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File size:	9.4M
Page count:	22
Word count:	66
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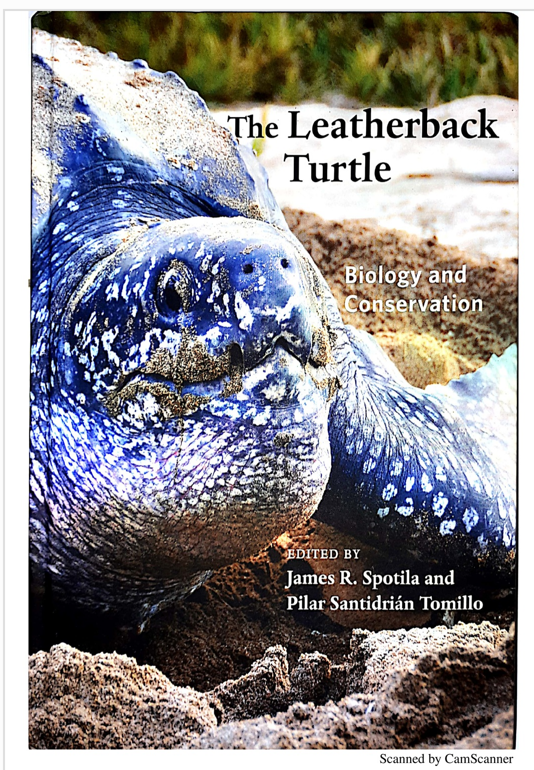
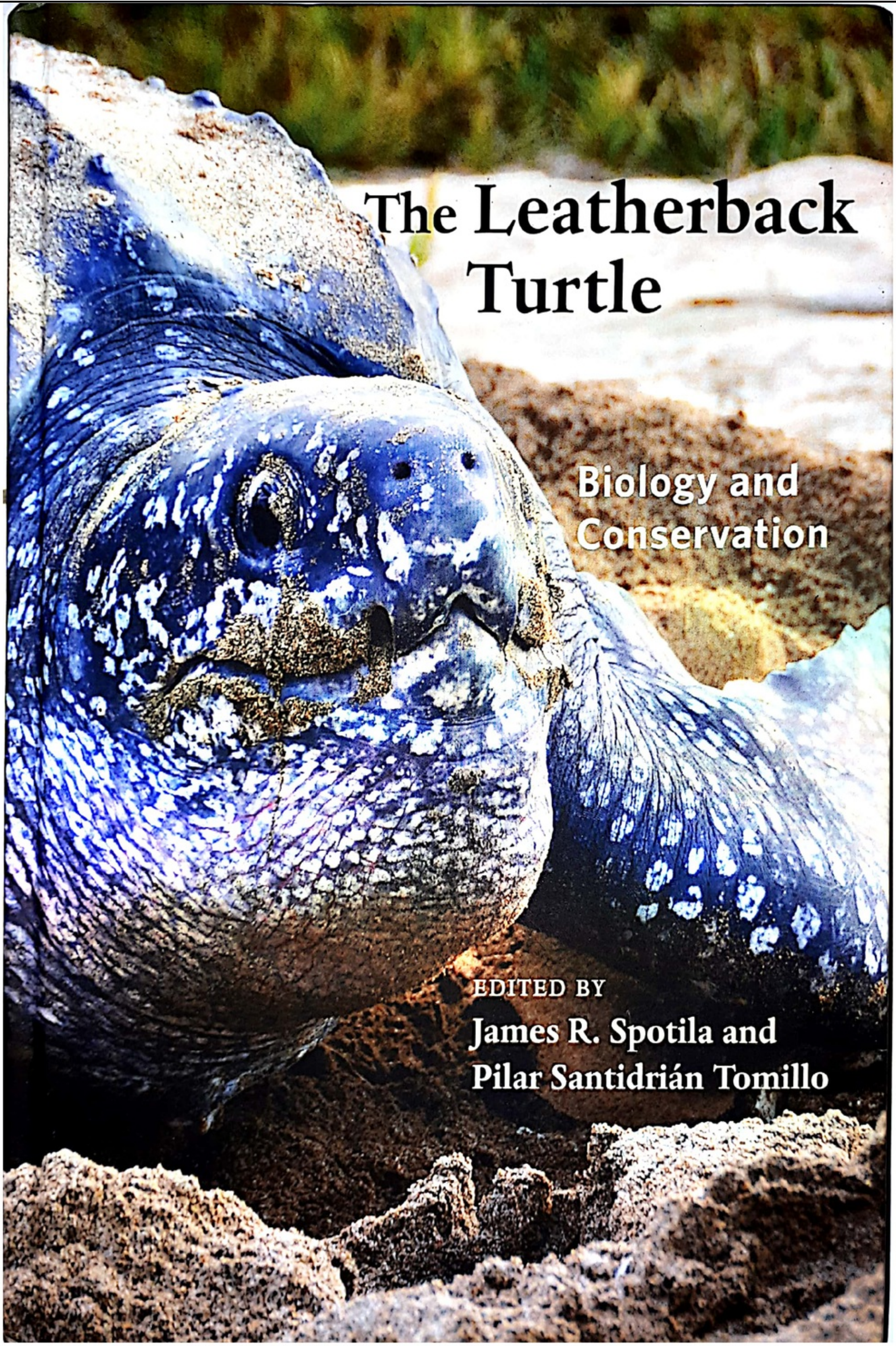


Leatherback Turtle Populations in the Pacific Ocean

by Scott Benson


The Leatherback Turtle
Biology and Conservation
EDITED BY
James R. Spotila and
Pilar Santidrián Tomillo

The Leatherback Turtle

Ricardo,
Thanks for your great
work on the book.

[illegible]

Drexel UNIVERSITY

Biodiversity, Earth and Environmental Science
College of Arts and Sciences

November 3, 2015
609-440-5158

Dr. Ricardo F. Tapilatu
Marine Laboratory
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Dear Ricardo:

It is our pleasure to enclose your copy of our book entitled "The Leatherback Turtle: Biology and Conservation." Please, find a link to the book at John Hopkins University Press website at the end of this letter. As an author you will receive a 40% discount on all books from the Press. To obtain the discount you have to call your order in and tell the person that you are an author.

We would like to thank you for your contribution to the book. You made it a much better product because of your hard work on the project. We think that the book will serve as a reference to sea turtle biologists, conservationists, marine biologists and other people interested in turtles. We are excited to see the project completed and, like you, look forward to reading the book in depth.

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All the best,

James R. Spotila
Drexel University
Philadelphia, USA

Pilar Santidrián Tomillo
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The Leatherback Turtle
Biology and Conservation

Edited by James R. Spotila
and Pilar Santidrián Tomillo

JOHNS HOPKINS UNIVERSITY PRESS | BALTIMORE

Printed in the United States of America on acid-free paper
9 8 7 6 5 4 3 2 1

Johns Hopkins University Press
2715 North Charles Street
Baltimore, Maryland 21218-4363
www.press.jhu.edu

Library of Congress Cataloging-in-Publication Data

The leatherback turtle : biology and conservation / edited by James R. Spotila and Pilar Santidrián Tomillo.
pages cm
Includes bibliographical references and index.
ISBN 978-1-4214-1708-0 (hardcover : alk. paper) — ISBN 1-4214-1708-1 (hardcover : alk. paper) — ISBN 978-1-4214-1709-7 (electronic) — ISBN 1-4214-1709-X (electronic) 1. Leatherback turtle. 2. Leatherback turtle—Conservation. I. Spotila, James R., 1944- editor. II. Santidrián Tomillo, Pilar, 1974- editor.
QL666.C546L43 2015
597.92'89—dc23 2014036887

A catalog record for this book is available from the British Library.

Contents

Color plates follow pages 48 and 128.

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10

Leatherback Turtle Populations in the Pacific Ocean

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NICOLAS PILCHER,
PILAR SANTIDRIÁN TOMILLO,
AND LAURA SARTI MARTÍNEZ

The leatherback turtle, *Dermochelys coriacea*, is globally listed as vulnerable under the International Union for the Conservation of Nature (IUCN) criteria (Wallace et al. 2013), but trends and status differ markedly among basins (Sarti Martínez 2000; Eckert et al. 2012). While populations in the Atlantic appear largely stable or increasing (Turtle Expert Working Group 2007; Stewart et al. 2011), populations in the Pacific Ocean basin have declined precipitously during the last several decades, including declines of more than 90% in Mexico and Costa Rica (Sarti Martínez et al. 2007; Santidrián Tomillo et al. 2007; Santidrián Tomillo et al. 2008) and 78% in Papua Barat, Indonesia (Tapilatu et al. 2013). Therefore, the Pacific populations are listed as critically endangered (Wallace et al. 2013). This is particularly notable because Pacific nesting populations once represented the largest breeding populations of leatherbacks in the world (Spotila et al. 2000). Land-based threats have included overharvesting of eggs, coastal development, beach erosion, lethal sand temperatures, predation of eggs and hatchlings by introduced predators, and harvesting of adult females for meat (e.g., Tapilatu and Tiwari 2007; Tiwari et al. 2011; Sarti Martínez et al. 2007; see Eckert et al. 2012 for overview). At-sea causes of mortality include incidental bycatch in diverse industrial and artisanal fisheries, killing of free-swimming animals for food or bait, and possibly ingestion of marine pollution such as plastic bags (e.g., NMFS and USFWS 1998; Sarti Martínez 2000; Eckert et al. 2012).

Within the Pacific basin, leatherbacks are known to inhabit a wide range of coastal and pelagic waters in tropical and temperate ecosystems. They are found from the equator to subpolar regions in both hemispheres, although nesting activity is confined to tropical and subtropical latitudes. Major nesting populations of leatherbacks are located on both sides of the Pacific basin. Genetic studies and movement data (Dutton et al. 2000; Dutton et al. 2007; Shillinger et al. 2008; Benson et al. 2011; chapter 2) have confirmed the existence of three genetically and demographically distinct subpopulations: eastern Pacific, Malaysian, and western Pacific (fig. 10.1), although the Malaysian population is now considered functionally extinct (Chan and Liew 1996). The level of research and monitoring activities has differed among populations, and each will be discussed separately in the pages that follow.

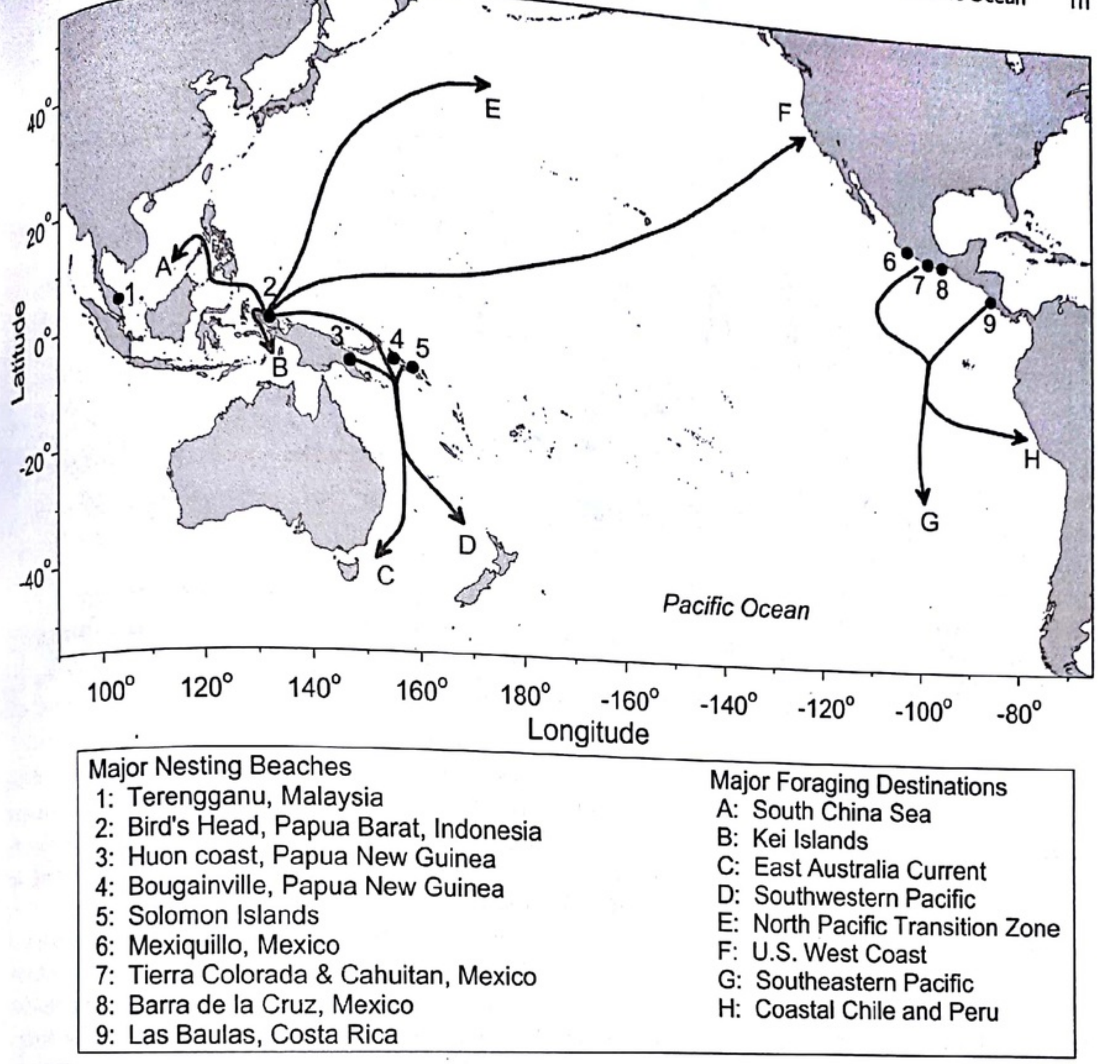

Fig. 10.1. Map of Pacific basin showing major known nesting beaches (1–9; past and present), major known foraging areas (A–H), and stylized movement patterns from nesting beaches to foraging grounds. Sources: Eckert and Sarti (1997), Mast (2006), Shillinger et al. (2008), and Benson et al. (2011).

Eastern Pacific Leatherback Population

Leatherback nesting in the eastern Pacific ranges from the southern tip of Baja California, Mexico, to Panama (Mast 2006; Seminoff and Wallace 2012). The nesting season extends from October/November through March, with a peak in December/January (Eckert et al. 2012; Sarti et al. 2003). Limited information is available on the total number of nesting females or total population size prior to the 1980s, and early estimates of total Pacific nesting activity and number of females varied widely. As recently as 1971, no areas of concentrated nesting activity were known (Pritchard 1971), but reports began to emerge of thousands of nesting leatherbacks at beaches along the Mexican Pacific coast (Márquez et al. 1981; Fritts et al. 1982), and the first eastern Pacific estimate was over 87,000 females (Pritchard 1982). Information on population trends is most comprehensive for leatherback nesting beaches in Costa Rica and Mexico (Sarti Martínez et al. 2007; Santidrián Tomillo et al. 2007).

Mexico

Pritchard conducted the first comprehensive aerial survey of leatherback nests along the Pacific coast of Mexico in 1981 (Pritchard 1982), resulting in an estimate of 75,000 nesting females within this region. Nests were so dense that Pritchard (1982) considered this to be a minimum estimate. Beginning in 1982, systematic

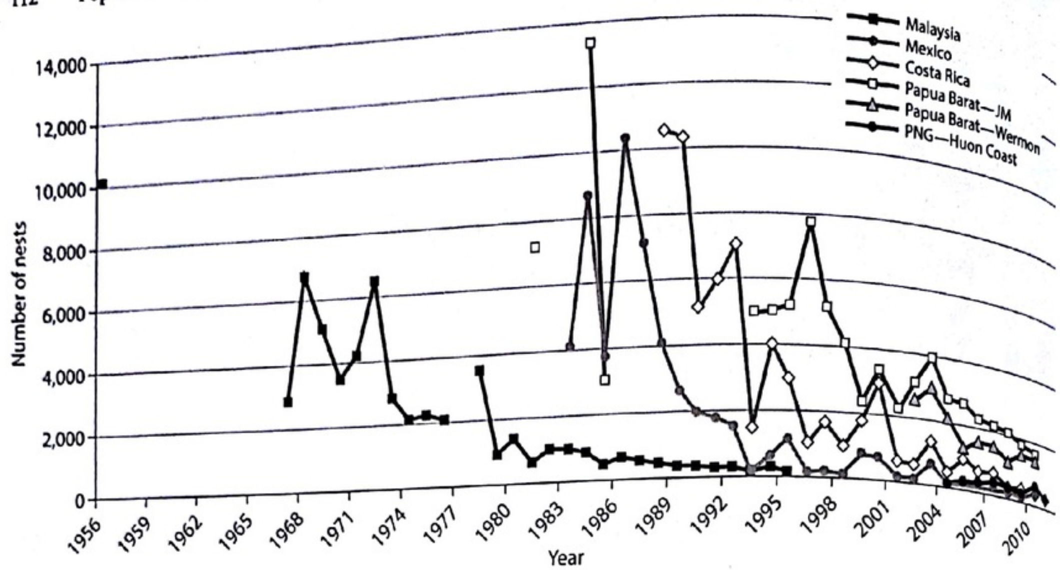

Fig. 10.2. Nesting trends of leatherback turtles (*Dermochelys coriacea*) at major nesting beaches in the Pacific, 1956–2011. Sources: Chan and Liew (1996) for Malaysia; Sarti Martínez et al. (2007) and L. Sarti Martínez (unpublished data) for Mexico; Santidrián-Tomillo et al. (2007) and F. V. Paladino and J. R. Spotila (unpublished data) for Costa Rica; Tapilatu et al. (2013) for Papua Barat; and N. Pilcher et al. (unpublished data) for PNG, Huon Coast.

monitoring and conservation activities began at nesting beaches in Mexico (Sarti Martínez et al. 2007). Standardized monitoring methods were implemented in 1997 at four index beaches spanning a total of 64 km (fig. 10.1), which were estimated to encompass about 42% of the total leatherback nesting activity on the Mexican Pacific coast. Several secondary beaches, spanning about 150 km in combined length and including an additional 31% of the total leatherback nesting activity, were monitored less frequently since 1982. Peak nest counts along a single 4 km stretch of beach at Mexiquillo included 5,000 nests in 1985–1986, resulting in a total estimate for the entire 18 km index site of over 10,000 nests. A marked decline in nest counts occurred at several beaches during the 1993–1994 season, followed by continued declines and a low of only 120 nests recorded across all four index beaches during 2002–2003 (fig. 10.2). Despite intensive conservation efforts to protect eggs and increase hatchling success during the past decade, this decline had not been reversed as of 2011 (fig. 10.2).

Central America

A similar pattern of sharp population decline occurred at the largest known nesting beach complex spanning 6 km of coastline in Parque Nacional Marino Las Baulas (PNMB), Nicoya Peninsula, Costa Rica (including Playa Grande, Playa Langosta, and Playa Ventanas). Monitoring began in 1988, and these beaches support about 85–90% of leatherback nesting on the Pacific coast of Costa Rica (Santidrián Tomillo et al. 2007). A population of over 1,500 leatherbacks that nested during the 1988–1989 season declined to only 100 individuals by 2006–2007 (Spotila et al. 1996; Spotila et al. 2000; Santidrián Tomillo et al. 2007; Santidrián Tomillo et al. 2008; fig. 10.2). For comparison with other nesting beaches for which only nest counts are available, this decline would correspond to a change from about 10,500 nests to 700 nests, based on a clutch frequency of 7 per season (Reina et al. 2002). As with the Mexican nesting populations, the steepest declines occurred during the 1990s.

Additional beaches in Costa Rica with lower levels of nesting activity (see Mast 2006 for details) include Ostional National Wildlife Refuge (59 nests in 2004, 4 nests in 2012); Caletas (24 nests in 2004); and San Miguel, Guanacaste (2 nests in 1999, 1 nest in 2000, no nests since 2001). The lengths of these beaches (3–7 km) are comparable to other major nesting beaches along the Central American Pacific coast, but historical nesting counts are not available for the evaluation of trends or past importance to the eastern Pacific leatherback population. Substantial nesting activity was also documented in 1989–1993 at Playa Naranjo in Santa Rosa National Park, Costa Rica (just north of the Nicoya Peninsula), with 466–1,212 leatherback crawls reported per season (Araúz-Almengor and Morera-Avila 1994). Recent nest count data for Playa Naranjo have not been published, but a 1999 aerial survey designed to identify major leatherback nesting areas along the entire Central American Pacific coast (Sarti et al. 2000) found only 11 nests in Costa Rica outside of the Nicoya Peninsula. Some additional nesting activity was documented during the 1999 aerial survey in Nicaragua (61 nests), Guatemala (6), El Salvador (4), and Panama (4). Sarti et al. (2000) concluded that the lack of any new major nesting beaches confirmed the decline of the eastern Pacific leatherback population, rather than a potential shift of nesting activity to new beaches. Since 2002, monitoring efforts at three major Nicaraguan nesting beaches identified 48 distinct females and documented up to 420 nests annually (Urteaga et al. 2012) Prior to 2002, nearly 100% of the eggs were poached, but conservation efforts are now protecting about 94% of the nests (Urteaga et al. 2012).

Causes of Decline and Conservation Efforts

Causes of the decline are documented most thoroughly for leatherbacks nesting at the main index beaches at PNMB, Costa Rica, and in Mexico. The dominant factor appears to be egg harvesting for consumption, although mortality of adult animals at sea and on nesting beaches contributed, and has become increasingly important as population sizes have decreased. Illegal harvest of eggs is the primary cause of population collapse at PNMB (Santidrián Tomillo et al. 2008). Although egg harvesting by local inhabitants who lived adjacent to the beaches occurred as early as the 1950s, systematic large-scale poaching occurred during the 1970s when newly constructed roads provided access to people from distant villages and cities. Illegal plunder of eggs continued for 16 years, removing an estimated 90% of eggs, until Parque Nacional Marino Las Baulas was established in 1991.

In Mexico, Sarti Martínez et al. (2007) reviewed the likely causes of the sharp decline in nesting activity at Mexiquillo during the 1993–1994 season. They identified (1) intensive egg harvest, slaughter of adults on the beaches, and bycatch at sea; (2) natural fluctuations in the reproductive biology of leatherbacks; or (3) movement by nesting females to un-monitored beaches as possible causes. To address these factors, "Proyecto Láud" (Leatherback Project) was developed to coordinate monitoring and management activities at multiple primary and secondary nesting beaches in Mexico (Sarti Martínez et al. 2007; Sarti and Barragán 2011). Investigators collected data to assess the size of the nesting population, including replicated aerial surveys of the entire Mexican coast to ensure that previously unknown nesting aggregations were not overlooked. They calculated reproductive parameters, such as average estimated clutch frequency (ECF) and average clutch interval (CI) and compared them to those at two other leatherbacks nesting beaches: PNMB, Costa Rica (where nesting has also declined), and St. Croix, US Virgin Islands in the Caribbean, where nesting activity was increasing. The effort spanned 214 km of Mexican coastline and included relocation of clutches when in situ incubation was unsafe due to likely poaching or predation.

Although some movement of turtles between various index sites occurred, aerial surveys did not locate any large, previously unknown aggregations of nesting leatherbacks, thereby refuting the hypothesis of possible movement to unknown areas as a cause of decline at index beaches. Reproductive parameters were similar to values reported from the declining nesting population in Costa Rica (Sarti Martínez et al. 2007; Spotila et al. 2000). The proportion of remigrant turtles (nesting turtles returning from previous seasons) for both of these declining populations (22–25%) was much lower than for the increasing population at St. Croix during the same period (52%). Estimated mortality of female leatherbacks nesting at PNMB, Costa Rica is 22–25% (Reina et al. 2002; Santidrián Tomillo et al. 2007). The combined results of these studies indicated substantial at-sea mortality of adult eastern Pacific leatherback turtles. Fishery bycatch of at least 1,500 animals per year was documented in a variety of gill net and longline fisheries in the North Pacific and off Central and South America (Spotila et al. 2000). However, the source population of these leatherbacks was not determined until genetic and telemetry studies were conducted beginning in the late 1990s, revealing that eastern Pacific leatherbacks are subject to bycatch in fisheries of the eastern tropical Pacific and off South America (fig. 10.1; Eckert and Sarti 1997; Dutton et al. 2000; Shillinger et al. 2008).

Although little is known about historic bycatch rates and the total number of leatherbacks killed in these areas, intentional and incidental takes of leatherbacks have occurred in waters off Central and South America since at least the 1970s (Brown and Brown 1982; Alfaro-Shigueto et al. 2007; Saba et al. 2008). Total leatherback mortality in coastal fisheries may have been substantial, and Eckert and Sarti (1997) estimated that a minimum of 2,000 leatherbacks were killed annually in gill net fisheries off Chile and Peru, based on data collected during the 1980s and 1990s. In a single Peruvian port (Pucusana), 200 adult and subadult leatherbacks were killed during the 1978 season alone (Brown and Brown 1982), and this fishery was not banned until 1995 (Morales and Vargas 1996). Bycatch also occurred in longline fisheries for swordfish off Chile and Peru; however, recent conservation efforts have reduced the number of turtles killed in these fisheries (Donoso and Dutton 2010) or show promise for future reductions (Alfaro-Shigueto et al. 2012).

Ongoing conservation efforts for eastern Pacific leatherbacks include active programs to protect nesting beaches and enhance reproductive output through increased hatchling survival (e.g., Arauz et al. 2003; Santidrián Tomillo et al. 2007; Santidrián Tomillo et al. 2008; Sarti Martínez et al. 2007). No indication of a reversal of the declining population trend is yet apparent (fig. 10.2); however, recent simulations (Saba et al. 2012) have highlighted the need to continue these programs to mitigate the projected adverse effects of climate change on eastern Pacific leatherback reproduction.

Malaysian Leatherback Population

The most dramatic decline in a Pacific leatherback population occurred at Terengganu, Malaysia, where there were over 10,000 nests annually during the 1950s and the population was reduced to less than 1% of its historic size by 1995 (Chan and Liew 1996). The primary cause was the nearly complete removal of eggs for many decades, although bycatch in fisheries that rapidly expanded during the 1970s accelerated the decline (Chan et al. 1988). As late as 1984–1985, when the population had already collapsed dramatically (Hamann, Ibrahim, and Limpus 2006), hundreds of leatherback deaths per year occurred in Malaysian fisheries. Low-level nesting activity along the adjacent coast of southeastern Thailand also ceased by the 1980s (Mortimer 1988). Similarly, a nesting population of leatherbacks in Vietnam that was estimated to include 500 females laying 10–20 nests per night prior to the 1960s, declined to a small remnant population with 10–20 nests per year by 2002 (Hamann, Kuong, et al. 2006). Only rare sporadic nesting has occurred at Terengganu over the last decade, and the Malaysian population appears to be functionally extinct (Liew 2011).

Western Pacific Leatherback Population

Monitoring activities in most areas of the western Pacific are relatively recent, and comparatively less is known about historically important nesting areas, status, and trends. The records are further confounded by changes in place names and jurisdictional boundaries during the past decades (e.g., the Indonesian province formerly known as Irian Jaya is currently comprised of two provinces named Papua and Papua Barat, and common-use village names have changed over time). Below we use current naming conventions, which may differ from those reported in the cited sources.

Papua Barat, Indonesia

Salm (1981) published the first indication of a significant nesting population in the western Pacific region outside Malaysia; this was based on an August aerial survey to assess four reputedly large leatherback nesting sites being considered for "reserve" designation on the north coast of Bird's Head Peninsula, Papua Barat, Indonesia. Leatherback nesting activity documented during the aerial survey was lower than expected, and one beach had no indication of leatherback nesting activity. Salm (1981) considered it likely that locals from adjacent villages had collected all the eggs, and concluded that turtle populations at those four beaches were already drastically depleted by egg and turtle collecting. However, in other areas on the north coast of Bird's Head Peninsula, Salm (1981) discovered previously undocumented nesting beaches that contained thousands of leatherback nests. His account was eerily similar to the description provided by Pritchard (1982) from Mexico, with nest densities so great that a precise count was impossible. At the time, Salm (1981) did not provide location details out of concern that public disclosure prior to protection would be detrimental. Follow-up studies during the 1980s and 1990s indicated that these large nesting populations were located along the less developed coastal beaches of northern Bird's Head Peninsula, at Jamursba-Medi Beach (Bhaskar 1985).

Systematic monitoring of leatherbacks, primarily in the form of annual nest counts, began during the early 1990s on the north coast of the Bird's Head Peninsula (Hitipeuw et al. 2007). Within this region, nesting occurs mainly at Jamursba-Medi, a complex of three beaches that span 18 km, and Wermon, a smaller 6 km beach approximately 30 km east of Jamursba-Medi. The primary nesting season at Jamursba-Medi occurs during May–September, while nesting occurs year-round at Wermon with peaks in July and December. Hitipeuw et al. (2007) provided the first assessment of trends at Jamursba-Medi between 1984 and 2004, concluding that the estimated number of nesting females declined from a peak of 2,303–3,036 in 1984 (based on nest counts by Bhaskar [1987]) to 667–879 during 2004. They also reported that nesting at Wermon during two seasons in 2002–2004 was only slightly lower than nesting at Jamursba-Medi, with year-round nesting and a second peak during January. However, beach erosion and predation by pigs and dogs caused the loss of 28% of nests at Wermon (Hitipeuw et al. 2007). Thus, although the leatherback nesting population at Bird's Head had not experienced the collapse observed at Malaysian and eastern Pacific rookeries, declines and population impacts were evident.

Follow-up studies at Bird's Head have increased monitoring activities at Jamursba-Medi and Wermon to identify trends in the total number of nesting females in this population. Tapilatu et al. (2013) applied correction factors to partial nest counts going back as far as 1984, based on more comprehensive data collected between 2004 and 2011. At Bird's Head, the total estimated number of nests has undergone a steady and sustained decline at both beaches, averaging about 5.9% per year since 1984. At Jamursba-Medi, total nest counts declined by 78.3%, from 14,522 nests in 1984 to 1,596 in 2011. A shorter time series at Wermon revealed a decline of 62.8% between 2002 and 2011 (from 2,994 to 1,096 nests). The most recent numbers of females nesting annually, for both beaches combined, were estimated to be 382 during the boreal summer 2011, and 93 during the austral summer of 2011–2012, based on estimated clutch frequency and clutch interval (Tapilatu et al. 2013). Thus, the last remaining significant nesting population of Pacific leatherbacks is also at risk of imminent collapse unless effective conservation efforts are implemented immediately.

Papua New Guinea

During a comprehensive review of marine turtles in Papua New Guinea (PNG) covering all areas except Morobe, Northern, and Gulf Provinces, Spring (1982a) reported regular, but low-density leatherback nesting activity along the north coast of PNG and on several islands including Manus, Long, New Britain, New Ireland, and Normanby. Occasional nesting was reported at Bougainville and Woodlark Islands. Village surveys indicated that population declines were already underway in many areas, primarily because of changes in village life brought about through the introduction of new technologies (e.g., outboard motors) and a cash economy (Spring 1982a, 1982b), which increased access to beaches and incentives for egg harvest. Local villagers in many areas regularly consumed eggs and nesting female leatherbacks. Substantial nesting activity was documented in Morobe Province, including a few hundred females along a 15 km beach at Busama (Maus Buang), and greater nesting activity was reported at Lababia village about 30 km to the south, within the Kamiali Wildlife Management Area (Quinn and Kojis 1985; Bedding and Lockhart 1989). Extensive and nearly complete egg harvest occurred at Busama, with up to 70% of leatherback eggs taken to markets in the nearby city of Lae, with another 20% consumed locally (Quinn and Kojis 1985). Peak nesting occurs during December–January.

Aerial surveys to assess leatherback nesting in PNG during January–February of 2004–2006 confirmed that the largest concentration of nesting activity within PNG occurred along the Morobe Province where there were up to 320 nests (Benson et al. 2007). A monitoring program for nesting leatherbacks began during 1999 and expanded to include additional beaches along the Huon coast during 2005–2007. Since 2006–2007, nesting activity has been relatively stable with 200–500 nests per year and the greatest level of nesting at two beaches near the city of Lae (Busama and Labu Tale) and at the Kamiali Wildlife Management Area (Pilcher 2012; fig 10.2).

Solomon Islands

Nesting of leatherbacks in Solomon Islands takes place along numerous isolated beaches on several islands (McKeown 1977; Vaughan 1981), peaking during November–January. Activity across all beaches varies from a few nests per season to over 20 nests in a single night, totaling a minimum of several hundred nests throughout the entire Solomon Island archipelago per season (Vaughan 1981; Dutton et al. 2007). The greatest annual nesting activity (summarized by Dutton et al. 2007) occurs on Santa Isabel (640–717 nests), Choiseul (50 nests), and Rendova and Tetepare (123 nests), but some nesting also occurs on most of the other major islands. Killing of nesting leatherbacks was common throughout Solomon Islands, and eggs were also consumed regularly. Declines were suspected as early as the 1970s, particularly at beaches near villages (Vaughan 1981). Breakdown of traditional customs, increasing population size, better access to nesting beaches, and lack of enforcement of laws protecting turtles were listed as contributing factors where declines were observed (Vaughan 1981; Leary and Laumani 1989).

Other South Pacific Islands

Low levels of nesting occur on several islands of Vanuatu, with 31 nests documented during November–February 2002–2003 on Epi Island (Petro et al. 2007). The islands of Fiji also have occasional leatherback nesting, but most early accounts involved capture and

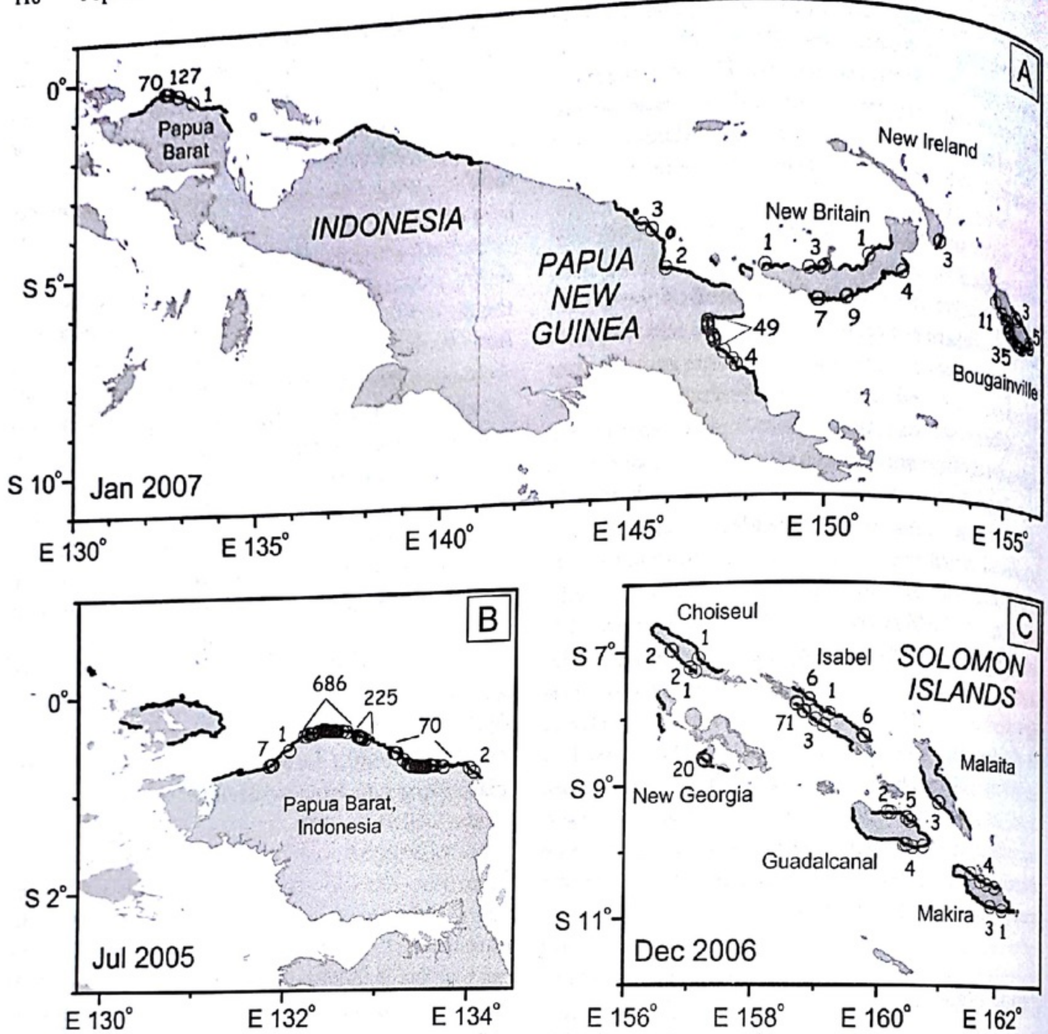

Fig. 10.3. Leatherback (*Dermochelys coriacea*) nests detected during tri-national aerial surveys conducted in (A) Papua and Papua Barat (Indonesia) and Papua New Guinea during January 2007, (B) Papua Barat during July 2005, and (C) Solomon Islands during December 2006. Black lines indicate aerial survey coverage and gray circles show areas of nesting activity with the number of nests shown. From Benson et al. (2012), and S. Benson (unpublished data).

killing of the animals (Guinea 1993). Nesting of leatherbacks is rare in Australia, but isolated historical records exist and report December–February nesting along the eastern coast of Queensland, in New South Wales, and in the Northern Territories (Limpus 2009).

Multinational Assessments

A summary of nest counts at 28 western Pacific nesting sites (Dutton et al. 2007) indicated there were 5,067–9,176 nests annually, with the majority of nesting activity occurring within the Jamursba-Medi and Wermon beaches of Papua Barat, and most remaining activity taking place on Huon Coast beaches of PNG and on Santa Isabel Island, Solomon Islands. Although the authors of that study suggested caution when deriving the number of turtles from nest counts, they estimated a minimum range of 844–3,294 females nesting annually. A coordinated, tri-national aerial survey to assess regional leatherback nesting activity in PNG, Solomon Islands, and along the north coast of Bird's Head, Papua Barat, was completed during December 2006–January 2007 (Benson et al. 2012). Although turtle nests are only visible from an aircraft for a period of time that depends upon tides, weather, and overall beach activity, such broad-scale aerial surveys are effective at identifying major nesting beaches within a region and documenting the relative importance of various beaches (Sarti

Martinez et al. 2007; Benson et al. 2012). Combined with a separate aerial survey in Papua Barat during July 2005 (fig. 10.3), the tri-national surveys confirmed that Bird's Head Peninsula in Papua Barat is the primary remaining nesting beach during both winter and summer seasons. Secondary, lower-level, boreal winter nesting occurs at a few beaches in PNG (Huon Coast and Bougainville; Kinch et al. 2012) and Solomon Islands, with scattered reports of occasional nesting elsewhere (e.g., Yapen and Waigeo Islands during boreal summer). No previously unknown nesting areas were identified. Leatherback nesting appears to be seasonally limited to those regions where beaches are in suitable condition. The seasonal monsoons affect wind, rain, and ocean current patterns, causing sand erosion and accretion to modify beach morphology markedly throughout the year (Benson et al. 2007; Hitipeuw et al. 2007).

Causes of Decline and Conservation Efforts

Kaplan (2005) conducted a Pacific-wide risk assessment of leatherback turtles that included consideration of multiple sources of mortality, including egg collection, killing of adults on nesting beaches and foraging grounds, and bycatch of turtles at sea. There is a long history, spanning many human generations, of harvesting sea turtles and their eggs for local subsistence use in the western Pacific region (Spring 1982b; Bhaskar 1987). Leatherback turtles have been an important part of the culture of indigenous populations through harvest of eggs and of adults (Suarez and Starbird 1995; Hitipeuw et al. 2007). With the introduction of a cash economy and motorized boats during the 1980s, the harvest of eggs and adults expanded to provide a source of income beyond the subsistence needs of local villages (e.g., Spring 1982b; Betz and Welch 1992); this involved nearby urban markets. This increased harvest pressure on leatherback populations caused sharp declines during the 1980s and beyond (Hitipeuw et al. 2007). Continued at-sea harvests of foraging leatherbacks and nesting females (e.g., in the Kei Islands, Indonesia; Benson et al. 2011) contributed to this trend.

Concern over the observed declines resulted in local programs to eliminate egg harvesting at key nesting beaches (Hitipeuw et al. 2007) and efforts to raise local awareness of the need to prevent the killing of adults. However, local customs vary and the success of such educational programs has been mixed. The taking of eggs and adults still occurs in many areas of western Pacific, especially where there are no active conservation programs (e.g., Kinch et al. 2012; Benson et al. 2011). Furthermore, recovery has remained hampered by other factors, including depredation by feral pigs and hunting dogs, loss of nests through beach erosion, and lethal sand temperatures leading to high rates of hatching failure (Tapilatu and Tiwari 2007).

At-sea bycatch of western Pacific leatherbacks occurs in a variety of gill net, trawl, and longline fisheries (as described below), but little is known about the total magnitude or full geographic extent of this source of mortality, in part because the movements of western Pacific leatherbacks are poorly understood. Recently, integrated telemetry studies identified movements of western Pacific leatherbacks into the North Pacific, southeastern Pacific, and Indo-Pacific tropical seas (fig. 10.1) and revealed fidelity to specific foraging regions (Benson et al. 2011; Seminoff et al. 2012). Several of the turtles tagged in Papua Barat, Indonesia, were known or suspected to have been killed in fisheries operating off Japan, Philippines, and Malaysia (Benson et al. 2011).

Historically, significant leatherback bycatch occurred in the North Pacific high seas drift net fishery, which expanded rapidly during the late 1970s and was banned in 1992 by United Nations resolution. Wetherall et al. (1993) estimated that over 750 leatherback turtles were killed in Japanese, Korean, and Taiwanese drift net fisheries during the 1990–1991 season. Although complexities of the fishery make extrapolation to a total mortality estimate very difficult, these estimates suggest that 5,000–10,000 leatherbacks may have been killed between the late 1970s and 1992. Based on current knowledge of movement patterns (Benson et al. 2011), all or most of these animals caught unintentionally would have originated from western Pacific nesting beaches during the boreal summer nesting period. Thus, high seas, drift net fishery bycatch was likely a significant contributor to the population declines observed at western Pacific nesting beaches during the 1980s and 1990s.

Additional detailed bycatch data are available for US drift net and longline fisheries in the central and eastern Pacific, indicating that tens of leatherbacks were killed or injured annually during the 1990s (Julian and Beeson 1998; McCracken 2000) and that there were markedly lower rates following implementation of sea turtle protection measures in the early 2000s. Genetic analysis indicated almost all of these killed and injured turtles originated from the western Pacific population (Dutton et al. 2000).

Bycatch data for the South Pacific regions within the known range of western Pacific leatherbacks (Benson et al. 2011) are more limited. Molony (2005) provides multinational turtle bycatch data for the 1990–2004 purse seine fishery and the deep, shallow, and albacore longline fisheries operating between 15° N and 31° S, indicating that an average of about 100 leatherbacks were killed per year. In Australia, bycatch records exist for pelagic longline fisheries (Stobutzki et al. 2006; Robins et al. 2002), prawn trawls off Queensland and Northern Territory, gill net fisheries off Queensland and Tasmania (Limpus 2009), and pot gear off Tasmania. Although no overall leatherback mortality estimates are available for Australian fisheries, gill net bycatch is reported as widespread (Limpus 2009). In particular, anecdotal reports of leatherback takes in Tasmanian tuna gill net fisheries may be of concern (Limpus 2009).

Pacific-wide Synthesis

The critically endangered status of Pacific leatherback populations is a reflection of conservation problems and challenges that globally affect large marine organisms whose ranges span entire ocean basins. Problems and successes in leatherback conservation have been determined by myriad factors operating at local, regional, and international scales spanning the jurisdictions of many developed and developing nations. Trends in Pacific leatherback populations illustrate that successful conservation and recovery will be dependent upon cooperation and coordination among diverse peoples throughout the Pacific region. When such coordinated efforts are lacking, recovery can be difficult or impossible, as illustrated by continued population declines despite decades of local conservation efforts (Sarti Martínez et al. 2007; Santidrián Tomillo et al. 2008).

The western Pacific leatherback population is the most robust remaining population with the best chance of survival in the Pacific (Dutton and Squires 2008), but it also experienced a dramatic decline during at least the past three decades, similar to that previously documented in the eastern Pacific and Malaysia (fig. 10.2). The population is still declining at an alarming rate of about 5.9 percent annually (Tapilatu et al. 2013), and effective long-term conservation and recovery actions must be implemented immediately to ensure the survival of this population.

The most critical needs are to (1) increase hatchling production, (2) eliminate killing of nesting females on the beaches, and (3) reduce at-sea bycatch of adults and subadults (Dutton and Squires 2008). Programs to protect nests and increase hatchling production are well established at major beaches in the eastern Pacific and are in varying stages of development at key western Pacific nesting beaches, but positive effects will take decades to realize (e.g., as in St. Croix; Dutton et al. 2005). Although bycatch in pelagic longline fisheries, particularly for swordfish, has received the most attention in recent years, it is clear that bycatch in small-scale coastal fisheries has been a significant contributor to population declines in many regions (Kaplan 2005; Alfaro-Shigueto et al. 2011).

Complicating this picture are the uncertain future effects of climate variability. Saba et al. (2007; 2008) identified a correlation between eastern Pacific leatherback reproductive frequency and El Niño / La Niña events, which could potentially increase this population's vulnerability to anthropogenic impacts compared to other leatherback populations. Longer term, a warming climate and rising sea levels could further affect leatherbacks through changes in beach morphology, increased sand temperatures leading to a greater incidence of lethal incubation temperatures, changes in hatchling sex ratios, and the loss of nests or nesting habitat due to beach erosion (chapter 16). Beach conservation measures must explicitly address these emerging challenges, requiring an even greater commitment of time and resources by biologists, local peoples, and the governments of many nations. Further, it will be important to preserve as many nesting populations, small and large, as possible to maintain the greatest geographic diversity in order to increase the resiliency of leatherback nesting populations in the face of a changing climate (McClenachan et al. 2006). This is particularly important given that current-driven hatchling dispersal patterns connect all western Pacific leatherbacks, such that adverse impacts in one region can have detrimental effects on leatherback persistence in many other regions throughout the Pacific (Gaspar et al. 2012).

Leatherbacks have survived many climate variations spanning millions of years, but at the current, critically low population sizes, past mechanisms of adaptation may no longer be effective, and human intervention is essential to prevent extirpation in the Pacific. The decline of Pacific leatherback populations is a shared international problem that can only be reversed by an immediate, holistic approach that enhances hatchling production through local programs and reduces anthropogenic mortality of adults and subadults wherever it occurs, particularly near nesting beaches and in key foraging areas (Kaplan 2005; Dutton and Squires 2008).

ACKNOWLEDGMENTS

We thank numerous people for sharing their data from multiple nesting sites throughout the Pacific.

These individuals include the coordinators of index beach monitoring projects that are part of Proyecto Laúd: Enrique Ocampo, Alejandro Tavera, Ana Barragán, Ma. del Rosario Juárez (CONANP); Karla López, Carlos Salas and Francesca Vannini (Kutzari, AC); Jim Spotila and Frank Paladino of the Leatherback Trust; Romey Piedra of Parque Nacional Marino Las Baulas; beach rangers from north Bird's Head villages; students from the State University of Papua (UNIPA); and John Ben (Huon Coast Leatherback Turtle Project). Aerial surveys of leatherback nesting beaches in the western Pacific were aided by John Pita, Peter Ramohia, Joe Horoku, Peter Pikacha, Vagi Rei, Rachel Groom, Barry Kreuger, Betuel Samber, Bas Wurlanty, Karen Frutchey, and Paul Lokani. Funding for the aerial surveys was provided by NOAA-NMFS-Pacific Islands Regional Office (Western Pacific) and NOAA-NMFS-SWFSC, CONABIO, and NFWF (Mexico and Central America). We thank P. Dutton and J. Seminoff for their helpful reviews of an earlier draft of this chapter.

LITERATURE CITED

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: 129–134.

Alfaro-Shigueto, J., J. Mangel, F. Bernedo, P. H. Dutton, J. A. Seminoff, and B. J. Godley. 2011. Small-scale fisheries of Peru: a major sink for marine turtles in the Pacific. Journal of Applied Ecology 48: 1432–1440.

Alfaro-Shigueto, J., J. C. Mangel, P. H. Dutton, J. A. Seminoff, and B. J. Godley. 2012. Trading information for conservation: a novel use of radio broadcasting to reduce sea turtle bycatch. Oryx 46: 332–339.

Arauz, R., E. López, E. Lyons, B. Wilton, L. Verrier, and W. Reyes. 2003. Sea turtle conservation and research using coastal community organizations as the cornerstone of support. Report, July–December, 2002. Asociación PRETOMA Programa Restauración de Tortugas Marinas, San Jose, Costa Rica.

Araúz-Almengor, M., and R. Morera-Avila. 1994. Status of the marine turtles *Dermochelys coriacea*, *Chelonia agassizii*, and *Lepidochelys olivacea* at Playa Naranjo, Parque Nacional Santa Rosa, Costa Rica. Abstract. In: K. A. Bjorndal, A. B. Bolten, D. A. Johnson, and P. J. Eliazar (compilers), Proceedings of Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-351. NOAA, Miami, FL, p. 175.

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

Benson, S. R., T. Eguchi, D. G. Foley, K. A. Forney, H. Bailey, C. Hitipeuw, B. P. Samber, et al. 2011. Large-scale movements and high-use areas of western Pacific leatherback turtles, *Dermochelys coriacea*. Ecosphere 2(7): art84. doi: 10.1890/ES11-00053.1.

Benson, S. R., K. M. Kisokau, L. Ambio, V. Rei, P. H. Dutton, and D. Parker. 2007. 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: 7–14.

Benson, S., V. Rei, C. Hitipeuw, B. Samber, R. Tapilatu, J. Pita, R. Ramohia, et al. 2012. A tri-national aerial survey of leatherback nesting activity in New Guinea and the Solomon Islands. Abstract. In: L. Belskis, M. Frick, A. Panagopoulou, A. F. Rees, and K. Williams (compilers), Proceedings of the Twenty-ninth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-620. NOAA, Miami, FL, pp. 19–20.

Betz, W., and M. Welch. 1992. Once thriving colony of leatherback sea turtles declining at Irian Jaya, Indonesia. Marine Turtle Newsletter 56: 8–9.

Bhaskar, S. 1985. Mass nesting by leatherbacks in Irian Jaya. In: World Wildlife Fund monthly report, January 1985, pp. 15–16. Internal report, World Wildlife Fund-Indonesia, Jakarta, Indonesia.

Bhaskar, S. 1987. Management and research of marine turtle nesting sites on the north Vogelkop coast of Irian Jaya, Indonesia. World Wildlife Fund, Jakarta, Indonesia.

Brown, C. H., and W. M. Brown. 1982. Status of sea turtles in the southeastern Pacific: emphasis on Peru. In: K. A. Bjorndal (ed.), Biology and conservation of sea turtles. Smithsonian Institution Press, Washington, DC, USA, pp. 235–240.

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

Chan, E. H., H. C. Liew, and A. G. Mazlan. 1988. The incidental capture of sea turtles in fishing gear in Terengganu, Malaysia. Biological Conservation 43: 1–7.

Donoso, M., and P. H. Dutton. 2010. Sea turtle bycatch in the Chilean pelagic longline fishery in the southeastern Pacific: opportunities for conservation. Biological Conservation 143: 2672–2684.

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., A. Frey, R. Leroux, and G. Balazs. 2000. Molecular ecology of leatherbacks in the Pacific. In: N. Pilcher and G. Ismael (eds.), Sea turtles of the Indo-Pacific: Research, management and conservation. ASEAN Academic, London, UK, pp. 248–253.

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

Dutton, P. H., and D. Squires. 2008. Reconciling biodiversity with fishing: a holistic strategy for Pacific sea turtle recovery. Ocean Development & International Law 39: 200–222.

Eckert, K. L., B. P. Wallace, J. G. Frazier, S. A. Eckert, and P.C.H. Pritchard. 2012. Synopsis of the biological data on the leatherback sea turtle (*Dermochelys coriacea*). US Fish and Wildlife Service, Biological Technical Publication BTP-R4015-2012. US Fish and Wildlife Service, Washington, DC, USA.

Eckert, S. A., and L. Sarti. 1997. Distant fisheries implicated in the loss of the world's largest leatherback nesting population. Marine Turtle Newsletter 78: 2–6.

Fritts, T. H., M. Stinson, and R. Márquez. 1982. Status of sea turtle nesting in southern Baja California, Mexico. Bulletin of South California Academy of Science 81: 51–60.

Gaspar, P., S. R. Benson, P. H. Dutton, A. Réveillère, G. Jacob, C. Meetoo, and S. Fossette. 2012. Oceanic dispersal of juvenile western pacific leatherback turtles: going beyond passive drift modeling. Marine Ecology Progress Series 457: 265–284.

Guinea, M. 1993. Sea turtles of Fiji. South Pacific Regional Environmental Programme, Reports and Studies No. 65. Apia, Fiji. http://www.sprep.org/att/IRC/eCOPIES/Countries/Fiji/35.pdf.

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

Hamann, M., K. Ibrahim, and C Limpus. 2006. Status of leatherback turtles in Malaysia. In: M. Hamann, C. Limpus, G. Hughes, J. Mortimer, and N. Picher (eds.), Assessment of the conservation status of the leatherback turtle in the Indian Ocean and South East Asia. IOSEA Species Assessment: Volume 1. IOSEA Marine Turtle MoU Secretariat, Bangkok, Thailand, pp. 78–82.

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: 28–36.

Julian, F., and M. Beeson. 1998. Estimates of marine mammal, turtle, and seabird mortality for two California gillnet fisheries: 1990–1995. Fishery Bulletin 96: 271–284.

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

Kinch, J., S. Benson, P. Anderson, and K. Anana. 2012. Leatherback turtle nesting in the Autonomous Region of Bougainville, Papua New Guinea. Marine Turtle Newsletter 132: 15–17.

Leary, T., and M. Laumani. 1989. Marine turtles of Isabel Province. A report of a survey of nesting beaches (7th–21st of November 1989). Unpublished report. Solomon Islands Fisheries Division, Honiara, Solomon Islands.

Liew, H.-C. 2011. Tragedy of the Malaysian leatherback population: what went wrong. In: P. H. Dutton, D. Squires, and A. Mahfuzuddin (eds.), Conservation and sustainable management of sea turtles in the Pacific Ocean. University of Hawai'i Press, Oahu, HI, USA, pp. 97–107.

Limpus, C. J. 2009. A biological review of Australian marine turtles, 6. Leatherback turtle, *Dermochelys coriacea* (Vandelli). Environmental Protection Agency of the Queensland Government, Brisbane, Australia.

Márquez, R., A. Villanueva, and C. Peñaflores. 1981. Anidación de la tortuga laúd *Dermochelys coriacea schlegelli* en el Pacifico mexicano. Ciencia Pesquera 1: 45–52.

Mast, R. B. (ed.). 2006. State of the world's sea turtles (SWOT) report, Vol. 1. State of the World's Sea Turtles, Arlington, VA, USA.

McClenachan L., J.B.C. Jackson, and M.J.H. Newman. 2006. Conservation implications of historic sea turtle nesting beach loss. Frontiers in Ecology and the Environment 4: 290–296.

McCracken, M. L. 2000. Estimation of sea turtle take and mortality in the Hawaiian longline fisheries. NOAA, National Marine Fisheries Service, Southwest Fisheries Science Center, Administrative Report H-00-06. NOAA. Honolulu, HI, USA.

McKeown, A. 1977. Marine turtles of the Solomon Islands. Ministry of Natural Resources Fisheries Division, Honiara, Solomon Islands.

Molony, B. 2005. Estimates of the mortality of non-target species with an initial focus on seabirds, turtles and sharks. Information Paper WCPFC-SC1-EBWP-1, First Meeting of the Scientific Committee, Noumea, New Caledonia, 8–19 August 2005. Western and Central Pacific Fisheries Commission, Kolonia, Pohnpei State, Federated States of Micronesia.

Morales, V. R., and P. Vargas. 1996. Legislation protecting marine turtles in Peru. Marine Turtle Newsletter 75: 22–23.

Mortimer, J. A. 1988. The pilot project to promote sea turtle conservation in southern Thailand. Unpublished Report to Wildlife Fund Thailand and World Wildlife Fund/USA. http://college.holycross.edu/faculty/kprestwi/chelonia/pubs/9_unpublished/Mortimer_Thailand_1988.pdf.

NMFS and USFWS. 1998. Recovery Plan for U.S. Pacific populations of the leatherback turtle (*Dermochelys coriacea*). National Marine Fisheries Service, Silver Spring, MD, USA.

Petro, G., F. R. Hickey, and K. MacKay. 2007. Leatherback turtles in Vanuatu. Chelonian Conservation and Biology 6: 135–137

Pilcher, N. 2012. Community-based conservation of leatherback turtles along the Huon coast, Papua New Guinea. Final report under contract 11-turtle-002 to the Western Pacific Regional Fishery Management Council, Honolulu, HI, USA.

Pritchard, P.C.H. 1971. The leatherback or leathery turtle. IUCN Monograph No. 1: Marine Turtle Series. International Union for Conservation of Nature and Natural Resources, Morges, Switzerland.

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: 741–747.

Quinn, N. J., and B. L. Kojis. 1985. Leatherback turtles under threat in Morobe Province, Papua New Guinea. PLES 85: 79–99.

Reina, R. D., P. A. Mayor, J. R. Spotila, R. Piedra, and F. V. Paladino. 2002. Nesting ecology of leatherback turtles, *Dermochelys coriacea*, at Parque Nacional Marino Las Baulas, Costa Rica: 1988–1989 to 1999–2000. Copeia 2002: 653–664.

Robins, C. M., S. J. Bache, and S. R. Kalish. 2002. Bycatch of sea turtles in pelagic longline fisheries—Australia. Fisheries Research and Development Corporation, Canberra, Australia.

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

Saba, V. S., G. L. Shillinger, A. M. Swithenbank, B. A. Block, J. R. Spotila, J. A. Musick, and F. V. Paladino. 2008. An oceanographic context for the foraging ecology of eastern Pacific leatherback turtles: consequences of ENSO. Deep Sea Research Part I: Oceanographic Research Papers 55: 646–660.

Saba, V. S., C. A. Stock, J. R. Spotila, F. V. Paladino, and P. Santidrián Tomillo. 2012. Projected response of an endangered marine turtle population to climate change. Nature Climate Change 2: 814–820. doi: 10.1038/nclimate1582.

Salm, R. V. 1981. Terengganu meets competition: Does Irian Jaya harbor Southeast Asia's densest leatherback nesting beaches? Conservation Indonesia, Newsletter of WWF Indonesia 5: 18–19, as reprinted in Marine Turtle Newsletter 20: 10–11 (1982).

Santidrián Tomillo, P., V. S. Saba, R. Piedra, F. V. Paladino, and J. R. Spotila. 2008. Effects of illegal harvest of eggs on the population decline of leatherback turtles in Las Baulas Marine National Park, Costa Rica. Conservation Biology 22: 1216–1224.

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: 54–62.

Sarti, A. L., and A. R. Barragán. 2011. Importance of networks for conservation of the Pacific leatherback turtle: the case of "Proyecto Laúd" in Mexico. In: P. H. Dutton, D. Squires, and A. Mahfuzuddin (eds.), Conservation of Pacific sea turtles. University of Hawai'i Press, Oahu, HI, USA, pp. 120–131.

Sarti, L., S. Eckert, P. Dutton, A. Barragán, and N. García. 2000. The current situation of the leatherback population on the Pacific coast of Mexico and Central America, abundance and distribution of the nestings: an update. In: H. J. Kalb and T. Wibbels (compilers), Proceedings of Nineteenth Annual Symposium on Sea Turtle Biology and Conservation, NOAA Technical Memorandum NMFS-SEFSC-443. NOAA, Miami, FL, pp. 85–87.

Sarti Martínez, A. L. 2000. *Dermochelys coriacea*. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. www.iucnredlist.org. Accessed 11 November 2012.

Sarti Martínez, L., A. R. Barragán, D. Garcia-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: 70–78.

Sarti Martínez, L., A. Barragán, F. Vargas, P. Huerta, E. Ocampo, A. Tavera, A. Escudero, et al. 2003. The decline of the Eastern Pacific leatherback and its relation to changes in nesting behavior and distribution. In: N. Pilcher (compiler), Proceedings of the Twenty-third International Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-536. NOAA, Miami, FL, pp 133–136.

Seminoff, J. A., S. R. Benson, K. E. Arthur, T. Eguchi, P. H. Dutton, R. Tapilatu, and B. N. Popp. 2012. Stable isotope tracking of endangered sea turtles: validation with satellite telemetry and ∂^{15}N analysis of amino acids. PLoS ONE 7(5); e37403. doi: 10.1371/journal.pone.0037403.

Seminoff, J. A., and B. P. Wallace (eds.). 2012. Sea turtles of the eastern Pacific: Advances in research and conservation. University of Arizona Press, Tucson, AZ, USA.

Shillinger, G. L., D. M. Palacios, H. Bailey, S. J. Bograd, A. M. Swithenbank, P. Gaspar, B. P. Wallace, et al. 2008. Persistent leatherback turtle migrations present opportunities for conservation. PLoS Biology 6: e171. doi: 10.1371/journal.pbio.0060171.

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: 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.

Spring, C. S. 1982a. Status of marine turtle populations in Papua New Guinea. In: K. A. Bjorndal (ed.), Biology and conservation of sea turtles. Smithsonian Institution Press, Washington DC, USA, pp. 281–289.

Spring, C. S. 1982b. Subsistence hunting of marine turtles in Papua New Guinea. In: K. A. Bjorndal (ed.), Biology and conservation of sea turtles. Smithsonian Institution Press, Washington, DC, USA, pp. 291–295.

Stewart K., M. Sims, A. Meylan, B. Witherington, B. Brost, and L. B. Crowder. 2011. Leatherback nests increasing significantly in Florida, USA: trends assessed over 30 years using multilevel modeling. Ecological Applications 21: 263–273.

Stobutzki, I., E. Lawrence, N. Bensley, and W. Norris. 2006. Bycatch mitigation approaches in Australia's eastern tuna and billfish fishery: seabirds, turtles, marine mammals, sharks and non-target fish. Information Paper WCPFC-SC2/EBSWG-IP4, Ecosystem and Bycatch Specialist Working Group of the Second Meeting of the Scientific Committee of the WCPFC, Manila, Philippines. Western and Central Pacific Fisheries Commission. Kolonia, Pohnpei State, Federated States of Micronesia.

Suarez, M., and C. Starbird, C. 1995. A traditional fishery of leatherback turtles in Maluku, Indonesia. Marine Turtle Newsletter 68: 15–18.

Tapilatu, R. F., P. H. Dutton, M. Tiwari, T. Wibbels, H. V. Ferdinandus, W. G. Iwanggin, and B. H. Nugroho. 2013.

Long-term decline of the western Pacific leatherback, *Dermochelys coriacea*, a globally important sea turtle population. Ecosphere 4: 25. http://dx.doi.org/10.1890/ES12-00348.1.

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: 154–158.

Tiwari, M., D. L. Dutton, and J. A. Garner. 2011. Nest relocation: a necessary management tool for western Pacific leatherback nesting beaches. In: P. H. Dutton, D. Squires, and A. Mahfuzuddin (eds.), Conservation and sustainable management of sea turtles in the Pacific Ocean. University of Hawai'i Press, Oahu, HI, USA, pp. 87–96.

Turtle Expert Working Group. 2007. An assessment of the leatherback turtle population in the Atlantic Ocean. NOAA Technical Memorandum NOFS-SWFSC-555. NOAA, Miami, FL.116 p.

Urteaga, J., P. Torres, O. Gaitan, G. Rodríguez, and P. Dávila. 2012. Leatherback, *Dermochelys coriacea*, nesting beach conservation on the Pacific coast of Nicaragua, (2002–2010). Abstract. In: T. T. Jones and B. P. Wallace (compilers), Proceedings of the Thirty-first Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-631. NOAA, Miami, FL, USA, p. 237.

Vaughan, P. W. 1981. Marine turtles: A review of their status and management in the Solomon Islands. Ministry of Natural Resources Fisheries Division, Honiara, Solomon Islands.

Wallace, B. P., M. Tiwari, and M. Girondot. 2013. *Dermochelys coriacea*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. iucn-redlist.org. Accessed 27 February 2014.

Wetherall, J. A., G. H. Balazs, R. A. Tokunga, and M.Y.Y. Yong. 1993. Bycatch of marine turtles in North Pacific high seas drift net fisheries and impacts on the stocks. In: J. Ito, W. Shaw, and R. L. Burgner (eds.), International North Pacific Fisheries Commission (INPFC) Symposium on Biology, Distribution, and Stock Assessment of Species Caught in the High Seas Driftnet Fisheries in the North Pacific Ocean. Bulletin International North Pacific Fisheries Commission 53: 519–538. International North Pacific Fisheries Commission, Vancouver, Canada.

Leatherback Turtle Populations in the Pacific Ocean

GRADEMARK REPORT

FINAL GRADE

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GENERAL COMMENTS

Instructor

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