

CARBON ESTIMATES FROM TWO BEAUFORT SEA KEY SITES, ALASKA

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The Alaskan Beaufort Sea coastline is ~1783 km long and is dominated by low, organic-rich tundra bluffs faced by lagoons and their barrier islands (722 km), exposed tundra bluffs without barrier islands (462 km) and deltas with or without barrier islands (599 km). The present report estimates the annual organic carbon inputs from shoreline erosion from our two lagoon key sites; Elson and Beaufort Lagoons. Elson Lagoon is at the extreme western side of the Beaufort Sea and Beaufort Lagoon site is 60 km west of the Canadian border (Brown et al. 2003; Jorgenson et al. 2003). Previous investigations by the USGS estimated the sediment yield for a 344 km portion of the eroding Alaskan Beaufort coast (average rate of erosion of 2.5m/yr) to be $3.5 \times 10^3 \text{ m}^3/\text{km}$ for bluff erosion, and $3.8 \times 10^3 \text{ m}^3/\text{km}$ for offshore (submarine) sections (Reimnitz et al. 1988) These estimates used the ground ice-depth curve developed for the fine-grained sediments at Barrow; but no carbon estimates were provided for these earlier studies.

Low bluffs along Elson Lagoon consist of ice-rich, fine-grained sediments, surface and buried peats, and ice-wedges. A time series of erosion rates from 1949 to 2000 along the 10.8-km long reach of lagoon coast were determined by georeferencing aerial and high-resolution satellite imagery. Erosion rates for the period 1979-2000 were 47% higher (0.86 m/yr) than 1948-1979 (0.56 m/yr) and 23% higher than the 51-year average (0.68 m/yr). A total of 28 hectares of land was lost between 1979 and 2000 (Table 1). A sustained shift of storm surge-inducing winds at Barrow appears to correspond to the trend of increased erosion along the shores of Elson Lagoon. Using an average value of 50% ice volume (Sellmann et al. 1975), our initial estimates of annual sediment yield above sea level are $1.6 \times 10^3 \text{ m}^3/\text{km}$ for mineral sediment. Soil organic contents were based on available published soil map and carbon values for the principal soil units. We assigned carbon values of $50 \text{ kg}/\text{m}^3$ for these tundra soils (Bockheim et al. 1999, 2001). For the Barrow estimates we did not consider the carbon that occurs below the one-meter depth since the majority of soil and buried peats were observed to occur in this upper one-meter section. Based on the previously estimated ground ice contents, elevations, and erosion rates annual carbon input from the eroding shorelines (above water portion) is estimated at $63,500 \text{ kg C}/\text{km}$ for this section of Elson Lagoon.

Coastal erosion over a fifty-year period, and permafrost characteristics of the shoreline associated with that erosion, were assessed at Beaufort Lagoon in northeast Alaska. Soil stratigraphy was obtained from two bank exposures on abandoned floodplain deposits and one exposure on a sand sheet deposit (Table 2). All exposures had a thin (10–11 cm) fibrous peat accumulation at the surface underlain by a thin (17–23 cm) eolian silt deposit. Below these surface layers were thick buried accumulations of disrupted, amorphous peat clumps extending as deep as 1.5 m. Moisture contents (% vol.) for soils with segregated ice ranged from 52.7% to 84.4% in frozen soils. The volume of excess ice from segregated ice in the entire profiles ranged from 12.3% to 49.7%. Volume of wedge ice ranged from 10% to 20%. Organic carbon stores were $48\text{--}79 \text{ kg C}/\text{m}^2$ in the top 1 m, and $54\text{--}136 \text{ kg C}/\text{m}^2$ for the entire portion of the banks above water level (1.7 to 3.3 m high). Photogrammetric analysis of aerial photography from 1948 and 1978, and IKONOS imagery from 2001, revealed a mean erosion

rate of 0.5 m/yr for the 1948–1978 period and 0.5 m/yr for the 1978–2001 period along a 10 km stretch of coastline. Annual organic carbon input from the eroding shorelines (above water portion) ranged from 37,800 to 68,000 kg C/km of shoreline for the three sites.

Based on these two widely separated sites ~11 km in length, we estimate that the annual carbon input from eroding shorelines facing lagoons (722 km) along the Beaufort Sea Coast fall within the range of 37,800 to 68,000 kg C/km of shoreline. Rates of carbon input from exposed tundra bluffs are not yet available but probably are higher because of higher erosion rates. In contrast, deltas are flat, depositional environments that are accreting instead of eroding sediments and we assume the carbon input from shoreline erosion along deltas to be zero.

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Table 1. Annual sediment and carbon losses due to erosion, Barrow, Alaska (modified from Brown et al. 2003).

Segment	Segment Length (km)	Mean Elevation (m)	Photo Interval	Area Lost (ha)	No. Years	Mean Width Lost (m)	Mean Width Lost (m/yr)	Annual Sediment Input* ($10^3 \times \text{m}^3/\text{km}$)	Annual Carbon Loss in Top 1 m (kg/km)
A	-2.9	2.1-	1979-00	4.4	21	18	0.86	0.9	43,000
B	2.0	3.3	1979-00	2.8	21	13.7	0.65	1.1	32,500
C	3.4	2.9	1979-00	6.4	21	18.8	0.9	1.3	45,000
D	2.5	-1.8	1979-00	14.6	21	57.7	2.75	2.5	137,500
A-D	10.8	2.5	1979-00	28.2	21		1.27	1.6	63,500

*assumes 50% of mean bluff height is ground ice.

Table 2. Annual sediment and carbon losses at Beaufort Lagoon, northwestern Alaska (modified from Jorgenson et al. 2003).

	Transect 1	Transect 2	Transect 3
Bank height above water (m)	1.7	3.3	2.1
Mean thaw depth – tundra (cm)	38.2	37.9	39.2
Mean thaw depth – foreshore (cm)	100	119	46
Mean thaw depth - lagoon (cm)	nd	177	73.5
Cumulative organic thickness (cm)	32	60	29
Maximum organic depth (cm)	>82	60	85
Total amount of excess segregated ice (%)	12.3	49	49.7
Total amount of wedge ice (%)	10	20	15
Total volume of all excess ice (%)	21	59	57
Total organic carbon in top 1m; excluding ice wedges (kg C/m ²)	48	79	49
Total organic carbon in entire bank to water level; excluding ice wedges (kg C/m ²)	60	170	76
Total organic carbon in entire bank to water level, including ice wedges (kg C/m ²)	54	136	65
Total mineral sediments in entire bank to water level; including ice wedges (kg C/m ²)	794	998	871
Average erosion rate 1948-2001(m/yr)	0.7	0.5	1
Annual organic carbon input (kgC/m of shoreline)	37.8	68	65
Annual organic carbon input (kgC/km of shoreline)	37,800	68,000	65,000
Annual mineral sediment input (kgC/km of shoreline)	555,800	499,000	871,000