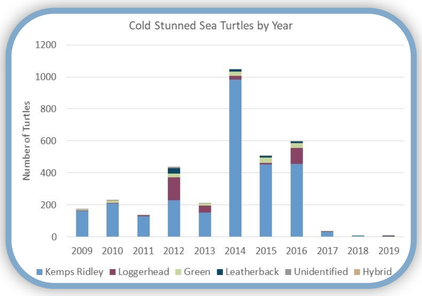
A Chilling Problem:

Cold Stunning in Kemp's Ridley Sea Turtles

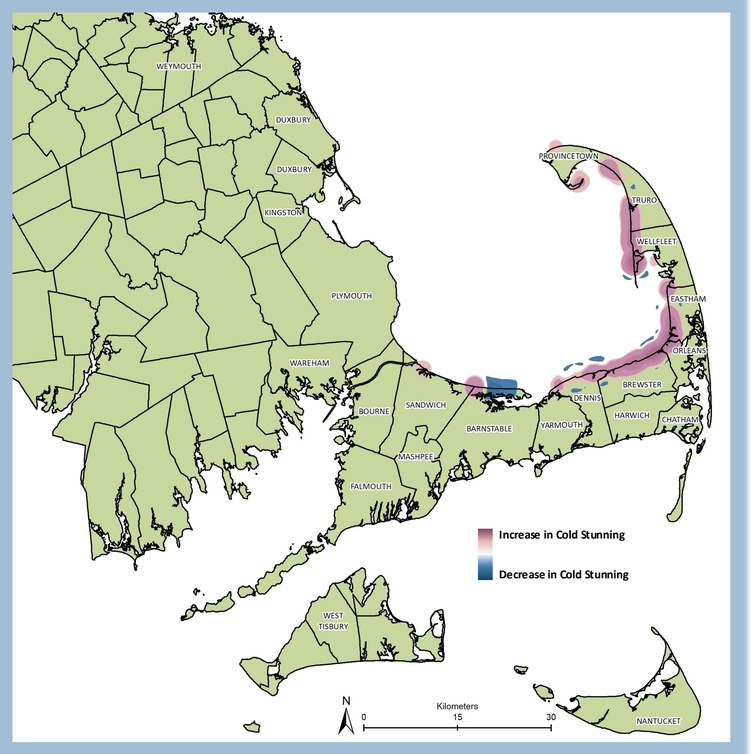
What is Cold Stunning?

An increasing number of Kemp's ridley sea turtles (*Lepidochelys kempii*) strand or die in Cape Cod Bay each year due to cold stunning, a poorly understood phenomenon. Cold stunning is a process by which a turtle's body temperature becomes too low to perform normal body functions, reducing their ability to move and weakening their immune system. Cold stunned turtles often wash up on beaches or are found dead. The total incidence of stranding is likely higher than recorded as these numbers only reflect the turtles that were found by organizations such as the Mass Audubon Society or the New England Aquarium.



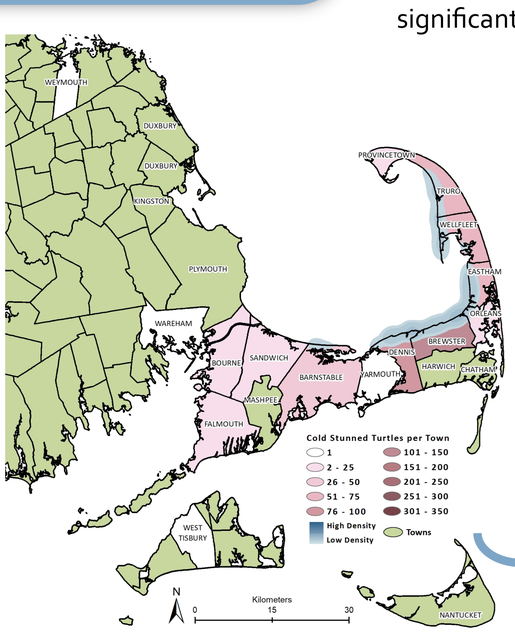
Why Kemp's Ridleys?

While multiple turtle species cold stun and strand on Cape Cod, Kemp's ridleys make up the largest percentage. Kemp's ridleys are currently listed on the International Union for Conservation of Nature's Red List as critically endangered. Prior to the sudden surge in cold stunning, Kemp's ridley populations were decimated due to bycatch, hunting and harvest pressures on adult turtles and eggs, and nesting habitat degradation. As the majority of stranded turtles are juvenile, and turtles have a long time to maturity, the significant loss in juveniles would have cascading effects on the future breeding populations, significantly decreasing the effective population size.



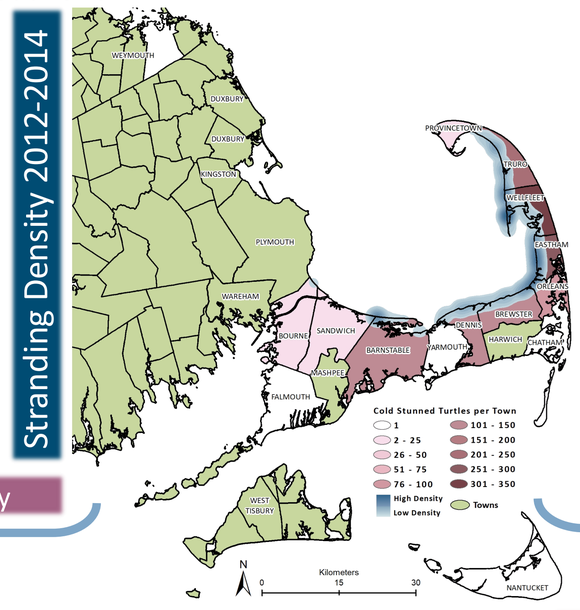
Total Change in Stranding Density from 2009 to 2019

Stranding Density 2009-2011



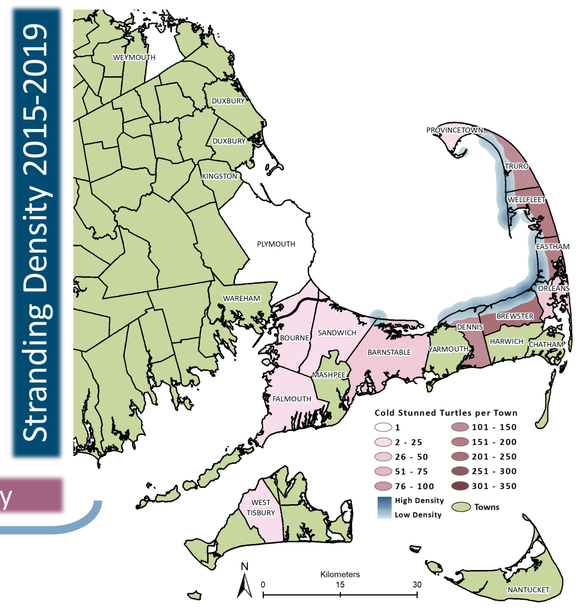
Change in Stranding Density

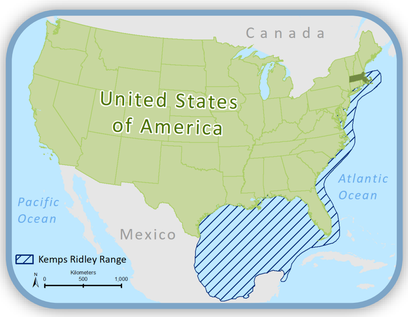
Stranding Density 2012-2014



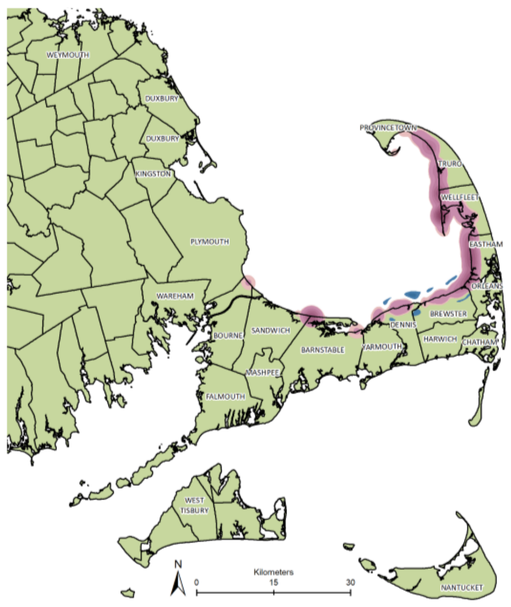
Change in Stranding Density

Stranding Density 2015-2019

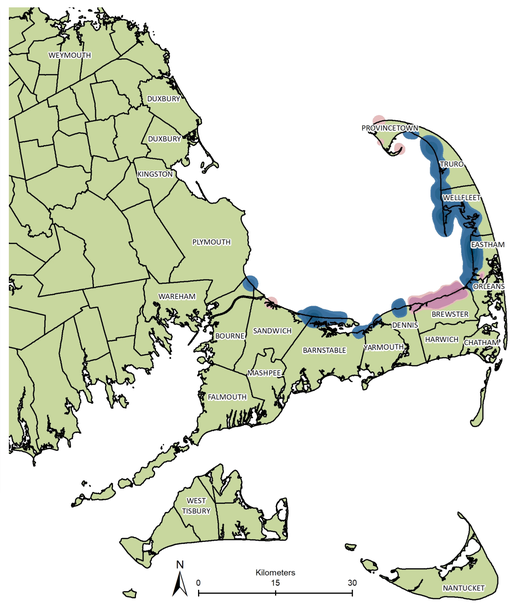


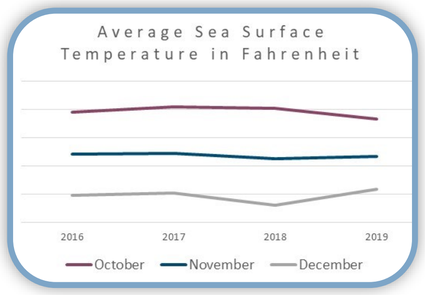


2009-2011 to 2012-2014



2012-2014 to 2015-2019



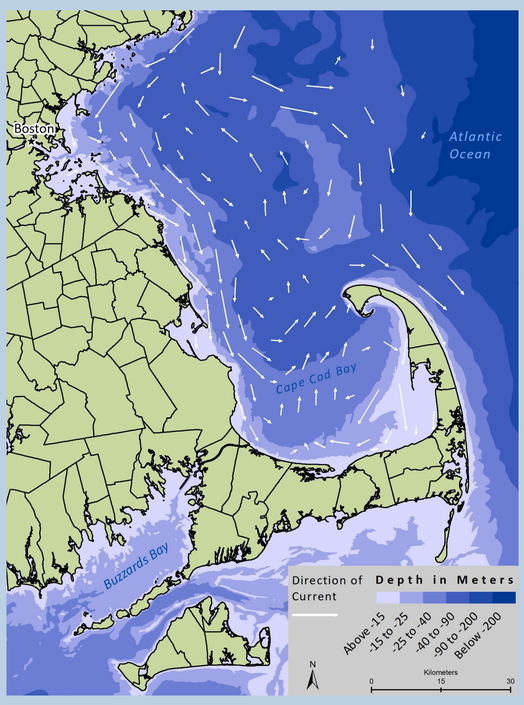


Methods

To examine the patterns in cold stun strandings the latitude and longitude points of recovered turtles were brought into ArcMap. The points were separated into three timespans, joined to Massachusetts towns, and classified by turtles per town. The kernel density tool was used to examine the concentrations of strandings which created a raster for each timespan. The raster calculator tool was then used to examine the change in stranding patterns between each timespan as well as the overall change in cold stun strandings.

Georeferencing based on a wind-induced model was used to visualize the currents. Data from a geomagnetic model was used to map total intensity, one component of the geomagnetic field. Latitude and longitude points were interpolated using inverse distance weighted (IDW) interpolation. IDW was used because as the new values are determined the tool operates under the assumption that the variable being mapped decreases in influence with distance from its sampled location. Three time ranges corresponding to the stranding data were interpolated and then the raster calculator was used to find the difference between the ranges.

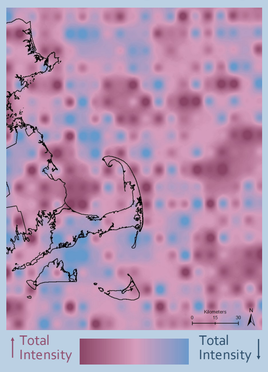
Bathymetry and Currents of Cape Cod Bay



Geomagnetic Change Between 2009 and 2014

↑ Total Intensity — Total Intensity ↓

Geomagnetic Change Between 2015 and 2019



↑ Total Intensity — Total Intensity ↓

Findings and Future Research

The stranding density maps show an increase in total cold stun strandings over time. In the first timeframe strandings are concentrated in Dennis and Brewster, but shift further out on the cape over time with Wellfleet and Eastham having the highest numbers of strandings. Both the counts by town and the higher density of cold stun cases represented by the darker blue demonstrate this shift. The earlier change map highlights the overall increase in cold stunning, while the second map seems to show a decrease in cold stunning. This decrease can be attributed to an incomplete data set, not an actual decrease in cold stunning. Despite this missing data, the Total Change in Strandings Density map emphasizes the overall increase in the incidence of Kemp's ridleys cold stunning.

Cold stunning is still not well understood and various factors contribute to its increase. Ocean waters warming globally have extended the northern range of the Kemp's ridley, contributing to an increased number of turtles in the Gulf of Maine. Additional factors such as the depth and currents as well as geomagnetism may contribute to trapping the turtles in Cape Cod Bay.

Sea turtles use the earth's magnetic field for navigation, most notably to return to their natal beaches for nesting. Though the exact mechanism of magnetic detection remains unknown, the factors used to orient the turtle are thought to be the intensity and inclination of the magnetic field. While these maps highlight the change in the total intensity of the magnetic field bound by 41 and 43 North and 69 and 71 West, further research is needed to determine the role of secular variation in the upsurge of cold stunning.

Acknowledgements

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Data Sources:

MassGIS, MassAudubon, ArcGIS Online (leifj_COSWFL), ESRI, USGS, NOAA, USEPA

Projection: NAD (1983) 2011 StatePlane, Massachusetts Mainland FIPS 2001

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