LOGGERHEAD SEA TURTLE DIVING BEHAVIOR

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By:

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INTRODUCTION

Virginia's estuarine and coastal waters are subject to a large range of temperature regimes over the course of four seasons. Temperatures in winter drop as low as 1 º C, while summer Bay temperatures may reach 30º C. Sea turtles are resident in Virginia waters between May and November (Lutcavage 1981, Musick et al. 1985), with a few strandings occurring as early as mid-April or as late as December. Analysis of sea surface temperatures during residency seasons indicate that turtles first migrate into Virginia's waters when sea temperatures warm to approximately 18º C (Bellmund et al. 1987; Byles 1988; Keinath et al. 1987; Musick 1988; Keinath 1993; Coles 1999). When sea surface temperatures drop below 20º to 15º C in the fall, turtles will begin their southern migration out of the Bay and coastal waters, over-wintering in waters ranging from North Carolina south to Georgia, Florida and the Gulf of Mexico (Keinath 1993). Prolonged exposure to temperatures lower than 8° to 10° C may result in cold stunning, or a disruption in the turtle's metabolic pathways, resulting in loss of buoyancy and inability to dive or swim (Spotila et al. 1997). Thus, sea turtles are not physiologically capable of utilizing Virginia's waters as over-wintering habitat.

Work conducted by VIMS in the 1980's suggests that environmental temperatures affect sea turtles differently during the spring migration versus the fall migration. Byles (1988) concluded that yearly migrations into the Chesapeake Bay are strongly associated with vernal warming and that the greatest concentrations of sea turtles are found south of the 18º isotherm. Byles suggested that the fall southerly migration starts with the onset of winter storms, rather than declining sea temperature. Coles (1999; Coles and Musick 2000) analyzed VIMS' aerial data for the North Carolina and Virginia coasts, plotting sea turtle locations against AVHRR satellite imagery of sea surface temperatures. Loggerheads were found within temperatures ranging between 13.3º C and 28.0º C with most turtles found in sea surface temperatures below 29.0º C. This suggests that sea turtles are not randomly distributed, but may be limited by sea surface temperatures (Coles and Musick 2000).

Telemetry research conducted by Mansfield (2006) and funded by the Army Corps of Engineers (ACOE) suggests that loggerheads and Kemp's ridleys exhibit significant fidelity to Bay and coastal waters south to Cape Hatteras. Several individuals established winter habitat south of Cape Hatteras, adjacent to the outer continental shelf and Gulf Stream. Fall migrations commenced when surface temperatures dropped below 20°C. Some turtles migrated south to Georgia, Florida and the Gulf of Mexico. Two turtles were transported by the Gulf Stream to the north Atlantic and the Grand Banks, indicating some plasticity in habitat use (Mansfield 2006).

Aerial surveys were conducted from 1982-1985, 1991-1992 and 2001-2004 to determine minimum densities of Chesapeake Bay juveniles using strip transect analyses. These estimates were adjusted to reflect the turtles' respiratory behavior since sea turtles are only visible to aerial observers within the top meter of water column in the Chesapeake Bay. Therefore, turtles counted at the surface represent only a fraction of the overall population. A correction factor was used to account for turtles that cannot be seen below the observable surface. This correction factor was determined based on the percentage of time turtles spend at the surface versus time they spend below the surface,

resulting in a ratio that estimates for every one turtle observed at the surface, there are 'x' number of turtles swimming below the surface.

Using radio telemetry, Byles (1988) determined that loggerhead sea turtles spend approximately 5.3% of their time at the surface while foraging in the Bay during summer months—or for every one turtle observed at the surface, there are approximately 18-19 turtles below the surface. Aerial surveys conducted in the 1980's and early 1990's indicate that maximum population estimates adjusted for surfacing behavior or sea turtle 'sightability', range between 6,500-9,700 turtles for Virginia waters within any given season (Byles 1988; Musick et al. 1985). These estimates were based on the number of aerially observed sea turtles extrapolated to account for the entire Chesapeake Bay. Only those turtles observed within the three-meter depth contour were used and estimates were adjusted to reflect surfacing times and diving behavior (Byles 1988; Keinath 1993). Importantly, the highest turtle densities were observed during the spring of the year (May-June), implying that the greatest numbers of sea turtles visit Virginia waters during springtime (Byles 1988). However, the correction factor used to account for turtles below the observable surface was based on summer and fall foraging behavior. No data were collected for respiratory behavior during the spring when turtles are first migrating into the bay and aerially observed sea turtle densities are highest.

Using radio/acoustic telemetry during 2002-2004, seasonal differences in sea turtle respiratory behavior were determined among Kemp's ridleys and loggerheads (Mansfield 2006). Mean time spent at surface in the spring ranged between 9.9%-30.0% with significant differences among individuals and species. Turtles with higher surfacing times were tracked in deeper, cooler waters of the Bay mouth or Atlantic coastline. Observed surfacing times were higher than historic summer/fall observations (Byles 1988; 5.3%), indicating that historic springtime abundances were overestimated by 50%-80%. Aerial surveys conducted from 2001-2004 indicated a 65%-75% decline in the Chesapeake Bay sea turtle population since the 1980's. Current sea turtle estimates, corrected for seasonal surfacing behavior, and extrapolated for the entire Bay, range between 2,500 and 5,500 turtles compared to 6,500-9,000 turtles observed in the Lower Bay alone in the 1980's.

On a management level, it is imperative that the best possible data be used to determine relative sea turtle abundances in Virginia waters. These data in turn are used to help determine appropriate take limits for local fisheries and permitted federal activities, such as hopper dredging that are known to take turtles as by-catch. The U.S. Army Corps of Engineers (ACOE), Norfolk Division has utilized hopper dredges off the coast of Virginia to obtain sand for placement on oceanfront beaches along Virginia Beach, Virginia. Hopper dredging and beach nourishment are activities that have the potential to adversely affect sea turtles, either directly by encounters with dredging equipment or indirectly by alteration of nesting habitat (Coston-Clements and Hoss 1983). In 2001 and 2002, and 2003, ACOE dredging operations in Thimble Shoals Channel exceeded or came close to exceeding the National Marine Fisheries Service sea turtle incidental take limits for loggerhead turtles (*Caretta caretta*) and Kemp's ridley sea turtles (*Lepidochelys kempii*). This resulted in temporary and voluntary cessation of dredge operations and the need for relocation trawling. The threat to Virginia's sea turtles can be minimized by gathering life history data on the sea turtles inhabiting Virginia's waters during the time that dredging operations are in effect. Examining sea turtle residency

periods and diving patterns will help determine their vulnerability to different fishing/commercial gears, aiding the development of management approaches that may reduce the number of incidental turtle takes in near-shore fisheries and dredging activities.

To improve estimates of regional abundance from surface densities, more data are needed on the amount of time turtles are visible on the sea surface throughout their residency in Virginia waters. The window for turtle safe dredging activities may broaden based on thermocline location, bottom temperature and associated sea turtle diving behavior.

The primary objectives and hypotheses for this study were to assess the threat seasonal dredging operations in Virginia's pose to loggerhead sea turtles utilizing Virginia's waters.

METHODS

UHF Satellite archival popup tags with time depth recorders (Microwave Telemetry) were used to remotely track the post-release and long-term movements of three Kemp's ridley sea turtles in 2006. Due to federally regulated closures of pound nets and no dredge or turtle relocation activities operating in 2006, turtles were obtained from the Virginia Sea Turtle Stranding and Salvage Network.

Prior to tag application, turtles were measured, weighed and flipper tagged. Turtles' scutes were lightly sanded with 100 grit sandpaper and cleaned with acetone. Archival pop-up tags were attached to the posterior vertebral scutes using a quick setting marine epoxy and/or fiberglass resin. Tags weighed less than 3% of the turtles' body weight. These transmitters were attached to a plastic loop formed by a cable tie embedded in approximately two ounces of epoxy. Tags were secured to the plastic loop via two to three cable ties. Tags were programmed to detach within 10 to 90 days post-release and to collect near real-time depth and temperature data for each individual turtle. Position and sensor data were transmitted to NOAA Tiros Satellites upon detachment from turtle. All data were transferred from the NOAA satellites to the ARGOS data processing system, which in turn sent the data in email format to VIMS. Microwave Telemetry processed and decoded the sensor data, providing raw data reports to VIMS within two months of the last tag transmission. Surfacing and diving intervals obtained from the archival tags were determined based on the average time the turtle is recorded spending at the surface vs. below the surface. Mean temperatures experienced by the turtles at depth and mean dive depths were calculated. Percent time spent at depth was calculated using archival data sorted into 2-m interval binned datasets. Percent time spent at temperature intervals of 1° C was also calculated from archival data received from the popup tags.

RESULTS

Three Microwave Telemetry popup tags were deployed on three juvenile Kemp's ridley sea turtles. Turtles were released between June 20 and September 7, 2006 (Table

1). Two of the deployed tags were archival tags set to pop off after 90 days. The third tag was a high resolution archival tag set to pop off after 10 days.

Table 1 Summary data for three sea turtles tracked in the Chesapeake Bay, 2006. LK= Kemp's ridley. Days represent days of data collection. P = popup archival tag.

Track ID	Species	Primary Tag #	SCL (cm)	Release Date	Release Location	Days Tracked	Track Type
41335	LK	PIT431028395F	29.2	6/20/06	37.355N; -75.995W	90	P
41336	LK	PIT4360735C39	29.7	6/20/06	37.355N; -75.995W	90	P
10401	LK	PIT4342624067	34.3	9/7/06	36.918N; -76.127W	10	P

Popup Archival Tag #41335; Kemp's ridley (juvenile)

Turtle #41335 was originally found as a cold-stunned stranding in Barnstable, MA during late fall of 2005. This turtle was transferred to the Virginia Aquarium for rehabilitation. It was released on June 20, 2006 from Cape Charles along the southern Bay side of the Eastern Shore. This turtle received a 90-day archival tag that recorded temperature and depth data every hour. The popup tag released from the turtle on September 21, 2006, 90 days after deployment. The tag popped off at 38.978 N, -76.332 W, in the northern Maryland portion of the Chesapeake Bay. Approximately 30% of the total data stream was successfully transmitted from the tag. Mean depth of all dives was 1.7 m (+/- 3.7 m SD) and ranged between 0 m and 16.1 m. This turtle spent 79.2% of its time within the top two meters of the water column and 11.4% of its time within the upper four meters of the water column during the days the tag collected data (Figure 1). Mean temperature recorded during dives was 26.19° C (+/- 1.56° C SD), ranging between 22.37° C and 30.48° C. Turtle #41335 spent 38.2% of its time in temperatures between 26° C and 27° C (Figure 2).

Popup Archival Tag #41336; Kemp's ridley (juvenile)

Turtle #41336 was also originally found as a cold-stunned stranding in Barnstable, MA during late fall of 2005. This turtle was transferred to the Virginia Aquarium for rehabilitation and was also released on June 20, 2005 from Cape Charles on the Eastern Shore of Virginia. This turtle received a 90-day archival tag that recorded temperature and depth data every hour. The popup tag released on September 21, 2006, 90 days after deployment. The tag popped off at 36.926 N, -76.172 W, in the lower

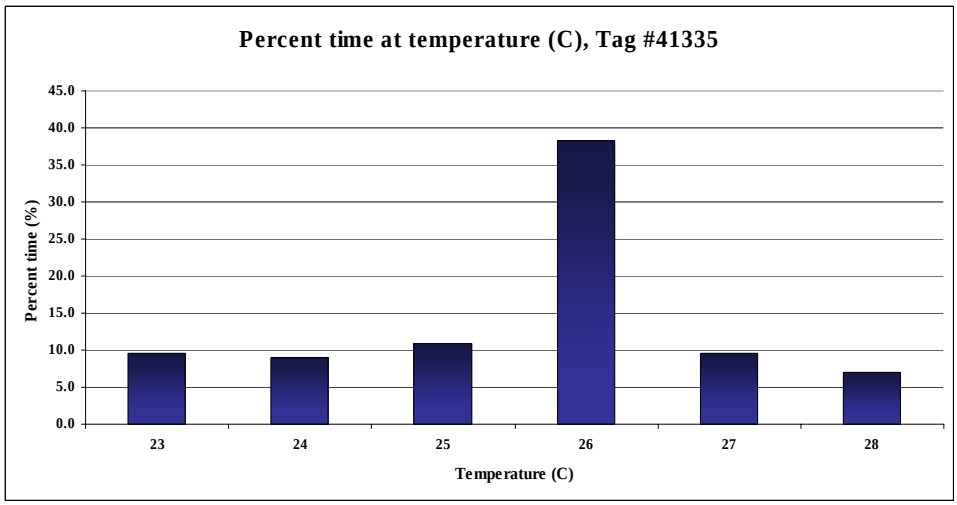

Figure 1. Percent time spent at temperature derived from popup archival tag #41335

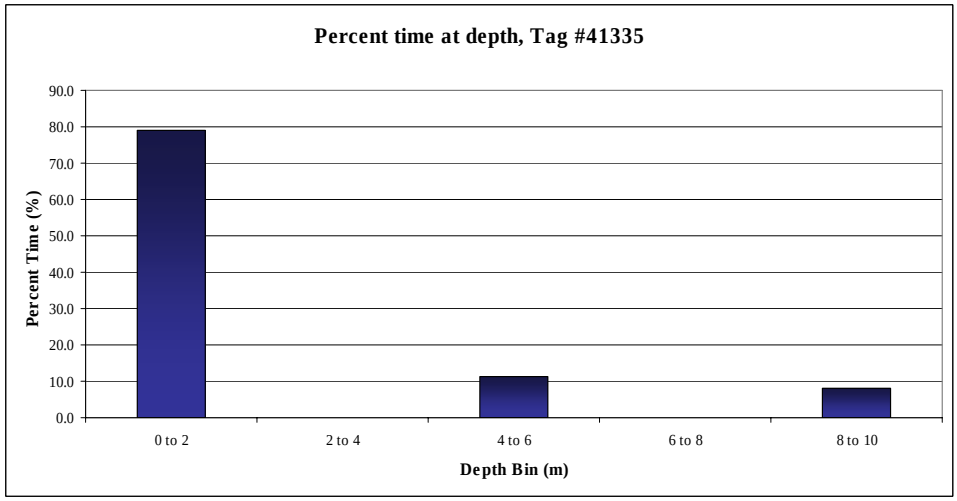

Figure 2. Percent time spent at surface derived from popup archival tag #41335

Chesapeake Bay near the southern portion of the Chesapeake Bay mouth/Southern Bay region. Only 11% of the dive data collected and archived over the course of the 90-day deployment was successfully downloaded. Based on this limited dataset, mean depth of all dives was 1.68 m (+/- 2.72 m SD) and ranged between 0 m and 10.8 m. This turtle spent 70.0% of its time within the top two meters of the water column during the days the tag collected data (Figure 3). Mean temperature recorded during dives was 25.51° C (+/- 0.7° C SD), ranging between 24.08° C and 27.28° C. This turtle spent 89.2% of its time in temperatures between 24° C and 27° C (Figure 4).

Popup Archival Tag # 10401; Kemp's ridley (juvenile)

Turtle #10401 originally captured by hook and line by a fisherman at Back Bay National Wildlife Refuge in Virginia late May, 2006. This turtle was rehabilitated by the Virginia Aquarium through the summer of 2006 and was released on August 28, 2006 from Chesapeake Bay Beach in Virginia Beach, Virginia. This turtle received a 10-day High Resolution archival tag that recorded temperature and depth data every minute. The popup archival tag released from the turtle on September 3, 2006, six days after deployment. The tag popped off at 37.318 N, -76.356 W, near the mouth of the York River and the Mobjack Bay. This tag was subsequently found late October 2006 by vacationers in Nags Head and returned to VIMS. All (100%) dive data collected and archived over the course of the 6-day deployment was successfully downloaded. Mean depth of all dives was 5.43 m (+/- 4.24 m SD) and ranged between 0 m and 16.1 m. This turtle spent 73.5% of its time within the top six meters of the water column during the days the tag collected data, and (Figure 5). Mean temperature recorded during dives was 24.27° C (+/- 0.43° C SD), ranging between 23.05° C and 25.66° C. This turtle spent 100% of its time in temperatures between 23° C and 25° C (Figure 6).

DISCUSSION

The popup tags used in this study recorded close to real-time depths encountered by the turtles. However, placement of the tags on the turtle may slightly bias the data collected by the pressure sensors. tags were placed close to the postmarginal scutes. When the turtle comes to the surface to breath, it is possible that the popup tags would remain at least partially submerged. The popup tags have a documented potential error of +/- 1.35 m (for depth sensor) and a 0.2° C (+/- 0.1° C) temperature sensitivity (P. Howie pers. comm.). Compared to the limited duration of radio tracks, popup archival data indicate that time spent at or near the surface several days post-release among displaced or migrating turtles is relatively high compared to Byles (1988) observations (5.3%) among loggerheads. Byles observed, however that Kemp's ridley sea turtles tended to remain within shallow, near-shore waters while foraging in the Bay. It is likely that the depths recorded by the popup tags deployed in this study reflect this shallow-water feeding behavior.

This behavior also suggests that during the summer foraging period, Kemp's ridleys may be less likely to be taken by hopper dredge than loggerheads, who tend to forage in deeper tidal and shipping channels. Regardless, during the spring and fall migration period, all turtles must swim through the Bay mouth to reach their summer

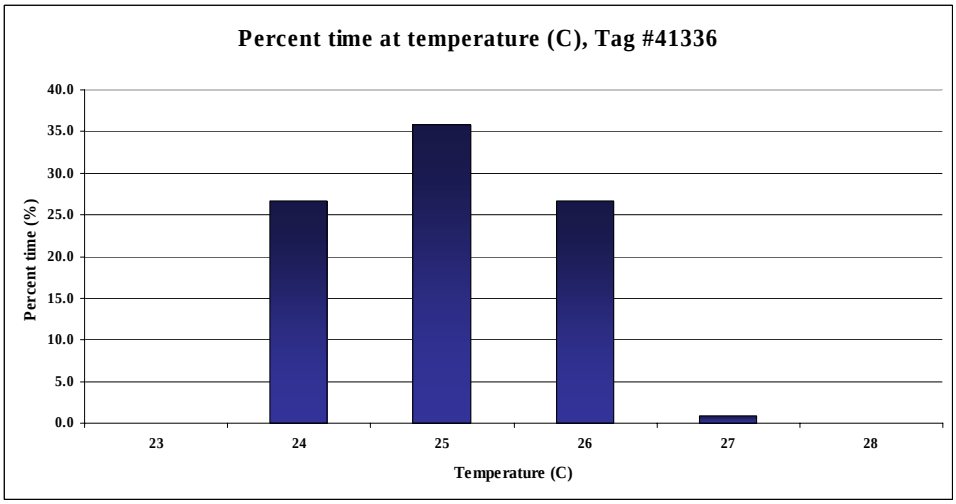

Figure 3. Percent time spent at temperature derived from popup archival tag #41336

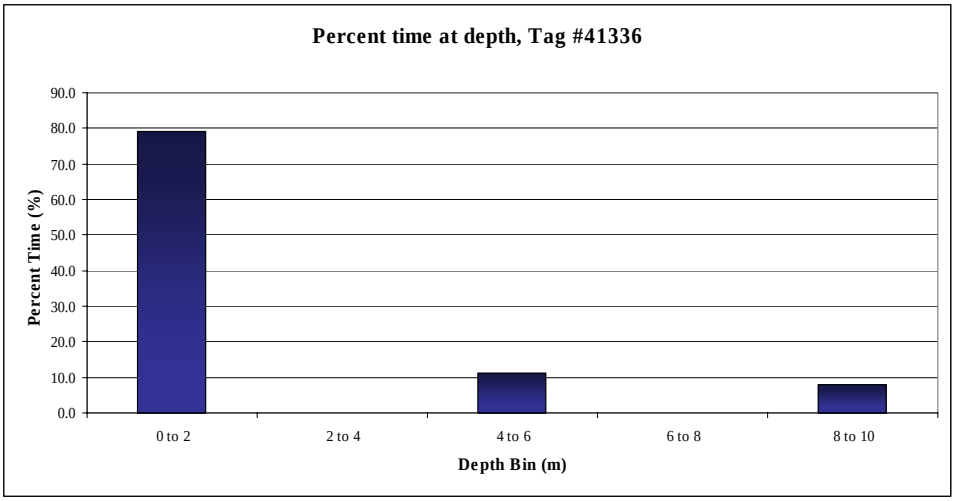

Figure 4. Percent time spent at surface derived from popup archival tag #41336

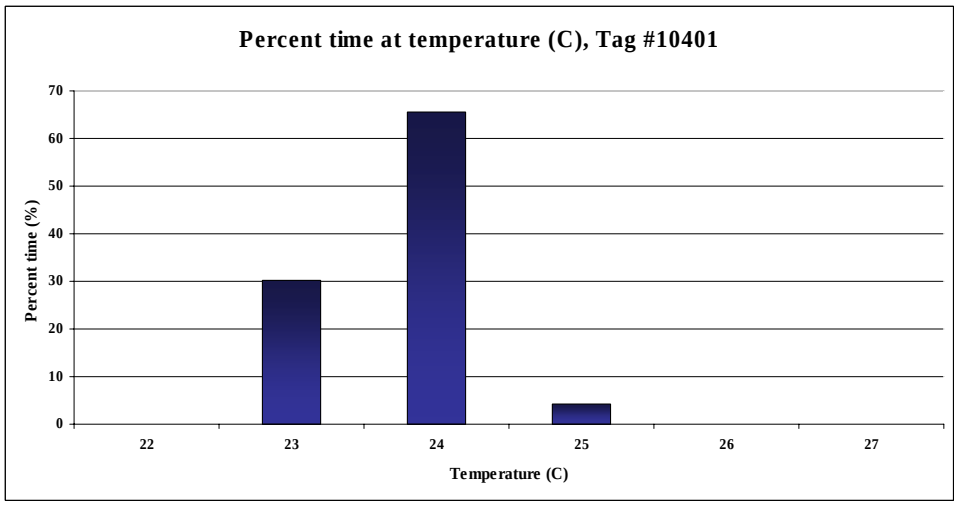

Figure 5. Percent time spent at temperature derived from popup archival tag #10401

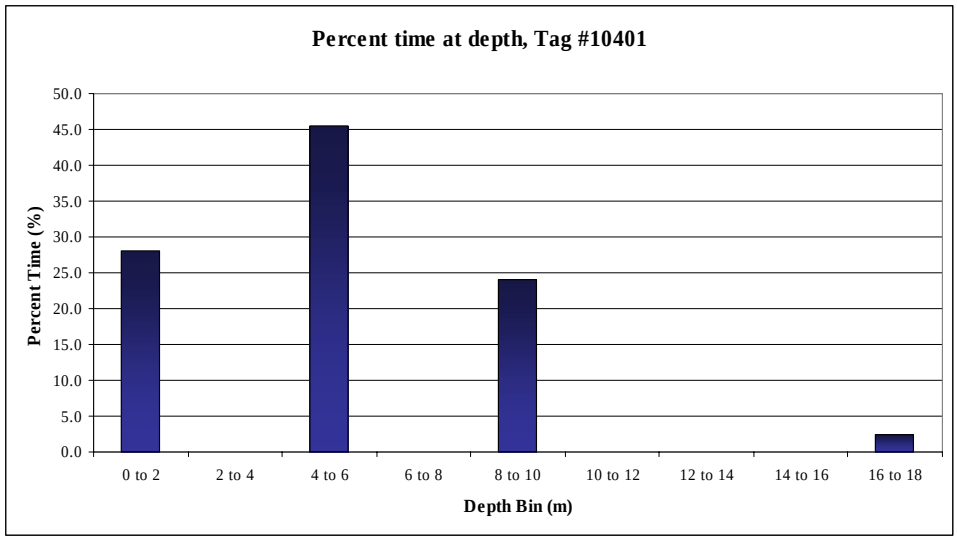

Figure 6. Percent time spent at surface derived from popup archival tag #10401

foraging or winter habitats. Thus, at least for Kemp's ridleys, the risk of capturing sea turtles by hopper dredge would likely be greatest during the spring/fall migratory periods.

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