Loggerhead Sea Turtle
(*Caretta caretta*)
North Pacific Ocean DPS
5-Year Review:
Summary and Evaluation

2020

National Marine Fisheries Service
Office of Protected Resources
Silver Spring, Maryland
and
U.S. Fish and Wildlife Service
Southeast Region
North Florida Ecological Services Office
Jacksonville, Florida

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5-YEAR REVIEW

Loggerhead sea turtle, North Pacific Ocean DPS (*Caretta caretta*)

1.0 GENERAL INFORMATION

1.1 Reviewers

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USFWS North Florida Ecological Services Office: Ann Marie Lauritsen, 904-731-3032

1.2 Methodology

The purpose of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 *et seq*.) is to provide a means to conserve and recover endangered and threatened species and the ecosystems upon which they depend. Under the ESA, the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS), together "we" or "the Services," share responsibility to conserve sea turtles (as described in the 2015 revision of the Memorandum of Understanding Defining the Roles of USFWS and NMFS in Joint Administration of the Endangered Species Act of 1973 as to Sea Turtles). NMFS has jurisdiction for sea turtles in the marine environment, and USFWS has jurisdiction for sea turtles in the terrestrial habitat. One of our responsibilities under the ESA is to conduct a review of each listed species at least every 5 years to determine whether its endangered or threatened status should be changed or removed (i.e., 5-year review, 16 U.S.C. 1533(c)(2)). The ESA requires us to make these determinations solely on the basis of the best scientific and commercial data available (16 U.S.C. 1533(b)(1)(A)). Under the ESA, the definition of species includes any subspecies of fish or wildlife or plants, and any distinct population segment (i.e., DPS) of any species of vertebrate fish or wildlife which interbreeds when mature (16 U.S.C. 1532). In 2011, after a status review of the species (the Status Review; Conant *et al*. 2009), the Services identified nine loggerhead sea turtle DPSs, including the North Pacific Ocean DPS (i.e., the DPS; 76 FR 58868; September 22, 2011), in accordance with the Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the ESA (i.e., the DPS Policy; 61 FR 4722, February 7, 1996). In 2016, we initiated this 5-year review for the DPS (81 FR 70394; October 12, 2016).

To compile the best available scientific and commercial data on the DPS, we first reviewed the Status Review (Conant *et al*. 2009), which was based on the best available scientific and commercial data available at that time. We then searched for relevant new information on the DPS, its biology and habitat, and threats to its existence. Specifically, we searched for published literature using scientific search engines (i.e., Science Direct and Google Scholar) and NMFS' scientific literature database. We solicited relevant information from other Federal agencies, States, Territories, Tribes, foreign governments, academia, nonprofit organizations, industry groups, and individuals by publishing a request in the Federal Register (81 FR 70394; October 12, 2016). We also solicited information from species' experts and/or individuals with expertise on particular threats. We compiled, reviewed, and evaluated data, including information we received in response to our Federal Register notice. We did not conduct new empirical studies because the ESA requires the use of the best *available* scientific and commercial information.

After compiling the data, we reviewed newly available information relevant to the DPS determination, following the DPS Policy. Under this policy, a DPS must be discrete and

significant relative to its species. We asked whether the new data supported or refuted our previous determinations of discreteness and significance.

Next, we next considered the biology and habitat of the DPS. We identified information that has become available since the publication of the Status Review in 2009. We also reviewed the best available information on abundance and trends, genetics, spatial distribution, and habitat conditions.

We then assessed threats to the DPS by identifying and evaluating the ESA section 4(a)(1) factors (i.e., the five factor analysis; 16 U.S.C. 1533(a)(1)):

1. Present or threatened destruction, modification, or curtailment of habitat or range
2. Overutilization for commercial, recreational, scientific, or educational purposes
3. Disease or predation
4. Inadequacy of existing regulatory mechanisms
5. Other natural or manmade factors affecting its continued existence

Because the abundance and trends are influenced by past threats, we focused on present threats. For each factor, we evaluated its likely impact and magnitude, as well as the DPS's vulnerability and exposure.

We synthesized the above information to assess the DPS's status. We identified the factors that weighed most heavily in our evaluation. We also described areas of high confidence, remaining uncertainties, and their relevance to our overall assessment. Based on this information, we provide a recommendation on the status of the DPS.

1.3 Background

1.3.1 Federal Register Notice

FR notice: 81 FR 70394
Date listed: October 12, 2016
Purpose: NMFS gave notice of our initiation of a 5-year review of the North Pacific Ocean DPS and recovery planning for this DPS; we requested relevant information from the public.

1.3.2 Listing History

Original Listing
FR notice: 43 FR 32800
Date listed: July 28, 1978
Entity listed: Loggerhead sea turtle (*Caretta caretta*)
Classification: Threatened

Revised Listing
FR notice: 76 FR 58868
Date listed: September 22, 2011
Entity listed: Loggerhead sea turtle (*Caretta caretta*), North Pacific Ocean DPS
Classification: Endangered

1.3.3 Associated Rulemakings

4(d) Rules
FR notice: 64 FR 14069
Date: March 23, 1999
Purpose: Applied section 9 prohibitions (16 U.S.C. 1538) to threatened sea turtles

FR notice: 64 FR 14070
Date: March 23, 1999
Purpose: Identified exceptions to section 9 prohibitions

Critical Habitat Rules
FR notice: 79 FR 39855
Date: July 10, 2014
Conclusion: NMFS determined that no marine areas meet the definition of critical habitat for the North Pacific Ocean DPS

FR notice: 79 FR 39756
Date: July 10, 2014
Conclusion: USFWS did not designate critical habitat for the DPS because North Pacific loggerheads do not nest within areas under U.S. jurisdiction

1.3.4 Review History

- In 1985, NMFS conducted the first 5-year review of the species, concluding that of 52 nesting populations evaluated throughout the Atlantic, Pacific, and Indian Oceans, 33 were thought to be declining, 18 were unknown, and only one – the U.S. southeast Atlantic – was thought to be increasing. Although the United States had implemented protective regulations and commercial harvest of eggs had decreased, many threats continued both domestically and abroad. NMFS determined that information was insufficient to assess whether a change in status was warranted.

- In 1991, USFWS conducted a 5-year review of many species, including the loggerhead sea turtle (56 FR 56882, November 6, 1991). USFWS requested new or additional information on the species and indicated that it would propose a change in status if warranted by the data received. Following the review, USFWS did not recommend a change in status.

- In 1995, the Services conducted a joint 5-year review (Plotkin 1995). Although we identified a need for further study of U.S. loggerhead population structure, we did not recommend a change in the status of the species.

- In 2007, we conducted a joint 5-year review on the loggerhead sea turtle (NMFS and USFWS 2007). We identified new information on statistically significant genetic population structure within and among ocean basins, based on the analyses of tissue samples collected at nesting beaches and foraging grounds. In addition, new information was available on age at first reproduction, survival rates, and in-water turtles that suggested discreteness among populations. Although we did not recommend a change in status at that

time, we recommended further analysis and review to apply the DPS Policy to the species (NMFS and USFWS 2007).

- On July 16, 2007, the Center for Biological Diversity and the Turtle Island Restoration Network petitioned us to identify the North Pacific loggerhead population as a DPS, list it as endangered, and designate critical habitat. On November 16, 2007, we found that the petition presented substantial scientific information indicating that the petitioned actions may be warranted (72 FR 64585) and conducted the Status Review (Conant *et al*. 2009). Following that review, the North Pacific Ocean Loggerhead DPS was listed as endangered in 2011 (76 FR 58868).

- On October 12, 2016, NMFS gave notice of our initiation of a 5-year review of the North Pacific Ocean Loggerhead DPS and our intent to draft a recovery plan for this DPS; we requested relevant information from the public (81 FR 70394).

1.3.5 Species' Recovery Priority Number

NMFS' Recovery priority number: 5C (NMFS 2019b), as defined in the Recovery Priority Guidelines (84 FR 18243; April 30, 2019), which reflects:

- moderate demographic risk;
- well understood major threats;
- low to moderate U.S. jurisdiction, authority, or influence to address major threats; and
- high certainty that management or protective actions will be effective.

USFWS' Recovery priority number: 9C (USFWS 2012), as defined in the Recovery Priority Guidelines (48 FR 43098; September 21, 1983), which reflects:

- moderate degree of threat;
- high recovery potential; and
- taxonomy (i.e., DPS).

1.3.6 Recovery Plan

Name of plan: Recovery Plan for the U.S. Pacific Populations of the Loggerhead Turtle (*Caretta caretta*) [Created prior to the listing of the DPS]
Date issued: January 12, 1998
Recovery planning currently under development (81 FR 70394; October 12, 2016)

2.0 REVIEW ANALYSIS

2.1 Application of the DPS Policy

2.1.1 Is the species under review a vertebrate?

__x__**Yes**
_____**No**

2.1.2 Is the species under review listed as a DPS?

__x__**Yes**
_____**No**

2.1.3 Was the DPS listed prior to 1996?

_____**Yes**
__x__**No**

2.1.4 Is there new information regarding the application of the DPS policy?

__x__**Yes**
_____**No**

After reviewing the Status Review and genetic, flipper tagging, and satellite tracking data that have become available since its publication, we confirmed the North Pacific Ocean DPS (Figure 1) to be reproductively and geographically discrete from all other loggerhead DPSs and significant to the species. The following paragraphs summarize the available data on discreteness and significance, which continue to support the DPS determination.

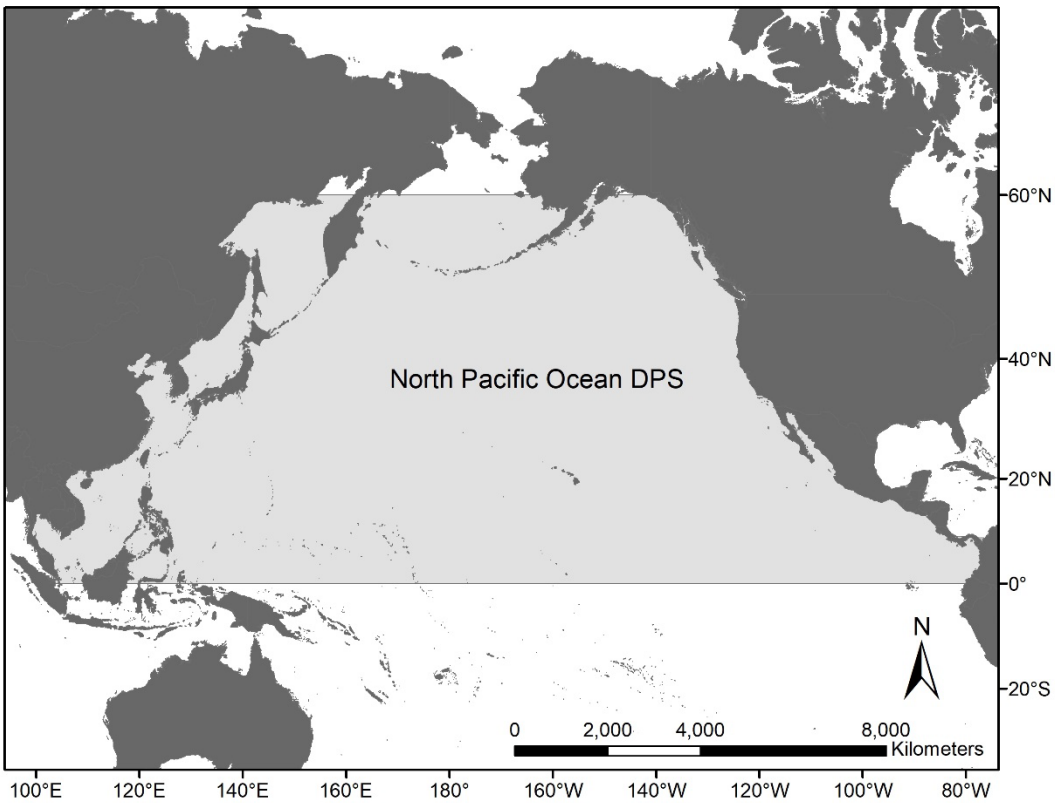

Figure 1. Range of the North Pacific Ocean DPS. The range is the North Pacific Ocean, bound by the Equator and the 60º N parallel.

As discussed in the Status Review, genetic data (i.e., population-level genetic differences, also called "genetic divergence" and "population structure") provide evidence for the discreteness of North Pacific Ocean DPS. After reviewing the genetic data available at the time of the Status Review (Bowen *et al*. 1995; Hatase *et al*. 2002b; Bowen *et al*. 2003; P. Dutton, NMFS, unpublished data), we conducted a literature search using the key words: "Pacific," and "loggerhead" or "caretta," and "genetics" or "DNA." We found and reviewed newly available information: Boyle *et al*. 2009; Watanabe *et al*. 2011; Nishizawa *et al*. 2014; and Matsuzawa *et al*. 2016. Pacific loggerheads are genetically isolated from loggerheads in other ocean basins, with the genetic distance (d = 0.017) between maternally inherited mitochondrial DNA (mtDNA) haplotypes reflecting approximately one million years of reproductive isolation (Bowen *et al*. 2003). In addition, there is genetic discontinuity between North Pacific loggerheads that nest in Japan and South Pacific loggerheads that nest primarily in Australia and New Caledonia (Bowen *et al*. 1995; Hatase *et al*. 2002b; Bowen *et al*. 2003; Boyle *et al*. 2009; Watanabe *et al*. 2011; Nishizawa *et al*. 2014; Matsuzawa *et al*. 2016; P. Dutton, NMFS, unpublished data). An early study of population structure (Bowen *et al*. 1995) did not detect any shared mtDNA haplotypes between samples (i.e., eggs, hatchlings, and nesting females) collected from Japan (haplotypes B and C; N = 26) and Australia (haplotype A; N = 26). In addition, Bowen *et al*. (1995) found haplotypes (B and C) in 33 of 34 samples collected from the North Pacific drift-net fishery and 24 of 26 samples collected from the Baja California, Mexico foraging area (Bowen *et al*. 1995). However, one sample from the North Pacific drift-net fishery and two samples from the Baja California, Mexico foraging area exhibited haplotype A. Because tagging data indicated that the turtles do not cross the Equator, Bowen *et al*. (1995) hypothesized that haplotype A must occur in low frequency at Japanese nesting beaches. Subsequent studies of additional Japanese nesting beaches confirmed the presence of haplotype A (Hatase *et al*. 2002b; Watanabe *et al*. 2011), which is common in the Ryukyu Archipelago (Matsuzawa *et al*. 2016). The occurrence of haplotype A at nesting beaches in both Japan (Hatase *et al*. 2002b; Watanabe *et al*. 2011; Matsuzawa *et al*. 2016) and Australia (Bowen *et al*. 1995; Boyle *et al*. 2009) does not imply gene flow between the North and South Pacific DPSs because it occurs at drastically different frequencies as demonstrated by high-magnitude, statistically significant genetic structure between the North and South Pacific Ocean DPSs ($F_{ST} = 0.82$; $P < 0.00001$; Boyle *et al*. 2009). Such results indicate female philopatry (i.e., females returning to their natal beaches to nest). The sharing of haplotype A may be due to ancient gene flow, inheritance from a common ancestor, or convergent evolution. Preliminary microsatellite (biparentally inherited nuclear DNA) analyses also indicate discreteness between the North and South Pacific Ocean DPSs (P. Dutton, NMFS, unpublished data). Therefore, the previous and newly available genetic data continue to support the discreteness of the North Pacific Ocean DPS.

Flipper tagging (externally attached tags and internally inserted passive integrated transponder tags) and satellite telemetry or tracking data continue to support discreteness by demonstrating that turtles of the North Pacific Ocean DPS remain in the North Pacific for their entire life cycle, geographically isolated from all other DPSs. Furthermore, despite ample tagging and tracking data, there is no evidence that loggerheads originating from nesting beaches in the South Pacific Ocean forage in the North Pacific Ocean. We reviewed the tagging and tracking data available at the time of the Status Review (Iwamoto *et al*.1985; Uchida and Teruya 1988; Kamezaki *et al*. 1997; Sakamoto *et al*. 1997; Resendiz *et al*. 1998; Japan Fisheries Resource Conservation Association 1999; Nichols *et al*. 2000; Nichols 2003; Hatase *et al*. 2002a,c,d; Seminoff *et al*. 2004; Y. Matsuzawa, Sea Turtle Association of Japan, pers. comm. 2006; Balazs 2006; Peckham

et al. 2007a,b; Kobayashi *et al*. 2008; NMFS, unpublished data; W.J. Nichols, Ocean Conservancy, unpublished data; H. Peckham, Pro Peninsula, unpublished data). We also conducted a literature search for the key words: "Pacific," and "loggerhead" or "caretta," and "tag," "telemetry," "recapture" or "satellite." We found and reviewed newly available information: Kobayashi *et al*. 2011; Mangel *et al*. 2011; Sakamoto 2013; Parker *et al*. 2014; Narazaki *et al*. 2015; Saito *et al*. 2015; Briscoe *et al*. 2016a,b; Saito *et al*. 2018. Overall, we found that tagging and tracking data indicate that individuals originating from nesting beaches in Japan remain in the North Pacific for their entire life cycle (Table 1). Of more than 30,000 tagged and 200 tracked North Pacific loggerheads, none have occurred south of the Equator (Conant *et al*. 2009). Likewise, we are not aware of any South Pacific loggerheads recovered or tracked in the North Pacific Ocean (e.g., Conant *et al*. 2009; Mangel *et al*. 2011). Therefore, the previous and newly available tagging and tracking data continue to support the discreteness of the DPS.

Table 1. Summary of tagging and tracking data on North Pacific loggerheads. All tag recoveries occurred, and all tracks remained, in the North Pacific Ocean.

Data	Turtles	Year(s)	Duration (days)	Reference
Tagging	175	1976–1983		Iwamoto *et al*. 1985
Tagging	1			Uchida and Teruya 1988
Tagging	1			Balazs 1989
Tagging	395	1990–1995		Sato *et al*. 1997
Tagging	2,219			Kamezaki *et al*. 1997
Tagging	1		478	Resendiz *et al*. 1998
Tagging	7	1996–2000		Seminoff 2004
Tracking	3			Sakamoto *et al*. 1997
Tracking	1	1996–1997	368	Nichols 2000
Tracking	5	1999	50–172	Hatase *et al*. 2002a
Tracking	3	2003–2005	386, 219, and 225	Balazs 2006
Tracking	30	1996–2005	5,594	Peckham *et al*. 2007b
Tracking	186	1997–2006	1.25–945.3	Kobayashi *et al*. 2008
Tracking	34	2002–2008	6–503	Kobayashi *et al*. 2011
Tracking	15	2004–2009	0–898	Parker *et al*. 2014
Tracking	9	2005–2010	17–403	Narazaki *et al*. 2015
Tracking	3		up to 449	Saito *et al*. 2015
Tracking	231	1997–2013		Briscoe *et al*. 2016b
Tracking	30	2011	22–752	Saito *et al*. 2018

Genetic, tagging, and tracking data continue to support the discreteness determination of the DPS; they also support the significance determination. Given the data, it is unlikely that loggerheads from other DPSs would repopulate nesting beaches and foraging areas in the North Pacific Ocean, if the North Pacific Ocean DPS was extirpated. Therefore, the DPS is significant to the species because its loss would result in a significant gap (i.e., the North Pacific Ocean) in

the range of the species. Based on the best available data, we conclude that the DPS continues to meet the discreteness and significance criteria of the DPS Policy.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan?

__x__**Yes**
_____**No**

Prior to the listing of the DPS, the Services published the 1998 Recovery Plan for the U.S. Pacific Populations of the Loggerhead Turtle (*Caretta caretta*), which applies to the DPS but was created before the DPS was identified. In 2016, the Services published their notice of intent to draft a recovery plan for the DPS; however, it has not yet been finalized or approved.

2.2.2 Do recovery criteria reflect the best available and most up-to-date information?

__x__**Yes**
_____**No**

The recovery criteria of the 1998 Recovery Plan contained only delisting criteria because the loggerhead, at that time, was listed globally as threatened. We accept and analyze the delisting criteria from the 1998 Recovery Plan because they reflect the best available information at that time and are still relevant to the DPS.

2.2.3 List the recovery criteria and discuss whether each criterion has been met.

The 1998 Recovery Plan for the U.S. Pacific Populations of the Loggerhead Turtle (*Caretta caretta*) identified 10 criteria that must be met to consider delisting:

1) To the best extent possible, reduce the take in international waters (have and enforce agreements). This criterion applies to fisheries bycatch, which remains the greatest threat to the DPS, and therefore has not been met.
2) All regional stocks that use U.S. waters have been identified to source beaches based on reasonable geographic parameters. This criterion is not threat-based, but rather, provides necessary information for managing the DPS. The entire DPS uses nesting beaches in Japan. Genetic structure among management units may allow foraging turtles to be assigned to source beaches (at least to a management unit: Mainland, Yakushima, or Ryuku; Matsuzawa *et al*. 2016). While Nishizawa *et al*. (2014) performed a mixed stock analysis of loggerheads foraging off Sanriku, Japan, no such analyses have been performed on loggerheads in U.S. waters. This criterion has not been met.
3) All females estimated to nest annually (FENA) at "source beaches" are either stable or increasing for over 25 years. This criterion is not threat-based, but rather, provides necessary information for evaluating the status of the DPS. Beginning in 1990, the North Pacific population experienced a decade-long decline in FENA. The Recovery Plan was published in 1998; this criterion reflects the Recovery Team's concern regarding this decline and established a forward-looking requirement for recovery. The best available data to evaluate FENA are nest counts at three source beaches at Yakushima Island (i.e., the index beaches), which represent 52 percent of overall nesting for this population (Martin *et al*. 2020). Data from all three index beaches are currently only available

between 1999 and 2015 (i.e., 17 years of data). Therefore, we do not have enough years of data at this time to evaluate this criterion. However, data from the three index beaches demonstrate an increase in nesting between 1999 and 2012 (Martin *et al*. 2020). Declines in 2013, 2014, and 2015 (Martin *et al*. 2020) may represent natural variation, which is common in sea turtle populations. Thus, FENA has increased for at least 14 years. We conclude that this criterion has not yet been met because the trend in nesting females has not been stable or increasing for over 25 years at source beaches; however the 14-year increasing trend is encouraging.

4) Each stock must average 5,000 FENA (or a biologically reasonable estimate based on the goal of maintaining a stable population in perpetuity) over six years. This criterion is not threat-based, but rather provides necessary information for evaluating the status of the DPS. Martin *et al*. (2020) evaluated nesting abundance and trends using nest count data from 1985 to 2015 on three nesting beaches for which data were available (Inakahama, Maehama, and Yotsusehama). Based on estimates derived from their trend analysis, they calculated an abundance "snapshot" of 4,541 nesting females (95 percent credible limit of 4,074 to 5,063) using those three beaches (Martin *et al*. 2020). Because these beaches comprise approximately 52 percent of the total nesting population, the extrapolated 2015 total nesting abundance for the entire DPS is approximately 8,733 nesting females (95 percent credible limit of 7,834 to 9,736). This estimate refers to all nesting females, over a 3-year remigration interval; thus the most recent estimate of FENA is approximately one third of this estimate and fewer than 5,000 FENA. We conclude that this criterion has not been met.

5) Existing foraging areas are maintained as healthy environments. This criterion applies to the modification or destruction of habitat, a threat that continues to affect the DPS. Marine pollution, including marine debris and bioaccumulative chemicals, is one of the main anthropogenic threats to sea turtles and a critical environmental concern (Tomás *et al*. 2002; Schuyler *et al*. 2016). Foraging areas are altered by fishing practices, derelict fishing gear, channel dredging, marine pollution, and climate change. Foraging turtles become entangled in active or discarded fishing gear, often resulting in death or injury (Wilcox *et al*. 2016). Loggerheads also ingest plastics and other marine debris in foraging areas. A review of 340 studies on the encounters between marine organisms and debris found that loggerheads experienced the greatest incidence of marine debris ingestion (Gall and Thompson 2015). Foraging loggerheads respond similarly to the odors of prey items and biofouled plastic, the scent of which stimulates foraging behavior and contributes to turtles' detrimental (and often fatal) interactions with marine debris (Pfaller *et al*. 2020). Marine debris ingestion can cause sub-lethal effects including dietary dilution or assimilation of contaminants (Bjorndal 1997; McCauley and Bjorndal 1999; Plot and Georges 2010; Tourinho *et al.* 2010). It results in death when the debris blocks or tears their digestive tracts (Bjorndal *et al*. 1994; Tomás *et al*. 2002; Lazar and Gračan 2011). Population-level impacts are unquantified and unknown because most incidents of ingestion or entanglement go unrecorded. Therefore, exposure and impact must be evaluated in stranded or captured turtles. For example, evaluating 246 necropsied and 706 stranded sea turtles (all species in Australia), Wilcox *et al*. (2018) modeled that 14 items of plastic in a turtle's gut corresponds to a 50 percent probability of mortality, and one piece of plastic corresponds to a 22 percent probability of mortality. With their wide alimentary tract, loggerhead turtles may be able to defecate some items (Bugoni *et al*. 2001; Tomás *et*

al. 2001, 2002; Hoarau *et al*. 2014); however, this may not mitigate sublethal effects (Nelms *et al*. 2016). Dietary dilution causes reduced energy and nitrogen intake in post-hatchling loggerheads, which are more likely to starve as a result of their smaller size (McCauley and Bjorndal 1999; Tomás *et al*. 2002; Nelms *et al*. 2016). Parker *et al*. (2005) reported 34.6 percent of the loggerheads examined (i.e., 52 oceanic loggerheads) had ingested marine debris. Four of five (80 percent) loggerheads, incidentally captured in longline fisheries between 2012 and 2016, had ingested plastic (Clukey *et al*. 2017). Wedemeyer-Strombel *et al*. (2015) examined two loggerhead specimens and found that both had ingested marine debris, which comprised up to 78 percent of the individuals' diets and included a toothbrush and plastic bottle parts. Severe Marine Debris Events (e.g., the March 11, 2011 earthquake and tsunami in Japan) produce large amounts of debris that remain afloat and move over large distances (Shiomoto and Kameda 2005; *https://marinedebris.noaa.gov/sites/default/files/Japan_Tsunami_Marine_Debris_Report.pdf*). Effects range from reduced foraging to mortality, but population-level impacts are unquantified and unknown. Direct or indirect disposal of anthropogenic waste introduces potentially lethal materials into loggerhead foraging areas. Sakai *et al*. (2000) found heavy metals in the tissues and organs of loggerheads captured from Japanese coastal waters. Effects of such pollutants may be lethal, and non-lethal effects increase the probability of mortality (Balazs 1985; Carr 1987; McCauley and Bjorndal 1999; Witherington 2002). We conclude that this criterion has not been met.

6) Foraging populations are exhibiting statistically significant increases at several key foraging grounds within each stock region. This criterion is not threat-based, but rather provides necessary information for evaluating the status of the DPS. We are unaware of continuous, standardized datasets that assess the trends of foraging populations and therefore cannot determine whether this criterion has been met.

7) All Priority #1 tasks (i.e., those actions that must be taken to prevent extinction or to prevent the DPS from declining irreversibly in the foreseeable future) have been implemented. Generally, this criterion is not threat-based, but rather provides necessary information for evaluating the status of the DPS. Some tasks have been fully implemented, but most require ongoing efforts:

    - Monitor nesting activity, identify important nesting beaches, determine population trends (continuing)
    - Evaluate nest success, implement nest-protection measures (continuing)
    - Define stock boundaries (implemented)
    - Identify stock type for major nesting beach areas (implemented)
    - Determine nesting beach origins of juvenile and subadult populations (continuing)
    - Determine genetic relationship among populations (continuing)
    - Determine distribution, abundance of post-hatchlings, juveniles, and adults (continuing)
    - Determine adult migration routes, internesting habitats (continuing)
    - Determine growth rates, survivorship, age sexual maturity (continuing)
    - Identify current threats to adults, juveniles on foraging grounds (continuing)
    - Monitor incidental mortality in commercial and recreational fisheries (continuing)
    - Reduce incidental mortality in commercial and recreational fisheries (continuing)

- Identify important marine habitat (continuing)
- Ensure long-term protection of marine habitat (continuing)
- Prevent degradation or destruction of reefs by dredge or disposal (continuing)
- Support agreements, conventions, and protections in foreign water (continuing)
- CITES membership and compliance (implemented)
- Develop new agreements to protect in foreign waters (continuing)

8) A management plan designed to maintain stable or increasing populations of turtles is in place. This criterion applies to inadequate regulatory mechanisms, a threat that continues to affect the DPS. International recovery planning is underway but has not yet been completed; therefore, this criterion has not yet been met.

9) Ensure formal cooperative relationship with a regional sea turtle management program. The Secretariat of the Pacific Regional Environment Programme (SPREP) has worked in collaboration with NMFS, the Western Pacific Regional Fishery Management Council, Secretariat of the Pacific Community, and other organizations to support research and outreach activities to benefit sea turtles in the insular Pacific. SPREP created the Turtle Research and Monitoring Database System to collate data from strandings, tagging, nesting, emergence and beach surveys as well as other biological data on turtles in the Pacific. This criterion has been met.

10) International agreements are in place to protect shared stocks (e.g., Mexico and Japan). This criterion applies to inadequate regulatory mechanisms, a threat that continues to affect the DPS. Some international agreements are in place but others, including recovery planning, are in progress; therefore, this criterion has not yet been met.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

Like all sea turtles, loggerheads of the North Pacific Ocean DPS exhibit a complex life cycle (Figure 2) that contains several life stages (i.e., hatchling, juvenile, and adult, for the purposes of this review), occurring across wide-spread and diverse habitats. Nesting occurs in Japan, where the Sea Turtle Association of Japan (STAJ) and other entities collect nesting data (Kamezaki *et al*. 2003; Casale and Matsuzawa 2015; STAJ 2017). Foraging occurs at different locations in waters of the North Pacific Ocean, dependent on life stage and foraging strategy. Adults migrate to the waters off their natal beach to mate. Below we describe habitat use, foraging strategies, and other behaviors for each life stage.

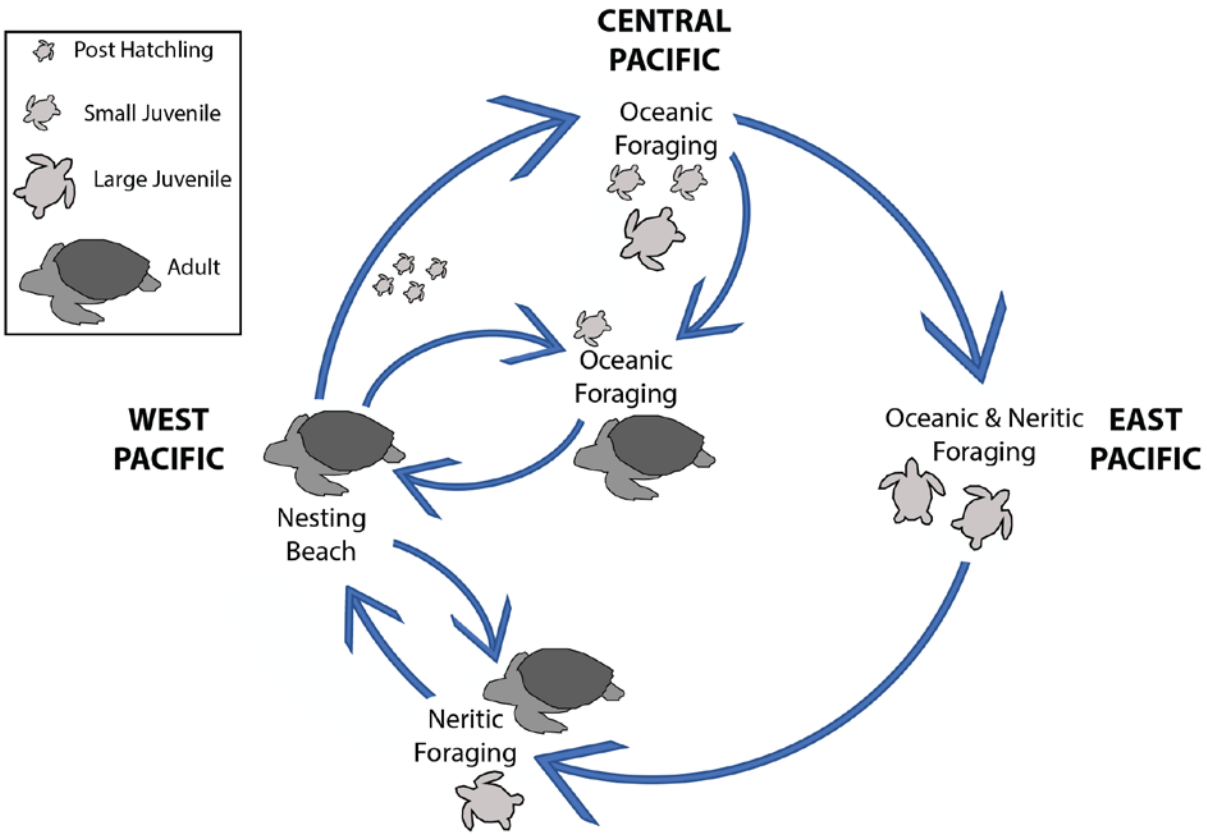

Figure 2. Complex life cycle of the North Pacific Ocean DPS.

2.3.1.1 Hatchling Biology and Habitat

On Japanese nesting beaches, hatchlings emerge from eggs between July and September. Sand temperature influences the incubation duration, sex determination, and hatching success rate.

After emerging from their nests, hatchlings crawl toward the sea, using as their guide near-ultraviolet to green light, which provides a consistent seaward marker, regardless of the phase and position of the moon (Kawamura *et al*. 2009). After the hatchlings enter the sea, they begin a swim frenzy toward offshore currents, including the Kuroshio Current. They likely imprint on the magnetic signature of the coastal area so that they can return to their natal waters and beaches to mate and nest (Lohmann and Lohmann 2019).

2.3.1.2 Juvenile Biology and Habitat

It is difficult to track small juveniles (i.e., post-hatchlings) over long durations and distances (Carr 1987); however, advances in tracking and modeling techniques, along with opportunistic sampling of juveniles incidentally captured in various fisheries, have provided important data on location and habitat use, summarized here.

After a swim frenzy toward offshore currents, small juveniles are passively transported via the Kuroshio Current, Kuroshio Extension, and other parts of the North Pacific Gyre (Okuyama *et al*. 2011). They also actively swim against currents to remain in more productive waters (i.e., foraging hotspots, such as the Kuroshio Extension Current Bifurcation Region and the Transition

Zone Chlorophyll Front; Polovina *et al*. 2006; Briscoe *et al.* 2016a,b; Christiansen *et al*. 2016) or to reach foraging areas in the eastern Pacific (Okuyama *et al*. 2011). During this time, they forage on planktonic animals, which are most abundant at oceanic fronts (Polovina *et al*. 2000, 2004, 2006; Hatase *et al*. 2004a; Etnoyer *et al*. 2006; Kobayashi *et al*. 2008). Their most common prey include the following sea surface invertebrates: *Janthina* spp., *Carinaria cithara*, *Velella*, *Lepas* spp., *Planes* spp., and *Pyrosoma* spp. (Parker *et al*. 2005).

As they grow, juveniles either remain in oceanic habitats to forage and mature or recruit to neritic habitats, where their development continues before migrating to adult foraging habitats. Oceanic habitats provide low abundance, pelagic prey (i.e., lower quality prey) leading to smaller sized turtles at maturity (Hatase *et al*. 2004b; Parker *et al*. 2005; Snover *et al*. 2010; Peckham *et al*. 2011); however, these loggerheads mature at an earlier age (Snover *et al*. 2010). Neritic habitats, such as those in Baja California, Mexico, provide higher quantity and quality forage, including higher trophic level organisms and benthic prey, resulting in turtles attaining larger sizes at maturity (Hatase *et al*. 2004b; Parker *et al*. 2005; Peckham *et al*. 2007b; Snover *et al*. 2010; Peckham *et al*. 2011; Seminoff *et al*. 2014; Briscoe *et al*. 2016b); however, these loggerheads mature at a later age and face higher rates of predation than oceanic foragers (Snover *et al*. 2010). For example, the highly productive waters off Baja California are a hotspot for foraging loggerhead turtles, with a mean annual abundance of 43,226 turtles (95 percent confidence interval of 15,017 to 100,444) from 2005 to 2007 (Seminoff *et al*. 2014). Juvenile loggerheads may also forage along the coast of southern California, where Eguchi *et al*. (2018) estimated more than 70,000 loggerheads during El Niño conditions in 2015 (compared to none in 2011 and two in 2018; J. Seminoff, NMFS, pers. comm. 2020). Immature loggerheads also forage in the coastal waters off Tanegashima Island, Japan (Kume *et al*. 2017).

The mechanism by which turtles remain in the oceanic zone or migrate to neritic waters is unclear, and several hypotheses exist. Hatase *et al*. (2004b) proposes that variation in oceanic prey availability leads to individual variation in growth rates, with larger juvenile turtles (i.e., those with higher growth rates) remaining in oceanic waters until reaching sexual maturity and smaller juvenile turtles (i.e., those with lower growth rates) recruiting to neritic waters for further growth and development, before recruiting to adult foraging areas.

Turner Tomaszewicz *et al*. (2017) hypothesize that juveniles use one of three foraging strategies: (1) fulltime oceanic; (2) long-term oceanic, followed by medium-term neritic; or (3) transit-only oceanic followed by long-term neritic. Juveniles of the fulltime oceanic habitat use strategy remain in pelagic waters until maturity, when they return to the western Pacific Ocean to nest and forage (Parker *et al*. 2005; Polovina *et al*. 2006; Kobayashi *et al*. 2008; Abecassis *et al*. 2013). The other two strategies involve juvenile movement from pelagic to neritic waters, as demonstrated by satellite tracking (Howell *et al*. 2008; Kobayashi *et al*. 2008; Abecassis *et al*. 2013; Briscoe *et al*. 2016b). Turner Tomaszewicz *et al*. (2017) used stable isotope analysis and skeletochronology to determine that juveniles of the long-term oceanic habitat use strategy remain in the Central North Pacific for over a decade, exceeding 60 cm curved carapace length (CCL), before recruiting to neritic foraging areas off the Baja California Peninsula. Juveniles of the transit-only oceanic habitat use strategy remain in the Central North Pacific for less than a decade, recruiting to neritic foraging areas off the Baja California Peninsula at sizes less than 60 cm CCL (Turner Tomaszewicz *et al*. 2017).

Some juveniles also move between locations within oceanic or neritic habitats. For example, some turtles move between the oceanic waters of the Kuroshio Extension Current Bifurcation Region and the Transition Zone Chlorophyll Front (Polovina *et al*. 2006; Ascani *et al*. 2016). Ascani *et al*. (2016) hypothesize that the Pacific Decadal Oscillation influences juveniles' ability to access highly productive waters. During positive phases, the Kuroshio Extension Current weakens and allows the juveniles to forage within the highly productive Transition Zone Chlorophyll Front. Whereas during negative phases, the Kuroshio Extension Current prevents northward movement resulting in lower prey availability for juveniles and lower recruitment to Japanese nesting beaches (Van Houtan and Halley 2011).

Within neritic habitats, juveniles may move between nearby locations, or, as they mature, they may cross the Pacific to use neritic foraging areas closer to nesting beaches. For example, Narazaki *et al*. (2015) hypothesize that large juveniles, returning from the eastern Pacific, use neritic foraging habitats of Japan (e.g., coastal areas of Sanriku) before reaching sexual maturity. These juveniles use the neritic foraging habitats during the summer but must migrate to warmer waters during the fall, winter, and spring to avoid cold stunning (Narazaki *et al*. 2015). Satellite tracking (N = 6) confirms that large juveniles overwinter in the warmer, highly productive oceanic waters of the Kuroshio Extension Current (Narazaki *et al*. 2015). Stranding events likely indicate that some juveniles (N = 4) and subadults (N = 10) forage in the neritic waters of the Boso Peninsula during the summer (Moriya 2009).

The above hypotheses explain different datasets, gathered from different locations and turtles. They are not mutually exclusive, and the different hypotheses likely explain the behavior of different turtles, as there appears to be a variety of juvenile foraging strategies. Reviewing all hypotheses, we conclude that variation among juvenile foraging strategies is likely dependent upon prey availability and quality, which vary over time, space, and environmental constraints, such as temperature and oceanic currents.

In summary, juveniles forage, develop, and grow in oceanic and sometimes neritic habitats. Oceanic foraging habitats occur in the East, West, and Central Pacific. Oceanic foraging hotspots include the Kuroshio Extension Bifurcation Region; the Transition Zone Chlorophyll Front; and the East China Sea (Polovina *et al*. 2006; Kobayashi *et al*. 2011; Allen *et al*. 2013; Turner Tomaszewicz *et al*. 2016). Important neritic juvenile foraging areas occur in the East and West Pacific. The most productive neritic foraging hotspot occurs off Baja California, Mexico (Peckham *et al*. 2007b; Kobayashi *et al*. 2008; Seminoff *et al*. 2014; Turner Tomaszewicz *et al*. 2015; Briscoe *et al*. 2016b; Turner Tomaszewicz *et al*. 2017). Neritic foraging also occurs off Japan: Boso Peninsula (Moriya and Moriya 2011); Muroto and Shimakatsu (Ishihara and Kamezaki 2011; Ishihara *et al*. 2011); Sanriku (Narazaki *et al*. 2013); and Tanegashima Island (Kume *et al*. 2017).

2.3.1.3 Adult Biology and Habitat

As adults, North Pacific loggerheads forage in the western Pacific Ocean. They use one of two foraging strategies:

- Planktonic prey in oceanic waters of the Northwest Pacific; or
- Benthic prey in neritic waters of Japan and the East China Sea.

Oceanic foragers consume nutrient-poor planktonic animals in pelagic habitats (e.g., jellies, salps, and other gelatinous animals in 0 to 25 m depth); whereas neritic foragers consume nutrient-rich benthic animals in neritic habitats (e.g., mollusks, crustaceans, and coelenterates at depths up to 150 m), as demonstrated by stable isotope analyses and satellite tracking of post-nesting females at Yakushima Island (Hatase *et al*. 2002d; Hatase *et al*. 2006; Hatase *et al*. 2018). As a result, oceanic foragers are smaller adults (less than 85 cm SCL) than neritic foragers (greater than 85 cm SCL; Iwamoto *et al*. 1985; Kamezaki and Matsui 1997a,b; Hatase *et al*. 2002d; Kamezaki 2003; Hatase *et al*. 2004; Nobetsu *et al*. 2003; Nobetsu *et al*. 2004; Balazs 2006). The smaller oceanic foragers also have smaller clutch sizes, lower clutch frequencies, and longer remigration intervals (Hatase *et al*. 2002d; Hatase *et al*. 2004; Hatase *et al*. 2013).

Hatase *et al*. (2004) hypothesize that juvenile foraging strategies determine adult foraging strategies. Once mature, loggerheads do not appear to change foraging strategy (e.g., from oceanic to neritic in order to increase fecundity; Hatase *et al*. 2002d; Hatase *et al*. 2004; Nobetsu *et al*. 2004). Juveniles foraging exclusively in oceanic waters reach sexual maturity at an earlier age but remain smaller as adults than neritic-foraging adults that foraged in both oceanic and neritic waters as juveniles. Population structure and natal beach do not determine and are not influenced by foraging strategy: Watanabe (2006) did not find any genetic differences between neritic (N = 40) and oceanic (N = 8) foragers nesting on Yakushima Island. Hatase *et al*. (2004) suggest that foraging strategy fidelity may be a result of imprinting. We conclude that juvenile foraging strategy likely determines adult foraging strategy as well as size and fecundity.

Tagging and tracking data indicate that adults make reproductive migrations between foraging areas (neritic or pelagic) and the waters off their natal beaches (Iwamoto *et al*. 1985; Nobetsu *et al*. 2004). Turtles likely use magnetic fields to guide them to their natal areas (Lohmann and Lohmann 2019). Males enter the waters off nesting beaches before females arrive (e.g., in January, off Tanegashima Island; Kume *et al*. 2017). Females enter these waters in April or May, with peak nesting in June (Kume *et al*. 2017). Adult females tagged (N = 10, Iwamoto *et al*. 1985; N = 9, Sato *et al*. 1997; Kamezaki *et al*. 1997) or tracked (N = 2, Sakamoto *et al*. 1997; N = 5, Hatase *et al*. 2002d; N = 5, Sakamoto 2013; N = 5, Oki *et al*. 2019) from nesting beaches in Japan foraged along coastal Japan and in the East China Sea. Male loggerheads released from coastal Japanese waters remained primarily in the waters around Japan (e.g., Sea of Japan and Kuroshio Current) and the East China Sea (N = 1, Sakamoto *et al*. 1997; N = 3, Saito *et al*. 2015).

Mating likely occurs at foraging areas, in migratory corridors, or off nesting beaches (i.e., waters of Japan or the East China Sea). Kume *et al*. (2017) documented mating turtles captured in the pound net fishery off Tanegashima Island. Rossi *et al*. (2008) reported adult-sized loggerheads and mating behavior in waters off Baja California, Mexico; however, nesting has never been documented in this area.

Females of the North Pacific Ocean DPS nest on beaches throughout the Japanese Archipelago (Nishimura 1967a,b; Kamezaki *et al.* 2003; STAJ 2017). STAJ (2017) reports annual nesting counts at 35 beaches. Tagging studies demonstrate that females exhibit nesting site fidelity (Iwamoto *et al*. 1985; Kamezaki *et al*. 1997; Sato *et al*. 1997; Hatase *et al*. 2002d). Of 2,219

nesting females tagged on Japanese nesting beaches, only five females changed their nesting sites, with remigration distances ranging from 74 to 630 km and all nesting remaining in Japan (Kamezaki *et al*. 1997; Hatase *et al*. 2002d).

Females remigrate every 3.3 years, laying 4.6 nests per year, with an average of 122 eggs per nest (Hatase *et al*. 2013). These values have changed to reflect a longer remigration interval and more nests and eggs annually since the Status Review. Some female turtles emerge onto sandy beaches in an attempt to nest, without laying eggs; these false crawls may be caused by disturbances by humans or dogs, absence of adequate substrate, or insufficient intrinsic conditions (Iwamoto *et al*. 1985).

2.3.1.4 New information on the species' biology and habitat

Information available since the Status Review refines our knowledge regarding the species' biology and habitat use, especially as it pertains to juvenile foraging strategies. Additional information confirms the complexity of the loggerhead life cycle, as a result of individual variation at each life stage. Multiple foraging strategies at juvenile and adults life stages indicate the importance of several different habitat types and locations to the DPS. This highlights the need for management and protection of such areas.

2.3.1.5 Abundance, population trends, and demographic or trends

Before considering the threats to the DPS, we describe its abundance, trends, and demographics to understand its vulnerability or resilience to threats. For example, a large, growing population with high birth rates and low mortality rates is more resilient to threats than a small, declining population with low birth rates and high mortality rates. As described in detail below, the North Pacific Ocean DPS exhibits: low abundance (an estimated 8,733 nesting females); recently (i.e., less than one generation) increasing population growth (2.3 percent annually); and average demographic characteristics for the species (with the exception of low return rates for nesting females).

2.3.1.5.1 Abundance

It is difficult to estimate overall abundance for sea turtle populations because individuals spend the majority of their time in water, where they are difficult to count, especially considering their large range and use of many different and distant habitats. Nesting females, however, converge on their natal beaches to nest, allowing the collection of abundance data on the individuals that most directly influence population productivity (i.e., reproductive females).

Martin *et al*. (2020) evaluated nesting abundance and trends using nest count data from three nesting beaches for which data were available (Inakahama, Maehama, and Yotsusehama on Yakushima). Based on estimates derived from their trend analysis, they calculated an abundance "snapshot" of 4,541 nesting females (95 percent credible limit of 4,074 to 5,063) using those three beaches in 2015 (Martin *et al*. 2020). Because these beaches comprise approximately 52 percent of the total nesting population, the extrapolated 2015 total nesting abundance for the entire DPS is approximately 8,733 nesting females (95 percent credible limit of 7,834 to 9,736 nesting females). The narrow credible interval reflects high confidence in the available data; however, data are unavailable for 48 percent of the nesting population.

In 2009, the estimated total number of nests was 7,000 to 8,000 nests (50 FR 58868, September 22, 2011), which was approximately equivalent to the total nesting female abundance for the DPS at that time. The Status Review concluded that population abundance of North Pacific loggerheads was small (Conant *et al*. 2009). Casale and Matsuzawa (2015) estimated the 8,100 nesting females, based on nest count data from 2009 to 2013 (using a remigration interval of 2.7 years and three nests per female). The 2015 nesting female abundance estimate (8,733) is similar to these estimates. Therefore, we conclude that abundance continues to be small for the North Pacific Ocean DPS. Small abundance contributes to the extinction risk of the DPS because small populations are more likely than large ones to be extirpated as a result of stochastic events and threats.

2.3.1.5.2 Trends

Martin *et al*. (2020) used a Bayesian state-space model to describe trends in nesting data to evaluate population-level impacts of the Hawaii-based shallow-set longline fishery. This model uses exponential population growth as its underlying process and allows the use of combined nesting data from beaches with different nesting levels and over different time series, i.e., the three index nesting beaches on Yakushima (Inakahama, Maehama, and Yotsusehama). As stated above, these index beaches comprise approximately 52 percent of the total nesting population (Martin *et al*. 2020); long-term, consistent nesting data are not available for the remainder of the population. The Bayesian state-space model indicates that the number of nesting females has increased an average of 2.3 percent annually (Martin *et al*. 2020; Figure 3). Though the 95 percent credible interval surrounding the growth rate is moderately wide (−11.0 to 15.6 percent) and includes the possibilities of no growth (i.e., zero) or decline (negative growth rates), the distributions around the model fit and the 2015 modeled abundance estimate are quite narrow, providing relatively high confidence in the positive trend. Data from all three index beaches were available from 1999 to 2015, with minimal gaps; however, two index beaches monitored since 1986 and 1989 demonstrated the decade-long decline between 1990 and 1999 (Martin *et al*. 2020). Short-term fluctuations (e.g., mid-2000s) are typical of sea turtle populations, in which females do not nest on an annual cycle. The most recent 3 years of data (2013, 2014, and 2015) also demonstrate a short-term decline (Martin *et al*. 2020), which may reflect natural variation. We conclude that North Pacific loggerhead nesting has increased between 1999 and 2012, at a minimum.

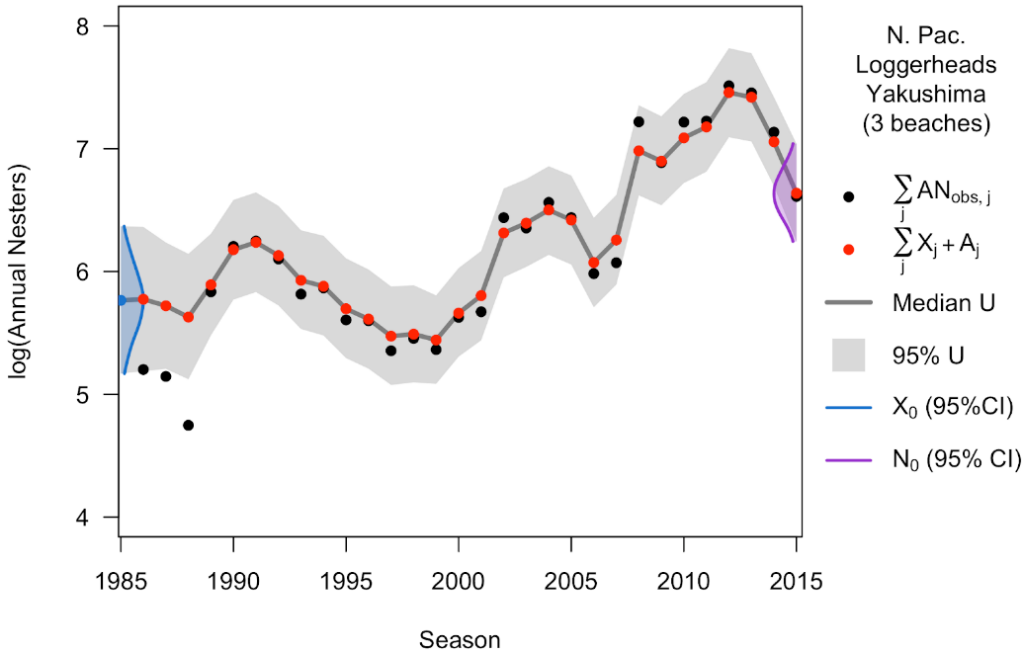

Figure 3. Model of nesting trend from 1985 to 2015. Figure 7 from Martin *et al*. (2020), the gray line (median U) depicts the median long-term trend. The gray shading depicts the 95 percent credible interval of the model fit. Observed data are shown in black and model-predicted data are shown in red. The purple line (N_0) depicts the distribution around 2015 model-predicted data.

This conclusion is similar to the conclusion of Casale and Matsuzawa (2015), who evaluated nest trends at 35 beaches, comparing past nest counts (from the 1980s, 1990s, or early 2000s) and more recent nest counts (2009 to 2013); they found an overall average annual increase of 1.69 percent.

These recent trend estimates differ from that of the Status Review (Conant *et al*. 2009), which identified a declining overall trend, based on the analyses of Snover (2008), who used STAJ data from 1998 to 2007 (STAJ and unpublished data provided to the Western Pacific Fisheries Management Council, 2008) and nesting data published by Kamezaki *et al*. (2002), dating back to 1990. Based on these prior two datasets, collected from 33 nesting beaches in Japan, Snover (2008) and Conant *et al*. (2009) concluded that loggerheads of the North Pacific declined in abundance over 18 years, from 1990 to 2007. Gilman (2009a,b) also concluded that the number of loggerheads nesting in the Pacific had declined by 80 percent over 20 years. These analyses were likely influenced by the decade-long declines experienced at most nesting beaches in the 1990s (Kamezaki *et al.* 2003).

The most recent trend analyses (Martin *et al*. 2020) compiled nesting data from three beaches, which may or may not be representative of other nesting beaches. Casale and Matsuzawa (2015) compared nest count trends at 35 beaches (Table 2). These data show increasing trends at most beaches wherethe “past” years (e.g., 1980s, 1990s, or early 2000s) often represented the years of the lowest nest counts recorded (Kamezaki *et al.* 2003). Despite the overall increasing trend,

some beaches exhibit stable or declining trends, indicating a general lack of consistency among trends at individual nesting beaches (Matsuzawa *et al*. 2016).

Table 2. Average nest count trends at individual beaches. Modified from Table 1 (Casale and Matsuzawa 2015)

Beach	Past estimate (year)	Past estimate (nests/year)	2013 estimate (nests/year)	Average trend (change/year)
Itoman Beach	1992	4	19	0.077
Maehama Beach	1989	611	1,637	0.040
Inakahama Beach	1986	540	2,504	0.056
Nagahama Beach	1997	106	612	0.109
Fukiage Beach	1993	64	51	-0.010
Nichinan Beach	1989	43	53	0.008
Miyazaki Beach	1985	607	1,143	0.022
Ohgi and Shimonokae Beach	1995	9	30	0.067
Okata Beach	1991	19	37	0.029
Moto Beach	1984	12	17	0.011
Hiwasa Beach	1979	76	18	-0.040
Kamouda Beach	1995	30	20	-0.023
Minabe Senri Beach	1985	162	236	0.013
Shingu Beach	1989	15	15	0.000
Shima Peninsula Beach	2000	25	43	0.040
Atsumi Beach	1996	19	50	0.054
Akabane Beach	1992	29	39	0.013
Toyohashi Beach	1992	82	87	0.003
Kosai Beach	1992	25	41	0.023
Hamamatsu Beach	1988	99	167	0.020
Omaezaki Beach	1973	55	139	0.023
Sagara Beach	1995	22	23	0.001
Kujukuri Beach	2004	15	39	0.101
Kunigami-Dana	2004	22	71	0.124
Kunigami-Iji	2002	7	6	-0.012
Kunigami-Jashiki	2002	15	50	0.104
Kunigami-Uzabama	2004	18	15	-0.017
Yoron-To Island	2003	64	178	0.098
Yakushima-Yotsuse	1999	70	223	0.080
Yakuhsima-Kurio	1994	70	296	0.075
Yakushima-Sagoshi	1994	35	52	0.020
Tanegashima-Maenohama	2003	58	176	0.106
Tanegashima-Takezaki	2003	29	198	0.189
Tanegashima-Okigahamada	2004	40	61	0.044
Tanegashima-Iseki	2004	26	48	0.066

North Pacific loggerheads have been estimated to have a generation time of 20 or more years (NMFS and USFWS 1998) or 45 years (Casale and Matsuzawa 2015). The recent trend analyses (Casale and Matsuzawa 2015; Martin *et al*. 2020) generally used data collected over less than one generation. It would be helpful to evaluate the trend over at least one, and if possible, several generations to better understand whether the trend represents interannual variability or true population productivity. In 1967, Nishimura compiled nesting data from 42 Japanese nesting beaches and concluded that loggerhead abundance was declining due to nesting habitat destruction and overexploitation of adults and eggs. This decline may have continued through the 1970s, prior to the ban on egg harvest (Matsuzawa *et al*. 2006; Matsuzawa *et al*. 2016); however, Kamezaki *et al.* (2003) found indications of approximate stability in nesting abundance in the 1970s. Kamezaki *et al*. (2003) identified increases at some beaches in the 1980s but found that, in most of these instances, nesting declined to pre-1980 levels by the end of the 1990s. Based on a comprehensive review of available nesting abundance data, Kamezaki *et al.* (2003) concluded that there had been substantial declines (50 to 90 percent) in the North Pacific loggerhead nesting population between the 1950s and the 1990s, which they estimated comprised fewer than three generations (Kamezaki *et al.* 2003). Kamezaki *et al.* (2003) based their conclusions on the following data:

- In the 1990s, large declines in annual nesting, especially at Hiwasa (89 percent) and Minabe (74 percent) beaches;
- For most beaches, the lowest nesting abundance was recorded between 1997 and 1999; and
- Severe declines at Kamouda Beach, which in the 1950s hosted the largest number of nesting females but was no longer a major nesting beach by the 1990s.

In their analysis for the IUCN Red List Assessment, which requires three generations of abundance data to apply Criterion A (IUCN 2014), Casale and Matsuzawa (2015) estimated generation time as 45 years. Because abundance data are not available for North Pacific loggerheads for three generations or approximately 135 years, Casale and Matsuzawa (2015) used the earliest historical values, which were the only values available to perform their statistical analyses. To be accurate, this would require the assumption that the population abundance three generations ago was "similar to the first observed abundance" on nesting beaches. We do not agree with this assumption. In many instances, the "first observed abundance" estimates were based on nest counts from the 1990s, which coincides with the nesting population nadir (Kamezaki *et al.* 2003). Nishimura (1967a,b) reported severe declines beginning in the middle of the 20th century, and Kamezaki *et al*. (2003) reported severe declines (50 to 90 percent) between the 1950s and late 1990s. Therefore, it is likely that historical nesting abundance (e.g., prior to the 1950s) was greater than that of the "first observed abundance" as reported by Casale and Matsuzawa (2015), i.e., in the 1980s, 1990s, or early 2000s. Gilman (2009a,b) concluded that the number of loggerheads nesting in the Pacific has declined by 80 percent in the past 20 years. Based on this information, we conclude that current nesting abundance is less than historical levels (i.e., one or more generations). We do not agree with the IUCN Red List Assessment that the population has shown an increase in nesting over the past three generations (*https://www.iucnredlist.org/species/83652278/83652322*; Casale and

Matsuzawa 2015) because such data (i.e., three generations of data) are not available and available information (i.e., since the 1950s) suggest otherwise.

In summary, we find that the DPS demonstrated an increasing trend between 1999 and 2013; however, current levels of nesting likely do not exceed historical levels, and several beaches exhibit stable or declining nesting trends. We conclude that the increasing nesting trend, while important and encouraging, is not of adequate magnitude and duration to alter the status of the DPS.

2.3.1.5.3 Demographics

We updated the estimated values for various life stage parameters summarized in the Status Review (Table 3). Hatase *et al*. (2013) reported increases in the remigration interval (from 2.7 to 3.3 years), clutch frequency (from 3 to 4.6 nests annually), and clutch size (from 112 to 122 eggs per nest).

Table 3. Life history parameters for the North Pacific Ocean DPS. Adapted from Table 1 (Conant *et al*. 2009), with updates (in bold) from Hatase *et al*. (2013).

Productivity	
Fecundity	
Remigration interval (years)	**3.3**
Clutch frequency (annual number of nests)	**4.6**
Clutch size (number of eggs per nest)	**122**
Sex ratio (percent female)	**65**
Emergence success	0.61
Habitat use	
Juveniles	
Proportion neritic	0.14
Years oceanic	27.0
Years neritic	2.0
Mean age of first reproduction (years)	30
Standard deviation of first reproduction age	5
Adults	
Proportion neritic (nesting and non-nesting)	0.82
Survival rates	
Aquatic hatchlings	0.400
Oceanic juvenile	
$\lambda_0 = 1.05$	0.858
$\lambda_0 = 1.10$	0.914
Neritic juvenile	
$\lambda_0 = 1.05$	0.928
$\lambda_0 = 1.10$	0.955
Oceanic adult	0.950
Neritic adult	0.950

The productivity of the DPS is dependent on females remigrating (i.e., returning to nest) on a regular basis (e.g., every 3.3 years). Like other sea turtles, the North Pacific loggerhead exhibits

nesting site fidelity, with most females returning to their natal beaches to nest (STAJ 2017). On mainland Japanese nesting beaches, observers report that as little as 30 percent of nesting females return to nest in subsequent years (Y. Matsuzawa, STAJ, pers. comm. 2017). Most known nesting beaches are surveyed by STAJ or other partner organizations. Given the high nesting beach fidelity demonstrated by tagging studies (Iwamoto *et al*. 1985; Kamezaki *et al*. 1997; Sato *et al*. 1997; Hatase *et al*. 2002a), it seems unlikely that 70 percent of nesting females nest on other, unsurveyed beaches. Alternatively, nesting females may nest one season and then fail to nest again, possibly due to mortality as a result of threats encountered in the marine environment.

2.3.1.6 Genetics diversity, genetic variation, or trends in genetic variation

The Status Review reviewed the genetic diversity of the DPS. Two studies analyzing 350 base pairs of the mtDNA control region found only three haplotypes (two common and one rare) in 223 samples (Bowen *et al*. 1995; Hatase *et al*. 2002b). To find newly available information, we searched Science Direct, Google Scholar, and our scientific literature database for a combination of the terms: "North Pacific;" "loggerhead" or "caretta;" and "genetics," "DNA," or "diversity." We found one publication on genetic diversity (Matsuzawa *et al*. 2016). Increasing the mtDNA control region sequence length to 820 base pairs revealed nine haplotypes in 555 samples (Matsuzawa *et al*. 2016). Within this larger sample size, haplotype diversity ranged from 0.44 to 0.78, and nucleotide diversity averaged 0.003. We conclude that genetic diversity is adequate for adaptation by natural selection.

2.3.1.7 Taxonomic classification or changes in nomenclature

Kingdom: Animalia
Phylum: Chordata
Class: Reptilia
Order: Testudines
Family: Cheloniidae
Genus: *Caretta*
Species: *caretta*
DPS: North Pacific Ocean
Common name: Loggerhead sea turtle

The taxonomy of the species has remained consistent and unchallenged since 1962 (Dodd 1988). Dodd (1988) reviewed the history of loggerhead sea turtle taxonomy, which was summarized in the Status Review (Conant *et al*. 2009). To identify newly available information on this subject since the publication of the Status Review, we searched for the terms "loggerhead turtle taxonomy" and "caretta taxonomy" in scientific research search engines (i.e., Science Direct and Google Scholar) and in our scientific literature database. We did not find any articles published since 2009. Therefore, we include the following summary of the information in the Status Review (Conant *et al*. 2009).

In 1758, Linnaeus first identified the loggerhead turtle as *Testudo caretta*. Over the next two centuries more than 35 names were applied to the species (Dodd 1988), but *Caretta caretta* has emerged as the valid name. The genus *Caretta* is monotypic, containing only the single species

(Bowen 2003). While Deraniyagala (1933) described an Indo-Pacific form as *C. gigas* in 1933, he later determined that *gigas* was a subspecies of *C. caretta* (Deraniyagala 1939). Since that time, many challenged the subspecific designation of *gigas* (Brongersma 1961; Hughes 1974; Pritchard 1979). Genetic (Bowen *et al*. 1994) and other diagnostic characters (Dodd 1988) do not support the recognition of a subspecies.

2.3.1.8 Spatial distribution, trends in spatial distribution, or historic range

Along with abundance and productivity, spatial distribution provides insight into the status of a DPS. For example, a widely distributed DPS is less likely to go extinct due to environmental perturbations or catastrophic events than one that is narrowly distributed. Spatial structure refers to the geographic distribution of individuals and the processes generating that distribution. On one end of the spectrum (i.e., panmixia or no spatial structure), individuals randomly move and reproduce throughout the range of the DPS. Spatially structured DPSs are subdivided into metapopulations, subpopulations, management units, or other subunits, in which individuals are more likely to remain and reproduce within their subunit than disperse and interbreed with an individual from another subunit (i.e., gene flow). Connectivity is the degree to which dispersal and gene flow link subunits.

The North Pacific Ocean DPS is defined as loggerhead turtles originating from the North Pacific Ocean, north of the Equator and south of 60º N latitude (Conant *et al*. 2009). The northern extent of their range is likely a result of limited thermal tolerance; in temperatures lower than 10 ºC, loggerheads may lose their ability to swim and dive, a phenomenon known as cold stunning (Witherington and Ehrhart 1989; Morreale *et al*. 1992). As described in the Status Review, loggerheads of the DPS remain north of the Equator throughout their lifespan and are essentially the only loggerheads found north of the Equator in the Pacific (Conant *et al*. 2009). Therefore, the range of the DPS is the same as the boundaries of the DPS: the North Pacific Ocean, north of the Equator and south of 60º N latitude (Figure 1).

The DPS occurs throughout the North Pacific Ocean. Foraging occurs in the western, central, and eastern North Pacific Ocean, with the location varying by individual, life stage, and environmental factors such as productivity and oceanic currents. Nesting is limited to the Japanese Archipelago, from Yaeyama in the south to Chiba in the north (Figure 4), a geographic distance of approximately 2,000 km. This is likely a contraction of the historical nesting range of the DPS, which once nested on beaches in Taiwan, China, and other areas in this region.

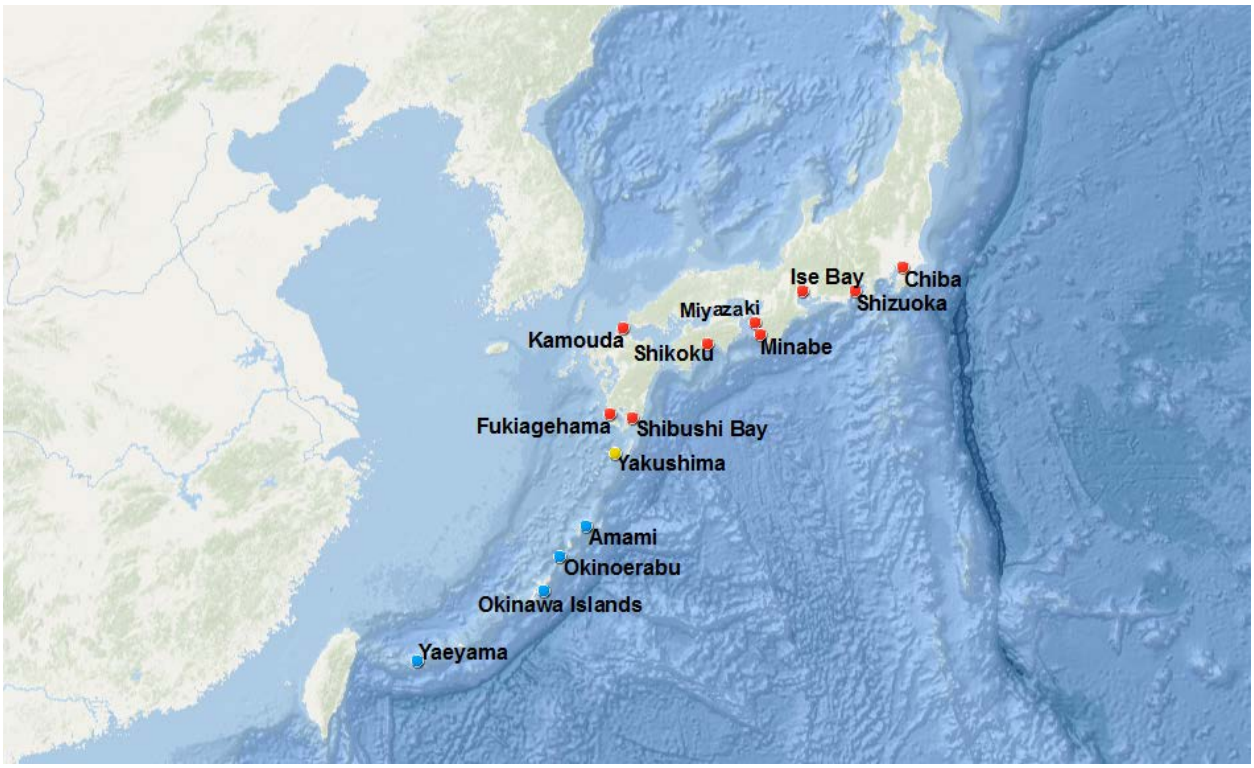

Figure 4. Genetically sampled nesting beaches. Nesting sites sampled in genetic studies (Hatase *et al*. 2002b; Watanabe *et al*. 2011; Matsuzawa *et al*. 2016). Colors identify management units: Mainland (red), Yakushima (yellow), and Ryuku Islands (blue), as defined by Matsuzawa *et al*. (2016).

In 2003, Inakahama and Maehama Beaches on Yakushima Island hosted approximately 30 percent of all loggerhead nesting in Japan (Kamezaki *et al*. 1989; Kamezaki *et al*. 2003). By 2009, those beaches plus Yotsusehama (also on Yakushima Island) hosted approximately 40 percent of all nesting (Conant *et al*. 2009). As of 2015, Yotsusehama, Inakahama, and Maehama hosted 52 percent of all nesting for the DPS (Martin *et al*. 2020). In 2003, nesting also occurred on Okinawa, Kuroshima, and Ishigakijima Islands. Previously, nesting had been identified on the western coast of Tanegashima Island (Inatani *et al*. 2001) and on the eastern coasts of the Amami, Miyako, and Yaeyama Islands (Kamezaki *et al*. 1989).

Tagging data indicate that most females exhibit nesting site fidelity (i.e., repeatedly returning to the same nesting beach; Iwamoto *et al*. 1985; Kamezaki *et al*. 1997; Sato *et al*. 1997). However, some do not. Five of 2,219 females nested at beaches 74 to 630 km from the nesting beach where they were tagged (Kamezaki *et al*. 1997). One female incidentally captured in a coastal pound net in Shikoku was satellite tracked to Hironohama Beach, Kii Peninsula; she had previously nested at Hiwasa Beach, Shikoku (Kamezaki *et al*. 2006).

To evaluate genetic structure among nesting aggregations, we searched Science Direct, Google Scholar, and our scientific literature database for a combination of the terms: “Japan” or “North Pacific;” “loggerhead” or “caretta;” and “genetics,” “DNA,” “structure,” or “connectivity.” We found that generally, females return to their natal beaches to nest, generating genetic subdivision

or structure among nesting beaches at maternally inherited loci (Hatase *et al*., 2002; Watanabe *et al*. 2011; Matsuzawa *et al*. 2016).

Hatase *et al*. (2002) compared 350 base pairs of the mtDNA control region among four nesting sites in Japan: Minabe (N = 51 in 1994 and N = 51 in 1995); Miyazaki (N = 19 in 1995 and 27 in 1999); Fukiagehama (N = 14 in 1997 and N = 8 in 1999); and Yakushima (N = 27 in 1995 and N = 62 in 1999). Hatase *et al*. (2002) found statistically significant differences in haplotype frequencies (i.e., genetic structure) between:

- Minabe and Miyazaki ($P < 0.0001$)
- Minabe and Yakushima ($P < 0.01$)
- Miyazaki and Fukiagehama ($P < 0.05$)
- Miyazaki and Yakushima ($P < 0.05$).

Watanabe *et al*. (2011) built upon the Hatase *et al*. (2002) study by adding another nesting site (Kamouda, N = 10) and evaluating all samples at five microsatellite loci (i.e., biparentally inherited, nuclear genetic markers). In addition to the statistically significant differences in mtDNA haplotype frequencies found by Hatase *et al*. (2002), Watanabe *et al*. (2011) detected statistically significant differences (i.e., genetic structure) between Miyazaki and Kamouda ($P < 0.05$). Generally, microsatellite results indicated male-mediated gene flow (Watanabe *et al*. 2011).

Matsuzawa *et al*. (2016) built upon these previous studies by evaluating longer mitochondrial sequences, increasing sample sizes, and expanding the number and distribution of sampling locations (including nesting sites in the Ryukyu Archipelago). Though they did not evaluate samples from Fukiagehama or Kamouda, Matsuzawa *et al*. (2016) analyzed samples from the following 12 nesting sites in Japan: Chiba (N = 10); Shizuoka (N = 38); Ise Bay (N = 11); Minabe (N = 101); Shikoku (N = 48); Miyazaki (N = 61); Shibushi Bay (N = 25); Yakushima (N = 108); Amami (N = 53); Okinoerabu (N = 24); Okinawa Islands (N = 70); and Yaeyama (N = 6). The additional data resulted in the identification of more haplotypes (N = 9) and an increased ability to detect genetic differentiation. Matsuzawa *et al*. (2016) found statistically significant differences in haplotype frequencies (i.e., genetic structure) between:

- Chiba and Minabe/Ise Bay ($P < 0.05$)
- Shizuoka and Minabe/Ise Bay ($P < 0.05$)
- Shizuoka and Yakushima ($P < 0.05$)
- Shizuoka and Yakushima ($P < 0.05$)
- Shizuoka and Amami ($P < 0.05$)
- Shizuoka and Okinawa Islands ($P < 0.01$)
- Minabe/Ise Bay and Shikoku ($P < 0.05$)
- Minabe/Ise Bay and Yakushima ($P < 0.01$)
- Minabe/Ise Bay and Amami ($P < 0.01$)
- Minabe/Ise Bay and Okinoerabu ($P < 0.01$)
- Minabe/Ise Bay and Okinawa Islands ($P < 0.01$)
- Shikoku and Yakushima ($P < 0.01$)
- Shikoku and Okinawa Islands ($P < 0.01$)
- Miyazaki/Shibushi Bay and Amami ($P < 0.01$)

- Miyazaki/Shibushi Bay and Okinoerabu ($P < 0.05$)
- Miyazaki/Shibushi Bay and Okinawa Islands ($P < 0.01$)
- Yakushima and Amami ($P < 0.01$)
- Yakushima and Okinoerabu ($P < 0.01$)
- Yakushima and Okinawa Islands ($P < 0.01$)
- Okinoerabu and Okinawa Islands ($P < 0.05$).

Matsuzawa *et al*. (2016) found inconsistent genetic differentiation (i.e., statistically significant differences found using pairwise exact test but not pairwise F_{ST} analysis) between Minabe and Miyazaki. Tagging data indicate that females move between these and other nesting sites on the mainland (Watanabe 2006), thus genetic structure between these areas is tenuous (Matsuzawa *et al*. 2016). Matsuzawa *et al*. (2016) included the islands of Honshu, Shikoku, and Kyushu with the mainland Japan. Yakushima Island is separated from mainland Japan by the Kuroshio Current, which along with visual cues that may encourage female nesting site fidelity, may act as a barrier to gene flow (Matsuzawa *et al*. 2016). Matsuzawa *et al*. (2016) concluded that loggerhead nesting sites in Japan are sufficiently isolated demographically and reproductively to be managed independently; however, low levels of genetic exchange occur within each of three management units:

- Mainland (Chiba, Shizuoka, Minabe/Ise Bay, Shikoku, Miyazaki/Shibushi Bay)
- Yakushima
- Ryukyu (Amami, Okinoerabu, and Okinawa Islands).

Based on the best available science, there is moderate genetic structure among mainland Japan, Yakushima, and the Ryukyu management units, indicating that females and their female offspring nest at or near their natal beaches. Therefore, if one management unit was extirpated, recolonization by nesting females from another unit is unlikely within one to several generations. Male-mediated gene flow provides a mechanism for genetic exchange among management units (e.g., to avoid inbreeding), but such exchange cannot alleviate the loss of nesting females. The presence of multiple nesting aggregations within each management unit, however, makes it highly unlikely that an entire unit would be lost. There is also low-level genetic structure *within* each management unit (i.e., among nesting aggregations within a unit). An extirpated nesting aggregation may be recolonized by a few females from nearby nesting beaches of that management unit within the foreseeable future, though the rate of recolonization is likely to be low.

In summary, the DPS has a broad distribution, with foraging throughout the North Pacific Ocean; however, the nesting range is limited to the Japanese Archipelago. There is spatial structure within the DPS, with subpopulations nesting on Mainland, Yakushima, and Ryuku beaches. The subdivision informs our consideration of abundance because, reproductively, the DPS is split into three units, rather than a single, panmictic population, causing further concern for the resilience of the DPS.

2.3.1.9 Habitat or ecosystem conditions

The DPS depends on adequate, diverse, and suitable nesting and foraging habitats. Nesting sites are limited to the beaches of Japan; however, the amount of nesting habitat appears to be

adequate, spanning the Japanese Archipelago, from the Yaeyama Islands to the Boso Peninsula (Chiba), a distance of approximately 2,000 km. There is moderate diversity among nesting beaches, some of which occur on high islands with wide sand beaches (e.g., Yakushima Island) and others occur on pocket beaches along rocky reefs (e.g., Shikoku Island). However, most beaches are vulnerable to inundation by typhoons, storm surge, and high tides, which often reduce the capacity and suitability for nesting. The nesting season is long, from April to September, with differences along a longitudinal gradient, providing some temporal diversity.

Both juveniles and adults exhibit diverse foraging strategies (i.e., oceanic versus neritic), which influence their size, development, and fecundity. In addition, juveniles may use neritic foraging areas in the eastern or western North Pacific Ocean. The most productive foraging area for juveniles occurs the greatest distance from nesting beaches (i.e., at Baja California, Mexico, where mortality rates are high). Some juveniles recruit to Muroto and Shimakatsu, Japan (Ishihara and Kamezaki 2011; Ishihara *et al*. 2011), neritic feeding areas that are relatively close to nesting beaches (Nishizawa *et al*. 2014). Other juveniles recruit to highly productive neritic feeding areas, such as Sanriku, which is 500 km from the nearest nesting beach (Narazaki *et al*. 2013; Nishizawa *et al*. 2014). Thus, there are energetic trade-offs between high productivity foraging areas and long migrations. There does not appear to be genetic spatial structure among these foraging areas, suggesting that individuals originating from different nesting beaches may mix in foraging areas (Nishizawa *et al*. 2014).

We conclude that there appears to be adequate, diverse, and suitable nesting and foraging habitat. As discussed in the threats section, inundation of nests is a concern at most beaches, reducing their capacity to host successful nesting. Foraging areas vary in productivity, with some of the most productive juvenile foraging areas requiring the longest migration. These factors have not changed since the Status Review and do not affect the status of the DPS.

2.3.1.10 Representation, resilience, and redundancy

The information presented above contributes to our understanding of the status of the DPS, especially as it pertains to representation, resiliency, and redundancy (USFWS 2016).

Representation describes the DPS's capacity to adapt to changing environmental conditions over time. The DPS is characterized by limited genetic and environmental diversity. Though there is some diversity in nesting habitat, the majority of nesting occurs on small pocket beaches. All nesting beaches are at risk of inundation. As discussed below in the threats section, rising sea level is likely to increase this risk of inundation, and beach armoring structures (designed to mitigate beach erosion) reduce available nesting habitat. We conclude that representation is not adequate to change the status of the DPS.

Resilience describes the DPS's capacity to withstand stochastic disturbance and is related to population size, trend, and spatial structure. The DPS has a low abundance, which is further subdivided into three management units. This limits the overall resilience of the DPS. The recent nesting trend suggests an increase in resilience; however, we are concerned with the estimated 30 percent remigration rate because population resilience is dependent upon females returning to nest on a regular basis. We conclude that resilience is not adequate to change the status of the DPS.

Redundancy is a measure of the DPS's capacity to withstand catastrophic events. The DPS nests at multiple beaches throughout the Japanese Archipelago, and each life stage forages at multiple areas throughout the North Pacific Ocean. Though this redundancy would not protect the DPS from large-scale environmental changes, such as those likely to occur as a result of climate change, it is likely to provide some insurance against local catastrophic events. While adequate, redundancy alone does not change the status of the DPS.

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

Section 4(a)(1) of the ESA requires the Services to determine whether a species is endangered or threatened because of any of the following factors (or threats) alone or in combination:

1) The present or threatened destruction, modification, or curtailment of its habitat or range;
2) Overutilization for commercial, recreational, scientific, or educational purposes;
3) Disease or predation;
4) Inadequacy of existing regulatory mechanisms to address identified threats; or
5) Other natural or human factors.

We first describe each factor and its effect on the DPS. If possible, we identify whether the threats are likely to influence abundance, trends, distribution, and/or diversity (in other words, how do the threats influence the representation, resiliency, and redundancy of the DPS). Finally, when possible we characterize the magnitude of the threat.

We found that the threats identified in the Status Review continue to negatively impact the DPS (Conant *et al*. 2009). The largest threat remains fisheries bycatch, with the highest mortality arising from Japanese pound net fisheries, coastal fisheries in Baja California, Mexico, and illegal, unreported, and unregulated (IUU) fishing in the South China Sea and throughout the North Pacific Ocean (Conant *et al*. 2009). Fisheries bycatch reduces abundance and has the potential to reduce future productivity, due to the loss of females, thus reducing the resilience of the DPS. Coastal development and armoring on Japanese beaches continues to reduce available nesting habitat. Increases in sea level and the frequency of storm events due to climate change will exacerbate these problems by increasing pressure for armoring at some nesting sites and further reducing nesting habitat on developed beaches that cannot migrate inland due to armoring structures or modified natural topographic features. Nesting beach loss as a result of coastal development, armoring, and climate change reduces the productivity, spatial distribution, and redundancy of the DPS. Threats related to climate change have increased in magnitude since the Status Review. We review all threats in detail in the following sections.

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

The destruction and modification of terrestrial and marine habitats contributes to the endangered status of the North Pacific Ocean DPS. Erosion, artificial lighting, beach use, and pollution reduce the availability of suitable nesting habitat. In foraging areas, marine debris entangles or is ingested by turtles, at times resulting in injury or death.

2.3.2.1.1 Beach erosion, shoreline structures, and coastal development

Erosion on Japanese nesting beaches is a result of anthropogenic and natural processes. Anthropogenic processes include coastal development, coastline alteration, and the construction

and use of armoring, stabilization, and erosion control structures. Natural erosion processes include seasonal storms including typhoons, storm surge, high tides, waves, changes in shoreline geology, and sea level rise. Erosion is often worsened when coastal and inwater structures interfere with natural coastal processes. Erosion leads to the loss of nesting habitat. While accretion/erosion dynamics occur on all beaches to some extent, significant, regular losses occur on pocket beaches, which tend to be steeper, have shallower overall sedimentation, and may take longer time to replenish. Erosion is also greater in areas where the natural coastal processes have been altered (Hatase 2013; STAJ 2017). For example, erosion led to the loss of nesting habitat from Isumi to Kujyukuri (Mainland, northern extent of the nesting range), likely reducing the number of nests laid along these beaches over the last 20 years (Moriya 2009).

Beach armoring structures decrease nesting activity by preventing females from accessing suitable nesting sites. Females abandon their nesting attempts more frequently on armored beaches (Rizkalla and Savage 2011). Where concrete walls occur on Hamawaki and Tanowaki Beaches, nesting females regularly return to the sea without nesting (STAJ 2017). On Chita Peninsula beaches, STAJ (2017) recorded non-nesting events at areas armored with concrete revetment. Nesting females have been recorded to wander along the foot of coastal dike, formerly a nesting area on the Kamoda Coast (Y. Matsuzawa, STAJ, pers. comm. 2017). When armoring structures prevent access to preferred nesting beaches, females nest in sub-optimal habitats, where nests are more vulnerable to erosion, inundation, and increased moisture from tidal overwash (Rizkalla and Savage 2011; Witherington *et al*. 2011). Armoring occurs in three of the five nesting beaches in Yakushima. As a result of armoring, almost all the nests laid at Maehama (Yakushima) need to be relocated, resulting in decreased hatching success (Y. Matsuzawa, STAJ, pers. comm. 2017). On Okinawa Island and Amami, approximately one third of nests are laid in front of a sea wall (Y. Matsuzawa, STAJ, pers. comm. 2017). Along the Kochi shoreline, wave dissipating blocks reduce overall nesting and force females to nest on a narrow area of the beach that is susceptible to inundation; those nests are moved to prevent the complete loss of nesting in this area (STAJ 2017). Along Miyazaki, erosion caused by sea walls forced females to nest on narrow beaches. The sea walls have since been replaced by revetments; however, these revetments require constant sand replenishment, which modifies nesting habitat. Beach armoring also modifies nesting habitat by changing natural beach morphology and processes by accelerating erosion seaward of and adjacent to the armoring, especially on the downdrift side (i.e., end scour; Pilkey *et al*. 2012). In addition, the structures limit the diversity of beach elevation, which reduces shoreline resiliency (Watanabe *et al*. 2002). Matsushita *et al*. (2006) reported shoreline changes as a result of the construction of sea walls. Beach armoring is likely to become an even greater threat as sea level rises (Conant *et al*. 2009).

Detachments, jetties, and other shore-perpendicular structures are designed to trap sand that would otherwise be transported by longshore currents. They change a beach's profile and width (e.g., downdrift erosion, loss of sandy berms, and escarpment formation) and interfere with nesting females' access to the beach (Komar 1983; Pilkey *et al*. 1984; National Research Council 1987). Along the Ichinomiya coast, concrete jetties and bamboo mats have been constructed, reducing available beach habitat for nesting (STAJ 2017). Sand rivers naturally supply the beaches along the Miyazaki coast; however, this sand transfer is obstructed by the construction of dams, embankments, and concrete walls. The placement of jetties does not allow enough sand

accumulation to support successful nesting along these beaches. Breakwaters constructed off the shoreline of Jibikihama, Shimonokae, Shichirimihama, and Fudeshima result in narrower beaches and decreased nesting. Along the coast of Kamoda, the construction of offshore breakwaters obstructed the nearshore current and changed the location of hatchling emergence, resulting in decreased hatching success (Watanabe 2002, 2008).

Coastal development includes the construction of roads, highways, public infrastructure, hotels, condominiums, houses, ports, and harbors. As of 1998, only 8.7 percent of the nesting habitat consists of untouched sandy beaches (Matsuzawa and Kamezaki 2018). The nesting beach at Kuroshima Island has eroded as a result of the construction of a port (STAJ 2017). Beach erosion at Kujukuri Beach is significant and likely occurs due to the construction of port embankments (STAJ 2017). Similarly, the construction of the port and airport along Myojinyama-Oida Beach caused increased erosion (Matsuzawa 2006). The construction of the port in Miyazaki involved the development of a groin, a yacht harbor with breakwaters and artificial beach, and an airport. As a result, the adjacent nesting beach shows significant erosion (Takeshita 2006). Sagara nesting beaches were also eroded when the construction of seawalls and dams changed current flows, removing sand (Matsushita *et al*. 2006). Upstream dams and jetties along the Atsumi Peninsula caused an increase in erosion on these beaches. Shoreline armoring with concrete blocks further exacerbates the loss of habitat due to erosion and blocks loggerheads from nesting higher up on the beach closer to the vegetation line. Because almost all nests in the area would be washed out, they are relocated to a hatchery. Because of mountainous terrain, the roads around Yakushima and Okinawa are located close to nesting beaches. On the Mainland, 25 to 50 percent of beaches are lined with buildings and roads. Coastal development alters nesting habitat, making it less suitable for nesting females, egg incubation, and hatchling emergence. However, development and construction require government authorization and are prohibited in the Special Protection Zones and Special Zones of Natural Parks, providing protection in these areas.

2.3.2.1.2 Artificial lighting

Developments, such as roadways, high rise hotels, and condominiums, also contribute to habitat degradation by increasing noise and light pollution. Loggerhead hatchlings orient toward near-ultraviolet radiation to enter the sea (Kawamura *et al*. 2009). Light pollution disorients hatchlings, causing them to move inland away from the ocean (Witherington 1997). Those lured into lighted parking lots or toward streetlights are often crushed by passing vehicles (Witherington and Martin 1996). If unable to find the ocean, or delayed in reaching it, they incur high mortality rates due to dehydration, exhaustion, or predation (Ehrhart and Witherington 1987; Witherington and Martin 1996). Hatchlings have been run over by cars along Shirahama beach (STAJ 2017). Loggerhead hatchlings were disoriented by illuminations of hotels of Hiwasa-Ohama Beach, Tokushima, which uses predominately-blue LED lights (Y. Matsuzawa, STAJ, pers. comm. 2017).

In addition, light pollution deters nesting females from emerging onto the beach to nest (Witherington 1992). In 1993, Kato *et al*. reported that loggerhead female emergence density on Enshunada Coast was highly related to darkness and width of the beach.

Light may be minimal, such as the headlights of cars in Yakushima Islands (Kudo *et al*. 2004), or extensive, such as the city and street lights of Nagahama coast. Tourist facilities near the

beaches of Ohama and Tatato and street lights near the road on the beaches on Chita Peninsula and Shirahama Beach are visible from the beach. Along some of the mainland beaches, close to cities, lights from highways are visible from the nesting beach. Thus, artificial lighting reduces overall nesting and hatchling survival, which impacts the productivity of the DPS.

Efforts have been made to reduce the impact of artificial lighting on nesting beaches. In Yakushima, trees have been planted to block road light visible from the Inakahama nesting beach. Cooperative Prefecture efforts and official guidelines (e.g., for "turtle walk") control lights from recreational activities.

2.3.2.1.3 Beach use

Beach use contributes to high mortality of eggs and pre-emergent hatchlings at many Japanese nesting beaches (Matsuzawa 2006). In Yakushima, egg and pre-emergent hatchling mortality is higher in public access areas, where foot traffic ("trampling") leads to sand compaction over the nests (Kudo *et al*. 2003; Omuta 2009; Matsuzawa 2012; Matsuzawa 2013). Nests laid close to beach entrances are more susceptible to trampling (Kudo *et al*. 2004). In addition, when people are present, nesting females spend less time creating body pits and covering their egg chamber (Y. Matsuzawa, STAJ, pers. comm. 2017). In 1993, Yakushima Island was designated a Ramsar Site, which resulted in increased tourism and greater pressure at nesting beaches, where people flocked to see nesting turtles (Omuta 2009). As a result, the Ministry of Environment and a local non-governmental organization established guidelines for conducting turtle surveys and minimizing impacts by humans on the nesting beaches (Omuta 2009). As of the 2009 nesting season, humans accessing Inakahama, Maehama, and Yotsuse beaches at night must comply with the established rules (Y. Matsuzawa, STAJ, pers. comm. 2009; Omuta 2009).

Driving on nesting beaches also degrades nesting habitat. The ruts left by vehicles in the sand prevent or impede hatchlings from reaching the ocean (Mann 1977; Hosier *et al*. 1981; Cox *et al*. 1994; Hughes and Caine 1994). Hatchlings impeded by vehicle ruts are at greater risk of death from predation, fatigue, desiccation, and being crushed by additional vehicle traffic. Vehicles also cause sand compaction, which hinders nest construction and reduces hatching and emergence success (Mann 1977). Vehicle lights also deter females from nesting and disorient hatchlings (Omuta 2009). Vehicle-use is prohibited in loggerhead nesting areas of at least three national parks: Yakushima, Kerama-shoto, and Iriomote-Ishigaki (*http://www.env.go.jp/en/laws/nature/law_np.pdf*). On U.S. military beaches in Okinawa, minimization measures to avoid driving over nests are required during training, beach grooming, events, and camping (Y. Matsuzawa, STAJ, pers. comm. 2017).

2.3.2.1.4 Beach debris

Beach debris may impede nesting females, potentially influencing their selection of nest sites. In rare instances, large debris entraps nesting females. Beach debris over nests impedes or prevents emergence and prevents hatchlings from reaching the ocean, reducing emergence and hatching success. Surveys indicate that plastics, which may entangle or entrap loggerheads, account for the majority of beach debris (Kusui and Noda 2003; *https://www.env.go.jp/en/headline/2167.html*).

2.3.2.1.5 Marine habitat modification

Fishing practices, channel dredging, marine pollution, and climate change modify loggerhead foraging and migratory habitat and alter ecosystem dynamics in the marine environment. Effects range from reduced foraging to mortality, but population-level impacts are unquantified and unknown. Habitat impacts stemming from climate change are reviewed in Section 2.3.2.6 Climate Change, Storm Events, and Ocean Features.

Marine pollution, including marine debris and bioaccumulative chemicals, is one of the main anthropogenic threats to sea turtles and a critical environmental concern (Tomás *et al*. 2002; Schuyler *et al*. 2016). Loggerheads become entangled in lost or discarded fishing gear, such as gillnets and crab pots (NOAA Marine Debris Program 2015), often resulting in death or injury (Wilcox *et al*. 2016). Loggerhead turtles of all life stages are especially prone to ingesting marine debris (Lutcavage *et al*. 1997; Gall and Thompson 2015). Foraging loggerheads respond similarly to the odors of prey items and biofouled plastic, the scent of which stimulates foraging behavior and contributes to turtles' detrimental (and often fatal) interactions with marine debris (Pfaller *et al*. 2020). Marine debris ingestion can cause sub-lethal effects including dietary dilution or assimilation of contaminants (Bjorndal 1997; McCauley and Bjorndal 1999; Plot and Georges 2010; Tourinho *et al*. 2010). Dietary dilution causes reduced energy and nitrogen intake in post-hatchling loggerheads, which are more likely to starve as a result of their smaller size (McCauley and Bjorndal 1999; Tomás *et al*. 2002; Nelms *et al*. 2016). Marine debris ingestion results in death when the debris blocks or tears their digestive tracts (Bjorndal *et al*. 1994; Tomás *et al*. 2002; Lazar and Gračan 2011; Velez-Rubio *et al*. 2018). Population-level impacts are unquantified and unknown because most incidents of ingestion or entanglement go unrecorded. Therefore, exposure and impact must be evaluated in stranded or captured turtles. Parker *et al*. (2005) found that 34.6 percent of the loggerheads examined (i.e., 52 oceanic loggerheads) had ingested marine debris. Loggerheads primarily ingest plastic and other marine debris mistaken for or associated with prey items (Wedemeyer-Strombel *et al*. 2015). Four of five loggerheads (80 percent), incidentally captured in longline fisheries between 2012 and 2016, had ingested plastic (Clukey *et al*. 2017). Severe marine debris events (e.g., the March 11, 2011 earthquake and tsunami in Japan) produced large amounts of debris that remained afloat and moved over large distances extending to the west coast of the U.S. and Hawaii (*https://marinedebris.noaa.gov/sites/default/files/Japan_Tsunami_Marine_Debris_Report.pdf*).

Direct or indirect disposal of anthropogenic waste introduces potentially lethal materials into loggerhead foraging habitats, including convergence zones, where oceanic juveniles forage. Contaminants include herbicides, pesticides, oil spills, and other chemicals resulting from shipping, dredging, and marine explosives (Francour *et al*.1999; Lee Long *et al*. 2000; Margaritoulis *et al*. 2003; Waycott *et al*. 2005). Effects may be lethal, and non-lethal effects increase the probability of mortality (Balazs 1985; Carr 1987; McCauley and Bjorndal 1999; Witherington 2002). Sakai *et al*. (2000) found heavy metals in the tissues and organs of loggerheads captured from Japanese coastal waters. Contaminant levels of loggerheads foraging in the eastern Pacific is unknown (Gardner *et al*. 2006); however, loggerheads may be exposed to high levels of heavy metals due to by bioaccumulation in their carnivorous diet (Sakai *et al*. 2000).

Oil spills affect sea turtles of all life stages, likely due to their lack of avoidance behavior, indiscriminate feeding in convergence zones, and large pre-dive inhalations (Milton *et al*. 2003).

Vargo *et al*. (1986) reported that sea turtles would be at substantial risk if they encountered an oil spill or large amounts of tar in the environment. In a review of available information on debris ingestion, Balazs (1985) reported that tar balls were the second most prevalent type of debris ingested by sea turtles.

2.3.2.1.6 Summary of habitat threats

Based on the best available data, we find that the DPS faces present and threatened destruction and modification of its habitat. Erosion, shoreline structures, and coastal development reduce the availability of suitable nesting habitat. Artificial lighting, beach use, beach debris, and some shoreline structures and coastal developments deter nesting females and prevent hatchlings from reaching the sea. These habitat modifications reduce the productivity of the DPS by reducing nesting, hatching success, and hatchling survival. The loss and modification of beach habitat are also likely to reduce the diversity and distribution of nesting beaches, thus impairing the representation, resilience, and redundancy of the DPS.

Important foraging habitats are modified by pollution, contaminants, and oil spills. Individuals are killed and injured by derelict fishing gear and other marine debris, either through ingestion or entanglement. The threat clearly affects many individuals; however, the magnitude of the threat to marine habitats is unknown because few injured or dead turtles are recovered or reported.

We conclude that habitat destruction and modification is a moderate threat that is likely to become a major threat to the DPS as sea level rises.

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

Although reduced from historic levels, loggerheads are still killed for their meat. In addition, eggs are relocated to hatcheries, and hatchlings are released during the day for educational purposes, which reduces hatchling survival.

Egg harvesting was once common in coastal areas of Japan (Kamezaki *et al*. 2003; Takeshita 2006; Ohmuta 2006; Omuta 2009). Prior to the 1970s, up to 90 percent of loggerhead nests were taken in Yakushima and Miyazaki (Kanno 1976; Uchida 1976; Takeshita 2006; Ohmuta 2006; Omuta 2009). Ohmuta (2006) reported that a public bidding system for each beach allowed individuals to gain access to sea turtle eggs, which were sold on the Yakushima Island. Laws enacted in 1973 prohibited egg collection on Yakushima and were extended throughout the entire Kagoshima Prefecture in 1988 (Ohmuta 2006). Loggerhead nesting populations are now regulated and managed at the local level (i.e., government prefectures, municipalities, and national parks). As a result, legal egg collection no longer occurs, contributing to increasing population trends (Omuta 2009; Y. Matsuzawa, STAJ, pers. comm. 2017).

In Japan, it is still legal to harvest loggerhead turtles at sea if the prefectural government or Ministry of Environment issues a permit (*http://www.env.go.jp/en/laws/nature/law_wphm-summary.pdf*). Legal harvest is allowed in eight prefectures.

In Mexico, loggerheads were once harvested for food, medicine, and decorations (Olguin-Mena 1990; Nichols 2003; Senko *et al*. 2009), with the highest exploitation occurring in Baja California Sur (Mancini *et al*. 2011). In 1990, a presidential decree banned all harvest of sea

turtles throughout Mexico, prohibiting the "extraction, capture and pursuit of all species of sea turtle in federal waters or from beaches within national territory ... [and a requirement that] ... any species of sea turtle incidentally captured during the operations of any commercial fishery shall be returned to the sea, independently of its physical state, dead or alive." Despite the ban, hundreds of loggerheads have been poached annually for human consumption in Mexico (Mancini and Koch 2009a,b; Senko *et al*. 2011). Nichols (2003) estimated a minimum annual mortality of 1,000 loggerheads, based on carapaces found between 1994 and 1999. Since 2000, thousands of loggerhead carcasses, killed for human consumption, have been found on beaches, villages, and in garbage dumps (Peckham and Nichols 2006; Mancini and Koch 2009a,b). Poaching likely continues, removing adults and large juveniles from the DPS.

Since the late 1980s, the Enshu-nada of Shizuoka prefecture has regularly relocated nests for educational purposes. In this area, most eggs are excavated and moved to hatcheries; the hatchlings are later released, during the day (Matsuzawa and Kamezaki 2008; STAJ 2017). Relocation of sea turtle nests into a hatchery can have a number of effects. Movement subsequent to approximately 24 hours of deposition kills developing embryos by disrupting delicate membranes inside of the egg. Nest relocation alters the incubation of the developing embryo (Pfaller *et al.* 2009). Changes in incubation temperature, gas exchange parameters, and hydric environment of nests may result in mortality, morbidity, and reduced behavioral competence of hatchlings (Tuttle *et al*. 2010). Changes in the incubation temperature also result in skewed sex ratios and reduced hatchling viability (Reid *et al*. 2009; McElroy *et al*. 2015). A study of nests at Isumi (Boso Peninsula, Chiba Prefecture) from 2007 to 2011 identified a significantly higher hatchling emergence rate ($X^2 = 6.412$; $P = 0.01133$) for in-situ nests as compared to relocated nests (Moriya and Moriya 2012).

Hatchlings are also retained for tourism hatchling release events. For example, at Hamamatsu beach, Shizuoka Prefecture approximately 200 nests are relocated annually, and hatchlings are retained to be released by tourists (Y. Matsuzawa, STAJ, pers. comm. 2017). These prolonged retention handling practices are inconsistent with sea turtle reproductive biology (Wyneken and Salmon 1992; Okuyama *et al*. 2009), and negatively impact conservation and recovery efforts. Matsuzawa and Kamezaki (2008) state that one tenth of all loggerhead hatchlings produced in Japan are released after prolonged retention. This practice reduces the productivity of the DPS and must be addressed to effectively conserve the species (Matsuzawa and Kamezaki 2008; Matsuzawa and Kamezaki 2018).

Legal and illegal harvest of turtles remains a source of mortality for the DPS. Without data, we are unable to estimate the magnitude of this threat; however, illegal harvest has been high in Mexico, based on carcasses alone. Harvest of adults and large juveniles reduces abundance and productivity. Nest relocation reduces hatching success, and prolonged retention prior to release reduces hatchling survival rates; both of these reduce productivity. Reductions in abundance and productivity reduce the resilience of the DPS. We conclude that overutilization is at least a moderate threat to the DPS.

2.3.2.3 Disease or predation

Little is known regarding loggerhead diseases or their population level effects. George (1997) describes at least two bacterial diseases in wild loggerhead populations: bacterial encephalitis and ulcerative stomatitis/obstructive rhinitis/pneumonia. Viral diseases have not been documented in free-ranging loggerheads, with the possible exception of sea turtle fibropapillomatosis, which may have a viral etiology (George 1997). Fibropapillomatosis is a disease that is characterized by the presence of internal and/or external tumors (fibropapillomas) that may interfere with swimming, vision, and feeding. Although fibropapillomatosis reaches epidemic proportions in some wild green turtle (Chelonia mydas) populations, the prevalence of this disease in most loggerhead populations is thought to be small. A variety of endoparasites, including trematodes, tapeworms, and nematodes have been described in loggerheads (Herbst and Jacobson 1995). Heavy infestations of endoparasites may cause or contribute to debilitation or mortality in sea turtles. Universidad Autónoma de Baja California Sur (UABCS) *et al*. (2014) also identified the potential for harmful algal blooms to impact loggerheads in the Gulf of Ulloa, Mexico.

Native and introduced species prey on loggerhead eggs and hatchlings on nesting beaches; however, the overall impact on the DPS is unknown. Raccoon dogs (*Nyctereutes procyonoides*) and weasels (*Mustela itatsi*) pose the greatest threats to eggs (Kamezaki *et al*. 2003). On Minabe Senri Beach, one of the largest nesting beaches in Honshu, nests were protected with wire cages because raccoon dogs destroyed a large percentage of nests (Ministry of the Environment 2014; Matsuzama 2017). At Yakushima Island, 34 nests were lost to raccoon dogs (STAJ 2012). On the Akabane Coast, the Japanese fox (*Vulpes japonica*) preys on eggs just before hatchling emergence; as a result, some nests are now protected with wire caging (Matsuzawa 2017). On Amami Oshima, wild boar (*Sus scrofa leucomystax*) destroy 47 to 146 nests per season. On the northern beaches of Okinawa-jima Island, the Ryukyu odd-tooth snake (*Dinodon semicarinatum*) destroyed 36 of 101 loggerhead nests (Matsumoto *et al*. 2014). Tiger sharks prey on hatchlings and larger turtles in Japanese waters. Examining the gut contents of 497 tiger sharks, Abe (2006) found that three had consumed a loggerhead turtle. Takahashi (2005) reported a tiger shark attack of a loggerhead turtle off the Coast of Chichijima Island in Ogasawara, Japan.

Predation has the potential to reduce abundance by removing individuals at all life stages. Predation of eggs and hatchlings reduces productivity. Such reductions likely have a small impact on the DPS, which has evolved in the presence of predators. We conclude that disease and predation pose a low level of threat to the DPS.

2.3.2.4 Inadequacy of existing regulatory mechanisms

The North Pacific Ocean DPS has a large range, extending throughout the North Pacific Ocean. As such, it is protected by numerous international, national, regional, and local regulations. We reviewed the regulations described in other sections of this review and the conservation efforts listed below. We conclude that fisheries bycatch remains a major threat to the DPS, in-part due to inadequate implementation, monitoring, and enforcement of regulatory mechanisms. In Japan, turtles are legally harvested for consumption. In Mexico, illegal poaching remains a concern in some areas, likely due to lack of surveillance and enforcement. The modification of nesting habitat also continues to be a concern, in part due to inadequate regulation of coastline

development near nesting beaches. Overall, we conclude that the DPS is negatively impacted by the inadequacy of existing regulatory mechanisms.

U. S. Magnuson-Stevens Fishery Conservation and Management Act
NMFS implements the U.S. Magnuson-Stevens Fishery Conservation and Management Act (MSA), the primary law governing marine fisheries management in United States (16 U.S.C. 1801). Passed in 1976 and amended in 2007, the MSA fosters the long-term biological and economic sustainability of marine fisheries. Section 301 (16 U.S.C. 1851) requires fishery management plans to include conservation and management measures to the extent practicable to minimize bycatch; to the extent bycatch cannot be avoided, fisheries are required to minimize the mortality of bycatch. Section 316 (16 U.S.C. 1865) requires a bycatch reduction program to develop technological devices and design other engineering changes to minimize bycatch. MSA revisions to Section 610 (16 U.S.C. 1826(k)) of the High Seas Driftnet Moratorium Protection Act requires identification of nations that: 1) are engaged in fishing activities that result in the bycatch of protected living marine resources; 2) fail to implement effective measures to reduce bycatch; and 3) have not adopted a regulatory bycatch reduction program comparable to that of the United States. It authorizes consultation with these nations to seek treaties or agreements that protect such species and to certify nations that document evidence of a comparable regulatory program and establish a management plan with monitoring and conservation requirements. Although Mexico is currently certified, the 2019 Improving International Fisheries Management Report to Congress reported IUU fishing activities (occurring from 2016 to 2018). The United States will consult with Mexico regarding this issue (*https://www.fisheries.noaa.gov/foreign/international-affairs/identification-iuu-fishing-activities*). Mexico's temporary federal regulations had reduced loggerhead bycatch along a 43 km index shoreline, from an annual average of 363 (2003 to 2011) to 113 loggerheads in 2016 (Peckham 2017). Counts were much lower during the primary fishing months (June, July, and August) for the local small-scale fleets that were previously found to experience high levels of bycatch (Peckham *et al*. 2008; Koch and Peckham 2017; Peckham 2017). However, since the fishery was reopened in 2018 and 2019, bycatch has returned to previous levels (A. Mancini, Grupo Tortuguero de las Californias, pers. comm. 2020).

FAO Guidelines to Reduce Sea Turtle Mortality in Fishing Operations
The Food and Agriculture Organization (FAO) of the United Nations provided technical guidelines to reduce sea turtle mortality in marine fisheries. These recommendations were endorsed by the FAO Committee on Fisheries (COFI), which called for the immediate implementation by member nations and Regional Fishery Management Organizations (RFMOs). These RFMO measures are now required of cooperating and non-party members.

Indian Ocean – South-East Asian Marine Turtle Memorandum of Understanding (IOSEA)
This Memorandum of Understanding (MOU) puts in place a framework through which States of the Indian Ocean and South-East Asian region, as well as other concerned States, can work together to conserve and replenish depleted marine turtle populations for which they share responsibility. This collaboration is achieved through the collective implementation of an associated Conservation and Management Plan. Currently, there are 35 signatory states. The United States became a signatory in 2001. Numerous accomplishments have been made under the auspices of this MOU, such as the development of an IOSEA Site network and regular

reports on the status of sea turtles in the IOSEA region. For detailed information, visit the IOSEA website at *https://www.cms.int/iosea-turtles/*.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
This Convention was designed to regulate international trade in a wide range of wild animals and plants. CITES was implemented in 1975 and currently includes 183 Parties. Although CITES has been effective at minimizing the international trade of sea turtle products, it does not limit legal harvest within countries, nor does it regulate intra-country commerce of sea turtle products (Hykle 2002). CITES is currently carrying out a review of illegal trade of sea turtles in Africa, Southeast Asia, and Latin America. Additional information is available at *http://www.cites.org*.

United Nations Convention on the Law of the Sea (UNCLOS)
To date, 157 countries, including most mainland countries in the western Pacific, have joined the Convention. The United States has signed the treaty. While the Senate has not ratified the treaty, the United States abides by all but the deep seabed mining provisions. Aside from its provisions defining ocean boundaries, the convention establishes general obligations for safeguarding the marine environment through mandating sustainable fishing practices and protecting freedom of scientific research on the high seas. Additional information is available at *http://www.un.org/Depts/los/index.htm*.

United Nations Resolution 46/215 on Large-Scale Pelagic Driftnet Fishing
In 1991, the United Nations called for the elimination of all high seas driftnets by 1992. Additional information is available at *http://www.un.org/documents/ga/res/44/a44r225.htm.*

The International Convention for the Prevention of Pollution from Ships (MARPOL)
The MARPOL Convention is a combination of two treaties adopted in 1973 and 1978 to prevent pollution of the marine environment by ships from operational or accidental causes. The 1973 treaty covered pollution by oil, chemicals, harmful substances in packaged form, sewage, and garbage. The 1978 MARPOL Protocol was adopted at the Conference on Tanker Safety and Pollution Prevention and included standards for tanker design and operation. The 1978 Protocol incorporated the 1973 Convention as it had not yet been in force and is known as the International Convention for the Prevention of Marine Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78). The 1978 Convention went into force in 1983 (Annexes I and II). The Convention includes regulations aimed at preventing and minimizing accidental and routine operations pollution from ships. Amendments passed since have updated the convention. To date there are six Annexes with Annexes I and II being mandatory for State Parties and the others being voluntary:

- Annex I Regulations for the Prevention of Pollution by Oil
- Annex II Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk
- Annex III Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form
- Annex IV Prevention of Pollution by Sewage from Ships
- Annex V Prevention of Pollution by Garbage from Ships
- Annex VI Prevention of Air Pollution from Ships.

The Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention)
The World Heritage Convention was signed in 1972 and, as of 2019, 193 states are parties to the Convention. The instrument requires parties to take effective and active measures to protect and conserve habitat of threatened species of animals and plants of scientific or aesthetic value. The forests of Yakushima Island, which hosts the greatest numbers of nesting loggerheads in the North Pacific, are protected. Additional information is available at *http://whc.unesco.org/en/marine-programme.Hampi+World+Heritage+Site+KarnatakaHampi*.

Ramsar Convention on Wetlands
The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. Currently, there are 170 parties to the Convention, with 2,200 wetland sites. In 2018 a resolution was passed to enhance conservation of coastal marine turtle habitats and the designation of key areas as Ramsar Sites (*https://www.ramsar.org/news/ramsar-convention-to-enhance-marine-turtle-conservation-in-cooperation-with-cms-and-iosea*).

Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC)
This Convention is the only international treaty dedicated exclusively to sea turtles, setting standards for their conservation and habitats with a large emphasis on bycatch reduction. It is the only binding multi-national agreement for sea turtles and is open to all countries in North, Central, and South America, and the Caribbean. It currently has 16 Contracting Parties, with the United States becoming a signatory in 1999. The IAC Loggerhead resolution calls on Mexico and the United States to work together to recover sea turtles, including North Pacific loggerheads. Additional information is available at *http://www.iacseaturtle.org*.

Ministry of Environment and Prefectural Protections, Japan
In 1988, the Kagoshima Prefecture enacted the Nature Protection Ordinance, which prohibited egg collection on Yakushima and was extended throughout the entire Kagoshima Prefecture (Ohmuta 2006). Loggerhead nesting populations are now regulated and managed at the local level (i.e., government prefectures, municipalities, and national parks; Matsuzawa and Kamezaki 2012). Legal collection of loggerheads caught in the water is allowed if the prefectural government or Ministry of Environment issues a permit. Additional information is available at *http://www.env.go.jp/en/laws/nature/law_wphm-summary.pdf*.

The Wildlife Protection and Hunting Management Law, Japan
This law protects wildlife protection areas if deemed necessary. National Wildlife Protection Areas are designated by the Minister of the Environment, and prefectural Wildlife Protection Areas are designated by the governor of the prefecture. Construction adjacent to nesting beaches is regulated by Ministry of Environment in Special Protection Zone and Special Zone of Natural Parks. Additional information is available at *http://www.env.go.jp/en/laws/nature/law_wphm-summary.pdf*.

2.3.2.5 Fisheries bycatch

At present, the most significant factor affecting the survival and recovery of the North Pacific Ocean DPS is bycatch in commercial and artisanal fisheries (i.e., fisheries bycatch). Bycatch occurs in pelagic and coastal waters throughout the range of the North Pacific Ocean DPS (Casale and Matsuzawa 2015). Bycatch of North Pacific loggerheads occurs in numerous types of commercial and artisanal fishing gear , including: pelagic and demersal longlines; drift and set nets (e.g., gillnets, trammel nets); bottom and mid-water trawling; fishing dredges; pound nets and weirs; haul and purse seines; pots and traps; and hook and line gear. Illegal, unreported, and unregulated fishing is undocumented and thus difficult to quantify; however, it is likely the single greatest source of loggerhead bycatch. While some fisheries have significantly reduced their bycatch of North Pacific loggerheads, bycatch continues to be the single greatest present threat to the DPS, reducing overall abundance (i.e., loss of individuals) and productivity (i.e., loss of reproductive potential).

The following coastal fisheries have the greatest negative impact on the DPS: Japan pound net fishery; small-scale fisheries of Baja California, Mexico; and IUU fishing in the East China Sea. Neritic foraging juveniles and adults are especially vulnerable to fisheries bycatch, and these fisheries kill a significant number of foraging loggerheads (Kamezaki *et al*. 2003; Peckham *et al*. 2007b).

Pelagic fisheries also contributed to the decline of North Pacific loggerhead (Kamezaki and Matsui 1997a,b; Sato *et al*. 1997; Suganuma 2002; Parker *et al*. 2005). Due to the low level of observer coverage, it is difficult to quantify the magnitude of North Pacific loggerhead bycatch in pelagic fisheries. Lewison *et al*. (2004) estimated that pelagic longline gear killed 2,600 to 6,000 Pacific loggerhead turtles in 2000; however, this estimate includes loggerheads from the North and South Pacific Ocean DPSs. Some previously large fishing pressures have been reduced or eliminated. For example, in December 1992, the United Nations' moratorium on foreign high-seas driftnet fishing for squid, tuna, and billfish in the North Pacific Ocean was implemented. Prior to this moratorium, observer reports from June 1990 to May 1991 indicate that the fishery entangled an estimated 2,986 loggerheads (mostly juvenile), of which 805 died (27 percent mortality rate; Wetherall 1997). Wetherall *et al*. (1993) estimated the total annual mortality of the fishery as 2,500 to 9,000 sea turtles, most of which were loggerheads. The impact to North Pacific loggerheads was significant (Wetherall 1997) and likely affected the age structure of the population by removing a large number of juveniles (which would now be adults). The dramatic decrease in loggerhead nesting in Japan followed a rise in high seas driftnet fishing (Kamezaki *et al*. 2003). The closure of that fishery has been one of the greatest conservation benefits to the population (Omuta 2009; Y. Matsuzawa, STAJ, pers. comm., 2017).

In the following sections, we describe ongoing fisheries bycatch impacts by area and gear type. We evaluate exposure (fishing effort and interaction) and mortality and their overall impact on the DPS.

2.3.2.5.1 Western North Pacific Ocean

The western North Pacific Ocean contains foraging and migratory habitat for North Pacific loggerheads, especially in the East China Sea and around Japan (Kamezaki *et al*. 1997; Kobayashi *et al*. 2011). Fisheries may be commercial, artisanal, or IUU. Coastal and pelagic

fisheries occur in this area, resulting in bycatch of both neritic and oceanic foraging individuals. Most of the turtles foraging in the East China Sea are adults or large juveniles (Nishimura and Nakahigashi 1992; Cheng and Chen 1997; Takeshita 2006; Kobayashi 2011; Saito *et al*. 2018), i.e., those individuals that have made it through decades of development and have the greatest potential to contribute to future generations. Thus, mortality from fisheries bycatch reduces abundance and productivity.

Illegal, unreported, and unregulated fishing is a significant threat to sea turtles worldwide, with 26 million tons of fish caught annually, valued at $10 to 23 billion U.S. dollars (*http://www.fao.org/iuu-fishing/en/*). Due to lack of reporting, we have no estimates of the impacts to loggerhead turtles, although bycatch and mortality rates for turtles throughout the North Pacific are likely high (FAO 2007). For example, 67 of 288 Chinese vessels operating near but outside of Japan's EEZ were reportedly engaging in IUU fishing (Fisheries Agency of Japan 2016). Because the East China Sea is a foraging hotspot (Takashita 2006; Kobayashi 2011; Saito *et al*. 2018), fishery bycatch of turtles is likely high. Because turtle bycatch is not regulated or reported, there is no incentive to use turtle-friendly gear, check gear frequently, or release turtles; therefore, mortality is likely high. Although we are unable to quantify the impact, IUU fishing in the East China Sea is likely a high source of mortality for the North Pacific Ocean DPS.

The pound net fishery off the coast of Taiwan sets 100 individual nets moored in shallow water (20 m deep; Gilman *et al*. 2010). Loggerhead bycatch is common, but mortality is low (Cheng and Chen 1997), as a result of frequent gear tending (two to three times per day), shallow water depth, and air-accessible catch chambers that allow turtles to surface and breathe (Ishihara 2007). Kobayashi *et al*. (2011) tracked 34 non-reproductive loggerheads bycaught in this fishery between 2002 and 2008; they found that the turtles remain in local residency in the East China Sea, around Taiwan, China, Japan, and South Korea. We conclude that the impact on the DPS from coastal pound net fisheries in Taiwan coastal waters is low.

Because numerous Japanese fisheries interact with loggerheads in the West Pacific, we describe these in detail below. Turtles use the waters around Japan for foraging, migration, and reproduction. Adult and large juveniles forage in coastal and pelagic waters. Reproductive females and males migrate through offshore and nearshore waters to mate off nesting beaches. Females move through coastal waters to access nesting beaches. For example, fisheries incidentally captured 37 of 2,219 females (1.7 percent), tagged while nesting on 16 beaches from the Ryukyu Archipelago to Shizuika; nine of the 37 turtles nested at Senri Beach, Minabe, which experienced a 67 percent decline in nesting females from 1990 to 1995 (Kamezaki *et al*. 1997; Sato *et al*. 1997).

Because fishing effort is high, the opportunity for bycatch is high. Mortality rates vary among fisheries, and Japan has regulated some fisheries, reducing the bycatch of sea turtles; however, some gear types still result in high mortality rates. It is difficult to assess the overall impact of fisheries because bycatch reporting is either not required or self-reported (e.g., questionnaire surveys). We have little recent fisheries data or fisheries-independent data from Japan; therefore, we generally rely on past published studies regarding the impact of fisheries on the DPS. One study involved a nationwide interview of 1,074 fisherman between 2009 and 2013 to evaluate sea turtle bycatch in Japanese coastal fisheries (Ishihara *et al*. 2014).

They found an annual bycatch frequency of more than five sea turtles per operation in the following fisheries: large and small pound nets, gillnet, bottom trawl, boat seine, surround net, rod and line, and trawl (Ishihara *et al*. 2014). Bycatch is often underreported due to many factors, including fishermen's concerns regarding increased regulation as a result of reporting bycatch (Alverson *et al*. 1994). Therefore, we have little confidence in the overall estimates of impact (i.e., low, medium, or high) described in self-reported surveys. Based on the best available scientific and commercial data, as detailed below, we conclude that cumulative bycatch from Japanese fisheries is a high threat to the North Pacific Ocean DPS.

2.3.2.5.1.1 Japanese Pound Net Fishery

Pound nets account for the majority of loggerhead bycatch in Japan. The pound net fishery is Japan's third largest fishery. Ishihara *et al*. (2014) report:

- 430 large-scale coastal pound net fisheries throughout Japan;
- 2,900 small-scale coastal pound net fisheries throughout Japan; and
- 820 pound net fisheries targeting salmon in northern coastal Japan.

There are two types of pound nets: one net opens to the sea surface, which allows turtles to surface and breathe; and the other remains fully submerged, preventing the turtles from surfacing (Mutsuki and Takahashi 2009). The former results in zero to 15 percent mortality; whereas the latter results in nearly 100 percent mortality (Conant *et al*. 2009). As reported in the Status Review (Conant *et al*. 2009), the fishing industry has expressed an interest in changing to the open-type gear; however, it is expensive, and there is limited support from the Japanese government (T. Ishihara, STAJ, pers. comm. 2007; Matsuzawa and Kamezaki 2018). Set net and pound net escape devices have been developed to allow turtle escape and retain target fish (STAJ 2014; Shiozawa *et al*. 2018); however, they are rarely used in the fishery (Matsuzawa and Kamezaki 2018). Ishihara *et al*. (2014) report that 75 percent of pound net fisheries use the open-type gear, and 12 percent use the fully submerged gear. The survey (Ishihara *et al*. 2014) characterizes pound net loggerhead bycatch as follows:

- From Hokkaido to Ibaraki and the Sea of Japan: "Few" bycatch
- From Chiba to Shizuoka: 75% of pound net fisheries have 10 bycatch/year
- In Kyushu: 70% of pound net fisheries have 10–50 bycatch/year
- In Kii peninsula: 79% of pound net fisheries have 10–50 bycatch/year
- In Shikoku: all pound net fisheries have 20–100 bycatch/year

Because reporting is not required, we do not know the magnitude of the effort or the total amount of bycatch, and we cannot confirm mortality rates. This reduces our confidence in the above self-reported data. A study of 1,392 loggerhead turtles recovered from Cape Muroto pound nets between 2002 and 2009 confirms that 75.9 percent were subadults (SCL = 56–75 cm; Ishihara *et al*. 2011). Of 278 loggerhead turtles captured in the pound net fishery off of Tanegashima Island between July 2009 and June 2016, 77.3 percent were immature (Kume *et al*. 2017).

Based on these data, we characterize the pound net fishery as one of high effort and high interaction; we characterize mortality rates as moderate because, while the rates are low for the majority of the fishery, they approach 100 percent mortality when submerged gear is used without escape devices. Therefore, we conclude that pound net fisheries are a high threat to the DPS, reducing abundance and productivity.

2.3.2.5.1.2 Japanese Longline (Shallow-set and Deep-set) Fishery

Sea turtle bycatch is a well-documented problem for longline fisheries (Lewison *et al*. 2004a,b; Parker *et al*. 2005; Taylor and Halpin 2008). In the past, direct measures of effort, bycatch, and mortality were not available; however, extrapolated estimates of fishing effort, bycatch, and mortality were high. For example, Nishemura and Nakahigashi (1990) compiled sea turtle sightings and capture rates from fisheries research, survey, and training vessels and extrapolated the estimates to the 1978 Japanese tuna longline fishery of the western Pacific and South China Sea. They estimated one capture for every 10,000 hooks with a 42 percent mortality rate, or 12,300 mortalities of 21,200 sea turtles captured annually (Nishimura and Nakahigashi 1990). Kamezaki *et al*. (2003) identified longline bycatch as one of the greatest threats to the survival of the North Pacific loggerhead population. Others cited longline bycatch as a contributing factor to the decline of the population (Kamezaki and Matsui 1997a,b; Sato *et al*. 1997; Gardner and Nichols 2001; Suganuma 2002; Hatase *et al*. 2002a; Hatase 2004; Watanabe 2011).

In 2015, Japan reported (ISC 2016):

- 227 longline vessels of 10 to 49 gross register tonnage;
- 18 longline vessels of 50 to 99 gross register tonnage;
- 24 longline vessels of 100 to 199 gross register tonnage; and
- 75 longline vessels over 200 gross register tonnage.

Japan licenses the shallow and deep-set longline fisheries similarly and requires them to use circle hooks or fish (not squid) bait to reduce bycatch (Minami *et al*. 2006; Yokota *et al*. 2009). Japan also requests fishermen to carry turtle release gear and trains them how to safely release turtles (Ishihara *et al*. 2014). According to the survey, bycatch is now rare and mortality is low (Ishihara *et al*. 2014); however, the Western and Central Pacific Fisheries Commission (WCPFC) reports 88 incidentally captured turtles in 1,012 operations and 73 fishing trips (WCPFC 2016). While fishing effort remains high, mortality and bycatch have likely been reduced as a result of mitigation measures. Though reduced relative to previous years, longline fisheries likely remain a moderate threat to the DPS, reducing abundance and productivity.

2.3.2.5.1.3 Japanese Gillnet Fishery

Commercial and artisanal gillnets are common in Japan (Narazaki 2015): approximately 13,000 companies and individuals operate gill net fisheries (Ishihara *et al*. 2014). In addition to pound net and trawl fisheries, gillnet fisheries were once a major source of strandings, which included at least 80 mature loggerheads annually (Suganuma 2002; Kamezaki *et al*. 2003). Gillnets are set in highly productive areas and entangle foraging loggerheads (Narazaki 2015). According to the questionnaire survey, bycatch is now low, despite the high effort, and green turtles comprise most (73 percent) the bycatch. Of 244 respondents, 198 reported no bycatch; 33 reported five bycatch annually; 9 reported twenty bycatch annually; and 4 reported more than twenty bycatch annually. Mortality estimates vary widely: 33 respondents identified no mortality; whereas 16 respondents identified mortality as “high” or 100 percent. Because reporting is not required, we do not know the magnitude of the effort or the total amount of bycatch, and we cannot confirm mortality rates. This reduces our confidence in the above self-reported data. We conclude that fishing effort remains high, and while bycatch and mortality may be reduced, we are unable to

confirm this hypothesis. Therefore, we consider gillnet fisheries in Japan to be a threat to the DPS.

2.3.2.5.1.4 Japanese Trawling Fishery

In addition to pound net and gillnet fisheries, trawl fisheries were once a major source of strandings, which included at least 80 mature loggerheads annually (Suganuma 2002; Kamezaki *et al*. 2003). Approximately 300 large-scale trawling vessels operate around Japan, and approximately 7,400 companies and individuals operate small-scale trawling vessels (Japan Fisheries Agency 2016). According to the survey, 83 of 94 respondents reported no bycatch; 5 reported two bycatch annually, and 2 reported twenty bycatch annually (Ishihara *et al*. 2014). Most sea turtles are loggerheads, and most are released alive (Ishihara *et al*. 2014). We conclude that fishing effort remains high, and while bycatch may be reduced, we are unable to confirm this hypothesis. Therefore, we consider trawling fisheries in Japan to be a threat to the DPS.

2.3.2.5.1.5 Japanese Purse Seine Fishery

Approximately 90 large- and middle-scale purse seine vessels operate around Japan, and approximately 375 companies and individuals operate small-scale purse seine vessels (Japan Fisheries Agency 2016). According to a survey, 22 of 27 respondents reported no bycatch; 4 reported five bycatch annually, and 1 reported twenty bycatch annually (Ishihara *et al*. 2014). Most sea turtles are loggerheads, and most are released alive (Ishihara *et al*. 2014). We conclude that fishing effort remains high, and while bycatch may be reduced, we are unable to confirm this hypothesis. Therefore, we consider purse seine fisheries in Japan to be a threat to the DPS.

2.3.2.5.1.6 Japanese Pole and Line Fishery

Approximately 300 companies and individuals operate pole and line fisheries in the western and central Pacific areas. Sea turtle bycatch is rare (20 reported from Enshu-nada between May and July, 2009 to 2013) and mortality is low (Ishihara *et al*. 2014). We conclude that fishing effort remains high, and while bycatch and mortality appear to be low, we are unable to confirm this hypothesis. Therefore, we consider pole and line fisheries in Japan to be a threat to the DPS.

2.3.2.5.1.7 Japanese Troll Fishery

Approximately 2,800 companies and individuals operate trolling fisheries around Japan (Japan Fisheries Agency 2016). According to a survey, bycatch is rare (only four of 182 respondents reported bycatch) and only reported from Yakushima Island between May and August (Ishihara *et al*. 2014). Mortality is also low. We conclude that fishing effort remains high, and while bycatch and mortality may be low, we are unable to confirm this hypothesis. Therefore, we consider troll fisheries in Japan to be a threat to the DPS.

2.3.2.5.2 Central North Pacific Ocean

Juveniles of the North Pacific DPS use the pelagic waters of the Central North Pacific Ocean for developmental habitat, before they transition to neritic foraging habitat in the eastern North Pacific Ocean or oceanic foraging habitat in the western North Pacific Ocean (Turner Tomaszewicz *et al*. 2017). While primary productivity is generally low in the Central North Pacific, foraging turtles (and fisheries) target productivity hotspots, such as the Transition Zone Chlorophyll Front (Kobayashi *et al*. 2008). Loggerhead bycatch in these hotspots occurs in several fisheries including: IUU fishing; U.S. longline fisheries based in Hawaii (shallow and

deep set); and international longline fisheries. Other fisheries have negligible or no impact on the DPS. For example, the Hawaii trolling fishery has low effort and low bycatch (1 to 3 captures annually) and releases all turtles alive; therefore, its impact is negligible. Since the ban in 1992, high-seas drift nets, which commonly captured loggerheads, and was considered to have been a significant source of mortality and contributor to the population decline, no longer impacts the DPS (Omuta 2009). Based on the best available scientific and commercial data, as detailed below, we conclude that documented cumulative bycatch within the Central North Pacific Ocean has a moderate impact on the North Pacific Ocean DPS. Most U.S. fisheries have a low impact on the DPS because of regulations that reduce bycatch and mortality (and because the fisheries primarily affect small juveniles, i.e., those individuals that have the lowest potential to contribute to population productivity). However, IUU fishing and the international longline fisheries continue to impact the DPS.

2.3.2.5.2.1 IUU Fishing

Though impossible to quantify, IUU fishing likely has the greatest impact on the DPS within the North Central Pacific. Such effort may be high. Because take is not regulated or reported, there is no incentive to use turtle-friendly gear, check gear frequently, or release turtles; therefore, mortality is likely high. As a result of high effort, bycatch, and mortality, IUU fishing may kill many juvenile loggerheads annually in the Central North Pacific (see Gilman 2011). Although this life stage has the smallest effect on productivity, a large loss would affect the age structure, reducing future productivity. Therefore, we recognize the potential for IUU fishing in the North Central Pacific to be a moderate threat to the DPS.

2.3.2.5.2.2 U.S. Longline Fisheries (Hawaii)

Longline fisheries in Hawaii include deep and shallow-set fisheries that incidentally capture foraging juvenile loggerheads in the waters of the Central North Pacific Ocean (Polovina *et al*. 2001, 2003, 2004, 2006).

Juvenile loggerheads are especially vulnerable to shallow-set fisheries that target swordfish (*Xiphias gladius*) and tuna (*Thunnus* spp.). Hooked or entangled turtles are unable to surface and breathe (Swimmer *et al*. 2013; Wallace *et al*. 2013; Lewison *et al*. 2014). Increasing loggerhead bycatch in the late 1990s led to closures of the Hawaiian shallow-set longline fishery in the 2000s (Howell *et al*. 2008). Subsequent regulations outlined requirements for the Hawaiian shallow-set longline fishery to monitor and reduce bycatch, including:

- 100 percent observer coverage;
- Immediate closure after exceeding bycatch and mortality limits;
- Specific gear and procedures to release sea turtles; and
- Requirements regarding gear (i.e., circle hooks), bait (fish bait), and location.

Implementation of these requirements has significantly reduced sea turtle bycatch within the Hawaiian pelagic shallow-set longline fishery (Gillman *et al*. 2007; Swimmer *et al*. 2017). Between 2004 and 2018, the fishery captured 177 loggerheads, with an estimated 28 mortalities (16 percent mortality rate; NMFS 2019). The most recent biological opinion on the authorization of this fishery anticipates up to 36 captures and six mortalities of North Pacific loggerheads annually (NMFS 2019). We conclude that although effort remains high, bycatch and mortality rates are low. Therefore, the overall impact on the DPS, as a result of the regulatory

requirements, is low.

Similarly, the Hawaiian deep-set longline fishery effort remains high but protective measures have reduced observed bycatch to 0 to 4 loggerheads annually as determined with 20 percent observer coverage (WPRFMC 2018). The vast majority (90 percent) are juveniles (i.e., the life stage during which the contribution to population productivity is at its lowest) with a mortality rate of 72 percent (NMFS 2014). The most recent biological opinion on the authorization of this fishery anticipates up to 18 captures and 13 mortalities of North Pacific loggerheads over 3 years (NMFS 2014). We conclude that the low interaction rate results in a low impact on the DPS.

2.3.2.5.2.3 International Longline Fisheries

In their comprehensive study of sea turtle bycatch, Wallace *et al*. (2013) classified longline effort and bycatch rate as low for North Pacific loggerheads. Based on 36 records, the bycatch per unit effort was 0.011, with a median mortality rate of zero (range of zero to 92 percent), and a bycatch impact score of 1.33 (Wallace *et al*. 2013). Per WCPFC requirements, observer coverage is 5 percent, but actual coverage may be less (Clarke 2010, 2017). Longline observer coverage for the WCPO tuna fleets varies between fleets and areas and may not be representative of longline fishing operations as a whole (Clarke 2017). We conclude that effort and mortality are high, but bycatch is low such that the overall impact on the DPS is moderate.

2.3.2.5.3 Eastern North Pacific Ocean

Juvenile loggerheads forage in the highly productive eastern North Pacific Ocean. Juveniles may spend more than 20 years foraging in the neritic habitats of Baja California, Mexico (Turner Tomaszewicz *et al*. 2015). This foraging strategy is energetically favorable and results in turtles with higher growth rates and eventually higher fecundity than those foraging in oceanic habitats of the central North Pacific Ocean (Peckham *et al*. 2011). The majority of loggerheads in Baja California, Mexico, are large juveniles, a life stage with high reproductive potential (Crouse *et al*. 1987). Through stable isotope analysis, a recent study demonstrated that loggerheads recruit to the neritic area at different ages, meaning some have longer oceanic stages with less time in the neritic environment and some have longer time in the neritic zone versus the oceanic environment (Tomaszewicz *et al*. 2017). While large juveniles foraging in the eastern North Pacific Ocean have great potential to contribute to future population productivity, lower survival rates reduce this potential (Peckham *et al*. 2011). Bycatch in this area results in high juvenile mortality rates, which contribute to overall declines in abundance and productivity (Turner Tomaszewicz *et al*. 2015).

Numerous commercial and artisanal fisheries incidentally capture juvenile loggerheads throughout the eastern North Pacific Ocean. Foraging turtles and intense small-scale fisheries overlap along the Pacific coast of the Baja California Peninsula, Mexico (Peckham *et al*. 2006; Peckham *et al*. 2008; Aguirre *et al*. 2012). Bycatch from this area is high and one of the most significant sources of mortality for the North Pacific Ocean DPS (Peckham *et al*. 2006; Peckham *et al*. 2013). Peckham *et al*. (2006) conclude that bycatch in the small-scale fisheries of Baja California, Mexico alone could preclude recovery of the North Pacific Ocean DPS. Compiling numerous datasets, including Peckham *et al*. (2007, 2008) and Koch *et al*. (2013), Seminoff *et al*. (2014) estimated an annual mortality rate of 1.2 to 11 percent in Baja California, Mexico, which is considered a major foraging area (Seminoff *et al*. 2014) and a global bycatch hotspot

(Peckham *et al*. 2008; Wallace *et al*. 2013). Since 2003, 5,553 loggerheads have been found stranded dead during shoreline surveys of Baja California Sur, Mexico (Peckham 2017). During 2016, 113 loggerhead turtles stranded along the 43km index shoreline, considerably fewer than the interannual average of 363 that stranded per year from 2003 to 2011. After 2016 regulations temporarily closed the gillnet fishery (Senko *et al*. 2017), 85 loggerheads stranded in 2017; however, 420–440 loggerheads stranded in 2018 and 2019, once the fishery was reopened (A. Mancini, Grupo Tortuguero de las Californias, pers. comm. 2020).

The Mexican longline and gillnet fisheries pose high threats to the DPS, killing a minimum of 1,000 loggerheads annually (Koch *et al*. 2006; Peckham *et al*. 2007b; Peckham *et al*. 2008). Additional fisheries in Mexican waters include: purse seine, bottom trawl, traps, and subsistence hook and line. Bycatch also occurs in the California and Oregon drift gillnet fishery. There are no or negligible interactions with Californian longline, buoy gear, hook and line, and pot/trap fisheries. We conclude that overall bycatch in the eastern North Pacific Ocean is the greatest threat to the North Pacific Ocean DPS.

2.3.2.5.3.1 Mexican Gillnet Fishery

Gillnet fisheries off the coast of Baja California, Mexico, produce some of the highest sea turtle bycatch rates documented worldwide (Maldonado-Diaz 2012; Senko *et al*. 2013). They have been the greatest cause of mortality for the North Pacific Ocean DPS (Peckham *et al*. 2011; Wingfield *et al*. 2011), causing twice the mortality of all other reported sources of mortality combined (NMFS 2000). For example, in 2005, one fleet consisting of 75 boats using bottom-set gillnets bycaught 11 loggerheads, eight of which died, for a mortality rate of 73 percent (Peckham *et al*. 2007b). Extrapolating to the fishery, Peckham *et al*. (2007) estimated that the bottom-set gillnet fishery killed 299 loggerheads in 2005.

In Sinaloa, Mexico, bycatch of loggerhead turtles occurs in entanglement nets used to catch sharks. During 15 fishing days in May and June of 2012, 18 loggerheads, with a mean SCL of 61.8 cm, were captured; all were released alive (Zavala-Norzagaray *et al.* 2017).

Historically, and as described in the published literature, the Mexican gillnet fishery is characterized by high effort, bycatch, and mortality, resulting in a high overall impact to the DPS. In 2016, however, regulations temporarily closed the fishery and increased observer coverage (Senko *et al*. 2017). These regulations temporarily reduced interaction; however, the fishery was reopened in 2018 and 2019 (A. Mancini, Grupo Tortuguero de las Californias, pers. comm. 2020), again resulting in a high threat to the DPS.

2.3.2.5.3.2 Mexican Longline Fisheries

Mexican longline fisheries include industrial, pelagic, bottom-set, and small-scale localized fleets. The bycatch rate from the small-scale longline fleet off the coast of Baja California, Mexico, is especially high. Bycatch per unit effort from this small-scale longline fleet is at least an order of magnitude higher (19.3 turtles per thousand hooks) than that of other Mexican and U.S. pelagic longline fleets (up to 1.40 loggerheads per thousand hooks; Peckham *et al*. 2007b). The mortality rates are also higher. For example, in 2005, one fleet consisting of five to six longline vessels using bottom-set longlines captured 26 loggerheads, of which 24 died, a 92 percent mortality rate (Peckham *et al*. 2007b). Extrapolating to the fishery, Peckham *et al*. (2007)

estimated that the bottom-set longline fishery killed 680 loggerheads in 2005. Peckham *et al*. (2008) performed a larger-scale study of the bottom-set longline fishery for 2005 and 2006 and reported a mean bycatch rate of 5.9 turtles per boat per day (with a 95 percent confidence level of 0 to 20 turtles) and a mortality rate of 89 percent (with a 95 percent confidence level of 77 to 96 percent mortality). Based on these data, the longline fleet kills 1,635 loggerheads annually, with a 95 percent confidence level of 1,160 to 2,174 turtles (Peckham *et al*. 2008). Because effort, bycatch, and mortality rates are high, we conclude that Mexican longline fisheries pose a high threat to the North Pacific Ocean DPS.

2.3.2.5.3.3 Other Mexican Fisheries

The bottom trawl fishery in Mexico includes 1,200 shrimp vessels, which operate with TEDs, from September to March *(http://www.fao.org/3/i0300e/i0300e02b.pdf*). There are 40 to 80 shrimp vessels in Baja California, where TEDs and fish excluders must be installed and in working condition. In 2017, there were no reported interactions with sea turtles in the Gulf of Ulloa, Baja California Sur. Thus, while effort is high, bycatch and mortality appear to be low.

The Mexican purse seine fishery includes larger ships operating hundreds of kilometers from shore. There are three types of sets, which had a total bycatch of 1,013 loggerheads (19 mortalities) between 1993 and 2016. From 2000 to 2016, the average annual bycatch for all sets was 50 loggerheads (IATTC Annual Data courtesy of M. Hall, 2018). Thus effort and bycatch are high, but mortality is low.

In the mid-2000s, an experimental bottom trap/pot fishery showed promise for catching small demersal fish such as grouper. However, this fishery died out within several years due to overfishing, and its current status is unclear.

We conclude that, cumulatively, these additional fisheries in Mexico have a low to moderate impact on the DPS. They impact the large juveniles found in these waters and thus lower productivity of the DPS.

2.3.2.5.3.4 U.S. Drift Gillnet Fishery (California/Oregon)

The drift gillnet fishery out of California and Oregon includes about 50 vessels that target swordfish and thresher sharks but also incidentally capture juvenile loggerheads (*https://www.st.nmfs.noaa.gov/observer-home/regions/westcoast/driftnet*). From July 1990 to January 2000, observers reported the bycatch of 17 loggerheads, of which four died and one was injured (NMFS 2000). To reduce loggerhead bycatch, NMFS now implements seasonal closures and additional closures during El Niño events (84 FR 24398; May 28, 2019), when loggerheads are likely to forage on multiple prey items, including pelagic red crabs (*Pleuroncodes planipes*), off southern California (Welch *et al*. 2019). As a result of the closures and as reported by 18.5 percent observer coverage, the estimated annual bycatch of the fishery was 5 loggerheads with one mortality in 2006 (Carretta and Enriquez 2007). The most recent biological opinion on the authorization of this fishery anticipates up to seven captures and four mortalities of North Pacific loggerheads over 5 years (NMFS 2013). More recently, the fishery has adopted a 2-year bycatch cap of two loggerheads and increased observer coverage (30 percent in 2016 and 2017; 100 percent in 2018). We conclude that effort is medium, but bycatch and mortality are low.

Therefore, the California and Oregon drift gillnet fisheries have a low overall impact on the North Pacific DPS.

2.3.2.5.4 Fishery Bycatch Summary

Although unquantified, IUU fisheries likely pose the greatest threat to the DPS because they are not required to use any mitigation measures that would reduce or prevent bycatch or limit mortality. Gillnet and longline fisheries, especially those in Mexico and Japan, are also among the greatest threats to the DPS. Total annual mortalities are likely in the thousands.

Fisheries bycatch reduces abundance; it also likely reduces productivity by removing those individuals (i.e., adults and large juveniles) that survived decades of development and have the greatest potential to contribute to future generations. Therefore, we conclude that fisheries bycatch is the greatest present threat to the DPS.

2.3.2.6 Climate Change, Storm Events, and Ocean Features

Climate change, ocean oscillations, and catastrophic events have large-scale impacts on the nesting and foraging success of the DPS. Climate change is characterized by increasing temperatures (air and sea surface), ocean acidification, and sea level rise. Such changes are likely to result in the increased frequency and severity of ocean oscillations and catastrophic events. Impacts to the DPS include increases in the erosion of nesting beaches, inundation of nests, temperature-linked nest failure, and changes in temperature-linked sex ratios. The availability and location of prey is also likely to change. Such issues are likely to intensify in the future, creating a high threat to the viability of the DPS.

To evaluate the impact of climate change on the DPS, we used the best available data, which includes the Intergovernmental Panel on Climate Change (IPCC) Special Report on Oceans and Cryosphere (IPCC 2019). The Revised Guidance for Treatment of Climate Change in NMFS' ESA Decisions (NMFS 2016) requires us to use climate indicator values projected under the IPCC Representative Concentration Pathway (RCP) 8.5 when data are available. RCP8.5 reflects a continued increase of greenhouse gas emissions and assumes that few mitigation measures will be implemented.

The IPCC (2019) reports the following consequences of climate change on sea turtles with high confidence, which is an evaluation of the underlying evidence and agreement in the conclusion. Loss of sandy beaches, due to sea level rise and storm events, reduces available nesting habitat (Fish *et al*. 2005; Fuentes *et al*. 2010; Reece *et al*. 2013; Katselidis *et al*. 2014; Patino-Martinez *et al*. 2014; Pike *et al*. 2015; Marshall *et al*. 2017). Storms, waves, and sea level rise are likely to increase erosion and sediment loss. Changes in beach morphology, dune scarping, vegetation loss, and reduction in beach area are likely to reduce the availability of sea turtle nesting sites, and the potential for landward migration of the beach profile is limited due to human development. Temperature directly affects important sea turtle life history traits, including: hatchling size, sex, viability, and performance (Hays *et al*. 2003; Pike 2014; Dudley *et al*. 2016; Santos *et al*. 2017). One of the greatest concerns is the effect of temperature on hatchling sex ratio because sex is determined by nest site (i.e., sand) temperature (Santidrián Tomillo *et al*. 2014; Patrício *et al*. 2017). Changes in ocean temperature indirectly impact sea turtles by altering

the abundance and distribution of their prey (Polovina 2005; Polovina *et al*. 2011; Doney *et al*. 2012; Sydeman *et al*. 2015; Briscoe *et al*. 2017; Woodworth-Jefcoats *et al*. 2017). Additionally, sea turtles require habitat associated with bathymetric and mesoscale features that aggregate their prey, and the persistence and location of these features are linked to variations in climate (Baez *et al*. 2011; Bjorndal *et al*. 2017; Santora *et al*. 2017). The IPCC (2019) states with high confidence that climate change is likely to alter foraging success, juvenile recruitment, breeding phenology, growth rates, and population stability.

2.3.2.6.1 Sea Level Rise and Storm Events

The melting of glaciers and ice sheets is the primary driver of sea level rise, which has accelerated in recent years (very high confidence; IPCC 2019). By 2100 (relative to 2005), global mean seal level is projected to rise 0.84 m with a likely range of 0.61 to 1.1 m, where likely refers to 66 to 100 percent probability (IPCC 2019). A recent study indicates that the rate of ice loss from the Greenland Ice Sheet has accelerated since the 1990s, supporting our application of the RCP8.5 predictions of sea level rise (Shepherd *et al*. 2019). Sea level rise is not globally uniform and varies regionally by ±30 percent (IPCC 2019). On average, sea level rise values along the entire Japanese coastline are similar to the global mean sea level values (Udo and Takeda 2017). However, sea level rise is greater along the southern coasts, where the majority of loggerheads nest.

Sea level rise is a threat to the DPS due to the loss of available nesting habitat. Under earlier (and thus smaller) projections of sea level rise (0.34 to 0.71 m; IPCC 2013), Udo and Takeda (2017) projected that Japan's 77 coastal zones would experience beach-loss rates of 62 to 83 percent by 2100. Given the more recent, accelerated rates (IPCC 2019), beach-loss rates would likely be higher, especially along the southern coasts of Japan. Therefore, the DPS is likely to lose a considerable amount of nesting habitat through sea level rise alone, reducing productivity and eventually abundance.

In addition to sea level rise, climate change is likely to result in an increase in wave heights and storm events (IPCC 2019). Extreme sea level events are associated with tropical cyclones, which have increased in intensity (high confidence) and are migrating poleward in the western North Pacific Ocean (IPCC 2019). These cyclones result in coastal storm surges, high water events, and coastal floods. These sea level extreme events are very likely (90 to 100 percent probability) to increase significantly over the 21st century, including in highly vulnerable coastal regions in Japan (IPCC 2019). Increases in cyclones and extreme waves, combined with sea level rise, are likely to exacerbate extreme sea level events (high confidence; IPCC 2019). Heavy rains and typhoons reduce hatching success rates (Matsuzawa *et al*. 2002a,b). Such events are likely episodic, but at some low-lying beaches and developed shorelines, they occur seasonally and reduce hatchling production and survival over multiple nesting seasons (Kamezaki *et al*. 2003). For example, during the 2004 and 2009 seasons, the Japanese Archipelago suffered a record number of typhoons, and many nests were inundated by typhoons in 2012 (Matsuzawa 2013). On several beaches, including Maehama, which is one of the primary nesting beaches on Yakushima Island, nests are relocated to avoid total nesting loss due to storm events and beach erosion (Matsuzawa 2006; Moriya and Moriya 2011). Over a nine year period (2004–2012) over 4,000 erosion-prone nests were relocated at Yakushima Island (WPRFMC 2015). Immediate impacts to

the DPS include nest loss and reduced productivity; long-term effects include the loss of nesting habitat and reduced abundance.

Sea turtles have evolved population resilience to storm events: females lay multiple eggs in multiple clutches over multiple years. With climate change, however, storm events are likely to increase in intensity as nesting habitat disappears due to sea level rise. The increased, consistent loss of nests from these events along with the permanent loss of nesting beach habitat, which is further exacerbated by coastal armoring structures, will likely become a major threat to this DPS by reducing productivity, abundance, and essential habitat.

2.3.2.6.2 Temperature Increases and Ocean Features

Global mean surface temperature change (relative to the pre-industrial era, 1850 to 1900) is projected to increase by a mean temperature of 4.3 °C (likely range, 3.2 to 5.4 °C) under RCP8.5 (IPCC 2019). Rising sand temperatures elevate the incubation temperature of nests, reducing hatching success rates (Howard *et al*. 2014) and creating female-biased sex ratios (Matsuzawa 2006; Hawkes *et al*. 2009). Lethal high temperatures (> 33°C) have been documented at loggerhead turtle nesting beaches, and some nesting beach projects help to mitigate temperatures by watering nests to cool them (Matsuzawa *et al*. 2002; Matsuzawa 2006). However, Lolavar and Wyneken (2020) demonstrated that moisture content does not alter pivotal temperatures, though high moisture content creates a narrower transitional range of temperature. Therefore, it is unclear if high moisture levels alleviate the effect of increasing sand temperatures on sex ratios.

In a global modeling study, Pike *et al*. (2014) found that the temperate beaches used by North Pacific loggerheads experience maximum summer temperatures of 27 to 32 °C. Temperatures exceeding 33 ºC for numerous days often lead to pre-emergence mortality as a result of reduced pipping activity, poor gas exchange, or direct death (Matsuzawa *et al*. 2002a,b). Based on their models, Pike *et al*. (2014) predicted hatchling success rates ranging from 60 to 80 percent; however, by 2050, hatching success is predicted to decline overall at many sites worldwide. Empirical studies already indicate local reductions in hatching success. Nests on the dark sands of Nagasakibana, Japan, are subject to high incubating temperatures (Kamezaki *et al*. 2003). On Senri Beach, Minabe, nests incubate at the extreme of their thermal tolerance range (> 33°C), inducing embryo mortality and pre-emergent loggerhead hatchlings (Matsuzawa *et al.* 2002a,b). Thus, this nesting population is vulnerable to even slight increases in temperature as a result of climate change.

Mean sea surface temperature (SST) has been slowly increasing over the past fifty years. Increasing SST is likely to alter foraging habitats. Nesting activity has been associated with SST just prior to nesting (Van Houtan and Halley 2011). Chaloupka *et al*. (2008) found an inverse correlation between nesting abundance (Kamouda and Yakushima) and mean annual SST in the core foraging region the previous year. Cooler ocean temperatures in the foraging habitat are associated with increased prey abundance and increased breeding capacity. Increasing temperatures could cause a negative change in prey abundance and affect the magnitude and timing of loggerhead nesting (Chaloupka *et al*. 2008). As SST increases, the remigration interval could increase (Hays 2000). Therefore, warming regional ocean temperatures are a major risk

factor that could lead to long-term decreased food supply and reduced nesting and recruitment for the DPS unless North Pacific loggerheads are able to adapt by shifting their foraging habitat to cooler regions (Chaloupka *et al*. 2008).

Increasing SST is also likely to result in changes to large-scale and periodic climate patterns, such as the Pacific Decadal Oscillation and El Niño Southern Oscillation. The Pacific Decadal Oscillation shifts between warm and cold phases. Loggerhead prey availability varies greatly between the phases, as does loggerhead population abundance and productivity. During the positive phase of the Pacific Decadal Oscillation, the Kuroshio Extension Current weakens, allowing post-hatchlings to reach the highly productive waters of the Transition Zone of Chlorophyll Front (Ascani *et al*. 2016). During the negative phase, however, a strong Kuroshio Extension Current prevents post-hatchlings from accessing this area and finding sufficient food resources required for their pivotal first year, resulting in lower recruitment (Ascani *et al*. 2016). Negative phases are likely to increase in the future, with increasing temperatures likely to cause the Transition Zone of Chlorophyll Front to migrate 5° to 10° N over the next century (Polovina *et al*. 2011). This, combined with an increasingly strong Kuroshio Extension Current, would make it more difficult for post-hatchlings to reach highly productive waters, reducing future juvenile recruitment rates (Ascani *et al*. 2016). Van Houtan and Halley (2011) used climate models to show that these changes will significantly reduce productivity and abundance for the DPS by 2040. Kobayashi *et al*. (2008) found that such changes could reposition migratory pathways and potentially increase loggerhead overlap with and bycatch in high-sea fisheries.

Temperature increases are also linked, with medium confidence, to extreme El Niño and Niño events (IPCC 2019). It is unclear how loggerheads would respond to these changes. They may leave the Central North Pacific to enter the Southern California Bight only during the warm phases of the El Niño Southern Oscillation (Carretta and Enriquez 2007; Eguchi *et al*. 2018). Alternatively, they may remain at low densities in the Southern California Bight year-round or enter opportunistically as they follow productive frontal zones (Allen *et al*. 2013). Such alternatives would expose them to greater bycatch potential because fisheries would not be required to close due to an El Niño event (Eguchi *et al*. 2018). Welch *et al*. (2019) found that a 0.77 increase in the 6-month average of local sea-surface temperatures was the best indicator of fisheries-turtle interaction. With sea temperature increases, bycatch in fisheries is likely to increase.

2.3.2.6.3 Ocean Acidification and Prey Availability

It is very likely that the ocean has taken up 20 to 30 percent of total anthropogenic carbon dioxide emissions since the 1980s, leading to ocean acidification rates of 0.017 to 0.027 per decade since the late 1980s (IPCC 2019). There is high confidence that increasing ocean acidification and oxygen loss have negatively impacted two of the most productive ocean ecosystems: the California and Humboldt Currents (IPCC 2019). It is virtually certain that continued carbon uptake through 2100 will exacerbate ocean acidification (IPCC 2019).

Loggerhead turtles are foraging generalists, meaning that they forage on a wide variety of prey. However, their prey often include shell-forming (i.e., calcifying) organisms, which requires the synthesis of calcium carbonate from the calcium and carbonate ions found in seawater. In a more acidic environment, a greater amount of hydrogen ions compete for the available carbonate ions.

Thus, ocean acidification may reduce the abundance of calcifying organisms; however, some organisms (e.g., corals, echinoderms, and molluscs) appear to be more vulnerable to these changes than others (e.g., crustaceans; Wittmann and Pörtner 2013). Other aspects of climate change may also influence the availability of prey for the DPS.

For example, North Pacific loggerheads forage on pelagic red crabs in the southern California Current Large Marine Ecosystem. Environmental changes, including climate change and El Niño events, have a significant effect on the distribution and abundance of red crabs (De Anda-Montañez *et al*. 2016). Although this species has evolved to survive in oxygen minimum zones, low oxygen levels trigger a cellular stress response (Seibel *et al*. 2018). Ocean warming and deoxygenation are likely to result in suppressed metabolism, reduced vertical migrations, and compressed latitudinal habitat compression (Seibel *et al*. 2018). Similar effects are expected with other prey species. Thus, we conclude that ocean acidification and oxygen loss are likely to reduce the availability of loggerhead prey, which will diminish the productivity of the DPS.

2.3.2.6.4 Summary of Climate Change Impacts

Species with high fecundity and low juvenile survival, such as sea turtles, are the most vulnerable to climate change and elevated levels of environmental variability (Halley *et al.* 2018). Halley *et al*. (2018) found that the survival curve plays a major role in how environmental variability leads to population fluctuations. Because the survival of early life stages is the primary driver of abundance variations in high fecundity populations, Halley *et al*. (2018) suggest that management measures should focus on protecting early life stages and their environments.

Evaluating 58 sea turtle populations, Fuentes *et al*. (2013) found the North Pacific loggerhead to be among the least resilient to climate change. Their assessment was based on expert opinion from the IUSC-SSC Marine Turtle Specialist Group (n = 33), which determined that nesting beach vulnerability and non-climate related threats (similar to the ESA section 4(a)(1) factors) were most likely to influence a population's resilience to climate change. Fuentes *et al*. (2013) concluded that the least resilient populations, such as the North Pacific loggerhead, are less able to absorb climate-related disturbances because they are already depleted, subject to other threats, and demonstrate nesting vulnerability.

Hazen *et al*. (2012) projected that the core habitat of the North Pacific loggerhead DPS would decline by up to 20 percent (or 35 percent, within one standard deviation) by 2100. Their model evaluated species' distribution as a function of SST, chlorophyll, and bathymetry. They concluded that longer migration times and loss of suitable pelagic habitat could inhibit recovery of this population (Hazen *et al*. 2012).

We agree that climate change is a major threat to the DPS. The erosion of nesting habitat, inundation of nests, and reduction of hatching success due to increased incubation temperature will reduce productivity in the short-term and abundance in the long-term. Changes to ocean temperatures and circulation will change migratory paths, reduce prey availability, and alter the location and predictability of prey accumulation. Ocean acidification and oxygen depletion will further stress prey populations and reduce availability. These changes are likely to reduce productivity by lengthening time to maturity and remigration intervals. We conclude that climate

change is a major threat to the DPS, and, in the near future, this threat is likely to rival fisheries bycatch in magnitude.

2.3.2.7 Factors with an unknown or low impact

The following factors are likely to have an unknown or low impact on the DPS: vessel strikes, power plants, research activities, and cold stunning. Vessel strikes (e.g., hull impacts and propeller lacerations) likely injure or kill loggerheads. Few vessel strikes are documented, and we are unable to estimate the frequency of occurrence. Therefore, the effect on the DPS is unknown.

Loggerheads may be impinged on the intake screens and entrained in the cooling water intake structures of power plants. We do not have access to information regarding sea turtle impingement and entrainment at Japanese power plants. Power plants near nesting beaches could represent a serious threat to adult loggerheads, especially if entrained turtles are not removed and released or if grates on intake pipes impinge turtles. Within the United States, the range of the DPS overlaps with power plants in California; however, most turtles impinged or entrained in the San Diego Gas and Electric Plant at Carlsbad and Southern California Edison Nuclear Generating Station at San Onofre are green turtles and are released unharmed (K. Miles, SDG&E, pers. comm. 2017; J. Cordaro, NMFS, pers. comm. 2017). We conclude that power plants have an unknown impact on the DPS.

Research activities involve handling loggerhead turtles for the purposes of tagging, measuring, and biological sampling. Turtles may also be incidentally captured while conducting research on fishing gear. Within the United States, researchers are required to obtain an ESA permit, which includes specific protocols to avoid, minimize, and mitigate the unintended adverse effects that may result from their activities (e.g., capture, handling, and performing various invasive procedures). Under a programmatic review of research permits, the maximum allowed number of mortalities for North Pacific loggerheads is seven turtles over a 10-year period (NMFS 2018). Other research permits that do not include allowances for unintentional mortality include NMFS' research efforts in the Southern California Bight and international waters (5 annual captures allowed) and sea turtle research in the Pacific Islands (12 annual captures allowed; *https://apps.nmfs.noaa.gov/*). We conclude that research activities have a low impact on the DPS, with little to no impact on abundance and productivity.

Loggerheads are also susceptible to cold stunning, a phenomenon in which turtles become incapacitated as a result of rapidly cooling water (Witherington and Ehrhart 1989; Morreale *et al*. 1992). The rate of cooling, rather than the temperature of the water, causes cold stunning (Milton and Lutz 2003). Sea turtles that overwinter in inshore waters are most susceptible because temperature changes are most rapid in shallow water (Witherington and Ehrhart 1989). Cold stunning annually affects few loggerheads along the coast of the Sea of Japan (Ishihara *et al*. 2017). We conclude that cold stunning has a low impact on the DPS.

2.4 Synthesis

The North Pacific Ocean DPS of the loggerhead turtle was listed as an endangered species on September 22, 2011 (76 FR 58868). Its 2019 recovery number is "5C," which reflects its

moderate demographic risk, well-understood major threats, high certainty that management actions will be effective, and low to moderate U.S. jurisdiction. Recovery planning for the DPS is in progress. The 1998 Recovery Plan for the U.S. Pacific Populations of the Loggerhead Turtle (*Caretta caretta*) identified 10 criteria that must be met to consider delisting, but only one has been met. We conducted this 5-year review to evaluate the best available information and to determine whether to recommend a change in the status or recovery priority of the DPS.

After reviewing the best available data, including new information that has become available since the Status Review (Conant *et al*. 2009), we agree that the DPS is reproductively and geographically discrete from all other loggerhead DPSs and significant to the species. Given the ample genetic, tagging, and tracking data that is available, it is unlikely that loggerheads from other DPSs would repopulate nesting beaches and foraging areas in the North Pacific Ocean, if the North Pacific Ocean DPS was extirpated. Instead, its loss would result in a significant gap (i.e., the North Pacific Ocean) in the range of the species. Therefore, the DPS continues to meet the discreteness and significance criteria of the DPS Policy.

Loggerheads of the North Pacific Ocean DPS exhibit a complex life cycle that contains several life stages (i.e., hatchling, juvenile, and adult), occurring across wide-spread and diverse habitats. Nesting occurs primarily in Japan. Foraging occurs at different locations in waters of the North Pacific Ocean, dependent on life stage and foraging strategy. Adults migrate to the waters off their natal nesting beach to mate. Information available since the Status Review refines our knowledge regarding the species' biology and habitat use, especially as it pertains to juvenile foraging strategies. We conclude that the previously described complex life cycle is even more nuanced, as a result of individual variation at each life stage. Multiple foraging strategies at juvenile and adults life stages indicates the importance of several different habitat types and locations to the DPS. This highlights the need for management and protection of such areas.

The best available abundance data are gathered at nesting beaches. In 2015, abundance was estimated to be 8,733 nesting females with a 95 percent credible limit of 7,834 to 9,736 nesting females. This estimate is similar to the 2015 estimate of 8,100 nesting females (Casale and Matsuzawa 2015) and the 2009 estimate of 7,000 to 8,000 nests (50 FR 58868; September 22, 2011), which was approximately equivalent to the estimated total nesting female abundance for the DPS at that time. The Status Review concluded that population abundance of North Pacific loggerheads was small, and we agree. Small abundance contributes to the extinction risk of the DPS because small populations are more likely than large ones to be extirpated as a result of stochastic events and threats.

At the time of the Status Review, nesting was declining. Since then, data indicate that the number of nesting females increased an average of 2.3 percent annually between 1999 and 2015 (Martin *et al*. 2020). Despite the overall increasing trend, some beaches exhibit stable or declining trends, indicating a general lack of consistency among trends at individual nesting beaches (Matsuzawa *et al*. 2016). Current levels of nesting likely do not exceed historical levels. We conclude that the increasing nesting trend, while important and encouraging, is not of adequate magnitude and duration to alter the listing status of the DPS.

The DPS retains adequate genetic diversity for adaptation. It has a broad distribution, with foraging throughout the North Pacific Ocean; however, the nesting range is limited to the Japanese Archipelago. There is spatial structure within the DPS, with subpopulations nesting on Mainland, Yakushima, and Ryuku beaches (Matsuzawa *et al*. 2016). The subdivision informs our consideration of abundance because, reproductively, the DPS is split into three units, rather than a single, panmictic population, causing further concern for the abundance of the DPS.

The DPS faces numerous threats. The greatest of these are fisheries bycatch and climate change. Additional threats include habitat modification, harvest, the relocation of eggs and retention of hatchlings for public outreach, and predation.

Fisheries bycatch continues to be the greatest threat to the DPS, in-part due to inadequate implementation of bycatch reduction measures, monitoring, and enforcement. Although unquantified, IUU fisheries likely pose the greatest threat because they are not required to use any mitigation measures that would reduce or prevent bycatch and mortality. Coastal set net and pelagic longline fisheries, especially those in Mexico and Japan, are major threats to the DPS. Overall annual mortality, as a result of bycatch, is likely in the thousands. Fisheries bycatch reduces abundance; it also likely reduces productivity by removing those individuals (i.e., adults and large juveniles) that survived decades of development and have the greatest potential to contribute to future generations.

Climate change is also a major threat to the DPS. Sea level rise is likely to reduce the availability and increase the erosion rates of nesting beaches, particularly on low-lying, narrow island beaches. Increased storm frequency and intensity are likely to result in altered nesting beaches and decreased egg and hatchling success. Increasing air and sea surface temperatures are strongly correlated to elevated sand temperatures, which can lead to embryonic mortality. Temperature changes and sea level rise are likely to change ocean currents and the movements of hatchlings, juveniles, and adults. Ocean acidification is likely to affect their forage-base. Climate change is a major threat that is likely to rival fisheries bycatch in magnitude in the near future.

The modification of nesting habitat also continues to be a concern, in part due to inadequate regulation of coastal development near nesting beaches. Erosion, shoreline structures, and coastal development reduce the availability of suitable nesting habitat. Artificial lighting, beach use, beach debris, and some shoreline structures and coastal developments deter nesting females and prevent hatchlings from reaching the sea. These habitat modifications reduce productivity of the DPS, by reducing nesting, hatching success, and hatchling survival. The loss and modification of beach habitat are also likely to reduce the diversity and distribution of nesting beaches, thus impairing the representation, resilience, and redundancy of the DPS. Important foraging habitats are modified by pollution, contaminants, and oil spills. Individuals are killed and injured by derelict fishing gear and other marine debris, either through ingestion or entanglement. The threat clearly affects many individuals; however, the magnitude of the threat is unknown because few injured or dead turtles are recovered or reported. We conclude that the destruction and modification of habitat, nesting habitat in particular, is a moderate threat that is likely to become a major threat to the DPS with climate change.

Although reduced from historic levels, loggerheads are still killed for their meat. Legal and illegal harvest of juveniles and adults remains a source of mortality for the DPS. It is difficult to estimate the magnitude of this threat because data on legal harvest are not available, and poaching is unreported. However, poaching in Mexico is likely high, based on stranded or discarded carcasses. Harvest of adults and large juveniles reduces abundance and productivity. The improper handling and prolonged retention of hatchlings by some education programs results in reduced productivity. Reductions in abundance and productivity reduce the resilience of the DPS. We conclude that overutilization is at least a moderate threat to the DPS.

Predation of hatchlings and eggs is a threat to the DPS. Predation of eggs and hatchlings reduces productivity; however, the impact is likely low. The impact of disease is unknown. We conclude that disease and predation pose a low level of threat to the DPS.

Synthesizing the best available data, we conclude that the threats described above continue to endanger the DPS. Representation, the capacity to adapt to changing environmental conditions over time, is limited. Although there is some diversity in nesting habitat, most beaches are at risk of habitat modification and the threats of climate change. Resilience, the capacity to withstand stochastic disturbance, is limited by the low abundance of the DPS. The nesting trend suggests an increase in resilience; however, we are concerned with the low remigration rate because population resilience is dependent upon females returning to nest on a regular basis. Redundancy, the capacity to withstand catastrophic events, is limited because the major threats caused by climate change are likely to affect all individuals, nesting beaches, and foraging areas.

Thus, the status of the DPS has not changed since it was listed as endangered in 2011. It continues to be endangered by intense (fisheries bycatch and climate change) and numerous (habitat loss and modification, overutilization, and predation) threats acting on a small, subdivided population. Although increasing, its low abundance places it at risk of extinction now (rather than in the foreseeable future). We conclude that the status of the species should remain endangered.

3.0 RESULTS

3.1 Recommended Classification

_____**Downlist to Threatened**
_____**Uplist to Endangered**
_____**Delist** *(Indicate reason for delisting per 50 CFR 424.11):*
_____*Extinction*
_____*Recovery*
_____*Original data for classification in error*
_x___**No change is needed**

3.2 New Recovery Priority Number

No change.

Brief Rationale: The North Pacific Ocean DPS of the loggerhead turtle continues to meet the definition of an endangered species because it is in danger of extinction throughout its range as a

result of numerous factors. The greatest threats are caused by fisheries bycatch, which reduces abundance, and climate change, which reduces productivity. Other threats include loss and modification of habitat, overutilization, and predation. These threats are reflected in the low abundance of nesting females. Nesting appears to be increasing; however, relatively few females return to nest on a regular basis, raising concern regarding the impact of threats on the survival of mature females and thus the resilience and recovery of the DPS. We conclude that the current endangered status of the DPS is warranted. The NMFS' and USFWS' recovery priority numbers continue to apply to the DPS.

4.0 RECOMMENDATONS FOR FUTURE ACTIONS

The publication of this 5-year review coincides with recovery planning efforts, which include an international effort involving Japan, Mexico, and the United States, led by NMFS and USFWS. The effort will provide recommendations for future actions. We recommend the following future actions to aid in recovery of the DPS:

- Protect nesting beach habitat through long-term nesting beach protection and practices that maintain these beaches as natural environments;
- Maintain commercial egg harvest prohibition;
- Prevent disturbance to nests, hatchlings, and nesting females by implementing programs to reduce the effects of artificial lighting and promoting best management practices for conservation and education projects;
- Improve monitoring and reporting of legal and illegal harvest of turtles;
- Continue efforts to reduce fisheries bycatch and expand efforts where needed; and
- Incorporate ecologically sound techniques to alleviate impacts from climate change.

5.0 REVIEWERS and REFERENCES

5.1 Reviewers

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW OF NORTH PACIFIC OCEAN LOGGERHEAD DPS

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X__ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: NA

Review Conducted By: Jennifer Schultz and Ann Marie Lauritsen

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Jay B. Herrington, Field Supervisor, North Florida ES Field Office Date 3/2/2020

NATIONAL MARINE FISHERIES SERVICE
5-YEAR REVIEW
NORTH PACIFIC OCEAN LOGGERHEAD DPS

Current Classification: Endangered

Recommendation resulting from the 5-Year Review

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X__ No change is needed

Review Conducted By: Jennifer Schultz and Ann Marie Lauritsen

HEADQUARTERS APPROVAL:

Assistant Administrator, NOAA Fisheries

__X__Concur _____ Do Not Concur

Signature RAUCH.SAMUEL.D.III.1365850948 Digitally signed by RAUCH.SAMUEL.D.III.1365850948 Date: 2020.04.06 15:54:19 -04'00'

Date April 6, 2020