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Editorial: Advances in Understanding Sea Turtle Use of the Gulf of Mexico

Donna J. Shaver[1*†], *Kristen M. Hart*[2†] *and Margaret M. Lamont*[3†]

[1] Division of Sea Turtle Science and Recovery, Padre Island National Seashore, National Park Service, Corpus Christi, TX, United States, [2] Wetland and Aquatic Research Center, U.S. Geological Survey, Davie, FL, United States, [3] Wetland and Aquatic Research Center, U.S. Geological Survey, Gainesville, FL, United States

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Editorial on the Research Topic

Advances in Understanding Sea Turtle Use of the Gulf of Mexico

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Mark Meekan,
Australian Institute of Marine Science (AIMS), Australia

***Correspondence:**
Donna J. Shaver
donna_shaver@nps.gov

†ORCID:
Donna J. Shaver
orcid.org/0000-0003-1379-8974
Kristen M. Hart
orcid.org/0000-0002-5257-7974
Margaret M. Lamont
orcid.org/0000-0001-7520-6669

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Six threatened and endangered sea turtle species use the Gulf of Mexico: Kemp's ridley (*Lepidochelys kempii*), green (*Chelonia mydas*), loggerhead (*Caretta caretta*), hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*), and olive ridley (*Lepidochelys olivacea*; Shaver, 1994; Valverde and Holzwart, 2017; USFWS, 2019; Frandsen et al., 2021). For this Research Topic, our goal was to increase knowledge of sea turtles residing in, or migrating through, the Gulf of Mexico. Though multiple threats to sea turtles exist in the Gulf of Mexico, less is known in this ocean basin in comparison to other locations. Further, most literature on sea turtles in the Gulf of Mexico has focused on the northern rather than the western and southern Gulf of Mexico (Valverde and Holzwart, 2017). In this Research Topic, contributing authors fill knowledge gaps on the behavior, ecology, habitat use, and population demographics of sea turtles in the Gulf of Mexico, and the resulting 16 papers significantly contribute to four subtopics:

1. Movements and habitat use.
2. Foraging ecology and food webs.
3. Growth, genetic stock, and population trends.
4. Conservation and management.

MOVEMENTS AND HABITAT USE

Sea turtles travel long distances using magnetic, solar, and local cues (Southwood and Avens, 2010). Satellite and GPS tags have enabled researchers to monitor migrations from nesting to foraging grounds and identify inter-nesting habitats (Block et al., 2011; Shaver et al., 2013; Shaver et al., 2016; Shaver et al., 2017a). Research has been weighted towards females from nesting beaches, and knowledge gaps exist regarding male turtle reproductive behavior, habitat use, movements, and demographic parameters due to challenges in accessing individuals in neritic and oceanic environments (Hatase et al., 2002; Plotkin, 2003; Hamann et al., 2010; Schofield et al., 2017). Contributing researchers answered lingering questions on male and female movements in the Gulf of Mexico.

Hart et al. showed that Florida's Big Bend region, a neritic northern Gulf of Mexico marine hotspot, provides year-round foraging habitat for migrating post-nesting loggerhead turtles. Thus, nearshore habitats in the northern Gulf of Mexico should be considered when discussing critical habitat designations for sea turtles in the southeastern USA. Lamont and Johnson compared multi-species aggregations in neritic northern Gulf of Mexico habitats, documenting loggerhead, and larger, turtles in coastal bay seagrass meadows, and green, and smaller, turtles in nearshore sand-bottom habitats thought to be more optimal for immature Kemp's ridley and loggerhead than green turtles. Siegfried et al. used non-invasive, stereo-video camera surveys to capture *in situ* data on species and size composition at nearshore northern Gulf of Mexico artificial habitats including reefs, jetties, and piers. From those data, they showed that species and habitat were the best predictors of size distribution.

Iverson et al. discovered high-use migration corridors for loggerhead turtles in the Gulf of Mexico: one in the eastern Gulf of Mexico and one through the Florida Straits to the Bahamas. Migration paths overlapped with anthropogenic threats including commercial line fishing (high threat), shrimp trawling (persistent threat), and shipping density (most problematic for migrating loggerhead turtles). Sloan et al. documented high-use green turtle inter-nesting and foraging areas in the Gulf of Mexico, Marquesas Keys, Florida Bay, and near the Everglades, for females tracked from nesting beaches in Florida. Sasso et al. identified the northern Gulf of Mexico as a high-use foraging area for adult leatherback turtles, and showed that the Yucatan Channel is an important migration route for Caribbean nesting leatherback turtles.

Gredzens and Shaver found most post-nesting Kemp's ridley turtles migrated to northern Gulf of Mexico foraging grounds and showed high fidelity to these areas and the migratory corridors used to travel there. This work reinforced earlier findings of Shaver et al. (2013) and showed that threats in the northern Gulf of Mexico may have a disproportionate impact on the adult population. Finally, Cuevas et al. provided a new analysis of male sea turtle satellite tracks in the southern Gulf of Mexico. Male sea turtles in that region largely resided in neritic habitats near mating areas, conducted very short migrations, and were found with post-nesting females.

FORAGING ECOLOGY

Multiple factors affect sea turtle foraging and prey availability in the Gulf of Mexico, including climate change (Sanchez-Rubio et al., 2011), hurricanes (Engle et al., 2009), fisheries (Robinson et al., 2015), hypoxic zones (Craig et al., 2001), oil spills (Wallace et al., 2017), and red tides (Dupont et al., 2010). Diet composition across species, life stages, and breeding populations differs due to geographic disparity of resources and may lead to somatic growth rate variation among these subsets (Bjorndal et al., 2003; Piovano et al., 2011). Conventional gut contents analyses are used to investigate temporal, seasonal, and ontogenetic diet trends, and improve nutrition interpretation (Parker et al., 2005; Hatase et al., 2006; Revelles et al., 2007; Casale et al., 2008; Hoarau et al., 2014; Behera et al., 2015). Contributors to this topic used novel methods and/or long-term datasets to better understand sea turtle trophic ecology in the Gulf of Mexico.

Pairing skeletal and isotopic analyses, Ramirez et al. reported strong regional variation in Kemp's ridley diet composition estimates in the Gulf of Mexico and Atlantic. Though limited by data gaps, Ramirez et al. provided a quantitative assessment of the connection between trophic ecology and somatic growth, presenting a new method for investigating drivers of somatic growth variation. Howell and Shaver presented a comprehensive assessment of green turtle trophic ecology in the western Gulf of Mexico, showing they exhibited foraging plasticity and that diet and habitat shifted between size classes.

POPULATION TRENDS

Contributing researchers provided insights on the status of several species across multiple life stages in the Gulf of Mexico. Sea turtle populations in the Gulf of Mexico have fluctuated in response to environmental and anthropogenic influences. The green turtle, once abundant in the Gulf of Mexico, was commercially exploited and overharvested in Texas in the mid-1800s, leading to population decline and sparse nesting along the western Gulf of Mexico (Hildebrand, 1981; Doughty, 1984; Shaver, 1989; Witzell, 1994a; Witzell, 1994b). Recent increases in stranding, including cold stunning, and nesting of green turtles indicate species recovery along the Gulf of Mexico (Shaver et al., 2017b). The Kemp's ridley, nearly decimated in the late 1900s, survived due to bi-national collaboration between Mexico and USA and intensive conservation strategies (Marquez et al., 2005; Bevan et al., 2016). Since 2010, exponential population growth abruptly ceased, and has since fluctuated, indicating that intensive management is still required to recover the population (NMFS, 2015; Caillouet et al., 2018).

Experimental at-sea work by Cook et al. advanced our understanding of sea turtle stranding patterns in the Gulf of Mexico. They used wooden effigy drifters and sea turtle cadavers to investigate seasonal stranding variations in the northern Gulf of Mexico. Season and distance from shore were the two greatest influences of if, and where, objects beached and the likelihood of carcass scavenging. Public reporting underestimated the actual frequency of strandings on mainland beaches based on tracked experimental carcasses.

Shaver et al. highlighted the importance of federally protected lands as green turtle nesting habitat in the western Gulf of Mexico and showed that nesting in Texas has increased since 2010, but at a lower rate than at other Gulf of Mexico beaches. Continued research, monitoring, and protection of females and nests could aid recovery efforts and help determine whether those turtles should be considered an independent management unit separate from the nesting stock in Mexico. DuBois et al. used an ocean circulation model to explore whether hurricane events could explain differences in transport distance among young-of-the-year Kemp's ridley cohorts dispersing from primary nesting

areas in the western Gulf of Mexico. Shorter dispersal distances and less variance within the first months of dispersal corresponded with high hurricane activity, indicating that hurricane frequency and intensity may influence survivorship and growth rates of the Kemp's ridley.

CONSERVATION AND MANAGEMENT

Multiple threats to sea turtles exist in the Gulf of Mexico including artificial light pollution, marine debris entanglement, incidental bycatch, habitat destruction, predation, and vessel strike (Cannon et al., 1994; Rudloe and Rudloe, 2005; Witherington et al., 2014; Purvin et al., 2020; Shaver et al., 2020a; Shaver et al., 2020b; Shaver et al., 2020c; Shaver et al., 2021; Stacy et al., 2021). Contributing authors highlighted the effect of these persistent anthropogenic and environmental threats on sea turtle abundance in the Gulf of Mexico. Kemp's ridley and loggerhead foraging grounds overlap with eight spatially explicit anthropogenic threats Hart et al. Climate change, leading to increased storm frequency and severity, threatens resiliency of multiple sea turtle species (Goldenberg et al., 2001; Knutson et al., 2010).

Cook et al. developed a survey to investigate fishing practices and sea turtle interactions at northern Gulf of Mexico piers. The resulting increase in reported incidental captures indicated that outreach was an effective means to increase public awareness and reporting. Cook et al. recommended those efforts be focused on areas where anglers are likely to interact with sea turtles. Stanley et al. assessed the impact of light pollution on loggerhead nest building and hatchling orientation along the northern Gulf of Mexico. Stanley et al. found that artificial light was partially responsible for the high frequency of hatchling misorientation and that lunar fraction and altitude had strong moderating influences on hatchling misorientation rates. Further, they found nest relocation was an effective management tool to improve hatching success and reduce misorientation.

Using lidar data, generalized linear models, and random forest models, Culver et al. determined that the presence of Kemp's ridley nests in the western Gulf of Mexico were influenced primarily by average beach slope, distance from shoreline, elevation, and maximum dune slope. Those findings indicate that females avoided nesting in areas with extreme beach characteristic values. The hotspot of Kemp's ridley nesting in Texas occurs along the central section of North Padre Island, in narrow beach areas prone to sea level rise and tidal inundation.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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