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Introduction

The Geological Survey of Canada (GSC) has been studying coastline change in the Canadian portion of the Beaufort Sea for the last 60 years or more. It is characterized by rapid rates of erosion and accretion forced by periodic storms, melting permafrost and long-term sea level rise. Much of the coastline is eroding at long term rates of 1-2 m/a but can be in excess of 20 m/a (Solomon, 2005). Numerous reports have been written describing annual rates of change across the region. These reports use coastline positions digitized from aerial photography and more recent satellite imagery to calculate coastline change rates at key representative sites in the region. This Open File contains a GIS data compilation of historical coastline positions and retreat rates that have been used for coastal change assessment. GIS data coverage includes the Mackenzie Delta, Tuktoyaktuk, North Head and Wolfe Spit in the Beaufort Sea and spans the time interval 1947 to 2008.

This work was spearheaded by the late Steve Solomon, a coastal geoscientist at GSC (Atlantic) who worked in the area for more than 20 years. Steve was an expert on Arctic coastal processes and the complexities of the Mackenzie Delta.

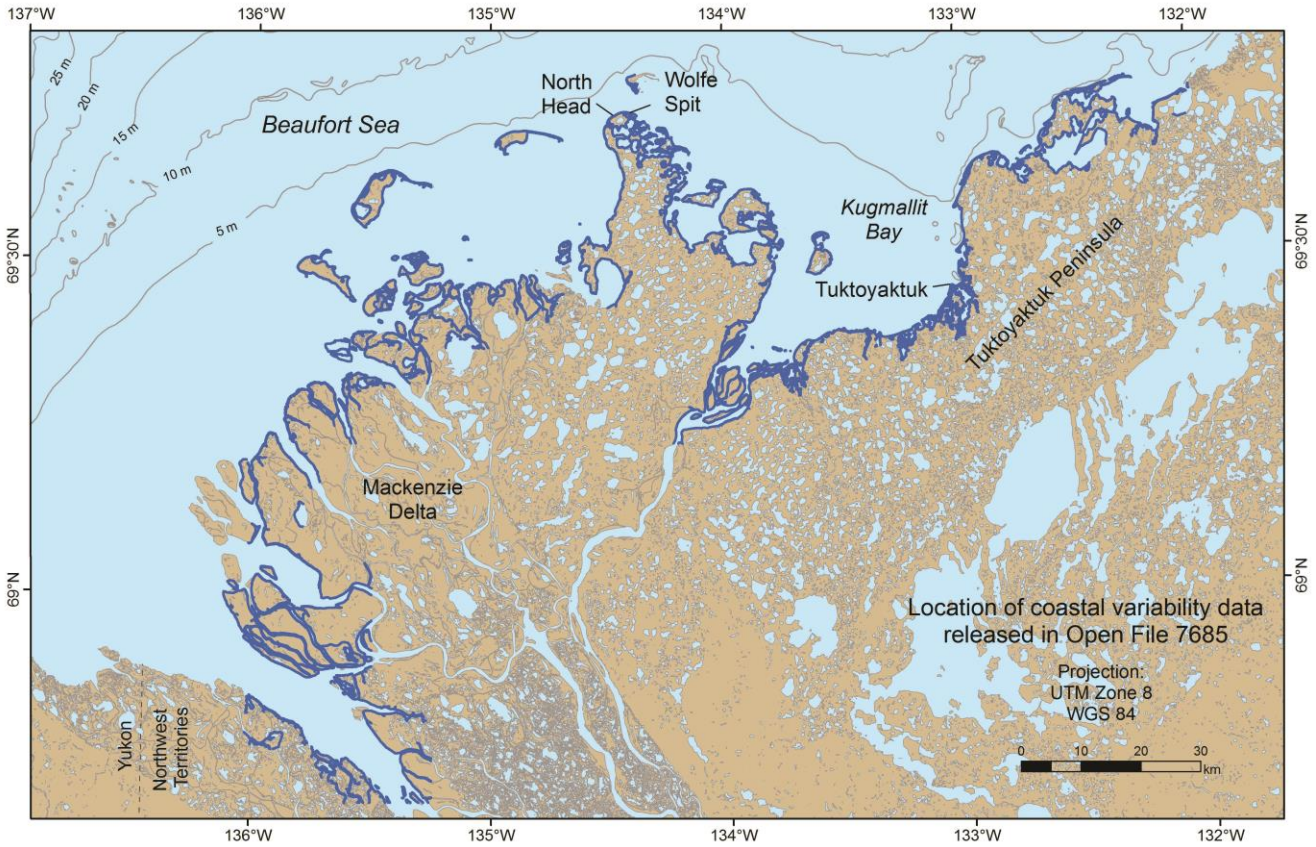

Figure 1. Location map of coastal variability data released in Open File 7685.

GIS Compilation

The data compilation was completed using ArcGIS™ software in version 9.3.1. The data are available as shapefiles for use in ArcGIS™ and other software packages that support the format. A published map file (pmf) was compiled using ArcGIS™ version 10.1 and is available for use in ArcReader™ version 10.1. ArcReader™ is a free desktop application that allows users to view and

explore the data in the published map file. The relative pathways to the shapefiles must be maintained as set up in the Open File directory in order for the published map file to open properly.

Historical coastlines in the Beaufort Sea have been georeferenced to different sources including aerial photographs, ground based GPS surveys and satellite images. The following sections outline the processing steps undertaken to georeference shapefiles representing the coastlines and other coastal features. Each shapefile in the compilation is accompanied by a complete metadata record, in Extensible Markup Language (XML) format, conforming to Federal Geographic Data Committee (FGDC) standards. Please refer to the FGDC metadata records of the shapefiles for more detail.

Mackenzie Delta

Steve Solomon re-examined coastal change in the Beaufort Sea region in 2005 due to an increased interest in exploration for hydrocarbon resources. This information was intended to provide a better understanding of coastal dynamics in the area in response to the observed effects of climate change on sea ice and temperatures. The results were published in Geo-Marine Letters in 2005 by Solomon. According to Solomon (2005):

The investigation was based on historical aerial photography collected by the National Air Photo Library (NAPL) in 1972 and 1985 and aerial photography acquired by a private company, Tarin Resource Services Ltd., during August 2000. Airborne kinematic GPS was used to provide control for the aerial photographs and to create the digital orthophotographs. The analysis of air photography from 1972 and 1985 and orthophotography from 2000 was conducted using Geographic Resources Analysis Support System (GRASS) developed by the US Army Corps of Engineers running on a UNIX workstation. Air photographs from 1972 and 1985 were scanned at 600 DPI. The rectification procedure involved importing the scanned imagery into GRASS and assigning each image to an "imagery group". The GRASS procedure "i.points3" was then used to assign geographic control points based on the 2000 digital imagery provided by Tarin Resource Services Ltd.. The average root mean square (RMS) error for the selected points was kept below 5.0 m based on a 2nd-order polynomial rectification. The image was rectified using the GRASS procedure "i.rectify3". Initially, a 2nd-order polynomial rectification was used. If the results were not satisfactory, a 3rd-order polynomial rectification was used. The average output resolution of the rectified images was 2.5 m. The coastlines were digitized by hand in GRASS software using the wet-dry line as a proxy for the high tide line. In cases where nearly vertical coastal bluffs are characterized by narrow to virtually nonexistent beaches, the coastline was mapped based on the position of the bluff-edge or waterline at the time of the survey.

A more recent aerial photography study was conducted in the Beaufort Sea-Mackenzie Delta region to determine rates of coastal change using imagery from 2004, 2007 and 2008. Orthophotographs acquired in August 2004 were provided by the Mackenzie Valley Air Photo (MVAP) Project. The MVAP was a multi-year mapping project (2003-2008) involving Indian and Northern Affairs Canada (now Aboriginal Affairs and Northern Development Canada), Natural Resources Canada, Environment Canada and the Government of Northwest Territories as partners (Retrieved from Government of Northwest Territories website, http://apps.geomatics.gov.nt.ca/ArcGIS/rest/services/Mosaics/MVAP_Mosaic_Combined_LCC/MapServer, 2008). Quickbird imagery acquired in 2007 and 2008 from DigitalGlobe Incorporated provided baseline data for this study. Line vectors representing the coastline of the Mackenzie Delta in 2004, 2007 and 2008 were digitized on the screen using ArcGIS™ version 9.3.1 editing tools.

Measurements of coastal change were analyzed to determine the degree of variability within and between different time intervals and in different regions within the Mackenzie Delta region and results were published in Geo-Marine Letters in 2005 by Solomon. This GIS compilation includes points

representing the total retreat and rate of retreat for the 28 year period from 1972-2000. According to Solomon (2005):

The 1972, 1985 and 2000 shorelines were used as a basis for making measurements of coastal change during the 13 (1972–1985), 15 (1985–2000) and 28 (1972–2000) year periods which intervened. An automated procedure was developed to insert an orthogonal line between the two shorelines and the length of the line was inserted into a text file along with its bearing. The measurements were checked by an operator to determine whether erosion or accretion occurred (i.e. whether the change in position was negative or positive). Measurements of coastal change were made for the 1972–2000 and 1985–2000 intervals every 200 m and were assigned a geographic point coincident with the 2000 shoreline. The rate of retreat was calculated for each point by dividing the total amount of retreat by the number of years between each photo survey.

North Head and Wolfe Spit

A historical aerial photography study was undertaken to determine the coastal stability at North Head and Wolfe Spit in the Canadian Beaufort Sea. Aerial photographs from 1947, 1972, 1985, 1992, 1993, 1994, 1996, 1997 and 2000 were georeferenced to real geographic coordinates using field survey data collected in 2001 using post-processed GPS data. The horizontal precision was 1 metre. The work was performed using GRASS software. The rectification procedure used an affine transformation to rubber sheet the imagery to the UTM projection. Coastline vectors were digitized for each year using the wet-dry line as a proxy for the high tide line. The coastline and cliff edge vectors were exported to shapefile format.

Tuktoyaktuk

Field survey work and an aerial photography study were conducted by GSC (Atlantic) in 2001 to study the stability of the coastline and to determine erosion rates and coastal processes in Tuktoyaktuk in the Beaufort Sea. Field survey data were acquired using a post-processed GPS. The horizontal precision was 1 metre. Aerial photographs from 1947, 1950, 1964, 1966, 1968, 1970, 1974, 1978, 1980, 1983, 1985, 1992, 1993, 1994, 1996, 1997, 1998, 2000 and 2001 were georeferenced to real geographic coordinates using field survey data collected in 2001. The work was performed GRASS software. The rectification procedure used an affine transformation to rubber sheet the imagery to the UTM projection. Coastline vectors were digitized for each year using the wet-dry line as a proxy for the high tide line at the time the image was taken. The coastline and cliff edges were exported to shapefile format.

Quickbird imagery acquired in 2008 were acquired for the study from DigitalGlobe Incorporated. Line vectors representing the coastline of Tuktoyaktuk in 2008 were digitized on the screen using ArcGIS™ version 9.3.1 editing tools.

Acknowledgments

We thank Bob Covill for the air photography analyses and GIS work performed in the Mackenzie Delta, Tuktoyaktuk, North Head and Wolfe Spit. We also thank Paul Fraser for the quality control of the GIS data and critical review of the Open File publication.

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