Text S1. Derivation of the Carcass Decomposition Temperature Correction

Within a carcass, the decomposition of organic material and the eventual production of gas, *vg*; is a function of the temperature of the environment, *Te*; and varies as a function of time, *t*. *dt* is the differential of time *t*. Integration of *vg(Te(t))* from the beginning of morbidity at *t=0*, to the time that a carcass floats to the surface, *t=TTF*; can be represented as the integration:

$$\int_0^{TTF} vg\big(Te(t)\big)dt = ADHf \qquad \text{(S1)}$$

giving the accumulated degree hours to float, *ADHf*. However experimental measurements and limited field studies suggest that the degree-hours required to float are non-linear, that is carcasses at warm temperatures (~>25 °C), float much faster than those at cool temperatures (~<10 °C), presumably because of the non-linear behavior of the autolysis and bacterial production of gas with temperature, that is much less gas is produced at cold temperatures and much greater amounts at warm temperatures.

Here we use a function

$$Tc = f(Te) \qquad \text{(S2),}$$

to correct for the temperature difference and rewrite (eq.S1) to include the correction as:

$$\int_0^{TTF} vg\big(Tc(t)\big)dt = cADHf \qquad \text{(S3).}$$

The correction (eq. S2), is based on the experimental measurements, however, its determination is indirect since the experiments measured the time to float but not the actual production of gas. The derivation follows in (eq. S4) through (eq. S8).

With steady temperatures maintained during long time intervals, the integration in (eq. S3) can be replaced with the summation term:

$$\sum_{t=0}^{t=TTF} vg\big(Tc(t)\big) = cADHf \qquad \text{(S4).}$$

A polynomial regression was fit to the *TTF* data for 37 carcasses incubated at various environmental temperatures, *Te*, ranging from 14 °C to 32 °C and with the TTF values standardized to a depth of 10 m (Fig. 3b in main text). Depth standardization was required as the ambient pressure likely influences the actual volume of gas generated (but not mass), at different depths. The regression was also constrained to pass through a value of zero at 40 °C, so that all values within the expected operational range of the model (15-35 °C) would remain above zero. The regression from Fig. 4 (main text) is:

$$TTF(10\ m) = 0.246Te^2 - 21.52Te + 468.0 \qquad \text{(S5).}$$

Since determinations of the *TTF* were conducted under steady temperatures maintained in the laboratory carcass trials (consistent *Tc*), the summation term on the left in (eq. S4) can be replaced by the multiplication of the *TTF* by the function for the corrected temperature *Tc* to give the sum of the mean time to float as:

$$TTF \cdot f(Tc) = \overline{cADHf} \qquad \text{(S6),}$$

and re-arranged as

$$f(\text{Tc}) = \frac{\overline{cADHf}}{TTF} \qquad \text{(S7).}$$

Substitution of the regression (eq. S5) for the *TTF*, and the midpoint value of the *cADHf* taken at 25 °C (15 °C to 35 °C) of 2086.4 as measured during the experiments, (eq. S7) becomes

$$Tc = \frac{2086.4}{0.246Te^2 - 21.52Te + 468.0} \qquad \text{(S8)},$$

which is the final form for converting the environmental temperature *Te*, to the corrected temperature *Tc*, and is applicable for predicting decomposition and time to float over the temperature range of 15-35 °C at which the regression (eq. S5) was determined. Note that 2086.4 is the midpoint *cADHf* for a 10 m depth (and 1014.9 as at the sea surface). The relationship between measured and the corrected temperatures is illustrated in Fig. S1. One final caveat is that the polynomial fit and correction, Equation S8, give erroneous values at cold temperatures below 15 °C since the polynomial continues its curvilinear shape beyond the data. A reasonable assumption is that as temperatures approach 0 °C decomposition would nearly cease. To achieve this effect we apply a simple linear correction to the experimental data below 15 °C using the dashed line depicted in Fig. S1. This has no influence in backtracking in the northern Gulf of Mexico, but only in the analysis of data from the harbor where extreme cold temperatures were encountered.

Text S2. Additional Individual Backtrack Examples

Backtrack Example 2

This sea turtle was found on the beach as a moderately decomposed carcass on a Mississippi barrier island and backtracks out over deep water. For brevity, just the final plots of *cADH* and *cADHf* (Fig. S2a), the probability curves (Fig. S2b), and the final mapped probability (Fig. S3) are shown. This example demonstrates how as the backtrack leaves the beach and goes over deeper water of about 20 m the *cADHf* rises quickly from 1500 to 3500 (Fig. S2a). The projected backtrack of cADH begins near 1730 at the beach and begins falling. The possible locations of origin occur a short distance from shore at time steps 0 to 50, thus resulting in a backtrack map with possible source locations very close to where the carcass was found beached on an offshore barrier island (Fig. S3). All the more distant backtrack locations in deep water are highly unlikely as the available cADH for this carcass would be exceeded. Backtracks later extend into shallow water but these locations would have resulted in much greater decomposition than the moderately decomposed carcass found on the barrier island. If this carcass had not sunk but always floated, then its possible source location would be much further away; in this case, close to where the backtrack heads back towards the coast (Fig. S3, purple dots).

Backtrack Example 3

This example is for a severely decomposed carcass that originates on the Mississippi mainland (Fig. S4 and S5). This carcass begins at 3258 cADH and is predicted to have traveled a long distance over shallow water with the curves finally intersecting at about 2000 cADH, around time step 380 (Fig. S4 a and b), occurring just past the final set of barrier islands and shoals (Fig. S5). The backtrack continues past these islands into deeper water, but the *cADHf* of 3000 to 4000, far exceeds the cADH remaining with the carcass. As the backtrack approaches the coast there is a brief period where the *cADHf* are low enough (1000), that at timesteps 600 to 700, a slight probability of origin is possible (Fig. S5). Within this same area, the cADH has fallen to zero giving a possible source location if this carcass had originated as floating (Fig. S5).

Table S1. Details of each turtle carcass used in the experimental trials. Carcass sources were: died in rehabilitation (DIR) and dead cold stun (DCS). SCL is straight carapace length.

Carcass ID	Species	Carcass Source & Treatment	Stranding Date	SCL (cm)	Experiment Date
K01	Kemp's ridley	DIR & Frozen	01/02/16	26.2	04/22/16
K02	Kemp's ridley	DIR & Frozen	12/23/15	23.9	04/28/16
K03	Kemp's ridley	DIR & Frozen	01/02/16	30.5	05/19/16
K04	Kemp's ridley	DIR & Frozen	12/30/15	30.6	06/07/16
K05	Kemp's ridley	DIR & Frozen	12/30/15	30.5	07/08/16
K06	Kemp's ridley	DIR & Frozen	12/21/15	26.2	07/15/16
K07	Kemp's ridley	DIR & Frozen	12/20/15	25.2	07/26/16
K08	Kemp's ridley	DIR & Frozen	12/04/16	24.3	03/21/17
G09	Green sea turtle	DIR & Frozen	01/22/16	24.6	"
K10	Kemp's ridley	DIR & Frozen	12/03/16	28.9	03/28/17
G11	Green sea turtle	DIR & Frozen	01/24/16	28.7	"
K12	Kemp's ridley	DIR & Frozen	11/28/16	21.1	04/06/17
G13	Green sea turtle	DIR & Frozen	01/19/16	22.5	"
K14	Kemp's ridley	DIR & Frozen	12/10/16	28.4	04/14/17
G15	Green sea turtle	DIR & Frozen	01/05/16	25.8	"
K16	Kemp's ridley	DIR & Frozen	11/27/16	28.5	04/21/17
G17	Green sea turtle	DIR & Frozen	01/05/16	26.0	"
K18	Kemp's ridley	DIR & Frozen	12/03/16	22.9	04/28/17
G19	Green sea turtle	DIR & Frozen	01/16/16	23.6	"
K20	Kemp's ridley	DIR & Frozen	12/10/16	28.5	06/06/17
G21	Green sea turtle	DIR & Frozen	01/18/16	28.4	"
K22	Kemp's ridley	DIR & Frozen	12/10/16	30.7	06/13/17
G23	Green sea turtle	DIR & Frozen	01/24/16	31.6	"
K24	Kemp's ridley	DCS & Unfrozen	12/11/17	27.4	12/13/17
K25	Kemp's ridley	DCS & Unfrozen	12/11/17	26.8	"
K26	Kemp's ridley	DCS & Frozen	12/07/17	21.7	"
K27	Kemp's ridley	DCS & Frozen	12/08/17	21.8	"
K28	Kemp's ridley	DCS & Frozen	12/07/17	23.5	"
K29	Kemp's ridley	DCS & Unfrozen	12/11/17	25.9	"
K30	Kemp's ridley	DCS & Unfrozen	12/11/17	25.9	"
G31	Green sea turtle	DCS & Frozen	12/29/17	27.7	01//03/18
G32	Green sea turtle	DCS & Frozen	12/29/17	26.9	"
G33	Green sea turtle	DCS & Frozen	12/29/17	28.1	"
G34	Green sea turtle	DCS & Unfrozen	12/29/17	25.9	"
G35	Green sea turtle	DCS & Unfrozen	12/29/17	27.8	"
G36	Green sea turtle	DCS & Unfrozen	12/29/17	25.6	"
G37	Green sea turtle	DCS & Unfrozen	12/29/17	23.2	"

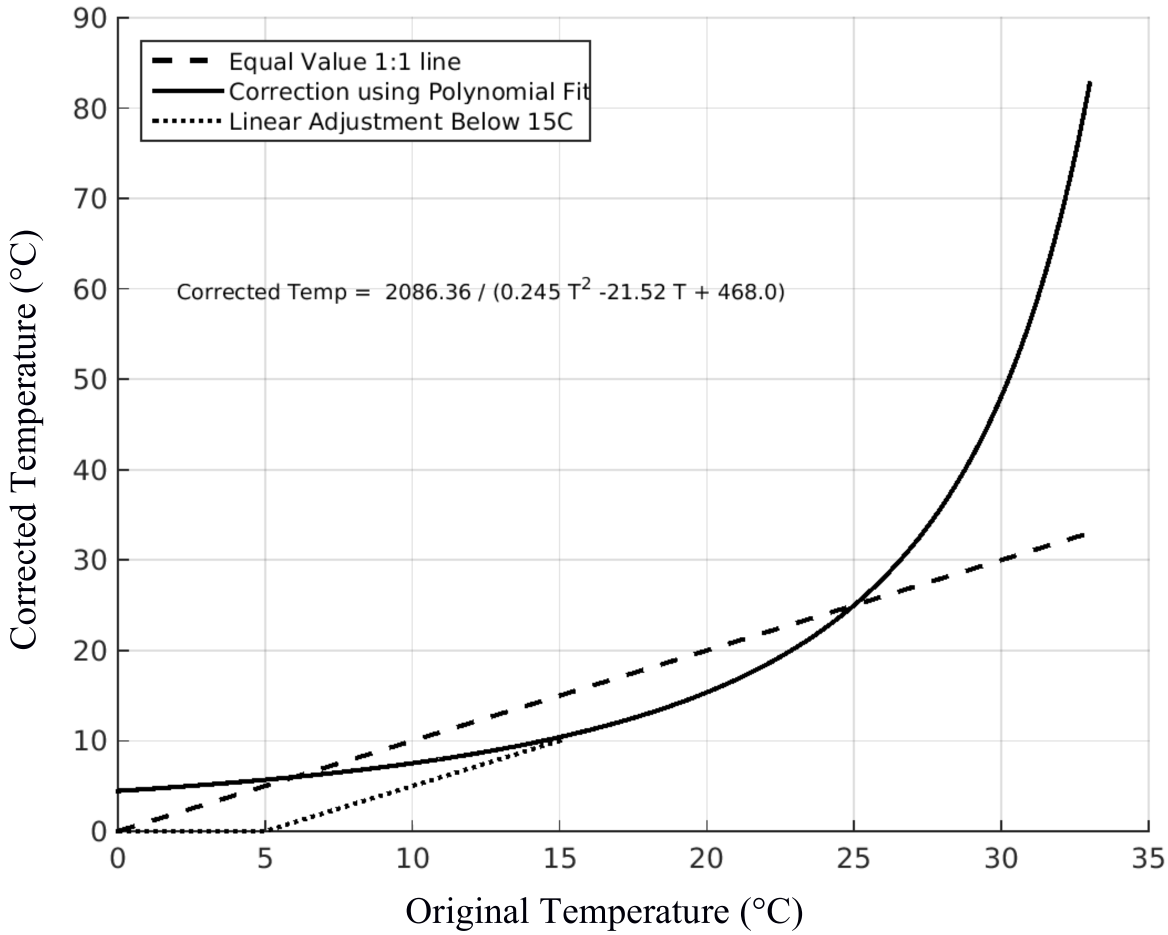

Fig. S1. Temperature conversion curves relating the original measured temperatures (x-axis) to the corrected temperature (y-axis) used in calculating the Corrected Accumulated Degree Hours (cADH) as well as the linear adjustment used below 15 °C.

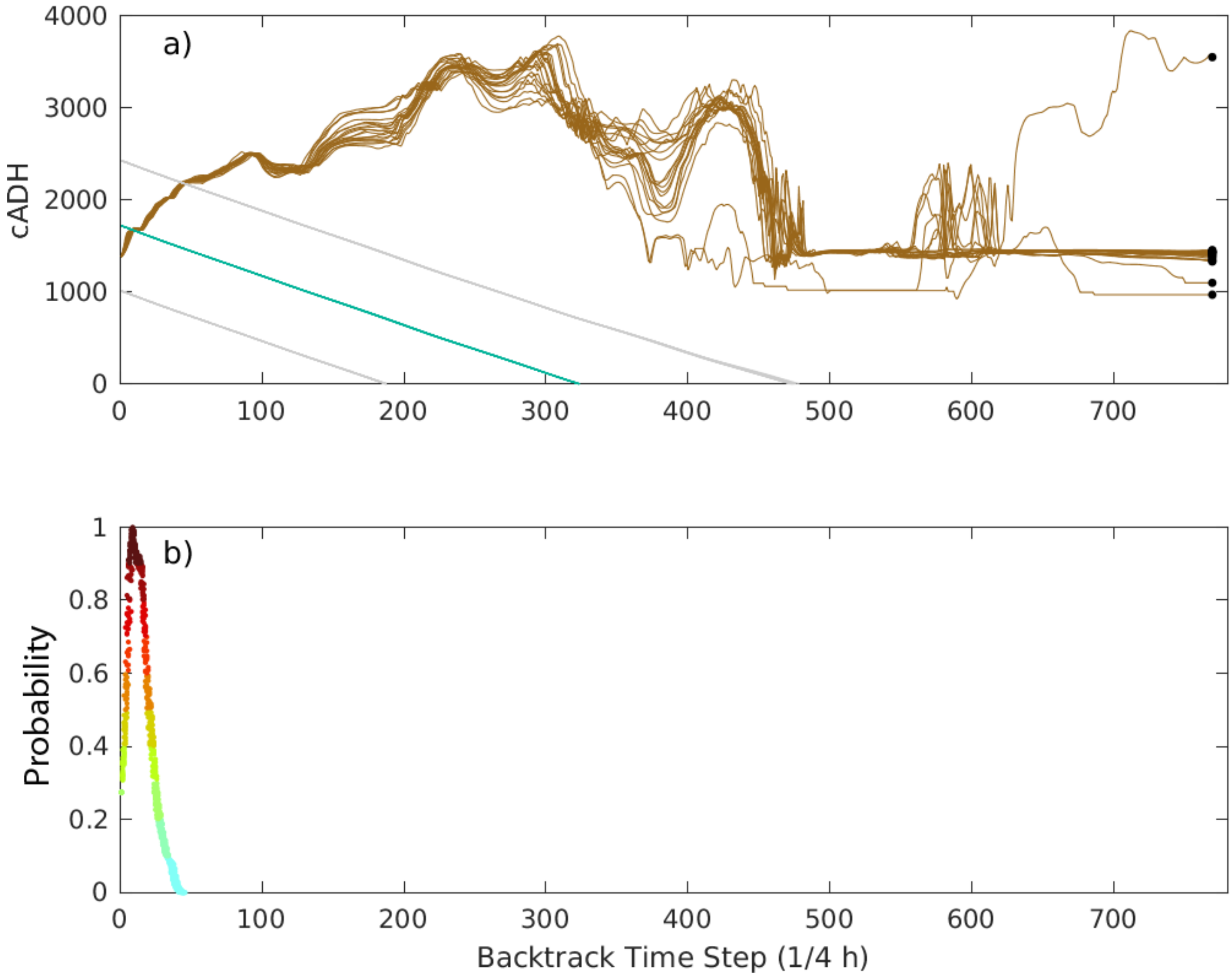

Fig. S2a) An overlay of the cADH budget along the backtrack (brown curves) with the cADH necessary for a moderately decomposed carcass to float up from the sea floor (green line) as well as the +/- error bounds on the cADH budget from the backtrack example 2, S2b) Matching probability values for backtrack example 2. Colors range from low probability (light blue) up to high probability (dark red).

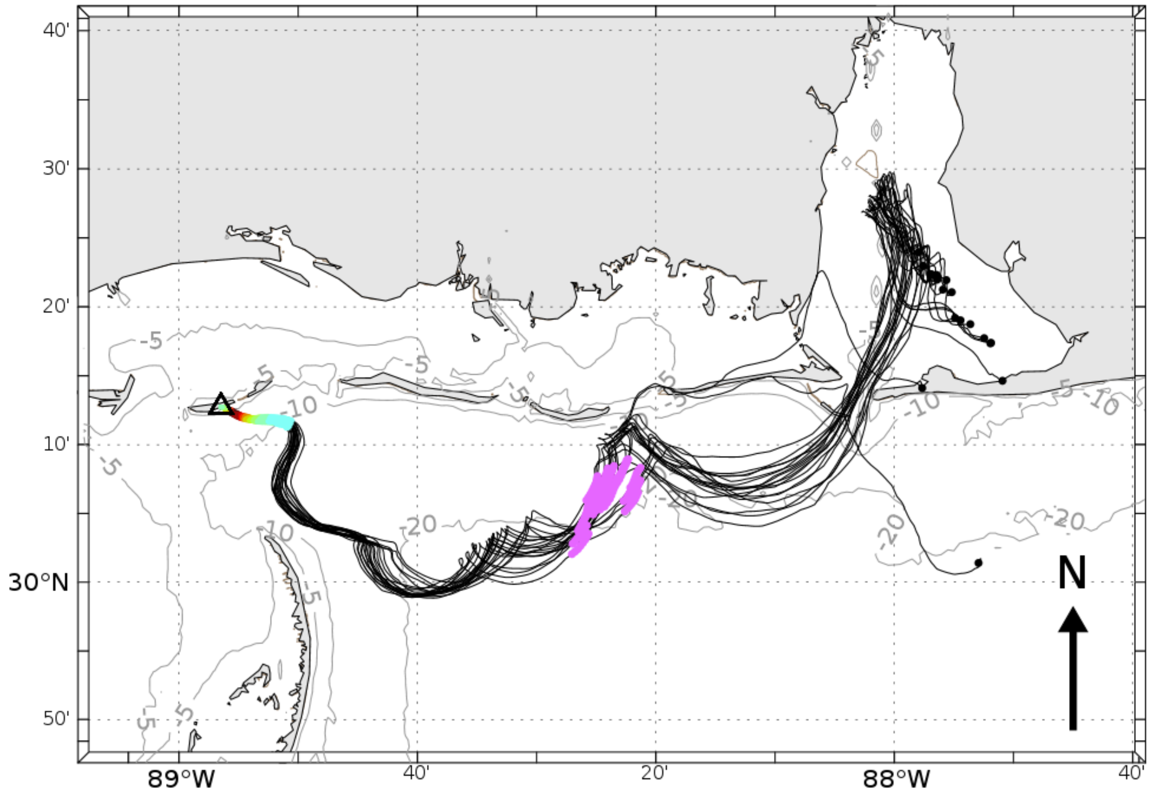

Fig. S3. Map of the resulting probability of origin for the moderately decomposed carcass from Example 2, backtracked from beach location (triangle). Colors range from low probability (light blue) up to high probability (dark red), with addition of the possible carcass source if having never sunk (purple dots) and backtrack endpoints (black dots).

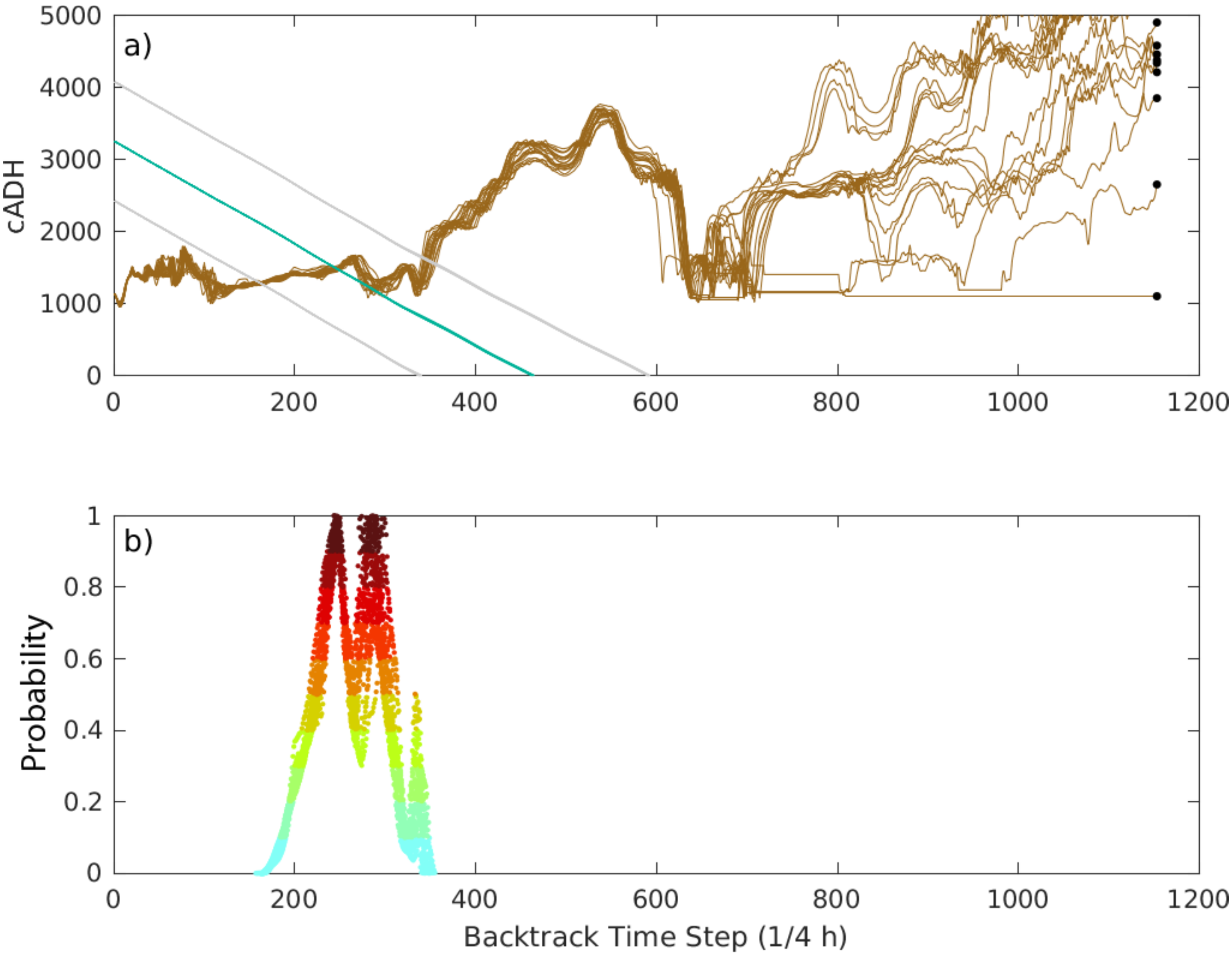

Fig. S4a) An overlay of the cADH budget along the backtrack (brown curves) with the cADH necessary for a severely decomposed carcass to float up from the sea floor (green line) as well as the +/- error bounds on the cADH budget from the backtrack example 3, S4b) Matching probability values for backtrack example 3. Colors range from low probability (light blue) up to high probability (dark red).

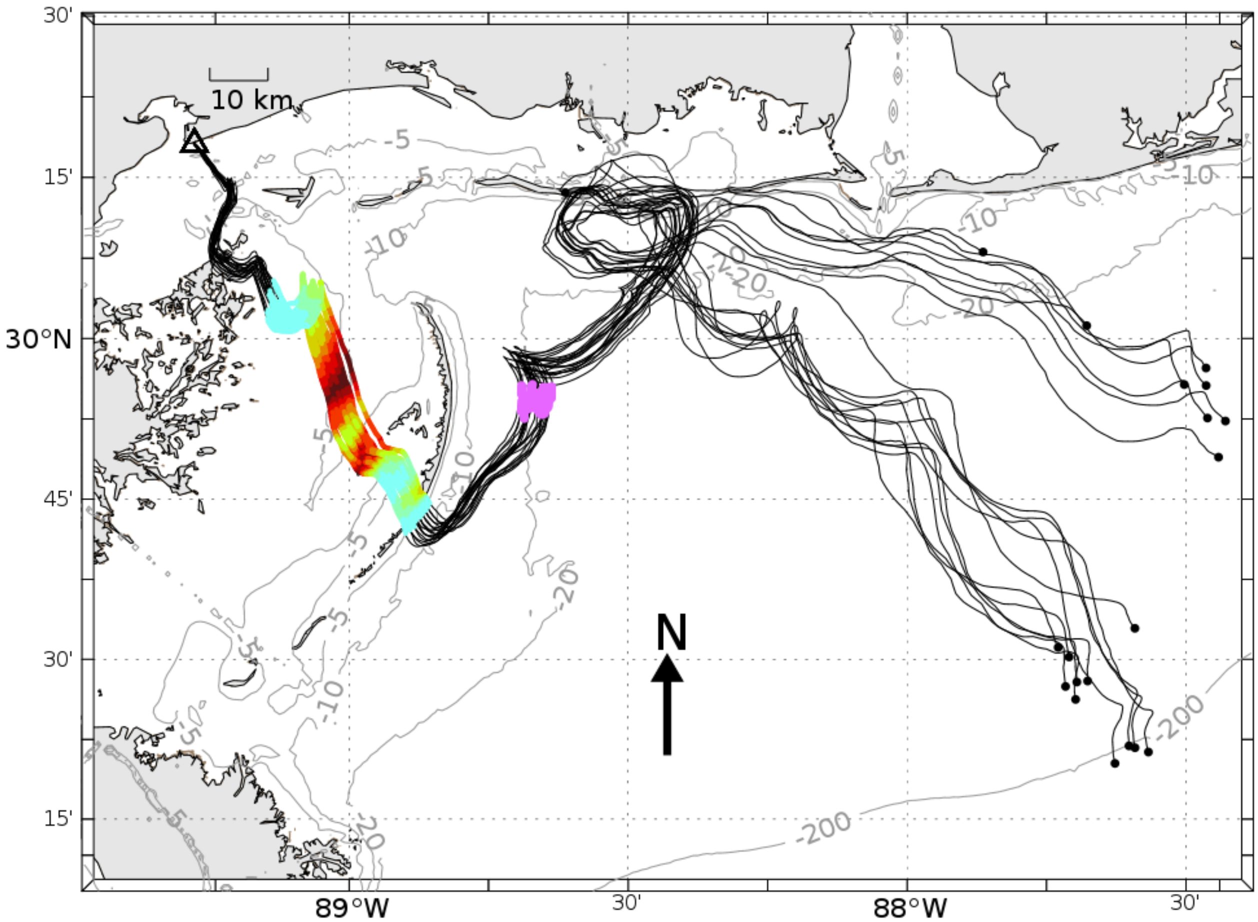

Fig. S5. Map of the resulting probability of origin for the severely decomposed carcass from Example 3, backtracked from beach location (triangle). Colors range from low probability (light blue) up to high probability (dark red), with addition of the possible carcass source if having never sunk (purple dots) and backtrack endpoints (black dots).