Computers & Geosciences 66 (2014) 228–236

Contents lists available at ScienceDirect

Computers & Geosciences

journal homepage: www.elsevier.com/locate/cageo

Evaluation of arctic multibeam sonar data quality using nadir crossover error analysis and compilation of a full-resolution data product

Ashton F. Flinders *, Larry A. Mayer, Brian A. Calder, Andrew A. Armstrong

Center for Coastal and Ocean Mapping, Joint Hydrographic Center, University of New Hampshire, Durham, NH 03824, USA

ARTICLE INFO

Article history:
Received 10 June 2013
Received in revised form
7 February 2014
Accepted 8 February 2014
Available online 21 February 2014

Keywords:
Arctic Ocean
Canada Basin
Chukchi
Crossover analysis
Multibeam
ECS

ABSTRACT

We document a new high-resolution multibeam bathymetry compilation for the Canada Basin and Chukchi Borderland in the Arctic Ocean – *United States Arctic Multibeam Compilation* (USAMBC Version 1.0). The compilation preserves the highest native resolution of the bathymetric data, allowing for more detailed interpretation of seafloor morphology than has been previously possible. The compilation was created from multibeam bathymetry data available through openly accessible government and academic repositories. Much of the new data was collected during dedicated mapping cruises in support of the United States effort to map extended continental shelf regions beyond the 200 nm Exclusive Economic Zone. Data quality was evaluated using nadir-beam crossover-error statistics, making it possible to assess the precision of multibeam depth soundings collected from a wide range of vessels and sonar systems. Data were compiled into a single high-resolution grid through a vertical stacking method, preserving the highest quality data source in any specific grid cell. The crossover-error analysis and method of data compilation can be applied to other multi-source multibeam data sets, and is particularly useful for government agencies targeting extended continental shelf regions but with limited hydrographic capabilities. Both the gridded compilation and an easily distributed geospatial PDF map are freely available through the University of New Hampshire's Center for Coastal and Ocean Mapping (ccom.unh.edu/theme/law-sea). The geospatial pdf is a full resolution, small file-size product that supports interpretation of Arctic seafloor morphology without the need for specialized gridding/visualization software.

1. Introduction

Advances in multibeam echosounding (MBES) and navigation technology, along with decreased summer sea ice extent and the recognition of potential economic, scientific and geopolitical advantages, have led to increasing acquisition of MBES data in the Arctic Ocean over the past decade. These new data have provided critical insights into the evolution of the Arctic Basins (Lawver et al., 2011), the nature of deep water circulation (Björk et al., 2007), oceanic mixing processes (Nghiem et al., 2012), and the history of ice in the Arctic Ocean (Jakobsson et al., 2010). With the commissioning of the ice-breaking vessel *United States Coast Guard Cutter* (*USCGC*) *Healy* in 1999 and its operation as a multibeam sonar-equipped platform for Arctic science, the quantity of Arctic MBES data has increased dramatically. A large portion of the MBES bathymetry collected by the *USCGC Healy* was done so as part of the United States effort to map regions beyond the 200 nm Exclusive Economic Zone that may be considered "extended continental shelf" (ECS) under Article 76 of the Convention on the Law of the Sea (Mayer et al., 2010; UNCLOS, 1982). The University of New Hampshire's (UNH) Center for Coastal and Ocean Mapping (CCOM) and the National Oceanic and Atmospheric Administration–UNH Joint Hydrographic Center (JHC) have taken a lead role in this effort, with seven dedicated ECS cruises aboard the *USCGC Healy*, three in collaboration with the Geological Survey of Canada and the *Canadian Coast Guard Ship* (*CCGS*) *Louis S. St-Laurent* (see http://ccom.unh.edu/theme/law-sea for detailed cruise reports). Much of the data collected by the *USCGC Healy* and other vessels are now in the public domain, available through government and academic repositories. The availability of data allows for the creation of high-resolution MBES compilations. Foremost among these compilations has been the International Bathymetric Chart of the Arctic Ocean – IBCAO (Jakobsson et al., 2012). Although IBCAO provides an indispensable representation of Arctic bathymetry, its large scope and incorporation of single-beam/spot-sounding sources inhibit it from preserving the highest resolution of the MBES data – a critical need for detailed interpretation of ECS regions.

* Corresponding author.
E-mail address: a_flinders@gso.uri.edu (A.F. Flinders).

http://dx.doi.org/10.1016/j.cageo.2014.02.003
0098-3004

We evaluate the quality of MBES data sets collected in the Arctic Ocean – essential for their potential use in an ECS submission – and present a subset of these data in a manner that preserves the highest level of spatial resolution. This newly compiled data set, the United States Arctic Multibeam Compilation (USAMBC Version 1.0), with a maximum spatial resolution of 40 m, is available both as a gridded bathymetric data set and a standalone geospatial pdf.

2. Methods

2.1. Multibeam data sources

MBES data were compiled from publicly available repositories (Figs. 1 and 2, Tables 1 and A1), specifically the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) which operates the *R/V Mirai* (8 cruises), and U.S. holdings from the National

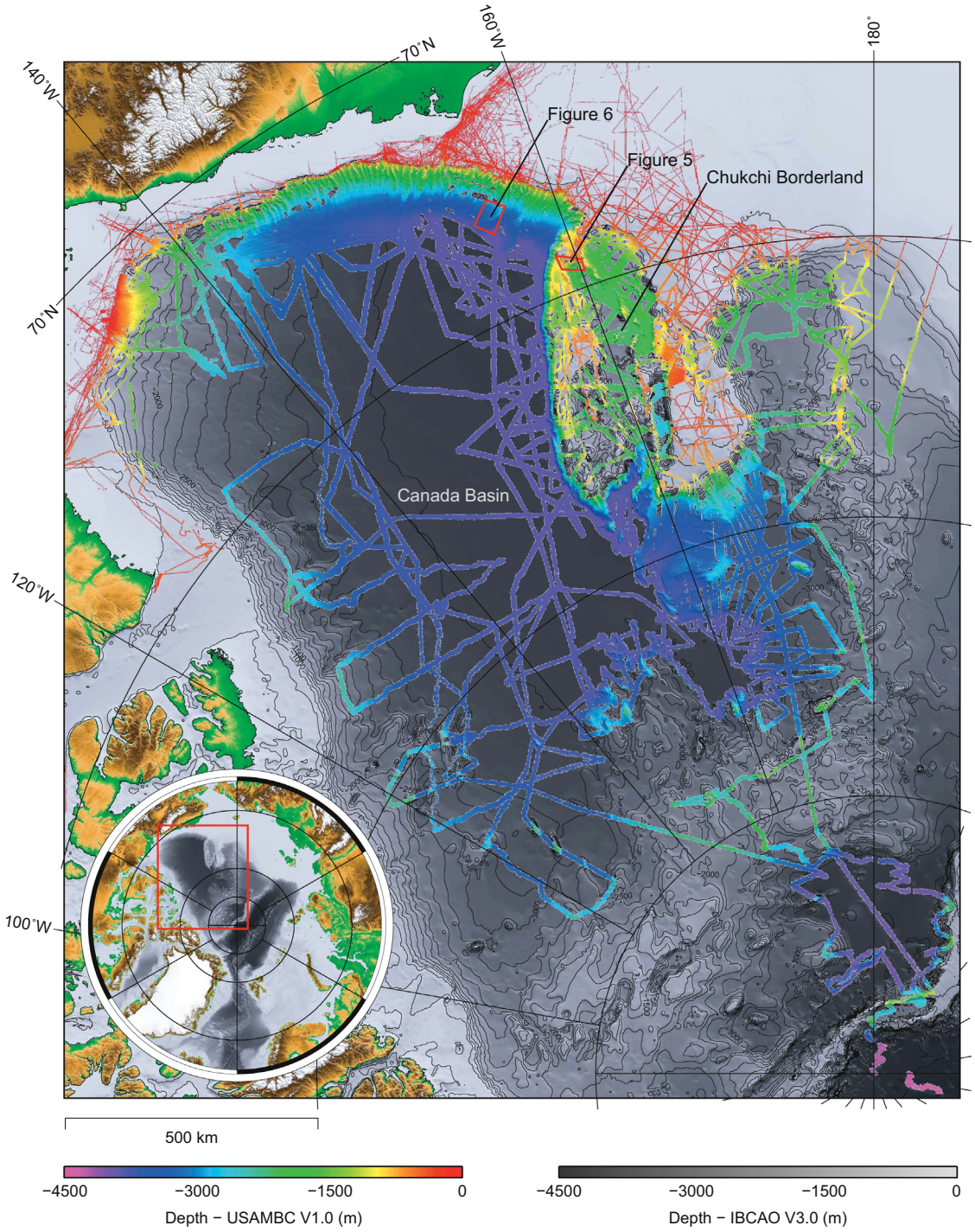

Fig. 1. A Polar stereographic map (center meridian 0°W, true scale 75°N) showing the coverage area and bathymetry of the newly compiled United States Arctic Multibeam Compilation (USAMBC V1.0), overlain over the International Bathymetric Chart of the Arctic Ocean (IBCAO V3.0) in gray (Jakobsson et al., 2012). Multibeam bathymetry nadir crossover error analysis for the region is shown in detail in Fig. 2. The majority of data are from dedicated ECS cruises operated in cooperation with the University of New Hampshire's Center for Coastal and Ocean Mapping (CCOM). The two red boxes outline regions of closer detail shown in Figs. 5 and 6. (*Inset*, *left corner*) An expanded view of the region, with the USAMBC study area outlined in red.