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Feeding of *Dermochelys coriacea* on Medusae in the Northwest Atlantic

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The leatherback turtle, *Dermochelys coriacea*, is the largest of the marine turtles. Leatherbacks nest on beaches in tropical and subtropical waters and range north to forage in temperate waters during summer and fall. In the north Atlantic, leatherbacks occur off the coast of Europe, including the United Kingdom, Ireland, France, and Norway (Brongersma, 1972; Duron and Duron, 1980; Gulliksen, 1990; Penhallurick, 1991; Dolmen et al., 1993), the northeastern United States (Lazell, 1980; Shoop and Kenney, 1992), and eastern Canada (Squires, 1954; Bleakney, 1965; Steele, 1972; Threlfall, 1978; Goff and Lien, 1988).

Although it is the most widespread reptile in the world (Mrosovsky, 1987), little is known about this species' basic biology beyond the nesting beach. Leatherback populations have precipitously declined in recent years, and, in an attempt to identify and address limiting factors in the marine environment, efforts to investigate the behavior of these turtles at sea have increased. However, as free-ranging leatherbacks are difficult to both locate and observe for extended periods, few data on the feeding habits of this species are available.

Most information on diet has been inferred from analysis of stomach contents of stranded animals (Bleakney, 1965; Den Hartog, 1984; Frazier et al., 1985). These studies have suggested that leatherbacks are dietary specialists, consuming planktonic gelatinous prey such as medusae, siphonophores, and salps (Ates, 1991; Lutcavage, 1996). Analysis of the fatty acid composition of leatherback tissue has corroborated this view (Davenport and Wrench, 1990; Holland et al., 1990). Small quantities of other organisms identified in leatherback gut contents, such as crustaceans, are generally assumed to be ingested incidentally while turtles are feeding on medusae (Frazier et al., 1985). This interpretation is supported by the fact that many of these organisms are known commensals of soft-bodied pelagic invertebrates (Frazier et al., 1985). The gross anatomy of the digestive tract of the leatherback is consistent with a stenophagous diet of jellyfish. Numerous keratinized spines line the inside of the esophagus. These papillae probably shred medusae and prevent them from being regurgitated (Bleakney, 1965; Den Hartog and Van Nierop 1984).

An improved understanding of leatherback feeding behavior would allow us to identify threats associated with foraging, with clear implications for conservation. Although medusae are generally plentiful, such a specialized diet may make leatherbacks vulnerable to ingestion of plastics and other buoyant marine debris (Mrosovsky, 1981, 1987; Carr, 1987; Uchida, 1990). Whether or not such ingestion is deliberate, since these materials may resemble their soft-bodied prey (e.g., Fritts, 1982), the magnitude of the threat that ingestion of marine debris poses may be grossly underestimated (Cornelius, 1975; Carr, 1987).

Associations between occurrence of leatherbacks and concentrations of jellyfish have been described (Leary, 1957; Collard, 1990; Grant et al., 1996); however, there are few published reports of leatherbacks actually observed feeding on these organisms (Duron and Duron, 1980; Eisenberg and Frazier, 1983; Penhallurick, 1991; Grant and Ferrell, 1993). Here we report on nine detailed observations of leatherbacks feeding on jellyfish in waters off Nova Scotia, Quebec, and Newfoundland, Canada.

Methods. — Leatherback turtles occur off the coast of eastern Canada principally between June and November (Bleakney, 1965; Lazell, 1980; Goff and Lien, 1988). It is logistically difficult to study the behavior of free-ranging leatherbacks at sea, particularly in the northwest Atlantic where frequent adverse sea conditions limit accessibility and visibility. To address this and improve the quantity of information gathered, we draw on the knowledge and experience of a large network of volunteer commercial fishermen to record data on leatherbacks. These observers, collectively known as the Nova Scotia Leatherback Turtle Working Group (Working Group), are trained in proper data collection techniques, are provided with standard data sheets to complete, and are encouraged to photo-document observations of leatherbacks.

To maintain a volunteer-driven, cost-effective program, leatherback turtle data are collected opportunistically, rather than in dedicated surveys. Working Group members are widely distributed across coastal Nova Scotia, and the areas they fish include both coastal and offshore waters. Since the Working Group was founded in 1997, members have reported leatherbacks feeding throughout these waters, and have provided photo-documented detailed observations.

Results. — Nine photo-documented records of leatherbacks feeding on medusae were made during the summers of 1997–99 (Fig. 1). In all cases, jellyfish were clearly visible and numerous at or near the sites where the turtles were encountered.

Leatherbacks were approached by vessels and observed at close range feeding at the surface of the

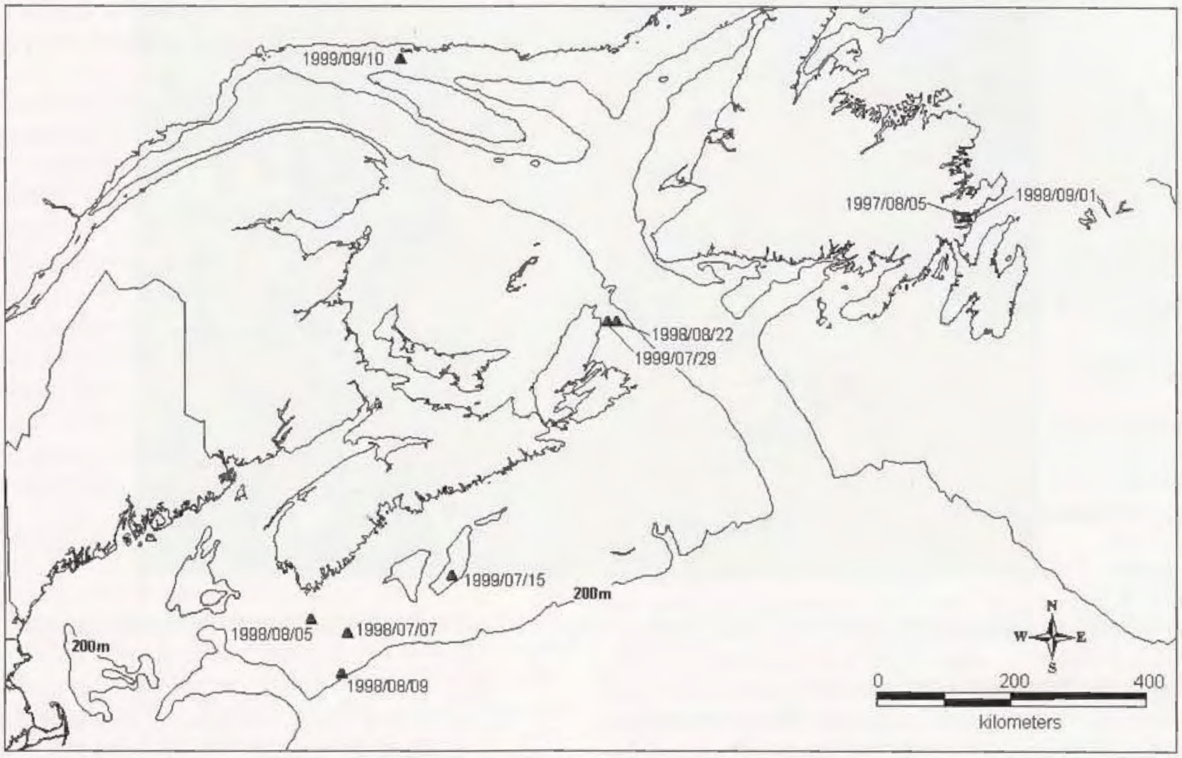

Figure 1. Locations of leatherback turtles (*Dermochelys coriacea*) photo-documented feeding on medusae.

water. The sequence of behavior described was consistent across all records. Turtles rested or moved slowly at the surface with their heads submerged or partially submerged with little noticeable movement of the front or rear flippers. Turtles periodically raised their heads out of the water and opened their mouths, at which time tentacles of medusae were clearly visible at the corners of the mouth and, in some cases, streaming down the sides of the face and neck (Figs. 2–3). Turtles then swallowed and lowered their heads back into the water. Successive raising and lowering of the head was observed until the tentacles of medusae were no longer visible, suggesting that elevation of the head may assist leatherbacks in swallowing the slippery, soft-bodied prey. One large male turtle was observed for approximately ten minutes tearing and consuming very long (> 2 m) strands of what was evidently the bell and tentacles of a large jellyfish (Fig. 3).

Figure 2. Leatherback turtle feeding on jellyfish. Note tentacles at the corners of the mouth. Photo by D. Ivany, Nova Scotia Leatherback Turtle Working Group

Figure 3. Mature male leatherback consuming a large *Cyanea capillata*. Photo by L. Hatcher, Nova Scotia Leatherback Turtle Working Group.

The color, length of tentacles, and size of the bell of the medusae consumed for each of the records reported here indicate that they were *Cyanea* sp. or *Aurelia* sp. (Shih, 1977). Both of these species are seasonally abundant in waters off Atlantic Canada. Large but ephemeral flotillas of these jellyfish are evident at the surface during summer and fall. These organisms may also be abundant lower in the water column where they are less apparent to human observers but no less available to foraging leatherbacks.

Time data for 7 of 9 records showed that 6 (86%) were made between 1000–1230 hrs, and one at 1730 hrs. The morning hours correspond with peak surfacing times exhibited by leatherbacks monitored via telemetry. For example, surfacing behavior of a subadult leatherback equipped with a radio transmitter off Rhode Island peaked between 0900 and 1200 hrs. (Standora et al., 1984).

Discussion. — While the presence of leatherback turtles in temperate waters off eastern Canada corresponds with the seasonal abundance of *Cyanea capillata* (Bleakney, 1965; Goff and Lien, 1988), this paper represents the first published account of these turtles feeding in this region of the North Atlantic.

Without direct observations of leatherbacks feeding on jellyfish, one cannot confirm a predator-prey relationship. Turtles could be actively aggregating for other reasons (e.g., mating, temperature preference) or passively aggregating due to physical oceanographic conditions (e.g., current convergence). Even with observations of feeding, as long as the picture of prey behavior is incomplete, the dynamics of the predator-prey relationship are open to misinterpretation, and the power of correlative studies is limited (e.g., Collard, 1990; Grant et al., 1996).

Medusae may be present in large numbers below the ocean's surface. As a result, these organisms, and to a lesser extent the leatherbacks that feed on them, may largely remain undetected during aerial and other surveys. Correlative evaluations of leatherback and jellyfish abundance and distribution would, therefore, be strengthened if such studies could incorporate detection of both predator and prey below the surface.

When dead leatherbacks wash ashore, plastics are commonly found in their digestive tracts (e.g., Mrosovsky, 1981; Fritts, 1982; Morgan, 1989; Lucas, 1992). Leatherbacks are known to ingest plastic sheeting, tar balls, monofilament, styrofoam, and other marine debris of anthropogenic origin (e.g., Sadove, 1980; Mrosovsky, 1981; Fritts, 1982; Lucas, 1992). These materials can directly affect the survival of marine turtles by causing fatal blockages in the digestive tract (Mrosovsky, 1987). Moreover, the potential toxic effects of such ingestion, while poorly understood, may be significant (Davenport et al., 1990).

Feeding behavior may also put leatherbacks at risk more indirectly. Since the horizontal movement of jellyfish is largely passive (van der Spoel, 1991), they tend to concentrate where currents converge. These same currents concentrate other buoyant objects, including marine debris (e.g., plastic bags, discarded and lost fishing gear, etc.). Therefore, leatherbacks foraging in areas where jellyfish are concentrated may encounter significant amounts of potentially harmful materials of anthropogenic origin (Carr, 1987). These convergence zones and other areas of high productivity also attract commercially valuable species of fish (Fielder and Bernard, 1987), inadvertently bringing leatherbacks into contact with fishing gear. By spatially and temporally defining key feeding areas for this species, we may be able to better understand its incidental capture in commercial fisheries.

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