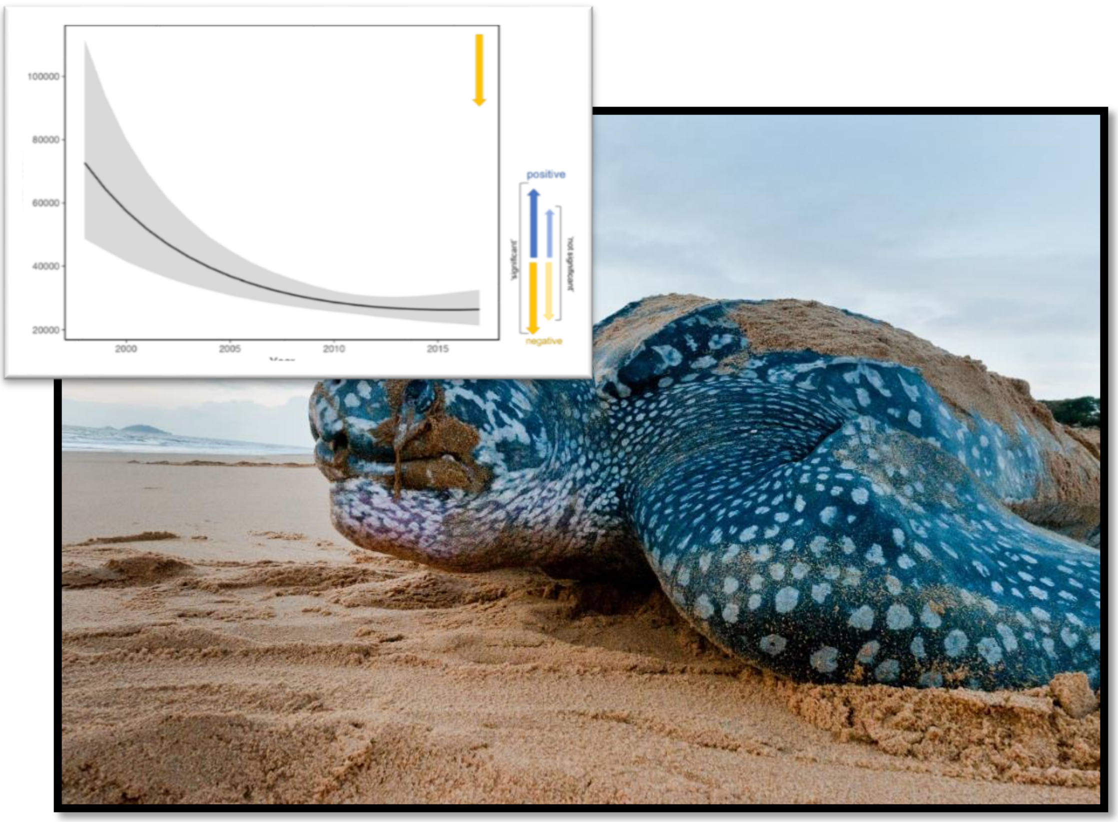
Northwest Atlantic Leatherback Turtle (*Dermochelys coriacea*) Status Assessment



Prepared by the Northwest Atlantic Leatherback Working Group

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Prepared by the Northwest Atlantic Leatherback Working Group

Bryan Wallace and Karen Eckert
(Compilers and Editors)

CONSERVATION SCIENCE PARTNERS

WIDECAST
Wider Caribbean Sea Turtle Conservation Network

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NFWF

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1. Executive Summary

Previous assessments of Northwest Atlantic (NWA) leatherback sea turtle (*Dermochelys coriacea*) status concluded that this regional management unit (RMU)—'subpopulation' in IUCN Red List parlance—was abundant with a stable and even increasing trend (TEWG 2007; Tiwari et al. 2013a). More recently, community-based monitoring efforts throughout the NWA region have noted with concern that annual counts of nests or nesting females appeared to be in decline. Dataholders from across the Wider Caribbean region convened as a "NWA Leatherback Working Group" to contribute existing nesting data to a region-wide trend analysis. The objectives of this effort were to: 1) compile available time-series datasets on leatherback nesting abundance, 2) perform analyses of regional trends, and 3) in response to results of the trend analyses, provide recommendations for priority conservation actions and research.

Leatherback nesting data were contributed from 17 different countries and territories (Table 1), accounting for nearly 450 data points (i.e., nest count in a given year at a given site) and more than 600,000 observed nests region-wide since 1990. The final dataset used for trend analyses (23 sites from 14 countries and territories) was limited to sites with at least 10 years of nest count data collected using consistent within-site methodology. We adapted a simplified version of a Bayesian regression model (Sauer et al. 2017) to estimate trends for all sites, stocks, and for the regional population during three temporal scenarios: 1) 1990-present, 2) 1998-present, and 3) 2008-present. We also used these updated datasets to evaluate the NWA leatherback population under IUCN Red List criteria (IUCN 2014). We convened in-person workshops both to initially assess and confirm a willingness to participate, and later to review preliminary results of trend analyses and discuss possible conservation measures and remaining data gaps.

Overall, regional, abundance-weighted trends were negative across temporal scenarios, and became more negative as the time series became shorter. Site-level trends also reflected this pattern, but showed more variation within and among sites and within and across temporal scenarios. The significant decline observed at Awala-Yalimapo, French Guiana—while mirrored elsewhere (e.g., Suriname, Tortuguero, St. Kitts)—essentially drove the regional results, particularly in the long-term scenario. These patterns, while highlighting the importance of timeframe when evaluating abundance trends, indicate statistically measurable regional-scale declines in leatherback nest abundance over time, particularly in the past decade.

The working group discussed drivers of the updated trends in the context of what factors might have changed or have not been sufficiently addressed to cause a divergence between previous findings and the current analysis. The working group identified anthropogenic sources, habitat losses, and changes in life history parameters as potential drivers for the observed declines in nesting abundance. It is likely that synergistic relationships exist among various drivers and types of drivers. The working group offered the following recommendations for enhanced conservation efforts to better understand and reverse the apparent population declines: 1) characterize and reduce anthropogenic threats, 2) characterize and reduce habitat loss (i.e., beach erosion), and 3) investigate patterns in life history and demographic parameters.

2. Introduction

The Northwest Atlantic (NWA) leatherback sea turtle (*Dermochelys coriacea*) regional management unit (RMU) or subpopulation ranges throughout the northern Atlantic Ocean, from nesting areas in the Wider Caribbean Region to foraging areas that extend from the equator north into temperate latitudes (Wallace et al. 2010; Eckert et al. 2012) (Fig. 1).

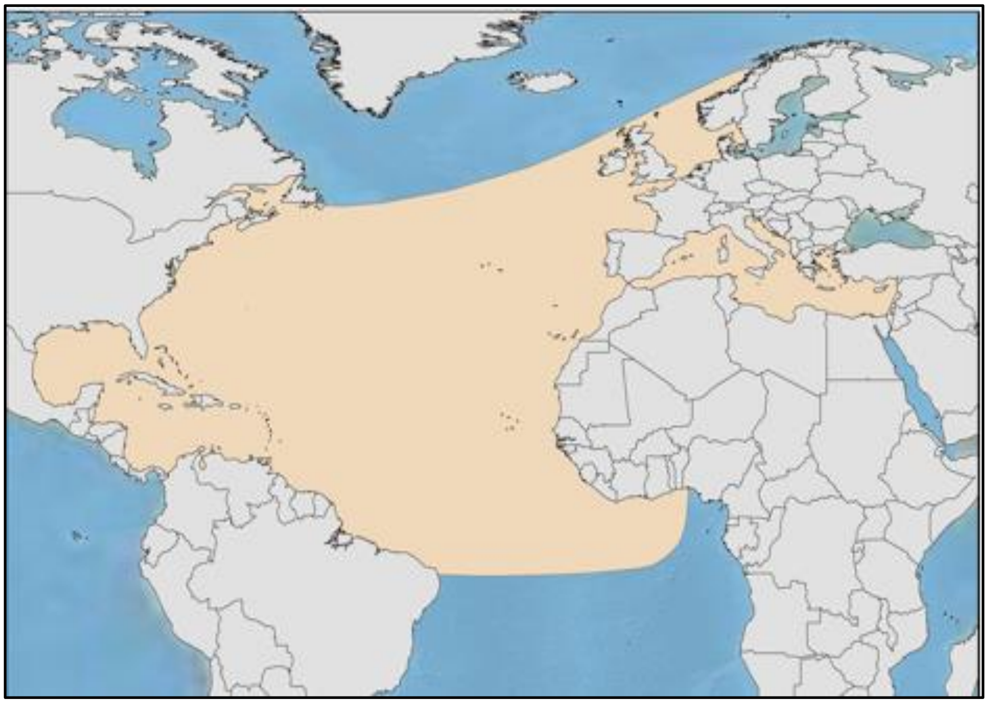

Figure 1. Distribution of the NWA leatherback turtle regional management unit. Source: Wallace et al. 2010.

There are only ten leatherback nesting beaches (2% of the total) in the Wider Caribbean Region that receive more than 1,000 nesting crawls per year. In contrast, 92% of all known nesting beaches host relatively small nesting populations (<100 crawls per year, the equivalent of <20 gravid females) (Dow et al. 2007, Dow Piniak and Eckert 2011) (Fig. 2).

Previous assessments of NWA leatherback status concluded that this RMU was abundant with a stable and even increasing trend (TEWG 2007; Tiwari et al. 2013a). TWEG (2007) collated data on various demographic parameters and abundance metrics (e.g., number of nesting females, number of nests) to estimate the overall adult population size and trend and concluded: "our current understanding of leatherback population dynamics in the Atlantic suggests that the adult female population is relatively stable but nest numbers could fluctuate considerably due to individual variance in remigration intervals, clutch number, and the reduced site fidelity in leatherbacks" (p 1). The report estimated 28,000 to 46,000 nests and 4,800 to 11,000 nesting females in 2004-2005, and increasing trends region-wide, except the Western Caribbean (TEWG 2007). Similarly, long-term trends in annual nest abundance evaluated against the criteria of the IUCN *Red List of Threatened Species*™ concluded that the NWA leatherback RMU—'subpopulation' in Red List parlance—was generally increasing in abundance through 2010, and thus qualified for the official Red List category of "Least Concern." [1] Despite this official category listing, the assessors highlighted the importance of continued conservation efforts to prevent collapses such as those documented for leatherback RMUs in the Pacific Ocean (Tiwari et al. 2013a,b; Wallace et al. 2013).

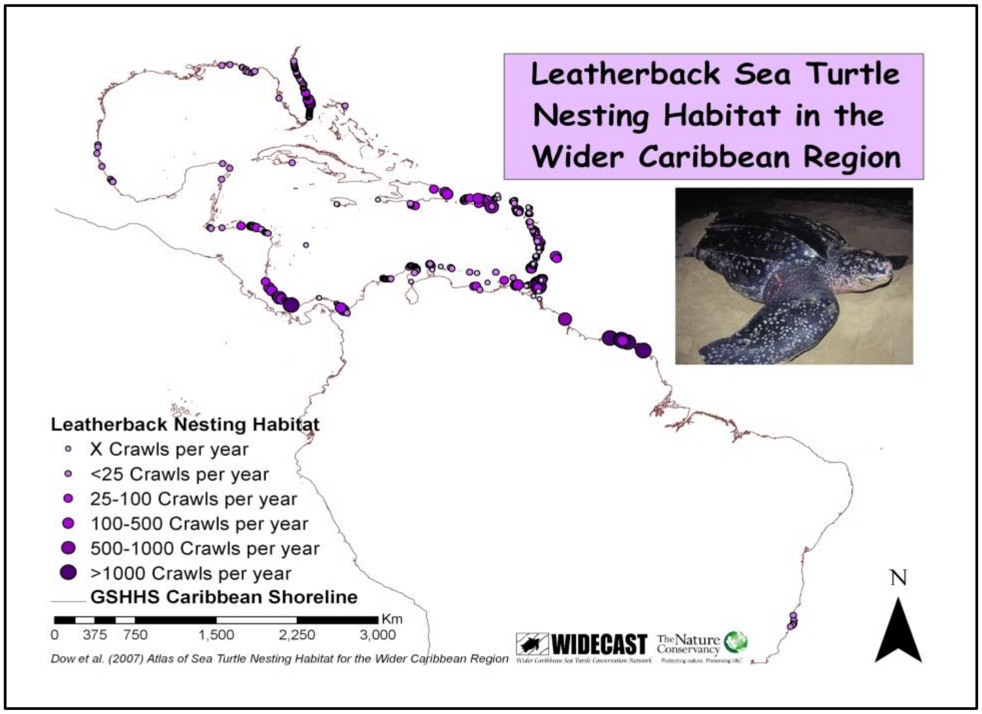

Figure 2. Distribution of nesting sites for NWA leatherback turtles. Source: Dow et al. 2007.

More recently, community-based monitoring efforts throughout the NWA region have noted with concern that annual counts of nests or nesting females appeared to be in decline. Members of the Wider Caribbean Sea Turtle Conservation Network (WIDECAST) began informal discussions about collaborating on an updated regional assessment to determine whether, in fact, a decline is occurring and, if so, how pervasive it might be. As these discussions were taking place, the U.S. National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (FWS) initiated a federal status review in response to a petition filed in December 2017 to identify the NWA subpopulation as a Distinct Population Segment (i.e., similar to RMU and IUCN 'subpopulation') and list it as Threatened under the U.S. Endangered Species Act (82 FR 57565, 2018). In addition, the National Fish and Wildlife Foundation (NFWF) was evaluating its grantmaking portfolio for all sea turtle populations, including the NWA leatherback population, to ensure prioritized allocation of available funding.

Dataholders met in Matura, Trinidad, during the 2018 WIDECAST Annual General Meeting to discuss the regional trends seen on their respective beaches. As French Guiana, Suriname, and

[1] The purpose of the Red List is to provide a triage for those species in imminent risk of global extinction. Thus, the terminology "Least Concern" is intended to reflect the relative risk of such species in that context; species can still be declining, experiencing significant threats, etc., and be classified as "Least Concern" based on evaluation of Red List criteria.

Guyana indicated that they saw a decline in their nesting numbers, they were interested to see if their nesting females were moving to other nesting beaches in the region. However, representatives from other countries also indicated seeing a decline in number of nests. Given this widely reported observation, WIDECAST members decided that a regional assessment of trends was warranted.

In response to this and the aforementioned management and grant-making needs, dataholders from across the Wider Caribbean then convened as a "NWA Leatherback Working Group" to contribute existing nesting data to a region-wide trend analysis. The objectives of this effort were to: 1) compile available time-series datasets on leatherback nesting abundance, 2) analyze regional trends, and 3) in response to results of the trend analyses, provide recommendations for priority conservation actions and research.

3. Methods

Data compilation

Beginning on April 17, 2018, data were requested from all individuals and groups that regularly collect data on the distribution and abundance of the annual reproductive effort by leatherback turtles nesting in the Wider Caribbean Region (Figs. 1 and 2). Specifically, information was requested regarding annual nest counts per site for all years during which data were collected using methods that were consistent across years (see Appendix A. Data sharing agreement). This was a particular requirement of the trend modeling framework (see below).

In total, more than 40 partners from 17 countries and territories contributed leatherback nesting data (Table 1)[2], accounting for nearly 450 data points (i.e., nest count in a given year at a given site) and more than 650,000 observed nests region-wide since 1990. The final dataset was limited to those with at least 10 years of nest count data collected using consistent within-site methodology, as described above (Table 2). The heterogeneity of site characteristics across the region (e.g., beach dimensions, mainland versus insular beaches, night versus morning patrols) results in heterogeneous data collection methods among sites. However, as long as monitoring methods and effort are relatively consistent across years within sites, site- and regional-level trends can be analyzed.

Data analysis

The final dataset used for trend analyses contained annual count data from 23 sites across 14 countries and territories (Table 3), although the site-level datasets do not span exactly the same timespan (i.e., start- and end-years vary across sites). We hypothesized that trends would vary depending on the time period of study. Further, several collaborators noted apparent declines at their sites in recent years, which was an impetus for this analysis. For these reasons, we analyzed trends during three different time periods, or temporal scenarios:

[2] See "Acknowledgements" for more detail on Dataholders and contributors.

1. 1990-present, i.e., long-term trend
2. 1998-present, i.e., an intermediate trend (past 20 years)
3. 2008-present, i.e., recent trend (past 10 years)

Site-level datasets were included in a temporal scenario if they had at least 10 years of data within that temporal scenario.

We fit a hierarchical model to the annual counts for each time period with sites nested within the region. We modeled the counts, denoted y_{it} where i indexes site and t indexes year, using negative binomial regression. We opted for negative binomial regression, rather than Poisson regression, due to the large variation in counts among years within sites and among sites. We modeled the counts for each time period as a log-linear function of year as follows:

$$log(\lambda_{it}) = \beta_{0i} + \beta_{1i} * year_t,$$
where: $y_{it} \sim negbin(\lambda_{it}, \kappa)$

In the equation, the β_{0i} are site-specific intercepts, and the β_{1i} are site-specific slopes (i.e., trends in nest counts for each site). Due to the hierarchical structure of the data and our expectation that site-level intercepts and slopes would be correlated (see below), we modeled β_{0i} and β_{1i} as arising from a multivariate, normal distribution with hyperparameters $\mu_{\beta 0}$, $\mu_{\beta 1}$, $\sigma^2_{\beta 0}$, $\sigma^2_{\beta 1}$, and $cov(\beta_0, \beta_1)$. Under this specification, $\mu_{\beta 0}$ and $\mu_{\beta 1}$are the mean intercept and trend across sites, and we interpreted $\mu_{\beta 1}$ as the region-level trend in counts.

We specified the model such that the trends at each of the sites came from a region-level distribution because we expect the trends (i.e., slopes) at the sites to be connected to one another. Females that nest on different beaches share areas for foraging and are exposed to similar broad-scale environmental conditions (James et al. 2006; Stewart et al. 2013) that influence site-level nesting dynamics.[3] In addition, specifying the model in this way allows sites with fewer data (i.e., shorter timeseries) to "borrow strength" from sites with more data (i.e., longer timeseries).

For all hyperparameters and κ, we specified diffuse priors, and fitted the model in the analytical platform STAN (Carpenter et al. 2017) through the R package brms (Burkner 2017). We specified three chains in the Markov Chain Monte Carlo (MCMC) algorithm with 1500 iterations per chain and discarded the initial 750 iterations as warm-up. We assessed convergence by inspecting traceplots and by the $\hat{R}$ statistic, with $\hat{R}$ < 1.1 as our criterion (Gelman and Rubin 1992).

Although $\mu_{\beta 1}$represented the regional trend, it did not account for differences in counts among sites and, as such, gave sites equal weight in terms of their influence on the regional trend. However, it could be argued that sites with higher counts should have greater influence on

[3] We recognize that variation in site-level characteristics (e.g., changes in available habitat, predation) can also cause divergent patterns among sites; such factors were discussed by the group when interpreting the results (see Potential Drivers).

estimates of regional trends; this is the conversion used in trend analyses of sea turtles such as in Red List assessments (e.g., Tiwari et al. 2013a). Therefore, we also generated region-level estimates of trend that were weighted by the magnitudes of the counts. Only weighted results are presented in this report.

In addition, previous research has identified five genetic stocks in the region (Dutton et al. 2013; Stewart et al. 2013; Roden et al. 2017). In the most comprehensive genetic stock structure evaluation to-date using microsatellite analysis in combination with mtDNA analysis, Dutton et al. (2013) concluded that there are five distinct stocks within the NWA (nine in the entire Atlantic): 1) Trinidad, 2) Suriname and French Guiana, 3) Costa Rica, 4) Florida, and 5) St. Croix (US Virgin Islands). However, when considering mtDNA of nesting females only, Trinidad and the Guianas comprise a single nesting stock. Thus, because estimates of stock-level trends were of interest, site-level time-series datasets were organized by nesting stock based on the current understanding of genetic population structure; i.e., four separate stocks (Dutton et al. 2013; Stewart et al. 2013; Roden et al. 2017) (Table 1). However, not all sites included in the current analysis have been sampled and assigned to specific stocks (e.g., Puerto Rico, Grenada). In these cases, we assigned these sites to known stocks based on proximity and known exchange of nesting females (Horrocks et al. 2016). Because of this uncertainty in stock assignment, we did not include stock in the original structure of the model. Therefore, estimates of stock-level trends should be cautiously considered.

We estimated region- and stock-level trends that were weighted by counts using an approach from the North American Breeding Bird Survey (BBS) (Sauer et al. 2017). The approach had three steps:

1. We used the posterior samples for β_{0i} and β_{1i} to compute expected counts for each site i in each year t, for the time window of interest (1990-2017, 1998-2017, and 2008-2017), which resulted in posterior samples of expected counts for each site and year. We derived the expected count as the mean of each posterior and computed upper and lower 95% credible limits for the expected counts by identifying the 2.5th and 97.5th percentiles of each posterior. We used a similar approach to derive estimates and their 95% credible limits for the quantities below.

2. For each year, we summed the expected counts across sites within a stock or across the region, which resulted in annual stock- or region-level expected counts.

3. We computed stock- or region-level trends, which we represent as B, as

$$B = 100 * \left(\frac{Count_{2017}}{Count_{1990}}^{\frac{1}{2017-1990}} - 1 \right)$$

In the equation, $Count_{1990}$ and $Count_{2017}$ are the expected, stock- or region-level counts for 1990 and 2017. We performed the same calculation for the other temporal scenarios by adjusting the beginning year and corresponding counts of the scenario (e.g., 1998, 2008). We defined these trends as annual geometric mean percentage change in expected counts over time (Sauer et al. 2017). Positive values indicated a stock or region with an average annual increase in counts over the time period of interest, and negative values indicated a stock or region with an average annual decrease. It should be noted that we calculated expected counts for all sites in all years, including sites for which raw counts were only available for portions of the time series.

Table 1. Seventeen site-level datasets were contributed to the present assessment. See Acknowledgements for individual Dataholders and contributors. Note: In the end, not every dataset met the criteria for inclusion in the trend analysis; therefore, while all datasets are acknowledged here, not all are included in Tables 2 and 3.

Stock	Site	Years	Data Credit
Florida (US)	Florida (27 beaches)	1989-2017	Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission
	North Carolina	1998-2017	North Carolina Wildlife Resources Commission
N. Caribbean	St. Croix, USVI	1982-2017	US Fish and Wildlife Service
	Puerto Rico		
	Culebra	1984-2017	Puerto Rico (PR) Department of Natural Resources, US Fish and Wildlife Service
	Luquillo-Fajardo	1996-2017	PR Department of Natural Resources
	Maunabo	1999-2017	PR Department of Natural Resources, ATMAR
	16 other beaches	2011-2017	PR Department of Natural Resources
	Tortola, BVI	1990-2017	BVI Department of Conservation and Fisheries
	St. Kitts & Nevis	2003-2017	St. Kitts Sea Turtle Monitoring Network
	Guadeloupe	2000-2017	Réseau Tortues Marines de Guadeloupe
	St. Barthélemy	2009-2017	Réseau Tortues Marines de Guadeloupe
	St. Martin	2009-2017	Réseau Tortues Marines de Guadeloupe
	Martinique	2006-2017	Réseau Tortues Marines de Martinique
W. Caribbean	Costa Rica		
	Pacuare	2004-2017	Latin American Sea Turtles (LAST)
	Mondonguillo	1991-2017	LAST, Ecology Project International
	Estacion Las Tortugas	2002-2017	LAST, Estación Las Tortugas
	Tortuguero	1995-2017	Sea Turtle Conservancy
	Cahuita	2000-2012	LAST

Stock	Site	Years	Data Credit
	Gandoca	1990-2009	LAST
	Panamá		
	Chiriqui	2004-2017	Sea Turtle Conservancy
	Soropta	2013-2017	Sea Turtle Conservancy
Guianas/ Trinidad	Grenada		
	Levera	2002-2017	Ocean Spirits, Inc.
	Venezuela		
	Querepare	2002-2017	IZET-UCV/CICTMAR
	Cipara	2000-2015	IZET-UCV/CICTMAR
	Guyana	1989-2017	TEWG (2007), WWF-Guianas, Guyana Marine Turtle Conservation Society (2001-2014), Protected Areas Commission (2015-2017)
	Suriname	1999-2017	TEWG (2007), WWF-Guianas
	French Guiana		
	Awala-Yalimapo (and remote oceanic beaches)	1989-1996, 2002-2017	Girondot and Fretey (1996) CNRS-IPHC, Réserve Naturelle de l'Amana, WWF France
	Cayenne	1999-2017	KWATA
	Trinidad & Tobago		
	Matura	2006-2017	Nature Seekers, Turtle Village Trust (TVT)
	Fishing Pond	2009-2017	Fishing Pond Turtle Conservation Group, TVT
	Grand Riviere	2009-2017	Grande Riviere Nature Tour Guides Association , TVT
	Tobago	2009-2017	Save Our Sea Turtles-Tobago

Table 2. Summary of monitoring effort at the 23 nesting sites (14 countries and territories) related to annual nest count datasets included in trend analysis. Note: The monitoring effort in Guadeloupe is unique because beaches are disconnected and occur on different islands. Monitoring in Guadeloupe occurs once every 6-7 days per month for high density beaches, and once every 14-22 days during the peak for low density beaches.

Site	Metric monitored (tracks, nests, females)	When does monitoring occur? (night, morning, both?)	How frequently does monitoring occur? (Daily, weekly, other?	Minimum start and end dates of monitoring
Florida and North Carolina (US)	tracks, nests	morning	daily	31 March - 31 Aug
St. Croix, USVI (US)[4]	tracks, nests, females	both	daily	31 March - 31 Aug
Culebra, PR (US)	tracks, nests	morning	daily	1 April - 31 July
Luquillo-Fajardo, PR (US)	tracks, nests	morning	daily	1 April - 31 July
Maunabo, PR (US)	tracks, nests	morning	daily	1 April - 31 July
Tortola, BVI (GB)	tracks, females	both	daily	31 March - 31 July
St. Kitts & Nevis	tracks, nests, females	both	daily	15 March - 31 July
Guadeloupe (FR)	tracks	both	See legend	28 Mar - 11 Nov
Pacuare (CR)	tracks, nests, females	both	daily	15 Feb - 15 Aug
Mondonguillo (CR)	tracks, nests, females	both	daily	15 Feb - 15 Aug
Estacion La Tortuga (CR)	tracks, nests, females	both	daily	15 Feb - 15 Aug
Tortuguero (CR)	tracks, nests, females	both	daily	15 Feb - 15 Aug
Cahuita (CR)	tracks, nests, females	both	daily	15 Feb - 15 Aug
Gandoca (CR)	tracks, nests, females	both	daily	15 Feb - 15 Aug
Chiriqui (PA)	tracks, nests, females	both	daily	1 Mar - 1 Oct
Levera (GD)	tracks, nests, females	both	daily	25 Feb - 31 Jul (2005: May + June only)
Querepare (VZ)	tracks, nests, females	both	daily	26 Apr - 31 Aug
Cipara (VZ)	tracks, nests, females	both	daily	20 Apr - 31 Aug
Guyana	tracks, nests	both	daily	April - July

[4] Country codes follow the International Organization for Standardization (ISO) abbreviations, https://www.iso.org/home.html

Site	Metric monitored (tracks, nests, females)	When does monitoring occur? (night, morning, both?)	How frequently does monitoring occur? (Daily, weekly, other?	Minimum start and end dates of monitoring
Suriname	tracks, nests	morning	daily	Mar - July
Awala-Yalimapo, GF (FR) (including remote beaches)	tracks, nests, females	both	daily	Mar - July
Cayenne, GF (FR)	tracks, nests, females	both	daily	May - Aug
Matura (TT)	tracks, nests, females	both	daily	15 Mar - 31 July

Review and validation workshop

The working group convened in-person to review and discuss preliminary results of the trend analyses, as well as to discuss possible conservation measures and identify remaining data gaps (See Appendix B. Participant workshop agenda). Eleven members of the working group attended the meeting in person, while another 10-15 attended via webinar. Presentations from nesting sites that contributed data to the analysis provided basic information on current status, monitoring and conservation efforts, and existing threats and challenges. Presentations from projects that work with leatherbacks in marine habitats also provided information on biological and demographic parameters, habitat use patterns, and in-water threats (James et al. 2006, 2007; Dodge et al. 2014; Hamelin et al. 2017). Preliminary results from the trend analyses were presented and discussed. Finally, the working group discussed possible causes and remaining data gaps that hinder interpretation of observed trends to identify priorities for conservation and research. After the workshop, existing datasets were reviewed, refined where necessary, and additional datasets were obtained where available.

Red List assessment update

The most recent Red List assessment result (Tiwari et al. 2013a) used leatherback nesting data through 2010 as the index of abundance under Criterion A (i.e., 'the decline criterion,' which estimates the percent decline in a species or subpopulation over the past 10 years or 3 generations, whichever is longer) (IUCN 2014). The result of this assessment listed NWA leatherbacks as 'Least Concern,' which, in Red List parlance, means that this subpopulation might be worthy of conservation attention but extremely unlikely to go extinct in the near future.

The 2013 Red List assessment relied heavily on data provided in the TEWG (2007) report, particularly for historical data (i.e., prior to the 1990s). However, the present status assessment exercise—in particular, the valuable insights of country project leaders with knowledge of historical and recent data—illustrated that most of those older nest counts were not collected using consistent or comprehensive effort within or across years. In fact, this issue is described in the country-specific accounts in TEWG (2007). Therefore, we opted to use the same datasets employed in the trend assessments as described above (Table 3)—i.e., at least 10 years of data per dataset, collected using consistent methodology over time—in an updated Red List assessment exercise. We acknowledge that this change in approach will affect the final result because many of the early counts provided by TEWG (2007) were quite low (in the tens of nests), especially when compared to counts in the 1990s (in the thousands or tens of thousands of nests at major rookeries such as French Guiana, Suriname, and Guyana), which produced several increasing trends that might have actually been artifacts of the inconsistent monitoring efforts in early years.

To evaluate available data under Red List Criterion A, Red List guidelines require calculation of the percent decline (i.e., percent change) from past to present estimates. Thus, we calculated five-year averages of annual nest counts for a past time point and a recent time point that included 2017. For example, if a dataset began in 1986 and continued through 2017, we calculated a 'past' estimate by averaging annual nest counts from 1986-1990 (5 years) and calculated a 'present' estimate by averaging annual nest counts from 2013-2017. The multi-year average is intended to account for inter-annual variation in nesting typical of non-annual breeders like sea turtles. We repeated this calculation for all sites with >10 yr of data. Next, in accordance with Red List guidelines, we calculated stock-level trends by averaging site-level trends within stocks, but weighting site-level trends by initial abundance. We then repeated this calculation to estimate an abundance-weighted subpopulation-level trend. We also calculated trends through 2010 using these more refined datasets to illustrate how our methodological approach might produce different results compared to the previous Red List assessment.

Note that the results presented here have not been evaluated under the IUCN Marine Turtle Specialist Group's standard protocol for Red List assessments, and thus are not official results. Our intention in offering these results is to provide Wider Caribbean sea turtle program managers and other natural resource professionals with as much information related to trends as possible, based on current data and utilizing standard guidelines and criteria, such as those offered by IUCN (IUCN 2014).

Table 3. Site-level datasets (n=23) included in the data analyses to determine site-level, stock-level, and region-level trends in annual abundance in three different time period scenarios. 'X' indicates that a given dataset was included in a given temporal scenario. Datasets were excluded from a temporal scenario if fewer than 10 years of data were available within that scenario.

Stock	Site	1990-present (n = 23)	1998-present (n = 23)	2008-present (n = 19)
Florida	Florida, North Carolina (US)	X	X	X
N. Caribbean	St. Croix, USVI (US)	X	X	X
	Tortola, BVI (GB)	X	X	X
	Culebra, PR (US)	X	X	X
	Luquillo-Fajardo, PR (US)	X	X	X
	Maunabo, PR (US)	X	X	
	St. Kitts & Nevis	X	X	X
	Guadeloupe (FR)	X	X	X
W. Caribbean	Pacuare (CR)	X	X	X
	Mondonguillo (CR)	X	X	X
	Estacion La Tortuga (CR)	X	X	X
	Tortuguero (CR)	X	X	X
	Cahuita (CR)	X	X	
	Gandoca (CR)	X	X	
	Chiriqui (PA)	X	X	X
Guianas-Trinidad	Levera (GD)	X	X	X
	Querepare (VZ)	X	X	X
	Cipara (VZ)	X	X	
	Guyana	X	X	X
	Suriname	X	X	X
	Awala-Yalimapo, GF (FR) (including remote beaches)	X	X	X
	Cayenne, GF (FR)	X	X	X
	Matura (TT)	X	X	X

4. Results and Discussion

Overall, regional, abundance-weighted trends were negative across temporal scenarios, and became more negative as the timeseries became shorter. Site-level trends also reflected this pattern, but showed more variation within and among sites and within and across temporal scenarios. Credible intervals around trend estimates (Figs. 3,4,5) were widest at the beginnings and ends of time series and narrowest in the middle of time series, generally reflecting presence of data within and among sites (fewer data points at beginnings and ends, more in the middle). Mean trend estimates appeared to reflect actual timeseries data within and among sites.

The variation in trends among temporal scenarios reflects available data and how the model estimates trends (i.e., drawing site-level trends from a distribution of regional-level trends, and borrowing strength from sites with a lot of data to inform datasets with fewer data). It also illustrates the influence of the timeframe in which a trend is being analyzed. As described below, annual counts of sea turtle nests typically show high interannual variation within and among sites. Several sites in our analysis showed low abundance in early years followed by many years of increasing abundance, and then more recent declines that returned populations to earlier (lower) levels of abundance (e.g., St. Croix, Florida, Culebra [Puerto Rico], Cayenne [French Guiana]) (Fig. 3).

For example, we selected 1990 as the beginning of the long-term scenario because few sites had data prior to that year. However, we could have initiated the 'long-term' scenario when data were first available at any single site, and the model would still have estimated counts for other sites, albeit with enormous confidence intervals because of limited data availability. To illustrate this another way, trends might have become 'more negative' as scenarios moved from long-term to recent in part because of the years that begin each scenario.

We selected 1998 as the beginning of the intermediate scenario because it initiated a 20-year timeframe through 2017, but counts for several sites were higher relative to other years. Thus, if we had selected a different year as the beginning of that scenario, and estimated counts were much different in that year than in 1998, trends for that scenario would likely have been different as well. In the same vein, the recent temporal scenario begins during relatively high abundance for several sites that had increased over time until that point, and have since declined. This likely contributed to intensified negative trends detected during the most recent period.

These observations warrant careful analysis of potential drivers of trends (see section below on potential drivers) that we highlight in this assessment to understand—or at least to keep in mind—the effects of data variability, temporal scenario definition, and the possibility of multi-decadal fluctuations in sea turtle populations. In the remainder of this section, we present site-, stock-, and region-level trends in more detail, and discuss potential drivers of the observed trends.

Site-level trends

Trends varied widely among sites due to differences in abundance and in time series lengths (Table 4; Fig. 3). For the long-term temporal scenario (1990-present), nearly half (12 of 23) of sites had positive trends, and seven of the 12 positive trends were ‘significant’ (i.e., 95% Credible Intervals around mean annual trend estimate did not include zero). However, this pattern shifted to nine of 23 positive trends (5 significant) in the intermediate scenario (1998-present), and finally to one of 19 (zero significant) in the recent scenario (2008-present).

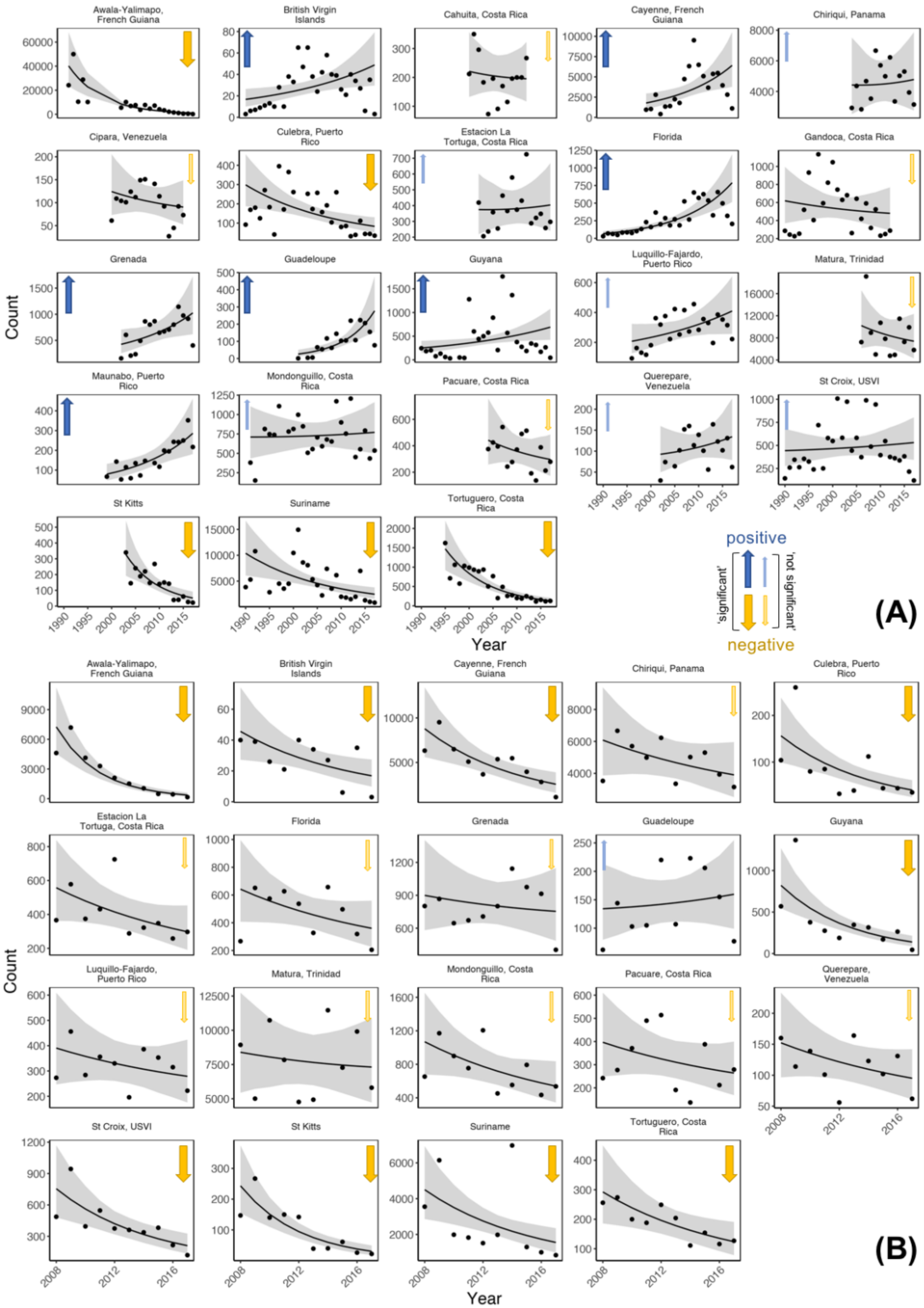

Figure 3. Site-level trends for (A) 1990-2017 and (B) 2008-2017 (results for intermediate scenario included in Appendix C). Line is annual mean trend and shaded area is 95% credible intervals. Black points are actual nest count data. Blue up arrows = positive trends, yellow down arrows = negative trends; large arrows = 'significant' trends; small arrows = 'non-significant' trends.

Table 4. Site-level trends in annual abundance (annual geometric mean percent changes [+/- 95% Credible Intervals]) in three different time period scenarios. Shading indicates positive (blue) or negative (yellow) trends, with darker colors indicating trends whose 95% CIs do not include zero (i.e., 'significant' trends) and lighter colors indicating trends whose 95% CIs include zero (i.e., 'not significant').

Stock	Site	1990-present (n = 23)	1998-present (n = 23)	2008-present (n = 19)
Florida	Florida, US	9.59 (6.53 - 12.67)	5.48 (0.85 - 10.16)	-6.86 (-15.4 - 2.58)
N. Caribbean	St. Croix, USVI (US)	0.68 (-2.18 - 3.68)	-4.93 (-8.92 - -0.76)	-14.66 (-22.16 - -6.97)
	Tortola, BVI (GB)	0.39 (0.06 - 0.83)	-0.21 (-0.38 - 0.02)	-0.29 (-0.46 - -0.06)
	Culebra, PR (US)	-4.61 (-7.44 - -1.76)	-10.46 (-14.43 - -6.55)	-15.6 (-23.01 - -7.52)
	Luquillo-Fajardo, PR (US)	3.32 (-0.56 - 7.46)	2.01 (-2.13 - 6.39)	-4 (-12.34 - 5.34)
	Maunabo, PR (US)	7.43 (2.76 - 12.47)	7.93 (3.36 - 12.56)	
	St. Kitts & Nevis	-12.43 (-18.37 - -6.26)	-14.54 (-20.03 - -8.90)	-22.87 (-30.41 - -14.88)
	Guadeloupe (FR)	16.24 (8.46 - 24.63)	18.10 (10.73 - 26.52)	2.36 (-7.09 - 13.77)
W. Caribbean	Pacuare (CR)	-2.97 (-9.53 - 3.83)	-3.84 (-9.8 - 2.49)	-4.84 (-13.2 - 4.56)
	Mondonguillo (CR)	0.35 (-2.62 - 3.31)	-1.35 (-5.56 - 2.85)	-8.1 (-16.4 - 1.05)
	Estacion La, Tortuga (CR)	0.54 (-4.98 - 6.49)	0.43 (-5.26 - 6.38)	-7.45 (-15.07 - 1.21)
	Tortuguero (CR)	-10.42 (-13.34 - -7.12)	-11.93 (-15.43 - -8.31)	-10.08 (-18.06 - -1.47)
	Cahuita (CR)	-0.97 (-7.51 - 6.04)	-1.61 (-7.96 – 5.00)	
	Gandoca (CR)	-1.13 (-4.99 - 2.88)	-7.58 (-12.7 - -2.18)	
	Chiriqui (PA)	0.67 (-6.39 - 7.80)	0.68 (-6.42 - 7.72)	-5.25 (-13.65 - 3.72)
Guianas-Trinidad	Levera (GD)	6.1 (0.27 - 12.29)	6.62 (0.49 - 13.07)	-2.05 (-10.64 - 7.08)
	Querepare (VZ)	2.62 (-3.70 - 9.47)	2.59 (-3.61 - 9.45)	-5.62 (-13.94 - 2.84)
	Cipara (VZ)	-2.06 (-7.75 - 3.62)	-2.74 (-8.08 - 2.76)	
	Guyana	3.86 (0.59 - 7.28)	-5.49 (-9.98 - -0.84)	-19.86 (-26.99 - -12.72)
	Suriname	-5.14 (-7.98 - -1.96)	-9.36 (-12.91 - -5.84)	-12.36 (-20.54 - -4.05)
	Awala-Yalimapo, GF (FR) (including remote beaches)	-12.95 (-15.87 - -10.20)	-19.05 (-24.27 – -13.52)	-31.26 (-38.11 – -23.6.0)
	Cayenne, GF (FR)	7.44 (2.21 - 13.03)	8.19 (2.81 - 13.81)	-14.21 (-22.17 - -6.03)
	Matura (TT)	-2.84 (-10.02 - 4.55)	-3.51 (-10.85 - 4.17)	-1.60 (-10.21 – 7.00)

Stock-level trends

Similar to the site-level trends, stock-level trends varied by relative abundance and data availability, and became more negative as temporal scenarios became more recent (Table 5; Fig. 4).

The Florida stock has increased significantly over the long-term, but has declined back to abundance observed in the beginning of the time series in the past decade. The shift in trend over time reflects the relatively high abundance Florida reached through the late 2000s and the recent consecutive years of declining annual abundance since 2015 (Fig. 3).

Although the Northern Caribbean stock has declined overall in the long-term scenario (Table 5; Fig. 4), 5 of the 7 sites showed increases over this time period (Table 4; Fig 3). The stock-level trend was negative because the initial abundance of the two sites that have declined significantly since 1990 (Culebra, Puerto Rico; St. Kitts) was higher than initial abundance of sites that increased during the same period (Fig. 3). Nonetheless, this stock declined significantly in the intermediate and recent scenarios as well (Table 5).

The trend for the Western Caribbean stock was negative across temporal scenarios, but the 95% Credible Intervals around the geometric mean trend estimates overlapped zero in all cases (Table 5; Fig. 4). Within this stock, there is wide variation in site-level trends that may reflect individual turtles shifting nesting beaches within the stock boundaries. For example, although abundance at Tortuguero, Costa Rica, has declined from well over 1,000 nests/year in the mid-1990s to ~100 nests/year in recent years, while abundance at other beaches (e.g., most Costa Rican beaches and at Chiriqui, Panamá) has not declined significantly (Table 4; Fig. 3). Notably, data were not available from the Caribbean coasts of Panamá and western Colombia; previous studies showed that these sites hosted several thousand nests/year in the mid-2000s (Patiño-Martinez et al. 2008).

The largest stock in the NW Atlantic – Guianas-Trinidad – declined significantly across temporal scenarios (Table 5; Fig. 4). These declines, particularly the long-term decline, were driven principally by the exponential decline in abundance observed at Awala-Yalimapo, French Guiana (Table 4; Fig. 3). The recent trend also reflects continued declines at Guyana, Suriname, Cayenne (eastern French Guiana), and a slight decline at Matura (Trinidad) (Table 4; Fig. 3).

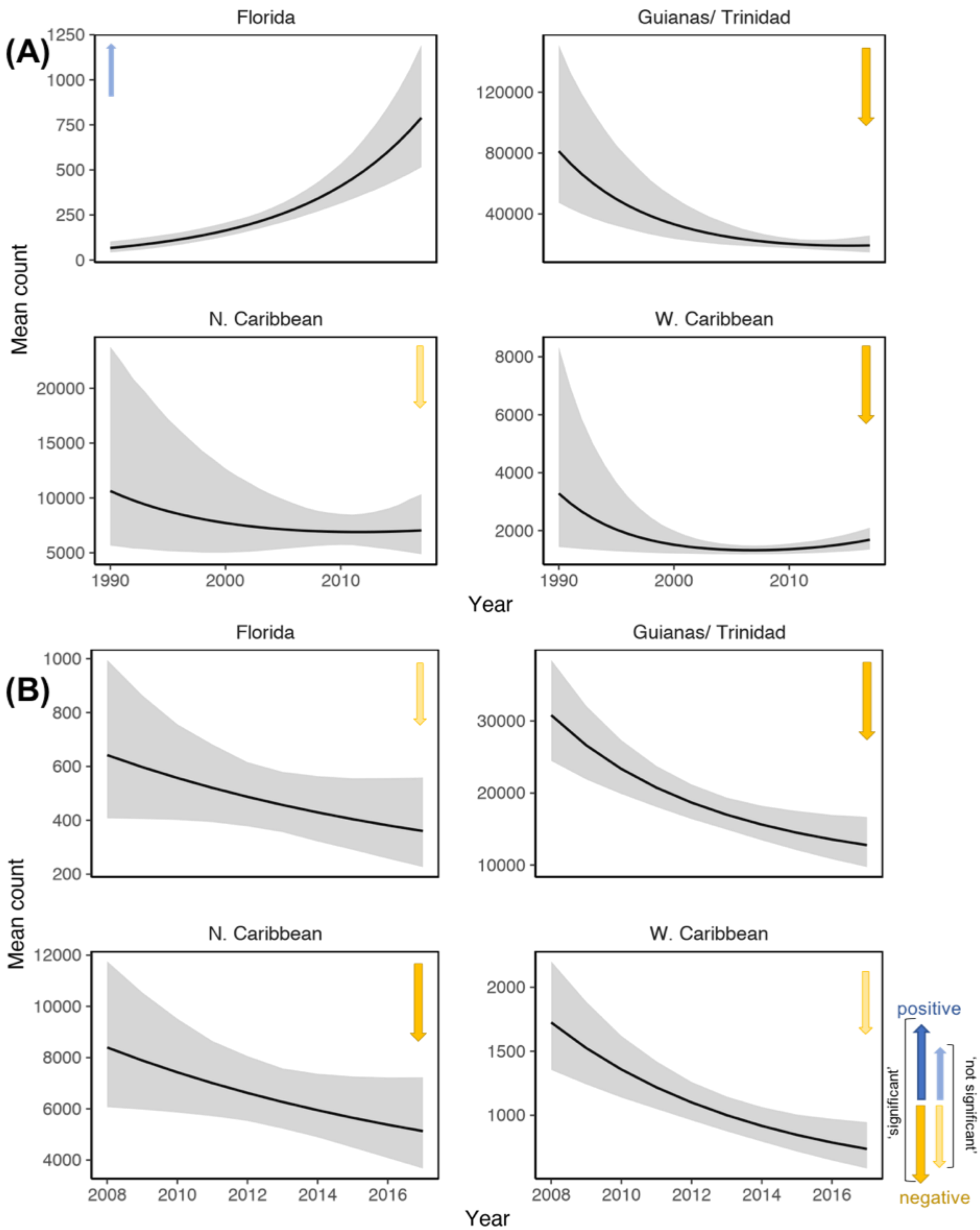

Figure 4. Stock-level trends (annual geometric mean change in nest counts) for (A) 1990-2017 and (B) 2008-2017 (results for intermediate scenario not shown). Line is geometric annual mean trend (weighted by relative site-level abundance) and shaded area is 95% Credible Intervals. Blue up arrows = positive trends, yellow down arrows = negative trends; large arrows = 'significant' trends; small arrows = 'non-significant' trends.

Table 5. Stock-level trends in annual abundance (annual geometric mean percent changes [+/- 95% Credible Intervals]) in three different time period scenarios. Shading indicates positive (blue) or negative (yellow) trends, with darker colors indicating trends whose 95% CIs do not include zero (i.e., 'significant' trends) and lighter colors indicating trends whose 95% Cis include zero (i.e., 'not significant').

Stock (n = # sites)	1990-present	1998-present	2008-present
Florida (n = 1)	9.59 (6.53 - 12.67)	5.48 (0.85 - 10.16)	-6.86 (-15.40 - 2.58)
N. Caribbean (n = 7)	-2.01 (-5.81 - 0.89)	-2.93 (-5.29 - -0.63)	-10.06 (-14.44 - -5.47)
W. Caribbean (n = 7)	-1.31 (-5.45 - 1.83)	-1.42 (-5.66 - 2.50)	-5.91 (-12.30 - 0.65)
Guianas-Trinidad (n = 8)	-5.04 (-7.88 - -2.69)	-6.53 (-9.83 - -3.31)	-10.43 (-14.91 - -5.68)

Regional trends

At the regional scale, the NWA leatherback has declined across all three temporal scenarios we analyzed. The relative magnitude of annual rates of decline increased (became more negative) as timeframes became shorter and more recent (Table 6; Fig. 5). The model results show wide variation around estimates for the early part of the long-term time series, which mainly reflects two factors: 1) fewer data were available for generating estimates of mean annual abundance in those years (e.g., Matura's time series does not begin until 2006), and 2) the data that did exist were extremely dispersed (i.e., counts varied from tens of thousands at Awala-Yalimapo, French Guiana, to hundreds elsewhere).

As mentioned above for the Guianas-Trinidad stock-level trends, the significant decline observed at Awala-Yalimapo—while mirrored elsewhere (e.g., Suriname; Tortuguero, Costa Rica; St. Kitts)—essentially drives the regional results, particularly in the long-term scenario. However, the recent regional trend was also significantly negative (Table 6; Fig. 5), which reflects declines across sites (Table 4) and stocks (Table 5).

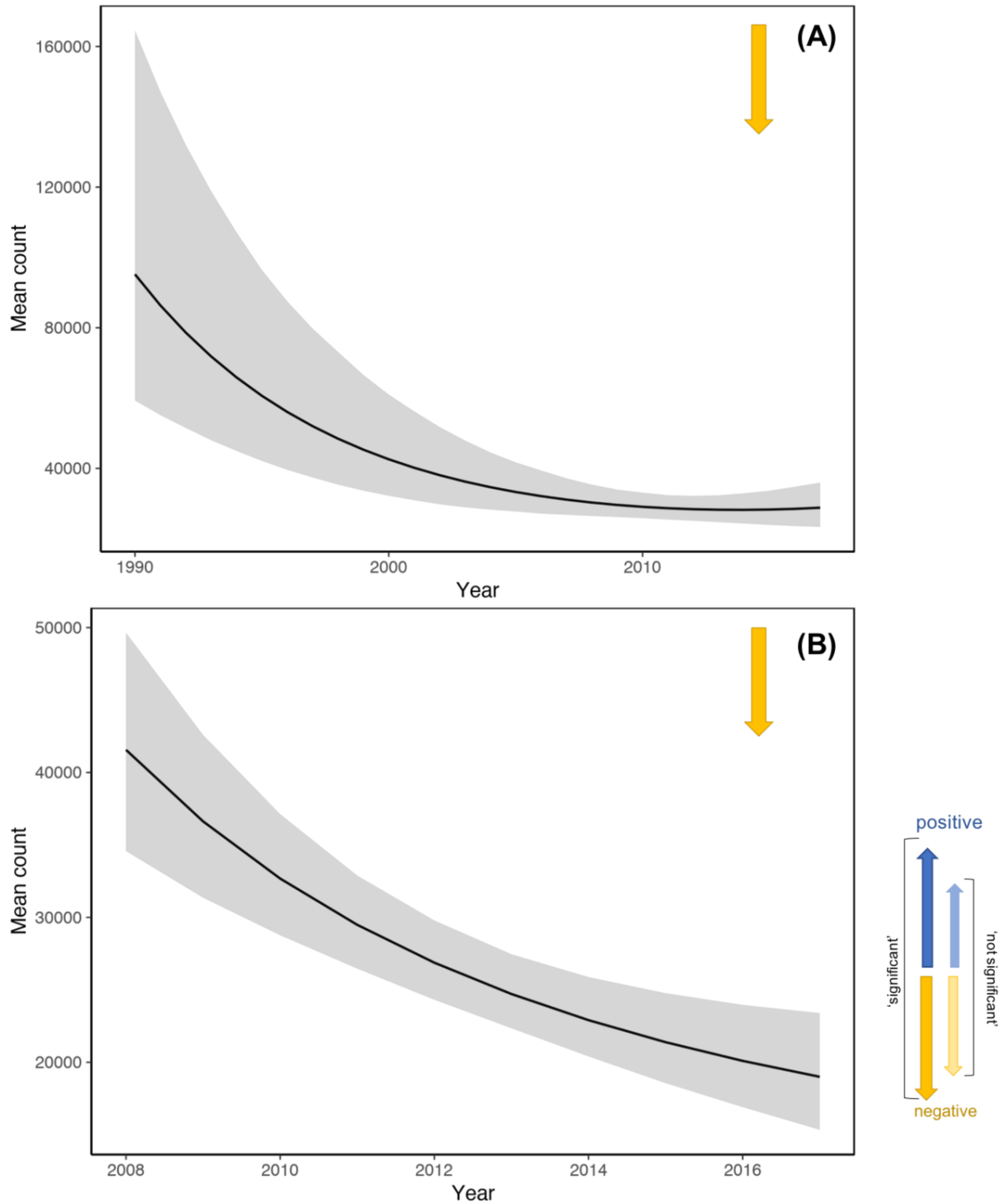

Figure 5. Regional-level trends (annual geometric mean change in nest counts) for (A) 1990-2017 and (B) 2008-2017 (results for intermediate scenario not shown). Line is geometric annual mean trend (weighted by relative site-level abundance) and shaded area is 95% Credible Intervals. Blue up arrows = positive trends, yellow down arrows = negative trends; large arrows = 'significant' trends; small arrows = 'non-significant' trends.

Table 6. Region-level trend in annual abundance (annual geometric mean percent changes [+/- 95% Credible Intervals]) in three different time period scenarios. Shading indicates positive (blue) or negative (yellow) trends, with darker colors indicating trends whose 95% CIs do not include zero (i.e., 'significant' trends) and lighter colors indicating trends whose 95% CIs include zero (i.e., 'not significant').

Regional Trend (n = # sites)	1990-present (n = 23)	1998-present (n = 22)	2008-present (n = 18)
REGIONAL	-4.21 (-6.66 - -2.23)	-5.37 (-8.09 - -2.61)	-9.32 (-12.9 - -5.57)

Potential drivers

Considering that earlier status assessments determined that the NWA leatherback sub-population was generally abundant and stable (TEWG 2007; Tiwari et al. 2013a), the working group discussed drivers of the updated trends in the context of what factors might have changed or have not been sufficiently addressed to cause a divergence between previous findings and the current analysis.

The working group identified anthropogenic sources, habitat losses, and changes in life history parameters as potential drivers for the observed declines in nesting abundance. It is likely that synergistic relationships exist among various drivers and types of drivers.

Anthropogenic impacts

Fisheries bycatch has been well-documented as a threat to leatherbacks on the high seas (Fossette et al. 2014; Stewart et al. 2016), in coastal foraging areas (Hamelin et al. 2017), and near key nesting beaches (Lee Lum 2006; Eckert 2013). Leatherback entanglements in vertical line fisheries (e.g., pot gear targeting crab, lobster, conch, fish) in continental shelf waters off New England, USA, and Nova Scotia, Canada, were discussed as potentially important mortality sinks that require continued monitoring and bycatch reduction efforts. Leatherback mortality due to vessel strike is also documented annually in coastal feeding habitats off New England, USA. Threats in coastal foraging areas off western Europe and western Africa (Houghton et al. 2006; Fossette et al. 2014) merit further attention, as well.

Off nesting beaches, particularly near Trinidad and the Guianas, net fisheries interact with leatherbacks and in high numbers (~3,000/yr; Lee Lum 2006; Eckert 2013). These high levels of leatherback bycatch near key nesting beaches during the nesting season is likely a primary driver of estimated declines in abundance. However, participants in the workshop noted that bycatch is poorly monitored and significantly underreported, and enforcement of existing regulations is weak or non-existent.

High-seas bycatch in longline gear throughout the North Atlantic and Gulf of Mexico was also discussed as an existing threat to leatherbacks (Fossette et al. 2014; Stewart et al. 2016), but review is necessary to determine whether this bycatch has increased in recent years. Effects of other threats such as hydrocarbon extraction and spills are unknown but deserve attention.

Habitat loss

One prevalent observation across multiple nesting sites regionally, particularly in the Guianas, was beach erosion that has significantly diminished available leatherback nesting habitat. For example, Awala-Yalimapo, the area in western French Guiana that has been monitored consistently since the 1990s (and inconsistently since the 1960s), undergoes dramatic fluctuations in beach length, width, and location within and across seasons. Participants from French Guiana described how Awala-Yalimapo has decreased from ~6 km in length to ~2 km in length just in the past ~5 years. Similarly, remote beaches eastward from Awala-Yalimapo have also eroded (Berzins and Paranthoen, pers comm.). Thus, leatherback nesting has declined ~99% at Awala-Yalimapo since the 1990s, but a portion of this decline appears related to loss of nesting habitat. However, while nesting increased over time at Cayenne in eastern French Guiana, this increase has not been in females shifting from west to east; Cayenne turtles are genetically distinct (Molfetti et al. 2013), and females tagged in Awala-Yalimapo are not seen in Cayenne (or vice versa). Similarly, French Guiana leatherbacks do not appear to be crossing the Maroni/Marowijne River that separates French Guiana from Suriname because leatherback nesting in eastern Suriname has also declined over long-term and recent periods; however, tagging of nesting females was discontinued in the mid-2000s in Suriname, which prevents confirmation of identities and origins of females nesting there. The working group supports renewed efforts to tag nesting females—and to share the tag recaptures—in these sites to improve understanding of leatherback beach exchange dynamics.

These examples illustrate that while leatherback nesting sites in the Wider Caribbean are often high-energy coastlines where sand erosion-transport-deposition processes are very dynamic, loss of leatherback nesting habitat—apparently without concomitant increases elsewhere—has contributed to some extent to the observed declines in annual nest abundance. Ideally, habitat availability (i.e., how much nesting habitat exists) could be included as a covariate in the trends models to better quantify variation in site-level trends that is due to habitat loss.

The working group recommended efforts regionwide to define patterns of beach loss and creation, which will clarify whether leatherback nesting is shifting with beach dynamics or whether there is truly a net loss of leatherback nesting habitat occurring in multiple areas in the region. Some sites already do this, as training in beach profiling and monitoring was provided to WIDECAST Country Coordinators at their 2010 Annual Meeting in Martinique as part of a larger focus on incorporating climate change into ongoing conservation work. In addition, several Eastern Caribbean islands participate in coastal monitoring through UNESCO's "Sandwatch" initiative which, within the framework of the UNESCO Small Island Developing States (SIDS) Action Plan, emphasizes observations and adaptation strategies relating to the impacts of climate change and natural disasters. Some insular datasets on beach loss go back several decades (e.g., Cambers 2009).

Given that these processes are highly dynamic and unpredictable, and do not, by themselves, result in mortality of nesting females, it is difficult to identify specific conservation actions at this time, aside from preventing or limiting coastal armoring and similar development practices that exacerbate beach habitat loss. Enhancements to beach monitoring programs to include PIT tagging of nesting females, and sharing of tag returns across nesting sites, would shed light on how shifts in available nesting habitat affects inter-beach nesting behaviors of leatherbacks.

Life history and demographic factors

The index of abundance in this assessment was the number of leatherback nests observed on individual nesting sites each year. This index poorly reflects overall dynamics of sea turtle populations because it integrates effects of mortality across life stages and environmental and physiological influences on reproduction (National Resource Council 2010). Inter-annual variation in sea turtle annual nest counts reflects non-annual breeding typical of sea turtle females, which itself is affected by environmentally-driven resource availability and individual-level physiological processes that determine whether a turtle will reproduce in a given year and the magnitude of her reproductive output (e.g., number of clutches, number of eggs per clutch) in a reproductive year. Thus, annual nest counts can vary over time for several reasons such as changes in: (a) female mortality rate (see above), (b) rate at which new females recruit to the breeding population, (c) probability that females will breed in a given year, (d) number of clutches a female lays in a given year, and/or (e) the distribution of reproductive effort across different nesting sites (Kendall et al. 2018). In addition to these biological factors, the number of nest counts documented at monitored sites can also vary if nesting shifts away from the places and/or times being monitored. For example, if nesting distributions shift in latitude in response to warming beach temperatures, or if nesting phenology shifts to periods outside of when monitoring effort occurs on nesting beaches, resulting nest counts will be affected.

In this context, the working group discussed possible increases in remigration intervals (already documented in St. Kitts: Kimberly Stewart, unpubl. data) and/or decreased clutch frequency as cryptic causes of decreased nest abundance. Changes in remigration intervals and clutch frequency could indicate fluctuations in oceanographic conditions that drive prey availability and distribution (e.g., Doney 2014). In addition, participants discussed possible extreme female biases in sex ratio and decreased hatching success caused by increased nest temperatures. Participants discussed a dedicated analysis of existing data on these demographic parameters and capture-recapture histories across sites in the context of key environmental parameters to test these hypotheses.

The working group discussed the possibility that sea turtle population abundance—or an index of abundance—can fluctuate over time, potentially on longer, multi-decadal timescales than is typically monitored by conservation groups or resource managers. In this context, the group discussed the NWA loggerhead population, which declined over a decade through the late 2000s, invoking significant concern in the conservation community (Witherington et al. 2009). However, in subsequent years, loggerhead nesting increased, and has maintained this trajectory since (FWC/FWRI Core Index Nesting Beach Survey Program Database as of 21 October 2017). This case study provides a cautionary tale about understanding sea turtle population dynamics in order to calibrate conservation response to apparent declines in NWA leatherbacks.

Assessment using Red List criteria

Based on our updated datasets that restricted annual count data to those collected with consistent methodology within-sites, evaluation of Red List Criterion A resulted in an approximate 60% decline between past and present estimates of leatherback nest abundance (Table 7). This result corresponds to a Red List threatened category of Endangered (IUCN 2014). Although derived using a very simplistic method to calculate overall change, the Red List results were generally similar in direction and magnitude to the mean trend estimates for site- and regional-levels (Tables 4, 6, 7).

Calculating overall trends between past estimates and 2010—the same year through which the official Red List assessment evaluated leatherback data—results in a 52% decline (Table 7). Thus, our updated datasets that adhere to more stringent standards of monitoring consistency significantly influenced the divergence in results from the current, official Red List assessment.

As in the trend analyses described above, the subpopulation-level Red List trend is mostly driven by the trend estimated for the stock with the highest relative abundance: Guianas-Trinidad (Table 7). The ~99% decline in Awala-Yalimapo, French Guiana, within the most recent leatherback generation from an average of more than 28,000 nests/yr between 1986-1990 to fewer than 600/yr between 2013-2017 accounted for this decline. Likewise, the divergence between the Red List assessment results through 2010 and our results through 2010 can be attributed largely to French Guiana (88% decline through 2010) (Table 7). For example, the Red List assessment used historical data from the late 1960s through the 1970s. However, these data, while accepted by IUCN as appropriately following Red List guidelines, were collected inconsistently across years. Data were collected using essentially consistent methods starting in 1986. In addition, the Red List assessment used estimates of total nest counts per year based on a statistical correction accounting for incomplete (<100%) monitoring coverage (Girondot et al. 2006; TEWG 2007), and the assessment had to use estimated nest counts between 2006-2010 because the raw data could not be modeled using the same approach. However, in the present exercise we used observed counts, as long as the counts could be attributed to a consistent monitoring methodology and coverage level over time. These changes in approach compared to the 2013 Red List assessment caused significant divergence (and improved accuracy) in results. We intend to submit a draft Red List assessment for official review by the IUCN Marine Turtle Specialist Group as an official update of the current assessment (Tiwari et al. 2013a).

Table 7. Summary of our unofficial Red List assessment using datasets analyzed to determine trends (methods described above). Only datasets of at least 10 yr were used in the below assessment; changes between past and present annual nest abundance were not calculated for datasets with fewer than 10 yr. Results shown through 2010 and through 2017 to compare with results of the current, official Red List assessment for NWA leatherbacks, which used data through 2010 (Tiwari et al. 2013a). 'Change through 2010' and 'Change through 2017' are annual mean percent changes; multiply values shown by 100 to calculate percentage values.

Stock	Site	Years	Change thru 2010	Change thru 2017
Guianas-Trinidad	Suriname: Galibi, Matapica	1999-2017	-0.54	-0.74
	French Guiana: Awala Yalimapo	1986-2017	-0.81	-0.99
	French Guiana: Cayenne	1999-2017	3.42	1.87
	Guyana	1989-2017	4.54	0.32
	Trinidad: Matura	2006-2017	--	-0.23
	Grenada: Levera	2003-2017	--	1.50
	Venezuela: Cipara	2000-2015	0.39	-0.37
	Venezuela: Querepare	2002-2017	--	0.72
	Guianas-Trinidad TOTAL		**-0.58**	**-0.69**
Western Caribbean	Costa Rica: Tortuguero	1995-2017	-0.72	-0.87
	Costa Rica: Gandoca	1990-2012	1.20	-0.20
	Costa Rica: Pacuare	2004-2017	--	-0.39
	Costa Rica: Estacion La Tortuga	2002-2017	--	0.03
	Costa Rica: Mondonguillo	1991-2017	0.53	0.06
	Costa Rica: Cahuita	2000-2012	-0.31	-0.17
	Panamá: Chiriqui	2004-2017	--	0.13
	W. Caribbean TOTAL		**0.02**	**-0.09**
Northern Caribbean	USVI: Sandy Point, St. Croix	1982-2017	3.80	1.13
	Puerto Rico: Culebra	1984-2017	0.15	-0.60
	Puerto Rico: Luquillo-Fajardo	1996-2017	1.15	0.93
	Puerto Rico: Maunabo	1999-2017	0.24	1.75
	St. Kitts & Nevis	2003-2017	--	-0.83
	Guadeloupe	2005-2017	--	0.75
	British Virgin Islands: Tortola	1990-2017	4.86	2.00
	N. Caribbean TOTAL		**1.49**	**0.30**
Florida	**Florida TOTAL**	1989-2017	**7.63**	**7.12**
	REGIONAL TOTAL		**-0.52**	**-0.60**
	Corresponding Red List Category			**Endangered**

5. Conclusions and Recommendations

Although the majority of site-level trends were positive in the long-term, over the past decade, nearly all site-level trends were negative. Further, long-term and short-term trends in regional NWA leatherback annual nest abundance were negative. These patterns, while highlighting the importance of timeframe when evaluating abundance trends, indicate statistically measurable regional-scale declines in leatherback nest abundance over time, particularly in the past decade.

As described above, there are several potential drivers for these trends, including mortality caused by anthropogenic threats, changes in nesting habitat availability, and changes in reproductive output that affect the annual nest counts used as our index of abundance. To address these drivers and provide guidance, we identified priority conservation actions and collaborative data analyses.

Characterize and reduce anthropogenic threats

- Compile and compare bycatch data across gear types, regionally, to identify highest priority opportunities for bycatch reduction from a population impact perspective
- Enhance efforts to mitigate leatherback bycatch in fishing gear deployed offshore key nesting grounds (e.g., Guianas, Trinidad)
    - Enhance enforcement of existing regulations to reduce turtle bycatch, particularly in areas near nesting beaches
    - Increase patrols in closed areas, develop and implement other protected areas, especially important at key nesting grounds (e.g., Guianas, Trinidad)
    - Leverage resolutions and reporting requirements regarding leatherback bycatch through the Inter-American Convention on the Protection and Conservation of Sea Turtles (IAC)
- Enhance monitoring of fisheries activities, specifically observations and standardized reporting of turtle bycatch
    - Advocate for deployment of trained onboard observers when and where such programs could contribute valuable data on the number, distribution, and seasonality related to fishery interactions with leatherbacks
- Enhance efforts to mitigate leatherback bycatch in fixed fishing gear in continental shelf habitats, especially in foraging areas, migratory pathways, and offshore nesting beaches
    - Characterize distribution and density of fixed gear and turtles in shelf waters using aerial surveys and other methods
    - Ensure continued work to monitor leatherback foraging populations and fisheries interactions in New England and Nova Scotia
    - Use well-established programs to model new efforts offshore the Guianas
    - Explore opportunities to leverage efforts to reduce interactions between right whales and vertical lines that could also benefit leatherbacks in northern foraging areas

- Begin work to monitor fisheries interactions between leatherback migrating populations and tuna longline fisheries occurring off of the Guianas
    - Leverage entities like the International Commission for the Conservation of Atlantic Tunas (ICCAT) to encourage members operating in the Guianas to report leatherback bycatch
- Ensure continued work to eliminate illegal, unreported and unregulated fishing (IUU) (e.g., for French Guiana see IFREMER 2012)
    - Explore opportunities to leverage existing regulations, such as the European Union's IUU regulations, to promote monitoring and prevention of IUU fisheries
- Increase protection and monitoring on nesting beaches to protect more nests from egg harvest and to increase coverage and tagging of nesting females (e.g., Costa Rica, Panamá)
- Investigate potential magnitude and types of effects from fossil fuel exploration and extraction, as well as from oil spills
- Investigate potential magnitude and types of effects from ocean plastic and other toxic debris, as well as aberrant coastal infestations of (typically pelagic) *Sargassum* weed

Characterize and reduce habitat loss

- Characterize response by leatherbacks to beach erosion; i.e., if we confirm they are not nesting elsewhere, where do they go? What was their fate?
- Engage resource managers to account for turtle nesting habitat viability when approving efforts to mine sand, fortify coastlines (e.g., beach armoring), and other coastal development activities
- Advocate for retaining/enhancing resilience in coastal ecosystems, particularly as it relates to residential and tourism infrastructure development in an era of climate change and sea level rise

Investigate patterns in life history and demographic parameters

- Prioritize collaborative data collection and analysis of existing data
    - Design and execute analysis of capture-recapture data analysis to determine regional patterns in remigration intervals, clutch frequency, and survivorship
        - Tagging data exist but data from high volume nesting sites are generally maintained by site-level organizations – while data from smaller nesting sites (<100 gravid females/yr) tend to be archived with WIDECAST's Regional Marine Turtle Tagging Centre (University of the West Indies-Cave Hill, Barbados), so there is a need to promote broader sharing of tag return data and enhanced tagging across nesting sites (cf. Meylan 1999; Horrocks et al. 2011, 2016)
    - Design and execute analysis to determine patterns and drivers of hatchling production across the region
        - Hatching success data exist for many sites, can be analyzed across months within nesting seasons and across years, in relation to handling and treatment of nests, temperature and other effects
        - Make collection of *in situ* temperatures more widespread

- Design and execute analysis of existing satellite tracking data to identify spatial and/or temporal shifts in post-nesting or foraging destination behavior

6. Acknowledgements

A regional assessment of this scope could not have been accomplished without the support and active participation of the Wider Caribbean Region's sea turtle research and conservation agencies and organizations. In particular, we are deeply grateful to the numerous volunteers and biologists who have contributed to the monitoring and data collection efforts across the Wider Caribbean region on which this project depended entirely. We thank the National Fish and Wildlife Foundation (NFWF), with funding provided by SeaWorld Parks and Entertainment Inc., for making for making it possible for the Working Group to convene and to collect, analyze, and report on our findings. We are especially grateful to Michelle Pico (NFWF) and Kristen Byler (NFWF) for facilitating the final Review and Validation Workshop. Finally, we acknowledge Bill Kendall (Colorado State University) and Scott Eckert (Principia College) for discussions about the methods and for reviewing a previous draft of this report; their insights were very beneficial.

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8. Appendices

A. Data Sharing Agreement

16 April 2018

Dear Colleague:

As you know, we are currently conducting a status assessment for the Northwest Atlantic subpopulation of the leatherback turtle (*Dermochelys coriacea*). The purpose of this exercise – supported by the National Fish and Wildlife Foundation – is to estimate long-term trends for stocks and the overall subpopulation that will inform conservation planning and status review initiatives currently underway in the region. This exercise will also be extremely useful for highlighting regional conservation priorities to safeguard the Northwest Atlantic leatherback population.

In order to ensure that this assessment accurately depicts the actual status of leatherbacks at local and regional scales, the best, most up-to-date information must be included. **To facilitate this regional analysis, we kindly request the following types of information:**

- annual counts of abundance (e.g., numbers of crawls, nests, or nesting females) for each year for which data are available from your site(s);
- available information about:
  - nesting success [% of successful nesting attempts]
  - clutch frequency [number of clutches per female per year]
  - remigration intervals [number of years between consecutive nesting seasons per female];
- information about monitoring effort such as length of beach monitored, monitoring error, person hours, % of coverage, etc.

Your data will be analyzed and presented with data from other colleagues throughout the Wider Caribbean in a summarized format during an in-person workshop in May/June 2018, and possibly in a written report summarizing all results. Each dataholder will be properly credited in any figures or reports that emerge from this process. **Please provide the desired format of data credit to be associated with your data contribution.**

DATA DISCLAIMER: *Your raw data will only be used for the purposes of conducting the status assessment for the Northwest Atlantic leatherback turtle subpopulation. Your raw data will only be accessible to Dr. Bryan Wallace and colleagues at Conservation Science Partners (CSP) for the purposes of this analysis only, and will not be disseminated, displayed, or otherwise made available without the expressed consent of you, the dataholder. Further, inclusion of your data in the assessment in NO way infringes upon or jeopardizes your ability to publish your data in other formats or in future publications. By sharing your data, you agree to allow Dr. Wallace and CSP to perform analyses of abundance and trends (in consultation with you), and to present these results in the aforementioned workshop and report, with proper attribution.*

Please let us know if you have any questions or concerns. Thank you very much for contributing to this process; your information and efforts are very valuable.

Sincerely yours,

Bryan Wallace, PhD | Conservation Science Partners | bryan@csp-inc.org

B. Participant Agenda: Review and Validation Workshop

Agenda for NWA Leatherback Status Review
May 29-31, 2018
Hyatt Place Dania Beach, Florida

Objectives

1) Review and discuss current status and trends of Northwest Atlantic leatherbacks
2) Discuss and draft recommendations to guide conservation actions

Arrive May 29th

6:00PM *Meet in lobby for NFWF hosted dinner*

Day 1 - May 30th

Goal: Share results from nesting programs and seek to validate population trends and status

8:00 am *Breakfast on your own – free at the hotel*

8:45 am Transfer any slides for the day and start Goto (for remote participation)

9:00 am Welcome, Introductions and Agenda Walkthrough

9:15 am NFWF interests in today's meeting/context

9:30 am Update on FWS efforts regarding this population

9:45am: Overview of stock structure of NWA leatherbacks

10:00 am Nesting Beach Updates by stocks/geography

Short overviews (10 min) of methods/effort, results and trends from monitoring efforts to provide context for discussion of trend analysis.

1) Florida
2) Northern Caribbean (St. Croix, USVI; Puerto Rico)
3) Western Caribbean (Costa Rica, Panamá, Colombia)
4) Guianas/Trinidad (Grenada, Guyana/Suriname, French Guiana, Trinidad)
5) Non-nesting updates (Northern foraging areas: New England, USA; Nova Scotia, Canada)

12:30 pm *Lunch (provided)*

1:30pm **Facilitated discussion:** Data Compilation, Analysis, Results to Date

3:00pm *Break*

3:15pm **Facilitated discussion:** Results of the Analysis

4:30pm Discuss plans for this evening and tomorrow

5:00pm Adjourn

6:30pm *Meet in Hotel Lobby for NFWF Hosted dinner*

Day 2 - May 31st

Goal: Outline next steps to address data and capacity gaps and mitigation measures to ensure long-term population viability.

8:00am *Breakfast on your own in the hotel lobby*

8:45 am Transfer any slides for the day and start Goto

9:00am Welcome and framing goals for the day, review key findings from Day 1

9:30am **Facilitated discussion:** Identify Threats/Hazards

12:30pm *Lunch (provided)*

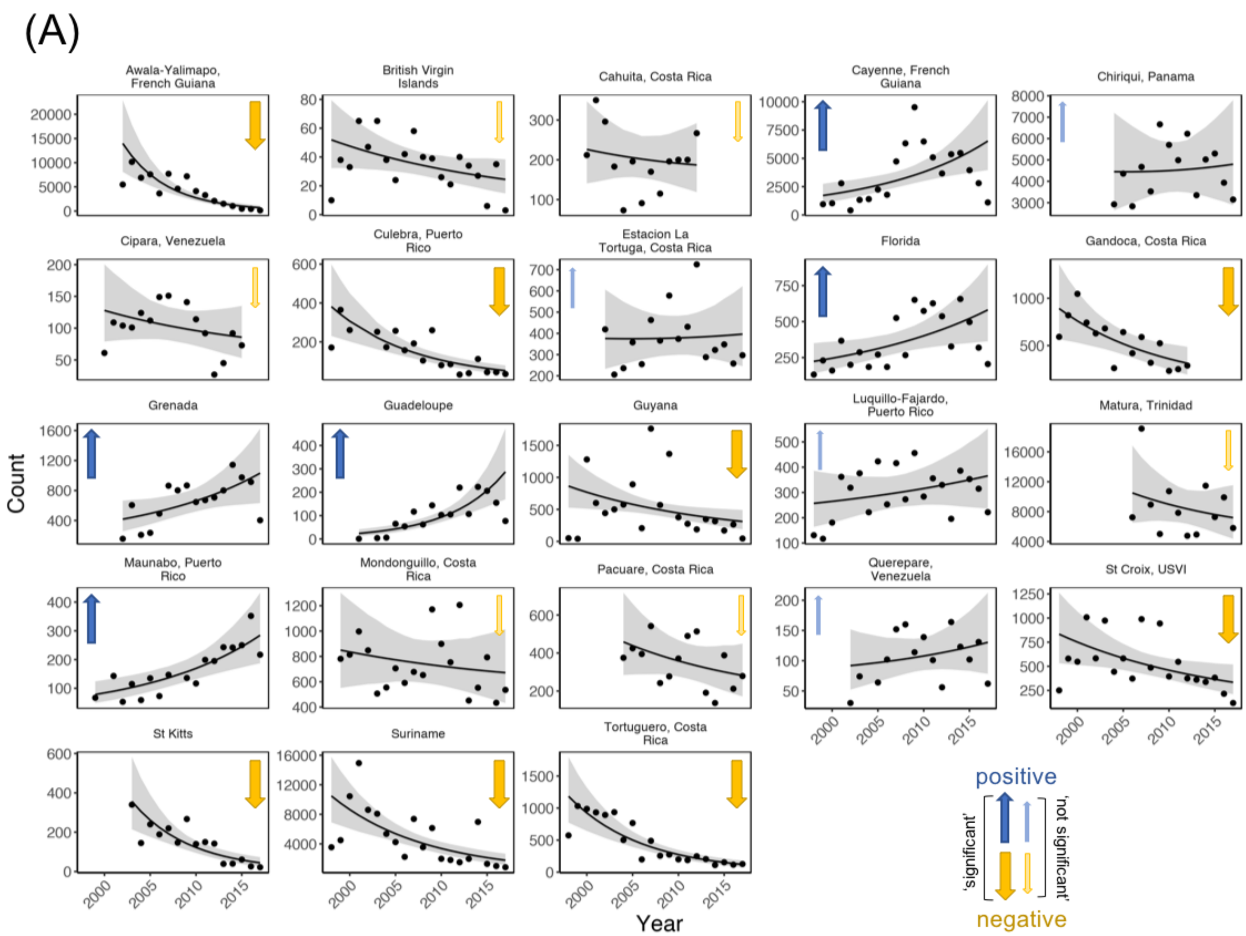
1:00pm **Facilitated discussion**: Prioritize Mitigation Measures

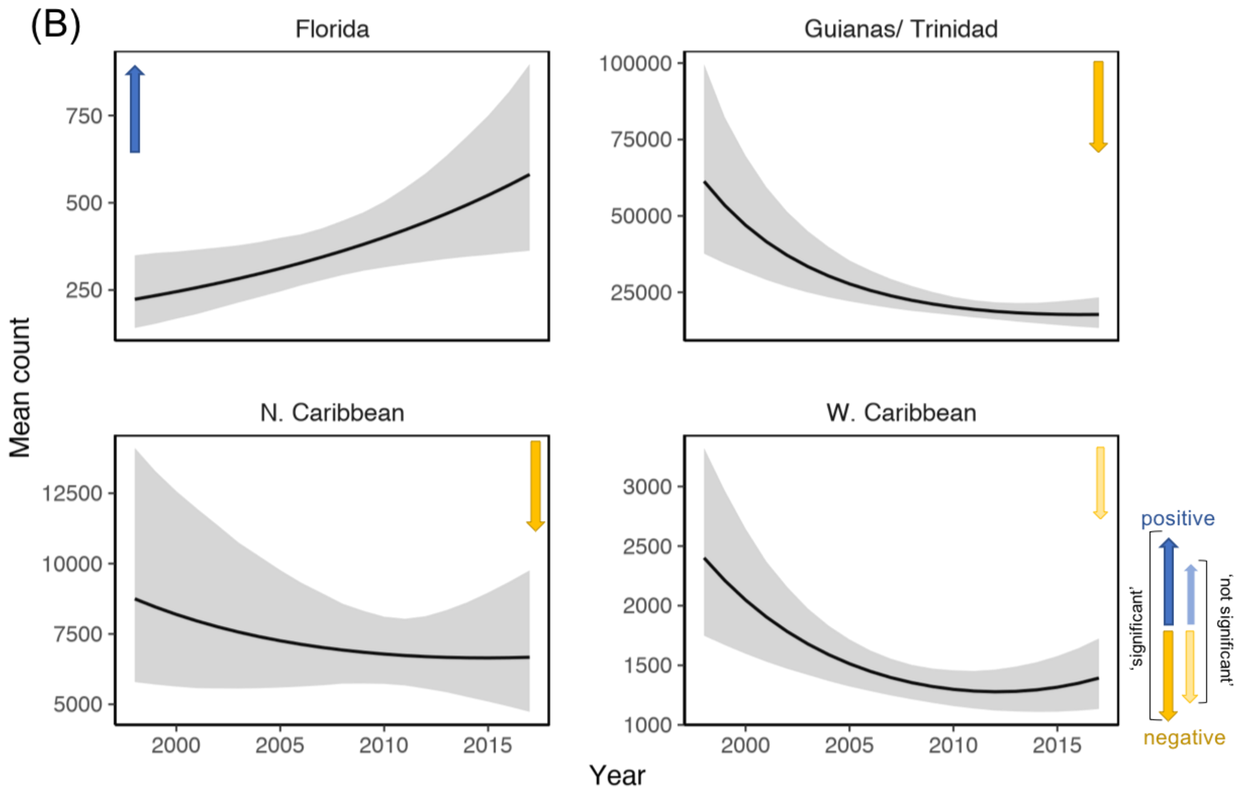
3:30pm Wrap up of outcomes and action steps

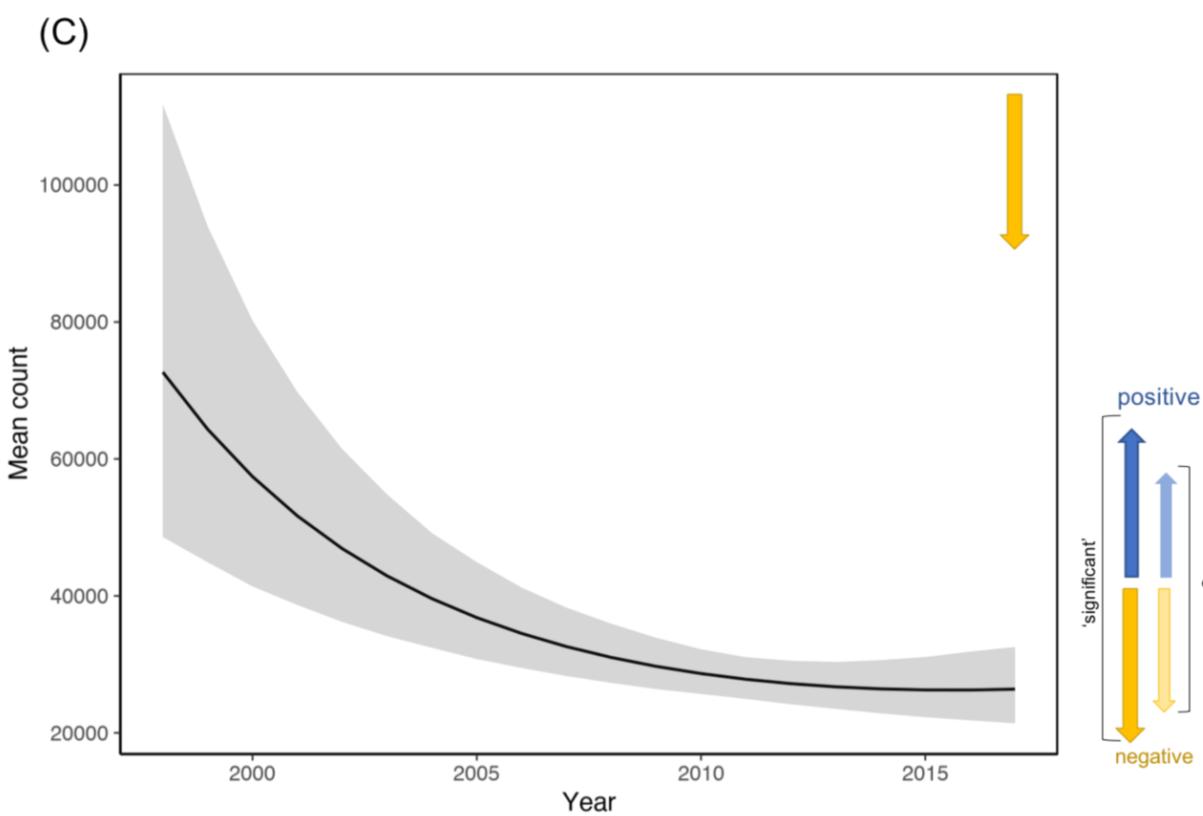
4:00pm Adjourn

C. Results of Intermediate Temporal Scenario (1998-2017)

Site-level (A), stock-level (B), and regional-level (C) trends (annual geometric mean percent change in nest counts) for 1998-2017. Lines in (B) and (C) is geometric annual mean trend (weighted by relative site-level abundance) and shaded area is 95% credible intervals. Blue up arrows = positive trends, yellow down arrows = negative trends; large arrows = 'significant' trends; small arrows = 'non-significant' trends.




(B)
Florida
Guianas/ Trinidad
N. Caribbean
W. Caribbean
Mean count
Year
positive
negative
'significant'
'not significant'


(C)
Mean count
Year
positive
negative
'significant'
'not significant'