DISTRIBUTION OF THE LEATHERBACK TURTLE (*DERMOCHELYS CORIACEA*) IN ATLANTIC CANADA: EVIDENCE FROM AN OBSERVER PROGRAM, AERIAL SURVEYS AND A VOLUNTEER NETWORK OF FISH HARVESTERS

by

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ABSTRACT

The globally endangered leatherback turtle (*Dermochelys coriacea*) occurs seasonally in the waters off Atlantic Canada; however, the significance of these waters to this species has not been previously clarified due to a paucity of records. To enhance the collection of leatherback turtle biological and environmental data in this region, a volunteer network of commercial fishers and whale watch operators was established (The Nova Scotia Leatherback Turtle Working Group). In 1998, this group reported the details of 171 geo-referenced sightings of leatherbacks. These records, combined with others collected from an observer program and aerial surveys, provide new insight into the spatial and temporal distribution of leatherbacks in Atlantic Canada. Leatherback density was highest in August and the majority of turtles were observed inshore from the continental shelf break (200m isobath). Mean sea surface temperature (SST) associated with 1998 sightings was 17.8°C. Records from temperate and boreal latitudes (where SST < 5°C) attest to this species' remarkable capacity for endothermy. Medusivory was confirmed by photo-documented feeding behaviour in nine turtles. The results of this study suggest that eastern Canadian waters are within the regular range of large numbers of migrating leatherbacks and should be considered critical seasonal foraging habitat for this species.

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CHAPTER 1

THE LEATHERBACK TURTLE: A GLOBAL CITIZEN

The leatherback turtle (*Dermochelys coriacea*) is the largest reptile in the world (Fig.1.1). One of only eight species of marine turtle, the leatherback is the sole member of the family *Dermochelyidae*. Distinguished from the cheloniid sea turtles by their large size, mature leatherbacks may attain a straight carapace length of nearly two metres and weigh up to 900kg (Davenport and Wrench, 1990). Unlike all other sea turtles, leatherbacks do not have scales, nor do they possess claws. Lacking shell scutes, the leatherback's carapace consists of a 4cm thick, slightly flexible covering of tough, cartilaginous, oil-saturated connective tissue. Seven longitudinal ridges run the length of the carapace, and immense front flippers often equal or exceed half the carapace length. The dorsum of the turtle is bluish-black, with scattered white blotches, while the ventrum is mostly white.

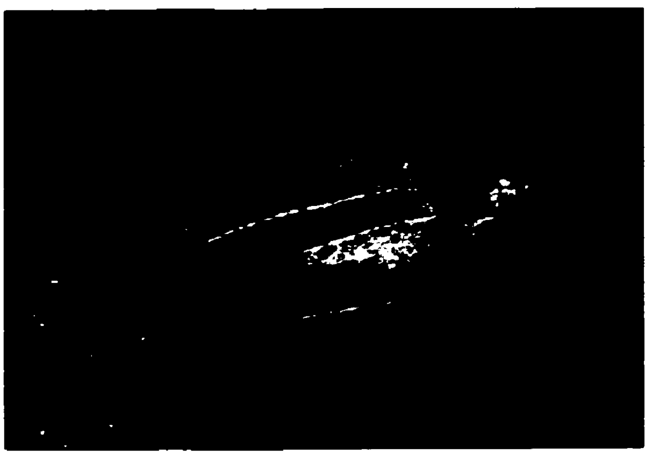

Figure 1.1. The leatherback turtle (*Dermochelys coriacea*) is the largest and most widely distributed reptile in the world.
Photo: D. Ivany, N.S. Leatherback Turtle Working Group

Leatherbacks undertake lengthy migrations in search of jellyfish, their principal prey (Lutcavage, 1996). Counter-current heat exchangers in the flippers (Greer *et al.*, 1973), a high volume to surface area ratio, dark body colour, and a thick subcutaneous insulating layer of fat (Goff and Stenson, 1988) allow these turtles to maintain body core temperatures as much as 18C° above ambient (Frair *et al.*, 1972). This enables them to spend extended periods of time foraging in cool temperate waters (Mrosovsky, 1987), which would normally induce hypothermia in other sea turtle species (Davenport, 1997). The leatherback is also the deepest-diving air-breathing vertebrate (Mrosovsky, 1987), and is capable of reaching depths of over 1000m (Eckert *et al.*, 1989).

The leatherback has the most extensive geographic range of any reptile (Mrosovsky, 1987). It is found in tropical, temperate, and even boreal waters of the Atlantic, Pacific, and Indian Oceans, with the northernmost recorded latitude at 71° N and the southernmost approximately 27° S (Boulon *et al.*, 1988). Flipper tag returns in the Atlantic have suggested both direct movements from nesting beaches to temperate waters (e.g., Pritchard, 1976, Goff *et al.* 1994) and deliberate return movements (Keinath and Musick, 1990).

In the Atlantic, major nesting beaches are located in Suriname, French Guiana, Trinidad and Tobago, Costa Rica and Gabon, Africa (Leslie *et al.*, 1996). Florida is the only state in the continental U.S. to consistently document nesting of the leatherback (Calleson *et al.*, 1998). Nesting occurs every two to three years, and females lay an average of six clutches per season (Van Buskirk and Crowder, 1994). Clutch size averages 82 eggs (Van Buskirk and Crowder, 1994). Evidence as to whether mating occurs mainly in tropical or temperate waters is inconclusive (Eckert and Eckert, 1988), as there are only two published observations of this behaviour (Carr and Carr, 1986; Godfrey and Barreto, 1998). Similarly, lifespan, age at sexual maturity, and growth rates are poorly understood (Rhodin *et al.*, 1981; Zug and Parham, 1996). However, there are some indications that leatherbacks grow much more rapidly than cheloniid sea turtles (Foster and Chapman, 1975) and may, therefore, reach sexual maturity in as little as nine years (Zug and Parham, 1996).

While leatherbacks do not nest in Canada, these turtles do occur here seasonally. In Atlantic Canada, leatherbacks have been recorded off the coasts of Nova Scotia (Bleakney, 1965), Newfoundland (Steele, 1972; Goff and Lien, 1998) and Labrador (Threlfall, 1978). Reports from New Brunswick are of turtles sighted in the Bay of Fundy, the Northumberland Strait, and the Gulf of St. Lawrence. In Prince Edward Island, a small number of records come from coastal strandings and reports made by fishers. Leatherbacks have also been reported in the Gulf of St. Lawrence off Quebec (D'Amours, 1983; Bosse, 1994).

A number of studies have used aerial and shipboard surveys to assess the seasonal occurrence of leatherbacks in waters off the northeastern United States. Shoop and Kenney (1992) reported 128 leatherback observations from three years of surveying continental shelf waters from the Gulf of Maine to Cape Lookout, NC. In eastern Canada, migrating leatherbacks venture seasonally into coastal waters off the Atlantic provinces to feed on abundant hydromedusae. During the summer and fall, leatherbacks are frequently sighted by boat operators. As leatherback travel routes often intersect with fishing grounds, each year there is some incidental catch in coastal and offshore fisheries.

Bleakney (1965) assembled 29 Canadian records of leatherbacks (1824 to 1964) to demonstrate a regular seasonal occurrence of these reptiles in Atlantic Canadian waters. Later, Goff and Lien (1988) reported on the distribution of 20 leatherbacks (1976-1985) recorded off Newfoundland and Labrador. In both studies, records principally came from entanglements in nearshore fixed fishing gear; no offshore data were presented. Apart from the present study, no research has considered the broad distribution of leatherbacks in eastern Canadian continental shelf and offshore waters.

A SPECIES AT RISK

The leatherback is at risk everywhere it is found. It has been classified as globally endangered since 1971 (IUCN) (Pritchard, 1971) and endangered in Canada since 1981 (COSEWIC) (Cook, 1981). The species has experienced a precipitous population decline of over 60% since 1982, and the total number of nesting females is now thought to number less than 35,000 worldwide (Spotila *et al.*, 1996). The most dramatic decreases have been observed at several nesting locales in the Pacific (e.g., Terengganu, Malaysia (Chan and Liew, 1996)); however, recent population modelling of the larger Atlantic population suggests current levels of egg exploitation and juvenile and adult mortality also cannot be sustained (Spotila *et al.*, 1996).

Several anthropogenic impacts are suspected to account for the leatherback's precipitous population decline and the high mortality of eggs, juveniles and adults. These include ingestion of anthropogenic debris (e.g., Mrosovsky, 1981; Carr, 1987; Uchida, 1990) and incidental capture in fishing gear. Leatherbacks readily become entangled in longlines, drift nets, fish traps, buoy anchor lines, and other ropes and cables (Balazs, 1982; Lutcavage and Musick, 1985; NMFS, 1992; Cheng and Chen, 1997; Eckert and

Sarti, 1997). Flipper entanglement is most common. While some entangled leatherbacks drown, unlike smaller sea turtle species, entrapped leatherbacks are often capable of towing large amounts of gear to the surface where they remain until they are discovered and released. Post-capture mortality of these turtles is not known. On nesting beaches, low recruitment rates due to high natural hatchling mortality and excessive human harvesting of eggs constitute key threats (e.g., Chan and Liew, 1996; Mrosovsky, 1997).

While these and other limiting factors have been identified, the reasons for leatherback decline are not fully understood; known threats to the leatherback do not adequately explain the magnitude of this species' reduction in numbers.

As the most widely distributed and individually far-ranging reptile in the world, specific regional research and conservation efforts are insufficient to address the global decline of the species. However, regional efforts can make valuable contributions to our global understanding of leatherbacks. This is especially true when there are opportunities for studying the biology of these elusive animals at sea, where they are most inaccessible to the research community.

Recognizing that commercial fishers observe and interact with leatherback turtles more than any other human group (although most of their observations of this species are unreported), I conducted exploratory interviews with fishers in winter and spring 1997. The results of this consultation with the fishing community suggested that leatherbacks were more common at higher latitudes than the existing literature indicated. This possibility required further investigation, as it could potentially contribute valuable insights into our global understanding of the biology and decline of this species.

Chapter 2

The leatherback Turtle Working Group

Part 1: Evolution of the Nova Scotia Leatherback Turtle Working Group

History of marine turtle work in Atlantic Canada

In his analysis of 112 records of marine turtles from Eastern Canada and New England, Bleakney (1965) dismissed traditional interpretations of marine turtle sightings in Canadian waters as accidental, and argued that marine turtles, and leatherbacks in particular, regularly enter temperate waters off Nova Scotia and Newfoundland. Bleakney (1965) suggested that the seasonal presence of leatherbacks in cool northwest Atlantic waters coincided with large concentrations of hydromedusae, their principal prey. Similarly, Lazell (1980) suggested that New England waters constituted important seasonal foraging habitat for large numbers of sea turtles.

The majority of records Bleakney considered were of turtles found entangled in inshore fishing gear in waters near Boston, MA and Halifax, N.S. While only 33% of the records he collected were of Canadian specimens, and precise geo-referenced locations were unavailable for many records, Bleakney concluded that marine turtles, especially leatherbacks (29 of 39 records), occur annually off the coasts of eastern Canada and move inshore during July to October when water temperatures are at seasonal highs. Bleakney maintained an active interest in marine turtles after the publication of his 1965 paper, and continued to opportunistically collect records and samples from coastal strandings in Nova Scotia for several years (e.g., Zullo and Bleakney, 1966).

Following Bleakney's work in the 1960s, apart from infrequent reports of single or small numbers of leatherbacks recorded off the Atlantic provinces (e.g., Miller, 1968;

Steele, 1972; Threlfall, 1978), little attention was paid to marine turtles in eastern Canada. No formal network was established to specifically record marine turtle sightings in any part of eastern Canada until Goff and Lien (1988) encouraged fishing community members in Newfoundland and Labrador to report incidental catches of marine mammals, sharks, and other pelagic organisms in inshore fishing gear. Between 1976 and 1985, Goff and Lien (1988) collected information on encounters with 20 leatherback turtles, including a female flipper-tagged in French Guiana 128 days prior to its capture in a net in Placentia Bay, NF (Goff *et al.*, 1994).

In Nova Scotia, staff at the provincial Museum of Natural History have maintained records of marine turtle strandings from the Halifax area for several years, and local papers have occasionally reported sea turtle strandings and entrapments; however, until recently, there was no dedicated effort to collect data on marine turtle distribution and abundance for this region.

The North Atlantic Leatherback Turtle Working Group

In November 1996, a workshop was held at Dalhousie University in Halifax to raise awareness about recent record numbers of leatherback strandings along the southwest shore of Nova Scotia. Co-hosted by Chris Harvey-Clark (Dalhousie University) and Molly Lutcavage and Jennifer Goldstein (New England Aquarium, Boston, MA), the meeting assembled biologists from Atlantic Canadian universities, the Department of Fisheries and Oceans, museums and aquaria. Representatives from the Nova Scotia Stranding Network and a recently formed provincial association linking fishers and scientists in fisheries research were also present. Workshop participants discussed leatherback biology and conservation issues and marine turtle handling, sampling and necropsy protocol, and explored possible approaches to gathering more information on these highly endangered reptiles in coastal waters of the northwest Atlantic. It was agreed that attempts should be made to involve the fishing community in research on this species, as fishers encounter leatherbacks and other marine turtles more than any other human group. The workshop closed with the decision to create a working group to organize the future collection and sharing of information on marine turtles. As the meeting considered issues affecting leatherbacks in the northeastern U.S. and eastern Canada, and workshop participants represented coastal communities in both of these areas, the group was named the North Atlantic Leatherback Turtle Working Group.

In September 1997, I met with Dr. Chris Harvey-Clark (Dalhousie University) to discuss the status of the North Atlantic Leatherback Turtle Working Group. The small number of leatherback records (n=8) that were collected by Working Group members, principally Harvey-Clark, during the 1997 field season, partially reflected serious time constraints on those individuals interested in leatherback conservation in Atlantic Canada. Existing research projects and other professional duties had precluded implementation of a broader marine turtle data collection program in 1997 and the Working Group had not had an opportunity to reconvene since the November 1996 meeting. Clearly, to initiate an effective data collection program, there was a need for someone to work full time on this project. I expressed my interest in pursuing this opportunity as part of my graduate program at Acadia, and, with Dr. Harvey-Clark's recommendation, I assumed the position of director of the Working Group.

APPROACHING THE FISHING COMMUNITY

In 1997, the Working Group consisted mostly of a small group of "landlocked" biologists from different areas of Atlantic Canada. While interest in marine turtles was high amongst members of this group, opportunities to gather data normally came from attendance at coastal strandings. Strandings occur infrequently (i.e., approximately one to four turtles per year in N.S.) and normally involve dead leatherbacks.

Recognizing that coastal stranding data represent only part of a potentially larger suite of information available on marine turtles, I considered alternative ways of collecting marine turtle data in eastern Canada. A theme of the November '96 Working Group workshop was the possible inclusion of commercial fishers in marine turtle research. Previous work in Canada suggested that approaching the fishing community might be productive. Bleakney (1965) gathered many of his records from fishers who reported incidental catch of leatherbacks in nearshore fixed gear, and Goff and Lien (1988) appealed to the fishing community to report leatherback entanglements as part of a broader program to collect data on incidental capture in coastal waters. These studies clearly identified the fishing community as a source of valuable data on marine turtles. However, the most recent of these programs was over a decade old, and, apart from limited work with members of one swordfish fleet in one community near Halifax, fishers in Nova Scotia had not been approached to report sightings of marine turtles in over 30 years. Clearly it would be necessary to assess the feasibility of asking fishers to contribute to a new marine turtle research initiative in Nova Scotia.

To explore the potential of working cooperatively with Nova Scotia fishers to collect data on marine turtles, I decided to survey fishing community members from different areas of the province. I informally interviewed fishers at wharves in Lunenburg Co. and Queens Co. during winter and spring 1998. Other fishers were interviewed at a Fishermen-Scientist Research Society (FSRS) meeting in February 1998. Conversations with these individuals revealed that, contrary to suggestions in the literature, fishers did encounter leatherback turtles with some frequency off the coast of Nova Scotia. More importantly, many of the individuals I approached indicated that they would be willing to report future sightings of leatherbacks.

As these initial contacts with fishers were generally positive, the feasibility of establishing a widespread network for regularized collection of data on marine turtles seemed promising. After this brief but informative introduction to the fishing community, it was evident that fishers possessed an indigenous knowledge of the marine environment and a capacity for detailed record keeping that would prove invaluable should they agree to participate in a marine turtle research program. It was also clear that without their active involvement, opportunities for collecting pertinent data would be extremely limited, as these individuals obviously had the best, and in most cases the only, opportunities for encountering and interacting with turtles at sea. Recognizing this, a decision was made to make the Working Group fisher-centred rather than scientist-centred. The short-term goal of the program focussed on enlisting the assistance of as many fishers as possible to record the details associated with marine turtle sightings during the 1998 field season (June to November). The long-term goal of the program was to effect community-based monitoring and conservation of marine turtles in eastern Canadian waters. A series of actions was initiated to accomplish this objective (Fig. 2.1).

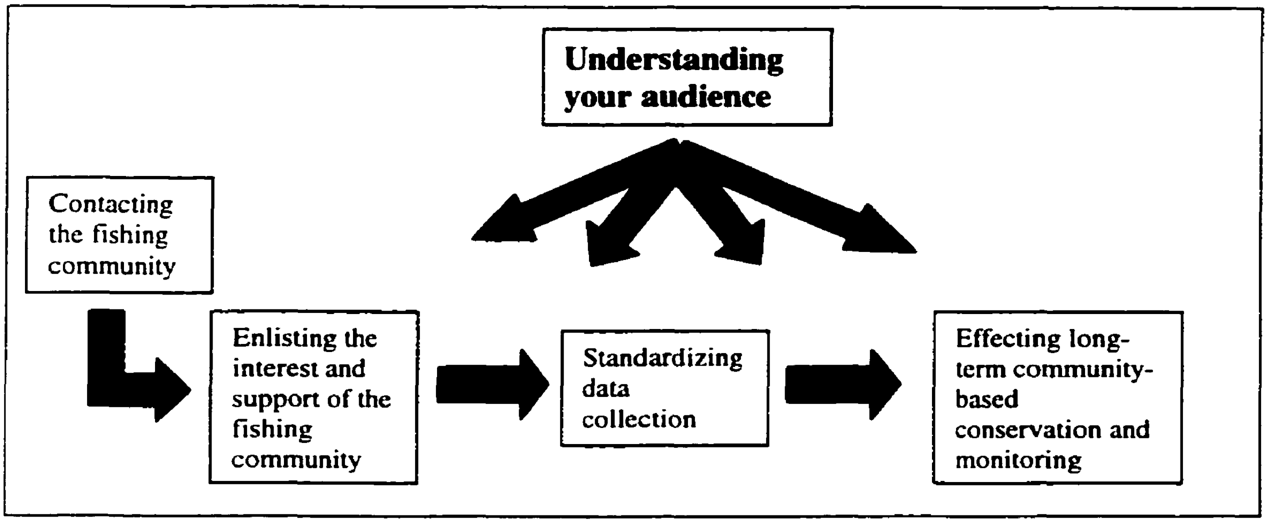

Figure 2.1. Sequence of Working Group Goals.

The varied contributions of fishers are an integral part of many fisheries research projects. For example, fishers are involved in marking commercially-valuable species (e.g., notching egg-bearing lobster, tagging bluefin tuna), sampling catch for subsequent analysis by fisheries biologists (e.g., removing ossicles of fish for age analysis) and recording detailed information associated with fishing activity (e.g., location of gear, surface temperature, kept weight, etc.). It is important to note that this information is rarely volunteered. Instead, there are typically direct or indirect monetary incentives (e.g., rewards for tags, opportunities to participate in select "test" fisheries, etc.) for fishers that assist scientists, or the fishers are required by regulations to record and submit particular information (i.e., completed logs, etc.). The net result of providing monetary incentives for information is that a precedent is established that equates the reporting of desired scientific information with some type of reward. Alternatively, when fishers are regulated to collect information for scientific purposes (i.e., by DFO, etc.), there is a negative association. Unfortunately, these precedents posed some serious challenges when I approached fishers with an interest in having them voluntarily participate in research on marine turtles. My reasons for deliberately avoiding the approach of paying for data were numerous. Principal amongst these was the fact that paid programs are often not affordable; outside of dedicated government funding they are rarely reliably sustained, and they do not necessarily foster an inherent interest in the relevance of the information gathered. As I envisioned the Working Group as a long-term program that would eventually be self-sustaining and community-based, I focussed my attention on designing a volunteer-driven project.

UNDERSTANDING YOUR AUDIENCE

To date, the evolution of the Leatherback Turtle Working Group has consistently revealed that the most important part of developing successful cooperative working relationships with people in rural coastal communities lies in understanding the audience. To promote interest in a volunteer-driven project and to facilitate long-term support of it, the program must recognize the social dynamics of Maritime communities. While there are certainly pronounced differences between fishing communities in different areas of the province, there are also many shared values, concerns, sensitivities and perceptions that inform approaches to working with the fishing community as a whole.

For someone who hails from outside the fishing community, it may never be possible to become integrated within the community. Therefore, it is not always possible to be fully aware of, and/or understand the concerns of the people with whom you wish to work. However, after interacting with fishing community members, in most cases the concerns of fishers and their families become readily apparent. These include the unpredictability of annual earnings or income in the industry. In some years, fish (or other harvestable species) may be less abundant and catch rates low. In other years, a low supply and high demand may translate into record prices per pound and high earnings. Fishing community members are also sensitive to the general decline in the industry. With the collapse of the groundfish fishery and other fisheries in Atlantic Canada, there is a growing sense of uncertainty about the future viability of fishing as a career choice.

Many people currently involved in the fishery fear having to look for work in an alternative sector that they lack the education or training to compete in. In many areas, there is a general suspicion of science and scientists because many studies of fisheries—including ones to which fishers willingly contribute—yield recommendations for decreased quota and/or additional regulations.

While these and other concerns often became readily apparent, other important lessons were learned by trial and error. For example, I learned that in order to encourage dialogue about encounters with marine turtles, it was important to identify myself as a university researcher, distinct from a DFO scientist.

THE IMPORTANCE OF IMAGE

For someone from outside the fishing community requesting information, it is important to find ways of approaching fishers in a non-threatening way. For a scientist, this may be especially difficult because fishers' perceptions of scientists are often negative; they are equated with regulations that directly or indirectly affect livelihoods. I soon discovered that my reception in different coastal villages was mediated by initial perceptions amongst fishers with respect to who I was and whom I represented. Consequently, it was critical to distinguish myself from other groups of which fishers were often suspicious. As I became increasingly aware of sensitivities in the industry, I learned that my position as a university student helped to earn the trust of fishers.

University students may be well poised to work with fishers because they do not necessarily have a history of interfering with fishing activities by challenging the industry on different grounds. Fishers are, however, very suspicious of individuals representing regulatory agencies (in Atlantic Canada, the Department of Fisheries and Oceans) because as an already highly-regulated group, they object to restrictions placed on their activities. Fishers are also wary of radical environmentalists or people affiliated with high-profile wildlife conservation organizations, as some of these groups have campaigned for fishing area closures, marine protected areas, gear modifications to reduce incidental catch of protected species, and have demonstrated against various sectors of the industry. As these actions have occasionally affected consumer demand for marine products in the past and have disrupted the livelihoods of fishing community members, fishers are generally reticent to share information with representatives of these groups.

In the fishing industry, words such as "endangered species" and "conservation" sometimes have negative connotations. Therefore, I was careful to avoid unnecessary use of these terms during interactions with fishers and in educational materials distributed to these groups. Before I became cognisant of these issues, I ordered project hats featuring an image of a leatherback and the text "N.S. Leatherback Turtle Conservation Program". The misconceptions in the fishery with respect to the word "conservation" later contributed to my decision to rename the program the Nova Scotia Leatherback Turtle Working Group. It was promising to hear only a few fishers comment on the original text on the hats, and even then, each did so in a lighthearted manner. This may be indicative of fishing community members recognizing the project as unthreatening.

My experiences revealed that many fishers perceive people conducting legitimate scientific research on marine species as environmentalists, or "green guys", as some fishers are inclined to call them. Unfortunately, the association of scientists with groups perceived to think or act radically can create major obstacles to developing trusting working relationships with members of the fishing community. Recognizing these issues, I was careful to make my affiliation as a university student conducting a research project clear. As I had not recently been preceded in the Nova Scotia fishing community by other scientists interested in marine turtles, fishers immediately began to associate me with my research interests, and my identity in the industry became directly linked to the turtles.

Again, as someone working with the community from the outside, it was not always possible to predict the types of reactions I would receive; however, I learned that consistency in image and approach was crucial (Fig. 2.2). Some were quick to offer advice to assist me in my interactions with their peers. For example, during an early visit to a wharf in Shelburne Co., I noticed that some of the fishers present on the wharf retreated into the wheelhouses of their boats after watching me chat with one captain. Surprised, I asked another captain to explain this reaction. He replied that he and his crew were reacting not to me, but to the fact that I was writing notes "like a journalist" in my field book during my last conversation. Obviously some fishers did not feel comfortable with this approach. This was a valuable learning experience for me, and guided my subsequent interview protocol.

My extensive interactions with fishers also enabled me to learn the vernacular for referencing direction, particular types of gear, marine species, etc. that are unknown to or rarely used by those outside of the industry. This knowledge, coupled with the practical experience of accompanying crews during fishing trips, proved invaluable in establishing working relationships with dozens of people associated with the fishing industry.

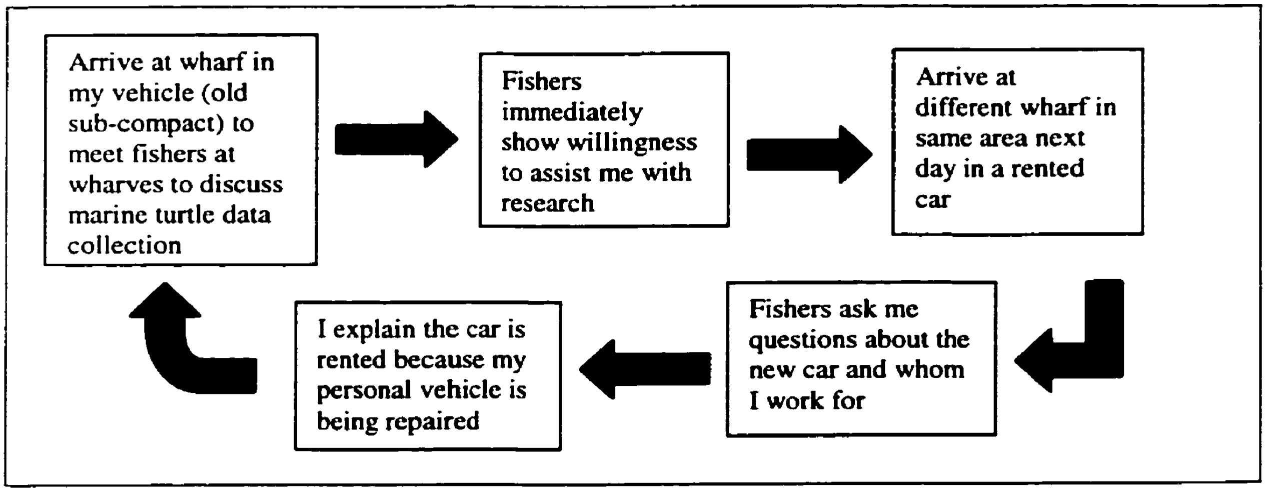

Figure 2.2. Working with fishers: the importance of consistency in image and approach.

Fishers were normally most responsive when I interacted with them informally. This was true both at wharves and during presentations made to fishing organizations or small groups of fishers. Presentations made to the fishing community were typically different from those prepared for delivery in conferences and other academic contexts. For example, presentations made to fishing community members seemed to generate the most interest when they were brief and provided opportunities for fishers to comment on issues and ask questions both during and after the session. As the context of presentations was relaxed and informal, when images were used, slide transparencies were used, rather than projection in PowerPoint. Textual slides were kept to a minimum to maintain an informal atmosphere.

CONTACTING THE COMMUNITY: A MULTIFACETED APPROACH

In 1998, 208 volunteer fishers had joined the Working Group. By August 1999, this number had risen to 343. This level of participation was the product of an effort to raise awareness across Nova Scotia of leatherback biology and conservation in coastal communities and to recruit fishers as volunteer leatherback data gatherers.

To enlist volunteers, I approached the fishing community directly and indirectly (Table 2.1). Informal information sessions held at wharves, on boats, or in the homes of interested fishers provided the most effective means of motivating fishers to become active members of the Working Group. Several formal presentations were made to fishing organizations during 1998; however, these sessions rarely recruited large numbers of volunteers. Clearly, one-on-one, face-to-face introductions were most important in earning the trust and cooperation of fishers. The timing of visits to wharves was also important. Not surprisingly, fishers were most receptive to talking about marine turtles when they were not preoccupied with other tasks (e.g., landing catch or preparing to depart on a trip). Early morning and early evening visits to wharves were often the most productive.

Methods of Contact
• Mail-out to provincial fishing organizations • Phone calls to fishing organization executives • Distribution of tri-fold brochure on leatherback biology and research • Leaving sighting kits on the decks of commercial fishing boats • Working Group three-panel display set up at coastal community events • Working Group presentations to fishing organizations (formal) • Media coverage of Working Group in local and national newspapers • Working Group presentations to school children in fishing villages • Approaching fishers directly at wharves or in gear co-ops, bait sheds, etc. • Informal meetings with small groups of fishers on their boats or in their homes • Working Group poster (including toll-free project phone number) featured on wharves, in co-ops, coffee shops, etc. • Distribution of postcard featuring leatherback and toll-free number for reporting sightings

Table 2.1. Promoting fishing community participation in leatherback turtle research: a multifaceted approach.

Presentations made to schools in fishing villages generated interest and enthusiasm about marine turtles in many students whose parents were directly linked to the fishing industry. As a result, this approach frequently yielded excellent contacts amongst local fishers.

Participation in the Working Group by members of the fishing industry was also likely a product of colourful project posters (Fig. 2.3) placed in high-traffic areas on wharves, in bait sheds, fish plants, ice stations, cooperatives, hardware stores, liquor stores, local restaurants, coffee shops, and community centres.

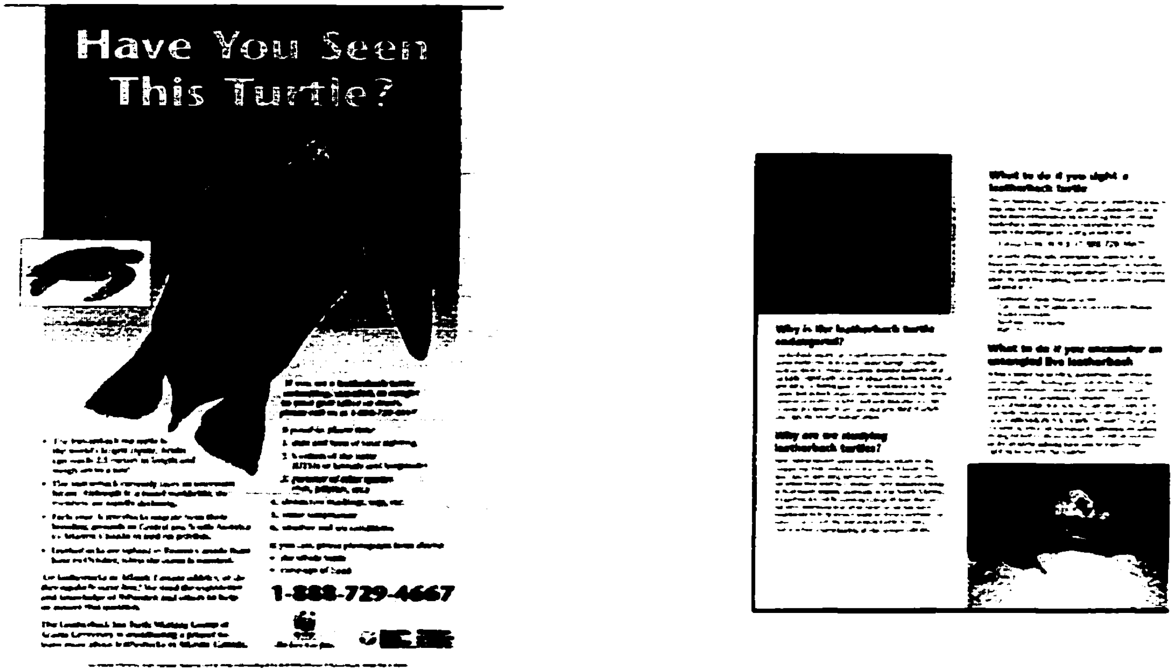

Figure 2.3. Working Group educational materials: 1998 poster (left) and brochure (right).

The Working Group poster evolved considerably from its initial design in early 1998 to its final form in 1999 (Fig.2.4). Other project materials, including the marine turtle identification key and sighting sheets, were also modified based on feedback from fishers.

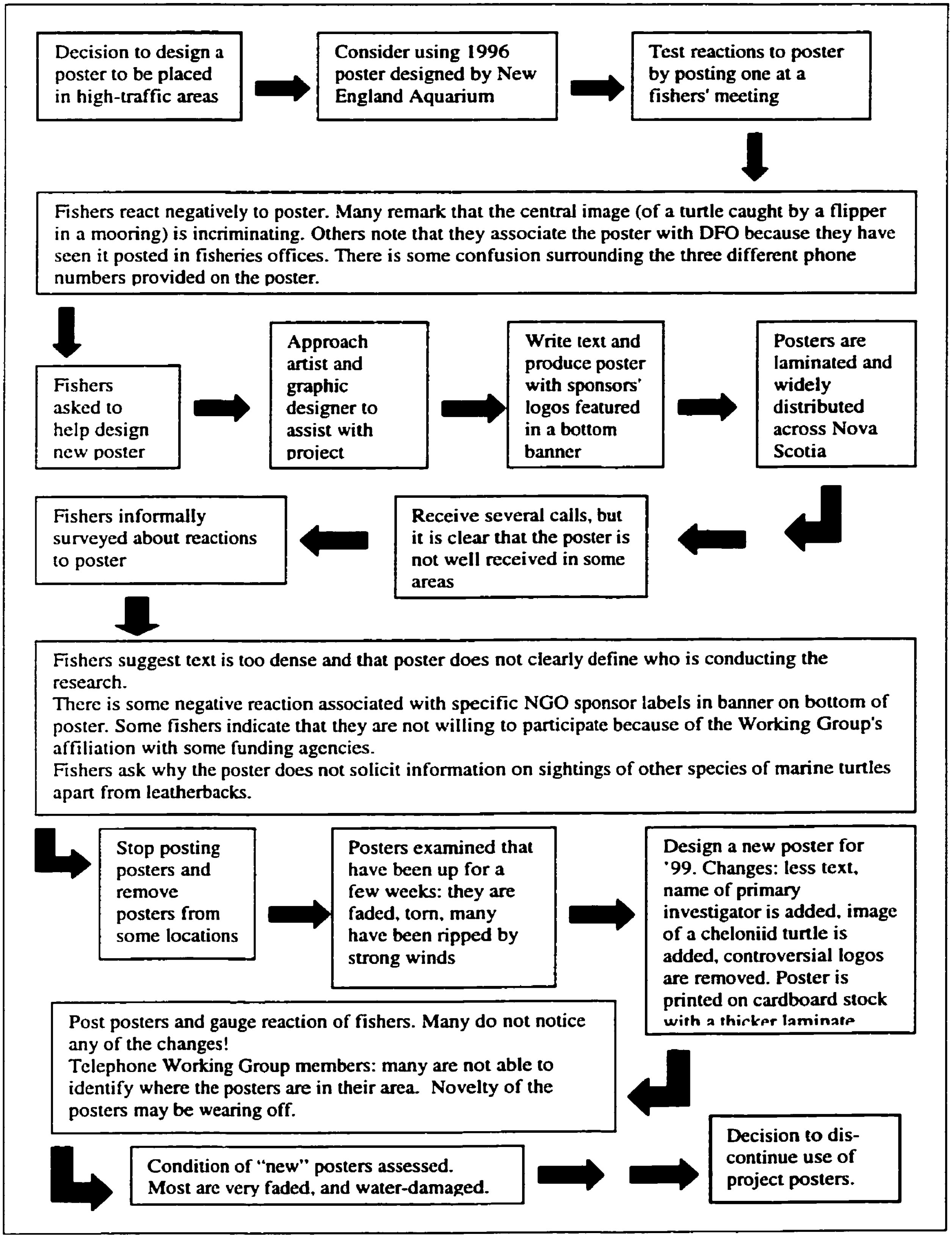

Figure 2.4. Evolution of the Working Group project poster.

It is important to recognize the significance of the toll-free phone service (1-888-729-4667) established to facilitate the reporting of marine turtle sightings. The turtle reporting hotline was advertised on all project materials, from posters to sighting kits. It was widely used by fishers in Nova Scotia, Newfoundland and Prince Edward Island to report both current sightings and historical encounters with turtles. Moreover, it provided fishers and other members of the general public with a simple way of contacting me to inquire about the Working Group's research and conservation efforts. It is interesting to note that the 1-888 exchange was not initially recognized as toll-free by some individuals, as 1-800 exchanges are more commonplace. However, it is unlikely that such confusion had any significant effect on the response rate.

Apart from the project poster, written communications (e.g., letters, distribution of the tri-fold project brochure, etc.) were not generally effective as a preliminary way of contacting fishers and promoting participation in the Working Group. However, written correspondence used after fishers were initially contacted in their communities was important.

PART 2: STANDARDIZATION OF DATA COLLECTION

A number of steps were taken to standardize data collected by commercial fishers. Informal training sessions normally held at wharves provided opportunities to explain the significance of the research to volunteers. These occasions were also typically used to share proper techniques for marine turtle identification and data recording. Sighting kits were also distributed to all Working Group members. These kits, packaged in large Ziploc bags, included the following materials:

- a laminated colour key to the cheloniid turtles of the northwest Atlantic
- a tri-fold brochure introducing the Working Group and providing basic information on leatherback biology
- instructions and forms for recording pertinent turtle and environmental data (SST, depth, etc.)
- a pencil
- a postage-paid envelope for the return of sighting sheets at the end of the season.

All written materials in the kit featured the toll-free phone number for reporting sightings of marine turtles. The sighting sheets were developed in association with Working Group members. As a result, the sighting sheets evolved from text-laden forms requiring a significant amount of writing, to forms that included numerous icons to direct observers to record particular data. The revised forms also integrated check-boxes and diagrams to reduce the amount of writing required. The end result was a more visually appealing form that also took significantly less time to complete. Several Working Group members were regularly consulted during the preparation of the marine turtle identification key (Fig.2.5).

When fishers who had not been previously contacted called to report sightings of leatherbacks, they were immediately sent sighting kits. Most of these individuals were responding to project posters on wharves or in other locales. They were normally very willing to join the Working Group. This is not surprising, as these individuals made the initial effort to contact us. It is important to recognize that these members of the fishing community were not actively recruited to become volunteer data gatherers, as was the case with many other Working Group members.

After initial contacts with volunteers, most Working Group members were contacted on a second occasion during the field season, either during a return visit to a wharf or by phone, to inquire if they had encountered any turtles since receiving their sighting kits. All Working Group members were also contacted at the end of the field season to collect completed sighting sheets. This normally involved calling fishers or sending them a brief reminder in the mail.

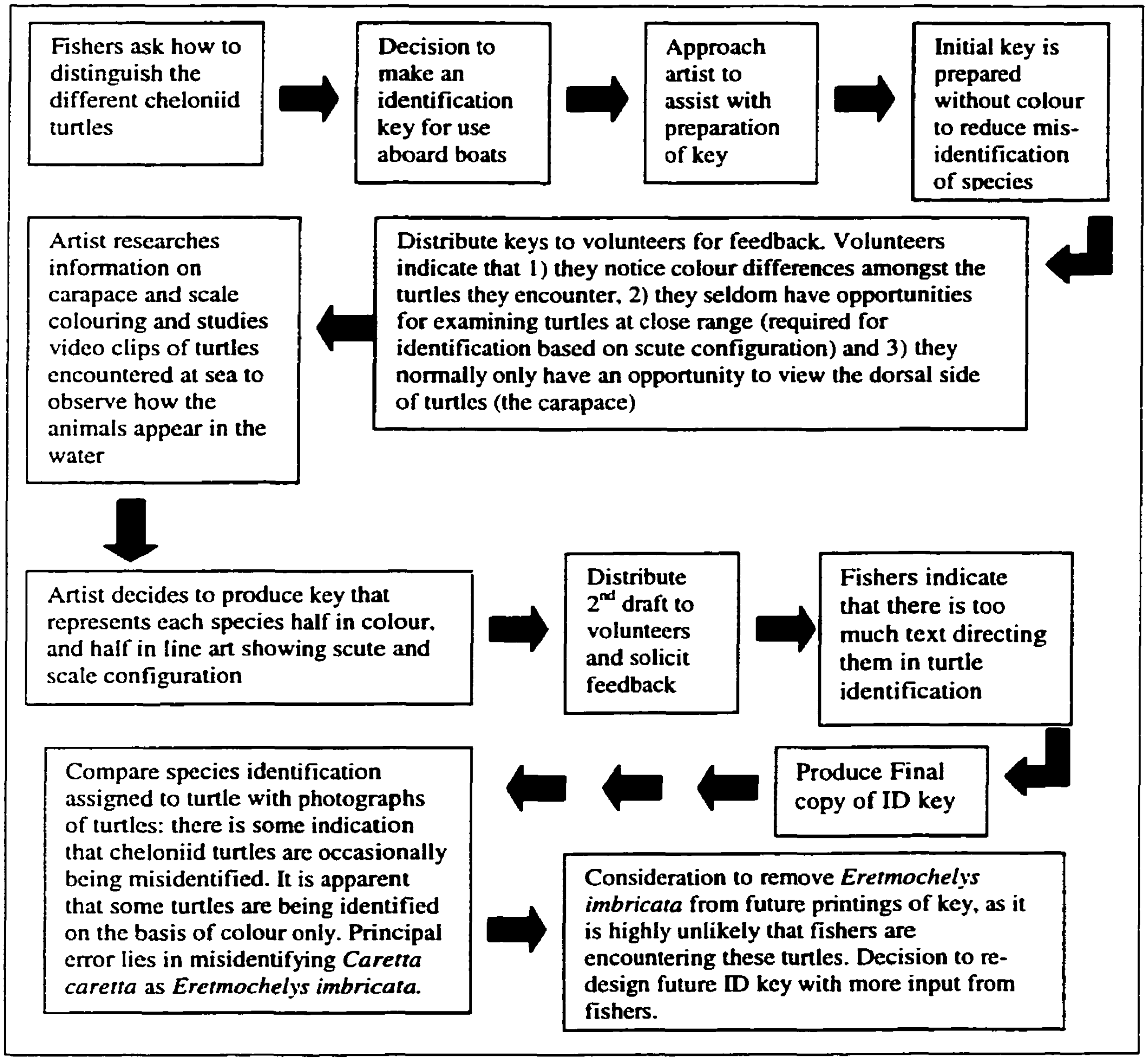

Figure 2.5. Development of a marine turtle identification key for Working Group members.

PART 3: PROMOTING LONG-TERM COMMUNITY-BASED MARINE TURTLE MONITORING AND CONSERVATION

Several measures were taken to promote interest in marine turtle biology and conservation amongst Working Group members and to maintain their long-term involvement in this project. First, this work revealed that regular contact with volunteer fishers is of paramount importance. The most effective contact with Working Group members came from meeting these individuals directly during visits to coastal communities during the summer and fall and accompanying them on fishing trips. While it was often possible to join Working Group members on specific trips, unfortunately, the irregular, but intense fishing schedules of most volunteers meant that these ventures were more often last-minute arrangements, rather than excursions planned long in advance. Similarly, unless sea conditions were highly unfavourable, it was normally unrealistic to expect to meet specific volunteers during visits to wharves. This was particularly true during summer, when many fisheries in Atlantic Canada are open.

Regular mail-outs reminding Working Group members to return completed sighting sheets provided other opportunities for regularly contacting volunteers. Maintaining the project's 24-hour toll-free phone line throughout the year also enabled volunteers to contact me at any time. A biannual newsletter, "The Leatherbacker", kept Working Group members informed about the program's findings, shared information on leatherback biology, and provided a medium for recognizing the contributions of individual volunteers to the research. It is important to observe that some Working Group members communicated their interest in not having their participation in the research publicly acknowledged in any way. This desire to remain anonymous may have stemmed from concerns regarding potential reproaches from family and/or peers who disagree with volunteering information to scientists. Similarly, the fishing organizations to which various fishers belong may not sanction participation in unpaid research. Whatever the reasons, it was clearly important to offer complete confidentiality to all Working Group members.

Another key in sustaining volunteer effort in this program involved maintaining consistency in personnel available to interact with Working Group members and potential Working Group members. This may be particularly important in rural coastal Nova Scotia, where word travels fast and people readily associate one person with a particular affiliation or organization. My experience revealed that representation of the program by several different biologist- and naturalist-members of the Working Group at wharves across the province was far less effective than when the same person (myself) consistently represented the Working Group in interactions with fishers. For example, this phenomenon may explain a marked decrease in participation in reporting marine turtles in Yarmouth Co. in 1999. Volunteer fishers across Nova Scotia expressed their interest in dealing with the same person when reporting the details of turtle sightings. As it sometimes required considerable effort to earn the trust of fishers and recruit them as volunteers, it seems obvious that interests such as these may be related to concerns fishers have with respect to confidentiality of volunteered information. As a "consistent face" is an important part of maintaining healthy public relations in this type of project, it was necessary to ensure that valuable contacts were not jeopardized by allowing the Working Group to grow too big or involve so many people that it became both impersonal and unmanageable.

While volunteers were not rewarded monetarily for their involvement in this research, various incentives were provided to fishers who participated. Principal amongst these was the project baseball hat. The decision to design and distribute project baseball hats came from the recognition that hats are both popular and essential items of clothing in the fishing industry. Working Group hats were given to captains and crew to recognize their contributions to the research. Fishers were not aware of this reward program until they received the hats in the mail. Project hats were deliberately distributed at the same time during the winter rather than during the field season in order to avoid falsification of data for the purpose of receiving a hat.

Single-use cameras, donated by Fuji Photofilm Canada, provided a second incentive for volunteering and definitely contributed to the success of this research program. Distribution of cameras was selective due to the limited number available (n=100). Volunteers issued cameras were encouraged to photograph the turtles they encountered. By providing volunteers with the added task of carefully photo-documenting their sightings, the quantity and quality of the data they recorded were enhanced (Working Group members were clearly motivated by the challenge of photographing turtles at sea). While volunteers were required to return project cameras or negatives from processed cameras at the end of the season, copies of the prints were sent to each crew member and the costs of developing the film were assumed by the project.

Annual presentations to schools in fishing communities provided a means of updating students and staff with respect to the Working Group's findings. These presentations were beneficial because they often served to contact individuals who were directly linked to the fishing industry (i.e., students and teachers directly related to Working Group members, and/or potential future volunteers).

Continued participation in the Working Group was also encouraged by responding to requests for information made by volunteers and their family members. For example, the Working Group was frequently approached by the children of volunteers for information that could assist them with school projects on marine turtles.

PART 4: EVALUATION OF THE WORKING GROUP

There are both advantages and disadvantages associated with the approach described here. The results from the Working Group (Chapter 3) attest to the success of this program in overcoming obstacles in leatherback data collection that other research groups have struggled with for some time. As an endangered species with a global distribution, leatherbacks are rare and widely distributed over a large area of ocean. Therefore, opportunities for observing and collecting information on these turtles are typically limited. By establishing a large network of willing and capable volunteers who spend extended periods at sea, are widely distributed in coastal and offshore waters, and are skilled observers, many of the challenges associated with leatherback data collection can be successfully addressed.

Conservation-oriented research on large, far-ranging marine species can be prohibitively expensive. However, by involving volunteers in the fishing community, the Working Group has facilitated the collection of much needed baseline data on leatherbacks and other marine turtle species on a very modest budget. As a volunteer program, the Working Group concept offers an economically sustainable alternative to costly research programs that invest tens of thousands of dollars in dedicated aerial and vessel surveys or provide monetary rewards to encourage data collection by fishers.

With over 350 Working Group members (1999), there is substantial sampling effort at minimal cost. Opportunities for marine turtle data collection by these individuals are widely distributed across a broad geographic area that includes the Gulf of Maine, Bay of Fundy, Grand Banks, Gulf of St. Lawrence, and Laurentian channel.

Beyond economic considerations, another advantage of the Working Group stems from the fact that this approach involves those individuals who are not only best poised to collect data on marine turtles, but who can also effect practical conservation of these animals. Volunteers are regularly consulted about practical and safe techniques for releasing incidentally-caught turtles. By discussing and sharing these techniques with large numbers of fishers, awareness of leatherback biology and conservation issues is increased. It is likely that this increased awareness translates into positive actions to conserve these animals at sea.

Another advantage of the Working Group is that this program is largely community based. The program has local support in many coastal communities, and is partly driven by those individuals most likely to observe and interact with marine turtles (i.e., commercial fishers). These features are critical, as the ultimate objective of the program is to support long-term monitoring and conservation of marine turtles.

The establishment of the Working Group has also provided a platform for expanding research on marine turtles in eastern Canada. By working cooperatively with fishers, it is possible to take advantage of occasional opportunities for hands-on work with turtles. For example, in summer 1999, I collaborated with a number of fishers to tag and obtain DNA samples from several leatherback turtles at sea. This exercise was only possible with the interest, knowledge and experience of the fishers involved. Therefore, by working with fishers, we can overcome many of the logistical challenges associated with marking and sampling marine turtles at sea. We can also broaden our research to include both male and juvenile animals (one of the leatherbacks tagged in summer 1999 was a male). This is significant, as work to date has focussed on females for logistical reasons (females are most accessible because of nesting); however, there is very little known about males and immature age classes of both sexes.

Many of the disadvantages associated with the Working Group approach are common across other wildlife surveys of this type. Working Group members collect marine turtle data opportunistically; they do not perform deliberate, transect-based surveys for turtles. Therefore, it is possible that some turtles are recorded on multiple occasions. The alternative, more likely scenario is that observers fail to detect turtles as they are fishing or travelling to and from fishing grounds. Relatively flat sea conditions are required for spotting turtles from a boat; therefore, visibility is affected by weather conditions. Bias in visibility and reporting may also be related to variation in fishing strategy and gear type. With respect to bias in reporting associated with gear type, individuals involved in the swordfish harpoon fishery may contribute a disproportionate number of sightings relative to fishers representing other fisheries because the harpoon fishery depends on continuous vigilance to detect basking swordfish from a distance. Therefore, it is not surprising that these fishers frequently see turtles while looking for swordfish. Crab fishers, on the other hand, often fish at night and are, as a result, less likely to spot turtles.

Gear type may modulate reporting of turtles in other ways, as fishers involved in fisheries censured by environmentalists and other groups may be less likely to report encounters with marine turtles. For example, the pelagic longline industry is frequently criticized regarding bycatch, and fishers in this industry are sensitive to widespread negative public opinion of this fishery. Therefore, this fleet may be less likely to volunteer information of any kind to scientists. While the Working Group includes representatives of all fisheries active in this region, pelagic longliners are under-represented. Harpoon swordfishers, by contrast, may be overrepresented partially because there is no bycatch in this fishery.

Another weakness associated with this approach concerns the distribution of fishing effort. An absence of sightings from a particular area does not necessarily indicate an absence of turtles. Instead, these areas may host little or no fishing activity. By contrast, highly productive areas that are popular fishing grounds (i.e., edges of Georges Bank, Gulf of Maine) may yield a disproportionate number of sightings because of intense fishing activity in those areas. Similarly, area closures will affect the distribution of sightings. Therefore, with this method of data collection, it is impossible to separate observer effort from actual abundance, due to spatial variation in fishing intensity.

Finally, external factors such as fish quota, price and availability can indirectly affect the amount of data collected by directly affecting fishing effort, and, therefore, opportunities for encountering turtles.

CHAPTER 3

DISTRIBUTION OF LEATHERBACK TURTLES (*DERMOCHELYS CORIACEA*) IN EASTERN CANADA: EVIDENCE FROM AN OBSERVER PROGRAM, AERIAL SURVEYS, AND A VOLUNTEER NETWORK OF FISH HARVESTERS

INTRODUCTION

The leatherback turtle (*D. coriacea*) is the largest and most widely distributed reptile in the world (Mrosovsky, 1987; Davenport, 1997). Counter-current heat exchangers in the flippers, thermal inertia, a high volume to surface area ratio, different compositions of peripheral and central lipids, and a thick layer of epidermal fat contribute to a remarkable endothermic physiology (Frair *et al.* 1972; Greer *et al.*, 1973; Goff and Stenson, 1988; Paladino *et al.*, 1989; Davenport *et al.*, 1990) that enables these massive marine reptiles to range from tropical to temperate and even to boreal latitudes (e.g., Brongersma, 1972; Lazell, 1980; Goff and Lien, 1988; Gulliksen, 1990).

The leatherback has long been known to occur in waters off Atlantic Canada, and there is evidence to suggest that this area is within the normal range of this turtle (Bleakney, 1965; Lazell, 1980; Goff and Lien, 1988). However, historically, a dearth of records has limited our understanding of the seasonal presence of leatherbacks in eastern Canadian waters and the relative importance of this habitat to this endangered species.

Previous accounts of leatherback occurrence in Atlantic Canada have mainly documented rare instances of coastal strandings and infrequent reports of entanglements in nearshore fishing gear (Squires, 1954; Bleakney, 1965; Steele, 1972; Threlfall, 1978; Goff and Lien, 1988). In all cases, authors have considered small numbers of records. Bleakney's (1965) review contained the largest number of records (29), collected over

140 years (1824-1964), and Goff and Lien (1988) reported 20 records from Newfoundland and Labrador (1976-1985).

Only one review (Goff and Lien, 1988) represents results of an actual study designed, in part, to collect information on leatherback sightings. All other published accounts of leatherback presence in Canadian waters represent reports of single records (e.g., Miller, 1968; Steele, 1972; Threlfall, 1978) or compilations of multiple records opportunistically collected over several years (e.g., Squires, 1954; Bleakney, 1965). While all of these accounts suggest that leatherbacks may be regular summer and fall migrants to the temperate waters of eastern Canada, these reports represent small sample sizes (1-29) and detail only inshore presence.

This study draws on 237 geo-referenced records of leatherbacks from three sources: aerial surveys, a fisheries observer program, and a volunteer network of fishing community members, to characterize the broad temporal and spatial distribution of this species in Atlantic Canada.

METHODS

Leatherback turtle records were collected from a broad area of the northwest Atlantic, including the Scotian Shelf, pelagic waters beyond the shelf break, the Northumberland Strait, and coastal Newfoundland (Fig.3.1).

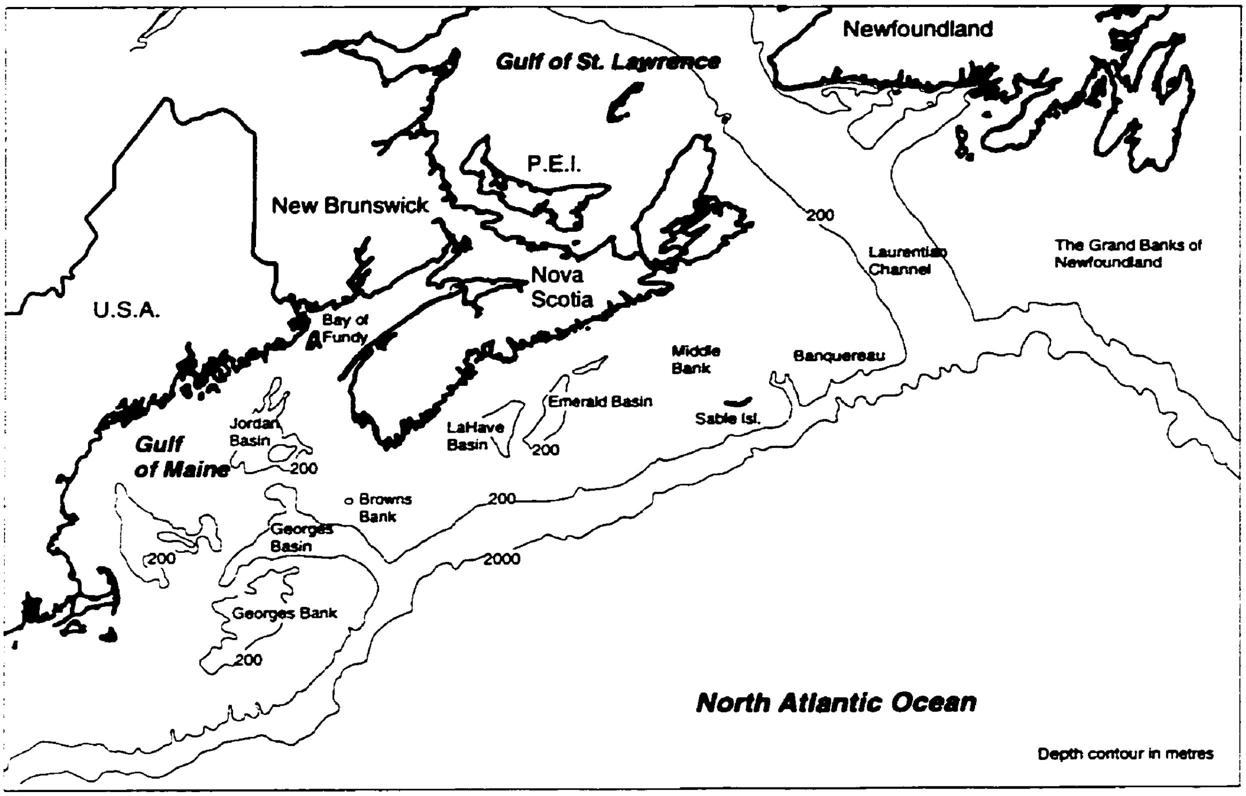

Figure 3.1. Study area.

Aerial Surveys

Several studies have demonstrated the utility of using aerial surveys to assess the distribution of marine turtles (e.g., Fritts *et al.*, 1983; Shoop and Kenney, 1992). As part of a program to monitor the distribution and abundance of endangered North Atlantic right whales in the Bay of Fundy and along the Atlantic coast of Nova Scotia, aerial surveys were conducted by East Coast Ecosystems (Freeport, N.S.) in 1998. In addition to recording marine mammals, the details of leatherback sightings (including date, time and latitide/longitude) were recorded. Systematic, stratified tracklines were flown in a Cessna Skymaster 337 at a standard altitude of 750 feet and ground speed of approximately 100 knots (Brown and Tobin, 1999). To enhance wildlife sighting potential, all surveys were flown under visual flight rule (VFR) flight conditions up to

Beaufort sea state four. This allowed observers to detect large cetaceans (e.g., fin whales, right whales), small cetaceans (e.g., minke whales, harbour porpoise), large fish (e.g., basking sharks, ocean sunfish), and large marine turtles (i.e., leatherbacks) at or near the surface. Tracklines were flown over the Scotian Shelf and Bay of Fundy in an area bordered by 67.25°W latitude and 62°W latitude (Fig.3.2). Forty-one tracklines were flown latitudinally (east to west) at either five or ten nautical mile intervals (Fig.3.2).

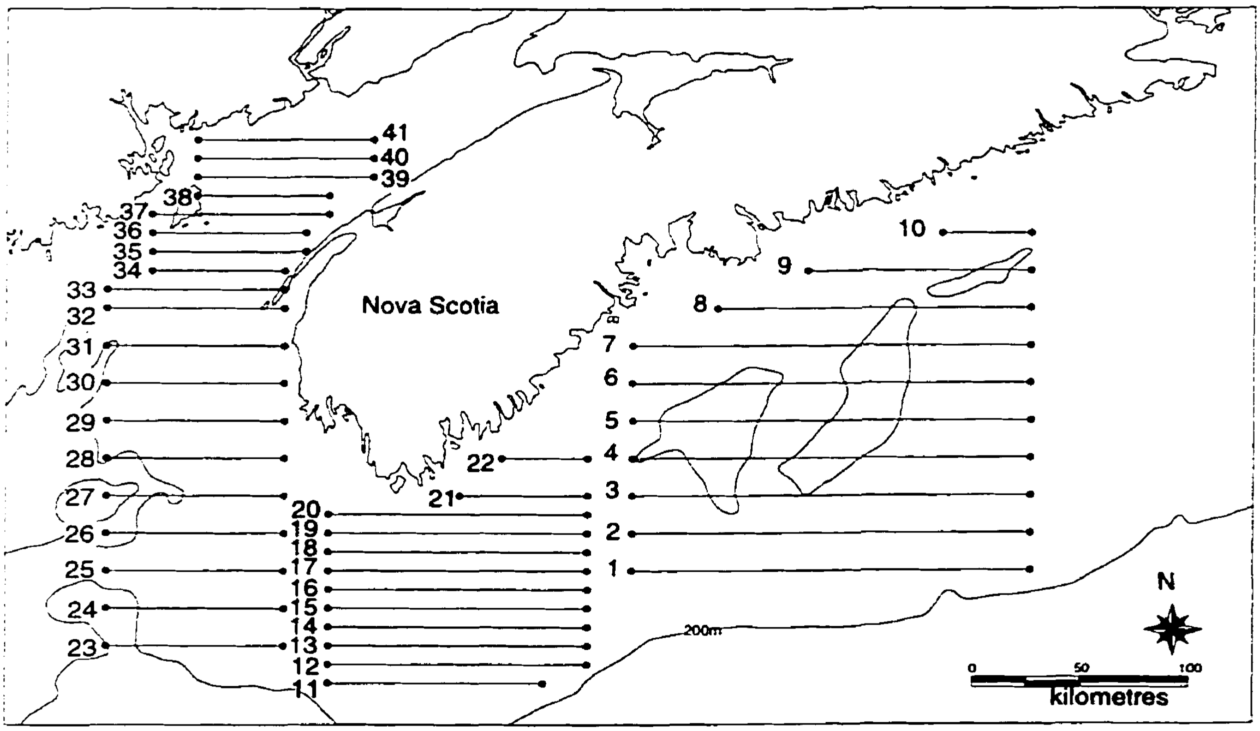

Figure 3.2. East Coast Ecosystems' aerial survey tracklines: July to September, 1998.
Adapted from Brown and Tobin, 1999.

Thirteen days of surveys allowed for replication of most tracklines (Table 3.1) and provided good opportunities for detecting leatherbacks present in surface waters in the sampled areas.

Day (yy/mm/dd)	Tracklines surveyed
98/07/25	38-41
98/07/27	28-37
98/08/01	23-27, 12,13
98/08/02	13-18
98/08/04	19-21, 1-3
98/08/07	4-9
Second replicate 98/09/02	34-41
98/09/03	24-33
98/09/14	13-17
98/09/15	1, plus one 5nm to the south and one 5nm to the north
98/09/17	2, 33-37
98/09/25	3-6
98/09/26	6-9

Table 3.1. East Coast Ecosystems' aerial surveys: tracklines by date.
Adapted from Brown and Tobin, 1999.

International Observer Program (Scotia-Fundy region)

As part of an initiative by the Department of Fisheries and Oceans to monitor marine fisheries in eastern Canadian waters, the International Observer Program (IOP) instructs observers to document incidental capture of many non-targeted species. The IOP coverage includes foreign and domestic vessels fishing in Canadian waters. Observers cover pelagic longline trips (directing for swordfish, tuna and shark) and trips representing other fisheries. Until recently, observers were not instructed to record incidental capture of marine turtles in their fishing trip reports, as the profile of marine turtles in this part of the world, and the importance of collecting such information has only recently come to light. In 1998, marine turtle species codes were developed by the IOP, and, in 1999, observers were asked to record the details of all encounters with turtles.

In any particular year, the IOP covers only a small percentage of the fishing trips conducted in Canadian waters, and, apart from a handful of reports volunteered from fishers, incidental catch data are not available for trips without observers. While IOP coverage of foreign pelagic longline vessel activity in Canadian waters is 100%, in 1998, IOP coverage of domestic pelagic longline vessels totalled only 221 sea days (G. Croft, Scotia-Fundy Sector, Observer Program, Department of Fisheries and Oceans, pers. comm.). This represented 6.5% of the annual total of 3,391[1] sea days associated with this fishery in Scotia-Fundy.

As there was no protocol in the IOP (1978-1998) for collecting data on incidental catch of marine turtles, and, therefore, no instruction regarding turtle identification and recording of pertinent data, basic information on sea surface temperature (SST), species identification, and the number and condition of entrapped animals was not consistently recorded. However, a preliminary review of trip reports revealed that incidental capture of marine turtles was sometimes noted, and, despite the fact that only one general (non species-specific) category code was available to document turtle bycatch, observers occasionally referred specifically to leatherbacks. This is likely due to the leatherback's marked divergence in morphology from cheloniid turtles, which are also known to occur in Canadian waters. Cheloniid turtles, which are more difficult for untrained observers to differentiate, were very rarely identified to species, and only since 1998. Therefore, two categories of marine turtles emerge from the data: "unidentified" turtles (which are likely mainly cheloniids, in particular, loggerhead turtles (*Caretta caretta*)) and leatherbacks

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[1] This figure represents total 1998 sea days for domestic pelagic longline swordfish, tuna and shark fisheries occurring in NAFO unit areas 4V, 4W, 4X and 5. There was a discrepancy between data obtained from the IOP, 2717 sea days (G. Croft, Observer Program, Scotia-Fundy Sector, Department of Fisheries and Oceans, pers. comm.), and that obtained from the regional commercial data division at DFO, 3391 sea days (E. Myers, Scotia-Fundy Commercial Data Division, Department of Fisheries and Oceans, pers. comm.). While I was advised to consider the higher figure, it is possible that this number reflects double counting of total sea days for vessels fishing multiple pelagic longline licenses during the same trips (G. Croft, Observer Program, Scotia-Fundy Sector, Department of Fisheries and Oceans, pers. comm.).

(*D. coriacea*). Other considerations of marine turtle data from observer programs have yielded an analogous grouping of records (e.g., Witzell, 1984). This analysis will consider records of leatherbacks only. An analysis of the remaining "unidentified" turtle records (1978-1999) will be presented elsewhere. The precise timing and location of entrapment on each set is not known, as only positional information associated with the start and end of retrieval of gear, or "haul back," is noted by observers.

Nova Scotia Leatherback Turtle Working Group

In 1997 and 1998, a province-wide leatherback educational campaign, focussing on fishing communities and active recruitment of interested commercial fishers at wharves across Nova Scotia, contributed to the establishment of a network of 235 volunteer marine turtle data gatherers, including 198 commercial fishers and 37 whale watch operators. This organization, known as the Nova Scotia Leatherback Turtle Working Group, was involved in opportunistic collection of the details of leatherback turtle sightings made at sea (for a detailed description of the Working Group, see Chapter 2). Working Group members were provided with leatherback turtle sighting kits that included forms designed for recording pertinent information associated with sightings (including turtle locations and sea surface temperature). Working Group members reported sightings of turtles from June 11 to November 5, 1998.

Evaluating fishing effort, sighting frequency, and the seasonality of leatherback occurrence in eastern Canada

To assess the relationship between fishing effort and turtle sighting frequency, all IOP and Working Group leatherback records were plotted by Northwest Atlantic Fisheries Organization (NAFO) subzones. Total fishing effort in those NAFO subzones containing turtles was then evaluated by collecting data on the number of fishing trips occurring in these areas (all gear types) by month (Scotia-Fundy Commercial Data Division, Department of Fisheries and Oceans).

RESULTS

Aerial Surveys

In 1998, aerial surveys off Nova Scotia detected a total of 31 leatherbacks during four days of surveying: August 2 (n=11 turtles), August 4 (n=8 turtles), August 7 (n=9 turtles), and September 3 (n=3 turtles). No leatherbacks were detected in the Bay of Fundy, and all turtles were recorded along the continental shelf (Jordan Basin, Browns Bank, Roseway Basin, Roseway Bank, LaHave Basin and Emerald Basin) (Fig. 3.3). Mean sea surface temperature for these sightings was 16.65 ± 1.97°C (range: 12.48-19.68°C).

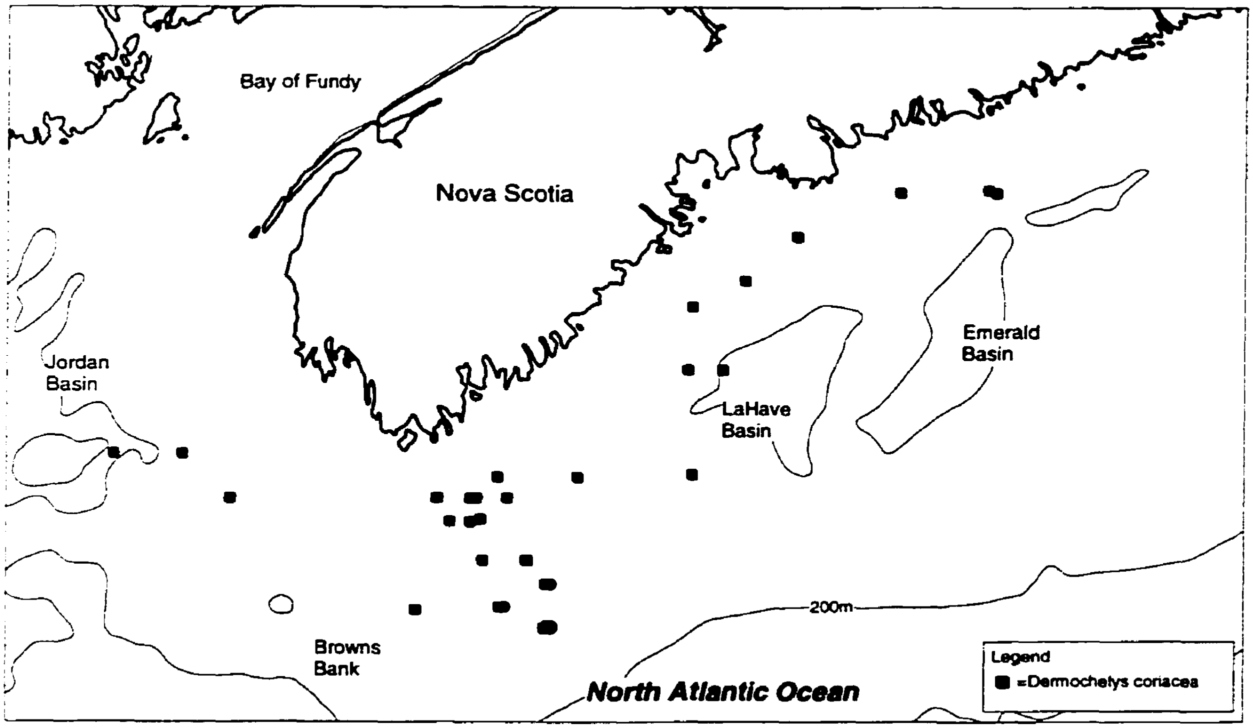

Figure 3.3. Aerial sightings of leatherback turtles (*Dermochelys coriacea*) along the Scotian Shelf, 1998.
Note: There are two instances of two animals at one location.
Source of data: Right whale aerial surveys (East Coast Ecosystems, Freeport, N.S.)

International Observer Program (Scotia-Fundy Region)

The earliest record of a leatherback from the IOP dates back to October, 1987. For the period ending October, 1998, IOP records reveal incidental capture of 25 leatherbacks in offshore waters (Fig.3.4). Eight of these records were from 1998 (Fig.3.7). IOP records of leatherbacks are widely distributed along and beyond the continental shelf break. All records are of turtles caught in the pelagic longline fishery on sets measuring between 24 and 147 km in total length (average set length 57.7 km).

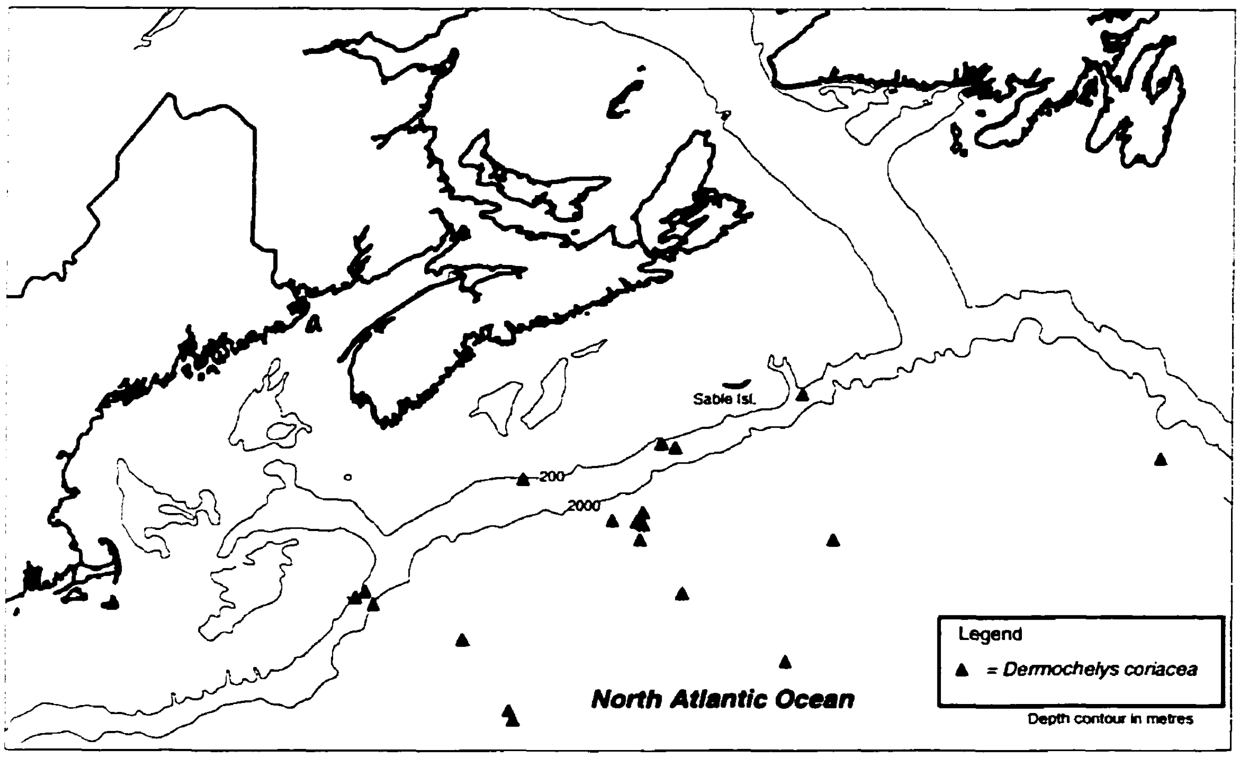

Figure 3.4. Incidental capture of leatherback turtles (*Dermochelys coriacea*), 1987-1998, as recorded by the International Observer Program (Scotia-Fundy Region).
Note: Each symbol represents incidental capture of one or more leatherbacks on a single set of gear.
Source of data: IOP (Scotia-Fundy)

Observers are instructed to record positional information (latitude and longitude) only at the beginning and end of a set. Mapped turtle locations reflect the latitude and longitude associated with the end of the set on which the turtle(s) were caught. Since gear deployed in pelagic longline fisheries in the northwest Atlantic can extend over 150 km (for these records 24-147 km) and routinely takes nearly 24 hours to deploy, fish, and retrieve, turtles can be captured when the longline is being set or hauled, or when it is left to fish (Witzell, 1984). Therefore, the mapped positions do not represent point locations of turtle entrapments. Instead, they represent general areas where leatherbacks were encountered. The length and method of deployment of longline gear (drifting, not fixed) make it impossible to identify specific locations of capture.

Recorded incidental catch of leatherbacks was highest in 1995 (n=10 turtles) and 1998 (n=8 turtles). Observers noted the condition of 20 of the 25 leatherbacks recorded as alive at the time of release. This information was not available for the remaining five animals. Multiple captures of leatherbacks were recorded on 5 of 19 separate sets of gear: there were four sets that captured two turtles each, and a fifth set that captured three turtles. Mean sea surface temperature associated with sets containing turtles (1987-1998) was 19.07 ± 2.02°C (range: 14.6-22.6°C). In 1998 only, mean sea surface temperature associated with sets with entrapped leatherbacks (n=8 turtles) was 19.9 ± 2.29°C.

Nova Scotia Leatherback Turtle Working Group

Working group members reported 171 geo-referenced sightings of leatherbacks in 1998 (Fig. 3.5). Sightings were most numerous along the east side of Georges Bank (Gulf of Maine) and in nearshore waters along the Atlantic coast of mainland Nova Scotia and Cape Breton. Records included four reports from the mouth of the Bay of Fundy and five from the Gulf of St. Lawrence. Mean sea surface temperature across those records for which remotely-sensed data were available (n=121) was 16.96 ± 2.59°C (range: 5.2-20.8°C).

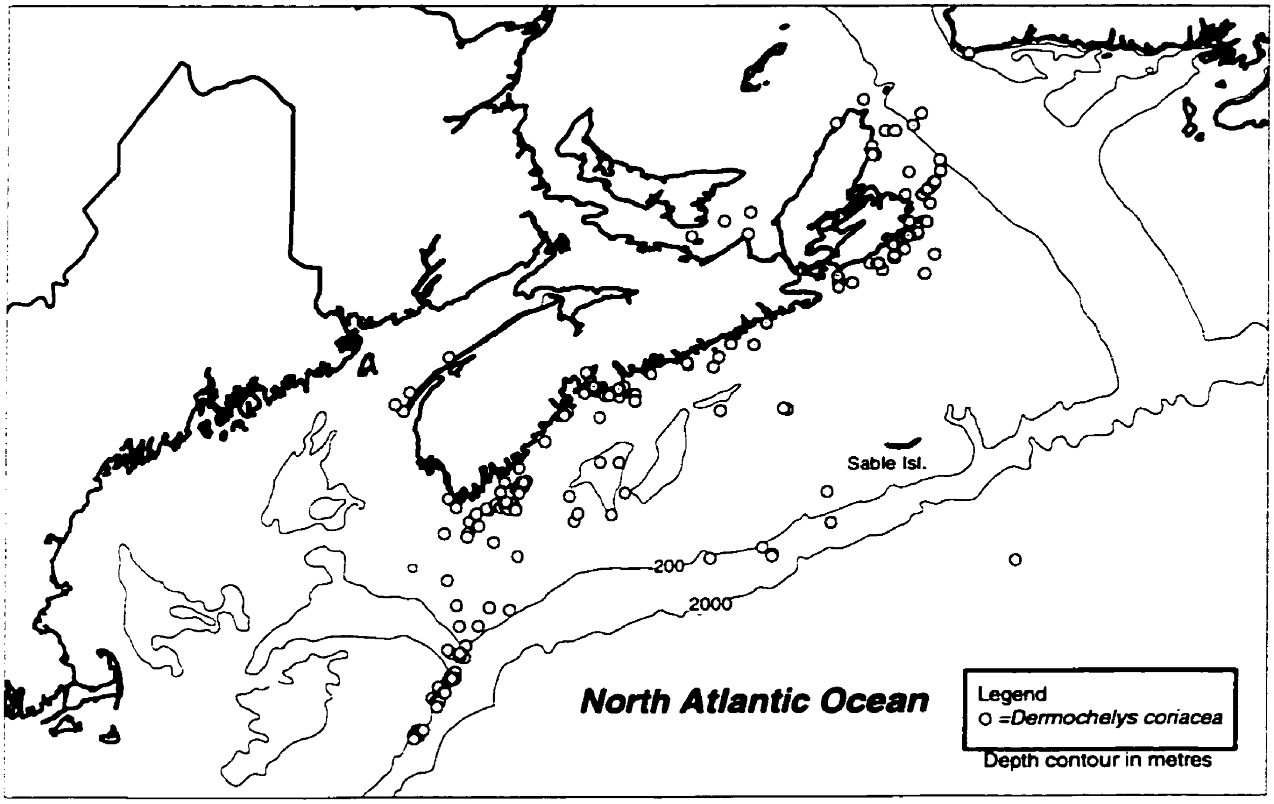

Figure 3.5. Records of leatherback turtles (*Dermochelys coriacea*) collected by the Nova Scotia Leatherback Turtle Working Group, 1998.

Distribution of leatherback sightings from all three sources of data: IOP, aerial surveys and the Working Group

1998 records of leatherbacks from all three sources of data (aerial surveys, IOP, and the Working Group) revealed a general distribution of sightings along the continental shelf (Fig.3.6). Nearshore records were common along the coast of mainland Nova Scotia and Cape Breton.

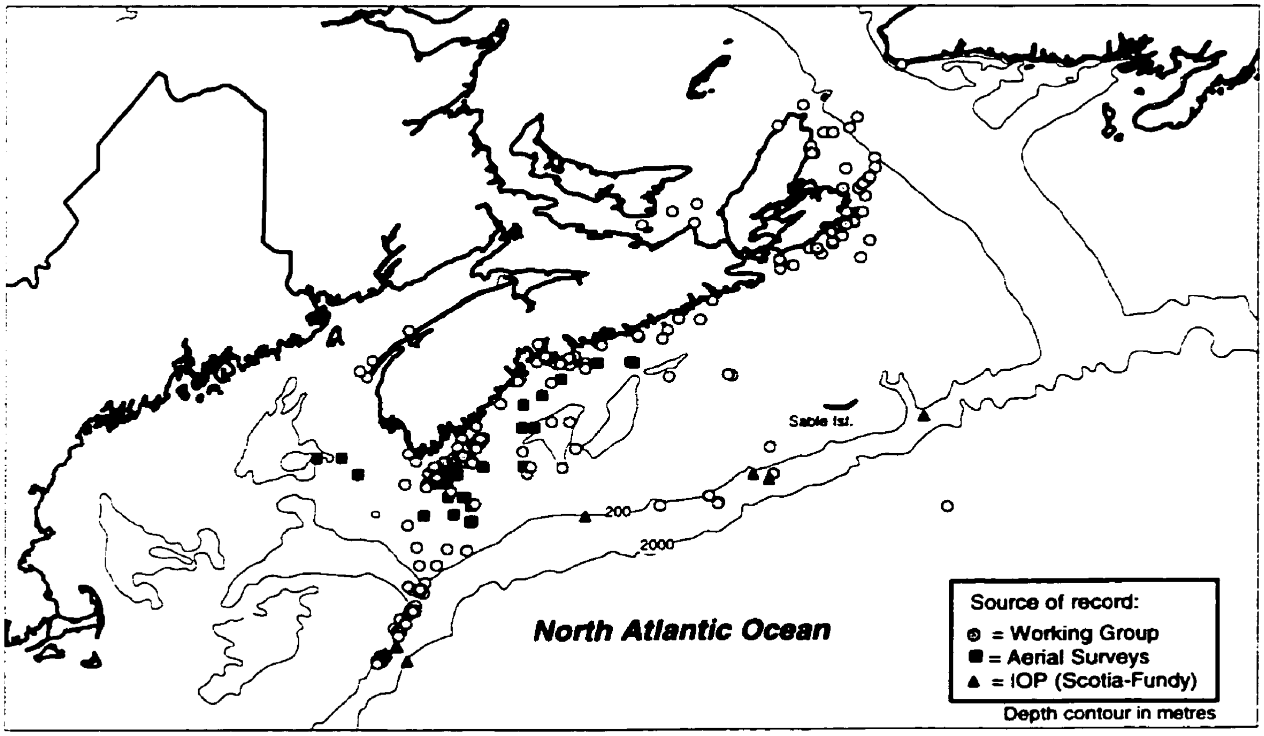

Figure 3.6. Distribution of 1998 leatherback turtle (*Dermochelys coriacea*) records from aerial surveys, Working Group shipboard surveys, and the International Observer Program (Scotia-Fundy Region).

Evaluating fishing effort, sighting frequency, and the seasonality of leatherback occurrence in eastern Canada

The Working Group and IOP data revealed leatherback presence in 20 separate NAFO subzone areas (Fig.3.7). Leatherbacks were most commonly recorded in four subzones: 4Xo, 4Vn, 4Xm, and 5ZEm (Fig.3.8).

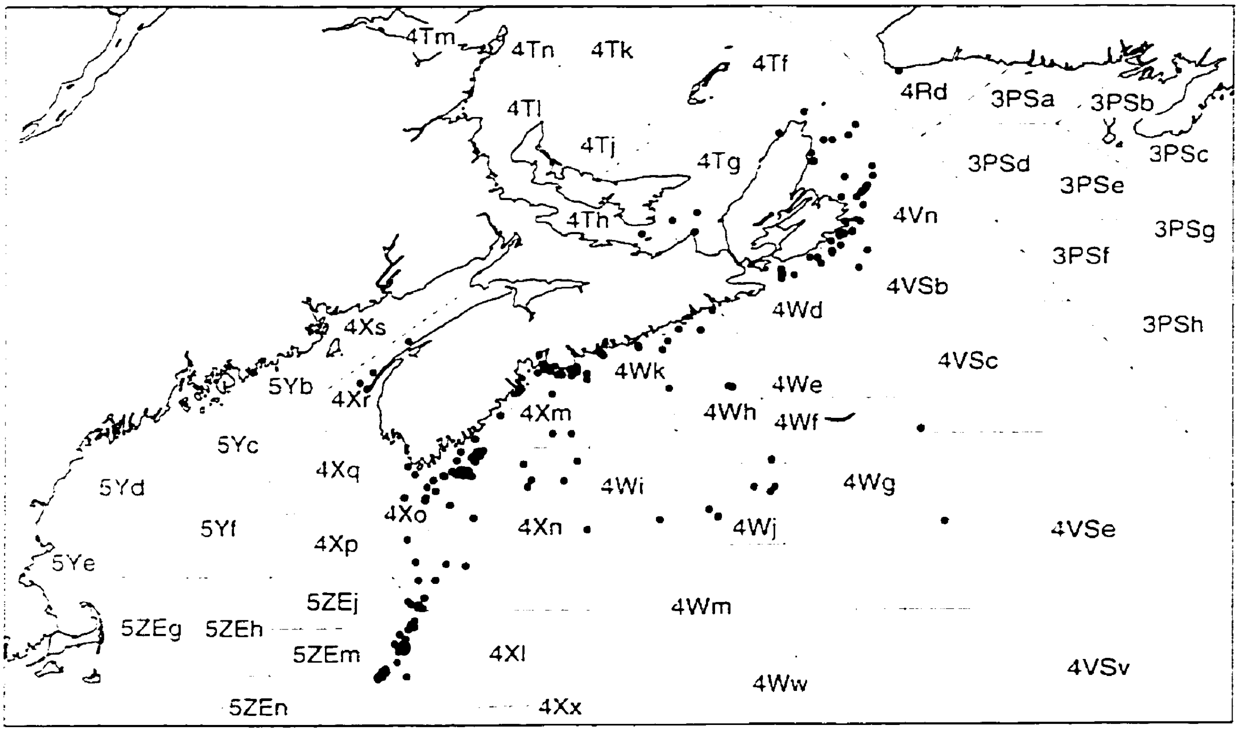

Figure 3.7. Distribution of 1998 leatherback turtle (*Dermochelys coriacea*) records from the International Observer Program (Scotia-Fundy Region) and Working Group by NAFO subzones.

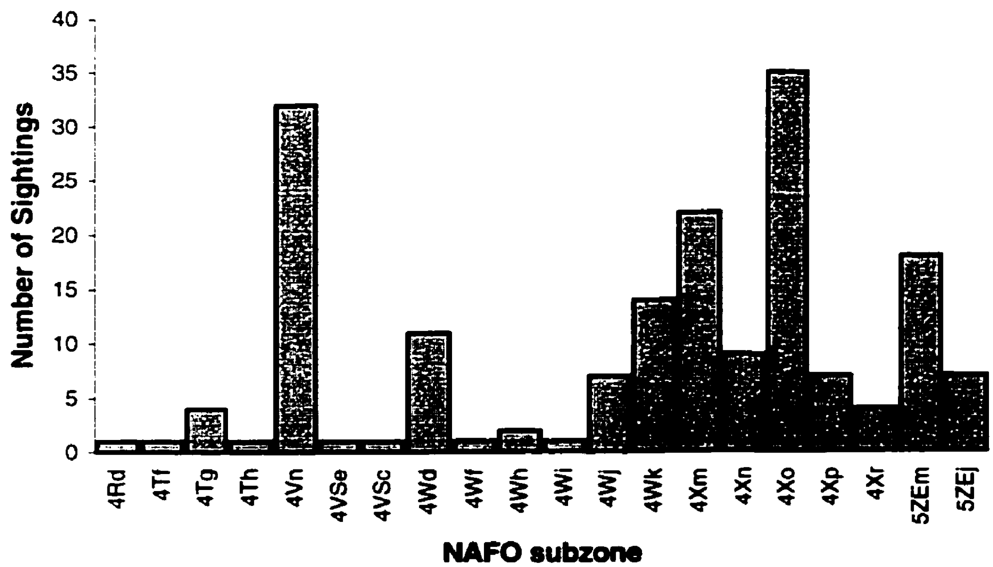

Figure 3.8. Leatherback turtle (*Dermochelys coriacea*) sightings for NAFO subzones, 1998 (where n $\geq$ 1 sighting).

Sighting data from all three sources of records (IOP, Working Group and aerial surveys) were pooled to profile the temporal distribution of leatherbacks in eastern Canada in 1998 (Fig.3.9). Turtles were recorded from March to November; however, sightings peaked during the summer months.

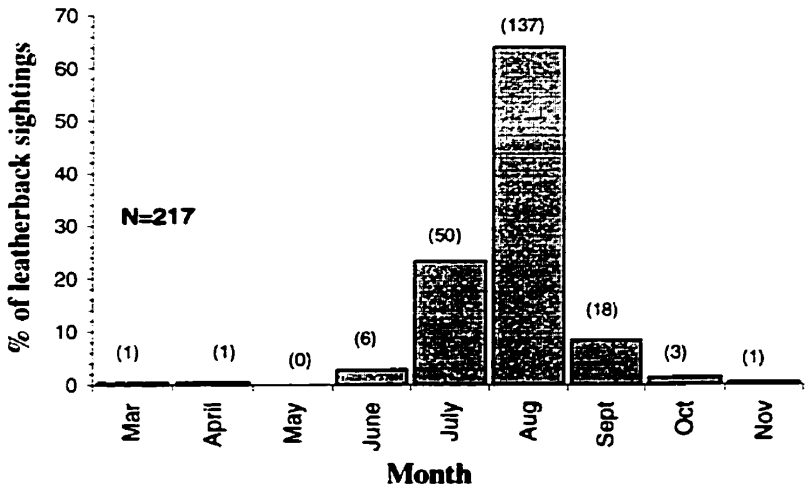

Figure 3.9. Frequency distribution of the percentage of leatherback turtle (*Dermochelys coriacea*) records per month in 1998, as recorded by the International Observer Program (Scotia-Fundy Region), Working Group, and aerial surveys.
Note: Numbers in parentheses above the bars represent the actual number of records.

The total number of trips occurring in each NAFO subzone where leatherbacks were recorded (Scotia-Fundy region only) was used as a rough index of fishing effort. Total fishing effort for the Scotia-Fundy region in 1998 roughly paralleled the frequency of leatherback sightings during summer and early fall (June to September) (Fig. 3.10). While fishing effort outside of this four-month period in Scotia-Fundy was less intense and typically more limited to nearshore areas (i.e., inshore lobster fishery), there were active fisheries occurring from January to June and from October to December; however, leatherbacks were very rarely observed.

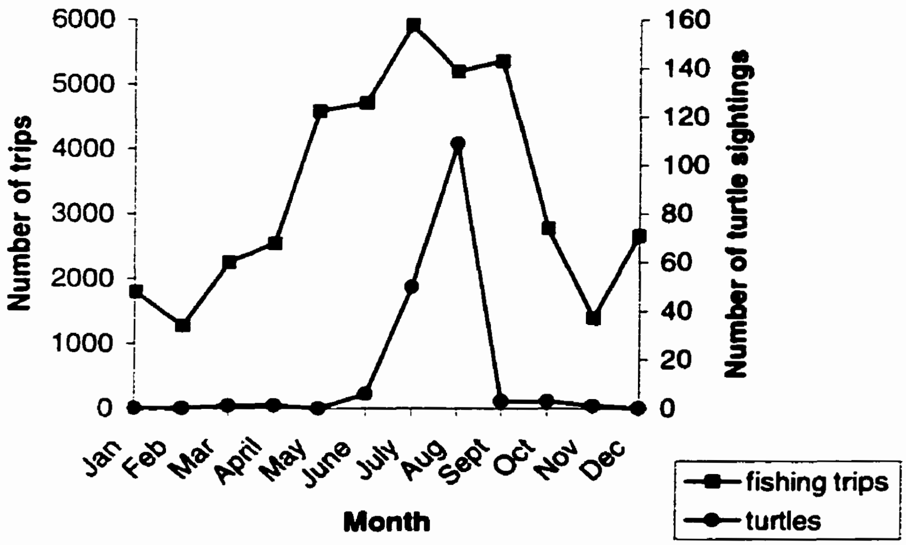

Figure 3.10. Leatherback turtle (*Dermochelys coriacea*) sightings and fishing effort by month (all Scotia-Fundy NAFO areas), 1998.
Source of fishery effort data: Commercial Data Division, Bedford Institute of Oceanography, Department of Fisheries and Oceans.

The total number of trips for June, July, August and September were combined to represent total fishing effort in each NAFO subzone (where n ≥ 1 leatherback sighting) in Scotia-Fundy during the "turtle season" (Fig.3.11). In the overall analysis, leatherback sighting frequency was highly correlated with fishing effort (r^2=0.78); however, sighting frequency did not parallel fishing effort in two NAFO subzones (4Xr and 5ZEj).

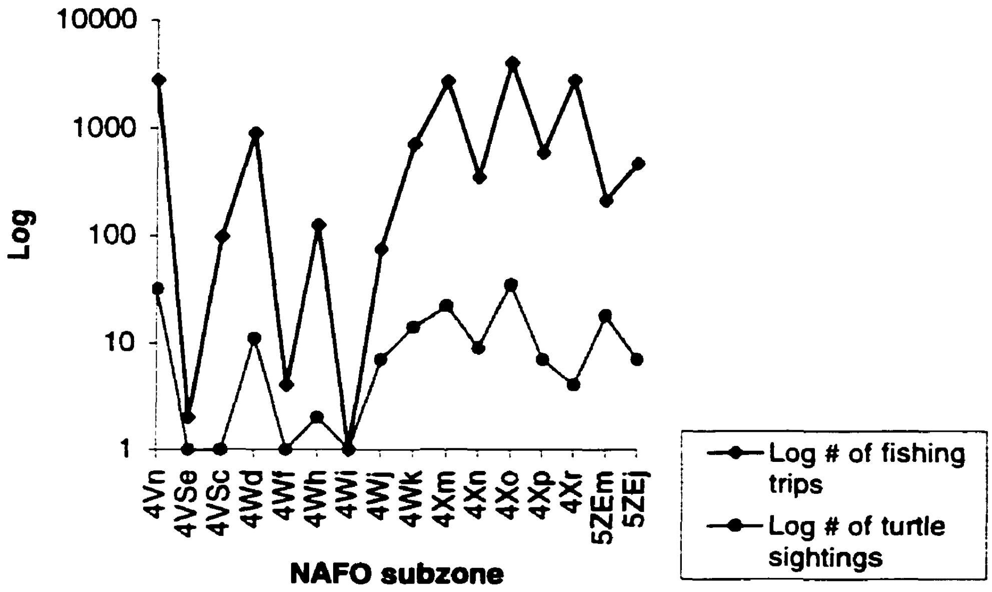

Figure 3.11. Leatherback turtle (*Dermochelys coriacea*) sightings (from the International Observer Program and the Working Group) and fishing effort (number of fishing trips) by NAFO subzone for the period June 01-September 31, 1998.
Source of fishery effort data: Commercial Data Division, Bedford Institute of Oceanography, Department of Fisheries and Oceans.

DISCUSSION

Aerial Surveys

Leatherback distributions revealed by aerial surveys and Working Group records overlapped considerably (Fig.3.6). This was particularly true off the southwest tip of Nova Scotia (in the areas of Browns Bank and Roseway Basin). Aerial surveys detected three leatherbacks in the Gulf of Maine (edge of Jordan Basin) where turtles were not reported by Working Group members. This may reflect low turtle abundance and/or fishing effort by Working Group members in this area. As the primary purpose of the aerial surveys was to detect North Atlantic right whales, tracklines were flown over a limited area, focussing on the southwest section of the Scotian Shelf and the Bay of Fundy, areas of known right whale concentration (Fig.3.2). A broader aerial survey program, extending from early summer to late fall and covering a larger area of the Scotian Shelf (including waters off Cape Breton) would further our understanding of the seasonal patterns of leatherback distribution and abundance off Nova Scotia.

International Observer Program (Scotia-Fundy Region)

The IOP distribution of leatherback records in warm offshore waters is largely a product of the observer program's focus on pelagic fisheries that operate in shelf waters. The bias in records along the continental shelf break may also reflect the higher entrapment rate of marine turtles in pelagic longline operations (directing for swordfish, tuna and shark), as compared to other fisheries. Both leatherback and cheloniid turtles frequently contribute to incidental capture on pelagic longline gear (Witzell, 1984; 1999). As pelagic longline sets are typically baited with fish or squid, medusivorous leatherbacks are not normally entrapped through deliberate ingestion of bait, although there is one published record of this (Skillman and Balazs, 1992). Instead, leatherbacks are foul-hooked in the flipper-shoulder area by drifting gear and/or become entangled (normally by the front flippers) in the mainline or buoy lines (Witzell, 1984).

These records reveal that mortality at time of release from pelagic longline gear may be low. Studies of incidental capture by this fishery in other areas of the Atlantic have reported similar results (e.g., Witzell, 1984; 1999). However, post-capture survival rates of leatherbacks are not known, and subsequent mortality may be significant (Spotila *et al.*, 1996).

The increased number of IOP records in recent years likely reflects increased interest in marine turtles and an increased tendency among observers to record encounters with these animals, rather than an increase in actual marine turtle abundance. The comparatively large number of records in 1998 (n=8 turtles) may also reflect the associated introduction of specific codes in the IOP for recording different species of marine turtles (these replaced the former general category code that included all marine turtles). It is interesting to note the high number of records in 1995 (n=10 turtles). Unfortunately, insufficient data are available to demonstrate a relationship between elevated incidental catch and increased leatherback abundance during summer 1995; however, anecdotal evidence, including record numbers of coastal strandings (>15) and entanglements in inshore gear in Nova Scotia that year, suggest that this may have been the case (J. Gilhen, Nova Scotia Museum of Natural History, Halifax, N.S.; C. Harvey-Clark, Dalhousie University, Halifax, N.S., pers. comm.).

The IOP records presented here do not necessarily confirm a patchy distribution of leatherback turtles in any particular area because the timing and location associated with entrapment on each set are not known (average set length measured 57.7 km).

While the IOP data set indicates some spatial and temporal characteristics of leatherback turtle distribution in offshore waters, and informs our understanding of incidental capture of this species in this region, its current utility is limited by the non-systematic, inconsistent recording of marine turtle encounters during trips.

As the IOP did not support a specific protocol for recording incidental capture of marine turtles until 1999, it is likely that the majority of turtle encounters were not recorded prior to this time. Therefore, the records considered here possibly represent a small proportion of the actual number of incidentally-caught leatherbacks encountered on trips with observers. Moreover, as the IOP provided only a single general category code for observers to use to indicate capture of all marine turtle species until program changes in 1998, it is possible that many of the records of "unidentified" turtles noted in trip reports represent leatherbacks. Recognizing that observer coverage of this fishery is low, incidental capture of leatherbacks and other marine turtles in Canadian waters, particularly by pelagic longline fleets operating along the shelf break, may be a more regular and widespread phenomenon than the IOP records suggest.

Nova Scotia Leatherback Turtle Working Group

Working Group records from the southwest tip of Nova Scotia extending out to the eastern edge of Georges Bank are relatively numerous compared to records from other areas (Fig.3.5). This clustering phenomenon may be explained by active groundfish fisheries and swordfish fisheries in the area of Browns Bank and the eastern edge of Georges Bank. As many Working Group members are involved in fisheries operating in these areas (especially the swordfish harpoon fishery), fishing effort, and, therefore, observer effort, may be biased, leading to numerous records at these locales and along the travel routes to and from these sites. Similarly, there is an apparent cluster of inshore records along the south shore of Cape Breton. This may be explained by seasonal inshore proliferations of jellyfish, which correspond with a very active seasonal snow crab fishery. Again, this fishery is well represented in the Working Group.

Working Group members reported five records from the Gulf of St. Lawrence (one off Cape Breton and four from the Northumberland Strait). These are significant, as leatherbacks are rarely recorded in these areas.

The Working Group data also include a leatherback reported by a Coast Guard vessel on June 14, 1998 (44°16'N, 66°21'W) in water 5.2°C. While the distribution of Kemp's ridley (*Lepidochelys kempii*) and the loggerhead (*C. caretta*), two other species of marine turtle known to occur in temperate waters, is constrained approximately by the 20°C surface isotherm (Davenport *et al.*, 1997), leatherbacks frequently migrate to high latitudes to feed on abundant coelenterates in water ranging from 5-15°C (Davenport *et al.*, 1997).

The lower limits of thermal tolerance in leatherbacks are not clearly understood; however, these turtles exhibit anatomical and physiological adaptations that confer endothermy (e.g., Frair *et al.*, 1972; Greer *et al.*, 1973), enabling them to maintain body core temperatures 18C° above ambient (Frair *et al.*, 1972). Several historical records also substantiate the remarkable cold-hardiness of leatherbacks. For example, Threlfall (1978) reported water temperature less than 6°C for a leatherback captured off Labrador, and Goff and Lien (1988) reported an observation of a leatherback swimming off Newfoundland (March 20, 1984), when water temperature was approximately 0°C. Shoop (1980) described an Inuit soapstone carving from Cape Dorset, Baffin Island, which he interpreted as depicting a leatherback. He, therefore, suggested that the Hudson Strait may occasionally host migrating leatherbacks despite the absence of actual specimens from this area. Leatherbacks have been recorded in the northeast Atlantic as far north as 66°34'N (Dolmen *et al.*, 1993) and 70°15'N (Gulliksen, 1990). The most northerly published Canadian record of a leatherback is 56°45'N, 61°00'W (Threlfall, 1978).

Leatherbacks are not successfully maintained in aquaria, therefore, it is impractical and unethical to study lower limits of thermal tolerance in captive animals (especially as thermal inertia, or heat generated by muscular activity, may be critical to maintaining endothermy in these turtles). As Canadian waters may represent the northern range limits of marine turtles in the northwest Atlantic, future collection of SST data associated with northern records of these turtles may contribute to our understanding of the cold water temperature tolerances of these reptiles

While many fishers have recently demonstrated their interest in our work by reporting encounters with marine turtles, it is not possible to quantify how well these reports reflect the total number of sightings made by members of the fishing community each year. Fishers may not report turtle sightings and entrapments for several reasons, including unawareness of the scientific interest in these organisms, or alternatively because of the species' high profile and endangered status.

Leatherback turtle distribution across three sources of records: aerial surveys, IOP and the Working Group

Working Group and aerial survey records were clustered along the continental shelf break and inshore waters (i.e., inshore from the 200m isobath). The association of leatherbacks with relatively shallow waters along and inside the continental shelf parallels findings of other studies (e.g., Hoffman and Fritts, 1982; Fritts *et al.*, 1983; Shoop and Kenney, 1992).

The IOP data, by contrast, revealed distribution in offshore waters (Fig.3.4). As previously stated, this is likely a product of this program's emphasis on the pelagic longline fishery in these areas. The relatively few offshore records, compared to numerous nearshore records reported by Working Group members (apart from in the area of the Scotian Shelf east of Georges Bank), may reflect greater abundance of leatherbacks in coastal waters and/or greater Working Group member involvement in inshore versus pelagic fisheries.

Most leatherbacks present in the northwest Atlantic probably do not come in direct contact with commercial fishing operations. Similarly, as marine turtles spend considerable portions of the day submerged, and, therefore, out of sight from aerial and shipboard observers, most migrating leatherbacks probably remain undetected by the commercial fishing fleet (including our volunteers). Therefore, the IOP, aerial and Working Group data probably highly underestimate the total number of turtles present in these waters. Until both presence and absence data are consistently recorded, it will be difficult to identify and characterise areas of high turtle abundance. Regardless, the data suggest that leatherbacks are widely distributed in both inshore and offshore waters of eastern Canada during the summer and fall. The data also reveal regular occurrence of leatherbacks in shallow coastal waters. These movements are likely related to seasonal inshore proliferations of hydromedusae (Bleakney, 1965; Lazell, 1980; Starbird *et al.*, 1993).

Fishing effort, sighting frequency, and the seasonality of leatherback occurrence in eastern Canada

Increased fishing effort positively affected the probability of sighting leatherbacks in all but two of the NAFO subunit areas from which these turtles were recorded (4Xr and 5ZEj) (Fig.3.11). Subzone 5ZEj corresponds to the northeast edge of Georges Bank, an area of intense fishing activity during the summer and fall (n=473 trips). It is surprising that so few turtles (n=7) were reported from this area, as adjacent NAFO subzones yielded turtle sightings. For example, NAFO subzone 5ZEm, to the south of 5ZEj, had less than half as many trips (n=214 trips) during the same period of time, but over twice as many leatherback sightings (n=18). Fishing effort in NAFO subzone 4Xr was high (n=2807 trips); however, only four leatherbacks were recorded in this area. In this case, small numbers of turtle sightings likely accurately reflected very low seasonal densities of leatherbacks in this area in 1998. This assertion is supported by the aerial survey data which did not detect any turtles in 4Xr. Moreover, whale watch boats operating in 4Xr have indicated that leatherback sightings in this area are exceedingly rare (H. Graham, Brier Island Whale and Seabird Cruises, Westport, N.S., pers. comm.).

This analysis considered the number of fishing trips in individual NAFO subzones as an index of fishing effort occurring in these areas. While this approach provides one means of quantifying fishing effort, a more accurate measure of effort would be the total number of fishing days. By obtaining information on total number of fishing days, it is possible to appropriately account for trips of varying length. This is important, as trip length necessarily affects the probability of sighting turtles. Unfortunately, corresponding trip length data were not readily available for consideration here; however, future studies involving shipboard data collection of this type would benefit from instructing data gatherers to record this information.

A consideration of the relationship between 1998 fishing effort and leatherback sighting data suggests there is a true seasonality associated with leatherback occurrence in eastern Canada (Fig.3.10). Leatherback presence in Atlantic Canada appears to correspond with seasonally high inshore sea surface temperatures from July to October. In 1998, most leatherbacks were observed in shelf waters (well beyond the edge of the Gulf Stream current), and in the case of the northern IOP records, a few turtles were found in very cold, but productive, waters of the Labrador current. Therefore, while sea surface temperature likely influences distribution of these turtles, unlike cheloniid turtles, leatherbacks are not limited to warm surface waters, and endothermy permits foraging migrations to boreal latitudes.

Until 1998, the significance of Canadian waters to leatherbacks was unclear due to limited information on occurrence and distribution. These results, which include 217 records from 1998, reveal that Canadian waters host large numbers of migrating leatherbacks. Therefore, this region should be considered critical habitat for this globally-endangered species.

CHAPTER 4

FEEDING HABITS OF *DERMOCHELYS CORIACEA* IN THE NORTHWEST ATLANTIC

Introduction

The leatherback turtle is the largest of the marine turtles. Leatherbacks nest on beaches in tropical and subtropical waters and venture north to forage in temperate waters during summer and fall. During this time, leatherbacks venture into waters of the north Atlantic off the coast of Europe, including the United Kingdom, Ireland, France and Norway (e.g., Brongersma, 1972; Duron and Duron, 1980; Dolmen *et al.*, 1983; Gulliksen, 1990; Penhallurick, 1991), the northeastern United States (e.g., 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. Global 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 behaviour 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 suggest 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 esophogus. These papillae probably shred medusae and prevent them from being regurgitated (Bleakney, 1965; Den Hartog and Van Nierop 1984).

An improved understanding of the feeding behaviour of this species allows us to identify foraging-associated threats to leatherbacks, with clear implications for conservation. Although mudusae are generally plentiful, such a specialized diet may make leatherbacks vulnerable to ingestion of plastics and other buoyant marine debris (Mrosovsky, 1981; Carr, 1987; Mrosovsky, 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; Grant *et al.*, 1996; Collard, 1990); 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 and Newfoundland, Canada.

Materials and methods

Leatherback turtles occur off the coast of eastern Canada principally between June and November (Bleakney, 1965; Lazell, 1980; Goff and Lien, 1988; Chapter 3). It is logistically difficult to study the behaviour 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 fishers 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 anecdotal observations of leatherbacks feeding throughout these waters, and six members have recorded and photo-documented detailed observations of feeding.

Results

Nine photo-documented records of leatherbacks feeding on medusae were made during the summers of 1997-1999 (Table 4.1; Fig.4.1). In all cases, jellyfish were clearly visible and numerous at or near the sites where the turtles were encountered.

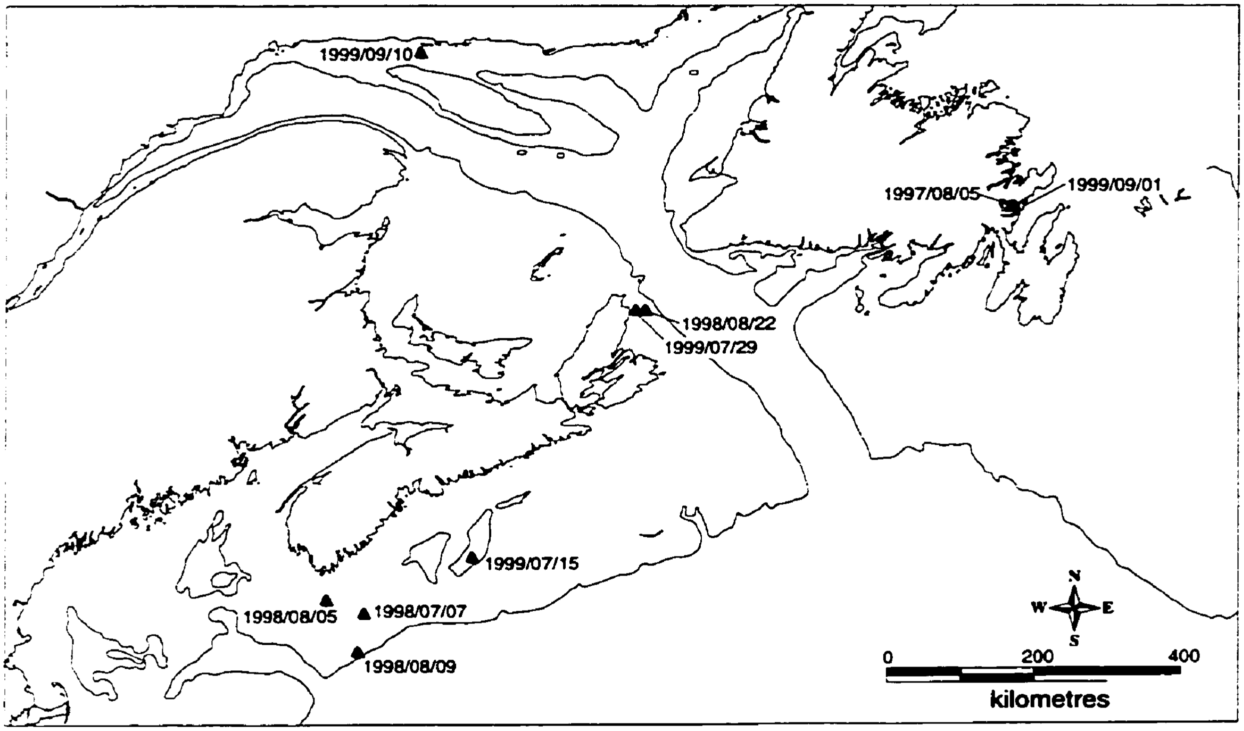

Figure 4.1. Locations of leatherback turtles (*Dermochelys coriacea*) photo-documented feeding on jellyfish.

Date (yy/mm/dd)	Time (24hr)	Latitude (decimal degrees N)	Longitude (decimal degrees W)
1997/08/05	10:00	48.155	53.734
1998/07/07	17:30	42.950	64.883
1998/08/05	12:30	43.123	65.533
1998/08/09	N/A	42.454	64.986
1998/08/22	12:06	46.836	60.02
1999/07/15	12:20	43.671	63.001
1999/07/29	11:23	46.834	60.191
1999/09/01	11:00	48.157	53.704
1999/09/10	N/A	50.117	63.917

Table 4.1: Photo-documented records of *Dermochelys coriacea* feeding on *Cyanea sp.* and *Aurelia sp.*

Turtles were approached by vessels and observed at close range feeding at the surface. The sequence of behaviour described was consistent across all records: turtles rested or moved slowly at the surface with their heads submerged or partially submerged. During this time, there was little noticeable movement of the front or rear flippers. The turtles then periodically raised their heads out of the water and opened their mouths. At this time, the 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 (Fig.4.2). Turtles then swallowed and lowered their heads back into the water. Presumably the elevated head assists these turtles in swallowing the slippery, soft-bodied prey. One large male turtle was observed for approximately ten minutes tearing and consuming very long (>2m) strands of what was evidently the bell and tentacles of a large jellyfish (Fig. 4.3). This sequence was documented in 27 photographs. The animal was still feeding in this manner when the observers left the area

Figure 4.2. Leatherback turtle feeding on jellyfish. Notice the tentacles visible at the corners of the mouth.
Photo: D. Ivany, N.S. Leatherback Turtle Working Group

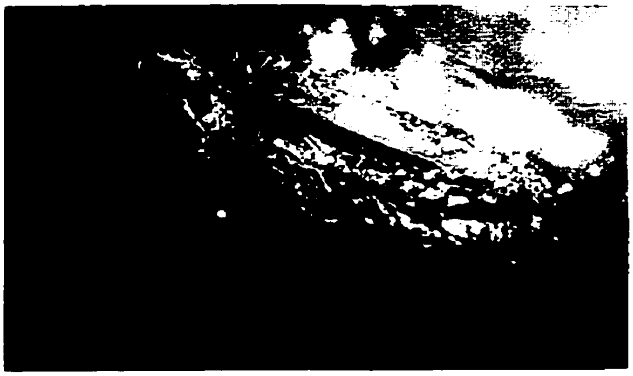

Figure 4.3. Adult male leatherback consuming a large *Cyanea capillata*.
Photo: L. Hatcher, N.S. Leatherback Turtle Working Group

The colour, length of tentacles and size of the bell of the medusae consumed for each of the records reported here indicate that they are *Cyanea sp.* or *Aurelia sp.* (Shih, 1977). Both *Cyanea sp.* and *Aurelia sp.* 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.

While time data were not available for two records, of the remaining seven records, six (86%) were made between 10:00 - 12:30 hrs. (Table 4.1). This corresponds with peak surfacing times exhibited by leatherbacks monitored via telemetry. For example, surfacing behaviour of a subadult leatherback equipped with a radio transmitter off Rhode Island, NY, peaked between 09:00 and 12:00 hrs. EDT (Standora *et al.*, 1984).

Discussion

Despite the wide geographic range of this species, there are remarkably few documented observations of leatherbacks feeding. 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 infer 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 behaviour 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, even in large numbers, below the 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 behaviour 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 and fishers in contact. By spatially and temporally defining key feeding areas for this species, we may be able to better understand its incidental capture in fisheries.

As specialized feeders, leatherbacks may be particularly vulnerable to global change. If climate change is accompanied by wide-scale changes in ocean circulation patterns (Davenport, 1997), concentration of medusae may be dramatically altered.

Continued collection of information on feeding behaviour throughout the leatherback's range will clarify how feeding contributes to risk and what conservation measures can reduce that risk. Identification of key foraging areas and their spatial and temporal dynamics is, therefore, essential.

CHAPTER 5

STUDYING LEATHERBACKS IN ATLANTIC CANADA: CONTRIBUTING TO A GLOBAL EFFORT

The leatherback's pelagic lifestyle and its unpredictable occurrence over a wide area present numerous challenges for researchers. While the nesting ecology of this species has been thoroughly described, little is known about the movement patterns, habitat selectivity and oceanic distribution of these reptiles (Morreale *et al.*, 1996). This is particularly true in the northern part of their range.

As known threats to leatherbacks do not adequately account for the severity of the population decline observed over the past two decades, it is critical that the scientific community work to better understand the habits of this cosmopolitan species throughout its entire range.

The present analysis has shown that the Nova Scotia Leatherback Turtle Working Group, a fishers-scientist collaborative research group, provides a cost-effective means of monitoring the seasonal distribution of marine turtles in eastern Canada and effecting practical conservation of these animals. Moreover, collaboration with partners in the fishing community has yielded rare opportunities for studying the biology of these highly migratory animals, including locating turtles at sea for behavioural observation and tagging and sampling purposes.

Data collected by the Working Group, combined with a review of IOP records and aerial survey data confirm that eastern Canadian waters are within the regular range of large numbers of leatherbacks. Moreover, this analysis demonstrates that historical evaluations of marine turtle abundance in Atlantic Canada may be overly conservative and, in some cases, inaccurate.

While providing an important contribution to the limited knowledge of this species' biology in northern latitudes, there is broader value to this work. Having overcome obstacles in leatherback data collection that other research groups have struggled with for some time, the Working Group represents an original, valuable contribution (in both information and approach) to international efforts to better understand the biology of this species and the reasons for its decline. Moreover, the Working Group can serve as a model for community-based marine turtle research and conservation in other areas of the leatherback's range.

As there are large gaps in our current understanding of the biology of this endangered species, and we are well-poised in Nova Scotia to address many of these questions regionally, we have a responsibility to pursue these opportunities and contribute to the global recovery of this species.

REFERENCES

Ates, R. M. L. 1991. Predation on Cnidaria by vertebrates other than fishes. Hydrobiologia 216/217:305-307.

Balazs, G. H. 1982. Driftnets Catch Leatherback turtles. Oryx 16:428-430.

Bleakney, J. S. 1965. Reports of marine turtles from New England and Eastern Canada. Canadian Field Naturalist 79:120-128.

Bossé, L. 1994. Une gigantesque tortue marine dans un havre de la Gaspesie. L'Euskarien 16:39-40.

Boulon, R. H., K.L. Eckert, and S. Eckert. 1988. Dermochelys coriacea (leatherback sea turtle) migration. Herpetological Review 19:88.

Brongersma, L. D. 1972. European Atlantic Turtles. Zoologische Verhandelingen 121:1-318.

Brown, M.W. and D. Tobin. 1999. Vessel and aerial surveys for North Atlantic right whales in Canadian waters, 1998. Contract F5245-8-0064: final report issued to Beford Institute of Oceanography, September, 1999.

Calleson, T. J., O. Bailey- George, and H. Edmiston. 1998. Rare nesting occurrence of the leatherback sea turtle, *Dermochelys coriacea,* in Northwest Florida, U.S.A. Herpetological Review 29:14-15.

Carr, A. 1987. Impact of Nonbiodegradable Marine Debris on the Ecology and Survival Outlook of Sea Turtles. Marine Pollution Bulletin 18:352-356.

Carr, T., and N. Carr. 1986. Dermochelys coriacea (leatherback sea turtle) copulation. Herpetological Review 17:24-25.

Chan, E. H., and H. C. Liew. 1995. Incubation temperatures and sex-ratios in the Malaysian leatherback turtle *Dermochelys coriacea*. Biological Conservation 74:169-174.

Chan, E.-H., and H.-C. Liew. 1996. Decline of the leatherback population in Terengganu, Malaysia, 1956-1995. Chelonian Conservation and Biology 2:196-203.

Cheng, I., and T. Chen. 1997. The incidental capture of five species of sea turtles by coastal setnet fisheries in the eastern waters of Taiwan. Biological Conservation 82:235-239.

Collard, S. B. 1990. Leatherback turtles feeding near a watermass boundary in the Eastern Gulf of Mexico. Marine Turtle Newsletter 50:12-14.

Cook, F.R. 1981. Status report on the Leatherback Turtle *Dermochelys coriacea*. Committee on the Status of Endangered Wildlife in Canada (COSEWIC), 18pp.

Cornelius, S. 1975. Marine turtle mortalities along the Pacific coast of Costa Rica. Copeia (1975):186-187.

D'Amours, D. 1983. A leatherback turtle (*Dermochelys coriacea*) on the coast of Quebec. Naturaliste Canadien 110:481.

Davenport, J. 1997. Temperature and the life history strategies of sea turtles. Journal of Thermal Biology 22:479-488.

Davenport, J., S. H. Magill, and N. De Verteuille. 1997. The effects of current velocity and temperature upon swimming in juvenile green sea turtles (*Chelonia mydas*). Herpetological Journal 7:143-147.

Davenport, J., and J. Wrench. 1990. Metal levels in a leatherback turtle. Marine Pollution Bulletin 21:40-41.

Davenport, J., J. Wrench, J. McEvoy, and V. Camacho-Bar. 1990. Metal and PCB Concentration in the 'Harlech' Leatherback. Marine Turtle Newsletter 48:1-6.

Den Hartog, J. C., and M. M. Van Nierop. 1984. A study on the gut contents of six leathery turtles *Dermochelys coriacea* (Linnaeus) (Reptilia: Testudines: Dermochelyidae) from British waters and from the Netherlands. Leiden (1984):4-36.

Dolmen, D., O. Wiig, and T. I. Guldberg. 1993. Leatherback sea turtle found in Norwegian waters. Fauna (Oslo) 46:68-75.

Duron, M., and P. Duron. 1980. Des tortues luths dans les Pertuis Charentais. Courrier Naturaliste 69:37-41.

Eckert, K. L., and S. A. Eckert. 1988. Pre-Reproductive movements of leatherback sea turtles (*Dermochelys coriacea*) nesting in the Caribbean. Copeia (1988):400-406.

Eckert, S. A., K. L. Eckert, P. Ponganis, and G. L. Kooyman. 1989. Diving and foraging behavior of leatherback sea turtles (*Dermochelys coriacea*). Canadian Journal of Zoology 67:2834-2840.

Eckert, S. A., and L. Sarti. 1997. Distant fisheries implicated in the loss of the world's largest leatherback nesting population. Marine Turtle Newsletter 78:2-6.

Eisenberg, J. F., and J. Frazier. 1983. A leatherback turtle (*Dermochelys coriacea*) feeding in the wild. Journal of Herpetology 17:81-82.

Fiedler, P. C., and H. J. Bernard. 1987. Tuna aggregation and feeding near fronts observed in satellite imagery. Continental Shelf Research 7:871-881.

Foster, P., and C. Chapman. 1975. The care and maintenance of young leatherback turtles at the Miami Seaquarium. International Zoo Yearbook 15:170-171.

Frair, W. R., R. G. Ackman, and N. Mrosovsky. 1972. Body temperature of *Dermochelys coriacea*: warm turtle from cold water. Science 177:791-793.

Frazier, J., M. D. Meneghel, and F. Achaval. 1985. A clarification on the feeding habits of *Dermochelys coriacea*. Journal of Herpetology 19:159-160.

Fritts, T. 1982. Plastic bags in the intestinal tracts of leatherback marine turtles. Herpetological Review 13:72-73.

Fritts, T. H., W. Hoffman, and M.A. McGehee. 1983. The distribution and abundance of marine turtles in the Gulf of Mexico and nearby Atlantic waters. Journal of Herpetology 17:327-344.

Godfrey, M.H., and R. Barreto. 1998. Dermochelys coriacea (Leatherback sea turtle) Copulation. Herpetological Review 29(1):38-39.

Goff, G. P., and J. Lein. 1988. Atlantic leatherback turtles, *Dermochelys coriacea*, in Cold Water off Newfoundland and Labrador. Canadian Field Naturalist 102:1-5.

Goff, G. P., J. Lein, G. B. Stenson, and J. Fretey. 1994. The migration of a tagged leatherback turtle, *Dermochelys coriacea*, from French Guiana, South America, to Newfoundland, Canada, in 128 days. Canadian Field Naturalist 108:72-73.

Goff, G. P., and G. B. Stenson. 1988. Brown adipose tissue in leatherback sea turtles: a thermogenic organ in an endothermic reptile? Copeia (1988):1071-1075.

Grant, G., S., and D. Ferrell. 1993. Leatherback turtle, *Dermochelys coriacea* (Reptilia: Dermochelidae): Notes on nearshore feeding behavior and association with Cobia. Brimleyana (1993):77-81.

Grant, G. S., H. Malpass, and J. Beasley. 1996. Correlation of leatherback turtle and jellyfish occurrence. Herpetological Review 27:123-125.

Greer, A. E., J. D. Lazell, and R. M. Wright. 1973. Anatomical evidence for a counter-current heat exchanger in the leatherback turtle (*Dermochelys coriacea*). Nature 244:181.

Gulliksen, B. 1990. Observation of the leatherback turtle (*Dermochelys coriacea*) in Northern Norway (Nord -Troms), Autumn 1989. Fauna (Oslo) 43:45.

Hoffman, W., and T. Fritts. 1982. Sea turtle distribution along the boundary of the Gulf Stream current off eastern Florida. Herpetologica 38 (3):405-409.

Holland, D. L., J. Davenport, and J. East. 1990. The fatty acid composition of the leatherback turtle *Dermochelys coriacea* and its jellyfish prey. Journal of the Marine Biological Association of the United Kingdom 70:761-770.

Keinath, J. A., and J. A. Musick. 1990. Life history notes: *Dermochelys coriacea* Migration. Herpetological Review 21:92.

Lazell, J. D., Jr. 1980. New England Waters: Critical habitat for marine turtles. Copeia (1980):290-295.

Leary, T. R. 1957. A schooling of leatherback turtles, *Dermochelys coriacea coriacea*, on the Texas coast. Copeia (1957):232.

Leslie, A., D. N. Penick, J. R. Spotila, and F. Paladino. 1996. Leatherback turtle, *Dermochelys coriacea*, nesting and nest success at Tortuguero, Costa Rica, in 1990-1991. Chelonian Conservation and Biology 2:159-168.

Lucas, Z. 1992. Monitoring persistent litter in the marine environment on Sable Island, Nova Scotia. Marine Pollution Bulletin 24:192-199.

Lutcavage, M. 1996. Planning your next meal: leatherback travel routes and ocean fronts *In:* Proceedings of the Fifteenth Annual Symposium on Sea Turtle Biology and Conservation. J. A. Keinath, D. E. Barnard, J. A. Musick, and B. A. Bell (eds.). NOAA Technical Memorandum NMFS-SEFSC-387, pp.174-178.

Lutcavage, M., and J. A. Musick. 1985. Aspects of the biology of sea turtles in Virginia. Copeia (1985):449-456.

Miller, M. D. 1968. An additional observation of the leatherback turtle off Newfoundland, Canada. Canadian Field Naturalist 82:226.

Morgan, P. J. 1989. Occurrence of leatherback turtles (*Dermochelys coriacea*) in the British Isles in 1988 with reference to a record specimen *In:* Proceedings of the Ninth Annual Workshop on Sea Turtle Biology and Conservation. S.A. Eckert, K.L. Eckert and T.H. Richardson (Compilers), pp. 119-120.

Morreale, S. J., A. B. Meylan, S. S. Sadove, and E. A. Standora. 1992. Annual occurrence and winter mortality of marine turtles in New York waters. Journal of Herpetology 26:301-308.

Morreale, S. J., E. A. Standora, J. R. Spotila, and F. V. Paladino. 1996. Migration corridor for sea turtles. Nature 384:319-320.

Mrosovsky, N. 1981. Plastic jellyfish. Marine Turtle Newsletter 17:5-7.

Mrosovsky, N. 1987. Leatherback turtle off scale. Nature 327:286.

Mrosovsky, N. 1997. A general strategy for conservation through use of sea turtles. Journal of Sustainable Use (1997):42-46.

NMFS. 1992. Recovery Plan for Leatherback Turtles in the U.S. Caribbean, Atlantic and Gulf of Mexico. National Marine Fisheries Service, Washington, D.C.

Paladino, F. V., M. P. O'Connor, and J. R. Spotila. 1990. Metabolism of leatherback turtles, gigantothermy, and thermoregulation of dinosaurs. Nature 344:858-860.

Penhallurick, R. D. 1991. Observations of leatherback turtles off the Cornish coast. Marine Turtle Newsletter 52:12-14.

Pritchard, P.C.H. 1971. The leatherback or leathery turtle *Dermochelys coriacea.* International Union for the Conservation of Nature Monograph No. 1. 1-39. Morges, Switzerland.

Pritchard, P. C. H. 1976. Post-nesting movements of marine turtles (Cheloniidae and Dermochelyidae) tagged in the Guianas. Copeia (1976):749-754.

Rhodin, A. G. J., J. A. Ogden, and G. J. Conlogue. 1981. Chondro-osseous morphology of *Dermochelys coriacea,* a marine reptile with mammalian skeletal features. Nature 290:244-246.

Sadove, S. 1980. Marine Turtles. SEAN Bulletin 5:15.

Shih, C. T. 1977. A Guide to the Jellyfish of Canadian Atlantic Waters. National Museums of Canada, Ottawa.

Shoop, C. R. 1980. Inuit turtle song: leatherback turtles near Baffin Island? Marine Turtle Newsletter 15:130-131.

Shoop, C. R., and R. D. Kenny. 1992. Seasonal distributions and abundances of loggerhead and leatherback sea turtles in waters of the northeastern United States. Herpetological Monographs 6:43-67.

Skillman, R. A., and G. H. Balazs. 1992. Leatherback turtle captured by ingestion of squid bait on swordfish longline. Fishery Bulletin 90:807-808.

Spotila, J. R., A. E. Dunham, A. J. Leslie, A. C. Steyermark, P. T. Plotkin, and F. V. Paladino. 1996. Worldwide population decline of *Dermochelys coriacea:* Are leatherback turtles going extinct? Chelonian Conservation and Biology 2:209-222.

Squires, H. J. 1954. Records of marine turtles in the Newfoundland area. Copeia (1954):68.

Standora, E. A., J. R. Spotila, J. A. Keinath, and C. R. Shoop. 1984. Body temperatures, diving cycles, and movement of a subadult leatherback turtle, *Dermochelys coriacea*. Herpetologica 40:169-176.

Starbird, C. H., A. Baldridge, and J. T. Harvey. 1993. Seasonal occurrence of leatherback sea turtles (*Dermochelys coriacea*) in the Monterey Bay region, with notes on other sea turtles, 1986-1991. California Fish and Game 79:54-62.

Steele, D. H. 1972. A leatherback turtle (*Dermochelys coriacea)* caught in Conception Bay. Osprey 3:44-46.

Threlfall, W. 1978. First record of the Atlantic leatherback turtle (*Dermochelys coriacea*) from Labrador. Canadian Field Naturalist 92:287.

Uchida, I. 1990. On the synthetic materials found in the digestive systems of, and discharged by sea turtles collected in waters adjacent to Japan *In:* Proceedings of the Second International Conference on Marine Debris, 2-7 April, 1989. R. S. Shamura and M. L. Godfrey (eds.). U.S. Dept of Commerce, Honolulu, Hawaii.

Van Buskirk, J., and L. B. Crowder. 1994. Life-history variation in marine turtles. Copeia (1994):66-81.

van der Spoel, S. 1991. Hydromedusan distribution patterns. Hydrobiologia 216/217:489-496.

Witherington, B. E., and L. M. Ehrhart. 1989. Hypothermic stunning and mortality of marine turtles in the Indian River lagoon system, Florida. Copeia (1989):696-703.

Witzell, W. N. 1984. The incidental capture of sea turtles in the Atlantic U.S. Fishery Conservation zone by the Japanese tuna longline fleet. Marine Fisheries Review 46:56-58.

Witzell, W. N. 1999. Distribution and relative abundance of sea turtles caught incidentally by the U.S. pelagic longline fleet in the western North Atlantic Ocean 1992-1995. Fishery Bulletin 97:200-211.

Zug, G. R., and J. F. Parham. 1996. Age and growth in leatherback turtles, *Dermochelys coriacea* (Testudines: Dermochelyidae): a skeletochronological analysis. Chelonian Conservation and Biology 2:244-249.

Zullo, V. A., and J. S. Bleakney. 1966. The cirriped *Stomatolepas elegans* (Costa) on leatherback turtles from Nova Scotian waters. Canadian Field Naturalist 80:162-165.