

Arctic Coastal Dynamics

Report of an International Workshop

Potsdam (Germany) 26-30 November 2001

Edited by Volker Rachold, Jerry Brown and Steve Solomon

Volker Rachold, Alfred Wegener Institute, Research Unit Potsdam, Telegrafenberg A43,
14473 Potsdam, Germany

Jerry Brown, International Permafrost Association, P.O. Box 7, Woods Hole, MA 02543,
USA

Steve Solomon, Geological Survey of Canada (Atlantic), Bedford Institute of Oceanography,
P.O. Box 1006, 1 Challenger Drive, Dartmouth, NS Canada B2Y 4A2, Canada

Preface

Arctic Coastal Dynamics (ACD) is a joint project of the International Arctic Sciences Committee (IASC) and the International Permafrost Association. Its overall objective is to improve our understanding of circum-arctic coastal dynamics as a function of environmental forcing, coastal geology and cryology and morphodynamic behavior. The second IASC-sponsored international workshop was held in Potsdam, Germany, on November 26-30, 2001. Participants from Canada (2), Germany (8), Norway (3), Russia (6), Austria (2) and the United States (5) attended. The main objective of the workshop was to review the status of ACD according to phase 1 of the Science and Implementation Plan. During the first part of the workshop status reports of the ACD working groups and several papers dealing with different aspects of circum-arctic coastal dynamics were presented. During the second part the progress and the next steps of the ACD working groups were discussed and, based on these discussions, the next steps were identified in the Steering Committee Meeting. The present report summarizes the program and the results of the workshop.

Financial support from the International Arctic Sciences Committee (IASC) is highly appreciated and was essential for conducting the workshop. Additional support was provided by the International Permafrost Association (IPA).

Table of Contents

Preface

1 History and Development of ACD	1
2 Program of the Workshop	5
3 Extended Abstracts	11
Establishment of the Elson Lagoon ACD Key Site, Barrow, Alaska (<i>J. Brown, T. Jorgenson, O. Smith and W. Lee</i>)	13
PANGAEA – an information system for environmental sciences (<i>M. Diepenbroek, H. Grobe, M. Reinke, U. Schindler, R. Schlitzer, R. Sieger and G. Wefer</i>).....	16
Shore dynamics on the northwest coast of the Lena Delta, Laptev Sea, Siberia (<i>M. N. Grigoriev, F. E. Are, H.–W. Hubberten, S. O. Razumov and V. Rachold</i>).....	17
Numerical modeling of shelf and estuary hydrodynamics in the Kara Sea (<i>I. H. Harms, J. O. Backhaus and U. Hübner</i>)	18
Sediment flux in arctic rivers (<i>R. M. Holmes, J. W. McClelland, B. J. Peterson, A. I. Shiklomanov, I. A. Shiklomanov, A. V. Zhulidov and V. V. Gordeev</i>)	20
Monitoring of coastal dynamics at Beaufort Lagoon in the Arctic National Wildlife Refuge, Northeast Alaska (<i>M. T. Jorgenson, J. C. Jorgenson, M. Macander, D. Payer and A. E. Morkill</i>)	22
A circum-arctic coastal geo information system (GIS) (<i>M. Lack, V. Rachold and H. Asche</i>).....	29
Integrated assessment of the impacts of climate variability on the Alaska North Slope coastal region (<i>A. Lynch, R. Brunner, J. Curry, A. Jensen, J. Maslanik, L. Mearns, G. Sheehan and J. Syvitski</i>).....	30
Describing Beaufort Sea coastal climate variability (<i>G. Manson, S. Solomon and A. MacDonald</i>)	31
Evolution of the coastal lake-lagoon-barrier island system of North Arctic Alaska – a synthesis (<i>A. S. Naidu and J. J. Kelly</i>)	35
Application of the wind-energetic method of Popov-Sovershaev for investigation of coastal dynamics in the Arctic (<i>S. A. Ogorodov</i>)	37
Organic carbon in permafrost sediments under thermal abrasion: load into marine basin and oxidation in aeration zone (<i>V. Ostroumov, D. Fyedorov - Davydov and V. Sorokovikov</i>).....	43
Modeling coastal erosion near Barrow, Alaska (<i>S. D. Peckham, W. Manley, M. Dyurgerov and J. P. M. Syvitski</i>).....	46
Ice content and sensitivity analysis based on landscape interpretation for several sites along the Beaufort Sea coast (<i>W. Pollard, C. Omelon, N. Couture, S. Solomon and P. Budkewitsch</i>).....	48
Investigation of sea level change in the Arctic Ocean (<i>A. Proshutinsky</i>).....	52

Terrestrial material fluxes in the North-Asian Arctic Seas: coastal erosion vs riverine transport (<i>I. P. Semiletov</i>).....	54
Amethyst project overview (<i>A. I. Sharov</i>)	55
Coastal erosion in Alaska (<i>O. P. Smith</i>).....	65
Beaufort Sea coastal mapping and the development of an erosion hazard index (<i>S. Solomon and P. Gareau</i>).....	69
Arctic Paleo-River Discharge (APARD) - report on 2000 activities (<i>R. Stein</i>).....	71
Siberian river run-off in the Kara Sea: characterization, quantification, and variability through late Quaternary times (<i>R. Stein and the SIRRO Scientific Party</i>).....	72
Sediment inclusions in Alaskan coastal sea ice: spatial distribution, interannual variability and entrainment requirements (<i>A. P. Stierle and H. Eicken</i>).....	74
Carbon content in coastal ecosystems of Russian Arctic (<i>V. Stolbovoi</i>)	75
Some problems of coastal mapping in the Russian Arctic (<i>A. A. Vasiliev</i>).....	77
Coastal dynamics in Marre-Sale, Kara Sea: a new observation program (<i>A. A. Vasiliev, G. A. Cherkashev, B. G. Vanshtein, Y. G. Firsov and M. V. Ivanov</i>).....	78
New approaches for the metadata development (<i>E. Vyazilov, N. Mikhailov, V. Ibragimova and N. Puzova</i>).....	80
Measurements of coastal change in the Russian Arctic and at Svalbard by means multi-temporal aerial photographs and digital photogrammetry (<i>B. Wangensteen, R. Ødegård, T. Eiken and J. L. Sollid</i>)	85
4 Appendices.....	91
Appendix 1: Information to be included in a metadata form for arctic coastal key section	93
Appendix 2: Proposed coastal classification	94
Appendix 3: Ground-ice estimates and mapping.....	95
Appendix 4: Recommendation for coastal change monitoring sites.....	96
Appendix 5: Environmental data requirements	97
Appendix 6: Guidelines for Arctic Coastal Dynamics mapping and data template	99
Appendix 7: Program of the 2 nd ACD Workshop	101
Appendix 8: List of participants of the 2 nd ACD Workshop	103

1 History and Development of ACD

Shore dynamics directly reflecting the complicated land-ocean interactions play an important role in the balance of sediments, organic carbon and nutrients in the Arctic Basin. Nevertheless, the contribution of coastal erosion to the material budget of the Arctic Seas has often been underestimated. In recent years, however, several studies underlined the importance of coastal erosion for the sediment budget of the Arctic Seas. Reimnitz et al. (1988) made calculations for 344 km of Alaskan coast in the Colville River area and found that coastal erosion here supplied 7 times more sediments to the Alaskan Beaufort Sea than rivers. Are (1999) suggested that the amount of sediment supplied to the Laptev Sea by rivers and shores is at least of the same order but that the coastal erosion input is probably much larger than the input of the rivers. This finding was supported by Rachold et al. (2000), who concluded that the sediment flux to the Laptev Sea through coastal erosion is twice larger than the river input. In the Canadian Beaufort Sea on the other hand, the Mackenzie River input is the dominant source of sediments and coastal erosion is much less important (MacDonald et al. 1998), which indicates that pronounced regional differences in the ratio between riverine and coastal erosion sediment input have to be considered. Figure 1 shows satellite images of the East Siberian and the Beaufort Sea, which clearly show the major sources of sediment. The strong river plume of the Mackenzie River is visible in the Beaufort Sea, whereas in the East Siberian Sea high turbidities, which are related to coastal sediment input, are observed along the coastline.

The Arctic Coastal Dynamics (ACD) program is a multi-disciplinary, multi-national forum to exchange ideas and information. The overall objective of ACD is to improve our understanding of circum-arctic Coastal Dynamics as a function of environmental forcing, coastal geology and cryology and morphodynamic behavior. In particular, we propose to:

- establish the rates and magnitudes of erosion and accumulation of arctic coasts;
- develop a network of long-term monitoring sites including local community-based observational sites;
- identify and undertake focused research on critical processes;
- estimate the amount of sediments and organic carbon derived from coastal erosion;
- refine and apply an arctic coastal classification (includes ground-ice, permafrost, geology etc.) in digital form (GIS format);
- extract and utilize existing information on relevant environmental forcing parameters (e.g. wind speed, sea level, fetch, sea ice etc.);
- produce a series of thematic and derived maps (e.g. coastal classification, ground-ice, sensitivity etc.);
- develop empirical models to assess the sensitivity of arctic coasts to environmental variability and human impacts.

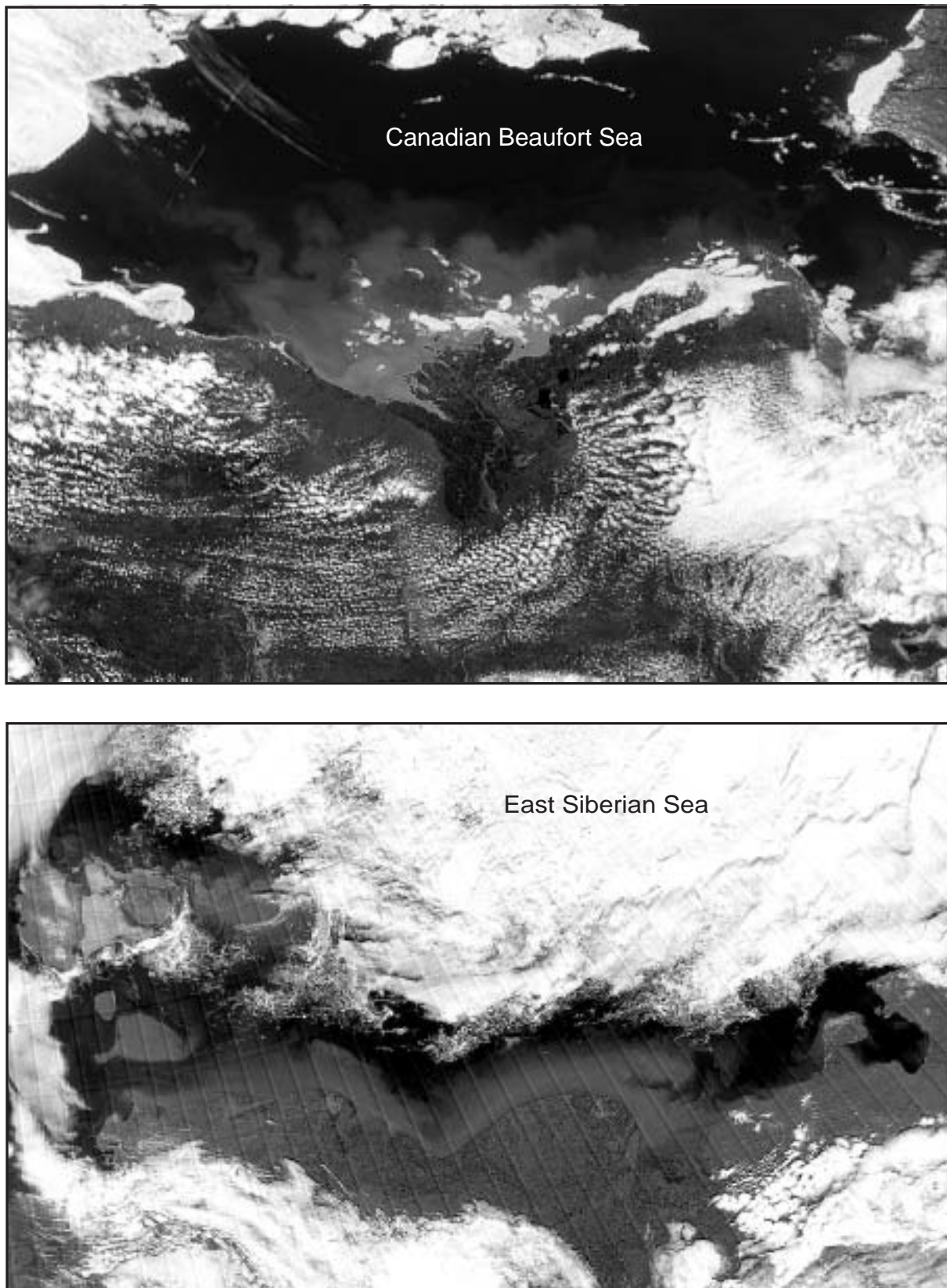


Figure 1. Satellite images of the East Siberian (bottom) and Beaufort Sea (top) showing the distribution of suspended sediments. The strong river plume of the Mackenzie River is clearly seen in the Beaufort Sea, whereas in the East Siberian Sea very high turbidities are observed along the coastline. Images are taken from <http://www.visibleearth.nasa.gov>.

The project elements were formulated at a workshop in Woods Hole in November 1999 carried out under the auspices of the International Permafrost Association (IPA), its working group on Coastal and Offshore Permafrost and its Coastal Erosion subgroup (Brown and Solomon 2000). As a result of the workshop a metadata form for the selection and establishment of key monitoring sites was developed (Appendix 1). A consistent and generalized coastal classification scheme was established based on morphology and materials (Appendix 2). Consensus was reached on direct and indirect methodologies for estimating ground-ice volumes and presentations of data on maps (Appendix 3). Finally, a suite of standard tools and techniques for development of long-term coastal monitoring sites was recommended (Appendix 4).

During the Arctic Science Summit Week in April 2000 in Cambridge, UK, and at the request of the IPA, the Council of the International Arctic Science Committee (IASC) approved funding for a follow up workshop to develop a Science and Implementation plan for ACD. The resulting international workshop, held in Potsdam (Germany) on 18-20 October 2000, produced a phased, five-year Science and Implementation Plan (Figure 2).

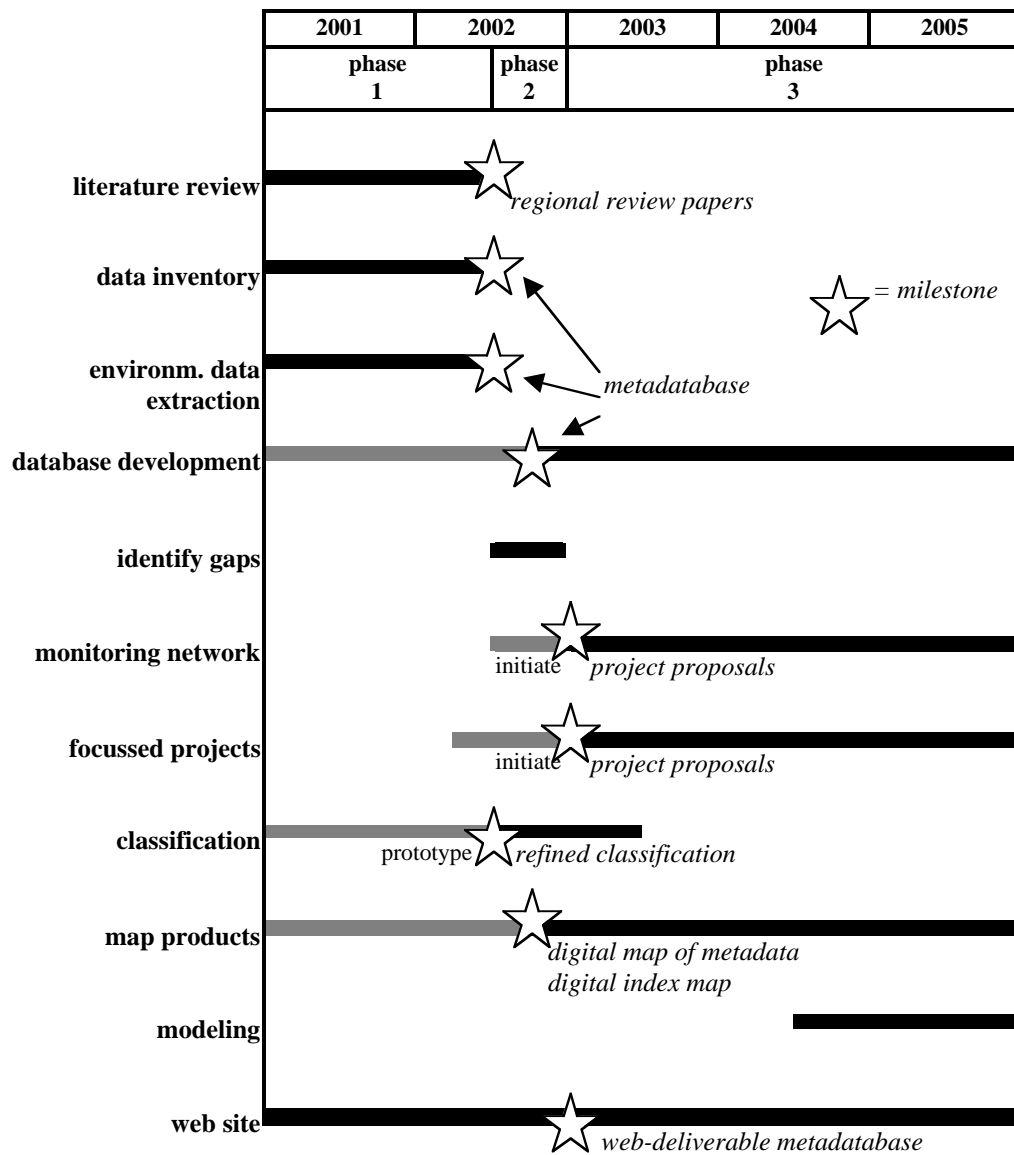


Figure 2. Main elements of the ACD Science and Implementation Plan, schedule and milestones.

The participants selected Volker Rachold to be the official IASC Project Leader. Hans Hubberten, Head of the AWI Potsdam Department, agreed to establish an ACD project office at AWI-Potsdam with a secretariat headed by Volker Rachold to maintain international communications including the web site (<http://www.awi-potsdam.de/www-pot/geo/acd.html>) and an electronic newsletter. The secretariat is assisted by the International Steering Committee (ISC) consisting of

- Felix Are, St. Petersburg State University of Means and Communication
- Jerry Brown, International Permafrost Association, Woods Hole
- George Cherkashov, VNIIOkeangeologia, St. Petersburg
- Mikhail Grigoriev, Permafrost Institute, Yakutsk
- Hans Hubberten, AWI, Potsdam
- Volker Rachold, AWI, Potsdam
- Johan Ludvig Sollid, Oslo University
- Steven Solomon, Geological Survey of Canada, Dartmouth

The Science and Implementation Plan (IASC Arctic Coastal Dynamics, 2001) was made available at the ACD web page and submitted to the IASC Council for review, approval and advice on future directions. At the Council Meeting during the Arctic Science Summit Week in Iqaluit, Canada (April 22-28, 2001), IASC officially accepted the ACD project and approved funding for the 2nd ACD workshop in Potsdam, November 26-30, 2001.

References

- Are, F.E. (1999) The role of coastal retreat for sedimentation in the Laptev Sea. In: Kassens, H., Bauch, H., Dmitrenko, I., Eicken, H., Hubberten, H.-W., Melles, M., Thiede, J. and Timokhov, L. (eds.) Land-Ocean systems in the Siberian Arctic: dynamics and history. Springer, Berlin, 287-299.
- Brown, J. and Solomon, S. (eds.) (2000) Arctic Coastal Dynamics – Report of an International Workshop, Woods Hole, MA, November 2-4, 1999. Geological Survey of Canada Open File 3929.
- IASC Arctic Coastal Dynamics (ACD) (2001) Science and Implementation Plan, International Arctic Science Committee, Oslo, April 2001.
- MacDonald, R.W., Solomon, S., Cranston, R.E., Welch, H.E., Yunker, M.B. and Gobiell, C. (1998) A sediment and organic carbon budget for the Canadian Beaufort Shelf. *Mar. Geol.* 144, 255-273.
- Rachold, V., Grigoriev, M.N., Are, F.E., Solomon, S., Reimnitz, E., Kassens, H. and Antonow, M. (2000) Coastal erosion vs. riverine sediment discharge in the Arctic shelf seas. *International Journal of Earth Sciences (Geol. Rundsch.)* 89, 450-460.
- Reimnitz E, Graves S.M., Barnes P.W. (1988) Beaufort Sea coastal erosion, sediment flux, shoreline evolution and the erosional shelf profile. U.S. Geological Survey. Map I-1182-G, and text, 22 pp.

2 Program of the Workshop¹

The main objective of the workshop was to review the status of ACD according to phase 1 of the Science and Implementation Plan. During the first part (Tuesday November 27 and morning of Wednesday November 28) several papers dealing with the following topics were presented. The extended abstracts are presented below.

- (A) Status reports of the ACD working groups of phase 1 of the Science and Implementation Plan
- Literature review
 - Metadata
 - Environmental data
 - Mapping and classification
- (B) Scientific reports on different topics
- Reports on recent field studies and mapping (9 papers)
 - Reports on remote sensing and modeling (8 papers)
 - Reports on data management (3 papers)
 - Reports on the sediment and organic carbon flux (7 papers)

During the second part (afternoon of Wednesday 28 to evening of Thursday 29) the progress and the next steps of the four working groups (WG) listed above were discussed:

Literature WG: Regional review articles summarizing the published information about coastal geomorphology, sediment and organic carbon yield are anticipated. At the first stage three papers dealing with the Laptev Sea (M. Grigoriev, F. Are and V. Rachold), the Beaufort Sea (S. Solomon and J. Brown) and Spitsbergen (J.L. Sollid, R. Ødegård and B. Wangenstein) will be prepared. Based on a bibliography of Russian literature related to ACD, which was presented during the workshop, review papers of the Russian coasts will follow (for names of responsible persons see Mapping and Classification WG).

Environmental data WG: Appendix 5 shows a list of environmental data, which will be considered. The Canadian Geological Survey (S. Solomon) is recruiting a post doctoral researcher who will be responsible for the extraction of ACD relevant environmental data.

Metadata WG: A circum-arctic coastal geographical information system (GIS) to display the metadata information was presented during the workshop (see Lack et al. abstract, p. 29). The existing ACD key sites are listed in Table 1 and indicated in Figure 3, which shows the Digital Elevation Model of the circum-arctic coastal GIS. During the following discussion on metadata it was decided to include the Metadata WG in the Mapping and Classification WG and to add a section on data management.

¹ The complete program and the list of participants are given in Appendices 7 and 8.

Table 1. List and locations of ACD key sites.

DATE PREP.	COASTAL SECTION NAME	TYPE SITE	COUNTRY	REGION	LAT	LONG	CONTACT:
02 Nov 00	North Head	Key	Canada	Mackenzie Delta	69.72	-134.49	S.Solomon (solomon@nrcan.gc.ca)
14 Feb 01	Elson Lagoon, Barrow, Alaska	Key	United States	Alaska	70.32	-156.58	Jerry Brown (jerrybrown@igc.org)
25 Jan 01	Cape Krusenstern	Key	USA	NW Alaska	67.67	-163.35	J.W.Jordan (jwjordan@sover.net)
22 Jan 01	Marre-Sale	Key	Russia	West Siberia	69.70	66.50	Alexandr Vasiliev (emelnikov@mtu-net.ru)
25 Jan 01	Bolvansky cape	Key	Russia	European North	68.30	54.50	Alexandr Vasiliev (emelnikov@mtu-net.ru)
13 Mar 01	Muostakh Island, Buor-Khaya Bay	Key	Russia	Laptev Sea Coast	71.61	129.94	Mikhail N. Grigoriev (grigoriev@mpi.ysn.ru)
13 Mar 01	Bykovsky Peninsula	Key	Russia	Laptev Sea Coast	71.79	129.42	Mikhail N. Grigoriev (grigoriev@mpi.ysn.ru)
13 Mar 01	Bolshoy Lyakhovsky Island, Novosibirsky Archipelago	Key	Russia	Laptev Sea Coast, Dmitri Laptev Strait	73.33	141.35	Mikhail N. Grigoriev (grigoriev@mpi.ysn.ru)
13 Mar 01	Terpyai-Tumsa Cape	Key	Russia	Laptev Sea Coast, Olenek Bay	73.57	118.40	Mikhail N. Grigoriev (grigoriev@mpi.ysn.ru)
01 Sep 01	Pesyakov Island	Key	Russia	Pechora (Barents) Sea Coast	68.75	57.60	Stanislav Ogorodov (ogorodov@aha.ru)
01 Sep 01	Varandei Island - Peschanka River	Key	Russia	Pechora (Barents) Sea Coast	68.82	58.10	Stanislav Ogorodov (ogorodov@aha.ru)
01 Sep 01	Peschanka River - Cape Polyarnyi	Key	Russia	Pechora (Barents) Sea Coast	68.91	58.60	Stanislav Ogorodov (ogorodov@aha.ru)
01 Sep 01	Cape Konstantinovskii - Cape Gorelka	Key	Russia	Pechora Bay Coast of Pechora (Barents) Sea	68.56	55.50	Stanislav Ogorodov (ogorodov@aha.ru)
15 Sep 01	Kharasavei settlement area	Key	Russia	Kara Sea Coast, Yamal Peninsula	71.10	66.70	Stanislav Ogorodov (ogorodov@aha.ru)
15 Sept 01	Cape Mutnyi - Ly-Yakha River	Key	Russia	Baidaratskaya Bay Coast of Kara Sea, Yamal Peninsula	69.30	68.10	Stanislav Ogorodov (ogorodov@aha.ru)
15 Sep 01	Yary village - Levdiev Island	Key	Russia	Baidaratskaya Bay Coast of Kara Sea, Ural region	68.80	66.90	Stanislav Ogorodov (ogorodov@aha.ru)
15 Sep 01	Yamburg Harbour area	Key	Russia	Ob' Bay Coast of Kara Sea	67.90	74.80	Stanislav Ogorodov (ogorodov@aha.ru)
10 Oct 01	Beaufort Lagoon, Arctic National Wildlife Refuge, Alaska	Key	United States	Alaska	69.88	-142.30	Janet Jorgenson (janet_jorgenson@fws.gov) Torre Jorgenson (tjorgenson@abrinc.com)
22 Oct 01	Cape Maly Chukochiy	Key	Russia	East Siberia Sea, Kolyma Lowland Coast	70.08	159.92	Vladimir Ostroumov (Vostr@issp.serpukhov.su)
20 Nov 01	Onemen gulf	Key	Russia	Chukotka	64.81	176.92	A.N. Kotov (nauka@anadyr.ru)

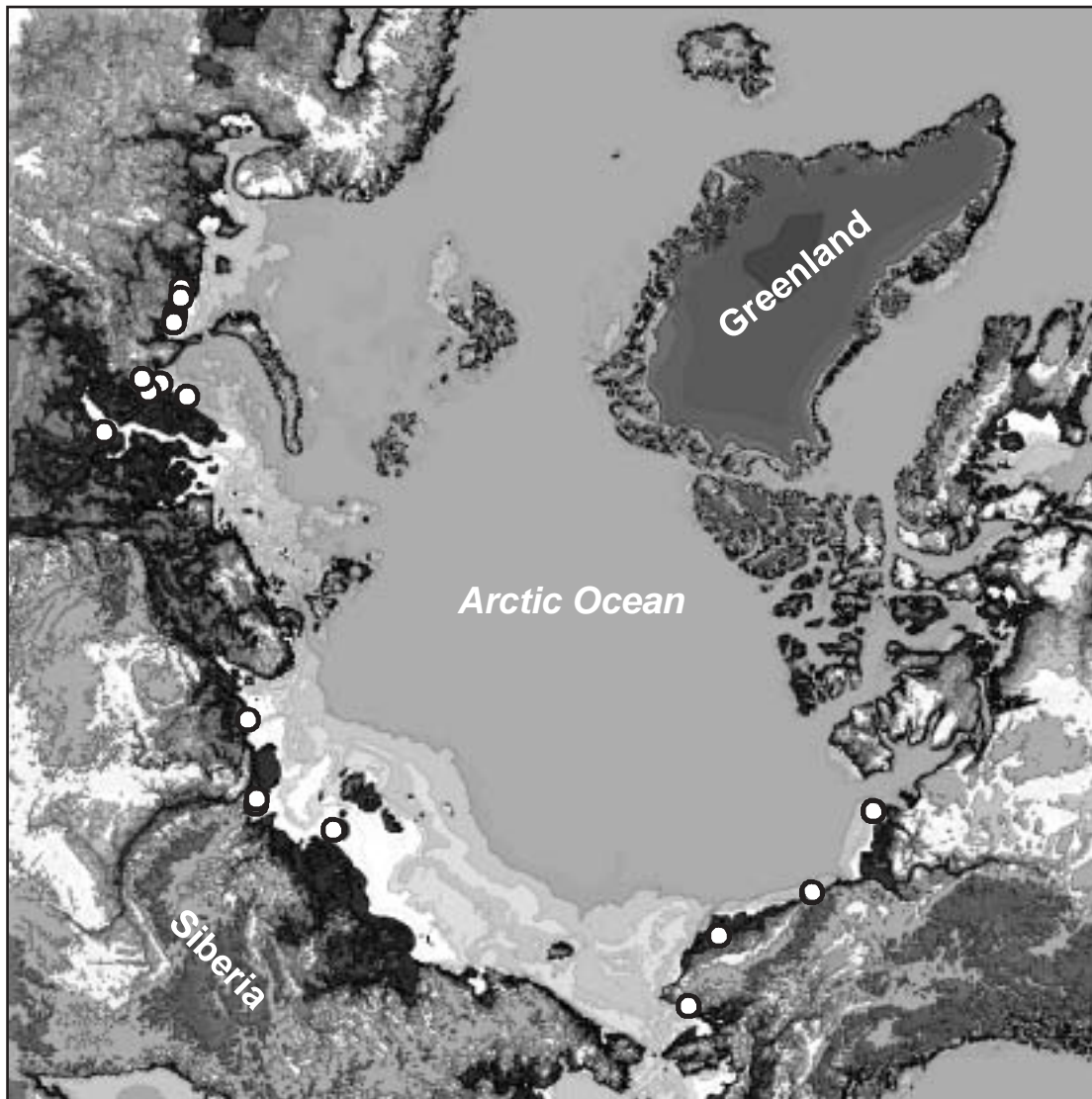


Figure 3. Circum-arctic coastal geographical information system (GIS) showing the digital elevation model and the ACD key sites.

Classification and Mapping WG: The participants agreed that at this stage of the project the highest priority is given to the assessment of sediment and organic carbon fluxes to the Arctic Ocean through coastal erosion. Accordingly, a coastal mapping template (Table 2), which allows coastal scientists to record information about arctic coasts, was developed. It will be used for a circum-arctic database of coastal retreat and sediment and organic carbon input. Regional experts will be responsible to define homogeneous coastal segments and apply the coastal mapping template following the instructions presented in the guidelines for the ACD mapping and data template (Appendix 6). The completed templates are to be submitted to vrachold@awi-bremerhaven.de and, after quality-check, will be imported into PANGAEA (www.pangaea.de). PANGAEA is the AWI web-deliverable data system for environmental and geological sciences (see Diepenbroek et al. abstract, p. 16). For further GIS based analyses the coastal data can be exported from the PANGAEA system. These analyses will include:

- the determination of the length of the coastline for the individual coastal segments based on the GEBCO coastline;
- the quantification of volume of eroded material based on morphology; and

- as a third step the assessment of the sediment and organic carbon flux based on the mapping and data template.

To check the accuracy of the GIS determination of the length of the coastline (fractal error), GIS-experts will compare the values obtained on the basis of the GEBCO coastline with that obtained from high-resolution digital coastlines, which are available for test areas (Lena Delta and Spitsbergen).

Table 2. ACD mapping template.

Coordinates of Segments	Latitude Start	
	Longitude Start	
	Latitude End	
	Longitude End	
Information Used to Define Segments	Surficial Geological Unit	
	Source of Surficial Geological Unit (Reference)	
	Soil Unit	
	Source Soil Unit (Reference)	
	Landscape Unit	
	Source Landscape Unit (Reference)	
Organic Carbon	Soil Organic Carbon (%)	
	Sediment Organic Carbon (%)	
	Average Organic Carbon (%)	
	Source Organic Carbon Data (Reference)	
Material	Material	
	Source Material (Reference)	
Ground Ice	Upper Ground Ice Content (%)	
	Thickness of Upper Ground Ice Unit (m)	
	Lower Ground Ice Content (%)	
	Average Ground Ice Content (%)	
	Source Ground Ice Content (Reference)	
Change Rate	Change Rate (m)	
	Change Rate Interval (years)	
	Source Change Rate (Reference)	
	Backshore Elevation (m)	
	Source Backshore Elevation (Reference)	
	Vertical Datum Reference	
	Distance to 10 m Isobath (m)	
	Source Distance to 10 m Isobath (Reference)	
	Depth of Closure (m)	
	Source Depth of Closure (Reference)	
	Remarks	Problems, Comments, Additional Information
	Classification According to ACD Science and Implementation Plan	ACD Onshore Classification
	ACD Backshore Classification	
	ACD Frontshore Classification	
	ACD Nearshore Classification	

Regional experts:

- Spitsbergen, Northern Norway, Greenland: Sollid, Ødegård, Wangensteen, Møller
- Barents and Kara Sea: Vassiliev, Ogorodov (supported by Nikolaev for Barents Sea and Bolshiyarov for western Taymyr Peninsula)
- Laptev Sea: Grigoriev, Are, Rachold
- East Siberian Sea: Ostroumov, Rasumov
- Chukchi Sea: Pavlidis
- Alaskan Beaufort Sea: Brown, Jorgensen, Naidu et al.
- Canadian Beaufort Sea: Solomon, Taylor, Pollard, Omelon, Forbes

Based on the WG discussions, the following next steps were identified in the Steering Committee meeting (Friday 30 November):

1. Classification and Mapping: The regional expert submit the completed EXCEL table with the coastal data following the guidelines for the ACD mapping and data template to vrachold@awi-bremerhaven.de. The data will be imported to the PANGAEA system. Since this topic has the highest priority, we agreed to start with the ACD key sites.

2. Workshop report: All participants and those unable to attend were invited to submit extended abstracts for the present workshop report.

3. Literature review: The bibliography of the Russian coastal literature will be revised and completed. The regional experts identified in the Mapping and Classification WG are responsible for writing the literature review articles. We did not announce a deadline, but expect the articles to be ready for submission by mid- 2002.

4. ACD relevant meetings

- Arctic Workshop (Boulder, 14-16 March 2002): ACD presentation by S. Solomon
- Arctic Science Summit Week (Groningen, 21-27 April 2002): ACD presentation at the Arctic Ocean Science Board by V. Rachold
- Annual Meeting of the Russian Permafrost Community (Pushchino, 12-15 May 2002): special ACD session to be organized (chairpersons: Are and Rachold)
- International Permafrost Conference (Zurich, 21-25 July 2003): special session on coastal permafrost
- Arctic Margins Meeting (Halifax, 29 September – 3 October 2003): special session on arctic coasts

5. Next ACD workshop

- To be organized in Oslo, November 2002