The mysterious lives of leatherbacks

"This animal was, and remains, an enigma."

Michael James
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by Laura Naranjo

When biologist Michael James captured and tagged his first leatherback sea turtle off the eastern coast of Canada in 1999, he was pursuing a mysterious animal. No one knew why Atlantic leatherbacks appeared in the frigid northern waters each year. In fact, researchers knew little at all about leatherbacks, except that they were endangered.

"This animal was, and remains, an enigma," James said. "Although fishermen had known for a long time that leatherbacks had been sighted off Canadian coasts, these were considered incidental reports." James, then a graduate student at Dalhousie University in Nova Scotia, Canada, had begun studying leatherbacks with one satellite-linked transmitter attached to a turtle. Long thought to be tropical creatures, the records that James and his colleagues collected suggested otherwise: leatherbacks spent up to five months foraging in Canadian waters before migrating south. Now, more than ten years later, James has tracked over sixty turtles by satellite. Tagging and tracking leatherbacks exposed their

Atlantic leatherbacks are the largest species of sea turtle. While they have few natural predators, they often become entangled in fishing nets and drown. Leatherbacks were declared critically endangered in 2000. (Copyright H. Segars)

behavior and yielded new insights about leatherback biology. But James didn't yet know what triggered their movements. To discover the answer, he and his colleagues turned to environmental satellite data.

Turtles at risk

During migration, leatherbacks travel the open ocean in relative safety. But between migrations, they spend several months foraging along the continental shelves. "When leatherbacks concentrate in these coastal feeding or breeding areas, they're most at risk because these are also the environments where fishing activity is most concentrated," James said.

This overlap between turtle habitat and commercial fisheries poses a problem for leatherbacks. In near-shore waters, the turtles are more likely to become entangled in nets or the vertical lines associated with fishing gear. Leatherbacks are the largest species of sea turtle, growing more than 2 meters (7 feet) long, and weighing up to 650 kilograms (1,400 pounds). When captured in the large, conical nets used in trawl fishing, they are often too large to be released from common turtle excluder devices, and are unable to swim backward to escape.

By studying how turtles use coastal foraging areas, and observing when they migrate to and from them, James hoped to glean information that may help ensure turtle safety and promote less harmful fishing practices.

Migration clues

Each year, James conducted summer fieldwork off the coast of Nova Scotia, capturing and equipping turtles with tracking devices. Every fall the turtles migrated south, and every summer the turtles returned to northern waters to feed on jellyfish and other gelatinous prey. James was beginning to understand their migration routes, but he did not yet understand the factors influencing when the turtles migrated. "Was there some kind of cue, such as day length or declining water temperature?" James asked. "Was it declining food availability? Could we predict when they were going to leave based on any of these variables?"

Turtle tracking devices relayed location and movement, but to understand potential environmental cues affecting migration, James needed more information. So he worked with Scott Sherrill-Mix, a graduate student at Dalhousie University in Nova Scotia. They studied data from twenty-seven turtles, tracked between 1999 and 2004, and matched turtle locations with environmental satellite data to see if changes in ocean temperature and food supply affected their behavior.

To complement the incomplete ocean temperature records obtained from the turtle tracking devices, Sherrill-Mix obtained sea surface temperature data from the Geostationary Operational Environmental Satellite (GOES) and the Advanced Very High Resolution Radiometer (AVHRR) Oceans Pathfinder instrument, available from the NASA Physical Oceanography Distributed Active Archive Center.

Observing leatherback food supply was more difficult than determining sea surface temperature. Sherrill-Mix said, "We were really interested in changes in jellyfish abundance, but there are no counts of jellyfish in the open ocean." Part of the reason there is little data on jellyfish is because satellite sensors cannot measure jellyfish populations directly. However, satellites can detect

The satellite tracking device attached to this leatherback sea turtle helps biologist Michael James learn more about the turtle's migration routes and behavior. His work depends on help from commercial fishermen, who work as field assistants and lend their boats. (Courtesy Canadian Sea Turtle Network)

a common jellyfish food source, phytoplankton, the microscopic plants that float near the ocean's surface. Because phytoplankton contain a green pigment called chlorophyll, large concentrations of them can color the ocean green; satellites can observe these changes in ocean color. "We hoped that chlorophyll data would approximate jellyfish concentrations," Sherrill-Mix said. He used ocean color data from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor and from the Sea-Viewing Wide Field-of-View Sensor (SeaWiFS), both available from the NASA Ocean Biology Processing Group.

James said, "We were able to tap into these databases pretty quickly and grab values relative to each turtle's position. I want to stress the value of making the environmental data free, and making it available on the Web. The continuity is really important for projects like ours."
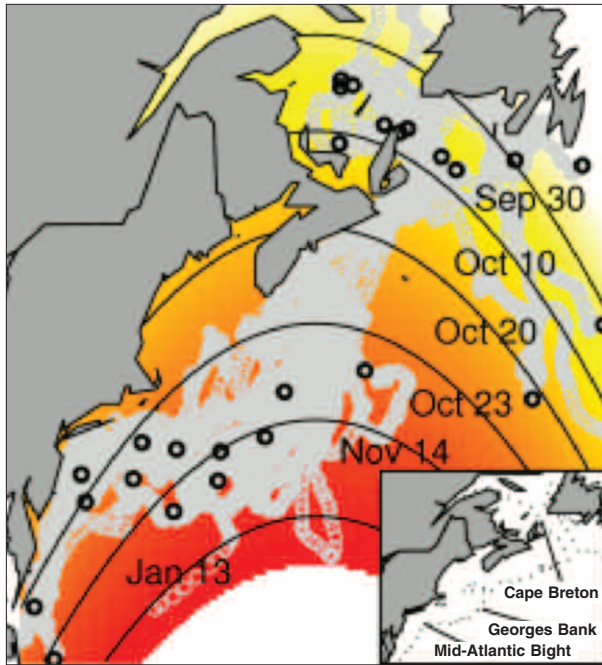
Researchers studied the migration patterns of leatherback sea turtles in hopes of learning more about protecting their populations. Dates indicate when 50 percent of the turtles departed that contour line. Each contour line marks a ten-fold increase in turtle departure rates from the line below. Gray circles indicate turtle movement, and black circles mark individual departures. Red indicates the lowest departure rates and yellow the highest rates. The inset shows locations discussed in the study. (Courtesy S. Sherrill-Mix)

Modeling turtle timing

Individual leatherbacks began their southward migration over a four-month span, ranging from September 8 to January 13. Sherrill-Mix combined the turtle departure dates they had observed with remotely sensed temperature and chlorophyll data, adding day length, water depth, and turtle gender and size to generate a model. The scientists hoped the model would reveal which of these factors prompted migration, and they initially focused on decreasing food supply and water temperatures. But the model results

suggested that the turtles did not leave for the reasons they expected. The largest factor in migration timing turned out to be turtle location.

The leatherbacks in their study tended to congregate in two locations: one group foraged in the waters off Newfoundland and Nova Scotia, and the other group foraged off the northeastern coast of the United States. "We thought that cold water might trigger turtle migration," Sherrill-Mix said. "But the northern-most turtles left sooner from warmer water. And we thought the same with chlorophyll. We figured that green water would have lots of food for them. But they left earlier from waters rich in chlorophyll." Sherrill-Mix and James also noticed that once the northern turtles began migrating, they did not stop to forage in the southern location. Sherrill-Mix said, "The northern turtles swim right past where the southern turtles are foraging. If they needed more food, they could easily stop and eat."

How could the researchers explain the unexpected results? The difference in migration distance between the northern and southern turtles was only 500 kilometers (300 miles). Leatherbacks could cover that distance in about ten days, so distance alone could not account for the wide range of departure dates. Sherrill-Mix and James thought one possible explanation was that jellyfish might have more extreme blooms in warmer, prey-filled waters. Sherrill-Mix said, "Increased prey and temperature speed up the jellyfish lifecycle. Since jellyfish die off after mating, this may mean that warm, chlorophyll-rich waters provide a more condensed jellyfish season for the turtles." The researchers theorized that seasonal jellyfish die-offs occurred earlier at higher latitudes, prompting turtles in these areas to begin migrating while waters were still warm. By

contrast, turtles in the southern comparison group were able to feed on jellyfish later into the season.

While some of the results were unexpected, the study provided new questions for James and Sherrill-Mix to explore. They were the first scientists to model and investigate potential migration cues and timing in leatherbacks, which required broader investigation into how seemingly unrelated factors, such as jellyfish lifecycles, might influence turtle behavior.

"This work relates fundamentally to the leatherback's status as an endangered species," James said. "We need a context in which to look at leatherback behavior and discover what we can do to help them recover." Knowing when leatherbacks leave or return to an area may aid conservation regulations and promote changes in fishing practices, particularly in near-shore environments where turtles forage and are most at risk. James collaborated extensively with fishermen, and is mindful that simple solutions, such as closing off entire areas, are not always the

Leatherback sea turtles have a thick layer of ridged, leathery skin on their backs instead of a bony shell, so researchers needed to develop safe ways to attach satellite tracking equipment. (Courtesy Canadian Sea Turtle Network)

answer. Having detailed information about turtle migration and behavior can lead to flexible conservation measures that protect both leatherbacks and local fishing industries. "We want to predict leatherback behavior and ultimately, we want fisheries and turtles to co-exist," James said.

To access this article online, please visit http://nasadaacs.eos.nasa.gov/articles/ 2009/2009_leatherbacks.html.

References

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Sherrill-Mix, S., M. C. James, and R. A. Myers. 2007. Migration cues and timing in leatherback sea turtles. *Behavioral Ecology*, doi:10.1093/beheco/arm104.

For more information

NASA Ocean Biology Processing Group (OBPG)
    http://oceancolor.gsfc.nasa.gov
NASA Physical Oceanography Distributed Active
    Archive Center (PO.DAAC)
    http://podaac.jpl.nasa.gov

Moderate Resolution Imaging Spectroradiometer
    (MODIS)
    http://modis.gsfc.nasa.gov
Sea-Viewing Wide Field-of-View Sensor (SeaWiFS)
    http://oceancolor.gsfc.nasa.gov/SeaWiFS
Canadian Sea Turtle Network
    http://www.freetheleatherback.com

About the scientists

Michael James is an adjunct professor at Dalhousie University in Nova Scotia, Canada, and the director of science for the Canadian Sea Turtle Network (CSTN). James founded the CSTN to involve fishermen, conservation agencies, and coastal communities in marine turtle research and conservation initiatives in Atlantic Canada. Fisheries and Oceans Canada, National Marine Fisheries Service (USA), and Natural Sciences and Engineering Research Council of Canada funded his research. (Photograph courtesy CSTN)

Scott Sherrill-Mix is a programmer analyst with the University of Pennsylvania. He studied fishery interaction and stock abundance before attending Dalhousie University in Canada, where he received a master's degree studying leatherback sea turtles. He will begin his PhD in bioinformatics at the University of Pennsylvania in fall 2009. Fisheries and Oceans Canada, National Marine Fisheries Service (USA), and Natural Sciences and Engineering Research Council of Canada funded his research. (Photograph courtesy S. Sherrill-Mix)

About the remote sensing data used

Satellites	Geostationary Operational Environmental Satellite (GOES)	NOAA Polar Orbiting Satellites	GeoEye SeaStar, Aqua	Aqua, GeoEye SeaStar
Sensors	GOES I-M Imager	Advanced Very High Resolution Radiometer (AVHRR)	Sea-Viewing Wide Field-of-View Sensor (SeaWiFS) and Moderate Resolution Imaging Spectroradiometer (MODIS)	MODIS, SeaWiFS
Data sets	GOES L3 6km Near Real-Time SST	AVHRR Pathfinder SST v5	OC3 and OC4 chlorophyll a concentration	Aqua MODIS merged chlorophyll product (with SeaWiFS)
Resolution	6 kilometer	4 kilometer	9 kilometer	9 kilometer
Parameters	Sea surface temperature	Sea surface temperature	Chlorophyll a concentration	Chlorophyll a concentration
Data centers	NASA Physical Oceanography Distributed Active Archive Center (DAAC)	NASA Physical Oceanography DAAC	NASA Ocean Biology Processing Group	NASA Ocean Biology Processing Group