Pacific to temperate waters off North America (Benson *et al*. 2007b). The prevailing southward current suggests that the Raja Ampat archipelago is an important migratory corridor and/or internesting habitat for Papuan leatherback breeding populations (Hitipeuw *et al*. 2007). Leatherbacks from Papua New Guinea beaches headed into the high latitude waters of the southern Pacific (Benson *et al*. 2007a). The north Pacific foraging grounds have animals from both the eastern and western Pacific rookeries (Dutton *et al*. 1998, 2000b; Dutton 2005-2006), although leatherbacks from the eastern Pacific generally forage in the southern hemisphere in the waters of Peru and Chile (Dutton 2005-2006). Four of 14 leatherbacks from the western Pacific have also been reported from Chile (Donoso *et al*. 2000, Dutton 2005-2006). Based on stable isotope analysis, Paddock *et al*. (2007) suggested that leatherbacks nesting in Papua, Indonesia, and Papua New Guinea forage in the western Pacific and the eastern Pacific. Leatherbacks tracked from Monterey Bay, California, moved southwest, and one turtle was tracked across the Pacific to north of Papua, Indonesia (Eckert and Dutton 2001, Dutton *et al*. 2006).

The declining eastern Pacific genetic population is more limited to foraging primarily in the southeastern Pacific. Genetic studies in Chile and Peru (Donoso *et al*. 2000; P. Dutton, NMFS, unpublished data) and telemetry studies (Morreale *et al*. 1996, Eckert and Sarti 1997) have indicated that leatherbacks foraging in the southeastern Pacific are primarily from the eastern Pacific nesting population. Shillinger *et al*. (2006) tracked leatherbacks at Playa Grande, Costa Rica, and found consistencies with earlier studies that suggested a leatherback "migration corridor" along the Cocos Ridge from Las Baulas National Park toward the Galapagos Islands (Morreale *et al*. 1996). One of the reasons put forth for the greater collapse of eastern Pacific populations compared to western Pacific populations is the difference in foraging strategies demonstrated by satellite telemetry work, genetics, and tag returns. The large nesting population in Papua, Indonesia, in the western Pacific uses several foraging areas both near and distant, just like Caribbean populations, whereas eastern Pacific populations have limited foraging areas that occur primarily in the southeastern Pacific (Dutton 2006).

Luschi *et al*. (2003a) reviewed the role of ocean currents in various ocean basins on long-distance movements of turtles and Gaspar *et al*. (2006) advised that tracking data analyses should take oceanic currents, usually neglected, into account to avoid misinterpretation of the animal's orientation and energy budget, as well the identification of foraging spots. Lambardi *et al*. (2006) described how oceanographic conditions may influence the migratory behavior of South African leatherbacks.

2.3.1.6 Habitat or ecosystem conditions:

Many explanations have been provided to explain the disparate population trends seen in the Pacific and the Atlantic. Some ideas put forth to explain, for instance, disparate trends on the Pacific and Atlantic coast of Costa Rica include higher hatching success, less leatherback bycatch in fisheries, and less overlap between fishing areas and leatherback habitats in the Atlantic than in the Pacific (Troëng *et al*. 2004). Using stable isotopes, Wallace *et al*. (2006a) calculated reproductive energy budgets for leatherbacks in the North Atlantic (St. Croix) and the eastern Pacific (Costa Rica) and found that resource limitation in the eastern Pacific due to the El Niño Southern Oscillation (ENSO) may be the cause of longer remigration intervals, thereby lowering reproductive success and increasing exposure to fisheries. Saba *et al*. (2007b) evaluated the effect of ENSO on the reproductive frequency of eastern Pacific leatherback turtles and reported that declines are not only due to fisheries causes but also due to sensitivity to the interannual climate variability, governed by ENSO, which is reflected in their remigration probabilities (higher remigration probability was seen during La Niña years than El Niño years). Variable remigration intervals result in variable egg production. During a La Niña year, increased oceanic productivity and favorable environmental conditions led to an abundance in turtles and shorter remigration intervals, possibly the result of improved leatherback prey availability allowing leatherbacks to reach reproductive condition more quickly (Reina *et al*. 2006).

Wallace *et al*. (2006b) highlighted differences in nitrogen signatures between the St. Croix population in the Atlantic and the Costa Rican population in the eastern Pacific indicating fundamentally different oceanic processes. Saba *et al*. (2007a) found that mean primary productivity in all the foraging areas of western Atlantic females is significantly higher (150% greater) than those of the eastern Pacific females; the reproductive output of western Atlantic females was double that of eastern Pacific females. Except for the eastern Pacific, which had interannual variability in primary production because of ENSO, all of the foraging areas had seasonal primary production. High reproductive output and consistent and high quality foraging areas in the Atlantic have contributed to the stable or recovering populations in the Atlantic (Saba *et al*. 2007a).

Several factors may contribute to the observed decline in the Pacific. Dutton (2006) highlighted the difference in foraging strategies between the eastern and western Pacific populations. While the large population in the western Pacific utilizes multiple nearshore and pelagic foraging areas in the northern and southern hemispheres, the eastern Pacific population has a very narrow foraging strategy (by feeding primarily in the southeastern Pacific), thereby making it more susceptible to negative anthropogenic impacts and climatic stochasticity. The western Pacific population, in contrast, is better buffered against such perturbations (Dutton 2006).

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

The determination to list a species under the ESA is based on the best scientific and commercial data regarding five listing factors (see below). Subsequent 5-year reviews must also make determinations about the listing status based, in part, on these same factors.

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

There are increasing impacts to the nesting and marine environment that affect leatherback turtles. Natural factors, including the recent tsunami in the Indian Ocean (see detailed report by Hamann *et al*. 2006c), impact leatherback habitat. Shifting mudflats in the Guianas also often make nesting habitat unsuitable (Crossland 2003, Goverse and Hilterman 2003). Human activities also impact leatherback habitat. Leatherback nesting beaches are affected by development and tourism in several countries (e.g., Maison 2006, Hamann *et al*. 2006a, Santidrian-Tomillo *et al*. 2007, Hernandez *et al*. 2007). Structural impacts to nesting habitat include the construction of buildings and pilings, beach armoring and renourishment, and sand extraction (Lutcavage *et al*. 1997, Bouchard *et al*. 1998). In addition, accumulation of timber and marine debris on the beach, as well as sand mining, can have a negative impact on available nesting habitat in some areas (Chacón-Chaverri 1999, Formia *et al*. 2003, Laurance *et al.* in press). These factors may directly, through loss of beach habitat, or indirectly, through changing thermal profiles and increasing erosion, serve to decrease the amount of nesting area available to nesting females, and may evoke a change in the natural behaviors of adults and hatchlings (Ackerman 1997; Witherington *et al*. 2003, 2007). In addition, coastal development is usually accompanied by artificial lighting. The presence of lights on or adjacent to nesting beaches alters the behavior of nesting adults and is often fatal to emerging hatchlings as they are attracted to light sources and drawn away from the water (Witherington and Bjorndal 1991, Witherington 1992, Cowan *et al*. 2002, Deem *et al*. 2007). In many countries, coastal development and artificial lighting are responsible for substantial hatchling mortality. Although legislation controlling these impacts does exist (Lutcavage *et al*. 1997), a majority of countries do not have regulations in place. Fortunately, some of the major nesting beaches occur in sufficiently remote areas, and large scale development is less of an issue there.

Considering that coastal development and beach armoring is detrimental to leatherback nesting behavior (Lutcavage *et al*. 1997), human population expansion is reason for major concern. This is underscored by the fact that over the next few decades the human population is expected to grow by more than 3 billion people (about 50%). By the year 2025, the United Nations Educational, Scientific and Cultural Organization (UNESCO) (2001) forecasts that population growth and migration will result in a situation in which 75% of the world human population will live within 60 km of the sea. Such a migration undoubtedly will change a coastal landscape that, in many areas, is already suffering from human impacts. The problems associated with development in these zones will progressively become a greater challenge for conservation efforts, particularly in the developing world where wildlife conservation is often secondary to other national needs.

As leatherbacks forage widely in the oceanic habitat, modifications to foraging areas are more difficult to monitor. However, their marine (and nesting) environment is impacted by the petroleum industry. Numerous oil platforms operate off Gabon. Billes and Fretey (2004) found debris and tar balls that likely came from these operations.

An anthropogenic factor that may affect leatherback habitat and biology is global warming. Impacts from climate change, especially due to global warming, are likely to become more apparent in future years (Intergovernmental Panel on Climate Change (IPCC) 2007a). The global mean temperature has risen 0.76ºC over the last 150 years, and the linear trend over the last 50 years is nearly twice that for the last 100 years (IPCC 2007a). There is a high confidence, based on substantial new evidence, that observed changes in marine systems are associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels, and circulation. These changes include shifts in ranges and changes in algal, plankton, and fish abundance (IPCC 2007b), which could affect leatherback prey distribution and abundance.

Global warming is expected to expand foraging habitats into higher latitude waters (James *et al*. 2006a, McMahon and Hays 2006), and there is some concern that increasing temperatures may increase feminization on some beaches (Mrosovsky *et al*. 1984, Hawkes *et al*. 2007). However, because of the tendency of leatherbacks to have individual nest placement preferences and deposit some clutches in the cooler tide zone of beaches, the effects long-term climate change may have on sex ratios may be mitigated (Kamel and Mrosovsky 2004). McMahon *et al*. (2005) have fitted leatherbacks with sensors that capture water temperatures of their environment; these types of studies will be important for assessing temperature regimes that leatherbacks are exposed to. Of all the sea turtle species, leatherbacks are speculated to be the best able to cope with climate change because they have the widest geographical distribution of any reptile and show relatively weak beach fidelity (Dutton *et al*. 1999). Witt *et al*. (2006) investigated the impact of global warming on leatherbacks and their prey (i.e., jellyfish). Work has recently focused on how prey distribution that is primarily jellyfish aggregations may shape the distribution of leatherbacks on a temperate coastal shelf in the northeastern Atlantic (Houghton *et al*. 2006, Witt *et al.* 2007). Analysis of leatherback sightings, strandings, and incidental captures from 1954 through 2003 indicates a seasonal and spatial overlap with aggregations of gelatinous prey in the northeast Atlantic (Witt *et al.* 2007). Houghton *et al.* (2006) suggest that 22.5% of leatherback distribution in the northeastern Atlantic can be explained by a spatial and temporal association with these prey. Basin scale changes to the North Atlantic Oscillation due to global warming will effect prey distribution and abundance. How this will affect leatherback distribution and foraging behavior is difficult to predict (Witt *et al.* 2007). Grant *et al*. (1996) found a correlation between jellyfish and leatherback presence in nearshore waters off North Carolina.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

Egg collection occurs in many countries around the world (e.g., Chan and Liew 1996; Kinan 2002; Billes and Fretey 2004; Hamann *et al*. 2006a, 2006b; de Dijn 2001; Hilterman and Goverse 2007; Troëng *et al*. 2007; Fretey *et al*. 2007a; Santidrián-Tomillo *et al*. 2007; Bräutigam and Eckert 2006) and has been attributed to catastrophic declines such as in Malaysia. On some beaches (e.g., South Africa), egg harvests are now a thing of the past (Hamann *et al*. 2006a). Harvest of females still remains a matter of concern on many beaches (e.g., Fournillier and Eckert 1999, Hamann *et al*. 2006a, Ordonez *et al*. 2007, Fretey *et al*. 2007a, Bräutigam and Eckert 2006, Chacón and Eckert 2007, Gomez *et al*. 2007). A traditional harvest of leatherbacks occurs in the Kei Islands (Suarez and Starbird 1996, Lawalata *et al*. 2006). Leatherbacks are also used in voodoo ceremonies and traditional medicine (Fretey *et al*. 2007b), as well as religious ceremonies (Cheng and Chen 1997).

Low hatching success is characteristic of leatherbacks despite high fertility rates (reviewed in Bell *et al*. 2003) and when additional anthropogenic or predation pressures are placed on incubating eggs, a management strategy commonly undertaken is nest relocation. However, many studies have found that hatching success of nests relocated to another section of the beach or to hatcheries is lower than *in* *situ* nests (e.g., Duque *et al.* 2000, Hernandez *et al*. 2007); although another study found adequate hatching success in relocated nests at St. Croix (Eckert and Eckert 1990), which may be a factor in the increase observed in this nesting population (Dutton *et al.* 2005). The consequences of nest relocation need to be carefully evaluated (Mrosovsky 2006).

2.3.2.3 Disease or predation:

The health status of and baseline blood indices for leatherbacks have been largely unstudied. Deem *et al*. (2006) presented the first baseline values for hematology, plasma biochemistry, and plasma protein electrophoresis from 35 leatherbacks nesting in Gabon and also measured plasma corticosterone, vitamin concentrations, and several toxicological parameters; the sampled leatherbacks were rated as being in good health. The first case of fibropapillomatosis in leatherbacks was reported from Pacific Mexico (Huerta *et al*. 2002). This disease is a condition likely caused by a herpesvirus (Ene *et al*. 2005) and is characterized by the presence of internal and external tumors (fibropapillomas) that may grow large enough to hamper swimming, vision, feeding, and potential escape from predators (Herbst 1994). Fibropapillomatosis is not as common in leatherbacks as in other sea turtle species (Huerta *et al*. 2002).

Predators of leatherback eggs include feral pigs and dogs, (e.g., Ordonez *et al*. 2007, Hamann *et al*. 2006a, Tapilatu and Tiwari 2007, Hitipeuw *et al*. 2007), mole crickets (Maros *et al*. 2003), raccoons and armadillos (Engeman *et al*. 2003), monitor lizards (Tapilatu and Tiwari 2007), mongoose, civets, genets, and ghost crabs (Billes and Fretey 2004), jackals (Hughes 1996), dipteran larvae (Gautreau *et al*. 2007), and army ants (Ikaran *et al*. 2007). Predation on sea turtle hatchlings by birds and fish (see Vose and Shank 2003) has been commonly reported. Nellis (2000) reported predation on leatherback hatchlings by tarpons, and Vose and Shank (2003) reported hatchling predation by gray snappers. Jaguar (Troëng 2000) and killer whale (Pitman and Dutton 2004) predation on adults has been recorded. Sharks are also known predators of adult leatherbacks (Long 1996).

2.3.2.4 Inadequacy of existing regulatory mechanisms:

The highly migratory nature of leatherbacks requires international collaboration to ensure their survival. Several sea turtle specific treaties have been developed in recent years. These include the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC), Memorandum of Abidjan for conservation of marine turtles along the Atlantic coast of Africa (MoU Abidjan), Tri-National Partnership to save leatherbacks in the Bismarck Solomon Seas Eco-region, Tri-Partite Agreement (international agreement for the conservation of Caribbean sea turtles), Indian Ocean and Southeast Asia Memorandum of Understanding (IOSEA), and Turtle Islands Heritage Protected Area (TIHPA). Frazier (2007) discusses these treaties at length, except for the Tri-National Partnership to save leatherbacks in the Bismarck Solomon Seas Eco-region, which was recently drafted. These treaties are young and hold much promise, despite their administrative, bureaucratic, political, and financial constraints.

The recently-amended U.S. Magnuson-Stevens Fishery Conservation and Management Act (MSA), implemented by NMFS, mandates environmentally responsible fishing practices within U.S. fisheries. Section 301 of the MSA establishes National Standards to be addressed in management plans. Any regulations promulgated to implement such plans for fisheries, including conservation and management measures, shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch. Section 301 by itself does not require specific measures. However, mandatory bycatch reduction measures can be incorporated into management plans for specific fisheries, as has happened with the U.S. pelagic longline fisheries in the Atlantic and Pacific oceans. Section 316 requires the establishment of a bycatch reduction engineering program to develop "technological devices and other conservation engineering changes designed to minimize bycatch, seabird interactions, bycatch mortality, and post-release mortality in Federally managed fisheries."

There are many other agreements, treaties, and conventions that are not sea turtle specific, but have implications for their survival: MEXUS-Pacific (Mexico and USA bi-national agreement for living marine resources conservation), Canada/Mexico/U.S. Trilateral Committee for Wildlife and Ecosystem Conservation and Management, Convention for Migratory Species (CMS), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), International Commission for the Conservation of Atlantic Tunas, United Nations Convention on the Law of the Sea, Protocol to the Cartagena Convention concerning Specially Protected Areas and Wildlife (SPAW), Bern Convention, Barcelona Convention, and the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention), to name a few. Hykle (2002) and Tiwari (2002) have reviewed the effectiveness of some of these international instruments. The problems with existing international treaties are often that they have not realized their full potential, do not include some key countries, do not specifically address sea turtle conservation, are handicapped by the lack of a sovereign authority to enforce environmental regulations, and are not legally-binding. The ineffectiveness of international treaties and national legislation is oftentimes due to the lack of motivation or obligation by countries to implement and enforce them. A thorough discussion of this topic is available in a special 2002 issue of the Journal of International Wildlife Law and Policy: International Instruments and Marine Turtle Conservation (Hykle 2002). The legislative framework and management policies of Wider Caribbean countries are comprehensively reviewed by Bräutigam and Eckert (2006).

2.3.2.5 Other natural or manmade factors affecting its continued existence:

Among the anthropogenic factors affecting leatherbacks, boat strikes (Dwyer *et al*. 2003, Turtle Expert Working Group 2007) and the ingestion of plastics, balloons, synthetic materials, and fishing hooks and nets have been reported (Duguy *et al*. 1998, Starbird and Audel 2000, Bugoni *et al*. 2001, Barreiros and Barcelos 2001). Ingestion of marine debris can result in starvation, gut strangulation, and toxicity; however, more studies are needed to determine the physiological effects of ingesting these materials.

Organochlorine contaminants, cadmium, copper, zinc, and toxic metals have been identified in leatherbacks, but it is difficult to interpret their effect on the health of this endangered species (Godley *et al*. 1998b, McKenzie *et al*. 1999, Caurant *et al*. 1999, Storelli and Marcotrigiano 2003). Guirlet (2005) found high levels of organochloride pesticides in the sand of a French Guiana nesting beach, which may explain low hatching success on this beach (Girondot *et al*. 2007). Stewart *et al*. (2007) provided some of the first baseline contaminant concentrations in leatherbacks and found that contaminants are passed from nesting females to their eggs.

A factor impacting leatherback populations worldwide is incidental capture in artisanal and commercial fisheries (e.g., Moncada and Rodriguez 1996; Cheng and Chen 1997; Duguy *et al*. 1998; Godley *et al*. 1998b; Brito M. 1998; Horikoshi *et al*. 2000; Billes *et al*. 2003; Morisson *et al*. 2003; Dwyer *et al*. 2003; Pinedo and Polacheck 2004; Lewison *et al*. 2004; Kotas *et al*. 2004; Petersen 2005; Eckert and Eckert 2005; James *et al*. 2005a, 2005b; Lee Lum 2006; Marcovaldi *et al*. 2006; Carranza *et al*. 2006; Livingstone and Downie 2005; Gass 2006; Gilman *et al*. 2006; Zeeberg *et al*. 2006; Gallo *et al*. 2006; Fallabrino *et al*. 2000; Domingo *et al*. 2006; Hamann *et al*. 2006a, 2006b; Laporta *et al*. 2006; Bal *et al*. 2007; Santidrian Tomillo *et al*. 2007; Alfaro-Shigueto *et al*. 2007; Fretey *et al*. 2007a; Georges *et al*. 2007; M. Griffin, Namibia Ministry of Environment and Tourism, personal communication, 2007). As an example, the decline in the Mexican population of leatherbacks has been suggested to coincide with the growth of the longline and coastal gillnet fisheries in the Pacific (Eckert and Sarti 1997); leatherbacks from this population migrate to the north Pacific and southeastern Pacific where these fisheries operate (Eckert 1997, Dutton *et al*. 2000b, Sarti Martinez *et al*. 2007). Lewison *et al*. (2004) estimated that more than 50,000 leatherbacks were likely taken as pelagic longline bycatch in 2000. Kaplan (2005) estimated that annual longline mortality was 5% in the eastern Pacific population and 12% in the western and central Pacific population, whereas coastal sources of mortality that include harvest of eggs and females and bycatch by inshore fishing gears was 28% in the eastern Pacific population and 13% in the western and central Pacific population. Lee Lum (2006) estimated that more than 3,000 leatherbacks were entangled by coastal gillnets off Trinidad in the Southern Caribbean annually, with a 30% mortality. Differences in bycatch rates among ocean basins may result from different fishing gear and fishing practices or may simply reflect divergent trends in the abundance of bycatch species among regions; nevertheless, overall this bycatch level is not sustainable (Lewison *et al*. 2004).

The need to reduce bycatch of leatherbacks has led to many experiments and new insights. Circle hooks with squid bait and J and circle hooks with mackerel bait were found to greatly reduce leatherback bycatch (Watson *et al*. 2005). For leatherbacks, neither daylight nor total soak time had a significant effect on catch rates (Watson *et al*. 2005). Leatherbacks are more likely to become entangled in the lines because they are less maneuverable than other sea turtle species (Davenport 1987). It has also been suggested that the use of smaller circle hooks with smaller gaps between the barb and shank will be effective in reducing foul hooking of leatherbacks (Watson *et al*. 2005). Gless and Salmon (2007) evaluated the responses of juvenile leatherbacks to lights used in longlines and found behaviorally complex reactions as they showed elements of attraction and repulsion to this stimulus. Furthermore, the potential post-hooking mortality can be significantly reduced with tools to remove hooks and line from the turtles (Watson *et al*. 2005). Entanglement in fishing gear in waters adjacent to nesting beaches has recently been identified as an important source of mortality for leatherbacks, and male leatherbacks could be more susceptible to entanglement in near shore fisheries because they do not appear to range as far offshore as females at the nesting beach (James *et al*. 2005b). Long-term telemetry data (Hays *et al*. 2004) suggest that leatherbacks spend time diving to depths targeted by longline fishermen.

Over 3,000 leatherbacks are estimated to interact with the shrimp trawl fishery each year in the U.S. (NMFS 2002). Turtle excluder devices (TED) have been used in trawl gear in areas of the U.S. since the late

1980s. However, a morphometric analysis of stranded sea turtles on beaches adjacent to fishing grounds indicated the TED escape opening was too small to allow large turtles, including leatherbacks, to pass through (Epperly and Teas 2002). Larger TED openings were not required until 2003.

Besides longline and trawls, leatherbacks are known to interact with gill nets, pots and traps, and pound nets (NMFS 2001). In temperate coastal foraging habitats, fixed gear interactions are a major threat to leatherbacks (James *et al*. 2005a).

2.4 Synthesis

The East Pacific and Malaysia leatherback populations have collapsed. However, the most recent population size estimate for the North Atlantic is a range of 34,000-94,000 adult leatherbacks, indicating stability (Turtle Expert Working Group 2007). See section 2.3.1.2 for a summary of abundance and population trends by each ocean basin and appropriate references.

Both natural and anthropogenic threats to nesting and marine habitats continue to affect leatherback populations, including the 2004 tsunami in the Indian Ocean and development and tourism impacts on nesting beaches in several countries. Egg collection continues to occur in many countries around the world and has been attributed to catastrophic declines in some areas. In addition, the killing of nesting females still remains a matter of concern on many beaches. Despite relatively large numbers of females nesting in certain regions of the western Pacific, hatchling production remains low (Hitipeuw *et al.* 2007, Tapilatu and Tiwari 2007). A wide variety of species depredate leatherback nests worldwide (e.g., feral pigs and dogs, raccoons, mongoose, civets, genets, armadillos, monitor lizards, ghost crabs, mole crickets, and dipteran larvae). Incidental bycatch in artisanal and commercial fishing operations, including longline, gillnet, and trawl fisheries, is a major impact that is far from being resolved. Additional factors affecting leatherbacks include boat strikes, the ingestion of and entanglement in marine debris, and exposure to heavy metals and other contaminants in the nesting and marine environments.

3.0 RESULTS

3.1 Recommended Classification:

Based on the best available information, we do not believe the leatherback turtle should be delisted or reclassified. However, we have information that indicates an analysis and review of the species should be conducted in the future to determine the application of the DPS policy to the leatherback turtle. See Section 4.0 for additional information.

3.2 New Recovery Priority Number: No change.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

We have preliminary information that indicates an analysis and review of the species should be conducted in the future to determine the application of the DPS policy to the leatherback. Since the species' listing, a substantial amount of information has become available on population structure (through genetic studies) and distribution (through telemetry, tagging, and genetic studies). The Services have not yet fully assembled or analyzed this new information; however, at a minimum, these data appear to indicate a possible separation of populations by ocean basins. To determine the application of the DPS policy to the leatherback, the Services intend to fully assemble and analyze this new information in accordance with the DPS policy. See Section 2.3 for new information since the last 5-year review.

The current "Recovery Plan for Leatherback Turtles (*Dermochelys coriacea*) in the U.S. Caribbean, Atlantic, and Gulf of Mexico" was signed in 1992 and the "Recovery Plan for U.S. Pacific Populations of the Leatherback Turtle (*Dermochelys coriacea*)" was signed in 1998. The recovery criteria contained in the plans, while not strictly adhering to all elements of the 2004 NMFS Interim Recovery Planning Guidance, are a viable measure of the species status. The species biology and population status information can be updated; however, the recovery actions identified in the plans are appropriate and properly prioritized. While some additional recovery actions can no doubt be identified, the Services believe that the current plans remain valid conservation planning tools. The recovery plans should be re-examined over the next 5-10 year horizon, particularly if the DPS analysis results in restructuring of the current listing, to update the plans to conform to the 2004 NMFS Interim Recovery Planning Guidance. In the near-term, additional information and data are particularly needed on genetic relationships among nesting populations, impacts of coastal and pelagic fisheries, foraging areas and identification of threats at foraging areas, and long-term population trends.

5.0 REFERENCES

Ackerman, R.A. 1997. The nest environment and the embryonic development of sea turtles. Pages 83-106 *in* Lutz, P.L. and J.A. Musick (editors). The Biology of Sea Turtles. CRC Press, Boca Raton, Florida.

Albright, III, L.B., M.O. Woodburne, J.A. Case, and D.S. Chaney. 2003. A leatherback sea turtle from the Eocene of Antarctica: implications for antiquity of gigantothermy in Dermochelyidae. Journal of Vertebrate Paleontology 23(4):945-949.

Alfaro-Shigueto, J., P.H. Dutton, M.-F. Van Bressem, and J. Mangel. 2007. Interactions between leatherback turtles and Peruvian artisanal fisheries. Chelonian Conservation and Biology 6(1):129-134.

Avens, L. and L.R. Goshe. 2007. Skeletochronological analysis of age and growth for leatherback sea turtles in the western North Atlantic. Page 223 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Myrtle Beach, South Carolina, USA.

Bal, G., N. Breheret, and H. Vanleeuwe. 2007. An update on sea turtle conservation activities in the Republic of Congo. Marine Turtle Newsletter 116:9-10.

Barata, P.C.R., E.H.S.M. Lima, M. Borges-Martins, J.T. Scalfoni, C. Bellini, and S. Siciliano. 2004. Records of the leatherback sea turtle (*Dermochelys coriacea*) on the Brazilian coast, 1969-2001. Journal of the Marine Biological Association of the United Kingdom 84:1233-1240.

Barragan, A.R. 1996. Anatomical basis for an intracardiac bloodflow model in sea turtles. Pages 34-37 *in* Keinath, J.A., D.E. Barnard, J.A. Musick, and B.A. Bell (compilers). Proceedings of the Fifteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-387.

Barragan, A.R. and P. Dutton. 2000. Genetic population structure of the leatherback turtle in the eastern Pacific: conservation implications. Page 154 *in* Abreu-Grobois, F.A., R. Briseño-Dueñas, R. Márquez, and L. Sarti (compilers). Proceedings of the Eighteenth International Sea Turtle Symposium. NOAA Technical Memorandum NMFS-SEFSC-436.

Barragan, A.R., P.H. Dutton, and A. Abreu-Grobois. 1998. Population genetics of the leatherback turtle in the Mexican Pacific. Pages 6-7 *in* Epperly, S.P. and J. Braun (compilers). Proceedings of the Seventeenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-415.

Barreiros, J.P. and J. Barcelos. 2001. Plastic ingestion by a leatherback turtle *Dermochelys coriacea* from the Azores (NE Atlantic). Marine Pollution Bulletin 42(11):1196-1197.

Bedding, S. and B. Lockhart. 1989. Sea turtle conservation emerging in Papua New Guinea. Marine Turtle Newsletter 47:13.

Bell, B.A., J.R. Spotila, F.V. Paladino, and R.D. Reina. 2003. Low reproductive success of leatherback turtles, *Dermochelys coriacea*, is due to high embryonic mortality. Biological Conservation 115:131-138.

Benson, S.R., K.A. Forney, P.H. Dutton, and E. LaCasella. 2006. Characterization of critical foraging habitat for leatherback turtles off California, USA. Page 182 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Benson, S.R., K.A. Forney, J.T. Harvey, J.V. Carretta, and P.H. Dutton. In press. Foraging in the shadows: abundance, distribution, and habitat of leatherback turtles (*Dermochelys coriacea*) off California, 1990-2003. Fishery Bulletin.

Benson S.R., K.M. Kisokau, L. Ambio, V. Rei, P.H. Dutton, and D. Parker. 2007a. Beach use, internesting movement, and migration of leatherback turtles, *Dermochelys coriacea*, nesting on the north coast of Papua New Guinea. Chelonian Conservation and Biology 6(1):7-14.

Benson S.R., P.H. Dutton, C. Hitipeuw, B. Samber, J. Bakarbessy, and D. Parker. 2007b. Post-nesting migrations of leatherback turtles (*Dermochelys coriacea*) from Jamursba-Medi, Bird's Head Peninsula, Indonesia. Chelonian Conservation and Biology 6(1):150-154.

Bhaskar, S. 1985. Mass nesting by leatherbacks in Irian Jaya. World Wildlife Fund International monthly report, January 1985 (pages 15-16).

Biasatti, D.M. 2004. Stable carbon isotopic profiles of sea turtle humeri: implications for ecology and physiology. Palaeogeography, Palaeoclimatology, Palaeoecology 206:203-216.

Bilinski, J.J., R.D. Reina, J.R. Spotila, and F.V. Paladino. 2001. The effects of nest environment on calcium mobilization by leatherback turtle embryos (*Dermochelys coriacea*) during development. Comparative Biochemistry and Physiology 130:151-162.

Billes, A. and J. Fretey. 2001. Nest morphology in the leatherback turtle. Marine Turtle Newsletter 92:7-9.

Billes, A. and J. Fretey. 2004. Nesting of leatherback turtles in Gabon: importance of nesting population is confirmed. Pages 6-8 *in* Coyne, M.S. and R.D. Clark (compilers). Proceedings of the Twenty-first Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-528.

Billes, A., J.-B. Moundemba, and S. Gontier. 2000. Campagne Nyamu 1999–2000. Rapport de fin de saison. PROTOMAC-ECOFAC. 111 pages.

Billes, A., J. Fretey, and J.-B.Moundemba. 2003. Monitoring of leatherback turtles in Gabon. Pages 131-132 *in* Seminoff, J.A. (editor). Proceedings of the Twenty-second Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum, NMFS-SEFSC-503.

Billes A., J. Fretey, B. Verhage, B. Huijbregts, B. Giffoni, L. Prosdocimi, D.A. Albareda, J.-Y. Georges, and M. Tiwari. 2006a. First evidence of leatherback movement from Africa to South America. Marine Turtle Newsletter 111:13-14.

Billes, A., J.-Y. Georges, S. Fossette, M. Tiwari, and J. Fretey. 2006b. Movements of eastern Atlantic leatherbacks during and after the nesting season: conservation implications at the Atlantic scale. Page 81 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Binckley, C.A., J.R. Spotila, K.S. Wilson, and F.V. Paladino. 1998. Sex determination and sex ratios of Pacific leatherback turtles, *Dermochelys coriacea*. Copeia 1998(2):291-300.

Bouchard, S., K. Moran, M. Tiwari. D. Wood, A. Bolten, P. Eliazar, and K. Bjorndal. 1998. Effects of exposed pilings on sea turtle nesting activity at Melbourne Beach, Florida. Journal of Coastal Research 14(4):1343-1347.

Bowen, B.W. and S. Karl. 1996. Population genetics, phylogeography, and molecular evolution. Pages 29-50 *in* Lutz, P.L. and J.A. Musick (editors). The Biology of Sea Turtles. CRC Press, Boca Raton, Florida.

Bradshaw, C.J.A., C.R. McMahon, and G.C. Hays. 2007. Behavioral inference of diving metabolic rate in free-ranging leatherback turtles. Physiological and Biochemical Zoology 80(2):209-219.

Bräutigam, A. and K.L. Eckert. 2006. Turning the tide: exploitation, trade and management of marine turtles in the Lesser Antilles, Central America, Colombia and Venezuela. TRAFFIC International, Cambridge, United Kingdom. 533 pages.

Briane, J.-P., P. Rivalan, and M. Girondot. 2007. The inverse problem applied to the observed clutch frequency of leatherback turtles from Yalimapo Beach, French Guiana. Chelonian Conservation and Biology 6(1):63-69.

Brito M., J.L. 1998. The marine turtle situation in Chile. Pages 12-15 *in* Epperly, S.P. and J. Braun (compilers). Proceedings of the Seventeenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-415.

Bugoni, L., L. Krause, and M.V. Petry. 2001. Marine debris and human impacts on sea turtles in southern Brazil. Marine Pollution Bulletin 42(12):1330-1334.

Byrne, R. and K.L. Eckert. 2006. 2004-2005 biennium project report: Rosalie Sea Turtle Initiative (RoSTI). Prepared by WIDECAST for the Ministry of Agriculture and the Environment (Forestry, Wildlife and Parks Division). Roseau, Dominica, West Indies. 51 pages.

Carranza, A., A. Domingo, and A. Estrades. 2006. Pelagic longlines: a threat to sea turtles in the Equatorial eastern Atlantic. Biological Conservation 131:52-57.

Casale, P., P. Nicolosi, D. Freggi, M. Turchetto, and R. Argano. 2003. Leatherback turtles (*Dermochelys coriacea*) in Italy and in the Mediterranean basin. Herpetological Journal 13:135-139.

Caurant, F., P. Bustamante, M. Bordes, and P. Miramand. 1999. Bioaccumulation of cadmium, copper and zinc in some tissues of three species of marine turtles stranded along the French Atlantic coasts. Marine Pollution Bulletin 38(12):1085-1091.

Caut, S., V. Hulin, and M. Girondot. 2006a. Impact of density-dependent nest destruction on emergence success of Guianan leatherback turtles (*Dermochelys coriacea*). Animal Conservation 9:189-197.

Caut, S., E. Guirlet, P. Jouquet, and M. Girondot. 2006b. Influence of nest location and yolkless eggs on the hatching success of leatherback turtle clutches in French Guiana. Canadian Journal of Zoology 84:908-915.

Chacón Chaverri, D. 1999. Anidacíon de la tortuga *Dermochelys coriacea* (Testudines: Dermochelyidae) en playa Gandoca, Costa Rica (1990 a 1997). Revista de Biologia Tropical 47(1-2):225-236.

Chacón-Chaverri, D. and K.L. Eckert. 2007. Leatherback sea turtle nesting at Gandoca Beach in Caribbean Costa Rica: management recommendations from fifteen years of conservation. Chelonian Conservation and Biology 6(1):101-110.

Chan, E.-H. and H.-C. Liew. 1996. Decline of the leatherback population in Terengganu, Malaysia, 1956-1995. Chelonian Conservation and Biology 2(2):196-203.

Cheng, I.-J. and T.-H. Chen. 1997. The incidental capture of five species of sea turtles by coastal setnet fisheries in the eastern waters of Taiwan. Biological Conservation 82:235-239.

Chevalier, J., M.H. Godfrey, and M. Girondot. 1999. Significant difference of temperature-dependent sex determination between French Guiana (Atlantic) and Playa Grande (Costa-Rica, Pacific) leatherbacks (*Dermochelys coriacea*). Annales des Sciences Naturelles 20(4):147-152.

Chevalier, J., G. Talvy, S. Lieutenant, S. Lochon, and M. Girondot. 2000. Study of a bimodal nesting season for leatherback turtles (*Dermochelys coriacea*) in French Guiana. Pages 264-267 *in* Kalb, H.J. and T. Wibbels (compilers). Proceedings of the Nineteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-443.

Clune, P., C. Williams, E. Flodin, J.R. Spotila, and F.V. Paladino. 2006. Nest-site selection by leatherback sea turtles on Playa Grande based on bathymetric data of Tamarindo Bay. Page 86 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Conrad, J.R., J. Wyneken, S.A. Garner, and J.A. Garner. 2007. Pulling weeds for leatherbacks: an experimental test of invasive beach plant removal on *Dermochelys coriacea* nest productivity. Page 105 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Myrtle Beach, South Carolina, USA.

Constantino, M.A. and M. Salmon. 2003. Role of chemical and visual cues in food recognition by leatherback posthatchlings (*Dermochelys coriacea* L). Zoology 106:173-181.

Cowan, E., J. Pennell, M. Salmon, J. Wyneken, C. Cowan, and A. Broadwell. 2002. Influence of filtered roadway lighting on the seaward orientation of hatchling sea turtles. Pages 295-298 *in* Mosier, A., A. Foley, and B. Brost (compilers). Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-477.

Crim, J.L., L.D. Spotila, J.R. Spotila, M. O'Connor, R. Reina, C.J. Williams, and F.V. Paladino. 2002. The leatherback turtle, *Dermochelys coriacea*, exhibits both polyandry and polygyny. Molecular Ecology 11:2097-2106.

Crossland, S.L. 2003. Factors disturbing leatherback turtles (*Dermochelys coriacea*) on two nesting beaches within Suriname's Galibi Nature Preserve. Pages 137-138 *in* Seminoff, J.A. (compiler). Proceedings of the Twenty-second Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-503.

Curtis, C. 1998. Genotyping with polymorphic markers reveals multiple paternity in leatherback turtle clutches. Unpublished Master's Thesis, Drexel University, Philadelphia, Pennsylvania.

Dalton, E.J, R.D. Reina, P. Santidrian-Tomillo, B.P. Wallace, J.R. Spotila, and F.V. Paladino. 2007. The leatherback turtle, *Dermochelys coriacea*: a model to test hypotheses of age related reproductive strategies. Page 149 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Myrtle Beach, South Carolina, USA.

Davenport, J. 1987. Locomotion in hatchling leatherback turtles *Dermochelys coriacea*. Journal of Zoology (London) 212:85-101.

Davenport, J. 1998. Sustaining endothermy on a diet of cold jelly: energetics of the leatherback turtle *Dermochelys coriacea*. British Herpetological Society Bulletin 62:4-8.

de Dijn, B. 2001. Country report Suriname. Pages 22-26 *in* Schouten, A., K. Mohadin, S. Adhin, and E. McClintock (editors). Proceedings of the Fifth Regional Marine Turtle Symposium for the Guianas. STINASU and WWF-Guianas.

Deem, S.L., F. Boussamba, A.Z. Nguema, G.-P. Sounguet, S. Bourgeois, J. Cianciolo, and A. Formia. 2007. Artificial lights as a significant cause of morbidity of leatherback sea turtles in Pongara National Park, Gabon. Marine Turtle Newsletter 116:15-17.

Deem, S.L., E.S. Dierenfeld, G.P. Sounguet, A.R. Alleman, C. Cray, R.H. Poppenga, T.M. Norton, and W.B. Karesh. 2006. Blood values in free-ranging nesting leatherback sea turtles (*Dermochelys coriacea*) on the coast of the Republic of Gabon. Journal of Zoo and Wildlife Medicine 37(4):464-471.

Desjardin, N.A. 2005. Spatial, temporal, and dietary overlap of leatherback sea turtles (*Dermochelys coriacea*) and ocean sunfishes (Family Molidae). Unpublished Master's Thesis, Florida Atlantic University, Boca Raton, Florida. 89 pages.

Dobbs, K. 2002. Marine turtle conservation in the Great Barrier Reef World Heritage Area, Queensland, Australia. Pages 79-83 *in* Kinan, I. (editor). Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop. Western Pacific Regional Fishery Management Council.

Domingo, A., L. Bugoni, L. Prosdocimi, P. Miller, M. Laporta, D. Monteiro, A. Estrades, and D. Albareda. 2006. The impact generated on sea turtles by fisheries in the southwestern Atlantic Ocean. World Wildlife Fund Progama Marino para Latinoamérica y el Caribe, San José, Costa Rica.

Donoso P., M., P.H. Dutton, R. Serra, and J.L. Brito-Montero. 2000. Sea turtles found in waters off Chile. Pages 219-221 *in* Kalb, H.J. and T. Wibbels (Compilers). Proceedings of the Nineteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-443.

Drake, D.L. and J.R. Spotila. 2002. Thermal tolerances and the timing of sea turtle hatchling emergence. Journal of Thermal Biology 27:71-81.

Duguy, R., P. Moriniere, and C. Le Milinaire. 1998. Factors of mortality of marine turtles in the Bay of Biscay (Facteurs de mortalité observés chez les tortues marines dans le golfe de Gascogne). Oceanologica Acta 21:383-388.

Duque, V.M., V.P. Paez, and J.A. Patino. 2000. Nesting ecology and conservation of the leatherback turtle, *Dermochelys coriacea*, at La Playona, Chocoan Gulf of Uraba (Colombia), in 1998 (Ecologia de anidacion y conservacion de la tortuga cana, *Dermochelys coriacea*, en La Playona, Golfo de Uraba Chocoano (Colombia), en 1998). Actualidades Biologicas Medellin 22(72):37-53.

Dutton, P.H. 1995. Molecular evolution of sea turtles with special reference to the leatherback, *Dermochelys coriacea*. Unpublished Ph.D. Dissertation, Texas A&M University, College Station, Texas. 137 pages.

Dutton, P.H. 2004. Insights into evolution, stock structure, migration and mating behavior of leatherbacks gained from genetic studies. Page 8 *in* Coyne, M.S. and R.D. Clark (compilers). Proceedings of the Twenty-first Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-528.

Dutton, P. 2005-2006. Building our knowledge of the leatherback stock structure. SWOT Report 1:10-11.

Dutton, P.H. 2006. Geographic variation in foraging strategies of leatherbacks: a hedge against catastrophe? Page 189 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Dutton, P.H. and S.K. Davis. 1998. Use of molecular genetics to identify individuals and infer mating behavior in leatherbacks. Page 42 *in* Byles, R. and Y. Fernandez (compilers). Proceedings of the Sixteenth Annual Symposium on Sea

Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-412.

Dutton, P.H., S.K. Davis, T. Guerra, and D. Owens. 1996. Molecular phylogeny for marine turtles based on sequences of the ND4-leucine tRNA and control regions of mitochondrial DNA. Molecular Phylogenetics and Evolution 5(3):511-521.

Dutton, P.H., G.H. Balazs, and A.E. Dizon. 1998. Genetic stock identification of sea turtles caught in the Hawaii-based pelagic longline fishery. Pages 45-46 *in* Epperly, S.P. and J. Braun (compilers). Proceedings of the Seventeenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-415.

Dutton, P.H., B.W. Bowen, D.W. Owens, A. Barragan, and S.K. Davis. 1999. Global phylogeography of the leatherback turtle (*Dermochelys coriacea*). Journal of Zoology (London) 248:397-409.

Dutton, P.H., E. Bixby, and S.K. Davis. 2000a. Tendency toward single paternity in leatherbacks detected with microsatellites. Page 39 *in* Abreu-Grobois, F.A., R. Briseño-Dueñas, R. Márquez, and L. Sarti (compilers). Proceedings of the Eighteenth International Sea Turtle Symposium. NOAA Technical Memorandum NMFS-SEFSC-436.

Dutton, P., G. Balazs, A. Dizon, and A. Barragan. 2000b. Genetic stock identification and distribution of leatherbacks in the Pacific: potential effects on declining populations. Pages 38-39 *in* Abreu-Grobois, F.A., R. Briseño-Dueñas, R. Márquez, and L. Sarti (compilers). Proceedings of the Eighteenth International Sea Turtle Symposium. NOAA Technical Memorandum NMFS-SEFSC-436.

Dutton, P., D. Broderick, and N. FitzSimmons. 2002a. Defining management units: molecular genetics. Pages 93-101 *in* Kinan, I. (editor). Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop. Western Pacific Regional Fishery Management Council.

Dutton, P.H., D.L. Dutton, and A.N. Frey. 2002b. Familial relationships among nesting female leatherbacks examined with genetic markers. Page 20 *in* Mosier, A., A. Foley, and B. Brost (compilers). Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-477.

Dutton, P.H., S. Roden, L.M. Galver, and G. Hughes. 2003. Genetic population structure of leatherbacks in the Atlantic elucidated by microsatellite markers. Pages 44-45 *in* Seminoff, J.A. (compiler). Proceedings of the Twenty-second Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-503.

Dutton, D.L., P.H. Dutton, M. Chaloupka, and R.H. Boulon. 2005. Increase of a Caribbean leatherback turtle *Dermochelys coriacea* nesting population linked to long-term nest protection. Biological Conservation 126:186-194.

Dutton, P.H., S.R. Benson, and S.A. Eckert. 2006. Identifying origins of leatherback turtles from Pacific foraging grounds off Central California, USA. Page 228 *in* Pilcher, N.J. (compiler). Proceedings of the Twenty-third Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-536.

Dutton, P.H., C. Hitipeuw, M. Zein, S.R. Benson, G. Petro, J. Pita, V. Rei, L. Ambio, and J. Bakarbessy. 2007. Status and genetic structure of nesting populations of leatherback turtles (*Dermochelys coriacea*) in the western Pacific. Chelonian Conservation and Biology 6(1):47-53.

Dwyer, K.L., C.E. Ryder, and R. Prescott. 2003. Anthropogenic mortality of leatherback turtles in Massachusetts waters. Page 260 *in* Seminoff, J.A. (compiler). Proceedings of the Twenty-second Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-503.

Eckert, K.L. 1993. The biology and population status of marine turtles in the North Pacific Ocean. NOAA Technical Memorandum NMFS-SWFSC-186. 156 pages.

Eckert, K.L. 1995. Leatherback sea turtle (*Dermochelys coriacea*). Pages 37-75 *in* Plotkin, P.T. (editor). Status Reviews of Sea Turtles Listed under the U. S. Endangered Species Act of 1973. National Marine Fisheries Service, Silver Spring, Maryland. 139 pages.

Eckert, K.L. and R.K. Bjorkland. 2004. Distribution and status of the leatherback sea turtle, *Dermochelys coriacea*, in the insular Caribbean region. Pages 8-10 *in* Coyne, M.S. and R.D. Clark (compilers). Proceedings of the Twenty-first Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-528.

Eckert K.L. and S.A. Eckert. 1990. Embryonic mortality and hatch success in in situ and translocated leatherback sea turtle *Dermochelys coriacea* eggs. Biological Conservation 53:37-46.

Eckert, K.L., K.A. Bjorndal, F.A. Abreu G., and M.A. Donnelly (editors). 1999. Research and Management Techniques for the Conservation of Sea Turtles. IUCN/SSC Marine Turtle Specialist Group Publication No. 4. Washington, D.C. 235 pages.

Eckert, S.A. 2002a. Distribution of juvenile leatherback sea turtle *Dermochelys coriacea* sightings. Marine Ecology Progress Series 230:289-293.

Eckert, S.A. 2002b. Swim speed and movement patterns of gravid leatherback sea turtles (*Dermochelys coriacea*) at St Croix, U.S. Virgin Islands. Journal of Experimental Biology 205:3689-3697.

Eckert, S.A. 2006. High-use oceanic areas for Atlantic leatherback sea turtles (*Dermochelys coriacea*) as identified using satellite telemetered location and dive information. Marine Biology 149:1257-1267.

Eckert, S.A. and P. Dutton. 2001. Following the leatherback sea turtle. Ecosystem Observations 2000:16-17.

Eckert, S.A. and K.L. Eckert. 2005. Strategic Plan for Eliminating the Incidental Capture and Mortality of Leatherback Turtles in the Coastal Gillnet Fisheries of Trinidad and Tobago: Proceedings of a National Consultation. WIDECAST Technical Report No. 5. Beaufort, North Carolina. 30 pages + appendix.

Eckert, S.A., D. Bagley, S. Kubis, L. Ehrhart, C. Johnson, K. Stewart, and D. DeFreese. 2006. Internesting, post-nesting movements and foraging habitats of leatherback sea turtles (*Dermochelys coriacea*) nesting in Florida. Chelonian Conservation and Biology 5(2):239-248.

Eckert, S.A. and L. Sarti M. 1997. Distant fisheries implicated in the loss of the world's largest leatherback nesting population. Marine Turtle Newsletter 78:2-7.

Eckert, S.A., H.-C. Liew, K.L. Eckert, and E.-H. Chan. 1996. Shallow water diving by leatherback turtles in the South China Sea. Chelonian Conservation and Biology 2(2):237-243.

Eguchi, T., P.H. Dutton, S.A. Garner, and J. Alexander-Garner. 2006a. Estimating juvenile survival rates and age at first nesting of leatherback turtles at St. Croix, U.S. Virgin Islands. Pages 292-293 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Eguchi, T., J.A. Seminoff, S.A. Garner, J. Alexander-Garner, and P.H. Dutton. 2006b. Flipper tagging with archival data recorders for short-term assessment of diving in nesting female turtles. Endangered Species Research 2:7-13.

Ene, A., M. Su, S. Lemaire, C. Rose, S. Schaff, R. Moretti, J. Lenz, and L.H. Herbst. 2005. Distribution of chelonid fibropapillomatosis-associated herpesvirus variants in Florida: molecular genetic evidence for infection of turtles following recruitment to neritic developmental habitats. Journal of Wildlife Diseases 41(3):489-497.

Engeman, R.M., R.E. Martin, B. Constantin, R. Noel, and J. Woolard. 2003. Monitoring predators to optimize their management for marine turtle nest protection. Biological Conservation 113:171-178.

Epperly, S.P. and W.G. Teas. 2002. Turtle excluder devices-Are the escape openings large enough? Fish. Bull. 100:466-474

Evans, D., C. Ordoñez, S.Troëng, and C. Drews. 2007. Satellite tracking of leatherback turtles from Caribbean Central America reveals unexpected foraging grounds. Pages 70-71 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Myrtle Beach, South Carolina, USA.

Fallabrino, A., A. Bager, A. Estrades, and F. Achaval. 2000. Current status of marine turtles in Uruguay. Marine Turtle Newsletter 87:4-5.

Ferraroli, S., J.-Y. Georges, P. Gaspar, and Y. Le Maho. 2004. Where leatherback turtles meet fisheries. Nature 429:521-522.

Formia A., M. Tiwari, J. Fretey, and A. Billes. 2003. Sea turtle conservation along the Atlantic Coast of Africa. Marine Turtle Newsletter 100:33-37.

Fossette, S., J.-Y. Georges, H. Tanaka, Y. Ropert-Coudert, S. Ferraroli , N. Arai, K. Sato, Y. Naito, and Y. Le Maho. In press. Dispersal and dive patterns in gravid leatherback turtles during the nesting season in French Guiana. Marine Ecology Progress Series.

Fournillier, K. and K.L. Eckert. 1999. Draft Sea Turtle Recovery Action Plan for Trinidad and Tobago. 132. Caribbean Environment Programme, Kingston, Jamaica.

Frair, W., R.G. Ackman, and N. Mrosovsky. 1972. Body temperature of *Dermochelys coriacea*: warm turtle from cold water. Science 177:791-793.

Franklin, A., R. Byrne, and K.L. Eckert. 2004. 2003 Annual Report: Rosalie Sea Turtle Initiative (RoSTI). Prepared by WIDECAST for the Ministry of Agriculture and the Environment (Forestry, Wildlife and Parks Division). Roseau, Dominica, West Indies. 57 pages.

Frazier, J. 2007. Treats on turtle treaties. Pages 219-220 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Myrtle Beach, South Carolina, USA.

Fretey, J., J.-F. Dontaine, and O. Neves. 1999. São Tomé et Príncipe: zone de croissance pour les tortues-luths? Canopée 15:1-2.

Fretey, J., A. Billes, and M. Tiwari. 2007a. Leatherback, *Dermochelys coriacea*, nesting along the Atlantic coast of Africa. Chelonian Conservation and Biology 6(1):126-129.

Fretey, J., G.H. Segniagbeto, and M. Soumah. 2007b. Presence of sea turtles in traditional pharmacopoeia and beliefs of West Africa. Marine Turtle Newsletter 116:23-25.

Fretey, J., A. Billes, B. Baxter, and C. Hughes. 2007c. Discovery of a Gabonese leatherback in South Africa. Marine Turtle Newsletter 116:25.

Fulton, K., M. Griffin, C. Williams, P. Clune, B. Wallace, J. Spotila, B. Block, and F. Paladino. 2006. Internesting dive patterns of leatherback sea turtles (*Dermochelys coriacea*) at Playa Grande, Costa Rica. Page 228 *in* Pilcher, N.J. (compiler). Proceedings of the Twenty-third Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-536.

Gallo, B.M.G., S. Macedo, B.D.B. Giffoni, J.H. Becker, and P.C.R. Barata. 2006. Sea turtle conservation in Ubatuba, southeastern Brazil, a feeding area with incidental capture in coastal fisheries. Chelonian Conservation and Biology 5(1):93-101.

Garner, J.A. and J. Lyle. 2007. Understanding steroid hormones related to reproduction in the nesting leatherback sea turtle (*Dermochelys coriacea*) Sandy Point, St. Croix. Pages 47-48 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Myrtle Beach, South Carolina, USA.

Garner, J.A., S.A. Garner, and W. Coles. 2005. Tagging and nesting research on leatherback sea turtles (*Dermochelys coriacea*) on Sandy Point, St. Croix, U.S. Virgin Islands, 2005. Annual report to Fish and Wildlife Service. 54 pages.

Gaspar, P., J.-Y. Georges, A. Lenoble, S. Ferraroli, S. Fossette, and Y. Le Maho. 2006. Marine animal behaviour: neglecting ocean currents can lead us up the wrong track Proceedings of the Royal Society B-Biological Sciences 273:2697-2702.

Gass, J. 2006. Bycatch mortality of leatherback turtles in Trinidad's artisanal gillnet fishery. Page 246 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Gautreau, S., R.J. Brooks, and D.Chacón. 2007. Dipteran larvae infestation of leatherback turtle (*Dermochelys coriacea*) nests on Gandoca Beach, Costa Rica. Page 256 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Myrtle Beach, South Carolina, USA.

Georges, J.-Y. and S. Fossette. 2006. Estimating body mass in leatherback turtles *Dermochelys coriacea*. Marine Ecology Progress Series 318:255-262.

Georges, J.-Y., S. Fossette, A. Billes, S. Ferraroli, J. Fretey, D. Gremillet, Y.L. Maho, A.E. Myers, H. Tanaka, and G.C. Hays. 2007. Meta-analysis of movements in Atlantic leatherback turtles during the nesting season: conservation implications. Marine Ecology Progress Series. 338:225-232.

Gill, B.J. 1997. Records of turtles and sea snakes in New Zealand, 1837-1996. New Zealand Journal of Marine and Freshwater Research 31:477-486.

Gilman E., E. Zollett, S. Beverly, H. Nakano, K. Davis, D. Shiode, P. Dalzell, and I. Kinan. 2006. Reducing sea turtle by-catch in pelagic longline fisheries. Fish and Fisheries 7:2-23.

Girondot, M. and J. Fretey. 1996. Leatherback turtles, *Dermochelys coriacea*, nesting in French Guiana, 1978-1995. Chelonian Conservation and Biology 2(2):204-208.

Girondot, M., A.D. Tucker, P. Rivalan, M.H. Godfrey, and J. Chevalier. 2002. Density-dependent nest destruction and population fluctuations of Guianan leatherback turtles. Animal Conservation 5:75-84.

Girondot, M., P. Rivalan, R. Wongsopawiro, J.-P. Briane, V. Hulin, S. Caut, E. Guirlet, and M.H. Godfrey. 2006. Phenology of marine turtle nesting revealed by statistical model of the nesting season. BMC Ecology 6:11.

Girondot, M., M.H. Godfrey, L. Ponge, and P. Rivalan. 2007. Modeling approaches to quantify leatherback nesting trends in French Guiana and Suriname. Chelonian Conservation and Biology 6(1):37-46.

Gless, J.M. and M. Salmon. 2007. Behavioral responses of leatherback juveniles (*Dermochelys coriacea*) to lights used in the longline fishery. Page 197 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Myrtle Beach, South Carolina, USA.

Godfrey, M.H. and R. Barreto. 1995. Beach vegetation and seafinding orientation of turtle hatchlings. Biological Conservation 74:29-32.

Godfrey, M.H. and R. Barreto. 1998. *Dermochelys coriacea* (Leatherback sea turtle) copulation. Herpetological Review 29(1):40-41.

Godfrey, M.H. and O. Drif. 2002. *Dermochelys coriacea* (Leatherback sea turtle) size. Herpetological Review 33(3):200-201.

Godfrey, M.H., R. Barreto, and N. Mrosovsky. 1996. Estimating past and present sex ratios of sea turtles in Suriname. Canadian Journal of Zoology 74:267-277.

Godfrey, M.H., R. Barreto, and N. Mrosovsky. 1997. Metabolically-generated heat of developing eggs and its potential effect on sex ratio of sea turtle hatchlings. Journal of Herpetology 31(4):616-619.

Godley, B.J., D.R. Thompson, S. Waldron, and R.W. Furness. 1998a. The trophic status of marine turtles as determined by stable isotope analysis. Marine Ecology Progress Series 166:277-284.

Godley, B.J., M.J. Gaywood, R.J. Law, C.J. McCarthy, C. McKenzie, I.A.P. Patterson, R.S. Penrose, R.J. Reid, and H.M. Ross. 1998b. Patterns of marine turtle mortality in British waters (1992-1996) with reference to tissue contaminant levels. Journal of Marine Biological Association of the United Kingdom 78:973-984.

Goff, G.P. and J. Lien. 1988. Atlantic leatherback turtles, *Dermochelys coriacea*, in cold water off Newfoundland and Labrador. Canadian Field Naturalist 102(1):1-5.

Gomez Penate, J., M. Karamoko, S. Bamba, and G. Djadji. 2007. An update on marine turtles in Cote d'Ivoire, West Africa. Marine Turtle Newsletter 116:7-8.

Gonzalez, E., V. Koch, A.L. Sarti, J.R. Guzmán, and R. Pinal. 2006. A comparison of two methods to produce leatherback hatchlings (*Dermochelys coriacea*) ex situ: greenhouse and incubation chamber. Page 135 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Goverse, E. and M. Hilterman. 2003. Leatherbacks stuck in the mud: a matter of life or death? Page 145 *in* Seminoff, J.A. (compiler). Proceedings of the Twenty-second Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFC-503.

Grant, G.S., H. Malpass, and J. Beasley. 1996. Correlation of leatherback turtle and jellyfish occurrence. Herpetological Review 27(3):123-125.

Gratiot, N., J. Gratiot, L. Kelle, and B. de Thoisy. 2006. Estimation of the nesting season of marine turtles from incomplete data: statistical adjustment of a sinusoidal function. Animal Conservation 9:95-102.

Greer, A.E., J.D. Lazell, Jr., and R.M. Wright. 1973. Anatomical evidence for counter-current heat exchanger in the leatherback turtle (*Dermochelys coriacea*). Nature 244:181.

Guirlet, E. 2005. Ecotoxicologie et écologie de la réussite d'incubation chez la tortue luth, *Dermochelys coriacea*, en Guyane française [Ecotoxicology and ecology of hatching success in the leatherback turtle, *Dermochelys coriacea*, in French Guiana].

Master Ecologie, Biodiversité et Evolution, Université Paris Sud et CNRS, Orsay, France.

Hamann, M., C. Limpus, G. Hughes, J. Mortimer, and N. Pilcher. 2006a. Assessment of the conservation status of the leatherback turtle in the Indian Ocean and South East Asia, including consideration of the impacts of the December 2004 tsunami on turtles and turtle habitats. IOSEA Marine Turtle MoU Secretariat, Bangkok.

Hamann, M., C.T. Cuong, N.D. Hong, P. Thuoc, and B.T. Thuhien. 2006b. Distribution and abundance of marine turtles in the Socialist Republic of Viet Nam. Biodiversity and Conservation 15:3703-3720.

Hamann, M., C. Limpus, G. Hughes, J. Mortimer, and N. Pilcher. 2006c. Assessment of the impact of the December 2004 tsunami on marine turtles and their habitats in the Indian Ocean and South-East Asia. IOSEA Marine Turtle MoU Secretariat, Bangkok.

Harvey, J., S. Benson, and T. Graham. 2006. Foraging ecology of leatherbacks in the California current. Page 192 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Hasting, M. 2003. A conservation success: leatherback turtles in the British Virgin Islands. Marine Turtle Newsletter 99:5-7.

Hastings, M.D., T.T. Jones, and D.R. Jones. 2007a. Effects of temperature and body size on metabolism in juvenile leatherback turtles (*Dermochelys coriacea*). Page 49 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Myrtle Beach, South Carolina, USA.

Hastings, M.D., T.T. Jones, and D.R. Jones. 2007b. Captive growth rates of leatherback (*Dermochelys coriacea*) hatchlings and juveniles. Page 49 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Myrtle Beach, South Carolina, USA.

Hawkes L.A., A.C. Broderick, M.H. Godfrey, and B.J. Godley. 2007. Investigating the potential impacts of climate change on a marine turtle population. Global Change Biology 13:923-932.

Hays, G.C., J.D.R. Houghton, and A.E. Myers. 2004. Pan-Atlantic leatherback turtle movements. Nature 429:522.

Hays G.C., V.J. Hobson, J.D. Metcalfe, D. Righton, and D.W. Sims. 2006. Flexible foraging movements of leatherback turtles across the North Atlantic Ocean. Ecology 87(10):2647-2656.

Herbst, L.H. 1994. Fibropapillomatosis of marine turtles. Annual Review of Fish Diseases 4:389-425.

Hernández, R., J. Buitrago, H. Guada, H. Hernández-Hamón, and M. Llano. 2007. Nesting distribution and hatching success of the leatherback, *Dermochelys coriacea*, in relation to human pressures at Playa Parguito, Margarita Island, Venezuela. Chelonian Conservation and Biology 6(1):79-86.

Herrera, M., A. Castell, L. Sarti, and P. Huerta. 2004. Apoptotic (TUNEL-positive) cells differential density on leatherback turtle *Dermochelys coriacea* hatchlings gonads. Pages 188-189 *in* Coyne, M.S. and R.D. Clark (compilers). Proceedings of the Twenty-first Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-528.

Hilterman, M.L. and E. Goverse. 2007. Nesting and nest success of the leatherback turtle (*Dermochelys coriacea*) in Suriname, 1999-2005. Chelonian Conservation and Biology 6(1):87-100.

Hitipeuw, C., P.H. Dutton, S.R. Benson, J. Thebu, and J. Bakarbessy. 2007. Population status and internesting movement of leatherback turtles, *Dermochelys coriacea,* nesting on the northwest coast of Papua, Indonesia. Chelonian Conservation and Biology 6(1):28-36.

Hodge, R.P. and B.L. Wing. 2000. Occurrences of marine turtles in Alaska waters: 1960-1998. Herpetological Review 31(3):148-151.

Horikoshi, K., F. Sato, M. Inaba, Y. Nakamura, and H. Shibata. 2000. Leatherback turtles caught by fishing gear in Ogasawara Islands, and in Niigata Prefecture, Japan. Umigame Newsletter of Japan 44:13.

Houghton, J.D.R., T.K. Doyle, M.W. Wilson, J. Davenport, and G.C. Hays. 2006. Jellyfish aggregations and leatherback turtle foraging patterns in a temperate coastal environment. Ecology 87(8):1967-1972.

Huerta, P., H. Pineda, A. Aguirre, T. Spraker, L. Sarti, and A. Barragan. 2002. First confirmed case of fibropapilloma in a leatherback turtle (*Dermochelys coriacea*). Page 193 *in* Mosier, A., A. Foley, and B. Brost (compilers). Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-477.

Hughes, G.R. 1996. Nesting of the leatherback turtle (*Dermochelys coriacea*) in Tongaland, KwaZulu-Natal, South Africa, 1963-1995. Chelonian Conservation Biology 2(2):153-158.

Hughes, G.R., P. Luschi, R. Mencacci, and F. Papi. 1998. The 7000-km oceanic journey of a leatherback turtle tracked by satellite. Journal of Experimental Marine Biology and Ecology 229:209-217.

Hykle, D. 2002. The Convention on Migratory Species and other international instruments relevant to marine turtle conservation: pros and cons. Journal of International Wildlife Law and Policy 5:87-103.

Hyman, M. and K. Watson. 2006. Hydrodynamic drag characteristics of the leatherback sea turtle. Pages 95-96 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Ikaran, M., Y. Braet, J. Fretey, L.F. Lozpez-Jurado, and D. Roumet. 2007. Dramatic impact of army ants on *Dermochelys coriacea* nests at Pongora National Park (Gabon, Central Africa). Page 260 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. Myrtle Beach, South Carolina.

Intergovernmental Panel on Climate Change. 2007a. Summary for Policymakers. *In* Solomon, S., D. Quin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (editors). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom, and New York, New York, USA.

Intergovernmental Panel on Climate Change. 2007b. Summary for Policymakers. *In* Solomon, S., D. Quin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (editors). Climate Change 2007: Climate Change Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom, and New York, New York, USA.

James, M.C. and N. Mrosovsky. 2004. Body temperatures of leatherback turtles (*Dermochelys coriacea*) in temperate waters off Nova Scotia, Canada. Canadian Journal of Zoology 82:1302-1306.

James, M.C., C.A. Ottensmeyer, and R.A. Myers. 2005a. Identification of high-use habitat and threats to leatherback sea turtles in northern waters: new directions for conservation. Ecology Letters 8:195-201.

James, M.C., S.A. Eckert, and R.A. Myers. 2005b. Migratory and reproductive movements of male leatherback turtles (*Dermochelys coriacea*). Marine Biology 147:845-853.

James, M.C., R.A. Myers, and C.A. Ottensmeyer. 2005c. Behaviour of leatherback sea turtles, *Dermochelys coriacea*, during the migratory cycle. Proceedings of the Royal Society (B) 272:1547-1555.

James, M.C., J. Davenport, and G.C. Hays. 2006a. Expanded thermal niche for a diving vertebrate: a leatherback turtle diving into near-freezing water. Journal of Experimental Marine Biology and Ecology 335:221-226.

James, M.C., C.A. Ottensmeyer, S.A. Eckert, and R.A. Myers. 2006b. Changes in diel diving patterns accompany shifts between northern foraging and southward migration in leatherback turtles. Canadian Journal of Zoology 84:754-765.

James, M.C., S.A. Sherrill-Mix, K. Martin, and R.A. Myers. 2006c. Canadian waters provide critical foraging habitat for leatherback sea turtles. Biological Conservation 133:347-357.

James, M.C., S.A. Sherrill-Mix, and R.A. Myers. 2007. Population characteristics and seasonal migrations of leatherback sea turtles at high latitudes. Marine Ecology Progress Series 337:245-254.

Jones, T.T. 2004. A comparison of the ontogeny of oxygen consumption in leatherback, *Dermochelys coriacea*, and olive ridley, *Lepidochelys olivacea*, sea turtle hatchlings. Unpublished Master's Thesis, Florida Atlantic University, Boca Raton. 57 pages.

Jonsen, I.D, R.A. Myers, and M.C. James. 2006. Robust hierarchical state-space models reveal diel variation in travel rates of migrating leatherback turtles. Journal of Animal Ecology 75:1046-1057.

Juarez, J.A., A.R. Barragan, H. Gomez, and G. Duarte. 1998. Lipid components of the yolk in leatherback turtle eggs. Pages 75-76 *in* Byles, R. and Y. Fernandez (compilers). Proceedings of the Sixteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-412.

Kamel, S. and N. Mrosovsky. 2003. Double-chambered nest cavities in the leatherback turtle. Chelonian Conservation and Biology 4(3):705.

Kamel, S.J. and N. Mrosovsky. 2004. Nest site selection in leatherbacks, *Dermochelys coriacea*: individual patterns and their consequences. Animal Behaviour 68:357-366.

Kaplan, I.C. 2005. A risk assessment for Pacific leatherback turtles (*Dermochelys coriacea*). Canadian Journal of Fisheries and Aquatic Sciences 62(8):1710-1719.

Kinan, I. (Compiler). 2002. Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop. Workshop held on February 5-8, 2002, in Honolulu, Hawaii, USA. Western Pacific Regional Fishery Management Council. 300 pages.

Kinan, I. (compiler). 2005. Proceedings of the Second Western Pacific Sea Turtle Cooperative Research and Management Workshop. Volume I: West Pacific Leatherback and Southwest Pacific Hawksbill Sea Turtles. Workshop held on May 17-21, 2004, in Honolulu, Hawaii, USA. Western Pacific Regional Fishery Management Council (pages 107-109).

Kloc, II, P.A., E.A. Standora, and F.V. Paladino. 1998. A biotelemetric study of near shore movements of hatchling leatherback turtles: do hatchlings use geomagnetic cues in orientation? Page 85 *in* Byles, R. and Y. Fernandez (compilers). Proceedings of the Sixteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-412.

Kotas, J.E., S. dos Santos, V.G. de Azevedo, B.M.G. Gallo, and P.C.R. Barata. 2004. Incidental capture of loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) sea turtles by the pelagic longline fishery off southern Brazil. Fishery Bulletin 102:393–399.

LaCasella, E.L. and P.H. Dutton. 2007. Longer mtDNA sequences resolve leatherback stock structure. Page 155 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Myrtle Beach, South Carolina, USA.

Lagueux, C.J. and C.L. Campbell. 2005. Marine turtle nesting and conservation needs on the south-east coast of Nicaragua. Oryx 39(4):398-405.

Lambardi, P., R. Mencacci, J. Lutjeharms, G.R. Hughes, S. Benvenuti, and P. Luschi. 2006. The influence of oceanographic conditions on the migratory behaviour of South African leatherbacks. Page 98 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Laporta, M., P. Miller, S. Horta, and G. Riestra. 2006. First report of leatherback turtle entanglement in trap lines in the Uruguayan Continental Shelf. Marine Turtle Newsletter 112:9-11.

Larese-Casanova, M. and D.N. Penick. 1998. Ontogeny of temperature independent metabolism in leatherback sea turtle hatchlings, *Dermochelys coriacea*. American Zoologist 38:51A.

Laurance, W.F., J.M. Fay, R.J. Parnell, G. Sounguet, A. Formia, and M.D. Lee. In press. Does rainforest logging threaten endangerd sea turtles? Oryx.

Lawalata, J., N. Ratnawati, D.U. Kikilaitety, C. Hitipeuw, and W.J. Nichols. 2006. Customary versus legal governance: integrated approach in addressing traditional hunting practices on leatherback turtles in Kei Islands, Maluku-Indonesia. Pages 142-143 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Lee Lum, L. 2006. Assessment of incidental sea turtle catch in the artisanal gillnet fishery in Trinidad and Tobago, West Indies. Applied Herpetology 3:357-368.

Leslie, A.J., D.N. Penick, J.R. Spotila, and F.V. Paladino. 1996. Leatherback turtle, *Dermochelys coriacea*, nesting and nest success at Tortuguero, Costa Rica, in 1990-1991. Chelonian Conservation and Biology 2(2):159-168.

Lewison, R.L., S.A. Freeman, and L.B. Crowder. 2004. Quantifying the effects of fisheries on threatened species: the impact of pelagic longlines on loggerhead and leatherback sea turtles. Ecology Letters 7:221-231.

Limpus, C. 2002. Conservation and research of sea turtles in the western Pacific region: an overview. Pages 41-50 *in* Kinan, I. (editor). Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop. Western Pacific Regional Fishery Management Council.

Livingstone, S.R. and J.R. Downie. 2005. Marine turtle conservation on the north coast of Trinidad. A Darwin Initiative Project. Testudo 6:3-16.

Long, D.J. 1996. Records of white shark-bitten leatherback sea turtles along the central California coast. Pages 317-319 *in* Klimley, A.P. and D.G. Ainley (editors). Great White Sharks: The Biology Of Carcharodon Carcharias. Academic Press, San Diego, California.

Luschi, P., G.C. Hays, and F. Papi. 2003a. A review of long-distance movements by marine turtles, and the possible role of ocean currents. Oikos 103:293-302.

Luschi, P., A. Sale, R. Mencacci, G.R. Hughes, J.R.E. Lutjeharms, and F. Papi. 2003b. Current transport of leatherback sea turtles (*Dermochelys coriacea*) in the ocean. Proceedings of the Royal Society of London Series B - Biological Sciences 270:S129-S132.

Luschi, P., J.R.E. Lutjeharms, P. Lambardi, R. Mencacci, G.R. Hughes, and G.C. Hays. 2006. A review of migratory behaviour of sea turtles off southeastern Africa. South African Journal of Science 102:51-58.

Lutcavage, M.E., P. Plotkin, B. Witherington, and P.L. Lutz. 1997. Human impacts on sea turtle survival. Pages 387-409 *in* Lutz, P.L. and J.A. Musick (editors). The Biology of Sea Turtles. CRC Press, Boca Raton, Florida.

Lutcavage, M., R. Andrews, A. Rhodin, S. Sadove, C. Rehm Conroy, and H. Horta. 2003. Post-nesting movements of leatherback turtles tracked from Culebra and Fajardo, Puerto Rico with pop-up archival and TDR satellite tags. Page 58 *in* Seminoff, J.A. (compiler). Proceedings of the Twenty-second Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-503.

Lux, J., R. Reina, and L. Stokes. 2003. Nesting activity of leatherback turtles (*Dermochelys coriacea*) in relation to tidal and lunar cycles at Playa Grande, Costa Rica. Pages 215-216 *in* Seminoff, J.A. (compiler). Proceedings of the Twenty-second Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-503.

Lynch, M. and R. Lande. 1998. The critical effective size for a genetically secure population. Animal Conservation 1:70-72.

Maharaj, A.M. 2004. A comparative study of the nesting ecology of the leatherback turtle *Dermochelys coriacea* in Florida and Trinidad. Unpublished Master's Thesis, University of Central Florida, Orlando, Florida. 80 pages.

Maison, K. 2006. Do turtles move with the beach? Beach profiling and possible effects of development on a leatherback (*Dermochelys coriacea*) nesting beach in Grenada. Page 145 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Marco, A., J. Patiño-Martínez, and L. Quiñones. 2006. Field and experimental evidence about the influence of the substrate water content on hatching success of leatherback turtle eggs. Pages 65-66 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Marcovaldi, M.A., G. Sales, J.C.A. Thome, A.C.C. Dias da Silva, B.M.G. Gallo, E.H.S.M. Lima, E.P. Lima, and C. Bellini. 2006. Sea turtles and fishery interactions in Brazil: identifying and mitigating potential conflicts. Marine Turtle Newsletter 112:4-8.

Maros, A., A. Louveaux, M.H. Godfrey, and M. Girondot. 2003. *Scapteriscus didactylus* (Orthoptera, Gryllotalpidae), predator of leatherback turtle eggs in French Guiana. Marine Ecology Progress Series 249:289-296.

Marquez M., R. 1990. Sea turtles of the world. An annotated and illustrated catalogue of sea turtle species known to date. FAO Species Catalogue, FAO Fisheries Synopsis No. 125, Volume 11. 81 pages.

Mast, R.B. (editor). 2005-2006. SWOT report: the state of the world's sea turtles. Volume 1. 36 pages.

Maurer-Spurej, E. 2005. Circulating serotonin in vertebrates. Cellular and Molecular Life Sciences 62:1881-1889.

McAlpine, D.F., S.A. Orchard, K.A. Sendall, and R. Palm. 2004. Status of marine turtles in British Columbia waters: a reassessment. Canadian Field-Naturalist 118:72-76.

McDonald, D.L. and P.H. Dutton. 1996. Use of PIT tags and photoidentification to revise remigration estimates of leatherback turtles (*Dermochelys coriacea*) nesting in St. Croix, U.S. Virgin Islands, 1979-1995. Chelonian Conservation and Biology 2(2):148-152.

McDonald, D., P. Dutton, R. Brandner, and S. Basford. 1996. Use of pineal spot ("pink spot") photographs to identify leatherback turtles. Herpetological Review 27(1):11-12.

McKenzie, C., B.J. Godley, R.W. Furness, and D.E. Wells. 1999. Concentrations and patterns of organochlorine contaminants in marine turtles from Mediterranean and Atlantic waters. Marine Environmental Research 47:117-135.

McMahon, C.R. and G.C. Hays. 2006. Thermal niche, large-scale movements and implications of climate change for a critically endangered marine vertebrate. Global Change Biology 12:1330-1338.

McMahon, C.R., E. Autret, J.D.R. Houghton, P. Lovell, A.E. Myers, and G.C. Hays. 2005. Animal-borne sensors successfully capture the real-time thermal properties of ocean basins. Limnology and Oceanography: Methods 3:392-398.

Merigo, C., C. Innis, S. Weber, K. Streeter, and J. Montague. 2006. The suspension vest, a breakthrough holding technique for leatherback sea turtle rehabilitation. Page 69 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Mills Flemming, J.E., C.A. Field, M.C. James, I.D. Jonsen, and R.A. Myers. 2006. How well can animals navigate? Estimating the circle of confusion from tracking data. Environmetrics 17(4):351-362.

Moncada, F. and O. Rodriguez. 1996. Occasional catch and some biological aspects of *Dermochelys coriacea* in Cuba. Pages 213-215 *in* Keinath, J.A., D.E. Barnard, J.A. Musick, and B.A. Bell (compilers). Proceedings of the Fifteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-387.

Montilla F., A.J., J.L. Hernández R., and H.J. Guada M. 2007. Hematological values in leatherback sea turtles (*Dermochelys coriacea*) in Querepare Beach, Paria Peninsula, Sucre State, Venezuela. Page 47 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Myrtle Beach, South Carolina, USA.

Morisson, M., L. Kelle, and F. Sehoe. 2003. Campagne Kawana 2003. Rapport d'activité. Guyane (FR): World Wildlife Fund, Octobre 2003. 32 pages.

Morreale, S.J., E.A. Standora, J.R. Spotila, and F.V. Paladino. 1996. Migration corridor for sea turtles. Nature 384:319-320.

Mrosovsky, N. 2006. Distorting gene pools by conservation: assessing the case of doomed turtle eggs. Environmental Management 38:523-531.

Mrosovsky N., P.H. Dutton, and C.P. Whitmore. 1984. Sex ratios of two species of sea turtle nesting in Suriname. Canadian Journal of Zoology 62(11):2227-2239.

Myers, A.E. and G.C. Hays. 2006. Do leatherback turtles *Dermochelys coriacea* forage during the breeding season? A combination of data-logging devices provide new insights. Marine Ecology Progress Series 322:259-267.

National Marine Fisheries Service. 2001. Stock assessments of loggerhead and leatherback sea turtles and an assessment of the impact of the pelagic longline fishery on the loggerhead and leatherback sea turtles of the western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-455.

National Marine Fisheries Service. 2002. Endangered Species Act Section 7 Consultation on Shrimp Trawling in the Southeastern United States, under the Sea Turtle Conservation Regulations and as Managed by the Fishery Management Plans for Shrimp in the South Atlantic and Gulf of Mexico. December 2, 2002.

Nel, R. 2006. Turtle monitoring in South Africa: 42 years worth of data. Pages 309-310 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Nellis, D.W. 2000. Predation on leatherback turtle hatchlings at Sandy Point National Wildlife Refuge, St. Croix, U.S. Virgin Islands. Unpublished Master's Thesis, Texas A&M University, Kingsville, Texas. 26 pages.

Noga, A.L. and K.E. Mantai. 2003. Environmental conditions of the sand substrate during the 2000 leatherback nesting season in Tortuguero, Costa Rica. Page 155 *in* Seminoff, J.A. (compiler). Proceedings of the Twenty-second Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-503.

Nolasco, D., X. Debade, and S. Troëng. 2007. Relationship between tidal and lunar phases and the emergence time of leatherback turtles (*Dermochelys coriacea*), nesting at Tortuguero, Costa Rica, in 2005-2006. Page 82 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Myrtle Beach, South Carolina, USA.

Nordmoe, E.D., A.E. Sieg, P.R. Sotherland, J.R. Spotila, F.V. Paladino, and R.D. Reina. 2004. Nest site fidelity of leatherback turtles at Playa Grande, Costa Rica. Animal Behaviour 68:387-394.

Oliver, L.J., M. Salmon, J. Wyneken, R. Hueter, and T.W. Cronin. 2000. Retinal anatomy of hatchling sea turtles: anatomical specializations and behavioral correlates. Marine and Freshwater Behaviour and Physiology 33:233-248.

Ordoñez, C., S. Troëng, A. Meylan, P. Meylan, and A. Ruiz. 2007. Chiriqui Beach, Panama, the most important leatherback nesting beach in Central America. Chelonian Conservation and Biology 6(1):122-126.

Paddock, S.N., J.A. Seminoff, S.R. Benson, and P.H. Dutton. 2007. Characterizing the foraging ecology of leatherback turtles (*Dermochelys coriacea*) using stable carbon and nitrogen isotope analysis of eggshells. Page 159 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Myrtle Beach, South Carolina, USA.

Paladino, F.V., J.R. Spotila, M.P. O'Connor, and R.E. Gatten, Jr. 1996. Respiratory physiology of adult leatherback turtles (*Dermochelys coriacea*) while nesting on land. Chelonian Conservation and Biology 2(2):223-229.

Patiño-Martínez, J., A. Suárez, A. Restrepo, L. Quiñones, V. Páez, and A. Marco. 2006. Leatherback turtle nesting monitoring in La Playona, Acandí, Chocó, Atlantic northwest of Colombia. Pages 313-314 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Penick, D.N., J.R. Spotila, M.P. O'Connor, A.C. Steyermark, R.H. George, C.J. Salice, and F.V. Paladino. 1998. Thermal independence of muscle tissue metabolism in the leatherback turtle, *Dermochelys coriacea*. Comparative Biochemistry and Physiology Part A 120:399-403.

Petersen, S. 2005. Initial bycatch assessment: South Africa's domestic pelagic longline fishery, 2000-2003. BirdLife South Africa.

Petro, G., F.R. Hickey, and K. Mackay. 2007. Leatherback turtles in Vanuatu. Chelonian Conservation and Biology 6(1):135-137.

Pineda, H., L. Cuellar, and A.L. Sarti. 2004. The influence of the moon and tides in the nesting of the leatherback sea turtle (*Dermochelys coriacea*). Pages 273-274 *in* Coyne, M.S. and R.D. Clark (compilers). Proceedings of the Twenty-first Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-528.

Pinedo, M.C. and T. Polacheck. 2004. Sea turtle by-catch in pelagic longline sets off southern Brazil. Biological Conservation 119:335-339.

Pitman, R.L. and P.H. Dutton. 2004. Killer whale predation on a leatherback turtle in the northeast Pacific. Pacific Science 58(3):497-498.

Pritchard, P.C.H. 1973. International migrations of South American sea turtles (Cheloniidae and Dermochelyidae). Animal Behaviour 21:18-27.

Pritchard, P.C.H. 1982. Nesting of the leatherback turtle, *Dermochelys coriacea* in Pacific Mexico, with a new estimate of the world population status. Copeia 1982(4):741-747.

Pritchard, P.C.H. and P. Trebbau. 1984. The Turtles of Venezuela. SSAR Contribution to Herpetology No. 2. 403 pages.

Quinn, N.J. and B.L. Kojis. 1985. Leatherback turtles under threat in Morobe Province, Papua New Guinea. Pacific Life and Environmental Studies 1:79-99.

Rader, H., M.A.E. Mba, W. Morra, and G. Hearn. 2006. Marine turtles on the southern coast of Bioko Island (Gulf of Guinea, Africa), 2001-2005. Marine Turtle Newsletter 111:8-10.

Ralph, C.R., R.D. Reina, B.P. Wallace, P.R. Sotherland, J.R. Spotila, and F.V. Paladino. 2005. Effect of egg location and respiratory gas concentrations on developmental success in nests of the leatherback turtle, *Dermochelys coriacea*. Australian Journal of Zoology 53:289-294.

Reina, R.D., T.T. Jones, and J.R. Spotila. 2002. Salt and water regulation by the leatherback sea turtle *Dermochelys coriacea*. Journal of Experimental Biology 205:1853-1860.

Reina, R.D., K.J. Abernathy, G.J. Marshall, and J.R. Spotila. 2005. Respiratory frequency, dive behaviour and social interactions of leatherback turtles, *Dermochelys coriacea* during the inter-nesting interval. Journal of Experimental Marine Biology and Ecology 316:1-16.

Reina, R., J. Spotila, F. Paladino, and A. Dunham. 2006. The effects of climatic conditions in the Pacific on leatherback reproductive schedule and population feasibility. Page 128 *in* Pilcher, N.J. (compiler). Proceedings of the Twenty-third Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-536.

Renatura Report. 2004. Study and protection of the marine turtles in Congo Republic program activity report 2003/2004 season.

Renatura Report. 2006. Rapport d'activite du programme d'etude et de sauvegarde des tortues marines au Congo. Septembre 2005 - Juillet 2006.

Rhodin, A.G.J. 1985. Comparative chondro-osseous development and growth of marine turtles. Copeia 1985(3):752-771.

Rhodin, J.A.G., A.G.J. Rhodin, and J.R. Spotila. 1996. Electron microscopic analysis of vascular cartilage canals in the humeral epiphysis of hatchling leatherback turtles, *Dermochelys coriacea*. Chelonian Conservation and Biology 2(2):250-260.

Rieder, J.P., P.G. Parker, J.R. Spotila, and M.E. Irwin. 1998. The mating system of the leatherback turtle: a molecular approach. Bulletin of the Ecological Society of America. 77 (Supplement 3, Part 2):375.

Rivalan, P., M.H. Godfrey, A.-C. Prévot-Julliard, and M. Girondot. 2005a. Maximum likelihood estimates of tag loss in leatherback sea turtles. Journal of Wildlife Management 69(2):540-548.

Rivalan, P., A.-C. Prevot-Julliard, R. Choquet, R. Pradel, B. Jacquemin, and M. Girondot. 2005b. Trade-off between current reproductive effort and delay to next reproduction in the leatherback sea turtle. Oecologia 145:564-574.

Rivalan, P., R. Pradel, R. Choquet, M. Girondot, and A.-C. Prevot-Julliard. 2006a. Estimating clutch frequency in the sea turtle *Dermochelys coriacea* using stopover duration. Marine Ecology Progress Series 317:285-295.

Rivalan, P., P.H. Dutton, E. Baudry, S.E. Roden, and M. Girondot. 2006b. Demographic scenario inferred from genetic data in leatherback turtles nesting in French Guiana and Suriname. Biological Conservation 130:1-9.

Roden, S., P.H. Dutton, and S.P. Epperly. In press. Stock composition of foraging leatherback populations in the North Atlantic based on analysis of multiple genetic markers. *In* Proceedings of the Twenty-fourth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum.

Rostal, D.C., F.V. Paladino, R.M. Patterson, and J.R. Spotila. 1996. Reproductive physiology of nesting leatherback turtles (*Dermochelys coriacea*) at Las Baulas National Park, Costa Rica. Chelonian Conservation and Biology 2(2):230-236.

Rostal, D.C., J.S. Grumbles, K.S. Palmer, V.A. Lance, J.R. Spotila, and F.V. Paladino. 2001. Changes in gonadal and adrenal steroid levels in the leatherback sea turtle (*Dermochelys coriacea*) during the nesting cycle. General and Comparative Endocrinology 122:139-147.

Rupeni, E., S. Mangubhai, K. Tabunakawai, and P. Blumel. 2002. Establishing replicable community-based turtle conservation reserves in Fiji. Pages 119-124 *in* Kinan, I. (editor). Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop. Western Pacific Regional Fishery Management Council.

Saba, V.S., J.R. Spotila, F.P. Chavez, and J.A. Musick. 2007a. Bottom-up and climatic forcing on the global population of leatherback turtles. Pages 162-163 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Myrtle Beach, South Carolina, USA.

Saba, V.S., P. Santidrián-Tomillo, R.D. Reina, J.R. Spotila, J.A. Musick, D.A. Evans, and F.V. Paladino. 2007b. The effect of the El Niño Southern Oscillation on the reproductive frequency of eastern Pacific leatherback turtles. Journal of Applied Ecology 44:395-404.

Sale, A., P. Luschi, R. Mencacci, P. Lambardi, G.R. Hughes, G.C. Hays, S. Benvenuti, and F. Papi. 2006. Long-term monitoring of leatherback turtle diving behaviour during oceanic movements. Journal of Experimental Marine Biology and Ecology 328:197-210.

Salmon, M., T.T. Jones, and K.W. Horch. 2004. Ontogeny of diving and feeding behavior in juvenile seaturtles: leatherback seaturtles (*Dermochelys coriacea* L) and green seaturtles (*Chelonia mydas* L) in the Florida Current. Journal of Herpetology 38(1):36-43.

Santidrián Tomillo, P., E. Vélez, R.D. Reina, R. Piedra, F.V. Paladino, and J.R. Spotila. 2007. Reassessment of the leatherback turtle (*Dermochelys coriacea*) nesting population at Parque Nacional Marino Las Baulas, Costa Rica: effects of conservation efforts. Chelonian Conservation and Biology 6(1):54-62.

Sarti Martínez, L., A.R. Barragán, D.G. Muñoz, N. Garcia, P. Huerta, and F. Vargas. 2007. Conservation and biology of the leatherback turtle in the Mexican Pacific. Chelonian Conservation and Biology 6(1):70-78.

Seminoff, J.A. and P.H. Dutton. 2007. Leatherback turtles (*Dermochelys coriacea*) in the Gulf of California: distribution, demography, and human interactions. Chelonian Conservation and Biology 6(1):137-141.

Shillinger, G., M. Castleton, J. Ganong, B. Wallace, J. Spotila, F. Paladino, S. Eckert, and B. Block. 2006. Post-nesting diving behavior, movements, and distribution of Pacific leatherback sea turtles tagged at Playa Grande, Parque Nacional Las Baulas, Costa Rica from 2003-2004. Page 113 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Sieg, A., E. Nordmoe, R. Reina, and P. Sotherland. 2003. Patterns in nest-site location of individual leatherback turtles (*Dermochelys coriacea*) nesting at Parque Nacional Las Baulas, Costa Rica. Page 231 *in* Seminoff, J.A. (compiler). Proceedings of the Twenty-second Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-503.

Sounguet, G.-P., A. Formia, and R. Parnell. In press. An assessment of leatherback nesting in Gabon by aerial survey. *In* Proceedings of the Twenty-fifth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC.

Southwood, A.L., R.D. Andrews, M.E. Lutcavage, F.V. Paladino, N.H. West, R.H. George, and D.R. Jones. 1999. Heart rates and diving behavior of leatherback sea turtles in the eastern Pacific Ocean. Journal of Experimental Biology 202:1115-1125.

Southwood A.L., R.D. Andrews, F.V. Paladino, and D.R. Jones. 2005. Effects of diving and swimming behavior on body temperatures of Pacific leatherback turtles in tropical seas. Physiological and Biochemical Zoology 78:285-297.

Spotila, J.R., A.E. Dunham, A.J. Leslie, A.C. Steyermark, P.T. Plotkin, and F.V. Paladino. 1996. Worldwide population decline of *Dermochelys coriacea*: are leatherback turtles going extinct? Chelonian Conservation and Biology 2(2):209-222.

Spotila, J.R., R.D. Reina, A.C. Steyermark, P.T. Plotkin, and F.V. Paladino. 2000. Pacific leatherback turtles face extinction. Nature 405:529-530.

Standora, E.A., K.P. Baker, and F.V. Paladino. 2000. Acoustic orientation and sound discrimination in leatherback (*Dermochelys coriacea*) and olive ridley (*Lepidochelys olivacea*) sea turtle hatchlings. Page 8 *in* Kalb, H.J. and T. Wibbels (compilers). Proceedings of the Nineteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-443.

Starbird, C. and H. Audel. 2000. *Dermochelys coriacea* (leatherback sea turtle). Fishing net ingestion. Herpetological Review 31(1):43.

Stewart, K. and C. Johnson. 2006. *Dermochelys coriacea*—Leatherback sea turtle. *In* Meylan, P.A. (editor) Biology and Conservation of Florida Turtles. Chelonian Research Monographs 3:144-157.

Stewart, K., C. Johnson, and S. Eckert. 2006. Nesting site fidelity in Florida leatherbacks determined using GPS tags. Pages 114-115 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Stewart, K., J.M. Keller, C. Johnson, and J.R. Kucklick. 2007. Baseline contaminant concentrations in leatherback sea turtles and maternal transfer to eggs confirmed. Page 61 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Myrtle Beach, South Carolina, USA.

Stewart, K., C. Johnson, and M.H. Godfrey. In press. The minimum size of leatherbacks at reproductive maturity, with a review of sizes for nesting females from the Indian, Atlantic and Pacific Ocean Basins. Herpetological Journal.

Storelli, M.M. and G.O. Marcotrigiano. 2003. Heavy metal residues in tissues of marine turtles. Marine Pollution Bulletin 46:397-400.

Suarez, A. and C.H. Starbird. 1996. Subsistence hunting of leatherback turtles, *Dermochelys coriacea*, in the Kai Islands, Indonesia. Chelonian Conservation and Biology 2(2):190-195.

Tapilatu, R.F. and M. Tiwari. 2007. Leatherback turtle, *Dermochelys coriacea*, hatching success at Jamursba-Medi and Wermon Beaches in Papua, Indonesia. Chelonian Conservation and Biology 6(1):154-158.

Thomé, J.C.A., C. Baptistotte, L.M. de P. Moreira, J.T. Scalfoni, A.P. Almeida, D.B. Rieth, and P.C.R. Barata. 2007. Nesting biology and conservation of the leatherback sea turtle (*Dermochelys coriacea*) in the State of Espírito Santo, Brazil, 1988-1989 to 2003-2004. Chelonian Conservation and Biology 6(1):15-27.

Threlfall, W. 1978. First record of the Atlantic leatherback turtle (*Dermochelys coriacea)* from Labrador. Canadian Field Naturalist 92(3):287.

Tiwari, M. 2002. An evaluation of the perceived effectiveness of international instruments for sea turtle conservation. Journal of International Wildlife Law and Policy 5:145-156.

Tiwari, M. and P.H. Dutton. 2006. To manage or not to manage: lessons from St. Croix for a leatherback nesting beach in Jamursba-Medi, Indonesia. Page 165 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Tomas J., J. Castroviejo, and J.A. Raga. 2000. Sea turtles in the south of Bioko Island (Equatorial Guinea), Africa. Pages 247-250 *in* Wibbels, T. and H. Kalb (compilers). Proceedings of the Nineteenth Annual Symposium on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFSC-443. .

Torres, C. 2003. Hatchling success estimates for leatherback turtles (*Dermochelys coriacea*) on Ya:Lima:Po Beach, French Guiana, using two sampling methods. Pages 168-169 *in* Seminoff, J.A. (compiler). Proceedings of the Twenty-second Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-503.

Troëng, S. 2000. Predation of green (*Chelonia mydas*) and leatherback (*Dermochelys coriacea*) turtles by jaguars (*Panthera onca*) at Tortuguero National Park, Costa Rica. Chelonian Conservation and Biology 3(4):751-753.

Troëng, S., D. Chacón, and B. Dick. 2004. Possible decline in leatherback turtle *Dermochelys coriacea* nesting along the coast of Caribbean Central America. Oryx 38(4):395-403.

Troëng, S., E. Harrison, D. Evans, A. de Haro, and E. Vargas. 2007. Leatherback turtle nesting trends and threats at Tortuguero, Costa Rica. Chelonian Conservation and Biology 6(1):117-122.

Turnbull, S. 2003. Effects of temperature on the timing of emergence of leatherback sea turtle (*Dermochelys coriacea*) hatchlings from the nest. Pages 233-234 *in* Seminoff, J.A. (compiler). Proceedings of the Twenty-second Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-503.

Turtle Expert Working Group. 2007. An assessment of the leatherback turtle population in the Atlantic Ocean. NOAA Technical Memorandum NMFS-SEFSC-555. 116 pages.

United Nations Educational, Scientific and Cultural Organization. 2001. Urban Development and Freshwater Resources Webpage. www.unesco.org/csi/pub/info/info54.htm

Vargas, S.M., F.C. Araújo, D. Monteiro, S.C. Estima, J.C.A. Thomé, L.S. Soares, and F.R. Santos. 2007. Occurrence of mtDNA haplotypes of leatherback turtles on the Brazilian coast. Page 167 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-seventh Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Myrtle Beach, South Carolina, USA.

Villanueva Mayor, V. 2002. Orientation of leatherback turtle hatchlings, *Dermochelys coriacea* (Vandelli, 1961), at Sandy Point National Wildlife Refuge, U.S. Virgin Islands. Unpublished Master's Thesis, University of Puerto Rico, Mayaquez, Puerto Rico. 54 pages.

Vose, F.E. and B.V. Shank. 2003. Predation on loggerhead and leatherback post-hatchlings by gray snapper. Marine Turtle Newsletter 99:11-14.

Wallace, B.P., P.R. Sotherland, J.R. Spotila, R.D. Reina, B.F. Franks, and F.V. Paladino. 2004. Biotic and abiotic factors affect the nest environment of embryonic leatherback turtles, *Dermochelys coriacea*. Physiological and Biochemical Zoology 77(3):423-432.

Wallace, B.P., C.L. Williams, F.V. Paladino, S.J. Morreale, R.T. Lindstrom, and J.R. Spotila. 2005. Bioenergetics and diving activity of internesting leatherback turtles *Dermochelys coriacea* at Parque Nacional Marino Las Baulas, Costa Rica. Journal of Experimental Biology 208:3873-3884.

Wallace, B.P., S.S. Kilham, F.V. Paladino, and J.R. Spotila. 2006a. Energy budget calculations indicate resource limitation in eastern Pacific leatherback turtles. Marine Ecology Progress Series 318:263-270.

Wallace, B.P., J.A. Seminoff, S.S. Kilham, J.R. Spotila, and P.H. Dutton. 2006b. Leatherback turtles as oceanographic indicators: stable isotope analyses reveal a trophic dichotomy between ocean basins. Marine Biology 149:953-960.

Wallace, B.P., P.R. Sotherland, P. Santidrian Tomillo, S.S. Bouchard, R.D. Reina, J.R. Spotila, and F.V. Paladino. 2006c. Egg components, egg size, and hatchling size in leatherback turtles. Comparative Biochemistry and Physiology Part A 145:524-532.

Watson, J.W., S.P. Epperly, A.K. Shah, and D.G. Foster. 2005. Fishing methods to reduce sea turtle mortality associated with pelagic longlines. Canadian Journal of Fisheries and Aquatic Science 62:965-981.

Weishampel, J.F., D.A. Bagley, L.M. Ehrhart, and B.L. Rodenbeck. 2003. Spatiotemporal patterns of annual sea turtle nesting behaviors along an East Central Florida beach. Biological Conservation 110:295-303.

White, R.W. and T.J. George. 2002. Leatherback turtles in mid-South Atlantic waters. Marine Turtle Newsletter 97:13.

Witherington, B.E. 1992. Behavioral responses of nesting sea turtles to artificial lighting. Herpetologica 48:31-39.

Witherington, B.E. and K.A. Bjorndal. 1991. Influences of artificial lighting on the seaward orientation of hatchling loggerhead turtles *Caretta caretta*. Biological Conservation 55:139-149.

Witherington, B., S. Hirama, and A. Mosier. 2003. Effects of beach armoring structures on marine turtle nesting. Florida Fish and Wildlife Conservation Commission final project report to the U.S. Fish and Wildlife Service. 26 pages.

Witherington, B., S. Hirama, and A. Mosier. 2007. Change to armoring and other barriers to sea turtle nesting following severe hurricanes striking Florida beaches. Florida Fish and Wildlife Conservation Commission final project report to the U.S. Fish and Wildlife Service. 11 pages.

Witt, M.J., B.J. Godley, A.C. Broderick, R. Penrose, and C.S. Martin. 2006. Leatherback turtles, jellyfish and climate change in the northwest Atlantic: current situation and possible future scenarios. Pages 356-357 *in* Frick, M., A. Panagopoulou, A.F. Rees, and K. Williams (compilers). Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Witt, M.J., A.C. Broderick, D.J. Johns, C. Martin, R. Penrose, M.S. Hoogmoed, and B.J. Godley. 2007a. Prey landscapes help identify foraging habitats for leatherback turtles in the NE Atlantic. Marine Ecological Progress Series. 337:231-243.

Witt, M.J., A.C. Broderick, M.S. Coyne, A. Formia, S. Ngouessono, R.J. Parnell, G.-P. Sounguet, and B.J. Godley. In press. Satellite tracking highlights difficulties in the design of effective protected areas for leatherback turtles during the internesting period. Oryx.

Wood, R.C., J. Johnson-Gove, E.S. Gaffney, and K.F. Maley. 1996. Evolution and phylogeny of leatherback turtles (Dermochelyidae), with descriptions of new fossil taxa. Chelonian Conservation and Biology 2(2):266-286.

Wyneken, J., A.G.J. Rhodin, A. Garces, and J.A.G. Rhodin. 2003. Cardiopulmonary structure and function in leatherback and green sea turtles. Page 28 *in* Seminoff, J.A.

(compiler). Proceedings of the Twenty-second Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-503.

Zangerl, R. 1980. Patterns of phylogenetic differentiation in the Toxochelyid and Cheloniid sea turtles. American Zoologist 20:585-596.

Zeeberg, J., A. Corten, and E. de Graaf. 2006. Bycatch and release of pelagic megafauna in industrial trawler fisheries off Northwest Africa. Fisheries Research 78:186-195.

Zug, G.R. and J.F. Parham. 1996. Age and growth in leatherback turtles, *Dermochelys coriacea* (Testudines: Dermochelyidae): a skeletochronological analysis. Chelonian Conservation and Biology 2(2):244-249.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Leatherback Sea Turtle*

Current Classification: Endangered

Recommendation resulting from the 5-Year Review: No change

Review Conducted By:

Manjula Tiwari, Barbara Schroeder, Therese Conant (National Marine Fisheries Service)
Sandy MacPherson, Earl Possardt, Kelly Bibb (U.S. Fish and Wildlife Service)

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve ______________________ Date 8/7/07
David L. Hankla

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service

Approve ______________________ Date 8/21/2007
ACTING Assistant Regional Director

NATIONAL MARINE FISHERIES SERVICE
5-YEAR REVIEW of *Leatherback Sea Turtle*

Current Classification: Endangered

Recommendation resulting from the 5-Year Review: No change

Review Conducted By:

Manjula Tiwari, Barbara Schroeder, Therese Conant (National Marine Fisheries Service)
Sandy MacPherson, Earl Possardt, Kelly Bibb (U.S. Fish and Wildlife Service)

REGIONAL OFFICE APPROVAL: The draft document was reviewed by the appropriate Regional Offices and Science Centers.

HEADQUARTERS APPROVAL:
Director, Office of Protected Resources, NOAA Fisheries

Approve: ______________________________ Date: AUG 7 2007
James H. Lecky

Assistant Administrator, NOAA Fisheries

_✓_ Concur _____ Do Not Concur

Signature______________________________ Date 8/17/07

Samuel D. Rauch, III
Deputy Assistant Administrator
For Regulatory Programs

APPENDIX

Summary of peer review for the 5-year review of
***Leatherback Sea Turtle* (*Dermochelys coriacea*)**

A. Peer Review Method: See B. below.

B. Peer Review Charge: On May 14, 2007, the following letter and Guidance for Peer Reviewers of Five-Year Status Reviews were sent via e-mail to potential reviewers requesting comments on the 5-year review. Requests were sent to William Coles (Virgin Islands Department of Planning and Natural Resources), Dr. Scott Eckert (WIDECAST - Wider Caribbean Sea Turtle Conservation Network), Dr. Angela Formia (Wildlife Conservation Society - Gabon, Africa), Dr. Marc Girondot (University of Paris, France), Dr. Matthew Godfrey (North Carolina Wildlife Resources Commission), Dr. Mike James (Dalhousie University, Canada), Dr. Laura Sarti (CONANP - National Commission for Natural Protected Areas, Mexico), and Dr. James Spotila (Drexel University).

We request your assistance in serving as a peer reviewer of the U.S. Fish and Wildlife Service and National Marine Fisheries Service's (Services) 5-year status review of the leatherback sea turtle (Dermochelys coriacea). The 5-year review is required by section 4(c)(2) of the United States Endangered Species Act of 1973, as amended (Act). A 5-year review is a periodic process conducted to ensure the listing classification of a species as threatened or endangered on the Federal List of Endangered and Threatened Wildlife and Plants is accurate. The initiation of the 5-year review for the leatherback turtle was announced in the Federal Register on April 21, 2005, and the public comment period closed on July 20, 2005. Public comments have been incorporated into the status review.

The enclosed draft of the status review has been prepared by the Services pursuant to the Act. In keeping with directives for maintaining a high level of scientific integrity in the official documents our agencies produce, we are seeking your assistance as a peer reviewer for this draft. Guidance for peer reviewers is enclosed with this letter. If you are able to assist us, we request your comments be received on or before June 11, 2007. Please send your comments to Sandy MacPherson at the address on this letter. You may fax your comments to Sandy MacPherson at 904-232-2404 or send comments by e-mail to Sandy_MacPherson@fws.gov.

We appreciate your assistance in helping to ensure our decisions continue to be based on the best available science. If you have any questions or need additional information, please contact Sandy MacPherson at 904-232-2580, extension 110. Thank you for your assistance.

Sincerely yours,

David L. Hankla
Field Supervisor
Jacksonville Ecological Services Field Office

Enclosures

Guidance for Peer Reviewers of Five-Year Status Reviews

U.S. Fish and Wildlife Service, North Florida Ecological Services Office

February 7, 2007

As a peer reviewer, you are asked to adhere to the following guidance to ensure your review complies with Service policy.

Peer reviewers should:

1. Review all materials provided by the Service.

2. Identify, review, and provide other relevant data that appears not to have been used by the Service.

3. Not provide recommendations on the Endangered Species Act classification (e.g., Endangered, Threatened) of the species.

4. Provide written comments on:

- *Validity of any models, data, or analyses used or relied on in the review.*
- *Adequacy of the data (e.g., are the data sufficient to support the biological conclusions reached). If data are inadequate, identify additional data or studies that are needed to adequately justify biological conclusions.*
- *Oversights, omissions, and inconsistencies.*
- *Reasonableness of judgments made from the scientific evidence.*
- *Scientific uncertainties by ensuring that they are clearly identified and characterized, and that potential implications of uncertainties for the technical conclusions drawn are clear.*
- *Strengths and limitation of the overall product.*

5. Keep in mind the requirement that we must use the best available scientific data in determining the species' status. This does not mean we must have statistically significant data on population trends or data from all known populations.

All peer reviews and comments will be public documents, and portions may be incorporated verbatim into our final decision document with appropriate credit given to the author of the review.

Questions regarding this guidance, the peer review process, or other aspects of the Service's recovery planning process should be referred to Sandy MacPherson, National Sea Turtle Coordinator, U.S. Fish and Wildlife Service, at 904-232-2580, extension 110, email: Sandy_MacPherson@fws.gov.

C. Summary of Peer Review Comments/Report:

A summary of peer review comments from the four respondents is provided below. The complete set of comments is available at the Jacksonville Ecological Services Field Office, U.S. Fish and Wildlife Service, 6620 Southpoint Drive South, Suite 310, Jacksonville, Florida, 32216.

Dr. Scott Eckert, Wider Caribbean Sea Turtle Conservation Network, Beaufort, NC: Dr. Eckert provided numerous edits and several research papers not currently cited, but felt that the biological information presented in the document was thorough. Dr. Eckert was concerned about the proper use of citations for data used by the Turtle Expert Working Group (2007). He felt that references to the Turtle Expert Working Group should only be used in those cases where the group derived or uniquely compiled information; otherwise the original authors should be cited. In Section 2.2.1, Dr. Eckert felt that a comparison between the recovery criteria and current status should be made.

Dr. Angela Formia, Wildlife Conservation Society - Gabon, Libreville, Gabon: Dr. Formia provided edits and several research papers not currently cited, but felt that the biological information presented in the document was excellent. Dr. Formia's main comment was that due to differences in methodologies, the values provided on population trends and abundance are not comparable, making it difficult to summarize broad comparisons. Dr. Formia recognized that developing a summary with a standard unit may involve too many assumptions, but would be valuable.

Dr. Matthew Godfrey, North Carolina Wildlife Resources Commission, Beaufort, NC, USA: Dr. Godfrey provided edits and several research papers not currently cited, but felt that the biological information presented in the document was comprehensive. Dr. Godfrey was concerned about the use of unpublished sources of information; in particular he was concerned about the use of the most recent Sea Turtle Symposium Book of Abstracts. He suggested that these be changed to personal communications or unpublished data or be deleted. Dr. Godfrey was also concerned about the lack of common values reported for population abundance and trends. He also felt that values should be reported for similar years. Dr. Godfrey disagreed with the statement that highly feminized sex ratios and the low probability of a female encountering a male may be a cause of observed declines in the Pacific. He felt the statement was speculative at this point, since there has been only one hatchling sex ratio study conducted in the Pacific and extrapolating to the entire region was inappropriate.

Dr. Mike James, Dalhousie University, Halifax, Nova Scotia, Canada: Dr. James provided edits and several research papers not currently cited, but felt the document was generally well written and biological information presented was very current. Dr. James' principal suggestion was to present the summary information in tables and graphs to enhance the document's accessibility to the reader. Dr. James also disagreed with the statement that highly feminized sex ratios and the low probability of a female encountering a male may be a cause of observed declines in the Pacific. He felt the likely existence of specific mating areas and homing to such areas provides an opportunity to mate even at low densities.

D. Response to Peer Review:

Dr. Scott Eckert, Wider Caribbean Sea Turtle Conservation Network, Beaufort, NC: All of Dr. Eckert's edits and new information were incorporated except the request to change the reference to the last status review in Section 1.3.4. The official citation is unchanged. The Services agree that information from the Turtle Expert Working Group must be properly referenced. We went through the document and where the Turtle Expert Working Group had not derived or uniquely compiled data, we referenced the original authors. We did leave in some references to the Turtle Expert Working Group where we felt the summary provided in their report was helpful. Regarding Section 2.2.1, we added accomplishments under the Recovery Criteria. In addition, the 5-year review provides new information on population status and trends since 1995, and the five-factor analysis under Section 2.3.2 provides information used to determine the appropriateness of the current listing status.

Dr. Angela Formia, Wildlife Conservation Society - Gabon, Libreville, Gabon: All of Dr. Formia's edits and new information were incorporated, except where she suggested enhancements that would not change the analysis. Although we agree that presentation of data could be enhanced by her suggestions, the Services are under time constraints to complete the sea turtle 5-year reviews by the end of August 2007. The Services agree that differences in methodologies present an obstacle to reporting values that can be summarized and compared. We also agree that it may require assumptions that could compound errors. We maintained the values reported by each study.

Dr. Matthew Godfrey, North Carolina Wildlife Resources Commission, Beaufort, NC, USA: Dr. Godfrey's edits and new references were incorporated. We agree that unpublished data are less desirable than peer-reviewed and published data, and we have replaced or deleted citations where published references or references with more rigorous peer review were available. However in many cases the unpublished data, including the Book of Abstracts, were the best available information, and those references were not deleted. Regarding values reported for population abundance and trends, see response to Dr. Formia. We agree that highly feminized sex ratios and low probability of encountering males as a causal factor in the Pacific declines is speculative at this point; therefore, the statement was deleted.

Dr. Mike James, Dalhousie University, Halifax, Nova Scotia, Canada: Dr. James' edits and new references were incorporated, except for the request to include Ocean Spirits nesting data from Grenada. The Services requested Ocean Spirits to provide citable data, but were unable to obtain any new information. With regard to the suggestion that we add tables and graphs of summary data to enhance the document, see response to Dr. Formia. We agree that highly feminized sex ratios and low probability of encountering males as a causal factor in the Pacific declines is speculative at this point; therefore, the statement was deleted.