DEVELOPMENT AND TESTING OF TAGGING AND ATTACHMENT EQUIPMENT FOR HARBOUR PORPOISES IN THE SOUTHWESTERN BAY OF FUNDY

FINAL REPORT
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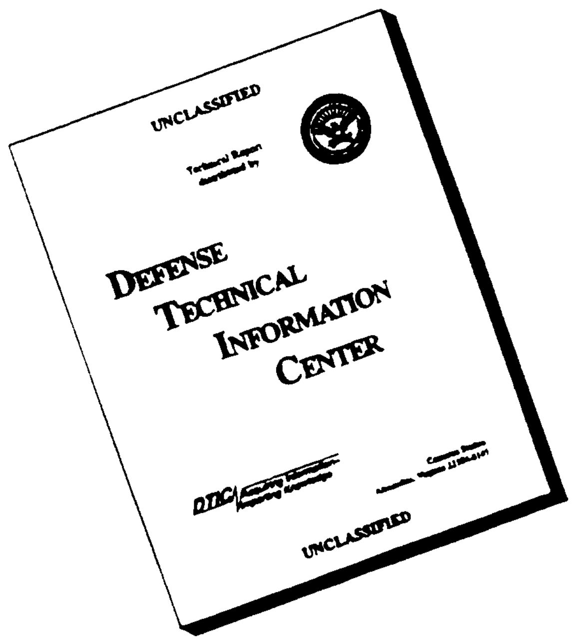

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1. Objectives

This report outlines work performed during 1995-6 under ONR grant N00014-94-1-1189 entitled "Development and testing of tagging and attachment equipment for harbour porpoises in the southwestern Bay of Fundy". The objectives were to:

1) test long-term tag attachment systems for harbour porpoises,

2) monitor the movements of harbour porpoises using satellite telemetry and

3) collect data on the postmortem cooling rates of harbour porpoises.

It was hoped that these data would be useful in management and mitigation of the problem of the incidental catch of harbour porpoises in the sink gillnet fishery in the Bay of Fundy and Gulf of Maine. Specifically, these data will:

(1) identify critical habitat areas used by harbour porpoises in the Bay of Fundy/Gulf of Maine,

(2) evaluate the potential of time-area restrictions to gillnet fishing that might reduce the level of incidental mortality in this fishery and

(3) develop a postmortem cooling curve for harbour porpoises that could be used to back calculate a time of death of animals retrieved from gillnets.

2. Outline of Work Performed

2.1 Satellite Transmitters

Our field research was conducted in southwestern New Brunswick during July, August and September 1995. We worked out of the Grand Manan Whale and Seabird Research Station (GMWSRS), located in the village of North Head, Grand Manan Island, New Brunswick. To study the habitat utilization of harbour porpoises in the Bay of Fundy, we monitored the movements of six animals using satellite telemetry (Table 1). With the co-operation and assistance of local fishermen, porpoises were obtained from local herring weirs. Porpoises were seined from the weirs and placed on pads of closed cell foam in one of our small boats, where they were measured, examined and tagged prior to release. Small blood samples were also drawn from the flukes of these animals. All six porpoises were fitted with satellite-linked transmitters; one of these animals was also fitted with a VHF transmitter.

The satellite-linked transmitters, or Platform Transmitting Terminals (PTTs), operate in the UHF range (401.650 MHz). We used Model ST-10 units, manufactured by Telonics (Mesa, Arizona), purchased for us by the U. S. National Marine Fisheries Service, Northeast Fisheries Science Center. The PTTs transmit to two polar-orbiting NOAA weather satellites, which receive and store data before relaying it to ARGOS ground stations located in Alaska, Virginia and France. The data are then processed and made available to users via modem or e-mail. Each PTT transmits a unique code which allows the ARGOS system to identify the tag. This identification code is followed by sensor data, to a maximum of 256 bits per transmission. To minimize the size of the transmitter packages, the only sensor we used was a surface time counter, which provided a cumulative record of the time the tag was above the surface. At each signal, the surface time count was transmitted twice- allowing us to compare the data to detect possible transmission errors. Each tag also incorporated a salt-water switch, which prevented the tag from transmitting when it was below the water's surface. The salt water switch sampled every 256 microseconds; if the tag was above water, the transmission cycle was started. If the two terminals were connected by sea water, the tag remained quiescent. To further conserve battery life, we used a duty cycle in which the transmitter operated for only eight hours each day. The PTTs were powered by two 2/3 A cells which, under these operating conditions, should provide several months of battery life. We learned this year that the expected battery life was much greater than predicted by the manufacturer (see results).

We wanted to determine the optimal configuration for a robust, long-term attachment that had minimal impact to the vasculature of the dorsal fin and the overall hydrodynamic efficiency of the porpoise. In 1994 we had reasonable success with the front mounted design but we wanted to see if we could modify the configuration to improve tag longevity. This year we deployed PTTs in two configurations, based on their position on the dorsal fin: front-mounted (n = 2) (Figure 1) and side-mounted (n = 4) (Figure 2).

With the front mounted design we used the Telonics stacked-board ST-10 PTT which was encased in a steel cylinder in order to provide protection from pressure experienced during deep dives. The PTTs were attached to the porpoises using protocols we developed during extensive testing in 1993 and 1994. The PTT cylinder was attached to a thin, neoprene lined, polyethylene saddle that was itself attached to the dorsal fin using three 5/16 inch delrin pins. The pins were secured with steel posi-lock nuts. Prior to tag attachment, the dorsal fin was cleaned with betadyne and the tagging site was treated with a local anesthetic and an antibiotic. The plastic saddles wrapped around the front of the dorsal fin and extended caudally approximately 3.5 cm; the PTT was mounted on the leading edge of the saddle. The saddles provided a firm base from which we could secure the PTT cylinder to the dorsal fin. The PTT was 15 cm long with a 17 cm semi-rigid antenna. The entire cylindrical PTT package, including saddle, weighed approximately 300 g in air.

The side-mounted configuration consisted of a Telonics flat-board ST- 10 PTT mounted in a low profile rectangular lexan box. These tags were attached directly to the side of the dorsal fin using three 1/4 inch delrin bolts. The backing plate on the transmitter's housing was left oversized in both top and the front bottom corner in order to provide attachment points for the delrin bolts. The bolts passed through the attachment points, dorsal fin and were then secured on the opposite side with steel posi-lock nuts which themselves were backed with small (30 x 1.5 mm) delrin washers. All backing plates and washers were lined with open cell foam to minimize heat resistance and reduce the possibility of abrasion. This tag weighed approximately 200 g in air, measured 1.1 x 5 x 2 cm and had a similar 17 cm whip antenna. The tag attachment protocol was the same as that described above.

We also deployed one standard Model 2 VHF transmitter, manufactured by ATS (Ipsanti, Minnesota) on one of the porpoises fitted with a side-mounted tag. This tag transmitted at frequencies in the 148 MHz range at 110 pulses per minute, without a salt water switch or duty cycle. This tag had a life expectancy of more than 50 days. The tag measured 1.1 x 2.5 x 5.5 cm and weighed 15 g. It was tiny enough so that it could be attached to the small roto-tag that we apply routinely to the trailing edge of the dorsal fin of all porpoises released from herring weirs. The transmitting antenna was a 33 cm-long whip, covered in shrink-wrap. The VHF transmitter had an effective range of approximately 5 km at sea, with increasing range from clifftops on shore or from aerial tracking platforms. As we did not charter an offshore vessel in 1995, most of our radiotracking efforts were shore-based.

We were able to access location and sensor data from the ARGOS system via a modem hook-up from our field station. In addition to the estimated position of the porpoises and surface time data, the ARGOS system provided information on the quality of the estimated location. PTT positions are estimated using the Doppler effect on received frequencies. The quality of an estimated location depends on a variety of factors, including: the number of transmissions received during a satellite overpass, the time elapsed between these receptions, movement of the PTT, and the stability of the transmitter oscillator. Several categories of locations are provided: Class 3 (6 messages received, position accuracy better than 150m), Class 2 (five messages received, position accuracy within 350 m), Class I (four messages received, position accuracy better than I 000 m), Class 0 (less than four messages received, position accuracy above 1 000 m), Class A (three messages received, no estimate of accuracy), Class B (two messages received, no estimate of accuracy), Class Z (an non-validated location).

2.2 Cooling Curves

Postmortem cooling curves were obtained from a 35.5 kg female and a 37 kg male harbour porpoise in 1994 and 1996 respectively. This work was carried out with Ann Pabst and Bill McLellan (University of Willmington, NC). Both harbour porpoises were collected from herring weir fishing operations within minutes of death. After retrieval the carcasses were brought aboard a small boat before being transported to a dockside platform.

1994 Experiment

Immediately upon being taken into the boat a colonic probe was inserted 25 cm into the colon to measure core temperature (following methodology of Pabst *et al.* 1995; Rommel *et al.* 1994). Initial temperatures were gathered within ten minutes after death. Transport to a dockside platform normally took 20-30 minutes. During this period deep core temperatures were being continuously monitored by colonic probe.

At dockside the carcass was secured to a platform and two thermocouple probes were inserted into the epaxial muscle mass (Figure 3). Each thermocouple probe consisted of a hollow metal cannula with a window near its sharpened tip. A thermocouple, threaded through the cannula was exposed at the window. In past studies these thermocouples were calibrated in copper tubing where all thermocouples registered within 0.1 °C at temperatures of 0 and 100 °C. (Pabst *et al.* 1995, Rommel *et al.* 1994). The cannula was then inserted into tygon tubing and dipped in plastic to waterproof the whole probe. The probes were designed to be inserted 9 cm deep to the skin surface and were secured using sealant and tape. Three probes were used in this study: one positioned within the thoracic epaxial muscle mass (A), one positioned with the caudal epaxial muscle mass (C), and one remaining outside of the carcass to measure ambient water temperature (B). The carcass was strapped to a board to keep it stationary. The board was secured with heavy weights and lowered into sea water to a depth of 2 m. Temperatures were gathered on a Fluke Hydra data logger at a sampling rate of once every three minutes. As a precaution, data was also recorded by hand every half hour. The experiment was run for 24 hours.

1996 Experiment

The procedure followed was essentially the same with the exception of the initial temperature collection. Rather than use a colic probe for the initial temperature readings, we relied on a Cox Stab thermometer. This probe was inserted into the epaxial musculature at the level of the dorsal fin. The carcass was suspended using the same protocol as described above. This experiment was run for 48 hours.

3. Results

Satellite tags

Below, we outline the results from each tag deployment of 1995.

PTT-4

The first front-mounted satellite-linked transmitter was deployed on a 142 cm porpoise, released from Whale Cove, Grand Manan on August 13 (Table 1). This porpoise, a mature male, was released with three other porpoises from the same weir. Chemistry and haematology values of blood drawn from the flukes of PTT-4 fell within normal ranges for this population (Koopman et al. 1995; Koopman, H. N. unpublished data), indicating that he was in good health.

We maintained satellite contact with PTT-4 for 21 days (Figure 4). During this period he moved slightly northwest of Grand Manan to a series of islands known as the Wolves. He then travelled east to the Nova Scotian coast and then returned to Grand Manan. He travelled once more to Nova Scotia and then gradually began making his way down into the Gulf of Maine, following the 50 fathom depth contour past Clay Bank to Cashes Ledge. He remained slightly northwest of Cashes Ledges until we lost contact with the tag on September 4, 1995.

There are a number of possible explanations for the premature loss of signal from a satellite-linked transmitter, the most likely being failure of the transmitter or the attachment. Our previous experience with the front-mounted configuration and subsequent long-term contact with the side mount tags (see below), supports this contention.

PTT-5

The second front-mounted tag was deployed on a 147 cm mature male porpoise released from Flagg's Cove, Grand Manan on August 13 (Table 1). Five additional porpoises were released from this weir with this porpoise. Blood values indicated that this porpoise was also healthy.

We received transmissions from this tag for 19 days. During this time the animal did not travel more than 60 km from Grand Manan (Figure 5). During the last few days of contact, PTT-5 moved southeast to Clay Bank. He remained south of Penobscot Bay, Maine just outside the 50 fathom line until we lost contact on September 2, 1995.

The short duration of contact with this tag supported our conclusion that the front-mounted design was not reliable for a secure long-term attachment. We felt that this type of front-mounted PTT was not suitable for long-term deployment on harbour porpoises and discontinued their use.

PTT-6

The third porpoise to receive a satellite tag, and the first to receive a side-mounted model, was a 147 cm mature female released with seven other porpoises from a weir in Flagg's Cove on August 16. High progesterone levels in the blood sample drawn from this female indicate that she was in the early stages (1st trimester) of pregnancy. All other blood parameters were normal. She was not lactating at the time of release.

We maintained contact with this tag for 33 days. Following release, PTT-6 spent several days in an area just north of Grand Manan, and then swam to the eastern portion of the Bay of Fundy, spending the majority of the deployment period off the coast of Nova Scotia, near Digby Neck and Long Island (Figure 6). She then returned to the waters off the eastern coast of Grand Manan, where she remained until September 19, 1995. We do not know why PTT-6 failed earlier than the other side-mounted deployments. It is possible that the tag failed but given the record of the other transmitters this seems unlikely. Gillnets were sighted in the proximity of the porpoise's last received position.

PTT-7

We deployed a second side-mounted model on a 141 cm mature male released on August 21 from Flagg's Cove, Grand Manan. Three other porpoises in the weir were released with this porpoise, including PTT-8 and PTT-9. Blood samples indicated that this animal was in good health. This porpoise was also fitted with a VHF tag on the tip of his dorsal fin.

This deployment was our most successful. We were unable to make use of the radio tag for tracking because the porpoise moved out of radio range within one day of deployment. After his release, PTT-7 moved southeast to the Grand Manan Basin (Figure 7). He then moved out of the Bay of Fundy and followed the 50-fathom contour south along Clay Bank to the Cashes Ledge/Jeffreys Bank area of the Gulf of Maine, covering 300 km in 21 days. The animal stayed in this area for approximately one month before travelling south to Jeffreys Ledge were he remained during the height of the U.S. fall gillnet fishery. In the middle of November, PTT-7 moved to the Franklin Basin, directly east of Cape Cod where he remained through December. Between January and the final contact in mid-March the animal moved throughout the central Gulf of Maine. Generally we received at least one signal of Class 0 or better per day from this tag which has enabled us to follow his daily movements for nearly 7 months. The transmission life of the tag was estimated by the manufacturer to be in the order of 70 days so the realized longevity comes as somewhat of a surprise. It is clear from the extended life of the transmitter that the interaction between the salt-water switch and the 50s transmission interval is much more complex than we expected making the transmission longevity difficult to estimate.

PTT-8

The third side-mounted tag was deployed on a 151 cm mature male, released from Flagg's Cove with PTT-7 and PTT-9 on August 16. Blood was not sampled from this porpoise.

This tag transmitted for 66 days, during which time this porpoise never left the Bay of Fundy. Following his release, PTT-8 travelled east to Long Island, off the Nova Scotia coast (Figure 8). He then moved west, spending several weeks along the 50 fathom contour line just south and southwest of Grand Manan. PTT-8 then travelled northeast, through the Grand Manan Basin to waters northeast of Grand Manan. After spending several days here, this porpoise again travelled south, returning to the 50 fathom line just north of Clay Bank. He remained here until we received the last signal from his tag on October 26, 1995.

PTT-9

The final tag was side-mounted on a 140 cm mature male, released with PTT-7 and PTT-8 on August 16. Blood values indicated that this animal was in good health.

We received signals from this tag for 67 days. At the beginning of the deployment period, PTT-9 moved northwest of Grand Manan to the Wolves (Figure 9). He then moved southeast to the 50 fathom contour line just west of the Grand Manan Basin, where he remained until he began to move southwest on October 10. He travelled between the 100 and 50 fathom contour lines to Clay Bank and then continued south to Jeffreys Bank. He was beginning to move west when we lost the signal from his tag on October 27, 1995.

We had originally assumed that contact was lost with both PTT-8 and PTT-9 because the batteries in their tags had been exhausted. This conclusion was supported by our calculations of maximum tag life (about 70 days, based on the diving behaviour of the "average" porpoise (Westgate et al. 1995)) and by the fact that we stopped receiving signals from both tags within days of each other. From the duration of contact with PTT-7, however, we now believe that PTT-8 and PTT-9 may have lost their tags in a heavy storm that affected the Bay of Fundy and Gulf of Maine during the days that signals from the tags were lost.

3.2 Cooling curves

Cooling curves for both porpoises are shown in Figures 10 and 11. The three lines on each graph correspond to water, epaxial muscle and peduncle muscle temperatures. Mass and morphometric data for both porpoises are shown in Table 2.

4. Discussion

In 1995 we were able to collect telemetry data from six individuals for periods up to 212 days (Table 1), the longest period of satellite-linked radio contact ever recorded from a cetacean. Tags operated for a mean period of 60 ± 77 days. We received an average of 3 positions from each tag per day, 63 % of which were reliable (0 class or better). This demonstrates the utility of using information derived from satellite telemetry to assess the habitat utilization of harbour porpoises and other small cetaceans.

Keeping electronic packages on harbour porpoises has proven to be a difficult task but the major problems we encountered have been overcome and we can now focus on maximizing the collection of data rather than expending time and effort on tag design. The proximate effects of invasive techniques are always of concern and until now have been difficult to address. The fact that we did not see any obvious changes in behaviour throughout the 212 days of tracking PTT-7, coupled with the extensive movements of this animal, have demonstrated that these effects are minor and within the tolerance of harbour porpoises.

The results of this project demonstrate that it is feasible to mount long-term telemetry packages on small cetaceans. It appears that the position of the package on the dorsal fin is crucial to its longevity. Based on the differences in retention times between the two types of PTT packages we feel that the front-mounted configuration is not suitable for harbour porpoises. We suspect that the placement of the front-mounted PTT on the leading edge of the dorsal fin created more drag than the side mounted type thereby decreasing its retention. We are presently collaborating with Brad Hansen of the National Marine Mammal Lab in Seattle on a project that will examine the relative hydrodynamic aspects of telemetry packages on small cetaceans.

We tested both delrin and high density polyethylene (HDPE) bolts for tag attachment and found the latter to be woefully inadequate. In the two instances where HDPE bolts were used (see ONR report N00014-93-1-0933, June 7 1996) the transmitters failed within a week of deployment and in one case we documented that the bolts had sheared after only 2 days at sea. HDPE was originally selected because of its promising bio-compatability (Geraci and Smith 1990), however, it would appear that it does not have the tensile strength that is required to hold a telemetry package on a dorsal fin. Delrin was used in all PTT deployments subsequent to PTT-2 and performed well. Although delrin has a much greater tensile strength it still is brittle enough to break if subjected to sharp or sustained force. This feature was deemed beneficial should the tag ever become fouled in fishing net or seaweed. We found the use of 5/16 " diameter bolts unnecessary for harbour porpoises although their increased tensile strength maybe necessary for more energetic and socially aggressive species like bottlenose dolphins. Materials testing of attachment devices for strength, bio-compatability and longevity still remains an impediment in the further development of tagging technology for marine mammals.

Conservation Significance of Project Results

We recognize two major results that can be applied directly to harbour porpoise conservation.

Single Management Unit in Fundy/Maine

The movements of five of the nine PTT tagged porpoises (1 in 1994 and 4 in 1995) into the Gulf of Maine indicate that porpoises utilize significant portions of this region during the summer and this supports the hypothesis that harbour porpoises in the Bay of Fundy and Gulf of Maine comprise a single sub-population. This works corroborates other evidence from: (1) mtDNA studies; synchronized life history parameters; and similarities in organochlorine profiles (see Palka et al. 1996). It would appear that the current management stategy, which is based on the single sub-population assumption, is appropriate for this stock of porpoises.

Implicit in the single sub-population assumption is that Fundy/Maine harbour porpoises are at risk of entanglement for a significantly greater period of time than would be predicted by examination of Canadian and US gillnet by-catches individually. This was reinforced by the movement patterns of PTT-95-4 (Figure 7). This porpoise moved from the high density gillnet region surrounding Grand Manan to the most intense US gillnet fishing zone located on Jeffreys Ledge. PTT-7 arrived on Jeffreys Ledge within a few days of the opening of the gill netting season and remained there until the day after the season closed, maximizing the time that this animal was potentially at risk of encountering a gillnet. Movements like these underscore the transboundary nature of the incidental catch problem as well as its management.

Our PTT data also indicate that harbour porpoises are utilizing waters near the 50-fathom contour extensively during the summer months, especially during periods of travel. These data are consistent with observer data from US gillnet boats that indicate that incidental catches are greater in this depth range than predicted by fishing effort alone. It is unclear why porpoises are utilizing waters of these depths to a greater extent than other areas but it may be related to the distribution of their prey. This is an area of study that may offer insights into the nature of entanglement and factors that contribute to its risk. We hope to continue our investigations in this area with additional PTT data as well as information from a study we have planned that will examine harbour porpoise foraging behaviour in relation to prey distribution and physical oceanographic variables.

Another feature of harbour porpoise behaviour that this work has highlighted is the high degree of individual variability in the movements of the animals. This has important consequences not only for management but also to the practice of applying telemetry data to conservation problems. Implementation of management schemes based on small data sets from a subset of reproductive classes could be ineffective.

Finally, we note the extensive utilization of areas that had not been previously identified as important harbour porpoise habitat. These include the region to the southwest of Grand Manan used by PTT-8 (Figure 8) extensively and the Franklin Basin region of the Gulf of Maine used during the late fall and winter by PTT-7 (Figure 7). Documentation of these previously unidentified harbour porpoise habitats may be important if fishing effort is displaced as a result of time-area closures.

Time Area Closures

With the PTT data we have collected thus far it is possible to evaluate, albeit in a very preliminary fashion, the efficacy of time-area closures for reducing the level of incidental mortality. Despite the adoption of time-area closures in the U.S. during 1995, incidental takes were still high in the American sink gillnet fishery. Our 1995 satellite telemetry data demonstrated that this may have been due to the high degree of individual variability in both habitat utilization and movement patterns of harbour porpoises, suggesting that effective closures will have to be extensive both in time and space. The inherent variability in harbour porpoise habitat utilization must be incorporated into fishing restriction schemes.

Related to this is the utility of trigger mechanisms. These mechanisms have been proposed by the fishing industry, so that fishing closures would be tied to values of environmental parameters that would predict the appearance of harbour porpoises in particular areas. This approach would minimize the extent of disruptions to fishing activity. Our results suggest that the movement patterns of individual harbour porpoises are extremely variable and may not be predictable by any set of environmental parameters on a scale useful as a trigger mechanism. More long-term data on harbour porpoise movements are required to confirm this hypothesis.

Post mortem cooling curves

The postmortem cooling curves demonstrate that it is possible to use body temperature an index of postmortem time in harbour porpoises. Although the slopes of the two curves are different, both were still above 15 °C, 8 hours after death (Figures 10 and 11). In the case of GM-96-03, 18 hours passed before the temperature fell below 15 °C. The differences we have found in the cooling rates suggests that data will have to be recorded from more animals before a robust postmortem time-body temperature curve can be generated. The fact that the core temperature of GM-96-03 did not increase any time during the 48 hour period suggests that porpoises do not undergo postmortem warming. This refutes the idea that postmortem time-body temperature curves maybe inaccurate due to the heat generated by decomposition processes.

Part of the variability in cooling rates may have resulted from a poor probe design which could have allowed seawater to enter around the muscle/probe interface, erroneously decreasing the cooling time. This is suggested by the sudden sharp drop off of epaxial temperature in GM-94-43 around 600 minutes and the marked disparity in the cooling rates of the peduncle temperatures (2 h vs. 6 h to 15 °C). The differences in cooling rates could also have been a result of the differences in body size (Table2). Surface area to volume ratios decrease with increasing body size therefore it would expected that the smaller porpoises would cool faster. Given these potential problems and the observed differences it would be premature to assign a time of death based on the body temperature data presented here, but the initial results look promising and may provide insights into when during the fishing process porpoises are at the greatest risk of entanglement.

5. Acknowledgements

We would like to thank, K. Anderson, T. Cox (DUML), K. Murray, D. Palka and D. Potter (NEFSC), M. Scott (IATTC), The Grand Manan Whale and Seabird Research Station, and especially the weir fishermen of Grand Manan, without whose dedicated assistance this work would not be possible. This work was carried out under permit 1995-168 (DFO) and University of Guelph Animal Utilisation Protocol 94-R082.

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Table 1. Summary of harbour porpoises tagged with satellite transmitters on Grand Manan Island, New Brunswick during the summer of 1995.

ID	Argos Number	Sex	Length (cm)	Mass (kg)	Release Date	Configuration	Contact duration (days)
PTT-4[1]	22914	M	142	48	August 13	Front mount	21
PTT-5	22915	M	147	51	August 13	Front mount	19
PTT-6	24850	F	147	56	August 16	Side mount	33
PTT-7	24851	M	141	48	August 21	Side mount/w VHF	212
PTT-8	24849	M	151	N/E	August 21	Side mount	66
PTT-9	24852	M	140	47	August 21	Side mount	67

[1] Four PTT deployments in 1994 were documented in ONR Final Report for N00014-93-1-0933 dated June 7 1996.

Table 2. Mass and morphometric data from two harbour porpoises that were used in the postmortem cooling study.

ID	Sex	Length (cm)	Body mass (kg)	Thoracic Blubber/Skin thickness (mm)	Caudal Blubber/skin thickness (mm)
GM-94-43	Female	125.5	35.5	15/5	16/5
GM-96-03	Male	136	39.5	13/3	13/3

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Figure 1.Front-mounted satellite transmitter

Figure 2.Side-mounted satellite transmitter

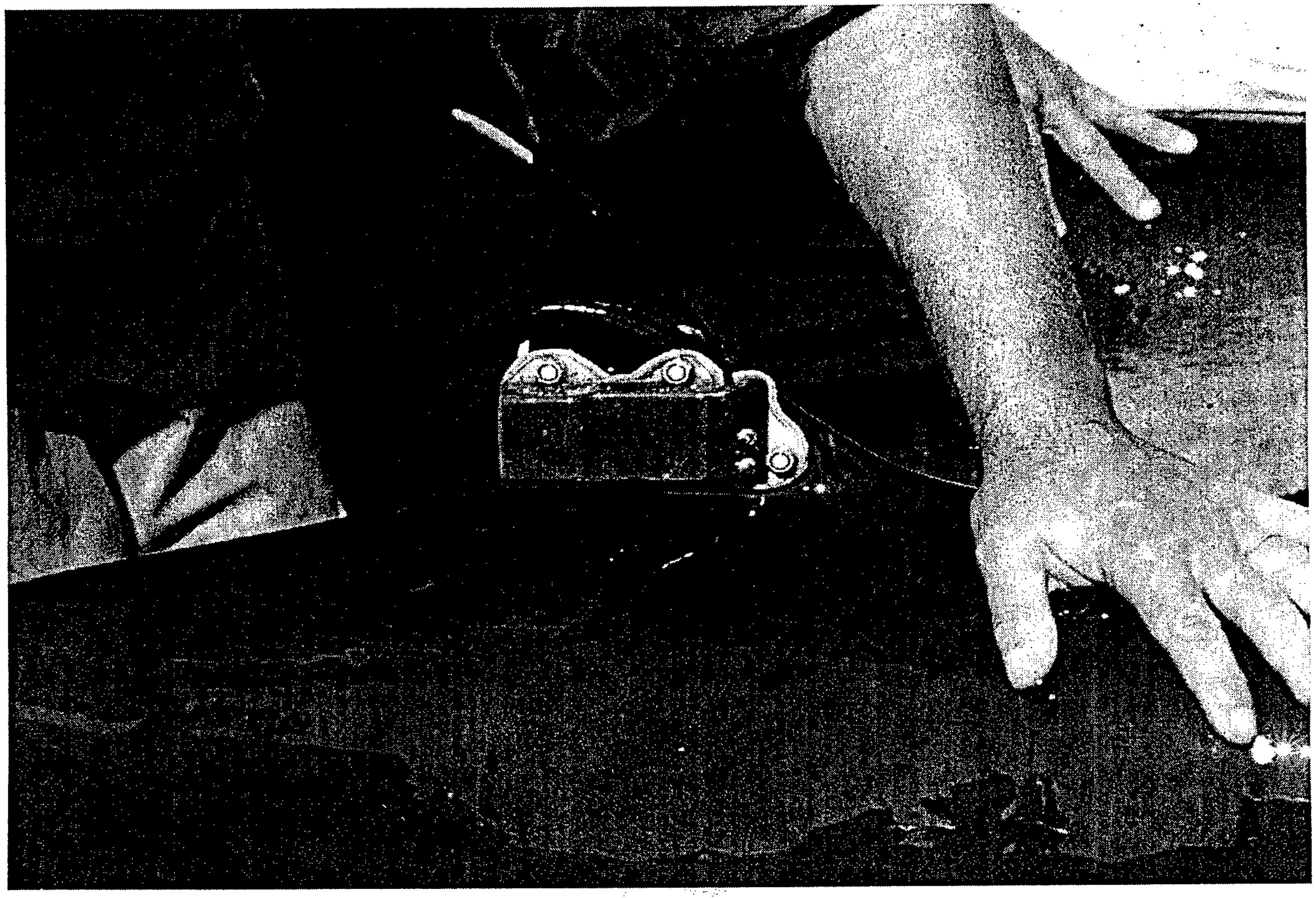
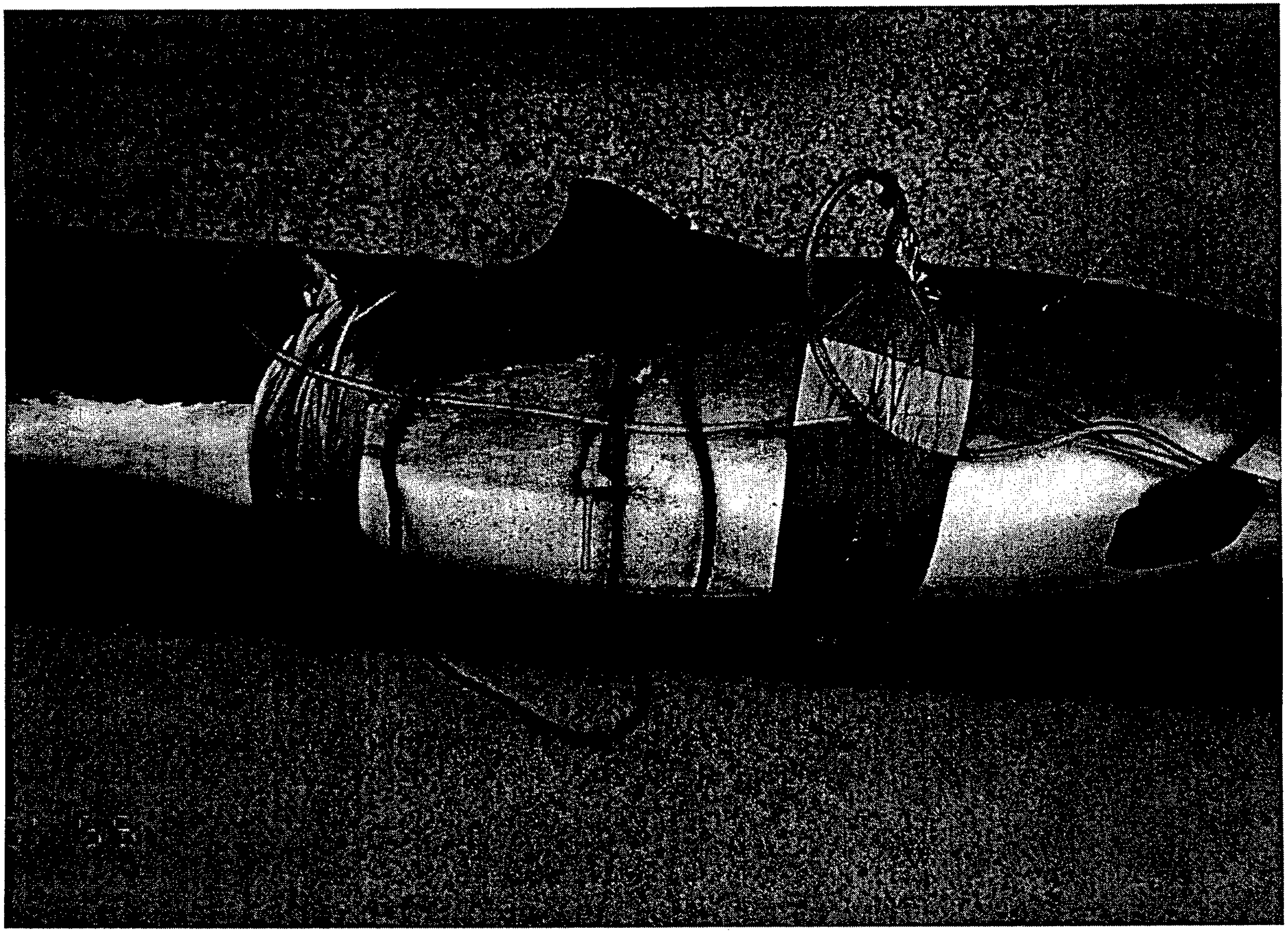
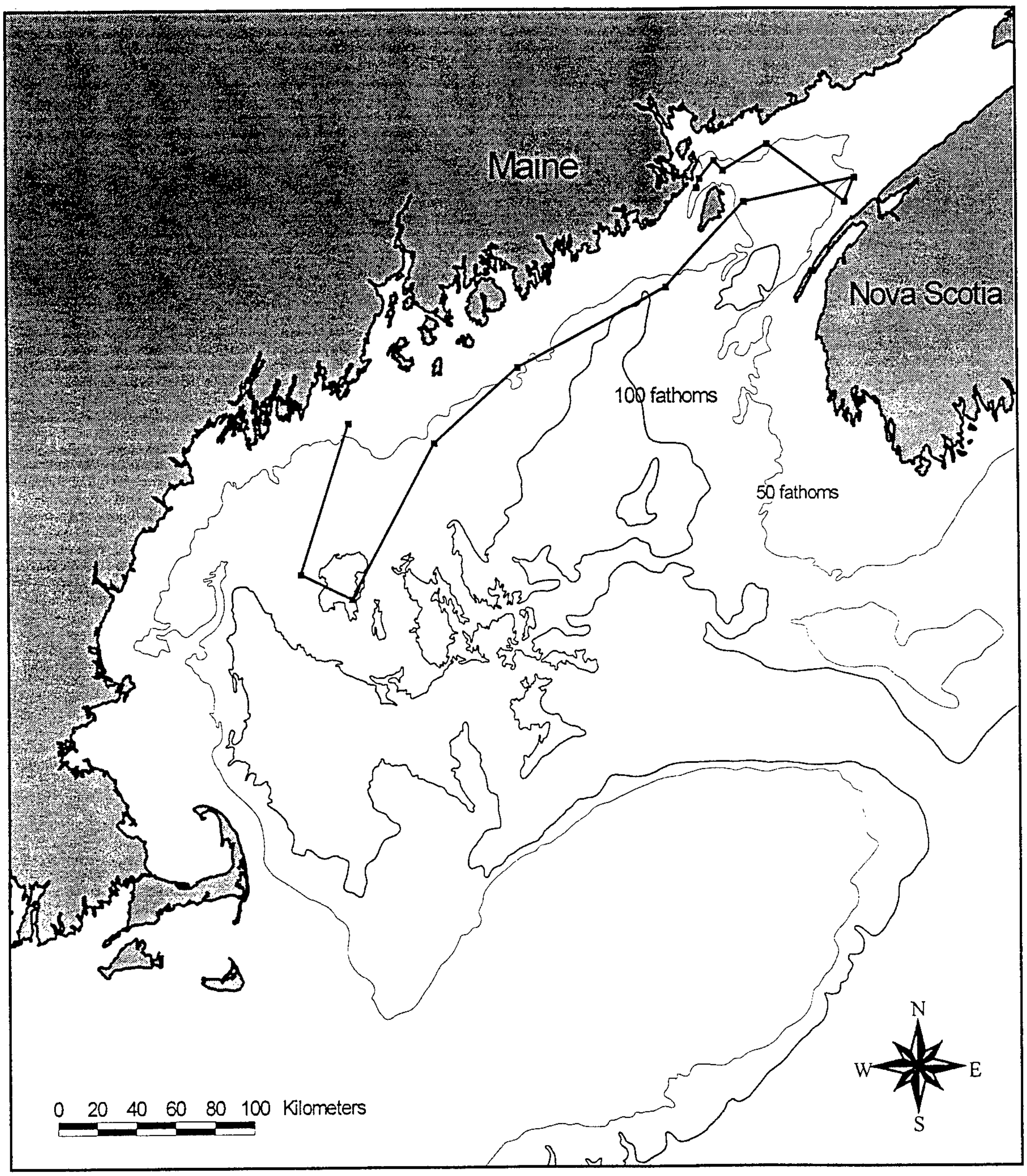


Figure 3. Positions of temperature probes used in post-mortem cooling study.



Porpoise 22914
(Best per Day, LC: 0-3)



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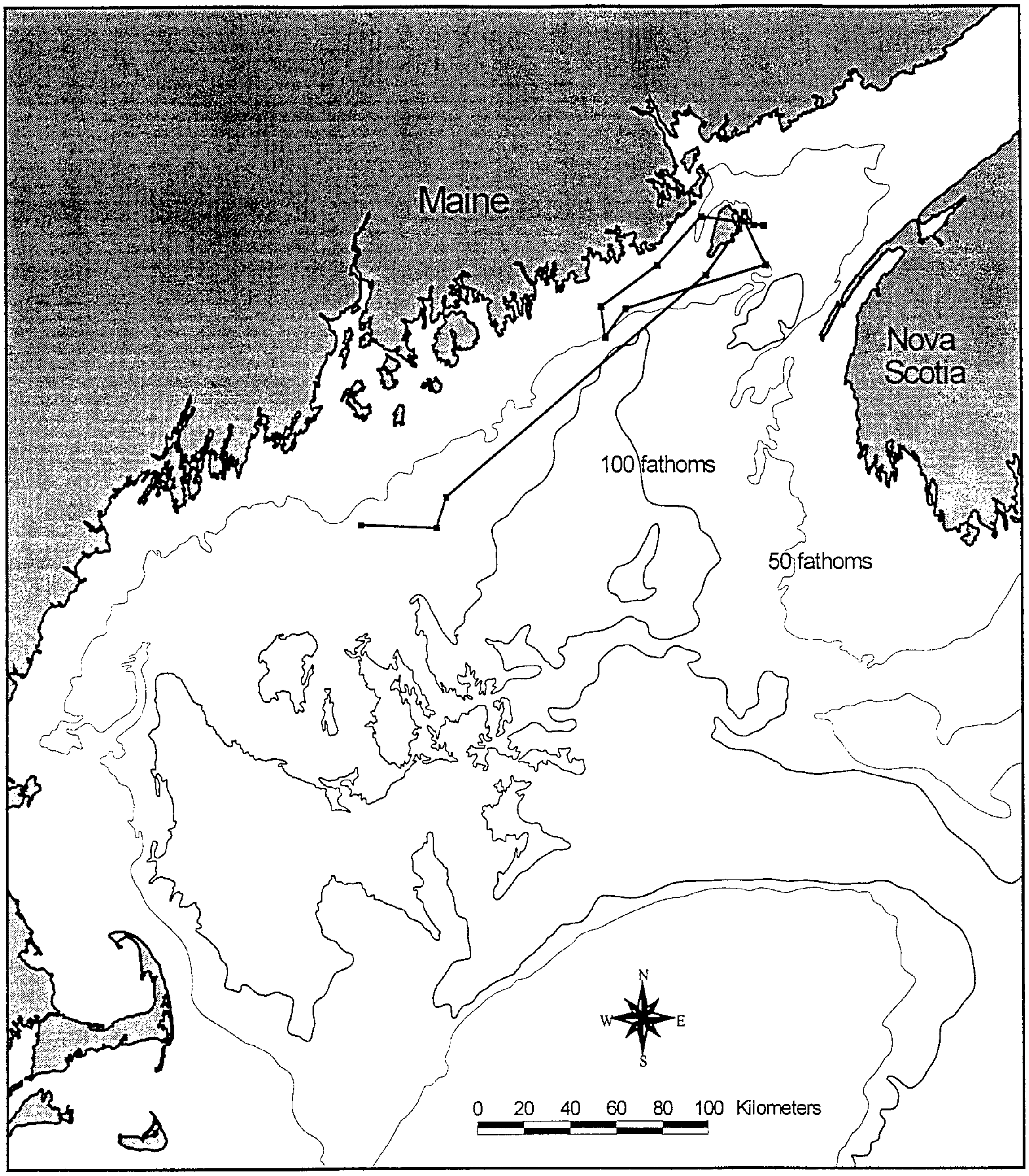

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Porpoise 24850
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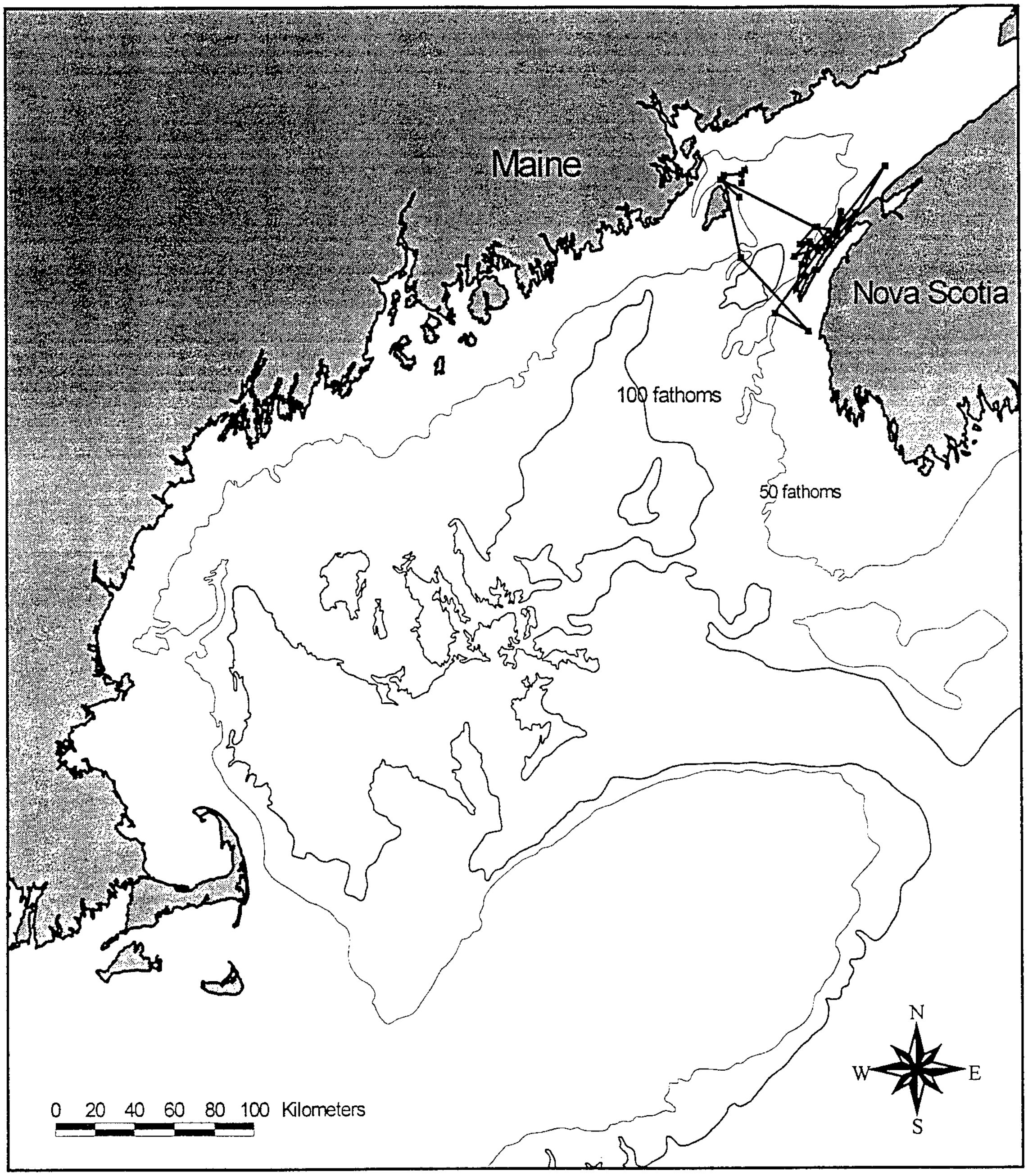

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Porpoise 24851
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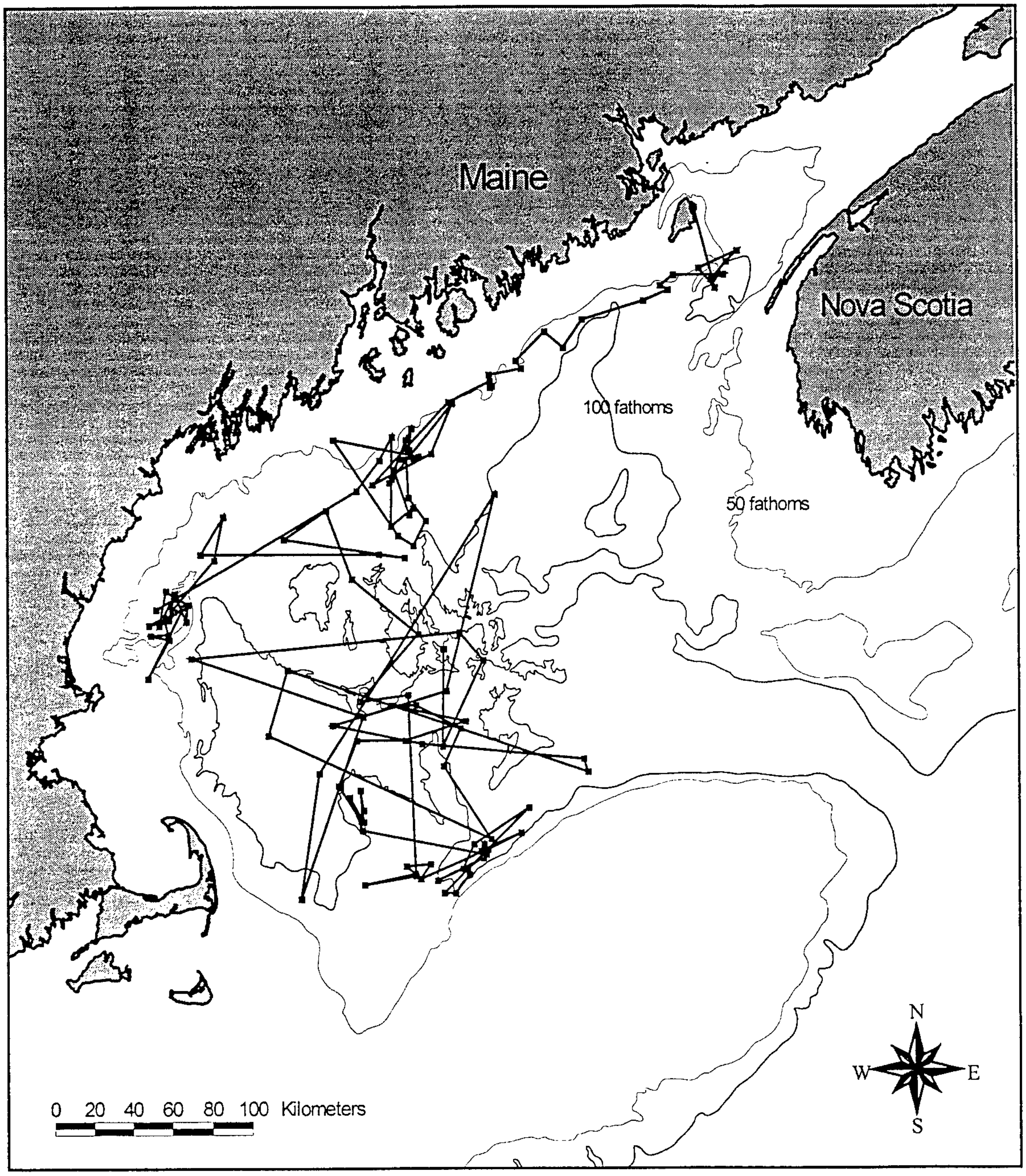
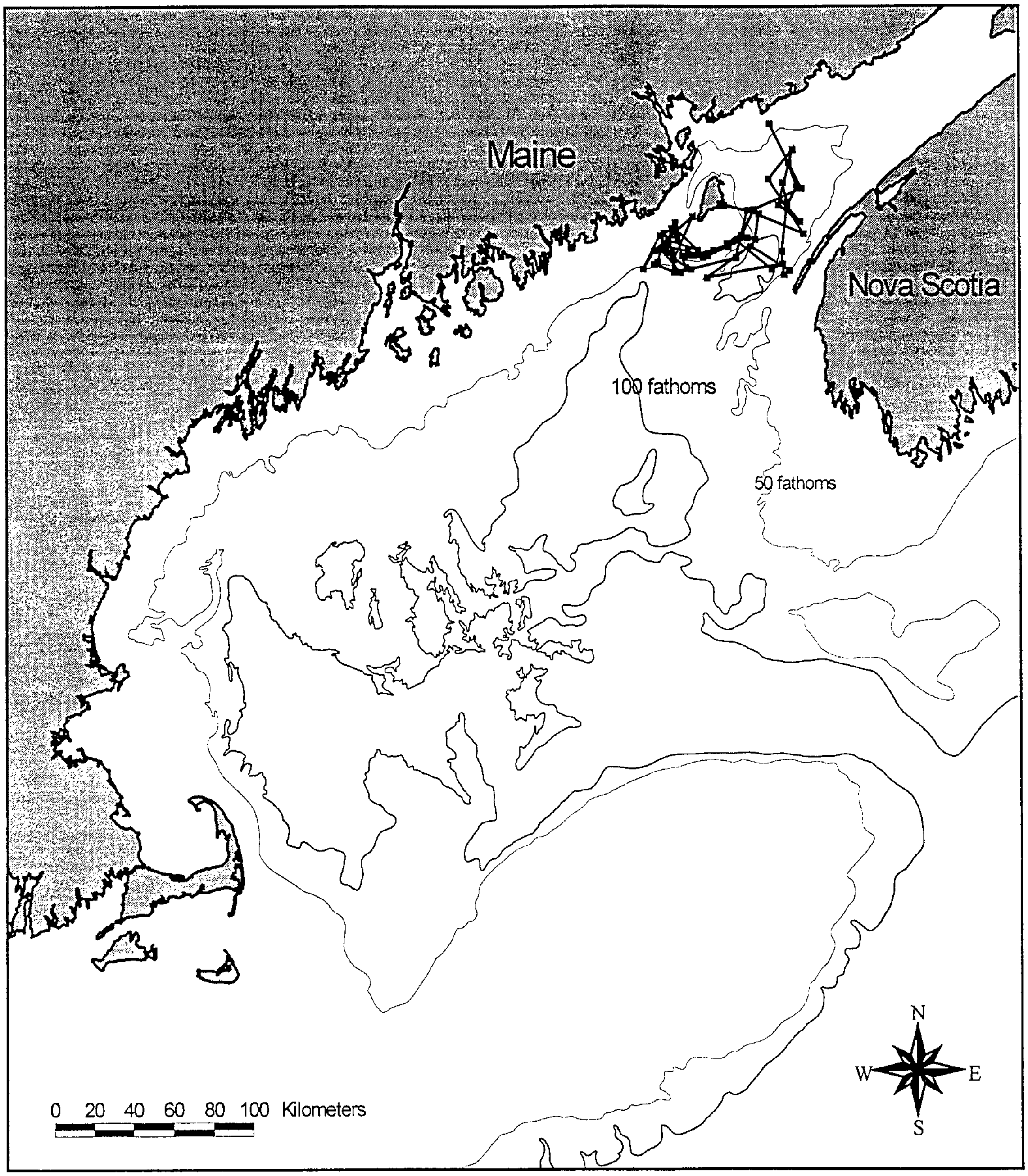


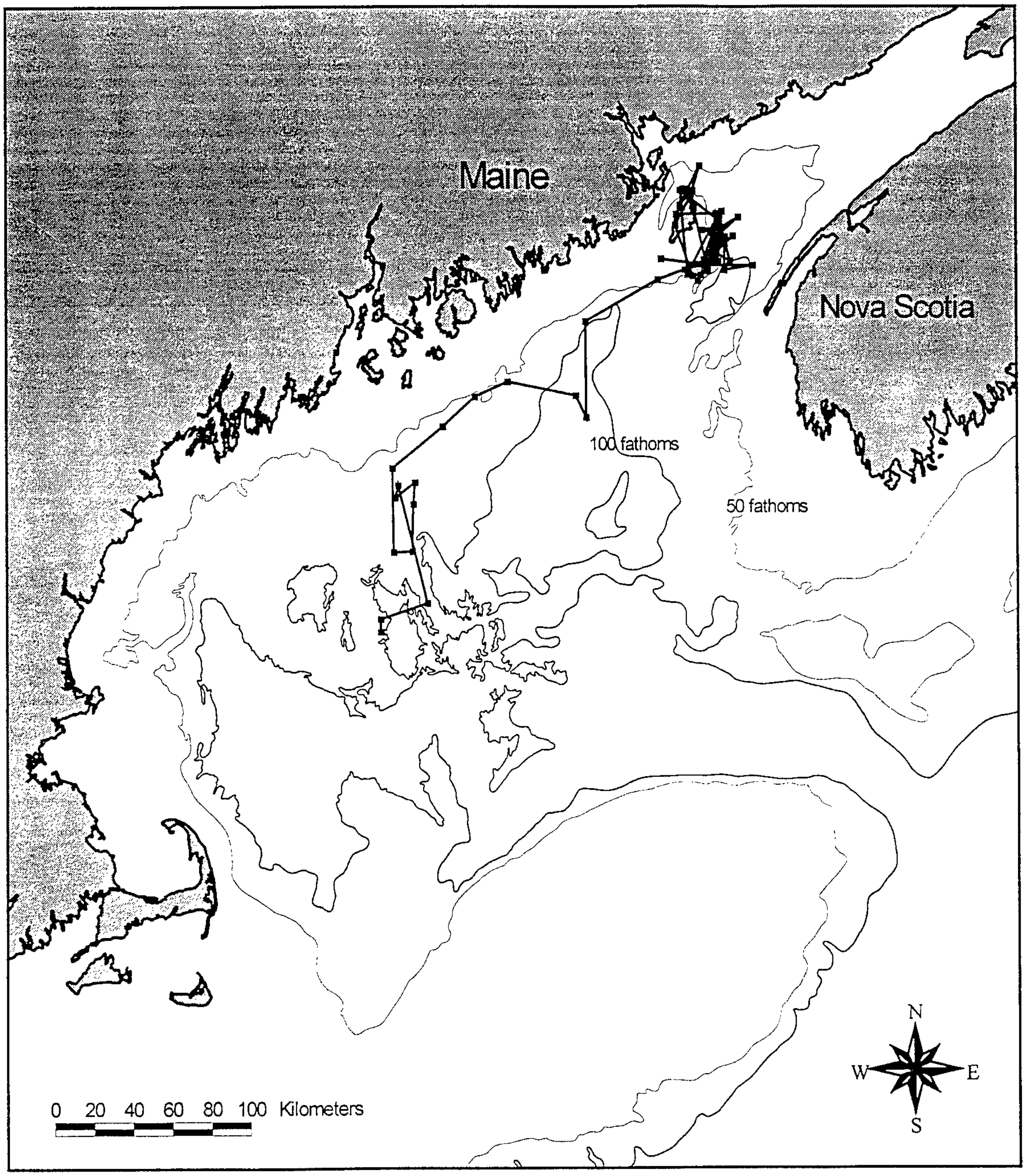
Source:
NMFS - WHOI coastline and bathymetry data
ARGOS satellite data

Porpoise 24849
(Best per Day, LC: 0-3)



Source:
NMFS - WHOI coastline and bathymetry data
ARGOS satellite data

Porpoise 24852
(Best per Day, LC: 0-3)



Source:
NMFS - WHOI coastline and bathymetry data
ARGOS satellite data

Figure 10

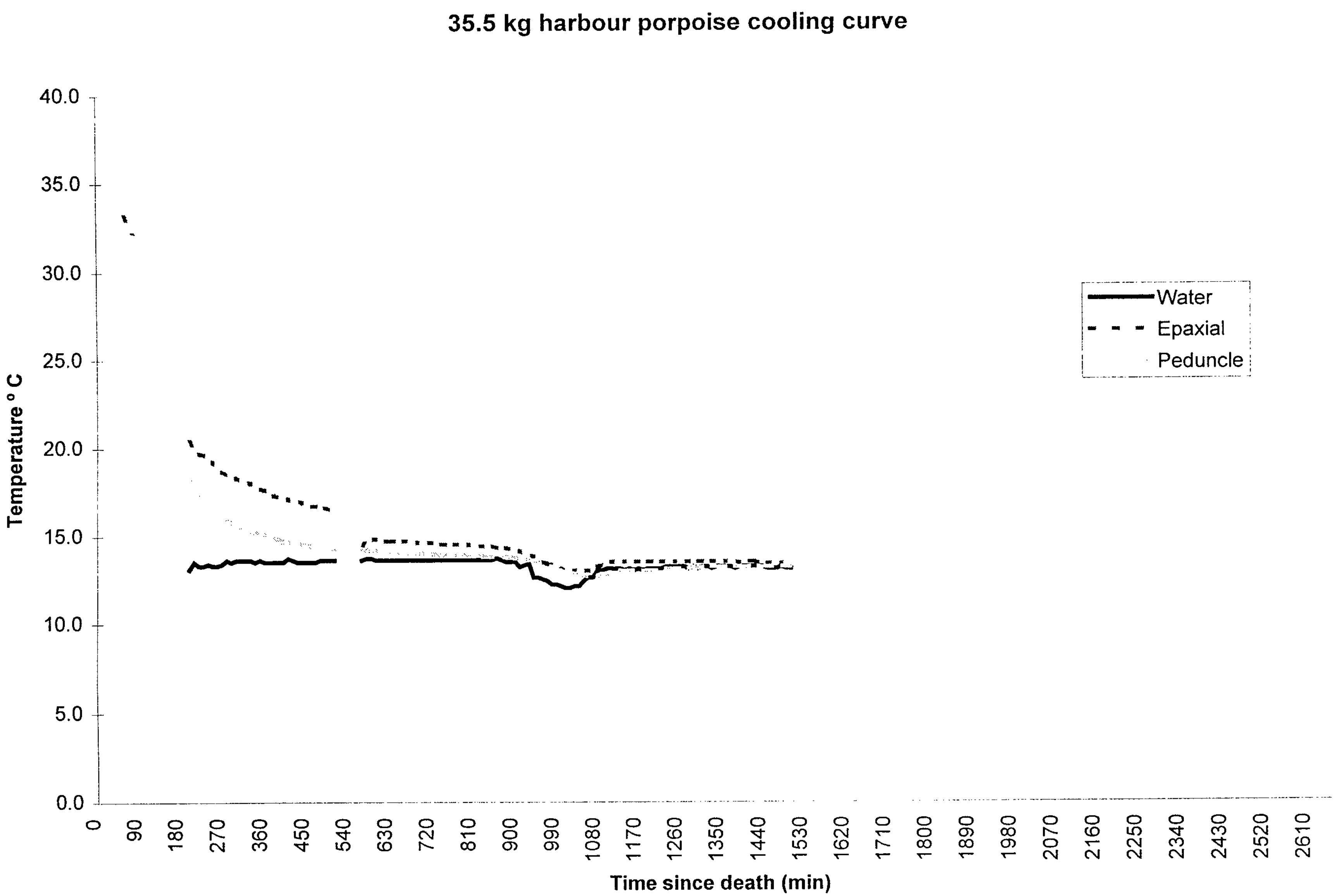
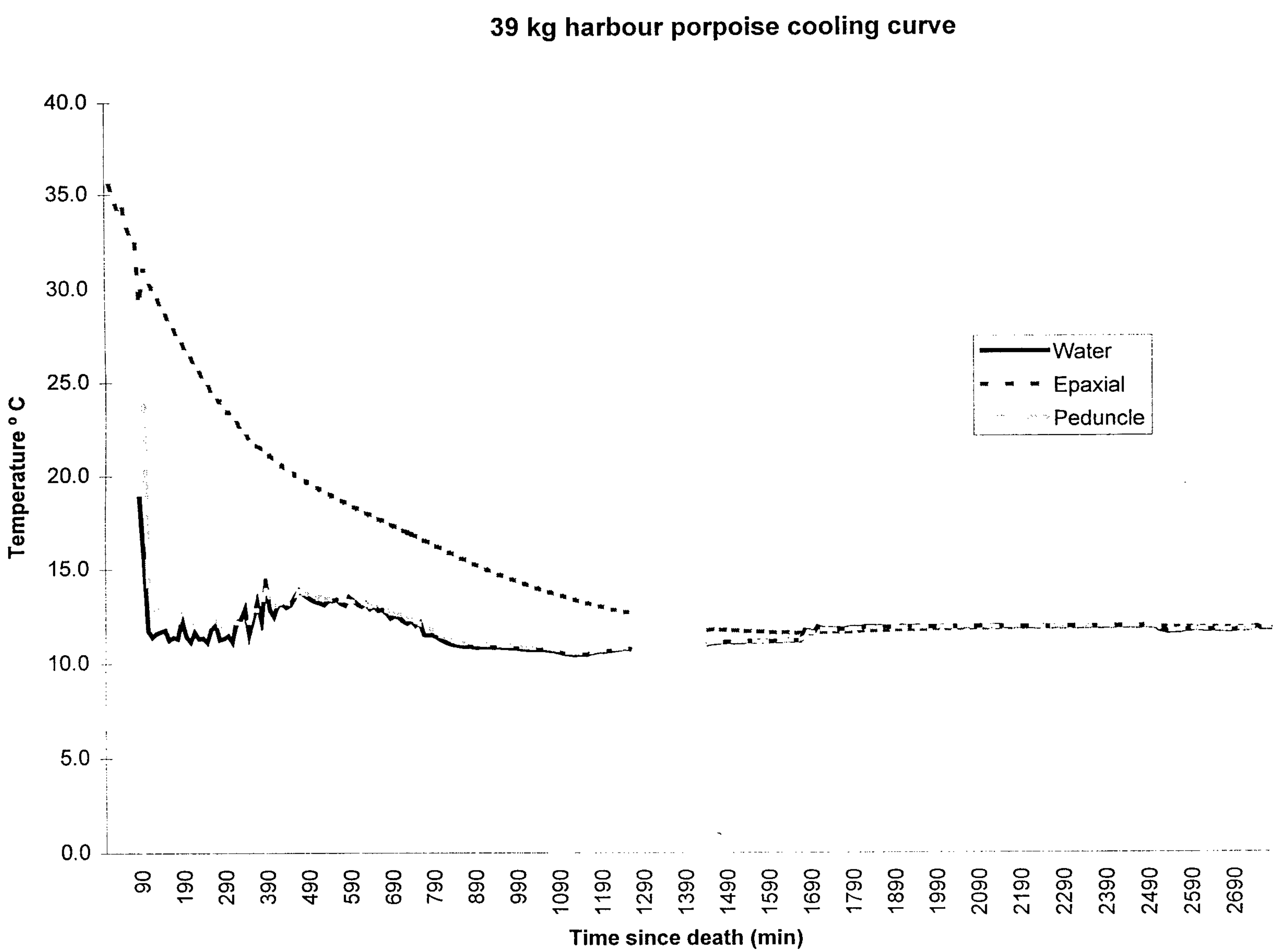

35.5 kg harbour porpoise cooling curve
Water
Epaxial
Peduncle
Temperature ° C
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
90
180
270
360
450
540
630
720
810
900
990
1080
1170
1260
1350
1440
1530
1620
1710
1800
1890
1980
2070
2160
2250
2340
2430
2520
2610
Time since death (min)

Figure 11


39 kg harbour porpoise cooling curve
Temperature ° C
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
90
190
290
390
490
590
690
790
890
990
1090
1190
1290
1390
1490
1590
1690
1790
1890
1990
2090
2190
2290
2390
2490
2590
2690
Time since death (min)
Water
Epaxial
Peduncle

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13. ABSTRACT *(Maximum 200 words)*
We deployed satellite-linked transmitters (PTTs) on two adult female and seven adult male harbour porpoises *Phocoena phocoena* released from herring weirs in the Bay of Fundy during the summers of 1994 and 1995. Our objectives were to evaluate the potential for monitoring long-term movements of these animals with satellite telemetry and to collect information on movements and patterns of habitat use of these animals. We used Telonics ST-10 transmitters in two configurations, a front mounted cylinder type and a side mounted box type. We received uplinks from each of the nine porpoises, allowing us to estimate reliable positions and monitor time spent at the surface. Transmissions were received for between 2 and 212 days. The side mounted design provided a more suitable long-term tag for harbour porpoises. Four male porpoises travelled into the Gulf of Maine, and one porpoise moved as far south as northern Georges Bank. Generally, porpoises exhibited a high degree of individual variability in both habitat utilisation and movement patterns. Movements of porpoises between the Bay of Fundy and Gulf of Maine are consistent with the hypothesis that this represents a single sub-population. These movements also underscore the trans-boundry nature of this sub-population as well as the problem of incidental catch in groundfish gillnets.

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