ARCTIC COASTAL EROSION: AN OVERVIEW

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INTRODUCTION (as presented orally in Barrow)

Thank you very much Jana. Mr. Mayor, Ladies and Gentlemen. It is a pleasure to see students from across the North Slope. I think your addition here is especially timely because if we say something that pertains to your village, you will be able to correct any mistakes we make and further you can add pertinent information that you have gained from your first hand experiences.

Photo #7: Dr. Jesse Walker presenting an overview of arctic erosion. Photo by Karen Brewster.

I would like to dedicate this talk to Nannie Woods (photo 8), who was a member of the commission until she died two years ago. Nannie and George Woods, two sons, a daughter and grandchildren have all assisted me during the 30 years I have worked in the Colville Delta. Nannie was not only always very helpful but also was one of the most remarkable persons I think I have ever met.

When Jana called me in Louisiana she suggested that I give an overview of coastal erosion. Taking her at her word, I used those words in the title given above. The talk is divided into six parts and is illustrated with about 100 color slides. These parts are: 1. A general introduction to the physical environment of the North Slope; 2. Comments about the factors involved in shoreline erosion with emphasis on thermal and aeolian processes; 3. Details about the bluff retreat that occurs along riverbanks and the seashore with comments about a few of

Photo 4. Nannie Woods who observed over 150 feet of riverbank erosion at Nigilik (see Fig. 10). Photo by J. Walker.

Table 1. Physiographic units of northern Alaska.[1]

Area	Physiographic unit (km^2)			North Slope area	
	Division	Province	Section	Km^2	Percentage
Interior Plains	70,900	....	....	....	100
Arctic Coastal Plain	....	70,900	....	....	100
Teshekpuk	....	....	54,000	54,400	100
White Hills	....	....	16,500	16,500	100
Rocky Mountain System ...	237,000	....	....	....	57
Arctic Foothills	....	100,800	....	....	95
Northern Foothills	....	....	62,400	62,400	100
Southern Foothills	....	....	38,400	33,100	86
Arctic Mountains	....	136,200	....	....	30
De Long Mountains	....	....	11,100	2,300	21
Noatak Lowlands	....	....	11,100	....	0
Baird Mountains	....	....	13,000	....	0
Central and Eastern Brooks Range	....	....	90,600	[2]38,200	42
Ambler-Chandalar Ridge and Lowland	....	....	10,400	....	0
Totals	307,900	307,900	307,900	[2]206,900	67

[1] Northern Alaska in this table includes the Arctic Coastal Plain, the Arctic Foothills, and the Arctic Mountains.
[2] Includes the 250 km^2 of the Alaskan portion of the Firth River which, although draining into the Arctic Ocean, is in the Intermontane Plateaus Division.

the archaeological sites that have been lost or damaged. Although I am not an archaeologist, I trust that all of the material on archaeological sites such as those in the Colville delta, Cape Krusenstern, Point Lay, Wainwright and Barrow will help set the stage for the experts who will be talking about archaeology per se.; 4. A discussion about some of the attempts already made in protecting the shoreline in the North Slope Borough; and 5. A bird's eye view of the bluffs along Barrow and Wainwright via slides taken from the air in 1985, 1987 and 1989. (For this submitted written paper, the text has been limited to parts 1-4.)

PHYSICAL ENVIRONMENT OF THE NORTH SLOPE

The area of the North Slope is a little more than 200,000 km^2 (80,000 mi^2) or about the size of Idaho or Kansas with the coastal plain totaling about one third of that. (Table 1, Fig. 2.) The coastal plain of Alaska is a continuation west of a low coastal area that begins in Banks Island and extends across north Canada into Alaska.

Although archaeological sites are numerous across the North Slope (especially along the rivers and seashore), present-day villages number fewer than a dozen (Fig. 2). This map was designed to show the locations of villages where there has been river and lagoon gravel and sand dredging by the NSB since 1980. By this dredging procedure bars, islands and beaches are saved.

In earlier years when beaches were used as gravel sources for road and airfield construction, bluff erosion was aggravated and important archeological material lost.

Drainage of the North Slope is toward the Arctic Ocean with the Colville drainage basin occupying about one-third of the total (Fig. 3). Although most of the rivers were important as lines of communication in earlier times, the Colville River was especially valuable because it was the route of travel from Anaktuvuk Pass to Nigilik on the Colville delta. Nigilik, a very important site, was the meeting and trading point for Point Barrow and Anaktuvuk Pass peoples.

The environmental factors that impact erosion in the North Slope are numerous; many of them are unknown to people who live outside the Arctic. Most of those non-Alaskans who know about the so-called "ice age" believe that all of Alaska and especially Arctic Alaska, was covered by ice and therefore expect that many of the surface forms of the state were caused by glacial ice. However, as it so happens, glacial ice, even during the glacial maximum, was restricted to the Brooks Range and part of its foothills. The rest of the North Slope was ice-free and only felt the impact of glacial ice by sediments brought to the ocean by glacial melt water streams.

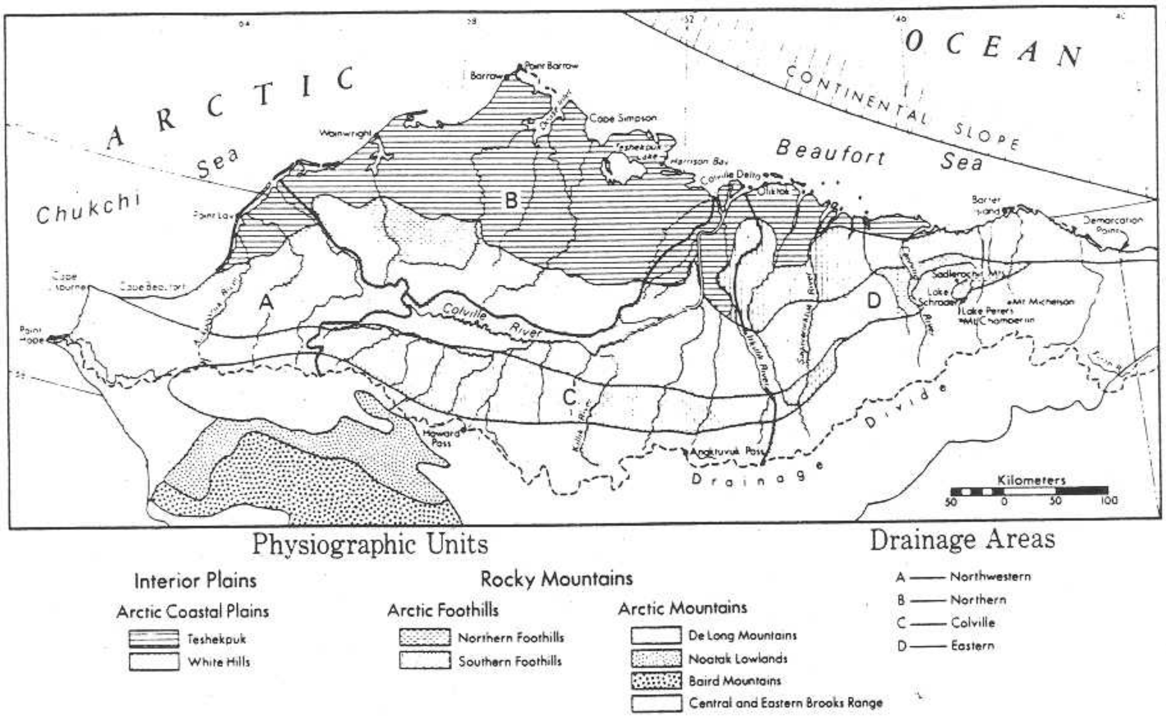

Fig. 1. The North Slope and its physiographic divisions.

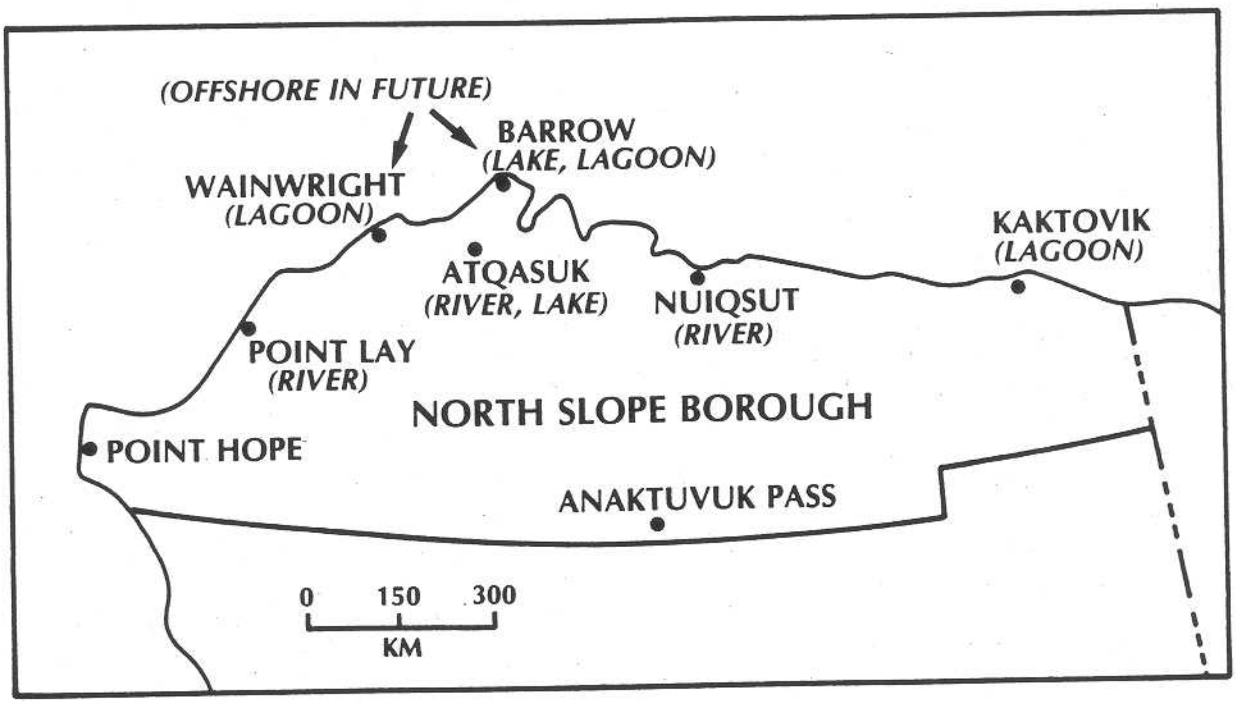

Fig. 2. The North Slope showing village locations and dredging types.

PROCESSES AND BLUFF EROSION

However, even though exempt from glacial ice, the North Slope was and still is subject to processes resulting especially from very low temperatures, usually referred to as periglacial processes. Environmental characteristics in the case of river bluffs include permafrost, frost mounds, pingos, and ice-wedge polygons among others.
Because of low temperatures, snow, ice and a frozen active layer prevail during 8-9 months per year and geomorphic activity is minimal. The major exception that has a bearing on shoreline erosion is the occasional *ivu* that can occur even during winter.

Another major factor in the erosion of riverbanks, lake shorelines and coastlines is the impact of water. Because these waters are solid most of the year, their impact is limited to a relatively short season. The intensity of the impact varies with stage, velocity, temperature, "tools", (any solid matter such as gravel moved by the water), and nature of the shoreline (its texture, composition, steepness, etc.).

Most of the erosion (and therefore retreat of the bluff line) occurs during the period of breakup. Once snowmelt begins water starts to flow over the tundra surface and accumulate on the river ice. As the meltwater increases in amount the stage of the river rises and flow seaward begins. Floating ice will fluctuate with stage until breakup occurs. This flowing water impacts the banks it flows against in two ways. First, the temperature differential will result in thawing of snowdrifts and then the permafrost of the bank. Second, the moving water will remove and transport the loosened materials causing bluff retreat. In the process a thermo-erosional niche will develop - i.e. undercutting of the permafrost bluff occurs. In time undercutting can lead to block collapse and rapid retreat. Much of this type of collapse occurs along ice wedges and it is not uncommon to have most of an ice-wedge polygon undercut and collapse (Photo 9 and Fig. 4).

These processes are especially severe at high water stages and high river velocity; usually they last for only a couple of weeks. However, even during mid-summer with heavy rainfall in a drainage basin relatively high stages can occur. In the wider rivers, such as the Colville, wind can cause waves of sufficient height to impact bluffs and hasten erosion.

Although these processes are similar along the ocean's shorelines there are numerous differences. Tides (which are low) and wind generated waves impact the shoreline and at times may be very severe. Fall storms are usually the most intense. They occur especially from August to October and are the result of westerly winds blowing over the relatively long fetch that may occur when the pack ice of the Chukchi and Beaufort seas are far from shore (Fig. 5). The storms of

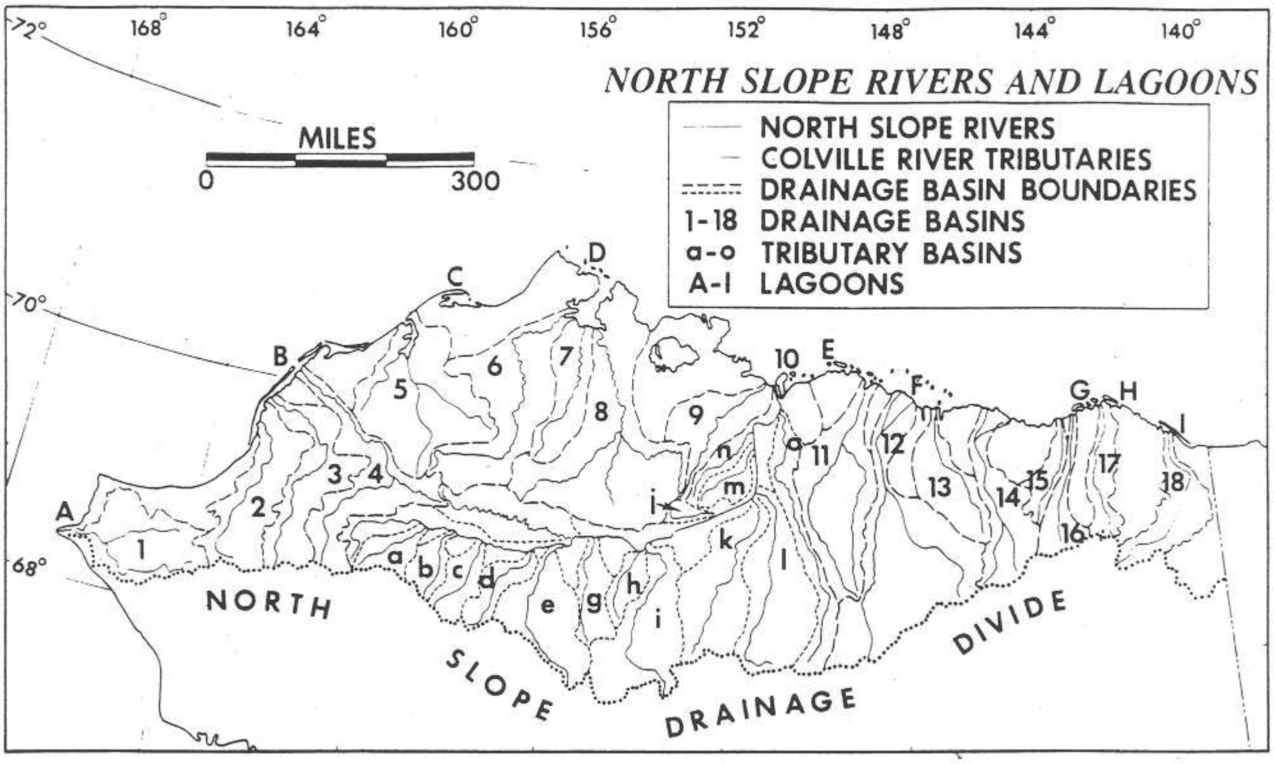

Fig. 3. North Slope drainage basins with the main tributaries of the Colville River listed from a to n.

Photo 9 Collapse blocks after undercutting at Nuiqsut.

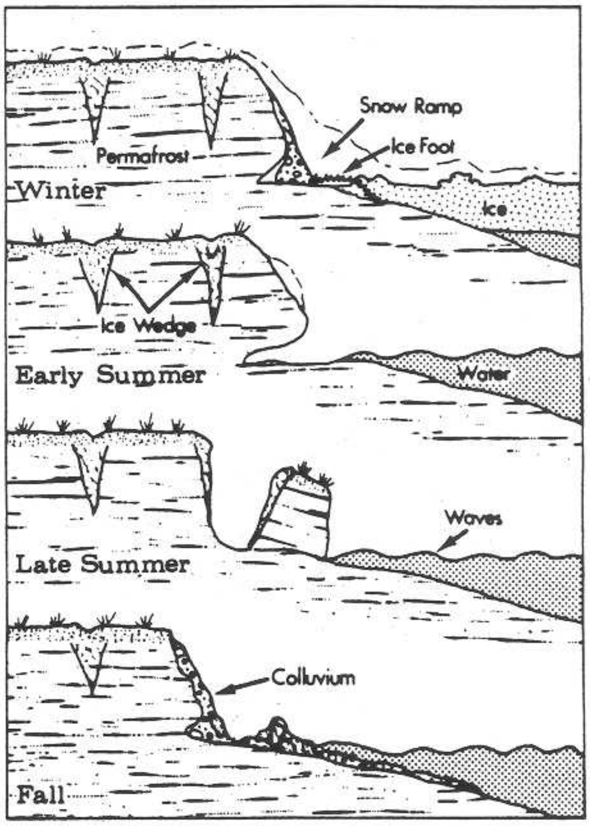

Fig. 4. Schematic sequence leading to blocks collapse.

September 1986, which caused major bluff retreat at Barrow (Photo 10) and Wainwright, were especially severe. The winds accompanying them were not as strong as many that blow along the coast. However, they lasted longer so that wave attack was continuous over a long period of time (Fig. 6).

It is believed that erosion from the 1986 storm was enhanced because of the narrowness of the beach which allowed increased wave impact on the bluffs. Part of the reason for this narrowness may have been caused by beach mining in earlier years.

Involved in coastal erosion along the Beaufort and Chukchi Seas are snow and ice. During winter, drifts of snow accumulate along the base of the bluffs. They may become quite thick and, partly because they usually face north and therefore have slow melting rates, may last late into the summer season. However, high water will cause melting at their base even as the snow limits active layer development in the bluff. Sea ice is a factor in several ways. During its shorefast state, it protects beaches. During periods with wave action, ice can act as a plow bringing gravel and sand up onto the shore. It also can erode or gouge the bank when it is part of wave action. Pressure ridges that form on the beach or in shallow foreshore waters will leave the sediment they are carrying on the beach when they melt. Much of the ice movement up the shore face is over other ice or snow which serves as a cushion limiting its erosional capabilities.

RATES OF EROSION: POTENTIAL FOR SITE DESTRUCTION

One of the interesting facts about erosion and archeological sites is that frequently the best sites to build on are at those locations where erosion is most likely to occur. A bluff overlooking the river or the sea provides high, dry ground and easy access to the all important water but at the same time adjacency subjects the site to potential disaster.

The Colville River. Within the Colville Delta, bluff erosion has been monitored at irregular intervals since 1961 and can be calculated by using air photos, the earliest of which date from 1948. An examination in the field showed that some 60% of the banks are erosional and 35% depositional. In addition, right banks are being eroded more extensively (74%) than left banks (46%). Of the erosional banks about 75% are composed of peat, 15% of laminated silts and 7% of Gubik sands and gravels.

Nigilik, the bartering station mentioned above, was the homesite of the Woods family. Its location is the last high (above flood stage) ground on the Nechelik Channel. It was occupied by the Woods from 1949 until they recently took up residence at Nuiqsut. In 1949, they built a house 48-50 m (appx. 150 feet) from the riverbank (Fig. 7). Erosion has been a persistent problem averaging about 1.3 meters (4 feet) per year.

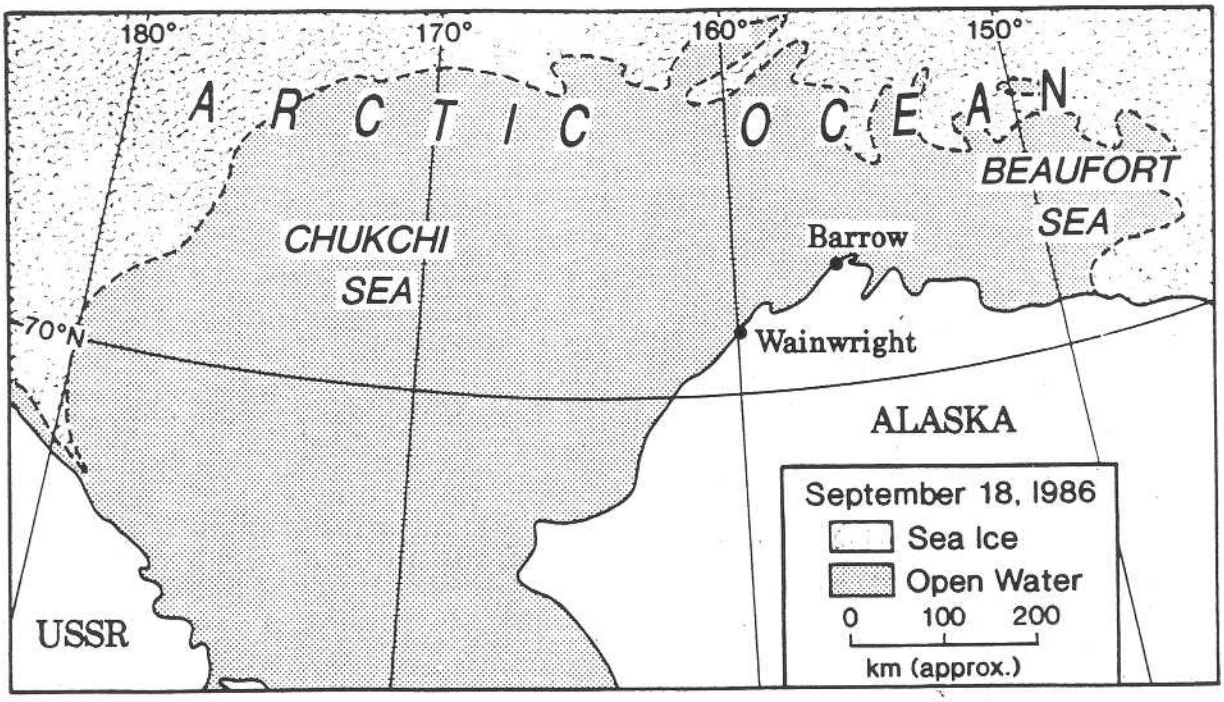

Fig. 5. Pack ice location on September 18, 1986 at time of severe storm (see Fig. 9).

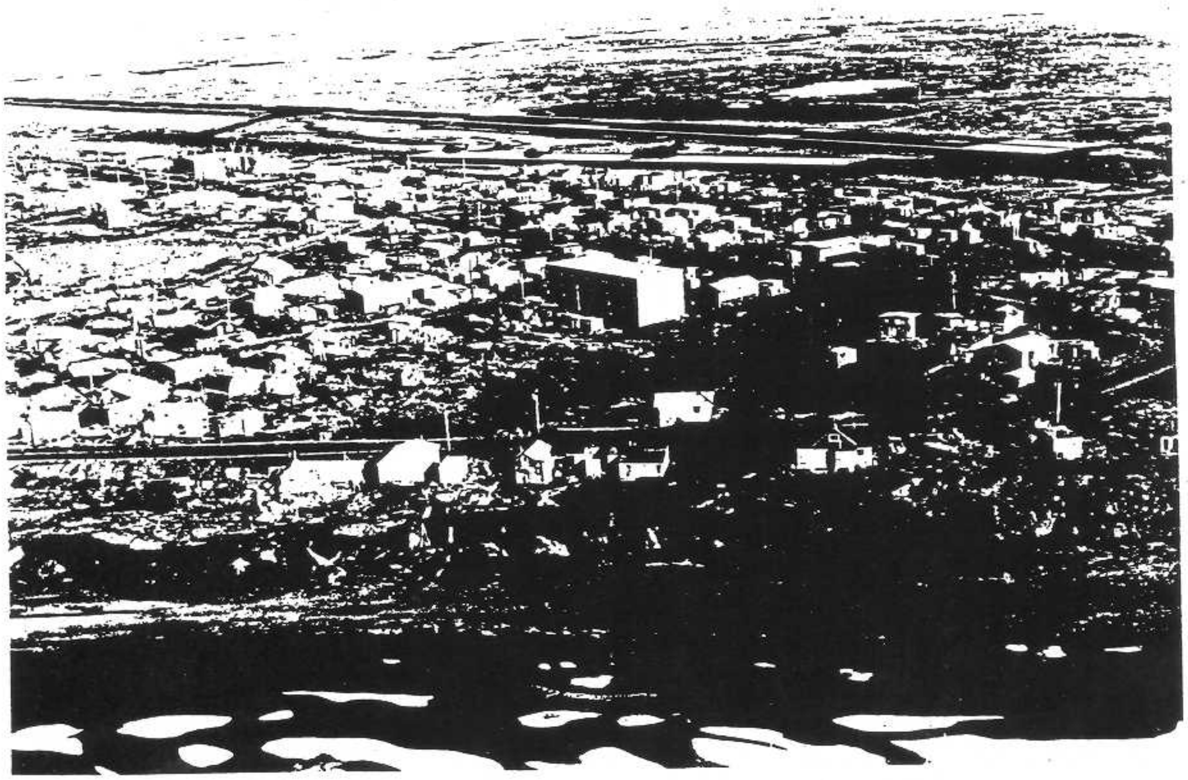

Photo 10 Bluff erosion at Barrow.

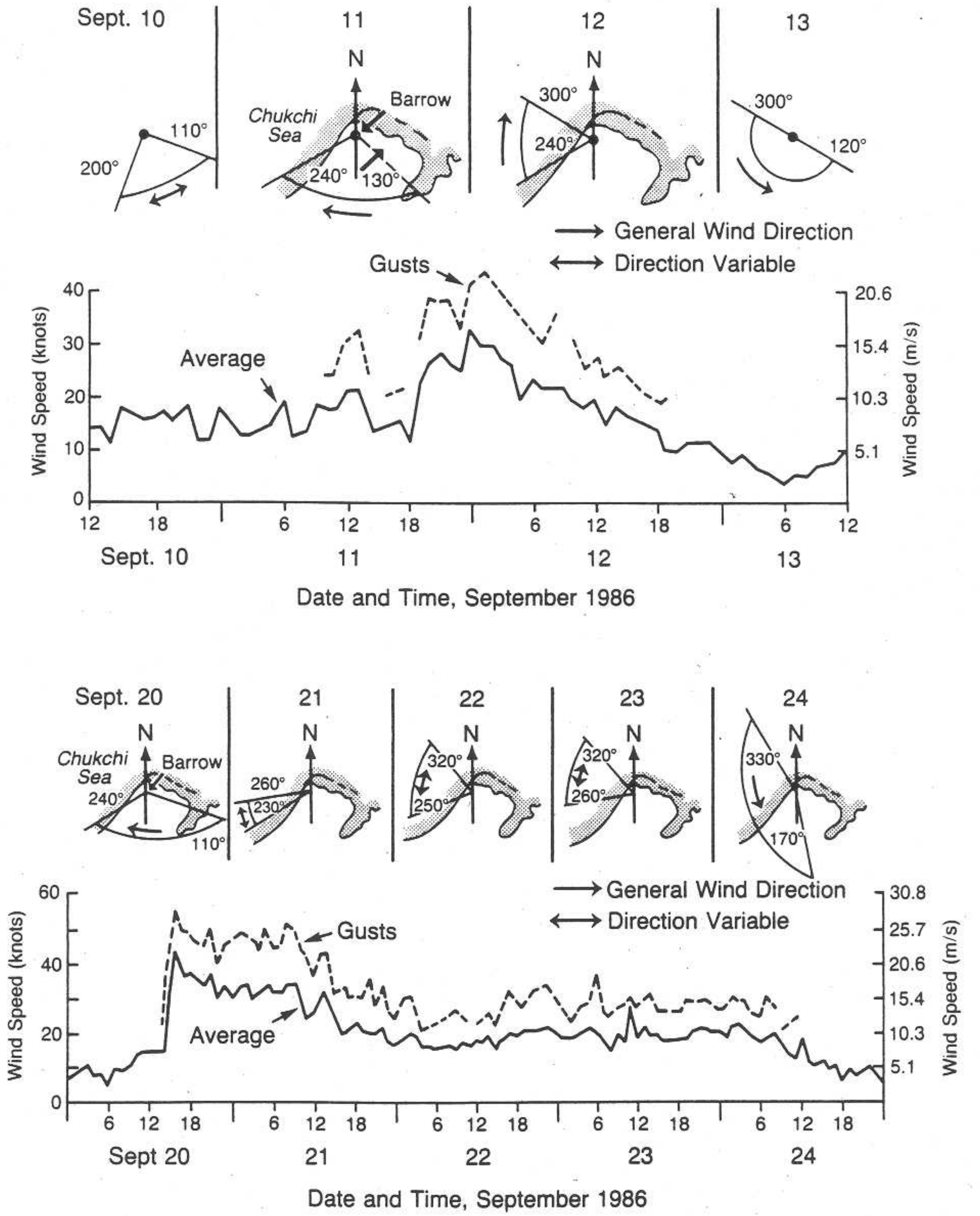

Fig. 6. Wind direction and speed during the 2 severe storms of September 1986.