*Pacific Ocean*
Loggerheads can be found throughout tropical to temperate waters in the Pacific; however, their breeding grounds include a restricted number of sites in the North Pacific and South Pacific. Within the North Pacific, loggerhead nesting beaches are found only in Japan (Kamezaki *et al*. 2003). In the South Pacific, nesting beaches are restricted to eastern Australia and New Caledonia (Limpus and Limpus 2003b).

Important loggerhead nesting locations in Japan include Yakushima Island, and Miyazaki, Minabe, and Atsumi beaches on the mainland. Approximately 40% of all loggerhead nesting in Japan occurs at three primary nesting beaches on Yakushima Island (Kamezaki *et al*. 2003). Important post-nesting adult female habitat has been identified in the East China Sea (Balazs 2006), while satellite tracking of juvenile loggerheads indicates the Kuroshio Extension Bifurcation Region to be an important pelagic foraging area for juveniles (Polovina *et al*. 2006). Other important juvenile foraging areas have recently been identified off the coast of Baja California Sur, Mexico (Pitman 1990, Peckham and Nichols 2006). Nesting occurs along the mainland of Australia from South Stradbroke Island to Bustard Head, and on the islands of the Capricorn Bunker Group and Swain Reefs, and on Bushy Island (Limpus and Limpus 2003b). Within this area, five rookeries account for 70% of nests in eastern Australia: (1) Mon Repos, (2) Wreck Rock, (3) mainland and Wreck Island, (4) Erskine Island, and (5) Tryon Island (Limpus and Reimer 1994). Nesting females tagged on the coast of eastern Australia have been recorded foraging in New Caledonia; Queensland, New South Wales, and Northern Territory, Australia; Solomon Islands; Papua New Guinea; and Indonesia (Limpus and Limpus 2003b). Foraging Pacific loggerheads originating from nesting beaches in Australia are known to migrate to Chile and Peru (Alfaro-Shigueto *et al*. 2004, 2008a; Donoso and Dutton 2006, Boyle et al 2008).

**Deleted:** Foraging Pacific loggerheads originating from nesting beaches in Australia are known to migrate to Chile and Peru (Alfaro-Shigueto *et al*. 2004, 2008a; Donoso and Dutton 2006).¶
¶

Although nesting in the South Pacific is concentrated in eastern Australia, nesting has also been reported in New Caledonia, Vanuatu, and Tokelau (Limpus and Limpus 2003b). Nesting may occur in other areas of the South Pacific, but it remains unsubstantiated. In New Caledonia, the most substantial loggerhead nesting has been reported on peripheral small coral cays offshore from the main island of Île des Pins (Beloff personal communication cited in Limpus and Limpus 2003b). The population in the Île des Pins area has been estimated at 10-100 females nesting annually (Limpus and Limpus 2003b). Based on aerial surveys of New Caledonia nesting beaches conducted between December 2006 and January 2008, it was estimated that the nesting female population for this nesting season was approximately 200 individuals (World Wildlife Fund 2008). In Vanuatu, low density nesting was reported at Malekula in 1993 (Atuary 1994 cited in Limpus and Limpus 2003b); however, the status of loggerhead nesting is uncertain because most of Vanuatu has been poorly surveyed. In 1981, nesting was reported in Tokelau, a territory of New Zealand that comprises three coral atolls in the South Pacific, but is believed to be uncommon (Balazs 1983).

### *Atlantic Ocean*

In the Northwest Atlantic, the overwhelming majority of loggerhead nesting is concentrated along the coasts of the United States from North Carolina through Florida. Additional nesting beaches are found along the eastern Yucatán Peninsula, at Cay Sal Bank in the eastern Bahamas (Addison and Morford 1996, Addison 1997), on the southwestern coast of Cuba (F. Moncada-Gavilán, personal communication, cited in Ehrhart *et al*. 2003), and along the coasts of Central America, Colombia, Venezuela, and the eastern Caribbean Islands. In the Southwest Atlantic, loggerheads nest in significant numbers only in Brazil. In the eastern Atlantic loggerheads nest in the Cape Verde Islands (L.F. López-Jurado, personal communication, cited in Ehrhart *et al*. 2003) and along the west Africa coast.

As post-hatchlings, loggerheads hatched on U.S. beaches migrate offshore and become associated with *Sargassum* habitats, driftlines, and other convergence zones (Carr 1986, Witherington 2002). The oceanic juvenile stage in the North Atlantic has been primarily studied in the waters around the Azores and Madeira (Bolten 2003). In Azorean waters, satellite telemetry data and flipper tag returns suggest a long period of residency (Bolten 2003), whereas turtles appear to be moving through Madeiran waters (Dellinger and Freitas 2000). Other concentrations of oceanic juveniles exist in the Atlantic (e.g., in the region of the Grand Banks off Newfoundland), but data on these assemblages are very limited (Bolten 2003).

After departing the oceanic zone, neritic juvenile loggerheads in the Northwest Atlantic inhabit continental shelf waters from Cape Cod Bay, Massachusetts, south through Florida, the Bahamas, Cuba, and the Gulf of Mexico (neritic refers to the inshore marine environment from the surface to the sea floor where water depths do not exceed 200 meters). Estuarine waters, including areas such as Long Island Sound, Chesapeake Bay, Pamlico and Core Sounds, Mosquito and Indian River Lagoons, Biscayne Bay, Florida Bay, and numerous embayments fringing the Gulf of Mexico, comprise important inshore habitat. Along the Atlantic and Gulf of Mexico shoreline, essentially all shelf waters are inhabited by loggerheads.

Habitat preferences of non-nesting adult loggerheads in the neritic zone differ from the juvenile stage in that relatively enclosed, shallow water estuarine habitats with limited ocean access are less frequently used. Areas such as Pamlico Sound and the Indian River Lagoon, regularly used by juveniles, are only rarely frequented by adult loggerheads. Estuarine areas with more open ocean access, such as Chesapeake Bay in the northeast U.S., are more frequently used by adults, primarily during warmer seasons. Shallow water habitats with large expanses of open ocean access, such as Florida Bay, provide year-round resident foraging areas for significant numbers of male and female adult loggerheads. Offshore, adults primarily inhabit continental shelf waters, from New York south through Florida, the Bahamas, Cuba, and the Gulf of Mexico. Seasonal use of mid-Atlantic shelf waters, especially offshore New Jersey, Delaware, and Virginia during summer months, and offshore shelf waters, such as Onslow Bay (off the North Carolina coast), during winter months has been documented (Hawkes *et al*. 2007a; GDNR, unpublished data; SCDNR, unpublished data). Shelf waters along the west Florida coast, the Bahamas, Cuba, and the Yucatán Peninsula have been identified, using satellite telemetry, as important resident areas for adult female loggerheads that nest in Florida (Foley *et al*. 2008).

### *Mediterranean Sea*

Loggerhead turtles are widely distributed in the Mediterranean Sea. However, nesting is almost entirely confined to the eastern Mediterranean basin, with the main nesting concentrations in Cyprus, Greece, and Turkey (Margaritoulis *et al*. 2003). In addition, nesting has been verified in Libya, although a better quantification is needed (Laurent *et al*. 1995). Minimal to moderate nesting also occurs in other countries throughout the Mediterranean including Egypt, Israel, Italy, Lebanon, Syria, and Tunisia (Margaritoulis *et al*. 2003). Recently, significant nesting has been recorded in the western Mediterranean basin, namely in Spain, Corsica, and in the Tyrrhenian Sea (Italy) (Bentivegna *et al*. 2005, Delaugerre and Cesarini 2004, Tomás *et al*. 2002).

In Cyprus, nesting occurs mainly on beaches of the western coast and Chrysochou Bay (Demetropoulos and Hadjichristophorou 1989), as well as along the northern coast (Broderick and Godley 1996). Seventeen important loggerhead nesting sites have been identified on Turkey's beaches (Margaritoulis *et al*. 2003). Nesting activity in Libya is spread throughout the entire coast, but may be less dense in western areas (Laurent *et al*. 1999). Nesting occurs along the western and southern coasts of Greece and on the island of Crete, with the vast majority of nesting occurring on the island of Zakynthos (Margaritoulis 1987, 1998, 2005; Margaritoulis *et al*. 1995, 2003).

Marine habitats have been suggested as: (1) Gulf of Gabès, and (2) northern Adriatic Sea, both of which constitute shallow benthic habitats for adults (including post-nesting females) and juveniles (Margaritoulis 1988, Argano *et al*. 1992, Laurent and Lescure 1994, Lazar *et al*. 2000). Some other foraging areas include Amvrakikos Bay in western Greece and Lakonikos Bay in southern Greece. In addition, tagged juveniles have been recorded crossing the Mediterranean from the eastern to the western basin and vice versa (Argano *et al*. 1992).

Reproductive migrations have been confirmed by flipper tagging and satellite telemetry. Female loggerheads, after nesting in Greece, migrate primarily to the Gulf of Gabès and the northern Adriatic (Margaritoulis 1988, Margaritoulis *et al*. 2003, Zbinden *et al*. 2008). Loggerheads nesting in Cyprus migrate to Egypt and Libya, exhibiting fidelity in following the same migration route during subsequent nesting seasons (Broderick *et al*. 2007). In addition, directed movements of juvenile loggerheads have been confirmed through flipper tagging (Argano *et al*. 1992) and satellite tracking (Rees and Margaritoulis 2009).

*Indian Ocean*

In the Southwest Indian Ocean, loggerhead nesting occurs on the southeastern coast of Africa, from the Paradise Islands in Mozambique southward to St. Lucia in South Africa, and on the south and southwestern coasts of Madagascar (Baldwin *et al*. 2003). Foraging habitats are only known for post-nesting females from Tongaland, South Africa, tagging data show these loggerheads migrating eastward to Madagascar, northward to Mozambique, Tanzania, and Kenya, and southward to Cape Agulhas at the southernmost point of Africa and into the Atlantic Ocean (Baldwin *et al*. 2003).

In the North Indian Ocean, Oman hosts the vast majority of loggerhead nesting. Outside of Oman, loggerhead nesting is rare, although small nesting concentrations are reported in Sri Lanka, southern India, and the Gulf of Mannar (Deraniyagala 1939; Kar and Bhaskar 1982;

Dodd 1988; K. Shanker, Indian Institute of Science, personal communication, 2006). The majority of the nesting in Oman occurs on Masirah Island, on the Al Halaniyat Islands, and on mainland beaches south of Masirah Island all the way to the Oman-Yemen border (IUCN - The World Conservation Union 1989a, 1989b; Salm 1991; Salm and Salm 1991). In addition, nesting probably occurs on the mainland of Yemen on the Arabian Sea coast, and nesting has been confirmed on Socotra, an island off the coast of Yemen (Pilcher and Saad 2000). Limited information exists on the foraging habitats of North Indian Ocean loggerheads; however, foraging individuals have been reported off the southern coastline of Oman (Salm *et al*. 1993). Satellite telemetry studies conducted in Oman have revealed new information about post-nesting migrations of loggerheads nesting on Masirah Island (Environment Society of Oman and Ministry of Environment and Climate Change, Oman, unpublished data). Results reveal extensive use of the waters off the Arabian peninsula, with the majority of telemetered turtles (15 of 20) traveling southwest, following the shoreline of southern Oman and Yemen, and circling well offshore in nearby oceanic waters. A minority traveled north as far as the western Persian (Arabian) Gulf (3 of 20) or followed the shoreline of southern Oman and Yemen as far west as the Gulf of Aden and the Bab-el-Mandab (2 of 20). These preliminary data suggest that post-nesting migrations and adult female foraging areas may be centered within the region (Environment Society of Oman and Ministry of Environment and Climate Change, Oman, unpublished data).

The only verified nesting beaches for loggerheads on the Indian subcontinent are found in Sri Lanka. No confirmed nesting occurs on the mainland of India despite historical papers suggesting loggerhead sightings on mainland beaches (Tripathy 2005, Kapurusinghe 2006). This discrepancy may be attributed to inaccurate identification of nesting species, as loggerheads are sometimes confused with olive ridleys in the Indian Ocean (Tripathy 2005). In addition, the Gulf of Mannar provides foraging habitat for juveniles and post-nesting adults (Tripathy 2005, Kapurusinghe 2006). The only loggerhead nesting reported in south and southeastern Asia occurs in Myanmar (Thorbjarnarson *et al*. 2000).

In the East Indian Ocean, western Australia hosts all known loggerhead nesting (Dodd 1988). Nesting distributions in western Australia span from the Shark Bay World Heritage Area northward through the Ningaloo Marine Park coast to the North West Cape and to the nearby Muiron Islands (Baldwin *et al*. 2003). Nesting individuals from Dirk Hartog Island have been recorded foraging within Shark Bay and Exmouth Gulf, while other adults range much farther (Baldwin *et al*. 2003).

## 2.4. Biological Characteristics

Loggerheads nest on ocean beaches and occasionally on estuarine shorelines with suitable sand. Although specific characteristics vary between rookeries, loggerhead nesting beaches tend to be wide, sandy beaches backed by low dunes and fronted by a flat, sandy approach from the water (Miller *et al*. 2003). Nests are typically laid between the high tide line and the dune front (Routa 1968, Witherington 1986, Hailman and Elowson 1992).

Sea turtle eggs require a high-humidity substrate that allows for sufficient gas exchange and temperatures conducive to egg development (Miller 1997, Miller *et al*. 2003). Mean clutch size varies greatly between populations, but on average is approximately 100-130 eggs per clutch (Dodd 1988). Loggerhead nests incubate for variable periods of time. The length of the incubation period is inversely related to nest temperature, such that between 26°C and 32°C, a change of 1°C adds or subtracts approximately 5 days (Mrosovsky 1980). The warmer the sand surrounding the egg chamber, the faster the embryos develop (Mrosovsky and Yntema 1980). Sand temperatures prevailing during the middle third of the incubation period also determine the sex of hatchlings (Mrosovsky and Yntema 1980). Incubation temperatures near the upper end of the tolerable range produce only female hatchlings while incubation temperatures near the lower end of the tolerable range produce only male hatchlings. The pivotal temperature (i.e., the incubation temperature that produces equal numbers of males and females) in loggerheads is approximately 29°C (Limpus *et al*. 1983, Mrosovsky 1988, Marcovaldi *et al*. 1997). Moisture conditions in the nest influence incubation period, hatching success, and hatchling size (McGehee 1990, Carthy *et al*. 2003).

Loggerhead hatchlings pip and escape from their eggs over a 1- to 3-day interval and move upward and out of the nest over a 2- to 4-day interval (Christens 1990). The time from pipping to emergence ranges from 4 to 7 days with an average of 4.1 days (Godfrey and Mrosovsky 1997). Hatchlings emerge from their nests en masse almost exclusively at night, and presumably using decreasing sand temperature as a cue (Hendrickson 1958, Mrosovsky 1968, Witherington *et al*. 1990). Moran *et al*. (1999) concluded that a lowering of sand temperatures below a critical threshold, which most typically occurs after nightfall, is the most probable trigger for hatchling emergence from a nest. After an initial emergence, there may be secondary emergences on subsequent nights (Carr and Ogren 1960, Witherington 1986, Ernest and Martin 1993, Houghton and Hays 2001).

Hatchlings use a progression of orientation cues to guide their movement from the nest to the marine environments where they spend their early years (Lohmann and Lohmann 2003). Hatchlings first use light cues to find the ocean. On naturally lighted beaches without artificial lighting, ambient light from the open sky creates a relatively bright horizon compared to the dark silhouette of the dune and vegetation landward of the nest. This contrast guides the hatchlings to the ocean (Daniel and Smith 1947, Limpus 1971, Salmon *et al*. 1992, Witherington 1997, Witherington and Martin 1996, Stewart and Wyneken 2004).

Immediately after hatchlings emerge from the nest, they begin a period of frenzied activity. During this active period, hatchlings move from their nest to the surf, swim, and are swept through the surf zone (Carr and Ogren 1960; Carr 1962, 1982; Wyneken and Salmon 1992; Witherington 1995). Orientation cues used by hatchlings as they crawl, swim through the surf, and migrate offshore are discussed in detail by Lohmann and Lohmann (2003).

Neonate loggerheads that have migrated away from land differ from swim frenzy stage hatchlings in that they are infrequently low-energy swimmers and they have begun to feed, no longer relying on their retained yolk (Witherington 2002). As post-hatchlings, loggerheads are pelagic and are best known from neritic waters along the continental shelf. This neritic post-hatchling stage is weeks or months long (Witherington 2002) and may be a transition to the oceanic stage that loggerheads enter as they grow and are carried within ocean currents (Bolten 2003).

In the northwest Atlantic, post-hatchling loggerheads inhabit areas where surface waters converge to form local downwellings (Witherington 2002). These areas are characterized by linear accumulations of floating material, especially *Sargassum*, and are common between the Gulf Stream and the southeast U.S. coast, and between the Loop Current and the Florida coast in the Gulf of Mexico. Post-hatchlings within this habitat are observed to be low-energy float-and-wait foragers that feed on a wide variety of floating items (Witherington 2002). Witherington (2002) found that small animals commonly associated with the *Sargassum* community, such as hydroids and copepods, were most commonly found in esophageal lavage samples. Post-hatchling loggerheads from southeast U.S. nesting beaches may linger for months in waters just off the nesting beach or become transported by ocean currents within the Gulf of Mexico and North Atlantic.

The oceanic stage begins when loggerheads enter the oceanic zone (Bolten 2003). Loggerheads from nesting beaches in the Northwest Atlantic, West Indian, and West Pacific Oceans appear to use oceanic developmental habitats and move with the predominant ocean gyres for several years before returning to their neritic foraging and nesting habitats (Bolten 2003, Bowen *et al*. 1995, Hughes 1974a, Musick and Limpus 1997, Pitman 1990, Zug *et al*. 1995). However, the actual duration of the oceanic juvenile stage varies with loggerheads leaving the oceanic zone over a wide size range (Bjorndal *et al*. 2000). In the Atlantic, the duration of the oceanic juvenile stage ranges between 7 and 11.5 years with juveniles recruiting to neritic habitats in the western Atlantic over a size range of 46-64 cm curved carapace length (CCL) (Bjorndal *et al*. 2000, Bolten *et al*. 1993). However, in Australia, juvenile loggerheads do not disperse to neritic habitats until 70 cm CCL or larger (Limpus *et al*. 1994).

The neritic juvenile stage begins when loggerheads exit the oceanic zone and enter the neritic zone (Bolten 2003). After migrating to the neritic zone, juvenile loggerheads continue maturing until they reach adulthood. Some juveniles may periodically move between the neritic and oceanic zones particularly during colder periods (Morreale and Standora 2005, McClellan and Read 2007, Mansfield 2006). The neritic zone also provides important foraging habitat, inter-nesting habitat, and migratory habitat for adult loggerheads. See Schroeder *et al*. (2003) and Limpus and Limpus (2003a) for reviews of this life stage for the Atlantic and Pacific, respectively.

The duration of the adult stage in the neritic environment can be reasonably estimated for females from tag return data at nesting beaches. For the Northwest Atlantic nesting assemblages, data from Little Cumberland Island, Georgia, show reproductive longevity, and hence duration of neritic adult female stage, as long as 25 years (Dahlen *et al*. 2000). This is likely an underestimate of the average reproductive life span given tag loss and incomplete surveys of nesting beaches at night. Comparable data for adult males do not exist.

Based on stable isotope analyses and satellite telemetry, Hatase *et al*. (2002a) demonstrated that some adult female loggerheads nesting in Japan inhabit oceanic habitats rather than neritic habitats. Satellite tagged adult loggerheads in western Africa have also been demonstrated to use oceanic foraging areas (Hawkes *et al*. 2006). Preliminary results from stable isotope analyses suggest that some loggerheads nesting in Florida also may inhabit oceanic habitats (Reich *et al*.

2007). In both Japan and Florida, the females inhabiting oceanic habitats were significantly smaller than those in neritic habitats. The extent to which adult loggerheads occupy oceanic habitats needs to be evaluated, and effects on survival probabilities and reproductive output should be assessed.

In both the oceanic and neritic zones, loggerheads are primarily carnivorous, although they do consume some plant matter as well (see Bjorndal 1997 and Dodd 1988 for reviews). Loggerheads are able to exist on a wide variety of food items with ontogenetic and regional differences in diet. Loggerhead diets have been described from just a few coastal regions, and very little information is available about differences or similarities in diet at various life stages. Very little is known of the diet of oceanic juveniles.

# SECTION 3—DETERMINATION OF DPS

## 3.1. Overview of Information Used to Determine DPS

The BRT considered a vast array of information in assessing whether there are any loggerhead population segments that satisfy the Distinct Population Segment criteria of being both discrete and significant.

First, the BRT discussed whether there were any loggerhead population segments that were discrete. As noted previously, joint NMFS/FWS policy defines a population to be a DPS if it is both discrete and significant relative to the taxon to which it belongs (FWS and NMFS 1996, 61 FR 4722). Under the policy, a population may be considered discrete if it satisfies either one of the following conditions: (1) it is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors; or (2) it is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of Section 4(a)(1)(D) of the ESA.

Data relevant to the distinctiveness question include physical, physiological, ecological, behavioral, and genetic data. Upon looking at the global loggerhead population, the physical separation of ocean basins by continents was first considered. The result was an evaluation of the data for each ocean basin (Pacific Ocean, Atlantic Ocean, and Indian Ocean). This was not to preclude any larger or smaller DPS delineation, but to aid in data organization and assessment. The BRT then evaluated genetic information by ocean basin. The genetics data consisted of maternally inherited mitochondrial DNA (mtDNA) and biparentally inherited microsatellite DNA. Next, tagging data (both flipper and PIT tags) and telemetry data were reviewed. Additional information, such as potential differences in morphology, was also evaluated. Finally, the BRT considered whether the available information on loggerhead population segments was bounded by any oceanographic or geographical features, such as current systems or the equator.

In accordance with the joint NMFS/FWS DPS policy, the BRT also reviewed whether the population segments identified in the discreteness analysis were significant. That is, if a population segment is considered discrete, its biological and ecological significance must then be considered. NMFS/FWS must consider available scientific evidence of the discrete segment’s importance to the taxon to which it belongs. Data relevant to the significance question include the morphological, ecological, behavioral, and genetic data, as described above. The BRT considered the following criteria in determining whether the discrete population segments were significant:

a) persistence of the discrete segment in an ecological setting unusual or unique for the taxon;
b) evidence that loss of the discrete segment would result in a significant gap in the range of the taxon;
c) evidence that the discrete segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historical range; and

d) evidence that the discrete segment differs markedly from other populations of the species in its genetic characteristics.

A discrete population segment needs to satisfy only one of these criteria to be considered significant. The NMFS/FWS policy also allows for consideration of other factors if they are appropriate to the biology or ecology of the species. As will be described in subsequent sections, the BRT evaluated the information and considered items (a), (b) and (d), as noted above, to be most applicable to loggerheads.

### 3.1.1. Discreteness Determination

The loggerhead sea turtle (*Caretta caretta*) is present in all tropical and temperate ocean basins, and has a life history that involves nesting on coastal beaches and foraging in neritic and oceanic habitats, as well as long-distance migrations between and within these areas. As with other globally distributed marine species, today's global loggerhead population has been shaped by a sequence of isolation events created by tectonic and oceanographic shifts over geologic time scales, the result of which is population substructuring in many areas (Bowen *et al*. 1994, Bowen 2003). Globally, loggerhead turtles comprise a mosaic of subpopulations, each with unique nesting sites and in many cases possessing disparate demographic features (e.g., mean body size, age at first reproduction) (Dodd 1988). However, despite these differences, loggerheads from different subpopulations often mix in common foraging grounds (Bolten and Witherington 2003), thus creating unique challenges when attempting to delineate distinct population segments for management or listing purposes.

Examining the phylogeography of loggerheads across their global distribution through mitochondrial DNA (mtDNA) sequence diversity, Bowen *et al*. (1994) found it to be similar to green turtles, with a separation of loggerheads in the Atlantic-Mediterranean basins from those in the Indo-Pacific basins since the Pleistocene period. The divergence between these two primary lineages corresponds to approximately three million years, based on a molecular clock for control region sequences assessed originally for green turtles (2% per million years; Dutton *et al*. 1996, Encalada *et al*. 1996). Geography and climate appear to have shaped the evolution of these two matriarchal lineages with the onset of glacial cycles, the appearance of the Panama Ithsmus creating a land barrier between the Atlantic and eastern Pacific, and upwelling of cold water off southern Africa creating an oceanographic barrier between the Atlantic and Indian Ocean (Bowen 2003). Recent warm temperatures during interglacial periods allowed bi-directional invasion by the temperate-adapted loggerheads into the respective basins (Bowen *et al*. 1994; J.S. Reece, Washington University, personal communication, 2008). Today, it appears that loggerheads within a basin are effectively isolated from populations in the other basin, but some dispersal from the Tongaland rookery in the Indian Ocean into the South Atlantic is possible via the Agulhas current (G.R. Hughes, unpublished data, cited in Bowen *et al*. 1994). In the Pacific, extensive mtDNA studies show that the northern loggerhead populations are isolated from the southern Pacific populations, and that juveniles from these distinct genetic stocks do not disperse across the equator (Hatase *et al*. 2002a; Dutton 2007, unpublished data).

mtDNA data indicate that regional turtle rookeries within an ocean basin have been strongly isolated from one another over ecological timescales (Bowen *et al*. 1994, Bowen and Karl 2007).

These same data indicate strong female natal homing and suggest that each regional nesting population is an independent demographic unit (Bowen and Karl 2007). It is difficult to determine the precise boundaries of these demographically independent populations in regions, such as the eastern U.S. coast, where rookeries are close to each other and range along large areas of a continental coastline. There appears to be varying levels of connectivity between proximate rookeries facilitated by imprecise natal homing and male mediated gene flow. Regional genetic stocks often are characterized by allelic frequency differences rather than fixed genetic differences.

**Deleted:** evolutionary

Through the evaluation of genetic data, tagging data, telemetry, and demographics, the BRT determined that there are at least nine distinct population segments for loggerhead sea turtles globally. These DPSs are markedly separated from each other as a consequence of ecological, behavioral, and oceanographic factors, and given the genetic evidence, the BRT has unanimously concluded that each regional subpopulation identified is discrete from other subpopulations of loggerheads. Information considered by the BRT in its determination of DPSs is presented below by ocean basin.

*Pacific Ocean*

Perhaps the most distinct and easily recognized of all loggerhead subpopulations is that from the North Pacific Ocean. The primary nesting areas for this subpopulation are found along the southern Japanese coastline and Ryukyu Archipelago (Hatase *et al*. 2002a, Kamezaki *et al*. 2003). Loggerhead turtles hatching on Japanese beaches undertake extensive developmental migrations utilizing the Kuroshio and North Pacific Currents (Balazs 2006, Kobayashi *et al*. 2008), and some turtles reach the vicinity of Baja California in the eastern Pacific (Uchida and Teruya 1988, Bowen *et al*. 1995, Peckham *et al*. 2007). After spending years foraging in the central and eastern Pacific, loggerheads return to their natal beaches for reproduction (Resendiz *et al*. 1998, Nichols *et al*. 2000) and remain in the western Pacific for the remainder of their life cycle (Kamezaki *et al*. 1997, Sakamoto *et al*. 1997, Hatase *et al*. 2002c).

Despite the long-distance developmental movements of loggerheads in the North Pacific, current scientific evidence, based on genetic analysis, flipper tag recoveries, and satellite telemetry, indicates that individuals originating from Japan remain in the North Pacific for their entire life cycle, never crossing the equator or mixing with individuals from the South Pacific (Hatase *et al*. 2002a; Dutton 2007, unpublished data; LeRoux and Dutton 2006). Indeed, this apparent complete separation of two adjacent subpopulations is unique and most likely results from: (1) the presence of two distinct Northern and Southern Gyre (current flow) systems in the Pacific (Briggs 1974), (2) near-passive movements of post-hatchlings in these gyres that initially move them farther away from areas of potential mixing among the two subpopulations along the equator, and (3) the nest-site fidelity of adult turtles that prevents turtles from returning to non-natal nesting areas.

Pacific loggerheads are further partitioned evolutionarily from other loggerheads throughout the world based on additional analyses of mtDNA. The haplotypes from both North and South Pacific loggerheads are distinguished by a minimum genetic distance (d) equal to 0.017 from other conspecifics, which indicates isolation of approximately one million years (Bowen 2003).

Within the Pacific, Bowen *et al*. (1995) used mtDNA to identify two genetically distinct nesting stocks in the Pacific – a northern hemisphere stock nesting in Japan and a southern hemisphere stock nesting primarily in Australia. This study also suggested that some loggerheads sampled as bycatch in the North Pacific might be from the Australian nesting population (Bowen *et al*. 1995). However, more extensive mtDNA rookery data from Japan (Hatase *et al*. 2002a) taken together with preliminary results from microsatellite (nuclear) analysis confirms that loggerheads inhabiting the North Pacific actually originate from nesting beaches in Japan (P. Dutton, NMFS, unpublished data). LeRoux *et al*. (2008) report additional genetic variation in North Pacific loggerheads based on analyses using new mtDNA primers designed to target longer mtDNA sequences, and suggest finer scale population structure in North Pacific loggerheads may be present.

Although these studies indicate genetic distinctness between loggerheads nesting in Japan versus those nesting in Australia, Bowen *et al*. (1995) did identify individuals with the common Australian haplotype at foraging areas in the North Pacific, based on a few individuals sampled as bycatch in the North Pacific. More recently, Hatase *et al*. (2002a) detected this common haplotype at very low frequency at Japanese nesting beaches. However, the presence of the common Australian haplotype does not preclude the genetic distinctiveness of Japanese and Australian nesting stocks, and is likely the result of rare gene flow events occurring over geologic time scales.

**Deleted:**

The distinct status of loggerheads in the North Pacific is further supported by the results from flipper tagging in the North Pacific. Flipper tagging of loggerheads has been widespread throughout this region, occurring on adults nesting in Japan (Y. Matsuzawa, Sea Turtle Association of Japan, personal communication, 2006), juveniles reared and released in Japan (Uchida and Teruya 1988, Hatase *et al*. 2002a), juveniles foraging near Baja California, Mexico (Nichols 2003, Seminoff *et al*. 2004), and loggerheads captured in and tagged from commercial fisheries platforms in the North Pacific high seas (NMFS, unpublished data). To date, there have been at least three transPacific tag recoveries showing east-west and west-east movements (Uchida and Teruya 1988; Resendiz *et al*. 1998; W.J. Nichols, Ocean Conservancy, and H. Peckham, Pro Peninsula, unpublished data) and several recoveries of adults in the western Pacific (Kamezaki *et al*. 1997). However, despite the more than 1,000 marked individuals, not a single tag recovery has been reported outside the North Pacific.

A lack of movements by loggerheads south across the equator has also been supported by extensive satellite telemetry. As with flipper tagging, satellite telemetry has been a tool used widely in the North Pacific, with satellite transmitters being placed on adult turtles departing nesting beaches (Sakamoto *et al*. 1997; Hatase *et al*. 2002b, 2002c), on headstarted juveniles released in Japan (Balazs 2006), on juvenile, subadult and adult turtles bycaught in the eastern and central North Pacific (e.g., Kobayashi *et al*. 2008), and on juvenile and subadult turtles foraging in the eastern Pacific (Nichols 2003; Peckham *et al*. 2007; J. Seminoff, NMFS, unpublished data). Of the nearly 200 transmitters deployed on loggerheads in the North Pacific, none have moved south of the equator. These studies have demonstrated the strong association loggerheads show with oceanographic mesoscale features such as the Transition Zone Chlorophyll Front or the Kuroshio Current Bifurcation Region (Polovina *et al*. 2000, 2001, 2004, 2006; Etnoyer *et al*. 2006; Kobayashi *et al*. 2008). Kobayashi *et al*. (2008) demonstrated that loggerheads strongly track these zones even as they shift in location, thus suggesting that strong habitat specificity during the oceanic stage also contributes to the lack of mixing. Telemetry studies in foraging areas of the eastern Pacific, near Baja California, Mexico (Nichols 2003; Peckham *et al*. 2007; H. Peckham, Pro Peninsula, unpublished data) and Peru (J. Mangel, Pro Delphinus, unpublished data) similarly show a complete lack of long distance north or south movements.

The North Pacific subpopulation of loggerheads appears to occupy an ecological setting distinct from other loggerheads, including those of the South Pacific subpopulation. In general, this is the *only* subpopulation of loggerheads to be found north of the equator in the Pacific Ocean, foraging in the eastern Pacific as far south as Baja California Sur, Mexico (Seminoff *et al*. 2004, Peckham *et al*. 2007) and in the western Pacific as far south as the Philippines (Limpus 2009). Pelagic juveniles have been found to spend much of their time foraging in the central and eastern North Pacific Ocean. The Kuroshio Extension Current, lying west of the international date line, serves as the dominant physical and biological habitat in the North Pacific and contains high productivity, likely due to unique features such as eddies and meanders that concentrate prey and allow food webs to develop. Juvenile loggerheads originating from nesting beaches in Japan were found to exhibit high site fidelity to an area referred to as the Kuroshio Extension Bifurcation Region, an area with extensive meanders and mesoscale eddies (Polovina *et al*. 2006). Juveniles also were found to correlate strongly with areas of surface chlorophyll a levels in an area known as the Transition Zone Chlorophyll Front, an area concentrating surface prey for loggerheads (Polovina *et al*. 2001, Parker *et al*. 2005, Kobayashi *et al*. 2008). Another area found ecologically unique to the North Pacific subpopulation of loggerheads, likely because of the high density of pelagic red crabs (*Pleuronocodes planipes*), is located off the Pacific coast of the Baja California Peninsula, Mexico, where researchers have documented a foraging area for juveniles based on aerial surveys and satellite telemetry (Seminoff *et al*. 2006, Peckham *et al*. 2007). Tag returns show post-nesting females migrating into the East China Sea off South Korea, China, and the Philippines, and the nearby coastal waters of Japan (Kamezaki *et al*. 2003). Clearly, the North Pacific subpopulation of loggerheads is uniquely adapted to the ecological setting of the North Pacific Ocean and throughout its long life history serves as an important part of the ecosystem it inhabits.

Loggerheads inhabiting the North Pacific Ocean are derived from Japanese beaches, with the possible exception of rare waifs over evolutionary time scales. Furthermore, nesting colonies of Japanese loggerheads are found to be genetically distinct based on mtDNA analyses, and when compared to much larger and more genetically diverse loggerhead populations in the Atlantic and Mediterranean, Pacific loggerheads have likely experienced critical bottlenecks (in Hatase *et al*. 2002a), underscoring the importance of management and protection in retaining this genetic stock.

In the South Pacific Ocean, loggerhead turtles nest primarily in Queensland, Australia, and, to a lesser extent, New Caledonia and Vanuatu (Limpus and Limpus 2003b, Limpus *et al*. 2006, Limpus 2009). Loggerheads from these rookeries undertake an oceanic developmental migration, traveling to habitats in the central and southeastern Pacific Ocean where they may reside for several years prior to returning to the western Pacific for reproduction. Loggerheads in this early life history stage differ markedly from those originating from western Australia beaches in that they undertake long west-to-east migrations, likely using specific areas of the pelagic environment of the South Pacific Ocean. An unknown portion of these loggerheads forage off Chile and Peru, and preliminary genetic information from foraging areas in the southeastern Pacific confirms that the haplotype frequencies among immature turtles in these areas closely match those found at nesting beaches in eastern Australia (Alfaro-Shigueto *et al*. 2004; Donoso and Dutton 2006, 2007; Boyle *et al*. 2009). Large immature and adult loggerheads generally remain in the western South Pacific, inhabiting neritic and oceanic foraging sites during non-nesting periods (Limpus *et al*. 1994, Limpus 2009).

Loggerheads from Australia and New Caledonia apparently do not travel north of the equator during their marine life phase. Flipper tag recoveries from nesting females have been found throughout the western Pacific, including sites north of Australia, the Torres Straight, and the Gulf of Carpentaria (Limpus 2009). Of approximately 1,000 (adult and immature; male and female) loggerheads that have been tagged in eastern Australian feeding areas, only two have been recorded migrating to breed outside of Australia; both traveled to New Caledonia (Limpus 2009). Flipper tagging programs in Peru and Chile tagged approximately 500 loggerheads from 1999-2006, none of which have been reported from outside of the southeastern Pacific (Alfaro-Shigueto *et al*. 2008a; S. Kelez, Duke University Marine Laboratory, unpublished data; M. Donoso, ONG Pacifico Laud - Chile, unpublished data). Limited satellite telemetry data (12 tags) in the area show a similar trend (J. Mangel, Pro Delphinus, unpublished data).

**Deleted:** moved

The spatial separation between the North Pacific and South Pacific loggerhead populations has contributed to substantial differences in the genetic profiles of the nesting populations in these two regions. Whereas the dominant mtDNA haplotypes among loggerheads nesting in Japan are B and C (Hatase *et al*. 2002a), loggerheads nesting in eastern Australia have a third haplotype (A) which is dominant (98% of nesting females) (Bowen *et al*. 1994, FitzSimmons *et al*. 1996, Boyle et al. 2009). Further, preliminary genetic analysis using microsatellite markers (nuclear DNA) indicates genetic distinctiveness between nesting populations in the North versus South Pacific (P. Dutton, NMFS, personal communication, 2008).

The separateness between nesting populations in eastern and western Australia is less clear, although these too are considered to be genetically distinct from one another (Limpus 2009). For example, mtDNA Haplotype CCP1 (previously A), which is the overwhelmingly dominant haplotype among eastern Australia nesting females (98%), is also found in western Australia, although at much lower frequency (33%) (FitzSimmons *et al*. 1996, 2003). The remaining haplotype for both regions was the CCP5 (previously B) haplotype. Further, FitzSimmons *et al*. (unpubl data) found significant differences in nuclear DNA microsatellite loci from females nesting in these two regions. Estimates of gene flow between eastern and western Australian populations was n order of magnitude less than gene flow within regions. Although some level of male-mediated gene flow may occur within ecological time frames, presumably during mixing at foraging areas near the Torres Straight and in the Gulf of Carpentaria, the result may also indicate homoplasy within the genetic markers in the two regions leading to a false impression of similarity.

**Comment [OU1]:** Add **FitzSimmons**, N. N.,, L. W. Farrington, M. J. McCann, C. Moritz and C. J. Limpus. 2003 Genetic Identification of Australian Marine Turtle Stocks and their Representation at Feeding Grounds and in Regional Harvests Final Report to Environment Australia

**Deleted:** 1996

**Deleted:** 1996

**Deleted:** similarities

**Deleted:** this suggests

**Deleted:** through

**Deleted:** sufficient data are not available to assess the significance of this finding. A substantial portion (39.3%) of observed alleles (n=56) were unique to either eastern or western Australian populations (FitzSimmons *et al*. 1996), thus suggesting that this male-mediated gene flow may be insignificant.

At present there is no indication from genetic studies that the loggerhead turtles nesting in eastern Australia are distinct from those nesting in New Caledonia. Of 27 turtles sequenced from

New Caledonia, 93% carried the CCP1 haplotype and the remaining had the CCP5 haplotype; similar to eastern Australia (Boyle *et al.* 2009). There remains a need to analyse these populations using nuclear DNA microsatellites.

**Formatted:** Font: Italic

**Comment [OU2]:** Ask col if there have been any swapping of nesting beeches between East Aust and New Cal- I don't think so

The South Pacific subpopulation of loggerheads occupies an ecological setting distinct from other loggerheads, including the North Pacific subpopulation. Much less is known regarding the ecosystem upon which this subpopulation depends and the oceanic environment it occupies. However, in general, loggerheads originating from these southwestern Pacific nesting beaches are thought to access areas near and far from their natal nesting beaches through semi-passive dispersal with surface currents including the East Australian Current, the Peru Current, and the Southern Equatorial Current (Limpus *et al*. 1994; J. Mangel, Pro Delphinus, unpublished data; Boyle *et al.* 2009). Sea surface temperature and chlorophyll frontal zones in the South Pacific have been shown to dramatically impact the movements of green turtles, *Chelonia mydas* (Seminoff *et al*. 2008) and leatherback turtles, *Dermochelys coriacea* (Shillinger *et al*. 2008), and it is likely that loggerheads similarly benefit from interactions with these mesoscale oceanographic features.

**Comment [OU3]:** This is only true for post hatchlings/pelagic turtles- there is a lot known of home foraging grounds

**Deleted:** such as

**Formatted:** Font: Italic

In addition to being exposed to the unique ocean current and front systems of the South Pacific, loggerheads in the South Pacific are substantially impacted by periodic environmental perturbations such as the El Niño Southern Oscillation (ENSO). This 3- to 6-year cycle within the coupled ocean-atmosphere system of the tropical Pacific brings increased surface water temperatures and lower primary productivity, both of which have profound biological consequences (Chavez *et al*. 1999). Loggerheads are presumably adversely impacted by the lower food availability that often results from ENSO events, although data on this subject are lacking. Although ENSO may last for only short periods and thus not have a long-term effect on loggerheads in the region, recent studies by Chaloupka *et al*. (2008) suggest that long-term increases in sea surface temperature within the South Pacific may influence the ability of the Australian nesting stock to recover from historic population declines.

**Comment [OU4]:** Does Col agree with this statement?

**Comment [OU5]:** If there were data on this Col would have it

Loggerheads originating from nesting beaches in the western South Pacific are the only population of loggerheads to be found south of the equator in the Pacific Ocean. As post-hatchlings, they are generally swept south by the East Australian Current (Limpus *et al*. 1994), spend a large portion of time foraging in the oceanic South Pacific Ocean, and likely a large fraction migrate to the southeastern Pacific Ocean off the coasts of Peru and Chile as juveniles (Alfaro-Shigueto *et al*. 2004, Donoso *et al*. 2000, Boyle et al. 2009). As large immatures and adults, these loggerheads' foraging range encompasses the eastern Arafura Sea, Gulf of Carpentaria, Torres Strait, Gulf of Papua, Coral Sea, and western Tasman Sea to southern New South Wales including the Great Barrier Reef, Hervey Bay, and Moreton Bay. The outer extent of this range includes the coastal waters off eastern Indonesia northeastern Papua New Guinea, northeastern Solomon Islands, and New Caledonia (in Limpus 2009).

**Comment [OU6]:** This is redundant with a previous pararaph- perhps drop part of prevous paragraph

**Deleted:** m

All loggerheads inhabiting the South Pacific Ocean are derived from beaches in eastern Australia and a lesser known number of beaches in southern New Caledonia and Vanuatu (Limpus 2009). Furthermore, nesting colonies of the South Pacific subpopulation of loggerheads are found to be genetically distinct from loggerheads in the North Pacific and Indian Ocean.

Given the information presented above, the BRT has unanimously concluded that two DPSs exist in the Pacific Ocean as a consequence of ecological, behavioral, and oceanographic factors, and genetic evidence: (1) North Pacific Ocean DPS and (2) South Pacific Ocean DPS.

The loss of the North Pacific and South Pacific DPS would result in a significant gap in the range of the taxon. As described above, the North Pacific DPS consists of a subpopulation of loggerheads found north of the equator in the Pacific Ocean and there is no evidence or reason to believe that given the loss of nesting females in Japan, that female loggerheads from South Pacific nesting beaches would repopulate the North Pacific nesting beaches. Tagging studies show that the vast majority of nesting females return to the same nesting area. As summarized by Hatase *et al*. (2002a), out of 2,219 tagged nesting females from Japan, only five females relocated their nesting sites. In addition, flipper tag and satellite telemetry research, as described in detail above, shows no evidence of north-south movement of loggerheads across the equator.

The loss of the South Pacific DPS would result in a significant gap in the range of the taxon. As described above, the South Pacific subpopulation is the only subpopulation of loggerheads found south of the equator in the Pacific Ocean and there is no evidence or reason to believe that given the loss of nesting females in eastern Australia, New Caledonia, and Vanuatu, that female loggerheads from North Pacific nesting beaches in Japan would repopulate the southern Pacific nesting beaches. Long term studies show a high degree of site fidelity by adult females in the South Pacific, with most females returning to the same beach within a nesting season and in successive nesting seasons (Limpus 1985, 2009; Limpus *et al*. 1994). This has been documented as characteristic of loggerheads from various rookeries throughout the world (Schroeder *et al*. 2003). In addition, flipper tag and satellite telemetry research, as described in detail above, shows no evidence of north-south movement of loggerheads across the equator.

### *Indian Ocean*

Loggerhead sea turtles in the Indian Ocean have a life history that involves nesting on coastal beaches, foraging in neritic and oceanic habitats, and long-distance migrations between and within these areas. The distribution of loggerheads in the Indian Ocean is limited by the Asian landmass to waters south of 30$^o$N latitude. In comparison to potential loggerhead distributions in southern waters of the Atlantic and Pacific, Indian Ocean distributions east and west are not restricted by landmasses south of approximately 38$^o$S.

Historical accounts of loggerhead turtles in the Indian Ocean were given by Smith (1849), who described the species in South Africa, and Deraniyagala (1933, 1939) who described Indian Ocean loggerheads within the subspecies *C. c. gigas*. Hughes (1974a) argued that there was little justification for this separation. This work by Deraniyagala provided evidence for the significant historical distribution of loggerheads around Sri Lanka.

Loggerhead nesting in the Southwest Indian Ocean includes the southeastern coast of Africa from the Paradise Islands in Mozambique southward to St. Lucia in South Africa, and on the south and southwestern coasts of Madagascar (Baldwin *et al*. 2003). Foraging habitats are only known for the Tongaland, South Africa loggerheads. Returns of flipper tags describe a range that extends eastward to Madagascar, northward to Mozambique, Tanzania, and Kenya, and southward to Cape Agulhas at the southernmost point of Africa (Baldwin *et al*. 2003). Satellite-tag tracks for four post-nesting loggerheads reported by Luschi *et al*. (2006) showed that turtles traveled to the same region where flipper-tag endpoints were recorded; they all moved northward, hugging the Mozambique coast and remained in shallow shelf waters for more than 2 months. No tag returns or satellite tracks indicated that South African loggerheads traveled north of the equator.

In the North Indian Ocean, Oman hosts the vast majority of loggerhead nests. The largest nesting assemblage is at Masirah Island, Oman, in the northern tropics at 21$^o$N (Baldwin *et al*. 2003). Other key assemblages occur on the Al Halaniyat Islands, and on mainland beaches south of Masirah Island to the Oman-Yemen border (IUCN - The World Conservation Union 1989a, 1989b; Salm 1991; Salm and Salm 1991). In addition, nesting probably occurs on the mainland of Yemen on the Arabian Sea coast, and nesting has been confirmed on Socotra, an island off the coast of Yemen (Pilcher and Saad 2000). Baldwin *et al*. (2003) list other major nesting assemblages (> approximately 400 nesting females/year) at Oman's Arabian Sea Coast (17-20$^o$S); Al Halaniyat Islands, Oman (17$^o$S); Tongaland, South Africa (27$^o$S); and Dirk Hartog Island, Western Australia, Australia (26$^o$S).

Outside of Oman, loggerhead nesting is rare in the North Indian Ocean, although small nesting concentrations occur in Sri Lanka, southern India, and the Gulf of Mannar (Deraniyagala 1939, Kar and Bhaskar 1982, Dodd 1988). The only verified nesting beaches for loggerheads on the Indian subcontinent are found in Sri Lanka. Reports of regular loggerhead nesting on the Indian mainland are likely to be from misidentifications of olive ridleys (*Lepidochelys olivacea*) (Tripathy 2005, Kapurusinghe 2006). The only loggerhead nesting reported in south and southeastern Asia occurs in Myanmar (Thorbjarnarson *et al*. 2000).

Limited information exists on foraging locations of North Indian Ocean loggerheads. Foraging individuals have been reported off the southern coastline of Oman (Salm *et al*. 1993) and in the Gulf of Mannar, between Sri Lanka and India (Tripathy 2005, Kapurusinghe 2006). Satellite telemetry studies conducted in Oman have revealed new information on post-nesting migrations of loggerheads nesting on Masirah Island. (Environment Society of Oman and Ministry of Environment and Climate Change, Oman, unpublished data). Results reveal extensive use of the waters off the Arabian peninsula, with the majority of telemetered turtles (15 of 20) traveling southwest, following the shoreline of southern Oman and Yemen , and circling well offshore in nearby oceanic waters. A minority traveled north as far as the western Persian (Arabian) Gulf (3 of 20) or followed the shoreline of southern Oman and Yemen as far west as the Gulf of Aden and the Bab-el-Mandab (2 of 20). These preliminary data suggest that post-nesting migrations and adult female foraging areas may be centered within the region (Environment Society of Oman and Ministry of Environment and Climate Change, Oman, unpublished data).
No tag returns or satellite tracks indicated that loggerheads nesting in Oman traveled south of the equator.

In the East Indian Ocean, western Australia hosts all known loggerhead nesting (Dodd 1988). Nesting distributions in western Australia span from the Shark Bay World Heritage Area northward through the Ningaloo Marine Park coast to the North West Cape and to the nearby Muiron Islands (Baldwin *et al*. 2003). Nesting individuals from Dirk Hartog Island have been recorded foraging within Shark Bay and Exmouth Gulf, while other adults range into the Gulf of Carpentaria (Baldwin *et al*. 2003). At the eastern extent of this apparent range, there is possible overlap with loggerheads that nest on Australia's Pacific coast (Limpus 2009). However, despite extensive tagging at principal nesting beaches on Australia's Indian Ocean and Pacific coasts, no exchange of females between nesting beaches has been observed (Limpus 2009). No tag returns suggest that loggerheads nesting in western Australia traveled north of the equator.

Bowen *et al*. (1994) described mtDNA sequence diversity among eight loggerhead nesting assemblages and found one of two principal branches in the Indo-Pacific basins. Using additional published and unpublished data, Bowen (2003) presented a phylogeographic tree showing divergence between these two lineages to be approximately three million years. Bowen points out evidence for more recent colonizations (250-12 thousand years before present) between the Indian Ocean and the Atlantic-Mediterranean. For example, the sole mtDNA haplotype (among eight samples) observed by Bowen *et al*. (1994) at Masirah Island, Oman, is known from the Atlantic and suggests some exchange between oceans some 250 thousand years ago. The other principal Indian-Ocean haplotype reported by Bowen *et al*. (1994) was seen in all loggerheads sampled (n=15) from Natal, South Africa. Encalada *et al*. (1998) reported that this haplotype was common throughout the North Atlantic and Mediterranean, thus suggesting a similar exchange between Atlantic and Indian oceans as recently as 12 thousand years ago (Bowen *et al*. 1994). Bowen (2003) speculated that Indian-Atlantic Ocean exchanges took place via the temperate waters south of South Africa and became rare as the ocean shifted to cold temperate conditions in this region.

In estimates of loggerhead gene flow in and out of the Indian Ocean, J.S. Reece (Washington University, personal communication, 2008) factored 100 samples from Masirah Island, 249 from Atlantic rookeries (from Encalada *et al*. 1998), and 311 from Pacific rookeries (from Hatase *et al*. 2002a and Bowen *et al*. 1995). Reece used lineage coalescence methods to estimate that gene flow, expressed as number of effective migrants, or exchanges of breeding females between Indian Ocean rookeries and those from the Atlantic or Pacific occurred at the rate of less than 0.1 migrant per generation. Reece estimated gene flow based on coalescence of combined mtDNA and nDNA data to be approximately 0.5 migrants per generation. These results, while somewhat theoretical, do indicate that there is restricted gene flow into and out of the Indian Ocean. The low level of gene flow most likely reflects the historical connectivity over geological timescales, rather than any contemporary migration, and is consistent with Bowen's hypothesis that exchange occurred most recently over 12,000-3,000,000 years ago, and has been restricted over recent ecological timescales.

The distinct status of three loggerhead groups in the Indian Ocean is supported by observations of tag returns, satellite telemetry, and matriarchal genetics. Distinct status is supported for the North Indian Ocean, Southwest Indian Ocean, and Southeast Indo-Pacific Ocean. Although there is not a sufficiently clear picture of male mediated gene flow between these regions, we propose that significant vicariant barriers exist between these three Indian Ocean groups that would prevent exchange of males on a time scale relative to management and conservation efforts. These vicariant barriers are the oceanographic phenomena associated with Indian Ocean equatorial waters, and the large expanse between continents in the South Indian Ocean without suitable benthic foraging habitat.

Given the information presented above, the BRT has unanimously concluded that three DPSs exist in the Indian Ocean as a consequence of ecological, behavioral, and oceanographic factors, and genetic evidence: (1) North Indian Ocean DPS, (2) Southwest Indian Ocean DPS, and (3) Southeast Indo-Pacific Ocean DPS.