GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7552

GIS compilation of coastline variability spanning 60 years, western Beaufort Sea, Yukon and Northwest Territories

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Publications in this series have not been edited; they are released as submitted by the author.

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Introduction

The Geological Survey of Canada (GSC) has been studying shoreline change in the Canadian Beaufort Sea for the last 60 years or more. Much of the coastline is known to be 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 shoreline 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 that have been used for coastal change assessment. GIS data coverage represents vector lines at nine sites spanning the time interval between 1950-2010 along the north slope of the Yukon and western Mackenzie Delta in the Northwest Territories. The ten sites are Clarence Lagoon, Komakuk Beach, Nunaluk Spit, Catton Point, Stokes Point West, Stokes Point, Niakolik Point, Shingle Point, Shallow Bay and Mackenzie Delta.

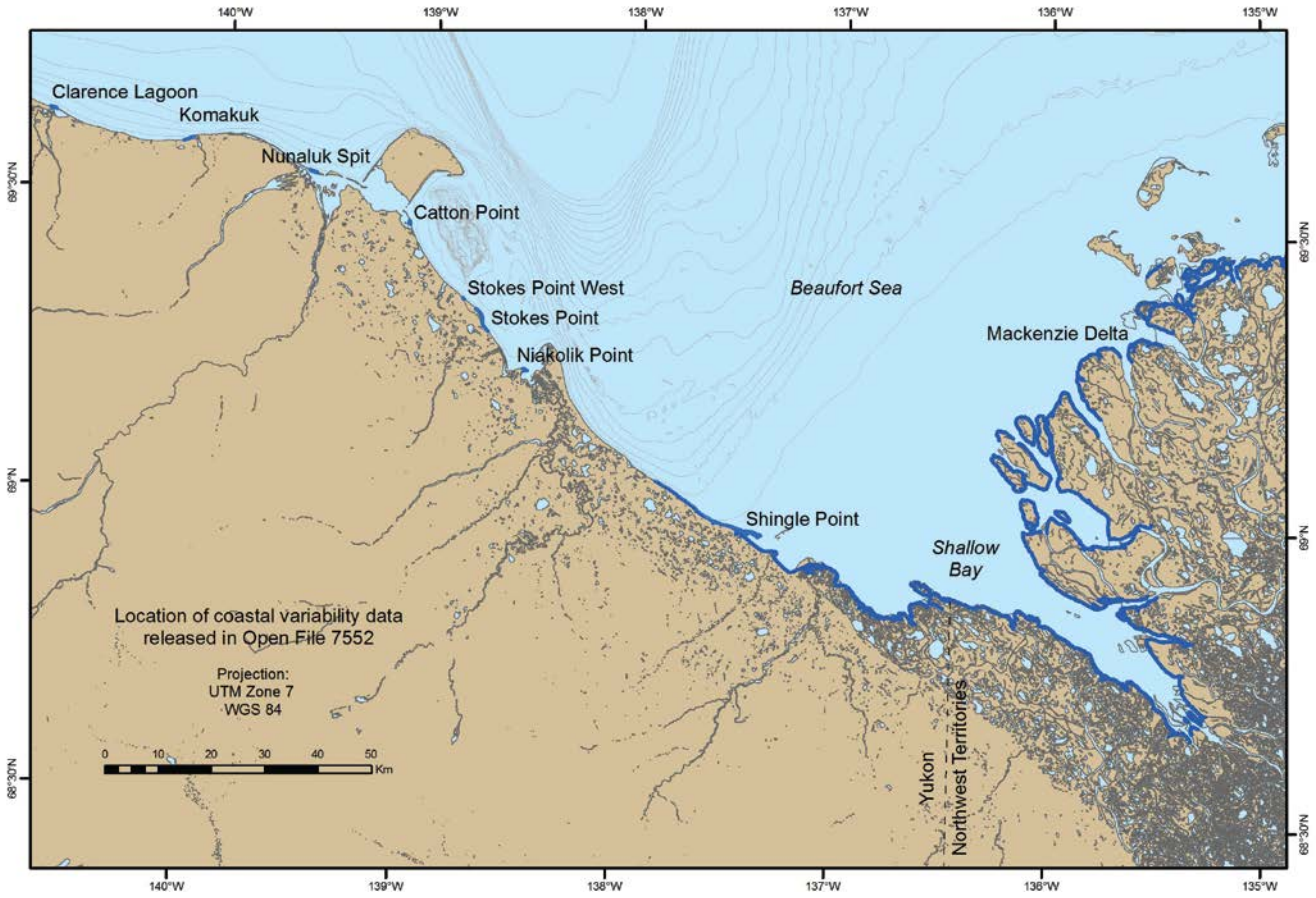

Figure 1. Location map of coastal variability data released in Open File 7552.

GIS Compilation

The data compilation was completed using ArcGIS™ software. 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.

Different methods have been employed to digitize and georeference historical coastlines in the Yukon and Northwest Territories from a number of sources including aerial photographs, satellite images, and ground based surveys. Older air photography studies produced shapefiles that were referenced to a common air photograph that originally had no georeferencing to real world coordinates. More recent studies have utilized orthophotographs or satellite imagery with georeferencing embedded in the product. Vectors derived from these products have the projection information defined. The following section outlines 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.

Catton Point, Nunaluk Spit, Clarence Lagoon, Stokes Point West and Niakolik Point

Field work and aerial photography studies were undertaken by GSC (Atlantic) in various sites in Ivvavik National Park during 1995 and 1996. The work was performed to study the stability of the coastline and to determine erosion rates, processes and hazards at five archaeological sites including Catton Point, Nunaluk Spit, Clarence Lagoon, Stokes Point West and Niakolik Point (Solomon, 1996 and Forbes, 1997). The stability of the coastline was assessed based on historical aerial photography collected by the National Air Photo Library (NAPL) and the GSC (Solomon, 1996). According to Forbes (1997):

The historical analysis of air photography performed in the 1995 and 1996 studies was conducted using Geographic Resources Analysis Support System (GRASS) developed by the US Army Corps of Engineers running on a UNIX workstation. Aerial photography from numerous years was used in the analysis. Air photographs were scanned at either 400 Dots Per Inch (DPI) or 600 DPI. The aerial photographs were imported into GRASS projects for each study site (Catton Point, Nunaluk Spit, Clarence Lagoon, Stokes Point West and Niakolik Point). The air photographs were rectified to a common air photograph for that location. The rectification procedure in GRASS removed tilt, rotation and lens distortion by a non-linear (rubber-sheet) least-squares algorithm. Coastlines, cliff tops, cliff bases and spit crests in the aerial photography were digitized as individual vector files within each GRASS project.

The vectors were exported out of the GRASS projects in shapefile format with no georeferencing related to real world coordinates. The shapefiles were compiled and georeferenced to the UTM coordinate system using ArcGIS™ software in 2012. A non-georeferenced image of aerial photography from 1996 superimposed with coastal line work existed for each of the five sites in Ivvavik National Park. The process involved georeferencing the imagery to match the map coordinates and the spatial reference of a GeoTIFF of 1996 aerial photography for the area. Next ArcGIS™ software was used to georeference the original shapefiles to the rectified GeoTIFF image containing the line work. For more information about the process, refer to the XML files that accompany each georeferenced shapefile and published Open Files 3323 and 3531 by Solomon and Forbes, respectively.

Komakuk

An analysis of cliff retreat rates was performed in 1997 at Komakuk Beach as part of a collaborative project supported by Ivvavik National Park and the GSC (Solomon, unpublished 1997). Work

involved analysis of air photos supplemented by a site visit and field survey. According to Solomon (unpublished, 1997):

Real-time kinematic differential global positioning (RTK-DGPS) data were collected at Komakuk on July 20, 26 and 28 in 1997. The RTK-DGPS is capable of centimetre accuracy both horizontally and vertically. BM 336 (located west of the runway) was used as a base station for the first two days; on the last day, a temporary base station was set up at the camp and tied back to BM 336. Observational data were collected on July 19 and July 22 and GPSPace (a program supplied by Geomatics Canada) was used to calculate a more accurate horizontal position for the base station based on precise satellite orbit information. These positions are within 1-2 m of each other. The average of the 2 positions was used for the coordinates of BM 336. Each of the RTK-DGPS files was processed with the raw coordinates for the base station and corrected using the accurate positions calculated from the observational data. For days July 20 and July 26, 1.538 m was added to the northing and 3.798 m was added to the easting. For July 28, 11.667 m was subtracted from the northing and 25.97 m was added to the easting. Echosounding data were collected on JD 203 (July 22) using the base station at BM 336. Processing was done with the program G2Mkoma.bas which produces a MapInfo .mif file in the UTM NAD83 projection. The program automatically adds the appropriate corrections to the positions.

Aerial photography from 1951, 1958, 1960, 1964, 1971, 1975, 1979, 1984, 1992, 1993, and 1997 was used in this study. Eleven images were scanned at 400 DPI, with the exceptions of the 1951 and 1958 air photography which were scanned at 600 DPI. GIS work was performed using GRASS software. The 1997 aerial photography was digitally rectified to the 1997 ground survey. All other aerial photography was then rectified to the 1997 imagery. The aerial photography was rectified using a UTM projection (Zone 7) with a horizontal datum of NAD83. The cliff edge and high waterline were digitized for each year.

Stokes Point

The GSC (Atlantic) undertook an examination of coastal change at the Stokes Point DEW Line site in 2007 (Solomon and Manson, unpublished 1997). Work involved an analysis of historical changes in the waterline and bluffs using air photos and satellite imagery supplemented by a site visit and field survey. According to Solomon and Manson (unpublished, 2007):

The DEW Line site was visited by GSC staff between August 4th and 6th 2007 to survey beach profiles, both along- and across-shore, and to collect validation points for the rectification of the 2006 IKONOS image and previous aerial photography. Surveys were conducted using an Ashtech Z-Xtreme RTK-DGPS which uses a mobile rover and a stationary base station, in mutual radio contact, to resolve errors inherent in single point GPS positioning. This system typically provides positions with approximately 5 cm horizontal and vertical precision. Accuracy of each survey depends upon survey control. Surveys were conducted using pipe C3, located approximately 75 m northwest of the latrine, as survey control. Coordinates provided by the Environmental Studies Group (ESG) of the Royal Military College (RMC) for C3 proved suspicious as surveyed water level elevations were approximately 11 m above datum (assumed to be CGVD28). A four hour occupation of C3 was processed using the Geodetic Survey of Canada's online Precise Point Positioning (PPP) service and ellipsoidal elevations were converted to CGVD28 using HTv2.0. When reprocessed to the revised position for C3, surveyed water level elevations were between 0.2 and -0.2 m CGVD28. Survey points collected on ground features plot within 2 m of corresponding features recognizable on the 2006 IKONOS image as geocorrected by TekMap Consulting.

TekMap Consulting performed an historical analysis of air photos to determine the local rates of coastal change in the vicinity of the DEW Line site. It involved scanning of air photos from the NAPL

(1952, 1970, 1976, 1985, 1993 and 1997) and georeferencing the air photography using an IKONOS satellite image from 2006 as a base. According to a report by TekMap Consulting (unpublished, 2007):

The original IKONOS image was rerectified to match the ground survey data provided by the client. This rerectified image was used as the base for all other rectification. All aerial photographs were rectified using gdalwarp (see http://www.gdal.org). A thin plate spline (tps) transformer was used with gdalwarp. The rectified images were imported into GRASS (see http://grass.itc.it). GRASS was used to create the image mosaics (where needed) and digitize the shoreline, cliff base, and cliff top. All aerial photographs, with the exception of 1985 and 1993, were scanned at 600 DPI. For each year the shoreline, cliff base, and cliff top was digitized as a separate vector files.

Shallow Bay and Mackenzie Delta

A historical air photography study was conducted in Shallow Bay to determine rates of coastal change and the spatial variability in the rates of coastal change within the bay. Orthophotographs acquired in August 2004 were provided by the Mackenzie Valley Air Photo (MVAP) Project. The MVAP is a multi-year, multimillion dollar mapping project (2003-2008) involving three federal departments (Indian and Northern Affairs Canada, Natural Resources Canada and Environment Canada) and the Government of Northwest Territories as partners (Indian and Northern Affairs Canada. Retrieved from Government of Northwest Territories website, **http://apps.geomatics.gov.nt.ca/ArcGIS/rest/services/Mosaics/MVAP_Mosaic_Combined_LCC/MapServer**, 2008). Air photography from 1950 to 1985 was obtained from the NAPL while Radarsat-2 and Worldview-1 and Worldview-2 imagery from 2009 and 2010 were also purchased for the study. The air photography was rectified to the 2004 orthophotograph using ArcGIS™ software to ensure similar baseline data was used throughout the study. Individual vectors representing the coastline of Shallow Bay for each year in the study were digitized on the screen using ArcGIS™ editing tools.

Shingle Point

Orthophotographs were acquired in August 2004 from the MVAP and aerial photography of 1953 from the NAPL. The aerial photography from 1953 was scanned and rectified to the 2004 orthophotograph using GRASS software. The coastline depicted in the 1953 air photography was digitized in GRASS and exported in shapefile format. The coastline in the 2004 orthophotograph was digitized using ArcGIS™ software.

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