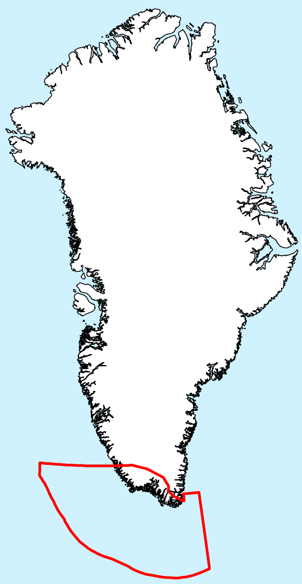
National Environmental Research Institute
Ministry of the Environment · Denmark

Environmental Oil Spill Sensitivity Atlas for the South Greenland Coastal Zone

NERI Techical Report, No. 493



This page is intentionally left blank

National Environmental Research Institute
Ministry of the Environment · Denmark

Environmental Oil Spill Sensitivity Atlas for the South Greenland Coastal Zone

NERI Technical Report, No. 493
2004

A. Mosbech, D. Boertmann, B.Ø. Olsen, S. Olsvig,
F. von Platen, E. Buch, K.Q. Hansen, M. Rasch, N. Nielsen,
H.S. Møller, S.Potter, C. Andreasen, J. Berglund, M. Myrup
National Environmental Research Institute
Geological Survey of Denmark and Greenland
Danish Meteorological Institute
Institute of Geography University of Copenhagen
SL Ross Environmental Research Ltd
Greenland National Museum and Archives,
Greenland Institute of Natural Resources

Produced for:
Bureau of Minerals and Petroleum,
Greenland Home Rule

Data sheet

Title:	Environmental Oil Spill Sensitivity Atlas for the South Greenland Coastal Zone.
Authors:	A.Mosbech [1], D.Boertmann[1], B.Ø. Olsen [1], S. Olsvig [1], F. von Platen [2], E. Buch [3], K.Q. Hansen [3], M. Rasch [4], N. Nielsen [4], H.S. Møller[4], S. Potter[5], C. Andreasen [6], J. Berglund[6] & M.Myrup[6]
Institutions:	1)National Environmental Research Institute, 2)Geological Survey of Denmark and Greenland, 3)Danish Meteorological Institute, 4)Institute of Geography University of Copenhagen, 5)SL Ross Environmental Research Ltd, and 6)Greenland National Museum and Archives, , Greenland Institute of Natural Resources.
Serial title and no.:	NERI Technical Report no. 493
Publisher:	National Environmental Research Institute© Ministry of the Environment
URL:	http://www.dmu.dk
Date of publication:	April 2004
Financed by:	Bureau of Minerals and Petroleum, Greenland Home Rule
Please cite as:	Mosbech, A., Boertmann, D., Olsen, B. Ø., Olsvig, S., von Platen, F., Buch, E., Hansen, K.Q., Rasch, M., Nielsen, N., Møller, H. S., Potter, S., Andreasen, C., Berglund, J. & Myrup, M. 2004: Environmental Oil Spill Sensitivity Atlas for the South Greenland Coastal Zone. National Environmental Research Institute, Denmark. 341 pp. – NERI Technical Report no. 493 (CD-ROM). http://environmental-atlas.dmu.dk/ Reproduction is permitted, provided the source is explicitly acknowledged.
Abstract:	This oil spill sensitivity atlas covers the shoreline and the offshore areas of South Greenland between 56°30′ N and 62° N. The coastal zone is divided into 220 areas and the offshore zone into 6 areas. For each area a sensitivity index value is calculated, and each area is subsequently ranked according to four degrees of sensitivity. Besides this general ranking a number of smaller sites are especially selected as: they are of particular significance, they are particularly vulnerable to oil spill and because effective oil spill response may be performed. The shoreline sensitivity ranking are shown on 20 maps-sheets (in scale 1:250,000), which also show the different elements included. These maps also show the selected areas. Coast types logistics and proposed response methods along the coasts are shown on another 20 maps. The sensitivities of the offshore zones are depicted on 4 maps, one for each season. Based on all the information, appropriate oil spill response methods have been assessed for each area.
Keywords:	South Greenland, oil spill sensitivity mapping, shoreline oil spill sensitivity, offshore oil spill sensitivity, coastal zone environmental mapping, meteorology, oceanography, ice conditions, coastal morphology, human use, archaeology, local knowledge, marine mammals, seabirds, fish, logistics, oil spill response.
Proof reading:	Kirsten Rydahl
ISBN:	87-7772-806-8
Number of pages:	365 incl. appendix
Price	DKK 400,- (CD-ROM)
Internet version:	The report is available in electronic format from NERI's homepage: http://environmental-atlas.dmu.dk/
For sale at:	Ministry of the Environment Frontlinien Rentemestervej 8 DK-2400 Copenhagen NV Denmark Tel.: + 45 70 12 02 11 frontlinien@frontlinien.dk

Contents

Contents continued in appendices

List of figures

List of figures – Appendices

Additional figures:

Seabird breeding colonies (26 photos): Linked from blue icons on shoreline sensitivity maps.

Archaeological sites (15 photos): Linked from text in 14.5 Achaeological and historic information,page 14-25.

Air photos (in total 122): Linked from each shoreline sensitivity map and from a keymap.

Additional living resource maps: Linked from relevant sites in the text and tables of chapter 8.1 and 14.4.

- Distribution of scallop catches
- Distribution of artic char rivers and fishing areas
- Distribution of capelin spawning and fishing areas
- Distribution of lumbsucker spawning and fishing areas
- Distribution of wintering seabirds
- Distribution of large baleen whales

2 Preface

This atlas was produced as a part of the preparations for exploratory oil/gas drilling offshore Greenland. It is a continuation of the atlas covering the region 62º N to 68º N, produced in 2000.

This atlas was produced using the best available information. Draft maps with environmental information was presented to local communities for quality assurance and gathering of supplemental information on resources and resource use. Further a draft of the complete Atlas was sent to relevant Greenlandic and Danish institutions for comments. However, the available information was by no means complete and as further information becomes available, it will be relevant to update the atlas. The atlas was produced in a dynamic GIS (Geographical Information System) where atlas updates can be produced easily, when input data is updated. It is our hope that this atlas with all its integrated information and suggestions will be a valuable tool for Greenlandic authorities, oil companies and others.

The study team

The National Environmental Research Institute, Department of Arctic Environment (NERI-AE) headed the study team.

NERI further provided the biological information in the atlas, and prepared the shoreline and offshore sensitivity maps. NERI also developed a CD presentation solution and an Internet version of the atlas.

The Geological Survey of Denmark and Greenland (GEUS) prepared the coastal morphology maps and the basic map layout.

The Institute of Geography, University of Copenhagen, was responsible for shoreline morphology classification based on air photo interpretation.

SL Ross Environmental Research Ltd. developed the sections on countermeasures, access and safe havens on the physical environment and logistics maps.

The Danish Meteorological Institute (DMI) reviewed and compiled data regarding ice, oceanography and climate, mainly the chapters 8.1 (part), 8.4, 8.5, 8.6, 8.7 and Appendix C (chapter 13).

The Greenland National Museum and Archives (GNMA) compiled and reviewed the archaeological information.

The Greenland Institute of Natural Resources (GINR) contributed with information regarding living resources (fish, shellfish, birds and whales) and their use in Greenland. The Greenland Ministry of Environment and Nature supplied various information's and commented on an early draft of the atlas.

The software application used to generate shoreline and offshore sensitivity scores was originally developed for the first atlas in co-operation with AXYS Environmental Consulting Ltd.

As a part of the project, a study of local knowledge was carried out by NERI and GINR (Olsvig & Mosbech in prep.).

A draft version of the atlas was presented at community consultations in July 2003 in Aappilattoq, Narsamijiit, Nanortalik, Alluitsup Paa, Saarloq, Eqalugaarsuit, Qaqortoq, Narsaq and Qassimiut. We thank the residents and the representatives for the local hunters and fishermens organisations for their constructive participation. The community consultations were carried out by Sara Olsvig and David Boertmann (both NERI).

Team members

Anders Mosbech (NERI) headed the study team producing the atlas.
The team consisted of (in alphabetic order):
Claus Andreasen (GNMA)
Joel Berglund (GNMA)
David Boertmann (NERI)
Erik Buch (DMI)
Keld Q. Hansen (DMI)
Niels Nielsen (Institute of Geography, University of Copenhagen)
Mikkel Nyrup (GNMA)
Bent Østergaard Olsen (NERI)
Sara Olsvig (NERI)
Frants von Platen (GEUS)
Steve Potter (SL Ross Environmental Research Ltd.)
Morten Rasch (Institute of Geography, University of Copenhagen)
Henrik S. Møller (Institute of Geography, University of Copenhagen).

Contributions from the Greenland Institute of Natural Resources were delivered by Helle Siegstad, Ole Jørgensen, Lars Witting, AnnDorte Burmeister, Lars Heilmann, Jesper Boje, Claus Simonsen and Flemming Merkel.

Peter Mikkelsen (NERI), Frank Riget (NERI) and Mikkel Tamstorf (NERI) contributed to the preparation of the offshore data analysis, and Mette Jensen (NERI) contributed to the design of the local knowledge studies. Greenland Command in Grønnedal commented on the proposed potential safe havens.

The Bureau of Minerals and Petroleum (Greenland Government) funded the atlas project.

3 Summary

Environmental Oil Spill Sensitivity Atlas for the South Greenland Coastal Zone

This atlas is produced as a part of the preparations for exploratory drilling offshore Greenland. The objective of the project is to produce an overview of resources vulnerable to oil spills, for example biological resources (fish, birds and whales), and a tool to respond to an oil spill. The project covers the South Greenland region, i.e. the land between 60° and 62° N and the sea as far south as 56°30′ N and west of 43° W.

The following elements are included in the project

- coast types,
- oceanography, ice and climate,
- biological resources (fish, birds etc.),
- fishing and hunting,
- protected areas,
- tourism,
- archaeological sites,
- logistics and oil spill response methods.

As the oil spill sensitive resources are very different in character (e.g. seabird breeding colonies, important fishing areas and archaeological sites), it has been common practice to calculate an index value of the sensitivity of a specific area in order to compare areas with different characteristics. The index calculations are based on a Canadian system which has been used in Lancaster Sound. An overview of the methods used in the atlas is given in Chapter 6.

The coastline is divided into areas (coastlines and groups of islands) approx. 50 km long. Each area has been ranked in one of four degrees of sensitivity based on the index calculation that includes abundance and sensitivity of a number of environmental or community elements (e.g. different birds and marine mammals, hunting areas and archaeological sites).

Besides the general classification of coastal sensitivity, the maps of the atlas also show smaller selected areas. They have been selected as being of particular significance, particular vulnerable to oil spills and as being of a size where an effective oil spill response may be performed.

As a part of the project classification of the coastline morphology has been conducted from aerial photographs, e.g. the occurrence of rocky shores and beaches. An index value of the self-cleaning ability of the coast after an oil spill has been calculated based on this classification in combination with shoreline exposure to waves and ice. For example oil on a rocky coast exposed to wave action will be cleaned faster than oil on a beach in a protected lagoon.

Based on all the information appropriate methods to respond to oil spills in the different areas have been assessed.

Chapter 8 in the atlas contains offshore and overview information, primarily in 1: 3.5 million scale maps, and Chapter 9 contains detailed coastal information in 1: 250,000 scale maps. Chapter 7 is a users guide common to Chapter 8 and 9.

Chapter 8 contains maps showing the sensitivity of the offshore areas and with each of the elements used in the classification (fishing areas, fish, birds and marine mammals). A number of maps show ice conditions and the most important biological resources and their use, e.g. deep sea shrimp and Greenland halibut.

Chapter 9 contains 20 maps in the scale 1: 250,000 showing index values for coastal sensitivity and symbols for the elements of the classification (hunting and fishing areas, fish, birds, marine mammals and archaeological sites). The maps also show the selected areas. Each map has a description of biological resources and human use of the area.

Chapter 9 also contains 20 maps showing coast types, logistics and proposed methods to oil spill response for each area.

A community consultation phase was carried out during the project. A draft version of the atlas was presented and discussed with local communities and user organisations in July 2003, and new information was incorporated.

The Bureau of Minerals and Petroleum (Greenland Home Rule) financed the preparation of the atlas.

The project was carried out by the National Environmental Research Institute, the Geological Survey of Denmark and Greenland, the Greenland Institute of Natural Resources, the University of Copenhagen (Institute of Geography), the Greenland National Museum and Archives, Danish Meteorological Institute and SL Ross Environmental Research Ltd.

4 Eqikkaaneq

Kujataata imartai kangerluilu – uuliaarluernermi piffiit immikkut sunnertiasut pillugit atlassi

Ukioq 2000-ip aasaanerani uuliasioqatigiiffik Statoil Nuup avataani Fyllap imartaata kitaani uuliamik/gassimik ujarlerluni qillerivoq. 1977-mili Kalaallit Nunaanni imaani qillerinerit siullersaraat. Tamatuma kingorna canadamiut uuliasioqatigiiffiat Encana aamma Kitaata imartaani uuliasiornermut akuersissummik tunineqarsimavoq, kitaanilu imarnersat allat sisamat piffissami aggersumi uuliasiornissamut neqeroorutigineqartussaapput. Taamaattumik uuliasiornerit Kitaata imartaani annertusisussaapput. Uuliasiornermi avatangiisinut sunniuteqarlussinnaasut annersaraat qillerisoqartillugu uuliarluerujussuarneq, tamatumalu kingorna uulia aqunneqarsinnaanngitsumik imaanut siaruaappat. Taamatulli pisoqarsinnaanerata ilimanassusaa annikitsuararsuuvoq, assersuutigalugulu Statoil-ip 2000-mi qillerinera avatangiisinut akornutaanani ingerlanneqarpoq.

Statoil-ip qillerinerinissaanut pilersaarusiornermut atatillugu qallunaat kalaallillu pisortaasa atlassiliorneq aallartissimavaat. Suliap siunertaraa uuliaarluernermi pinngortitami sunnertiasut tamakkerlugit suunerisa nalunaarsorneqarnissaat. Tamakku ilagaat uumasut (aalisakkat, timmissat il.il.) kiisalu aalisarnermut piniarnermullu soqutigisaqaqatigiinnut attuumassuteqartut. Uuliaarluertoqartillugu suut siulliullugit illersortariaqarnersut aalajangiisoqartariaqalernissaa pisariaqalissappat uuliasioqatigiiffik pisortallu ilisimasat nalunaarsorneqarsimasut tunngavigalugit siumut naliliisinnaalersimapput. Suliaq taamani Kitaani allorniusat sanimukartut 62° N aamma 68° N akornanni ingerlanneqarsimavoq.

Maannakkut atlassi siulleq kujataanut ilaneqarpoq, tassa Paamiunit Nunap Isua tikillugu tamatumalu imartaa tamaat ilanngullugu. Kiisalu atlassi avannamut ilaneqarpoq (immikkut saqqummersinneqassaaq), taamaalilluni avannarpasissutsimi 72° N-mi Sigguk tikillugu sineriak tamakkerneqassalluni.

Suliami immikkoortut maku ilaapput:

- sinerissap iluasaanik allaaserisat,
- imaq, siku silalu,
- uumasut pisuussutit (timmissat, aalisakkat il.il.),
- aalisarneq piniarnerlu,
- piffiit immikkut illersorneqartut (soorlu timmissat inaat),
- itsarnitsat eriagisariaqartut,
- angalanermut tunngasut uuliaarluernermilu akiueriaatsit.

Immikkoortut assigiinngeqisunik pisuussuteqarmata (soorlu timmissat ineqarfii, aalisarfiit pingaartut itsarnitsallu eriagisariaqartut), nunani allani nalinginnaavoq piffiup ataatsip qanoq sunnertiatiginera kisitsisinngorlugu nalilersuisarneq, taamaalilluni piffiit assigiinngitsut imminnut assersuunneqarsinnaanngorlugit pingaarnerutitallu tulleriiaarneqarsinnaanngorlugit. Tamanna siunertaralugu nalilersueriaatsit assigiinngitsut inerisarneqarsimapput. Suliami uani canadamiut nalilersueriaasiat aallaaviuvoq, taannalu Canadap kangiata avannaani Lancaster Sound-imi aamma atorneqarsimavoq.

Sineriak immikkoortunut 50 km-rit missiliorlugit isorartutigisunut agguarneqarsimavoq malussarissutsinullu immikkoortunut sisamanut agguarneqarsimasunut. Immikkoortiterneranullu atatillugu qanoq sunnertiatiginerisa nalilersorneranni avatangiisinut inuiaqatigiinnullu tunngassuteqartut ilanngunneqarsimapput (timmissat imaanilu uumasut miluumasut eqimattat assigiinngitsut, piniarfiit, aalisarfiit, itsarnitsanik eriagisariaqartut il.il.). Tamakku ataasiakkaat uuliaarluernermut qanoq sunnertiatiginerat, kiisalu immikkoortut ataasiakkaat qanoq amerlatiginerat/pingartiginerallu nalilerneqarsimalluni. Uumaasut immikkuutaartut uuliaarluernermut malussarissusaat taakku uuliaarluertoqartillugu uuliamik sunnerneqarsinnaanerata ilimanassusaa uuliamullu malussaritsiginerat tunngavigalugu nalilerneqarsimavoq. Uumasut immikkoortut taakkulu atorneqarnerat immikkoortut ataatsimut katillugit malussaritsiginerata naatsorsorneqarnerani pingaartinneqarnerpaasimavoq.

Sineriak tamakkerlugu malussaritsiginerata nalinginnaq nalilersorneqarnerata saniatigut nunap assingini piffiit minnerusut immikkut toqqarneqarsimasut nalunaarsorneqarsimapput. Piffiit tamakku immikkut naleqassusaat, uuliaarluernermut immikkut malussarissusaat kiisalu annertussusaat naapertorlugu uuliaarluertoqartillugu pitsaasumik siaruatsaaliorsinnaanerat tunngavigalu immikkoortinneqarsimapput.

Suliamut atatillugu timmisartumit assilisat tunngavigalugit sinerissat nalunaarsorneqarsimapput (ilusaat sunillu sananeqaateqarnerat, soorlu qaarsoqarfiunersut sioraqarfiunersulluunniit). Ilisimasaq taanna aallaavigalugu aammalu mallinut sikunullu qanoq sunnerneqartigisarnerat tunngavigalugu uuliaarluernermi imminut salissinnaassusaat kisitsisinngorlugu nalilerneqarsimavoq. Soorlu sineriak qaarsorissoq mallinit sunnerneqartuartoq sissamut kangerliumanermi oqquartamiittumut naleqqiullugu uuliamik sukkanerusumik akuiarneqartarpoq.

Paasisat katersorneqarsimasut tunngavigalugit piffinni assigiinngitsuni uuliaarluernermik siaruatsaalioriaatsit naleqquttut nalilersorneqarsimapput.

Atlassi aamma nassuiaatinik immikkoortortaqarpoq (kapitali 8), nunap assinganut uuttuut 1:3.5 million tunngavigalugu nalunaarsorneqarsimasunik kiisalu sukumiinerusumik nassuiaatitalimmik immikkoortortaqarpoq (kapitali 9) nunap assinganut uuttuut 1:250.000 tunngavigalugu nalunaarsorneqarsimasunik. Kapitali 7 kapitalit 8-mi 9-milu nunap assingisa atornissaannut ataatsimut ilitsersuummik imaqarpoq.

Kapitali 8 nunap assinginik imaani piffiit sunnertiatigineri tunngavigalugit immikkoortut ataasiakkaat ilisarnaataannik nalunaaqutserneqarsimasunik (aalisartarfiit, aalisakkat, timmissat imarmiullu miluumasut) imaqarpoq. Taassuma saniatigut piffiup sikusarneranut tunngasunik nunap asseqarpoq kiisalu uumasut pisuussutit arlallit sumiissusaat taakkulu atorneqarneri nalunaarsorneqarsimallutik, soorlu kinguppaat qalerallillu.

Kapitali 9 nunap assinginik uuttut 1:250.000 tunngavigalugu sananeqarsimasunik 20-nik imaqarpoq taakkunanilu sinerissat sunnertiatiginerat nalilerneqarsimavoq sumullu atorneqartarnera ilisarnaaserneqarsimalluni (piniarfiit aalisarfiillu, aalisakkat, timmissat imaanilu uumasut miluumasut itsarnitsallu eriagisariaqartut). Nunap assingi piffiit immikkut pingaaruteqartut ilanngunneqarsimapput. Nunap assinginut ataasiakkaanut piffiup sumut atorneqartarneranut kiisalu sunik uumasoqarneranik paasissutissat allaaserineqarsimapput.

Kapitali 9 nunap assingi 20-it saniatigut aamma nunap assinginik sinerissap qanoq ilusaanik, periarfigitsigineranik kiisalu piffinni ataasiakkaani uuliaarluernerup qanoq akiorneqarsinnaaneranik siunnersuutinik imaqarpoq.

Paasissutissat pissarsiarineqarsimasut suliap ingerlanerani kommuninut soqutigisaqaqatigiinnuullu ataasiakkaanut saqqummiunneqarsimapput oqallisigineqarsimallutillu.

Suliaq Namminersornerullutik Oqartussat Aatsitassanut Ikummatissanullu Pisortaqarfiannit Avatangiisinillu aqutsisoqarfimmit aningaasaliiffigineqarsimavoq (avatangiisinik misissuinermik tapiissuteqartartoq Dancea aqqutigalugu – Danish Cooperation for Environment in the Arctic). Suliffeqarfiillu makku ingerlatsisuusimapput: Qallunaat Nunaanni Avatangiisinut Misissuisoqarfik (DMU), Pinngortitaleriffik (Grønlands Naturinstitut), Qallunaat Nunaanni Kalaallit Nunaannilu Ujarassiuut Misissuisoqarfiat (GEUS), Københavnip Universititiani Geografisk Institut, Nunatta Katersugaasivia Allagaateqarfialu, Qallunaat Nunaanni Silasiornermut Misissuisoqarfik (DMI) kiisalu canadamiut siunnersuisoqatigiiffiat S.L. Ross Environmental Research Ltd.

This page is intentionally left blank

5 Sammenfatning

Sydgrønlandske havområder og fjorde – atlas over områder der er særligt følsomme overfor oliespild

I sommeren 2000 udførte olieselskabet Statoil en boring efter olie/gas på havbunden vest for Fyllas Banke ud for Nuuk. Det var den første boring til havs i Grønland siden 1977. Siden har det canadiske selskab Encana fået tildelt en efterforskningstilladelse ud for Vestgrønland, og fire nye vestgrønlandske havområder forventes udbudt i den kommende tid. Aktiviteterne omkring olieefterforskning vil derfor intensiveres på havet ud for Vestgrønland. Den alvorligste miljømæssige påvirkning fra sådanne aktiviteter vil opstå, hvis der sker et stort oliespild fra en boring, og olien efterfølgende spredes ukontrolleret i havet. Sandsynligheden for et stort olie spild er dog lille.

Som led i forberedelserne til Statoils boring iværksatte de danske og grønlandske myndigheder et atlasprojekt. Hensigten med dette projekt var at få et samlet overblik over de ressourcer, der er følsomme over for et oliespild. Det drejer sig bl.a. om de biologiske ressourcer (forekomst af fisk, fugle m.v.) og om fiskeri- og fangstinteresser. Med en kortlægning af denne viden fik såvel selskabet som myndighederne mulighed for på forhånd at vurdere, hvor de særligt følsomme områder findes med henblik på planlægning og prioritering af en indsat i tilfælde af et oliespild. Projektet blev afsluttet i 2000 og omfattede områderne mellem 62° N og 68° N ved Vestgrønland.

Nu udvides det oprindelige atlas med den sydgrønlandske region, dvs. fra Paamiut til Kap Farvel og hele havområdet ud herfor. Samtidigt udvides atlasset mod nord (udgives særskilt) så hele kysten op til Svartenhuk-halvøen ved 72° N bliver dækket.

I projektet indgår følgende elementer:

- beskrivelser af kysttyper,
- oceanografi, is og klima,
- biologiske ressourcer (fugle, fisk o.s.v.),
- fiskeri og jagt,
- særligt beskyttede områder (fx fuglefjelde),
- turisme,
- fortidsminder,
- logistiske forhold og metoder til at bekæmpe oliespild.

Da elementerne har meget forskellig karakter (f.eks. fuglekolonier, vigtige fiskeriområder og fortidsminder), er det almindeligt i andre lande at udregne index-værdier som udtryk for et områdes følsomhed, så det er muligt at sammenligne og prioritere forskellige områder. Der er udviklet en række forskellige index-systemer til dette formål. I dette projekt tages udgangspunkt i et canadisk system, der bl.a. er brugt i Lancaster Sound i det nordøstlige, arktiske Canada.

Kysten er inddelt i segmenter (områder) af ca. 50 km's længde, der er blevet klassificeret i fire grader af følsomhed. Klassifikationen er sket ved hjælp af en index-beregning, hvor der indgår et antal miljø- og samfundselementer (forskellige fugle og havpattedyrgrupper, jagtområder, fiskeriområder, fortidsminder m.v.). Disse elementer er dels givet en værdi for følsomhed overfor oliespild, dels en værdi for, hvor talrig/vigtig forekomsten er i hvert segment. De biologiske elementers følsomhed overfor oliespild beregnes ud fra, hvor sandsynligt det er, at den pågældende art kommer i kontakt med olie under et oliespild, samt hvor følsom arten er overfor olie. De biologiske elementer og deres udnyttelse indgår med den største vægt ved beregningen af segmenternes samlede følsomhed.

Udover den generelle klassificering af hele kystens følsomhed er der på kortene udpeget en række mindre områder. Disse områder er udvalgt fordi de er særligt værdifulde, særligt følsomme overfor oliespild eller fordi de har en størrelse, der generelt gør det praktisk muligt at gennemføre en effektiv oliebekæmpelse.

Som en del af projektet er der ud fra luftfotografier foretaget en morfologisk kortlægning af kysterne (deres opbygning og materialesammensætning, fx om de består af klippeflader eller sand). Ud fra denne viden og hvor udsatte kysterne er overfor påvirkning fra bølger og is, er der udregnet et mål (index) for deres selvrensende evne. Fx. vil en klippekyst, der er meget udsat for bølgeslag, hurtigere blive "vasket ren" for olie end en strand i en beskyttet lagune.

På baggrund af det samlede materiale er der lavet en vurdering af egnede metoder til bekæmpelse af oliespild i de forskellige områder.

Atlasset indeholder en sektion med oversigtsinformation og kortlægning af offshore-områderne (kapitel 8), der hovedsageligt er angivet på kort i målestoksforholdet 1: 3,5 million, og en sektion med detaljeret information om de kystnære områder (kapitel 9) på kortblade i målestoksforholdet 1: 250.000. Kapitel 7 indeholder en fælles brugervejledning til kortene i kapitel 8 og 9.

Kapitel 8 indeholder kort, der viser offshore-områdernes følsomhed med symboler for elementerne i klassifikationen (fiskeriområder, fisk, fugle og havpattedyr). Desuden er der en række kort over isforholdende i området samt kort over de vigtigste områder for en række biologiske ressourcer og deres udnyttelse, bl.a. for rejer og hellefisk.

Kapitel 9 indeholder 20 kortblade i målestoksforholdet 1: 250.000 med angivelse af index-værdier for kysternes følsomhed og symboler for elementerne i klassifikationen (jagt- og fiskeriområder, fisk, fugle og havpattedyr samt fortidsminder). Kortene viser også de særligt udvalgte områder. Til hvert kortblad er der udarbejdet en beskrivelse med oplysninger om områdets udnyttelse og biologiske forekomster.

Kapitel 9 indeholder derudover 20 kortblade med angivelse af kysttyper og logistiske forhold samt forslag til metoder til bekæmpelse af oliespild for hvert område.

Projektets resultater er blevet præsenteret for og diskuteret med berørte kommuner og interesseorganisationer i en høringsfase undervejs.

Projektet finansieres af Råstofdirektoratet, Grønlands Hjemmestyre. Det er udført af Danmarks Miljøundersøgelser (DMU), Grønlands Naturinstitut, Danmarks og Grønlands Geologiske Undersøgelse (GEUS), Geografisk Institut v. Københavns Universitet, Grønlands Nationalmuseum og Arkiv, Danmarks Meteorologiske Institut (DMI) samt det canadiske konsulentfirma S.L. Ross Environmental Research Ltd.

6 Introduction

6.1 Objectives

This environmental oil spill sensitivity atlas has been prepared to provide oil spill response planners and responders with tools to identify resources at risk, establish protection priorities and identify appropriate response and clean-up strategies.

The atlas is designed for planning and implementing year-round oil spill countermeasures in both coastal and offshore areas in South Greenland between 56º30′ N and 62º N latitude and west of 43º W longitude. An important component of the atlas is a sensitivity ranking system, which is used to calculate an index value describing the relative sensitivity of coastal and offshore areas. The sensitivity index value is calculated based on information on resource use (human use), biological occurrences and physical environment. The sensitivity ranking system is based on a Canadian system used in Lancaster Sound (Dickins et al. 1990) and modified to meet the specific requirements of the Greenland study area (see Chapter 6.3). As a supplement to the Canadian ranking system, a number of smaller areas have been selected for priority in case of an oil spill (see Chapter 6.4). The selection of these areas is based on the principles from a Norwegian system (Anker-Nilssen 1994), which gives priority to particular sensitive areas.

South Greenland between 60º N and 62º N latitude has, in a Greenland context, a relative dense population in the southern half. The region is important for fisheries and it is ecologically important to a number of seabird and marine mammal species. It is therefore essential that all possible measures are taken to minimise the environmental risk of oil activities in the area. The objective of this atlas is to contribute to that effort.

This atlas is an extension of a similar atlas prepared for the central part of West Greenland between 62° N and 68° N in 2000 (Mosbech et al. 2000). As an atlas covering the Northwest Greenland region between 68° N and 72° N is prepared along side the present atlas, the whole West Greenland coast from 60° N north to 72° N is now mapped.

6.2 Contents and organisation

The study area covers the coast of South Greenland between 60º N and 62º N including offshore areas within the midline between Canada and Greenland and further south to the 200 nm border (56º30′ N) and west of 43º W.

The information in the atlas is organised by map scale, moving from summary information (Chapter 8) in a scale of approx. 1: 3.5 million to operational information (Chapter 9) in a scale of 1: 250,000 (G/250 Vector copyright Danish Survey & Cadastre 1998).

Chapter 7 contains a user guide to the maps, which supplement the legend.

Chapter 8 contains the offshore and summary maps, which include:
- bathymetry,
- sea surface currents,
- overall distribution of important species,
- overview of extreme and high sensitivity areas and special status areas,
- offshore sensitivity (winter, spring, summer and autumn),
- ice conditions.

Chapter 9 contains the coastal operational maps, which include shoreline sensitivity maps with:
- shoreline species,
- resource use (human use),
- archaeological sites,
- sensitivity rankings,
- selected areas.

and physical environment and logistics maps with:
- shoreline geomorphology,
- anchorage sites and safe havens,
- access by boat or aircraft,
- descriptions of potential countermeasures.

Further information on the physical environment is given in Appendix C: Climatic data for logistics.

Detailed accounts of methodology and data documentation and limitations are given in Appendix D.

6.3 Sensitivity index system

An environmental sensitivity ranking system is used in the atlas to determine and illustrate the relative sensitivity of shoreline and offshore areas of South Greenland to the effects of an oil spill. This pre-spill ranking allows spill responders and on-scene planners to do a quick evaluation of which areas and environmental components that are most susceptible to an oil spill, and thus provides the information to consensus regarding protection priorities during a spill event.

Through the use of the sensitivity ranking system, each shoreline and offshore area receive a single numeric value, which represents the relative sensitivity of that area to a marine oil spill. This numeric value is ranked as extremely high, high, moderate or low and is illustrated on the offshore and shoreline maps by the use of a colour code.

This ranking system is based on the scheme developed for Canadian oil spill sensitivity atlases (e.g. Lancaster Sound, Dickens et al. 1990) with some modifications to account for the different biological and physical features of the region. The sensitivity ranking system incorporates the biological, physical and social elements of the region that are important from an oil spill perspective. These elements are assigned to and ranked on a relative scale within three major categories: 1. resource (human) use, 2. species occurrence and 3. oil residence. The latter category considers the oil residence periods associated with various coastal types and the differences in ice and open water zones for the shoreline and offshore areas of West Greenland, respectively. Each of the categories is assigned a weighting factor, which is based on their relative importance within the region. The elements within each of the categories are ranked based on their relative sensitivity to potential effects of oil spills. These assigned values are then multiplied by the weighting factor to produce a single numeric value the PI (priority index). It is the sum of the priority indices that determines the overall sensitivity of a specific shoreline or offshore area.

PI = AV x WF

and

S = sum of PI

where

AV = assigned value of the element

WF = weighting factor of the category

PI = priority index

S = relative sensitivity of an area: the **sensitivity value**

Criteria for ranking the relative sensitivity of the human use elements are based on their importance to local residents from a cultural/historic and economic perspective and the replaceability of the resource.

Biological elements (species or species group) selected for the sensitivity index are listed in Table 6.1. They are selected based on their sensitivity to oil spills, their ecological importance and their importance to biodiversity and the local human population.

The following formula is used to calculate the AV (assigned value) for each biological element (species or species group):

AV = (RS x RA x TM x ORI) / C

Where

RS = relative sensitivity of the species

RA = relative abundance of the species

TM = temporal modifier

ORI = oil residence index

C = constant used to reduce the maximum possible score

The relative sensitivity (RS) for the species rely on available information regarding the vulnerability, recovery potential and the potential for lethal and sublethal effects, which are summarised in Table 6.1. The relative sensitivity for the selected species ranges from 7 to 25. The relative abundance and timing of occurrence of the selected species (biological elements) is extracted from available knowledge and encoded for each shoreline and offshore area.

Table 6.1. The relative sensitivity (RS) and characteristics of the selected species or species groups in relation to oil spills.

Species (or species group) name	**Vulnerability**	**Mortality potential**	**Sublethal potential**	**Recovery period**	**Relative sensitivity**
Alcids	Very high	Very high	Very high	Very high	25
Arctic char	Moderate	Low/short	Moderate	Moderate	14
Baleen whales	Low	Very low	Very low	Moderate	9
Capelin	Very high	High	High	Moderate	21
Cormorants	High	High	High	Moderate	19
Deep sea shrimp	Very low	Very low	Low	Short	7
Greenland halibut	Very low	Very low	Low	Short	7
Gulls	Moderate	High	Very high	Short	17
Harbour seal	Moderate	Moderate	High	No recovery	18
Hooded seal	Moderate	Moderate	Moderate	Moderate	15
Lumpsucker	Moderate	Moderate	High	Short	15
Scallop	High	Low	High	Long	18
Seaducks	Very high	High	Very high	Long	23
Seaducks breeding	Very high	High	Very high	Long	23
Snow crab	Very low	Low	Moderate	Short	9
Tubenoses offshore	Moderate	High	High	Moderate	17
Tubenoses shoreline (breeding)	Moderate	High	High	Long	18

The biological resource constant "C" refers to a value which is used to limit the maximum possible biological resource score, and thus to balance the importance of the biological components with the other components.

The oil residence index (ORI) provides a relative estimate of the potential residence period of oil stranded within the shore zone under normal conditions. The index is only an approximation, because many aspects of a spill are unknown until the time of the spill incident (e.g. the volume of spill, oil type and degree of weathering). The oil residence is ranked from 1 to 5 mainly based on the shoreline exposure class and the shoreline substrate. Table 6.2 shows the basic relation. A few minor modifications to the basic classification of the ORI value are made to account for slope (where steep shorelines are less vulnerable) and to account for a few geomorphologic coast types considered to have longer residence times (archipelagos, pocket beach, barrier beach and delta).

See also Appendix A (page 11-1), where the RS, RA, TM, AV, PI and S values are listed for each segment.

Table 6.2. Basic oil residence index (ORI) ranking based on a combination of shoreline substrate and exposure class.

Substrate / Exposure class	Protected	Semi-protected	Semi-exposed	Exposed
Coarse sediment	4	3	1	1
Fine sediment	4	3	1	1
Ice	1	1	1	1
Not classified	4	3	2	1
Rock	4	3	1	1
Rock and coarse sediment	5	4	2	1
Rock and fine sediment	5	4	2	1

6.4 Selected areas

In particular, a total of 15 areas along the coast and within fjords have been selected for priority in an oil spill situation. These areas are identified on the maps by a black polygon border and a number with the prefix, 'S'. They are selected because they are, relative to the shoreline in general: 1. of high value either environmentally or for resource use, 2. sensitive to oil spills and 3. of a size and form that may allow effective protection in an oil spill situation with a manageable amount of manpower and equipment. A summary of the 15 selected areas are given in Appendix D, 14.6. Their selection has been supported by a grid-based GIS analysis described in Appendix D, 14.6.

6.5 Countermeasure overview

Oil spill countermeasure considerations are described for each of the 20 operational maps in Chapter 9. The following is an overview of their basis and content.

The low level of industrial and marine activity in the waters off West Greenland leads to a very limited number of spill possibilities, both currently and in the foreseeable future. The main possibilities at present are those related to fuel resupply to the communities and fuel carried by fishing vessels and other ships. A small but finite risk will be added with the advent of exploration drilling for crude oil, which is anticipated on the offshore area to the north of the present region in the coming years.

If a significant spill occurs, there would be severe limits to the response, particularly during the critical initial stages of the incident. The remoteness of the region, the distance of existing response bases and, most importantly, the low level of marine activity practically eliminate the possibility of an effective initial marine-based response unless dedicated response plans and equipment are available as is the case for offshore exploration drilling. The main countermeasure activities that could be carried out are described in general terms below, with specific local notes where applicable on each of the operational maps. These countermeasures could include surveillance and tracking, *in situ* burning of spills in ice, use of dispersants in offshore areas and the protection and clean-up of important coastal entities, such as the "selected areas", site specific resources (such as sea bird breeding colonies) and extremely sensitive shore lines (see Chapter 6.4).

Surveillance and tracking activities will be critical in determining the location and extent of spilled oil. This will be particularly important in establishing clean-up priorities and adjusting strategies when a long-term and geographically widespread response is required. Aircraft-based remote sensing and surveillance overflights could be mounted from airports at Kangerlussuaq, Narsarsuaq and Nuuk. A program to track oiled ice would be required for spills that occur among pack ice or for open water spills that reach the pack ice edge or persist through freeze-up in protected inshore waters.

Conventional containment and recovery techniques will be severely limited by the lack of vessels with which to deploy and operate equipment unless vessels and equipment are available on standby in the area as part of a response plan for specific activities such as offshore drilling. Spills that are not contained within the first few days of a response will likely be too thin and widespread to allow effective recovery.*In situ* burning may be applicable as an initial response measure for spills in ice conditions. Pack ice concentration of 6 tenths or greater will limit the spread of an oil spill and may allow the opportunity for burning until some time after an incident. For inshore areas and fjords that freeze over winter, oil that persists through the freezing season may be available for burning the following melt season when released into leads and melt pools. This would require a tracking and monitoring program through the winter to delineate oiled areas and to prepare for the likely release period.

Dispersants could be considered for use in offshore areas to prevent or reduce surface oil from contaminating more sensitive inshore areas. Dispersants should receive particular consideration in situations where containment and recovery countermeasures may not be fully effective due to the size of the spill, the limited logistical support for a large-scale clean-up, the prevailing weather and sea conditions or a combination of the three.

Shoreline protection countermeasures will also be limited by a lack of logistical support. In case of an oil spill threat, countermeasure priority should be given to the selected areas, the site specific resources and the extremely sensitive shore lines considering the time of the year (e.g. no birds are present at breeding colonies in the winter). Particular priority should be given to the selected areas, which are vulnerable to oiling. They can generally be protected with a relatively modest effort, and in some cases, they could be difficult to clean if heavily oiled.

In many cases deflection rather than containment booming will be preferred because the tidal currents exceed 1 knot. While deflection booming may not offer complete protection of the "selected area" it will be valuable in limiting the extent and degree of contamination and lead to faster and more complete post-spill recovery. Deflection booming strategies will require monitoring and perhaps repositioning periodically to account for changes in current strength and direction.

A more significant limitation for shoreline protection countermeasures will be that dictated by the water currents and topography. Little water current information is available for the area. The few data available indicates that tidal currents are strong in most areas - as high as 4 knots. This coupled with steep, rocky shorelines and bottom contours may preclude effective booming. As noted above, for areas that can be boomed, the most effective strategy may be to use deflection booming to limit the extent of shoreline oiling and thereby hasten recovery.

It should be noted that there are many areas, including some of the "selected areas", for which effective containment operations are not likely to be possible. In many areas, offshore countermeasures present the only realistic option for effective protection. For spills that may affect such areas, consideration should be given to use of dispersants (and *in situ* burning for spills in ice conditions).

Much of the coastline in the region covered by this atlas consists of high-relief rocky shoreline that is moderately or highly exposed to prevailing weather and sea conditions as well as some ice action. In many areas fjords, bays and other inshore areas may also be somewhat protected from extensive contamination by the flushing action of tidal currents and by the natural outflow of streams and rivers. As a result much of the shoreline may not require a widespread active cleaning effort unless it is heavily contaminated. Where active shoreline clean-up is required, priorities for restoration can be established based on both the environmental sensitivity and oil persistence factors. Preference should be given to *in situ* cleaning techniques such as in-place washing of rocky shores, use of shoreline cleaning agents, *in situ* burning, and bioremediation. Use of these techniques will minimise the amount of oily material collected and subsequent hauling requirements. Disposal site selection was beyond the scope of this study and would require extensive study involving technical, logistical, environmental and political factors. An alternative to land disposal within the region would be the trans-shipment of collected oily materials from temporary stockpiles to disposal sites and/or incineration elsewhere.

Marine access for shoreline clean-up may be limited in some areas by shoaling and off lying rocks and islets. In some areas locally forming ice and the encroachment of seasonal pack ice may also limit access. The steep shorelines in many areas will rule out the use of remote staging areas and may necessitate ship- or bargebased clean-up operations.

One potential safe haven has been proposed. It is a site where unloading and/or stabilisation operations could be carried out on a stricken vessel with limited risk of fouling extensive and sensitive shorelines. It is indicated on the map sheets. There are a number of other locations that could be considered for use as safe havens, but they have insufficient information (usually limited or no soundings) to fully recommend them. In these instances, reconnaissance at the time of the spill would be required to determine their acceptability. These locations are identified in the text but not on the map sheets.

This page is intentionally left blank

7 Users guide

The region covered by this atlas is here termed South Greenland, and it includes the municipalities Nanortalik (except the eastern part north of Prins Christian Sund), Qaqortoq, Narsaq, Ivittuut and Paamiut south of 62º N. The offshore waters out to the Canadian border or to the 200 nm limit (at 56º30′ N) and west of 43º W are also included. The entire region is generally refereed to as 'the study region/area', 'the region covered by this atlas' or 'the sensitivity mapping region'.

Offshore sensitivity information is given in Chapter 8. This information covering the entire study area is presented on one-page maps with an approximate scale of 1: 3.5 million.

Detailed shoreline information is given in Chapter 9 on maps with a smaller scale. The entire study area is covered by a total of 20 separate maps with a scale of 1: 250,000 (A4 size). The code no. of each map reflects the northern latitude (degrees N) of the area covered and the position of the area from west to east, where numbering starts from west to east. For example the western-most map (map number 1) that covers the area at 62º N, is named Map 6201, and the next to the east is named Map 6202. Note that there are two rows for each latitudinal degree, thus the map to the north of Map 6201 is at 62.5º N and is named Map 6251.

In Chapter 9 there are two series of detailed maps: **shoreline sensitivity maps** and **physical environment and logistics maps**. The shoreline sensitivity maps are on the left-hand side, and physical environment and logistics maps are on the right. Descriptive text appears on the pages between these maps.

7.1 Shoreline and offshore sensitivity maps

7.1.1 Sensitivity index and icons (animals and other symbols)

The shoreline zone in the study area has been divided into 220 shoreline areas, each consisting of approximately 50 km of shoreline or in the archipelagos: a group of islands and skerries having roughly 50 km shoreline. The 220 shoreline areas are numbered from south to north, and the numbers are given on the map with the latitude as a prefix e.g. 60-59.

The offshore zone in the study area has been divided into 6 offshore areas. The boundaries of the offshore areas are based on oceanographic, climatic and bathymetric features.

An oil spill sensitivity index value has been calculated for each of the 220 shoreline and 6 offshore areas based on:

1. the abundance and sensitivity of selected species (or species groups),
2. resource use (human use), mainly fishing and hunting,
3. the potential oil residency on the shoreline (oil residency index) based mainly on wave exposure, substrate and slope of coast,
4. the presence of towns, settlements and archaeological sites (only shorelines).

The sensitivity index value for each of the 220 shoreline areas and 6 offshore areas is given on the opposite page to the corresponding map. All areas are ranked as having extreme, high, moderate or low sensitivity indicated on the maps by a corresponding colour code. Detailed index value calculations for each shoreline and offshore area are given in Appendix A and Appendix B, respectively. These can be accessed by links on the opposite pages in the pdf-document. For

segments cut by map edges (where there is a considerable overlap with adjacent map sheet), 'Environmental description' notes shall be found at the map sheet depicting the largest part of the segment. The importance of resource use and the abundance of a number of biological resources in each of the 220 shoreline and 6 offshore areas have been rated on a scale from 0 to 5 (see map legend or Chapter 6.3 for a list of species and species groups included in the index). If resource use and abundance of a particular species in an area is significant (rated 5, 4 or 3) it is indicated on the map with a black icon (and a letter code) after the shoreline area number. However all resource use and species are shown on the offshore maps
Blue icons (animal symbols) indicate a site-specific significant habitat. In South Greenland these sites are important seabird breeding colonies. Photos of the coastal setting for about 30 bird colonies have been included in the pdf-document and can be accessed from links on the opposite page to the shoreline sensitivity map.

Species and resource occurrences. For each shoreline sensitivity map is given a figure showing (by a horizontal, pale blue bar) the temporal occurrence of each of the species and resources shown on the map. These figures are based on all the segments irrespective of their sensitivity rating.

7.1.2 Selected areas

To supplement the rather general mapping of shoreline sensitivity using the 50 km long shoreline areas, a number of small sensitive localities have been selected. A total of 10 areas along the coast and within fjords have been selected as priority areas in the case of an oil spill situation. These areas are identified by a black polygon border and a number with the prefix, **'s'** for **selected**. They are selected because, compared to the coastline in general, they are:

1. of high value either environmentally or for resource use,
2. sensitive to oil spills and
3. of a size and form that may allow effective protection in an oil spill situation with a manageable amount of manpower and equipment.

7.1.3 Season information

The sensitivity of offshore areas is presented on seasonal maps reflecting the changes in sensitivity during winter (January-March), spring (April-May), summer (June-August) and autumn (September-December).

Seasonal occurrence of species and resource use in the shoreline areas is presented on species and resource occurrence graphs, corresponding to each of the shoreline sensitivity maps. These graphs are based on all the segments irrespective of their sensitivity rating.

7.1.4 Resource use data

Data on resource use was extracted from NERI's interview surveys (Nielsen et al. 2000, NERI unpublished) regarding fishery for capelin, lumpsucker and Arctic char as well as from unpublished material collected by H.C. Petersen (1992, 1993a, b, c & d). Additional information of resource use, especially shrimp, halibut, snow crab and scallop fisheries, and hunting of seabirds (mainly guillemots and eiders), seals and whales were received from Greenland Institute of Natural Resources (GINR). Finally unpublished data from NERI is included. Tourist attractions and activities in coastal sites are also included in the resource use.

The interview survey carried out in connection the oil spill sensitivity mapping project covering 62°-68° N also included the northern part of the South Greenland region (Nielsen et al. 2000). Similar up-to-date information from the rest of this region was achieved by an interview survey carried out in the summer of 2003 (NERI unpublished). This moreover included the use of coasts by tourist companies and -guides.

7.1.5 Species distribution and abundance data

Information on species distribution and abundance is mainly derived from a number of NERI reports reviewing data on biological resources and resource use in the area (Boertmann 2003, Boertmann et al. 1996, Boertmann et al. 1998, Boertmann & Mosbech 2001a, b, Mosbech et al. 1996, Mosbech et al. 1998). In these reports relevant aspects of the species status and ecology are further described.

7.1.6 Archaeological and historical sites included

All known prehistoric and historic sites are included in the background database to the present atlas. However only sites likely to be threatened by a marine oil spill are included on the maps (as purple squares). In order to protect the sites from illegal excavations only the most basic information is given.

To illustrate what archaeological sites in the coastal zone look like, some photos are presented in the pdf-version of this atlas.

Further information on the archaeological sites are available from either the Greenland National Museum or the Greenland Secretariat at the Danish National Museum, if needed e.g. in an oil spill situation.

All man made relics from before 1900 are protected according to "*Landstingslov nr. 5/1980 af 16. oktober 1980 om fredning af jordfaste fortidsminder og bygninger*" (the Conservation Act). The Greenland National Museum & Archives manages the legislation and is responsible for the recording of the sites concerned.

7.2 Physical environment and logistics maps

7.2.1 Coastal types description

The shores in the study area are classified into twelve different shore types on the operational maps of physical environment and logistics. Shore type definitions are given in Table 7.1 and photos of shore types in Figures 7.1-15. See also Appendix D section 14.3.

7.2.2 Access

For each operational map, access information is provided to cover the following areas:

- **Marine access**. Navigational information, prevailing currents, tides, local ice conditions, shoal hazards, identified anchorages and beach landing sites,
- **Air access**. Size, surface and seasonality of airstrips within the area.

Marine information is taken from the nautical charts for the area and from the corresponding descriptions in the Arctic Pilot, Volume III published by the British Admiralty.

Table 7.1. *Classification of shore types in South Greenland between 60° N and 62° N.*

Shores developed in solid rock

Shore type	Characteristics
Rocky coast	- Coast developed in bedrock of varying morphology, elevation and gradient. - Narrow beach with coarse sediment consisting of boulders, cobbles and pebbles might occur. - The occurrence of abraded inter-tidal platforms is indicated by the gradient.
Archipelago	- Several smaller islands, normally developed in solid rock. - Rocky coasts and pocket beaches might occur but have only been classified individually if the perimeter of the island exceeds 6 kilometres.
Glacier coast	- Occurrence of a glacier in the intertidal zone.

Shores developed in sediments of glacial, alluvial or colluvial origin

Moraine	- Shore developed in unconsolidated glacial sediments. - Narrow beach with coarse sediment consisting of boulders, cobbles and pebbles might occur. - The occurrence of abraded intertidal platforms are indicated by the gradient.
Alluvial fan	- Shore developed in alluvial fan. - Narrow beach with sediment consisting of boulders, cobbles, pebbles, gravel and sand might occur. - The occurrence of intertidal platforms is indicated by the gradient.
Talus	- Shore developed in talus (colluvial fan) of varying gradient. - Narrow beach with coarse sediment consisting of boulders, cobbles and pebbles might occur.

Shores developed in marine sediments

Beach	- Long, linear depositional beaches of well-sorted sand, gravel, pebbles, cobbles or boulders. - Beach ridge plains often occur landwards the beach.
Barrier beach	- Coastal environment consisting of coastal barriers and lagoons with beaches, dunes, salt marsh and tidal flats. - Spits often occur near tidal inlets. - Washover fans might occur on barriers. - Beaches consisting of well-sorted sand, gravel, pebbles or cobbles.
Salt marsh and/or tidal flat	- Wide salt marshes with or without salt marsh cliff and/or wide intertidal flats. - Consisting of relatively fine sediments (mud, sand, silt and clay).
Pocket beach	- Beach developed in the inner part of an embayment in solid rock. - No larger rivers run into the embayment. - Beaches normally consist of well-sorted sediments consisting of sand, gravel, pebble or cobbles.

Shores developed in deltaic sediments

Delta	- Low gradient intertidal platform developed by fluvial sediments in front of a river valley. - Braided river channels often occur within the inter-tidal zone. - Sediment normally fine grained ranging from clay to fine sand.

Others

Not classified	- The shore has not been classified due to lack of air photo information (cloud cover, shadow etc.)


Figure 7.1. Rocky coasts, near Cape Desolation on Nunarsuit.


Figure 7.2. Rocky coast near Aappilattoq.

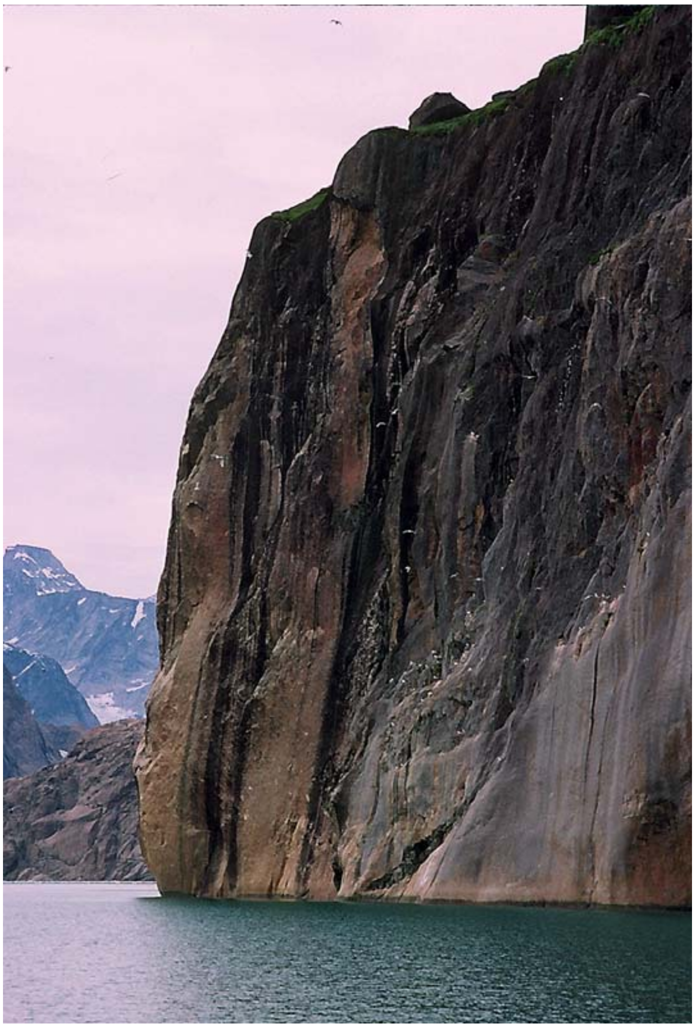


Figure 7.3. Steep rocky coast near Aappilattoq.

Figure 7.4. The archipelago Indre Kitsissut in Kobberminebugt.


Figure 7.5. Glacier coast, head of Brede Fjord.


Figure 7.6. Moraine coast near Tasiusaq.

Figure 7.7. Alluvial fan in Tunulliarfik near Narsarsuaq.

Figure 7.8. Talus near Aappilattoq.


Figure 7.9. Barrier beach near Narsarsuaq.


Figure 7.10. Pocket beach surrounded by rocky coast.


Figure 7.11. Delta with tidal flat at Narsarsuaq.


Figure 7.12. Beach of well-sorted sand at Uunartoq.

Figure 7.13. Beach of well-sorted gravel at Tasiusaq near Nanortalik.

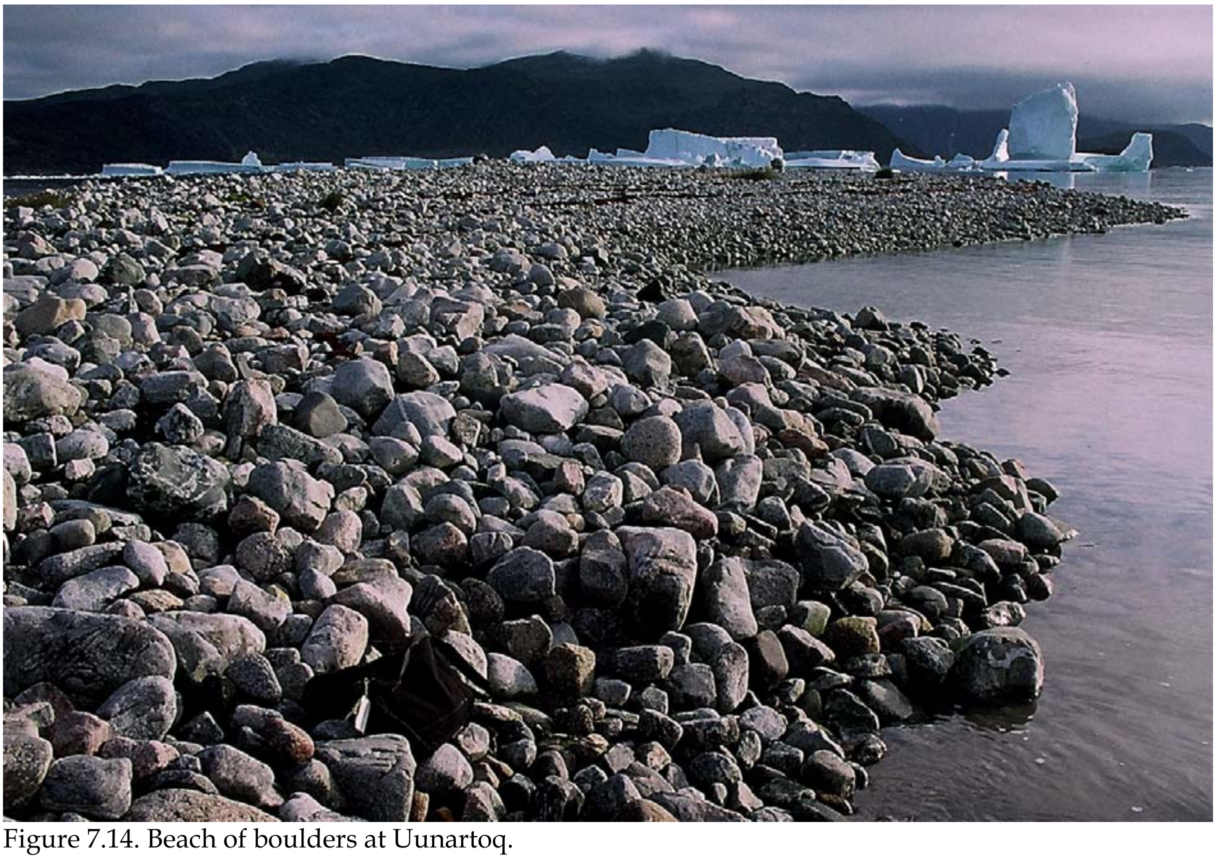


Figure 7.14. Beach of boulders at Uunartoq.

Figure 7.15. Salt marsh and tidal flats (some rocky and covered with brown-algae).

7.2.3 Potential safe havens

A safe haven is a site where unloading and/or stabilisation operations can be carried out on a stricken vessel with limited impact on the environment. Small bays and inlets which can be exclusion boomed and which are situated in areas with low sensitive coasts qualify for such areas. A few potential safe havens which generally qualify and where the navigation information apparently is good are indicated on the map sheets. However, the general knowledge on the navigability and water depth on other potential safe haven sites within the mapped region is very limited, and such sites should be investigated for their suitability. Therefore in the text we have also included a number of sites which possibly might be used as safe havens after a reconnaissance or by involving local knowledge. It will be more feasible, at the time of an incident, to investigate the use of such a nearby potential safe haven, rather than searching for safe havens within the entire region. If only those areas that unreservedly can be recommended for use as a safe haven were to be identified, very few would be left.

7.2.4 Countermeasures

Countermeasure information is given for each map. Potential sites for booming and inshore containment lengths are indicated on the maps.

7.2.5 Topographic maps and nautical charts

Topographic map no. (at a scale of 1: 250,000) and nautical chart no. (at a scale of 1: 80 000) are given for each map. Topographic maps and nautical charts were available from the Danish National Survey and Cadastre until 2002. When writing these lines, it is not possible to give information on where to obtain these maps and charts, except in local marine stores and shops.

8 Offshore and summary information

8.1 Study area introduction

8.1.1 The offshore area

The offshore part of the study region (55º 30'-62º N and west of 43º W) is the eastern Davis Strait and northwestern Labrador Sea. The shelf with waters less than 200 m deep is rather narrow compared to the shelf further north in West Greenland (< 80 km). On the shelf there are several fishing banks with water depths less than 200 m. There is deep water down to 3,700 m to the west and south of the shelf (Figure 8.1).

As a result of the current pattern the waters are normally free of ice cover, except in spring and early summer when drift ices enters carried by the East Greenland Current.

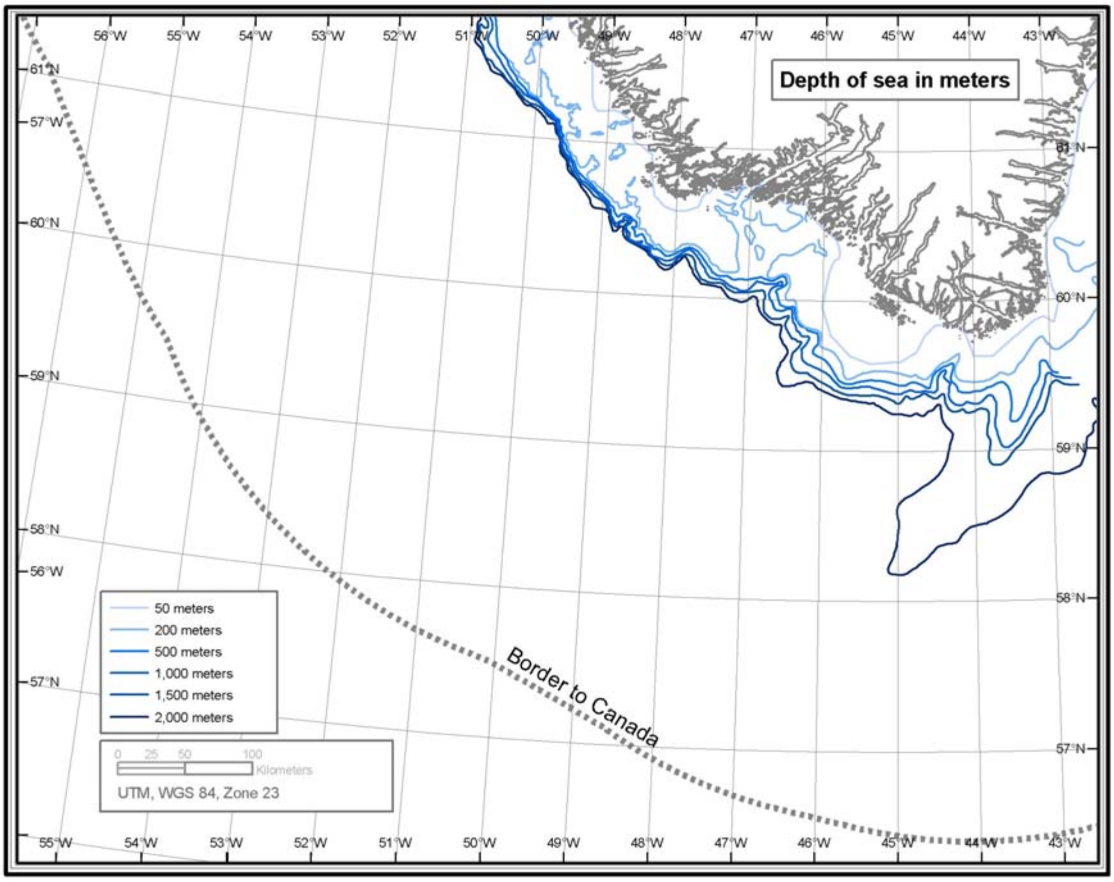


Figure 8.1. Bathymetry of the South Greenland offshore waters.

The banks in the study have a high biological production. This high production is the basis for high densities of small schooling fish and large plankton organisms, which again are important food for large numbers of marine mammals and seabirds as well as for larger fish species, which all (including the deep sea shrimp) constitute important resources to the Greenland human population through hunting and fishing. The high production is nourished by upwelling of nutrients from the deep sea west of the banks, and it last throughout the summer.

8.1.2 Currents

Along the South and West Greenland coast flows the West Greenland Current with two principal components. Closest to the shore brings the East Greenland Current component water of polar origin northward. On its way, this water is diluted by run-off water from the various fjord systems. The East Greenland Current component looses its momentum on the way northward and at the latitude of Fyllas Bank (64° N) it turns westward towards Canada where it joins the Labrador Current. West for and below the Polar Water of the East Greenland Current, another water component is found originating from the Irminger Sea and the North Atlantic Current. This relatively warm and salty water can be traced all the way along West Greenland from Cape Farewell to Thule (Avanersuaq), see Figure 8.2.

The Polar Water inflow is strongest during spring and early summer (May-July), and since the East Greenland Current carry large amount of polar ice with it, the distribution of polar ice along the coasts of West and South Greenland will attain its maximum during the same period. The inflow of Atlantic Water masses is strongest during autumn and winter explaining why the waters between 58° and 67° N normally are ice free during winter time.

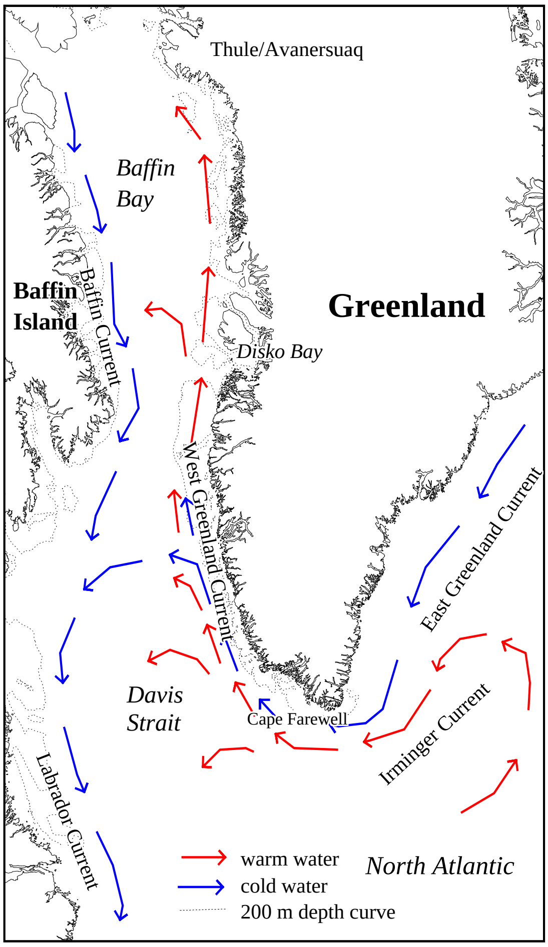


Figure 8.2. Surface current patterns in the waters off South and West Greenland.

A fifty year long time-series of temperature and salinity measurements from West and South Greenland oceanographic observation points reveal strong inter-annual variability in the oceanographic conditions off West and South Greenland. Moreover some distinct climatic events are obvious, of which three cold periods within the recent thirty years are the most dominant. The inter-annual variability is caused by changes in the atmospheric circulation or by variation in the strength of the ocean currents transporting water to the West and South Greenland area, and both seem to be related to the North Atlantic Oscillation Index (NAO-index) reflecting the difference in mean sea level air pressure between the Icelandic Low and the Azores High.

8.1.3 Ice and weather

The waters off South Greenland are normally covered with sea ice only for short periods during late winter or during spring and early summer months when multi-year ice originating from the Arctic Ocean drifts into the area with the East Greenland Current.

Icebergs and growlers originating from glaciers occur in the entire region, but the density of icebergs is normally low increasing towards the Cape Farewell area to the south. However the drift and distribution of glacial ice at sea have never been investigated systematically, and they are therefore only known roughly.

The meteorological conditions in the area are influenced by the North American continent and the North Atlantic Ocean, but also the Greenland Inland Ice and the steep coasts of Greenland have a significant impact on the local climate. Many Atlantic depressions develop and pass near the southern tip of Greenland and cause frequently very strong winds off South Greenland. Also small scale phenomena such as fog or polar lows are common features near the West and South Greenland shores, and in the long and narrow fjords strong local winds may occur in sunny days. Another local phenomenon is the very strong foehn winds. The probability of severe winds increases close to the Greenland coast and towards the Atlantic Ocean. (See also Appendix C)

8.1.4 Coastal zone geomorphology

The coastal zone in the study area (60º-62º N) is dominated by bedrock shorelines with many skerries and archipelagos. Small bays with sand or gravel are found between the rocks in some sheltered areas.

The tidal amplitude is 1-3 m, and a rich subtidal flora and fauna exists on the bedrock shorelines. The geomorphology of the Southwest Greenland coast between c. 60º N and 62º N has been classified according to shore type, sediment type, slope and exposure. The classification covers the coastline from the mouth of Prins Christian Sund at 60º N on the east coast around Cape Farewell to Paamiut at 62º N on the west coast. The total shoreline length is c. 11,367 km.

The division of the shoreline into shoretype segments is based on the geomorphology of the coast. A lower shore type segment length of c. 2 km has been applied. Therefore shore types with an extent less than c. 2 km are not categorised separately, but have been included in the neighbouring shore type. Therefore, shore types with an extent of less than 2 km, are underrepresented in the classification. For example the widespread pocket beaches are typically less than 2 km, and such has been classified as their surrounding shore type, rocky coast or archipelago.

The total number of shoretype segments identified is 7,384. Of these 1,282 segments (2,872 km) are on the mainland coast, 1,298 segments (4,174 km) are on bigger islands (perimeter > 6 km) and 4,804 segments (320 km) are on smaller islands (perimeter < 6 km).

The segmental distribution of shore type, sediment type, slope and exposure categories respectively are given in Tables 8.1-8.4. In terms of shoreline length, the 'rocky coast' is the dominant shore type (64.8%). 'Rock' is the dominant substrate (87.6%). 'Inclined' is the dominant slope (50.5%) and 'semi-protected' is the dominant exposure type (50.4%). The majority of the coasts within the 'archipelago' shore type are rocky coasts. Together the archipelago' and 'rocky coast' shore types by length constitute 88.9% of the total investigated shoreline.

Table 8.1. Shore type statistics.

Shore type	**No. of segments**	**Km**	%
Rocky coast	2,528	7,367	64.8
Rocky coast with erosional cliff	5	15	0.1
Archipelago	4,290	2,735	24.1
Glacier coast	28	50	0.4
Moraine	258	643	5.7
Moraine with erosional cliff	16	28	0.2
Alluvial fan	9	19	0.2
Alluvial fan with erosional cliff	1	6	0.1
Talus	79	231	2.0
Talus with erosional cliff	2	1	0.0
Beach	4	5	0.0
Beach ridge plain with erosional cliff	58	129	1.1
Barrier beach	0	0	0.0
Salt marsh and/or tidal flat	0	0	0.0
Pocket beach	0	0	0.0
Delta	70	86	0.8
Not classified	18	52	0.5
Total	**7,384**	**11,367**	**100.0**

Table 8.2. Sediment type statistics.

Sediment type	**No. of segments**	**Km**	%
Ice	28	50	0.4
Rock	6,735	9,953	87.6
Rock and coarse sediment	36	105	0.9
Rock and fine sediment	62	117	1.0
Coarse sediment	212	509	4.5
Fine sediment	311	633	5.6

Table 8.3. Slope statistics.

Slope type	**No. of segments**	**Km**	%
Steep	2,265	5,480	48.2
Inclined	5,007	5,744	50.5
Flat	112	142	1.2

Table 8.4. Exposure statistics.

Exposure type	**No. of segments**	**Km**	%
Protected	975	1,896	16.7
Semi-protected	2,605	5,727	50.4
Semi-exposed	1,443	1,893	16.7
Exposed	2,361	1,851	16.3

8.1.5. Marine fish and invertebrates

Table 8.5. Important fish and large invertebrate species in the study area (56°30'-62°N).

Species	Main habitat	Spawning area	Spawning period	Exploitation
Blue mussel	Subtidal, rocky coast			s
Scallop	Inshore and on the banks, in areas with high current velocity, 20-60 m depth		July-August	c & s
Deep sea shrimp	Mainly offshore, 100-600 m depth	Larvae released at relatively shallow depth (100-200 m), larvae in middle water-column	(July-September) larvae released March-May	Important c
Snow crab	Coastal and fjords, 180-400 m depth		Larvae released April-May	c
Atlantic cod		Pelagic eggs and larvae in upper water column		See text
offshore stock	On banks north to 65° N	(Former) western slope of banks	March-April,	c & s
inshore stock	Fjords	Inner fjords	April-May	c & s
Greenland cod	Inshore/fjords	Inshore/fjords, demersal eggs	February-March	c & s
Sand eel	On the banks at depths between 10 and 80 m	On the banks, demersal eggs, larvae in the water column	June-July	No important prey item
Spottet wolffish	Inshore and off-shore	Hard bottom	Peaks in September	c & s
Atlantic salmon	Offshore and coastal	Freshwater (outside area)	-	c & s
Arctic char	Coastal, fjords	Freshwater	-	c & s
Capelin	Coastal	Beach, demersal eggs	April-June	c & s, important prey item
Atlantic halibut	Offshore and in-shore, deep water	western slope of banks south of 66° N, pelagic eggs and larvae, deep water	Spring	c & s
Greenland halibut	Offshore and fjords, deep water	Offshore south of 66° N, deep water, pelagic eggs and larvae	Winter	Important c & s
Redfish	Offshore and in fjords, 150-600 m depth	Main spawning south-west of Iceland, larvae drifts to West Greenland banks		
Lumpsucker	Pelagic coastal, demersal eggs	Shallow water near coast	May-June	c & s

Exploitation of the species are categorised in c: commercial and s: subsistence fishery.

The offshore fish assemblage in the area is dominated by bottom fish. The most important fish and invertebrate species in the study area are listed in Table 8.5. Major changes in the fish assemblage have occurred in last few decades (Rätz 1999, Horsted 2000). The most noteworthy is the disappearance of the offshore Atlantic cod stock. There are important fisheries for deep sea shrimp (Figure 8.3) in the area. A stationary stock of sand eel is believed to be the most important prey species for marine mammals and seabirds on the banks.

Lumpsucker and capelin are coastal spawners, and capelin is found inshore during most of the year. During summer Arctic char also feed in coastal waters.

In recent years new recourses have been exploited, and the most successful are scallop and snow crab, which both are utilised in several areas now. However snow crab stocks recently show signs of overexploitation.

8.1.6 Seabirds

The study area (56°30'-62° N) is rich in seabirds with many species adapted to different ecological niches (Table 8.6).

Some species feed predominately on fish, such as the Brünnich's guillemot (outer coast and offshore) and cormorants (coastal and fjords), some are surface feeders like the kittiwakes and some are bottom feeders like common eiders (hard bottom) and king eiders (soft bottom). The largest seabird populations are present in the area during winter.

Spring
From April through June, when the ice starts to break up further north, wintering seabirds move out of the study area. Common eiders head for breeding areas along the Canadian and West Greenland coast, little auks for the huge colonies in Thule (Avanersuaq) and Brünnich's guillemots for the large colonies in the northern Baffin Bay as well as Svalbard, Canada, Russia and possibly Iceland.

Large numbers of kittiwakes and fulmars, which winter to the south of Greenland, also pass through the area on their way to colonies further north, leaving the area to local breeders and summering non-breeders.

Summer
Fourteen species of colonial seabirds breed in the area (60°- 62° N) (Figure 8.4). The most important colonies are two Brünnich's guillemots colonies: one in the archipelago Ydre Kitsissut and one in Arsuk Fjord. There are many small (a few hundred pairs) colonies with different gull species (mainly Iceland, great black-backed and lesser black-backed), and black guillemots are found at many sites. Arctic terns breed only in the innermost parts of Julianehåb Bay, and common eiders occur in low numbers along most of the outer coasts.

In July-August post-breeders of seaduck species gather in the coastal zone for moulting and feeding. They loose the ability to fly for 3-4 weeks and therefore they are particularly sensitive to disturbance and oil spill. Small flocks of common eiders occur in the archipelagos along the outer coast, and harlequin ducks use the rocky shores west of the Brede Fjord mouth in the post-breeding season.

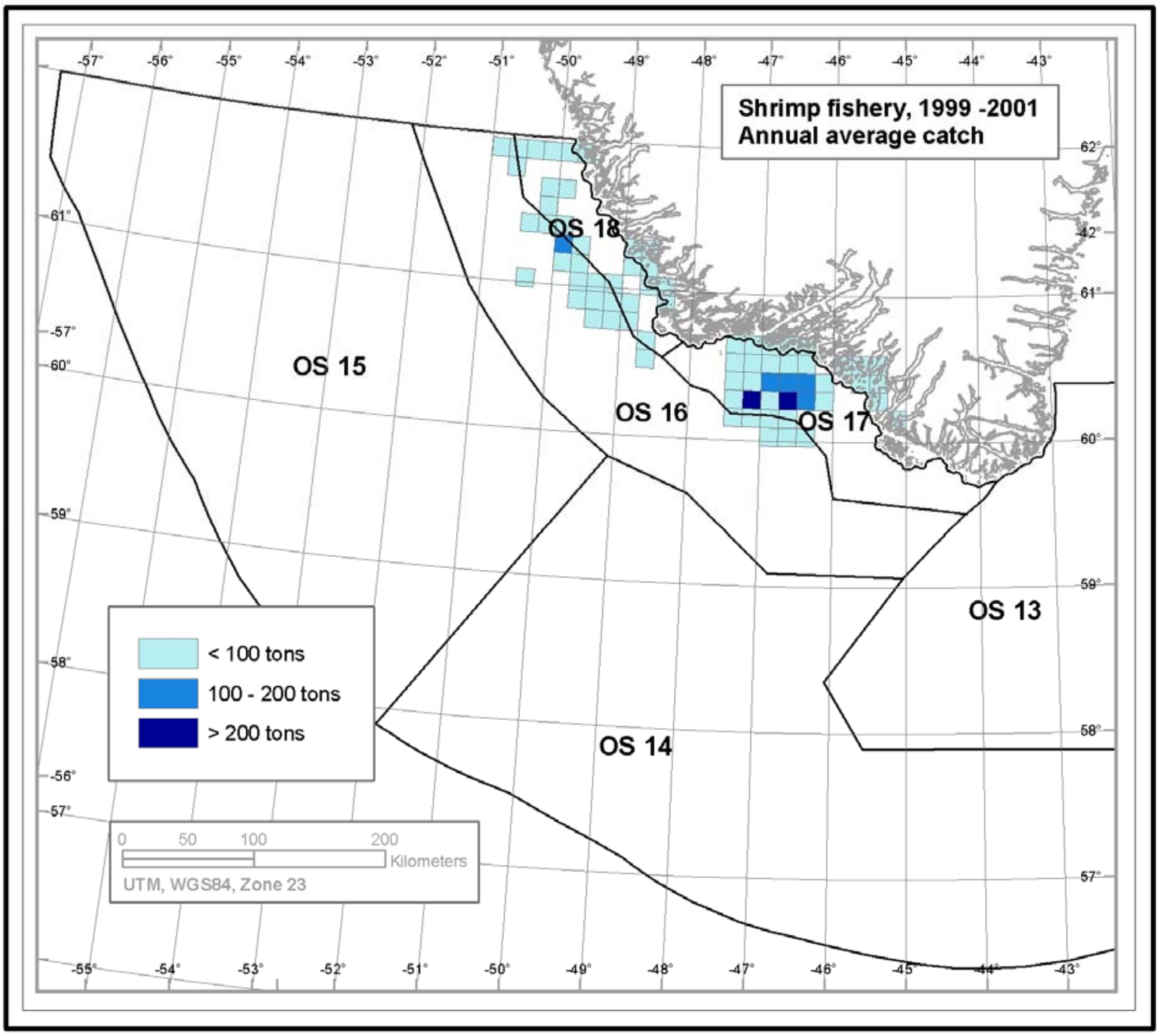


Figure 8.3. Distribution of deep sea shrimp catches in South Greenland waters. Annual average over 1999 to 2001 based on data from GINR.

Table 8.6. Seabird occurrence and activity in the coastal zone and offshore areas between 56°30′ and 62°N.

Species	Occurrence		Distribution
Fulmar	b/s/w	Year-round	c & o
Great shearwater	s	July-October	c & o
Cormorant	s/w	Year-round, most numerous in winter	c
Common eider	b/s/m/w	Year-round	c
King eider	w	October-May	c
Long-tailed duck	b/m/w	Year-round	c
Red-breasted merganser	b/m/w	Year-round	c
Harlequin duck	m w	August-September September-April	c (rocky shores) c (rocky shores)
Kittiwake	b/s/(w)	Year-round, few in winter	c & o foraging
Glaucous gull	b/s/w	Year-round	c & o
Iceland gull	b/s/w	Year-round	c & o
Great black-backed gull	b/s/w	Year-round	c & o
Arctic tern	b	May-September	c
Brünnich's guillemot	b/s/w	Year-round	c & o
Common guillemot	b/w	Year-round	c & o
Razorbill	b/w	Year-round	c & o
Puffin	b/w	Year-round	c & o
Black guillemot	b/w	Summer Winter	c c & o
Little auk	w	September-May	c & o
White-tailed eagle	b/w	Year-round	c

Categories of occurrence: b: breeding, s: summering, m: moulting, w: wintering.
Categories of distribution: c: coastal, o: offshore.

In the offshore area there are mainly fulmars and kittiwakes during the summer. These are mainly non-breeding birds from local populations and also populations from other parts of the North Atlantic. Late in summer flocks of several thousand great shearwaters arrive on the banks and along the coast. They breed in the southern hemisphere and spend the winter in the North Atlantic.

Autumn and winter

During the autumn concentrations of different seabird species build up on the banks of the study area. Brünnich's guillemots arrive from colonies further north in Greenland, from Canada and Svalbard and little auks from the colonies in Thule (Avanersuaq).

As the ice covers the sea in Baffin Bay and Disko Bay in December, common eiders (from breeding areas in arctic Canada and high arctic Greenland) move south to West and South Greenland to winter. Common eiders occur in the study region often in large concentrations along the coasts and in particular in the fjords.

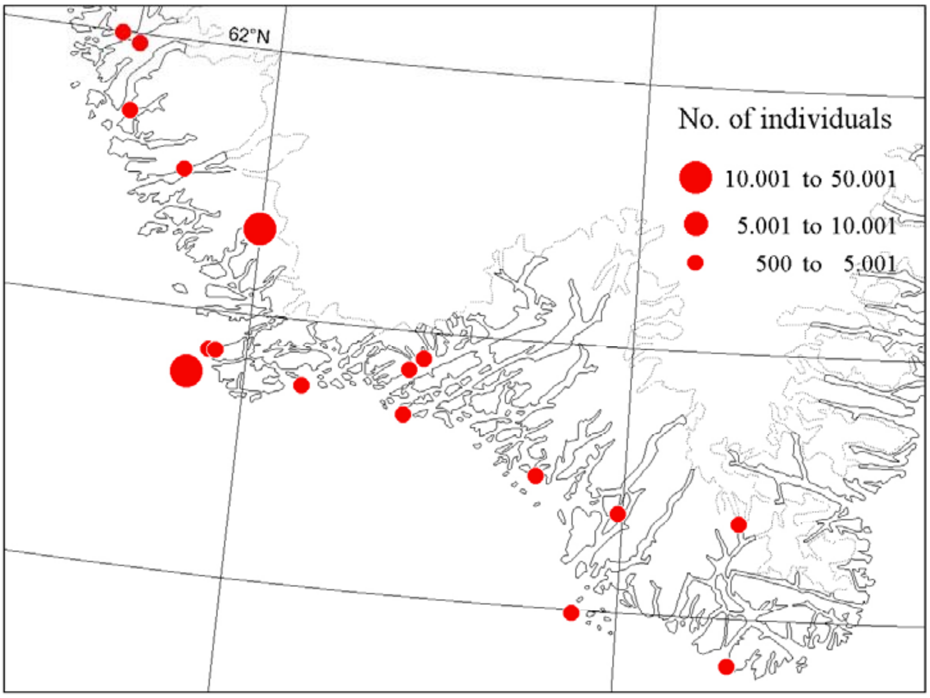


Figure 8.4. Distribution and size of seabird breeding colonies in South Greenland. Only colonies with more than 500 individuals included.

8.1.7 Marine mammals

Table 8.7 gives an overview of the marine mammal species occurring in the region. Ringed seals and harbour seals are mainly stationary in the area. Hooded seals arrive from the whelping grounds in April, and occur on their migration towards the moulting grounds particularly along the outer coasts of Nanortalik municipality. The harp seal is also a migrant seal which arrives in large numbers at the South Greenland coasts in May and June. Whales like minke, humpback, fin and blue whales arrive also to the region in spring and early summer from wintering grounds in the Atlantic. These patterns are summarised in Table 8.7.

Some of the marine mammals, such as bearded seals, feed on the bottom fauna. Ringed seals, harp seals and harbour seals feed on a broad range of pelagic prey items, whereas hooded seals mainly feed close to the bottom at great depths. Baleen whales feed on krill and smaller schooling fish species, which often are present in the productive upwelling areas of the banks at depths less than 200 m. Toothed whales cover a broader depth range. Harbour porpoises feed on fish in the upper water layers whereas other toothed whales e.g. sperm whales may dive as deep as 1,000 m to feed. The harbour seal is the only seal that hauls out on land in the study area. Harbour seals occur in archipelagos, on remote skerries and also on the sand banks in the head of undisturbed fjords during summer time. The harbour seal is however rare today.

Table 8.7. Overview of marine mammals present in the study area in southeastern Davis Strait (56°30'-62 °N).

Species	Period	Main habitat	Stock size in the area/ occurrence	Protection / ex-ploitation	Species status (IUCN 1996 cate-gories)
Minke whale	April-November	Whole area	Common	Hunting regulated	Lower risk
Sei whale	July-October	Offshore waters	Rare	Protected (1977)	Endangered
Humpback whale	July-November	Edge of banks and fjord mouths	common	Protected (1986)	Vulnerable
Fin whale	June-October	Edge of banks	Common	Hunting regulated	Endangered
Blue whale	June-October	Edge of banks	Few	Protected (1966)	Vulnerable*
Harbour porpoise	Whole year	Whole area	Common	Hunting unregu-lated	Vulnerable
Bottlenose whale	(June-August)	Deep water	Few	Protected (1978)	Lower risk
Pilot whale	July-October	Deep waters, edge of banks	Fluctuating	Hunting unregu-lated	Lower risk
White-beaked dolphin	May-September	Offshore	Unknown	Hunting unregu-lated	Lower risk
Killer whale	Whole year	Whole area	Rare	Hunting unregu-lated	Lower risk
Sperm whale	May-November	Deep water	Few	Protected (1985)	Vulnerable
Harp seal	May-October	Whole area	Very com-mon	Hunting unregu-lated	Lower risk
Hooded seal	May-October	Whole area	Common	Hunting unregu-lated	Lower risk
Ringed seal	Whole year	Whole area, mainly fjords with ice	Common	Hunting unregu-lated	Lower risk
Harbour seal	Whole year	Coastal waters	Rare	Hunting regulated	Lower risk**
Bearded seal	Mainly winter	Drift ice	Common	Hunting unregu-lated	Lower risk
Polar bear	February-May	Drift ice, the 'Storis'	Rare	Hunting regulated	Lower risk

* apply to the Northwest Atlantic stock, ** local population vulnerable

8.1.8 Archaeological and historic sites

Greenland has been populated for two long periods, which together span c. 4,400 years. The oldest period is c. 2400 BC-200 AD, the later period is c. 1000 AD until the present day.

The settlement strategy of the various cultures, the visibility of the features and the utilisation of the resources of the country have left their marks on the landscape. The area in question covers the west coast from 59° N to 62° N plus the east coast from Cape Farewell to Cape Discord at Danell Fjord.

The natural conditions within the mapped coastal stretch vary greatly from the outer coast to the inner fjords. Climatically it is in the southern part of the low arctic zone, but in the inner fjords the climate is subarctic (characterised by relatively warm summers). In certain places the land between the inland ice sheet and the sea consists of bare, alpine, barren Archaean rock, while in other places there are deeply ramified fjord landscapes with the large vegetation-covered areas which were among the preconditions for the Norse way of life.

In the early summer the southern part of the region is characterised by the drift ice that usually come with the sea currents from East Greenland. In the winter many fjords are closed by fast ice, while there is still open water out at sea. These conditions provide very different possibilities for settlement, for transport and for access to resources depending on the traditions and cultural preconditions that form the starting-point for the settlers.

The Thule-people migrated from Canada into Greenland around AD 1300 and constitute the direct ancestors of the present day Inuit of Greenland. The earliest Thule-people, who were primarily whale hunters, were far more mobile than the earlier Inuit inhabitants of Greenland. Soon after their arrival to Greenland their activities encompassed all of the Greenland west coast and the majority of the east coast. The complex settlement-patterns of the Thule-people, the historic Inuit and their predecessors are reflected in the archaeological record and their distribution can be seen on the shoreline sensitivity maps.

Around the year 1000 AD immigration came from the east, as Icelandic farmers settled in South Greenland, and with Hans Egede's establishment of the mission station "Håbets Koloni" ("Hope Colony") in 1721 (the predecessor of present-day Nuuk), the foundation was laid for the development of modern Greenland.

The sensitivity to oil spills of archaeological interests are expressed on a scale from 1 to 3:

Sites considered not likely to be impacted by marine oil spills.

Sites considered likely to be directly impacted by marine oil spills.

Sites of special importance, which requires special status in the event of an oil spill or other activities in connection with raw material exploration and extraction.

See further in Appendix D (14.5)

8.1.9 Tourism

Many coastal areas are of high importance for the tourist industry. Areas of high importance for tourism have been mapped based on interviews in 2003 with tourist trade and tourist association professionals (Olsvig et al. in prep.)

8.2 Areas of extreme and high sensitivity

Figure 8.6 shows an overview of the shoreline areas of extreme (red) and high (yellow) sensitivity to marine oil spills. In total there are 41 areas of extreme sensitivity and 50 of high sensitivity.

Included on the map are also the special status areas, which can be affected by a marine oil spill. These comprise the socalled Ramsar-areas, wetlands of international importance especially as waterfowl habitats designated according to the Ramsar convention (Egevang & Boertmann 2001) and an area protected by the nature conservation law (Ikka Fjord).

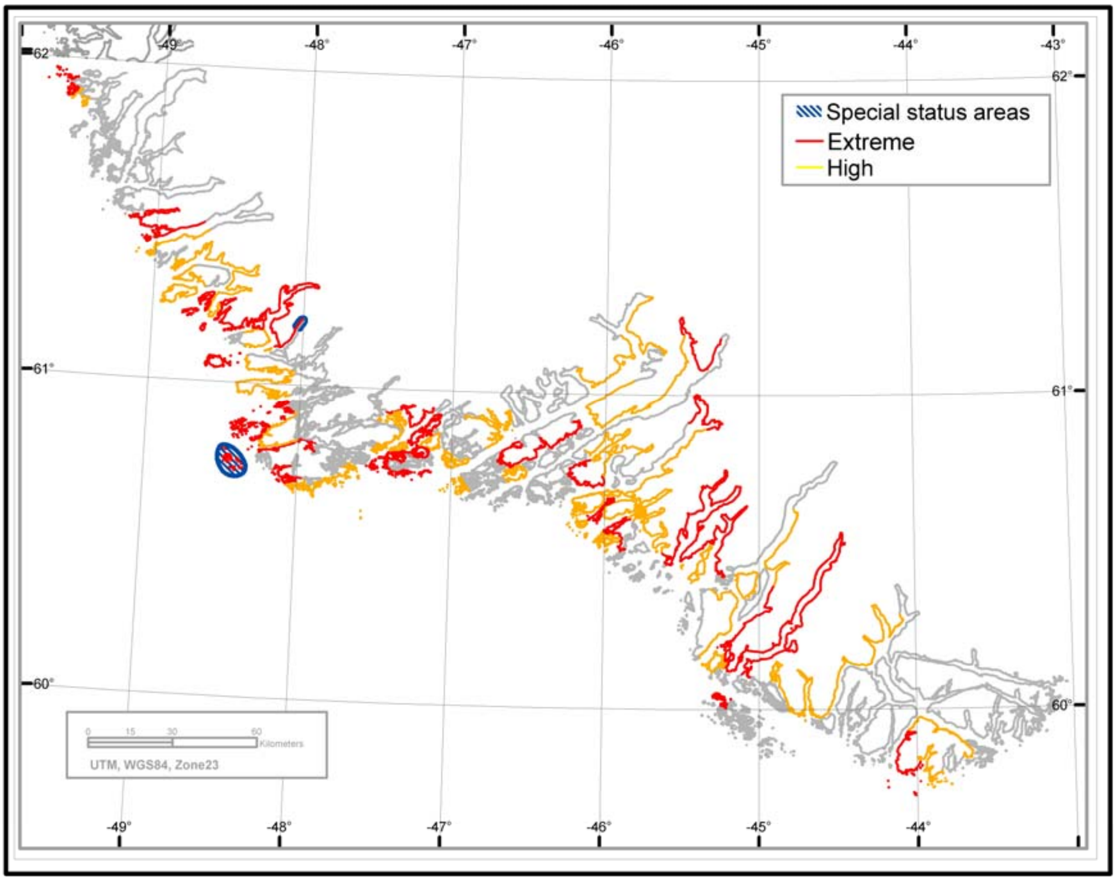


Figure 8.6. Areas of extreme and high sensitivity and special status areas (Ramsar-areas and nature conservation areas).

8.3 Offshore sensitivity

This chapter presents the four maps showing the sensitivity of the offshore areas between 56º30′ and 62º N for each of the seasons winter, spring, summer and autumn.

See Chapter 7, Users guide, for further information on map interpretation.

Legend to the offshore maps (Figures 8.7-10).

Offshore species*

- Ba Baleen whales
- Tu Tubenoses offshore
- De Deep sea shrimps
- An Alcids nonbreeding

* Icons visible for all species
(Relative abundance = 1, 2, 3, 4 or 5)

Offshore resource use

- Human use
- Sea depth (200 meters)

Offshore areas sensivity ranking

- Extreme (> 50)
- High (35 - 50)
- Moderate (20 - 35)
- Low (< 20)

Environmental description (Figure 8.7)

Offshore area 13 (OS 13): *Resource use* (**R OS 13**): No fisheries or hunting activities have been reported for this area. *Species occurrence*: No species have been reported from this area.

Offshore area 14 (OS 14): *Resource use* (**R OS 14**): No fisheries or hunting activities have been reported for this area. *Species occurrence*: Wintering fulmars (Tu OS 14).

Offshore area 15 (OS 15): *Resource use* (**R OS 15**): No fisheries or hunting activities have been reported for this area. *Species occurrence*: Wintering fulmars (Tu OS 15).

Offshore area 16 (OS 16): *Resource use* (**R OS 16**): Hunting for seals and seabirds may take place in eastern parts. *Species occurrence*: Wintering fulmars (Tu OS 16), large stock of deep sea shrimp in waters 100-600 m deep (De OS 16).

Offshore area 17 (OS 17): *Resource use* (**R OS 17**): Important fishery for deep sea shrimp takes place in periods without ice. Hunting for seals and seabirds. *Species occurrence*: Wintering Brünnich's guillemots (An OS 17), deep sea shrimp stock in waters 100-600 m deep (De OS 17).

Offshore area 18 (OS 18): *Resource use* (**R OS 18**): Fishery for deep sea shrimp takes place along the western border of the area and in periods without ice. Hunting for seals and seabirds. *Species occurrence*: Wintering fulmars (Tu OS 18), little auks and Brünnich's guillemots (AN OS 18), deep sea shrimp stock in waters 100-600 m deep (De OS 18).

Offshore Sensitivity Summary, Winter

Area	Sensitivity value	Ranking
OS 13	10	Low
OS 14	12	Low
OS 15	9	Low
OS 16	31	Moderate
OS 17	53	Extreme
OS 18	53	Extreme

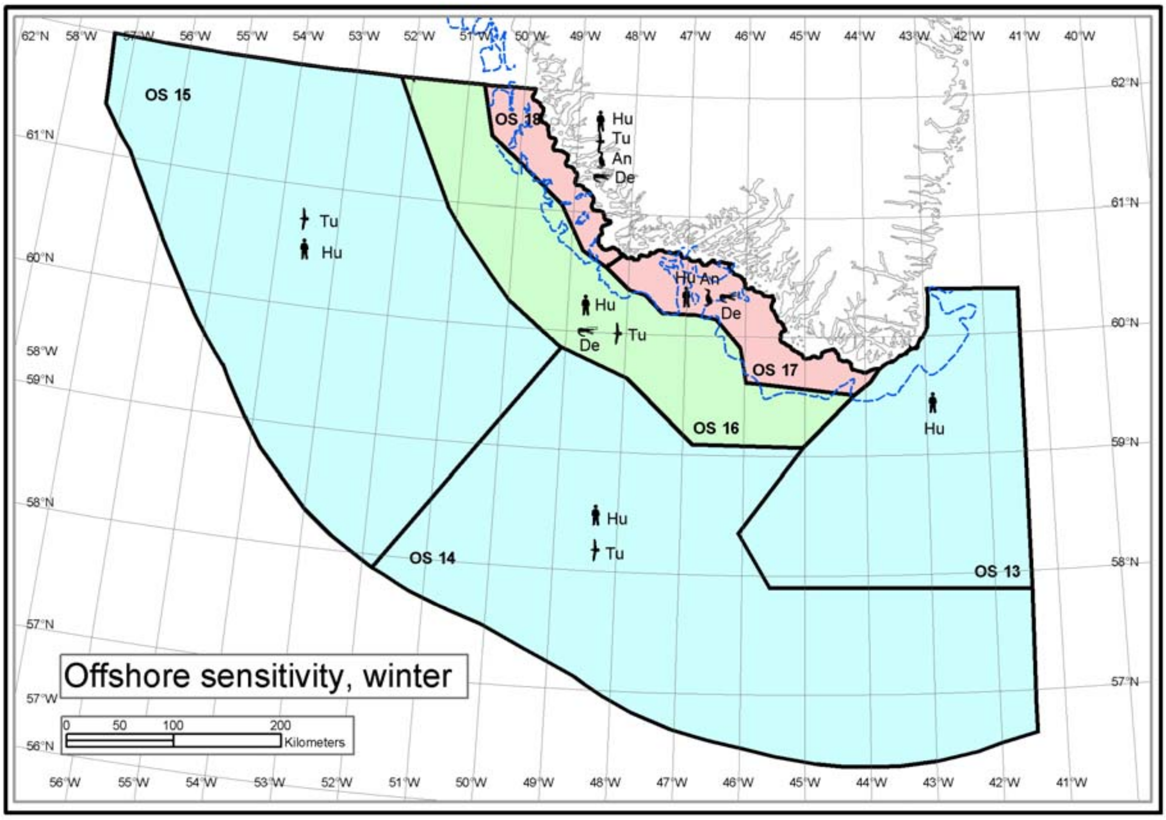


Figure 8.7. Offshore sensitivity in winter. Legend to map on page 8-13

Offshore sensitivity   Spring (April-May)

Environmental description (Figure 8.8)

Offshore area 13 (OS 13): *Resource use* (**R OS 13**): No fisheries or hunting activities have been reported for this area. *Species occurrence*: No species have been reported from this area.

Offshore area 14 (OS 14): *Resource use* (**R OS 14**): No fisheries or hunting activities have been reported for this area. *Species occurrence*: Breeding and non-breeding fulmars (Tu OS 14).

Offshore area 15 (OS 15): *Resource use* (**R OS 15**): No fisheries or hunting activities have been reported for this area. *Species occurrence*: Breeding and non-breeding fulmars (Tu OS 15).

Offshore area 16 (OS 16): *Resource use* (**R OS 16**): Hunting for seals and seabirds may take place in eastern parts. Important fishery for deep sea shrimp in eastern parts in periods without ice. *Species occurrence*: Large deep sea shrimp stock in waters 100-600 m deep (De OS 16), breeding and non-breeding fulmars (Tu OS 16).

Offshore area 17 (OS 17): *Resource use* (**R OS 17**): Fishery for scallops takes place in northeastern part. Important fishery for deep sea shrimp takes place in periods without ice. Hunting for seabirds and seals. *Species occurrence*: Wintering and spring migrating Brünnich's guillemots and little auks (An OS 17), breeding and non-breeding fulmars (Tu OS 17), deep sea shrimp stocks in waters 100-600 m deep (De OS 17).

Offshore area 18 (OS 18): *Resource use* (**R OS 18**): Fishery for deep sea shrimp takes place along the western border of the area and in periods without ice. Hunting for seals and seabirds. *Species occurrence*: Wintering and spring migrating Brünnich's guillemots and little auks (An OS 18), breeding and non-breeding fulmars (Tu OS 18), deep sea shrimp stocks in waters 100-600 m deep (De OS 18) and minke whales from May (Ba OS 18).

Offshore Sensitivity Summary, Spring

Area	Sensitivity value	Ranking
OS 13	10	Low
OS 14	12	Low
OS 15	9	Low
OS 16	31	Moderate
OS 17	53	Extreme
OS 18	55	Extreme

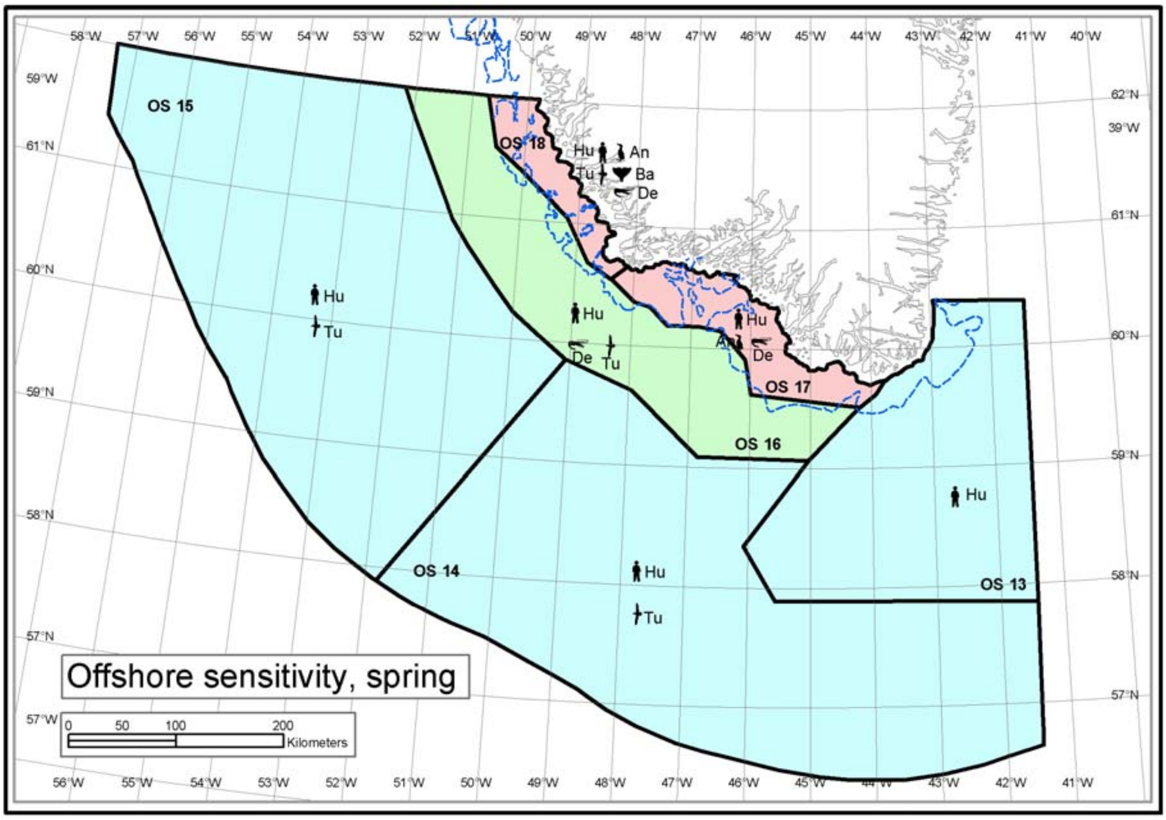


Figure 8.8. Offshore sensitivity in spring. Legend to map on page 8-13

Environmental description (Figure 8.9)

Offshore area 13 (OS 13): *Resource use* (**R OS 13**): Fishery for redfish takes place outside the 1,000 m isobath from July. *Species occurrence*: Minke and fin whales occur (Ba OS 13), fulmars and great shearwaters occur (Tu OS 13).

Offshore area 14 (OS 14): *Resource use* (**R OS 14**): Fishery for redfish takes place outside the 1,000 m isobath from July. *Species occurrence*: Fulmars and great shearwaters occur (Tu OS 14).

Offshore area 15 (OS 15): *Resource use* (**R OS 15**): Fishery for redfish takes place in the southern part and outside the 1,000 m isobath from July. *Species occurrence*: Fulmars and great shearwaters occur (Tu OS 15).

Offshore area 16 (OS 16): *Resource use* (**R OS 16**): Fishery for redfish takes place July-October outside the 1,000 m isobath. Important fishery for deep sea shrimp on and along upper part of shelf break. *Species occurrence*: Fulmars and great shearwaters occur (Tu OS 16), minke and fin whales occur mainly along shelf break and edges of banks (Ba OS 16) and there are large stocks of deep sea shrimp in waters 100-600 m deep (De OS 18).

Offshore area 17 (OS 17): *Resource use* (**R OS 17**): Important fishery for deep sea shrimp in central part throughout the year, fishery for scallop in northeastern part. Hunting for fin and minke whales and seals. *Species occurrence*: Fulmars and great shearwaters occur (Tu OS 17), minke and fin whales occur mainly along shelf break and edges of banks (Ba OS 17) and there are large stocks of deep sea shrimp in waters 100-600 m deep (De OS 17).

Offshore area 18 (OS 18): *Resource use* (**R OS 18**): Fishery for deep sea shrimp along western border. Hunting for minke and fin whales and seals. *Species occurrence*: Fulmars and great shearwaters occur (Tu OS 18), minke and fin whales occur mainly along shelf break and edges of banks (Ba OS 18) and there are large stocks of deep sea shrimp in waters 100-600 m deep (De OS 18).

Offshore Sensitivity Summary, Summer

Area	Sensitivity value	Ranking
OS 13	13	Low
OS 14	12	Low
OS 15	9	Low
OS 16	45	High
OS 17	44	High
OS 18	44	High

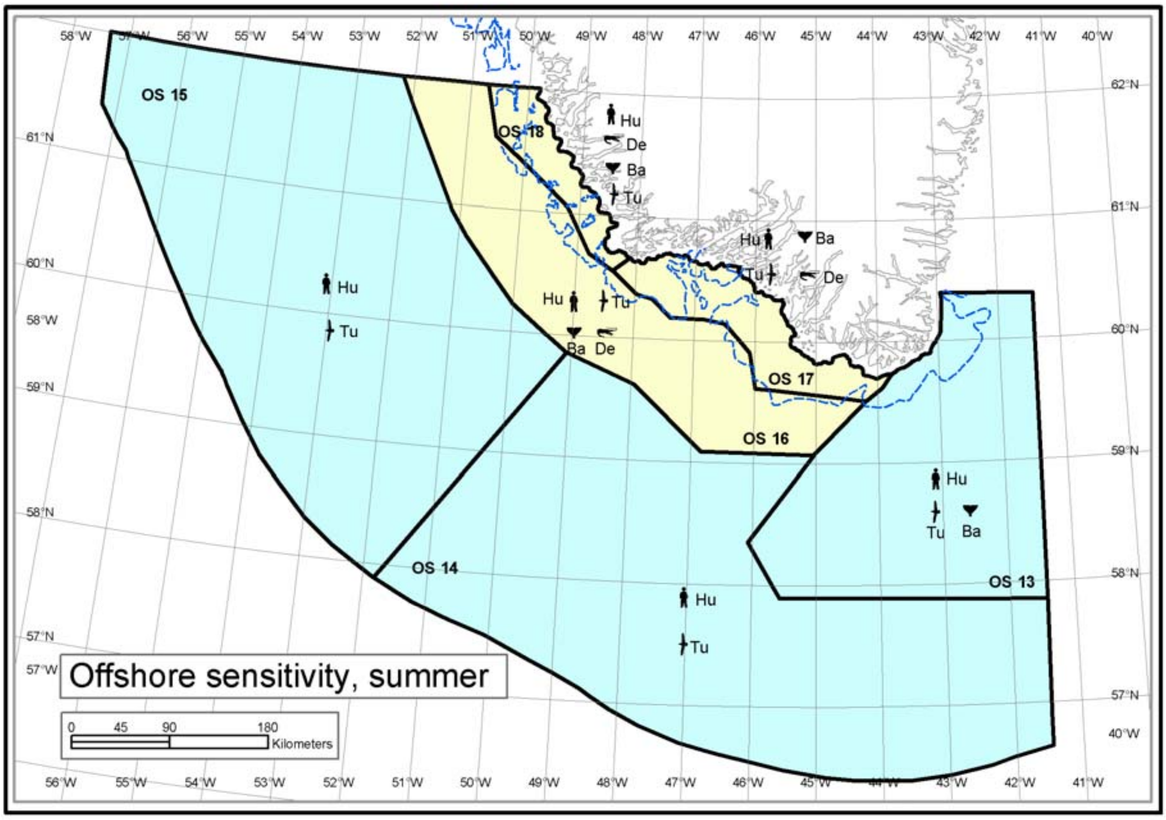


Figure 8.9. Offshore sensitivity in summer. Legend to map on page 8-13.

Environmental description (Figure 8.10)

Offshore area 13 (OS 13): *Resource use* (**R OS 13**): Fishery for redfish takes place outside the 1,000 m isobath until October. *Species occurrence*: Autumn migrating and wintering fulmars (Tu OS 13), fin and minke whales until November (Ba OS 13).

Offshore area 14 (OS 14): *Resource use* (**R OS 14**): Fishery for redfish takes place outside the 1,000 m isobath until October. *Species occurrence:* Autumn migrating and wintering fulmars (Tu OS 14).

Offshore area 15 (OS 15): *Resource use* (**R OS 15**): Fishery for redfish takes place in the southern part and outside the 1,000 m isobath until October. *Species occurrence*: Autumn migrating and wintering fulmars (Tu OS 15).

Offshore area 16 (OS 16): *Resource use* (**R OS 16**): Fishery for redfish takes place July-October outside the 1,000 m isobath. Important fishery for deep sea shrimp on and along upper part of shelf break. *Species occurrence*: Autumn migrating and wintering fulmars (Tu OS 15), large stocks of deep sea shrimps in waters 100-600 m deep (De OS 16) and fin and minke whales until November (Ba OS 16).

Offshore area 17 (OS 17): *Resource use* (**R OS 17**): Important fishery for deep sea shrimp in central part, fishery for scallop in northeastern part. Hunting for fin and minke whales until November, hunting for seals throughout the year and seabirds from November. *Species occurrence*: Autumn migrating and wintering fulmars (Tu OS 17), wintering and autumn migrating Brünnich's guillemots and little auks (An OS 17), large stocks of deep sea shrimps in waters 100-600 m deep (De OS 17) and fin and minke whales until November (Ba OS 17).

Offshore area 18 (OS 18): *Resource use* (**R OS 18**): Important fishery for deep sea shrimp in central part throughout the year and fishery for scallop in northeastern part. Hunting for fin and minke whales until November and for seals and seabirds from November. *Species occurrence*: Autumn migrating and wintering fulmars (Tu OS 18), wintering and autumn migrating Brünnich's guillemots and little auks (An OS 18), large stocks of deep sea shrimps in waters 100-600 m deep (De OS 18) and fin and minke whales until November (Ba OS 18).

Offshore Sensitivity Summary, Autumn

Area	Sensitivity value	Ranking
OS 13	10	Low
OS 14	9	Low
OS 15	9	Low
OS 16	38	High
OS 17	70	Extreme
OS 18	53	Extreme

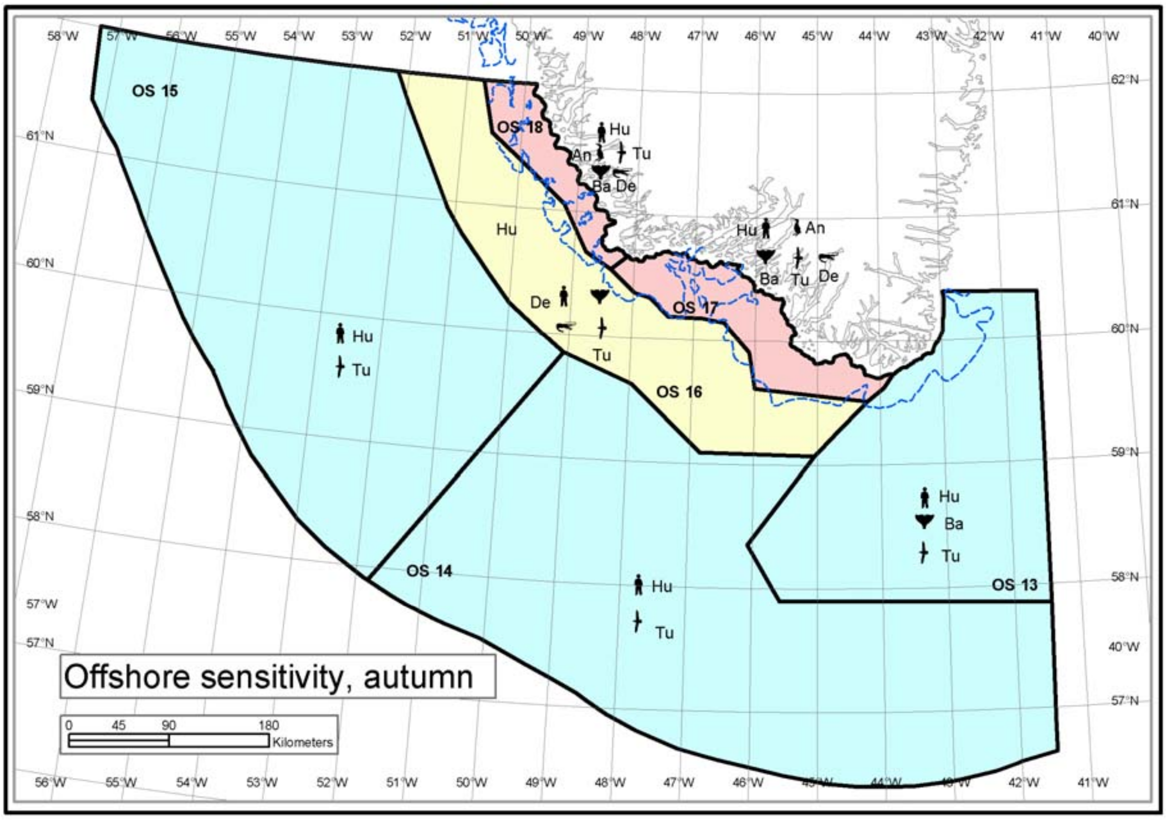


Figure 8.10. Offshore sensitivity in autumn. Legend to map on page 8-13.

8.4 Offshore ice zones and ice edges in Davis Strait and West Greenland Waters (60°-72° N)

8.4.1 Definitions and terminology

This chapter (8.4) apply to entire West Greenland from Cape Farewell in the south (app. 60° N) to southern Upernavik municipality at 72° N.

The following description of the sea ice environment contains a number of terms describing the sea ice thickness or stage of development as defined by World Meteorological Organization.

Ice types:	Thickness	WMO-code ('Egg-code')
New ice-frazil, grease, slush, shuga	0-10 cm	1
Nilas, ice rind	0-10 cm	1-2
Young ice	10-30 cm	3
Grey ice	10-15 cm	4
Grey-white	15-30 cm	5
First year ice	30-200 cm	6
Thin first year ice	30-70 cm	7
Medium first year ice	70-120 cm	1•
Thick first year ice	120-200 cm	4•
Multi year ice	> 2 m	7•

8.4.2 The "West Ice"

The ice conditions between 60° N and 72° N are primarily determined by the relatively warm north or northwest flowing West Greenland Current (WGC) and the cold south flowing Baffin Current (BIC). The WGC delays the time of ice formation in eastern Davis Strait and results in an earlier break up than in the western parts of the Davis Strait (Figure 8.11). The BIC conveys large amounts of sea ice from Baffin Bay to the Davis Strait and the Labrador Sea for most of the year, especially during the winter and early spring months. During this period sea ice normally covers most of the Davis Strait north of 65° N, except areas close to the Greenland coast, where a flaw lead (open water or thin ice) of varying width often appears between the shore or the fast ice and the drift ice offshore as far north as latitude 67° N**.** South of 65-67° N sea ice free areas dominate throughout the year. The sea ice edge (the boundary between drift ice and sea ice free water) is normally oriented to the southwest towards Hudson Strait or the Labrador Coast. In the beginning of the melt season a wide lead or polynya-like feature often forms west of Disko Island in front of Disko Bay. The eastern part of Davis Strait, south of Disko Island, is free of sea ice during this period (Figure 8.14), whereas drifting ice is dominating to the west and north. In Greenland this ice regime is recognized as the 'The West Ice' (Figure 8.12a & 8.12b).

The predominant sea ice type in the Davis Strait and the southern Baffin Bay is first year ice. Small amounts of multi year ice of Arctic Ocean origin drift to the western parts of the area from Lancaster Sound or Nares Strait, however, the multi year ice from these waters does not usually reach the West Greenland shores. At the end of the freeze up season first year ice in the thin and medium categories dominate in eastern parts (up to about 100 km from the Greenland coast). The western and central parts of Davis Strait and southern Baffin Bay are dominated by medium and thick first year ice categories mixed locally with small amounts (1-3 tenths) of multi year ice.

The dominant size of ice floes range from large floes of about 1 kilometer wide to vast floes larger than 10 km. Near the ice edge in Davis Strait, the size of the common floes are reduced to less than 100 meters as a result of melting and break up by waves. These floes are often very consolidated.

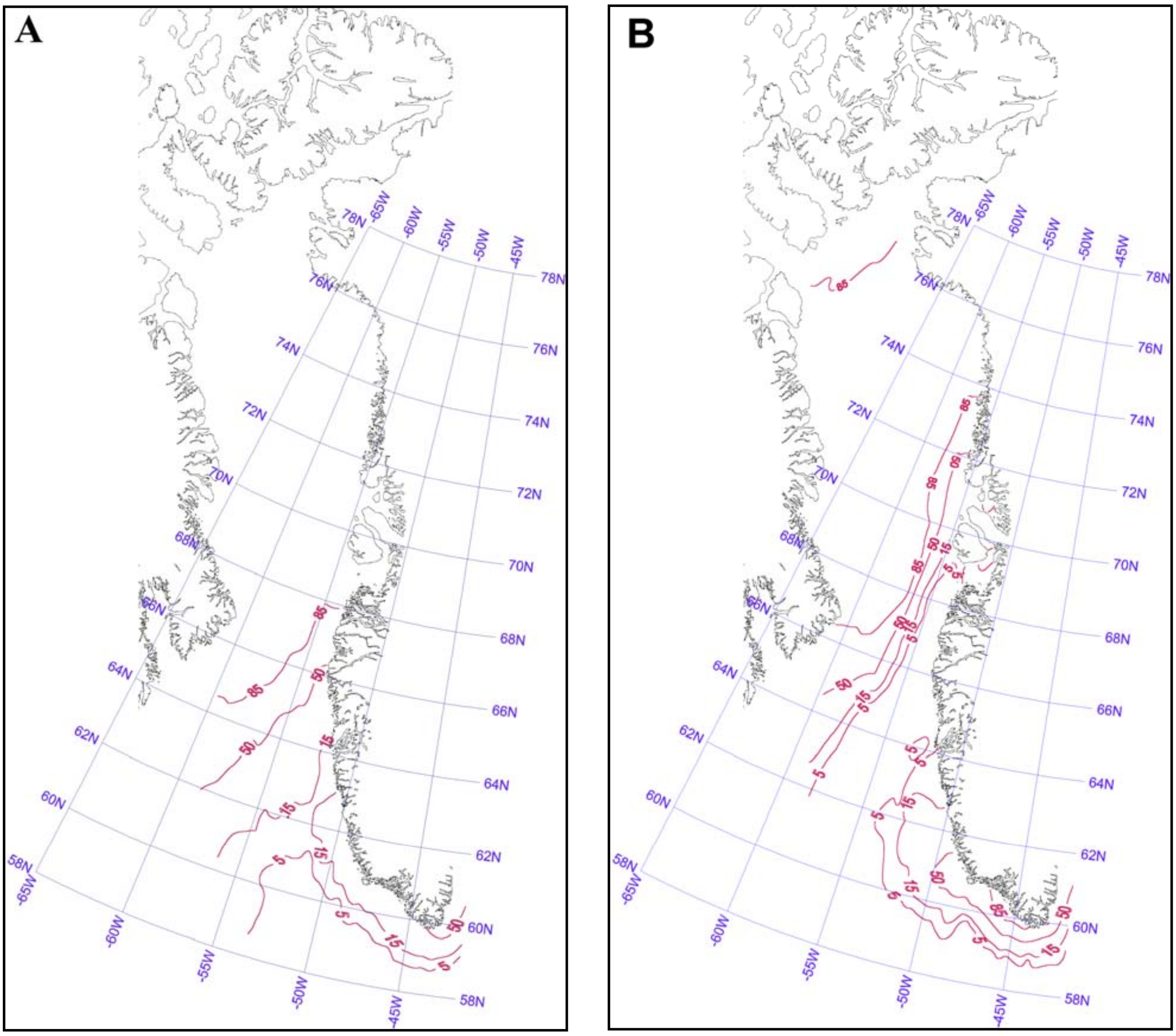


Figure 8.11. Probability of sea ice in West Greenland waters based on data from the period 1960-96. (A) March 1st, (B) June 4th, (C) September 3rd and (D) December 3rd (Data sources: Danish Meteorological Institute and Canadian Ice Service).

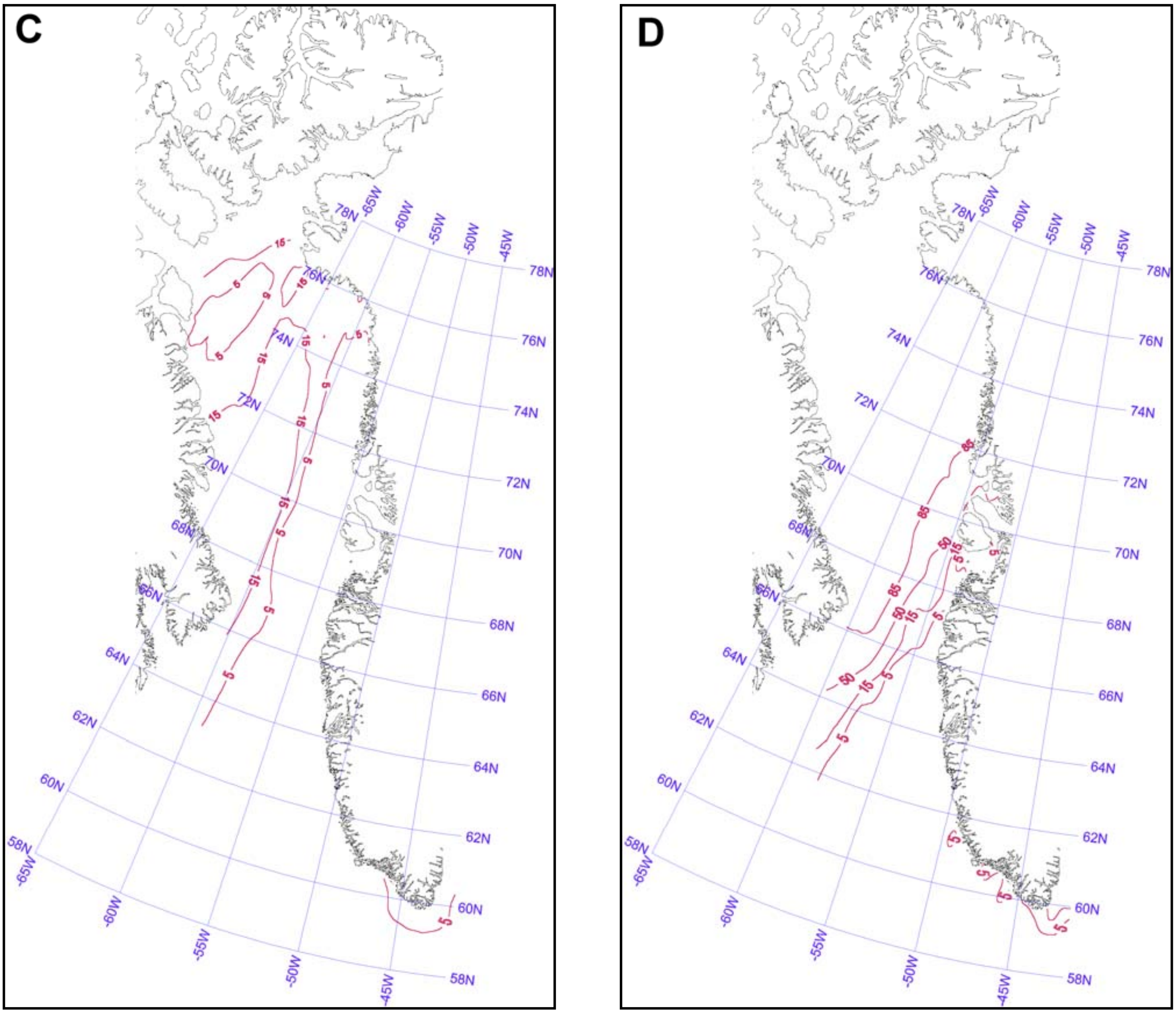


Figure 8.11 (cont.). Probability of sea ice in West Greenland waters based on data from the period 1960-96. (A) March 1st, (B) June 4th, (C) September 3rd and (D) December 3rd (Data sources: Danish Meteorological Institute and Canadian Ice Service).

Figure 8.12a. Typical winter phenomenon in eastern Davis Strait, February 26th 1999 at a position near 66° N, 55° W. Convection clouds develop rapidly near the sea ice edge when cold air masses meet the warm sea surface (Photo: Keld Q. Hansen).

Figure 8.12b. The 'West Ice', eastern Davis Strait, February 26th 1999 at a position near 66° N, 57° W, normally consists of large floes of a variety ice types ranging from young (grey) ice to thin/medium first year ice. Cracks and leads indicate that the ice is drifting (Photo: Keld Q.Hansen).

8.4.3 Multi year sea ice ("Storis" from the Greenland east coast)

A wide belt of multi year sea ice originating from the Arctic Ocean is normally present most of the year covering the entire east coast of Greenland. Under normal conditions the multi year ice reaches the Cape Farewell area in December-January, depending on the intensity of the East Greenland Current and the amount of ice in it. The track and intensity of low pressure systems in the North Atlantic Ocean also influence the distribution of sea ice near Cape Farewell (Figure 8.13).

Due to long periods with strong north-westerly winds resulting from cold air out breaks from northern Canada during the winter, the ice often only passes Cape Farewell for short periods. The amount of multi year ice in South Greenland waters peaks in early summer. The intensity of the lows normally decrease in spring and summer and may cause the multi year ice to drift north-westwards along the Southwest Greenland coast in the West Greenland Current. The width, concentration and position of this ice belt vary from year to year. Some years the ice never passes Nunarsuit, while other years it passes Nuuk and the 'Fyllas Bank' area. The northernmost position of the multi year ice on the west coast is normally situated around Paamiut (Frederikshåb) at 62° N. These waters are normally free of sea ice from early August. The diameter of the multi year ice floes is always less than 100 m and normally about 5 to 20 meters. When multi year ice occurs off Southwest Greenland, it is usually characterized by low or medium concentrations when averaged over large areas, however long narrow belts of high concentrations are also common. In Greenland this ice regime is known as the 'Storis' ('Great Ice') mainly because of the thickness of the ice. However, the key word for the sea ice distribution in the South Greenland waters is *variability* due to strong ocean currents and severe weather, which characterize the area.

8.4.4 Sea ice drift

The drift pattern of the sea ice off West Greenland is not very well known. The local drift is to some extent controlled by the major surface current systems, the West Greenland Current and Baffin Current, however the strength and direction of the surface winds also affect the local drift of sea ice, especially in the southern waters.

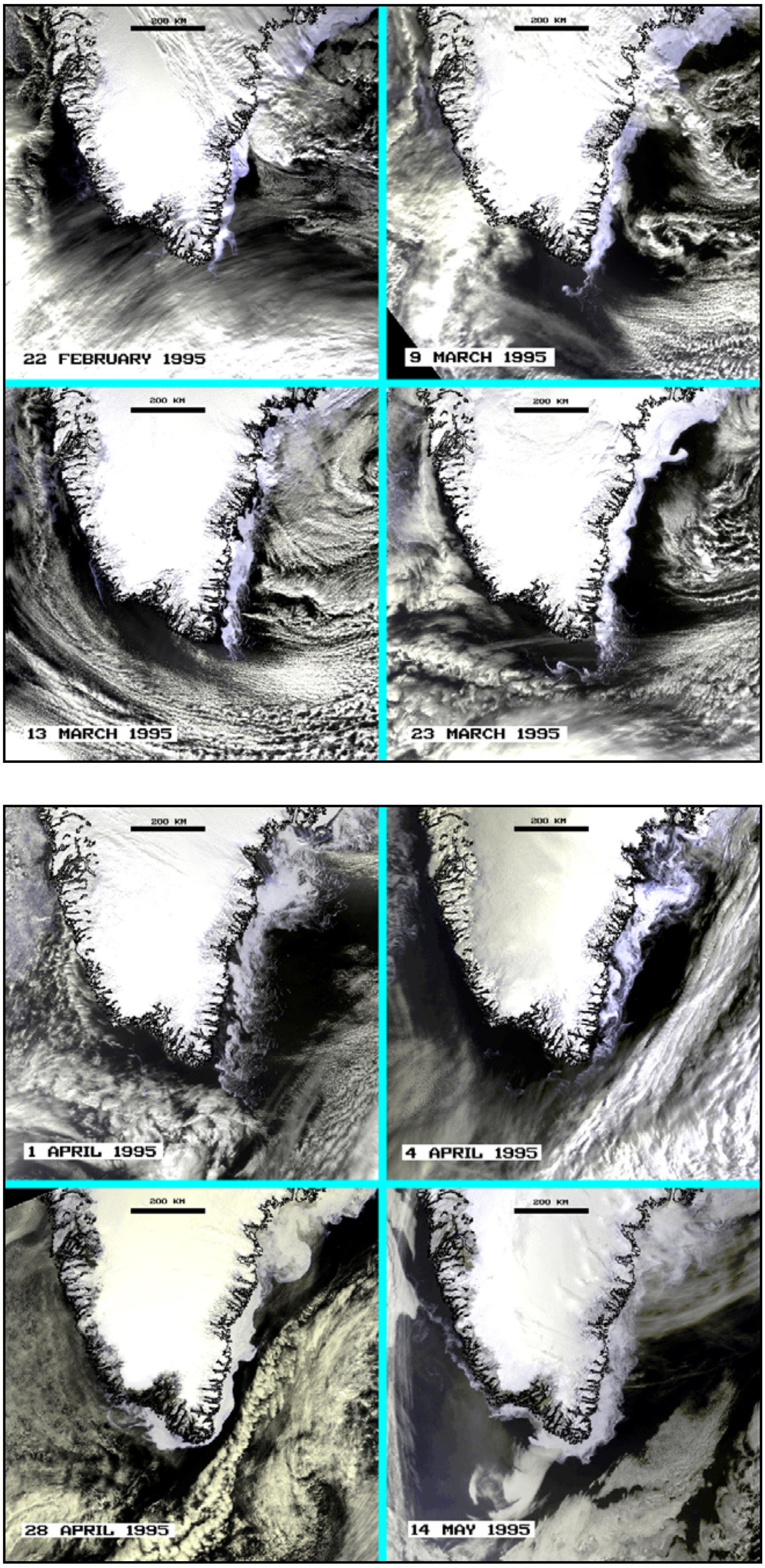


Figure 8.13. The end of the freeze-up season 1994/95. Some of the characteristic physical features:
- The ‘West Ice’ covers most of the Davis Strait including the ‘Fyllas Bank’ area, but open water areas occur north of Nuuk.
- Close to the southwest Greenland coast sea ice often forms locally but is very dependant on the air temperature and the salinity stratification in the sea. Due the changeable winds in the area this kind of ice cover normally only exists for short periods (less than one week).
- Large amounts of ‘Storis’ off the east coast of Greenland. Depending on the dominant wind direction the ice from time to time drifts far south of Cape Farewell. In March 1995 multi year ice was reported south of 58° N more than 200 km from the Greenland coast, but only for a few days.

The maximum coverage of the ‘West Ice’ occurred in early April this year (1995). March 31st and April 1st a very violent meteorological event was observed. The pass of an atmospheric low southeast of Greenland caused ‘Piteraq’ (very strong katabatic winds) on most of the east coast, and this event affected the sea ice dramatically as can be observed on the satellite image. After a few days the ice conditions were back to a normal state again. From late April the ‘Storis’ covered most of the Julianehåb Bay and drifted later to the Davis Strait area due to dominant weak or southeasterly winds.

8.5 Fjord and coastal ice freeze-up and break-up

Isolated from the offshore conditions, sea ice forms locally throughout the winter in many fjords in South Greenland. Freeze-up begins at the inner parts of the fjords in November or December but may be significantly affected or reduced by very strong winds in the fjords throughout the winter.

The presence of a sea ice cover can protect the West Greenland shores and fjords from offshore oil spills. Although large local differences are to be expected.

On the basis of data from the literature, historical ice charts, satellite data and local experience it is possible to evaluate which shores are likely to be susceptible to oil exposure over time. The result of this evaluation is shown in Figure 8.14 and Figure 8.15. however, it is important to note that the estimates of potential exposure periods are only evaluated roughly due to the high number of fjords and islands on the South Greenland coast. Thus, the maps and tables in this section will not necessarily reflect the actual conditions of oil exposure, i.e. in a very mild winter or during exceptional oceanographically conditions. In addition strong winds frequently occur along the shorelines resulting in a localised break-up of fast ice.

Figure 8.14. The West Greenland shore was divided into four subgroups. A study of the potential oil exposure was conducted for each of these:

- cities/settlements,
- offshore areas 10-20 nm from the coast,
- major fjords,
- the near shore environment.

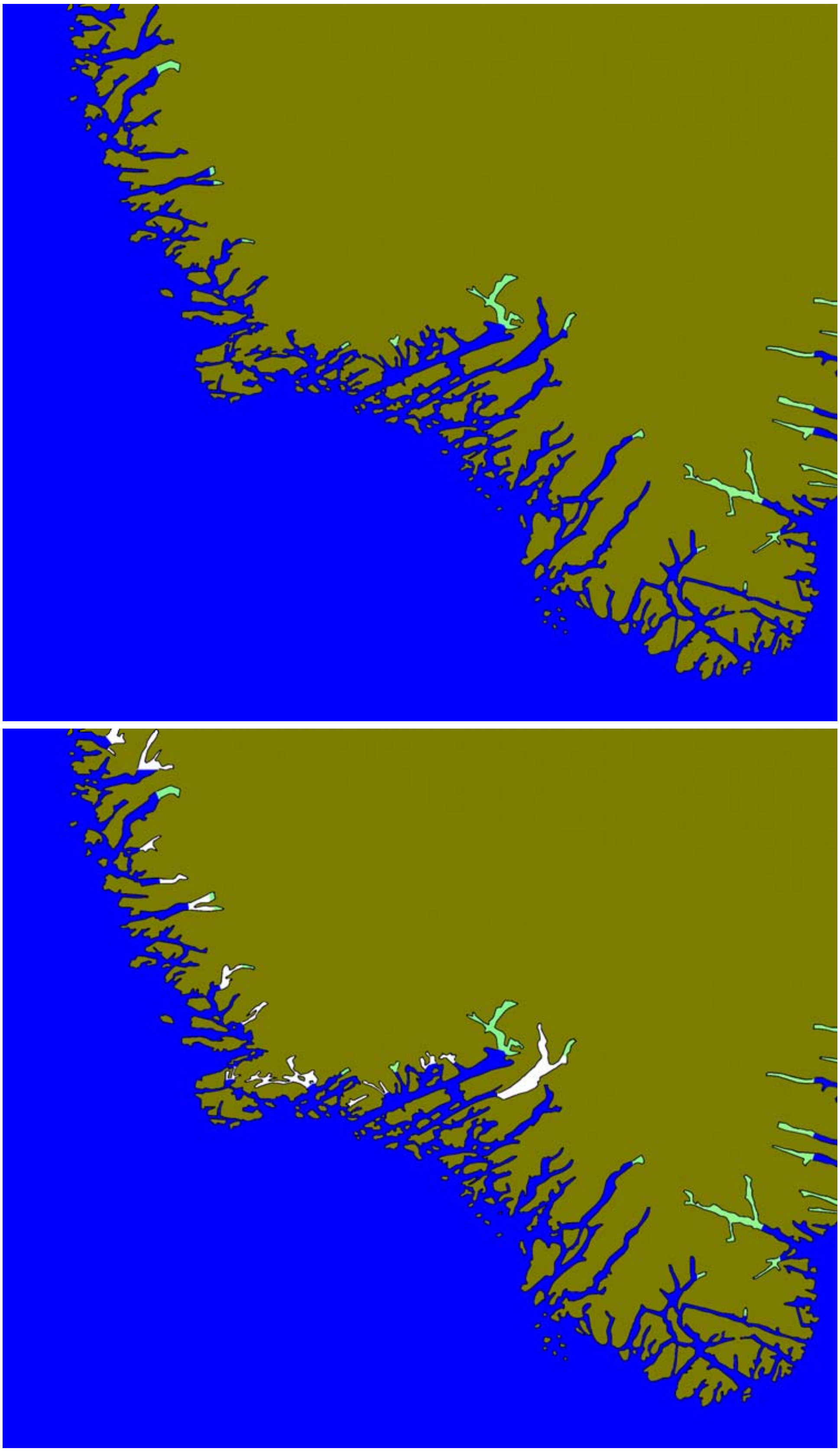


Figure 8.15. Distribution of fast ice (white) and glacier ice (pale green) in South Greenland. Upper map shows the conditions in early (November) and late winter (April), while the lower map shows the conditions in mid-winter (December to March). Ice cover is extremely variable both during the winter period and between winters, and short-lived fast ice areas may occur in many shallow and protected sites.

8.6 Summary of regional observations of sea ice

8.6.1 Northeastern Labrador Sea between Nunarsuit and 63° N

This area is normally free of sea ice from late summer until mid-winter. In the late winter the 'West Ice' occasionally affects the area. In very cold periods sea ice forms locally within 50-60 kilometres of the Greenland coast. Varying amounts of 'Storis' occur almost every year from late winter/early spring until mid-summer. Due to the offshore component of the West Greenland Current, the multi year ice is sometimes only present far from the shoreline.

8.6.2 Julianehåb Bay and Cape Farewell waters

The 'West Ice' almost never affects the area. The occurrence of 'Storis' varies from nothing to huge amounts from early-or mid-winter depending on the storm tracks and low pressure intensity. In spring and summer wide belts of close packed multi year ice are normally present close to the Greenland coast.

8.7 The West Greenland iceberg environment

This section applies to entire West Greenland from Cape Farewell in the south (app. 60º N) to Melville Bay in the north (74º N).

To shipping the most dangerous aspect of ice in the sea is the occurrence of icebergs. They differ from sea ice in many ways:

- they originate from land,
- they produce fresh water on melting,
- they are deep-drafted with appreciable heights above sea level,
- they are always considered as an intense local hazard to navigation and offshore activity.

The process of calving from the front of a glacier produces an infinite variety of icebergs, bergy bits and growlers with calving occurring throughout the year. Icebergs are described by their size according to the following classification:

Type	Height (above sea level)	Length
Growler	less than 1 m	up to 5 m
Bergy bit	1 to 5 m	5 to 15 m
Small iceberg	5 to 15 m	15 to 60 m
Medium iceberg	16 to 45 m	61 to 120 m
Large iceberg	46 to 75 m	121 to 200 m
Very large iceberg	over 75 m	over 200 m

The production of icebergs on a volumetric basis varies only slightly from year to year. Once calving is accomplished, meteorological and oceanographic factors begin to affect the icebergs. Icebergs are carried by sea currents directed by the integrated average of the water motion over the whole draft of the iceberg. However wind also plays an important role, either directly or indirectly.

8.7.1 Iceberg sources

Glaciers are numerous in West Greenland, however the productive glaciers are concentrated between Nares Strait and Disko Bay. Although icebergs occur throughout the West Greenland waters between 60° N and 72° N they are rare in some areas, e.g. off Sisimiut. In other areas, e.g. in Disko Bay, hundreds of icebergs are always present (Figure 8.16 and 8.17).

Eastern Baffin Bay north of Upernavik is a major source of icebergs. Every year more than 10,000 icebergs are calved from 19 major glaciers (Figure 8.18). Some of these are capable of producing icebergs of about 1 kilometre in diameter. Several active glaciers in Uummannaq Fjord and Disko Bay produce 10-15,000 icebergs per year, and they are very important for the iceberg input to the northern Davis Strait and Baffin Bay. The most active glacier is located near Ilulissat moving at the rate of 20 m per day. This glacier produces more than 20 km^3 of ice per year. The total annual production of icebergs calved in the Baffin Bay and the northern Davis Strait is estimated to be about 25-30,000, estimates however vary up to as high as 40,000. Surveys conducted by USCG International Ice Patrol decades ago indicate that the total number of icebergs in Baffin Bay and the northern Davis Strait are of the same order of magnitude. Almost no icebergs are produced south of Disko Bay. Here the fjords are longer, narrower and shallower than in the northern areas of the Greenland west coast, and the calving is in the form of growlers and bergy bits rather than icebergs. Growlers and bergy bits nearly always melt before reaching the open sea. However, from time to time the glacier in Narsalik Fjord produces ice, which affects offshore areas for a couple of days.

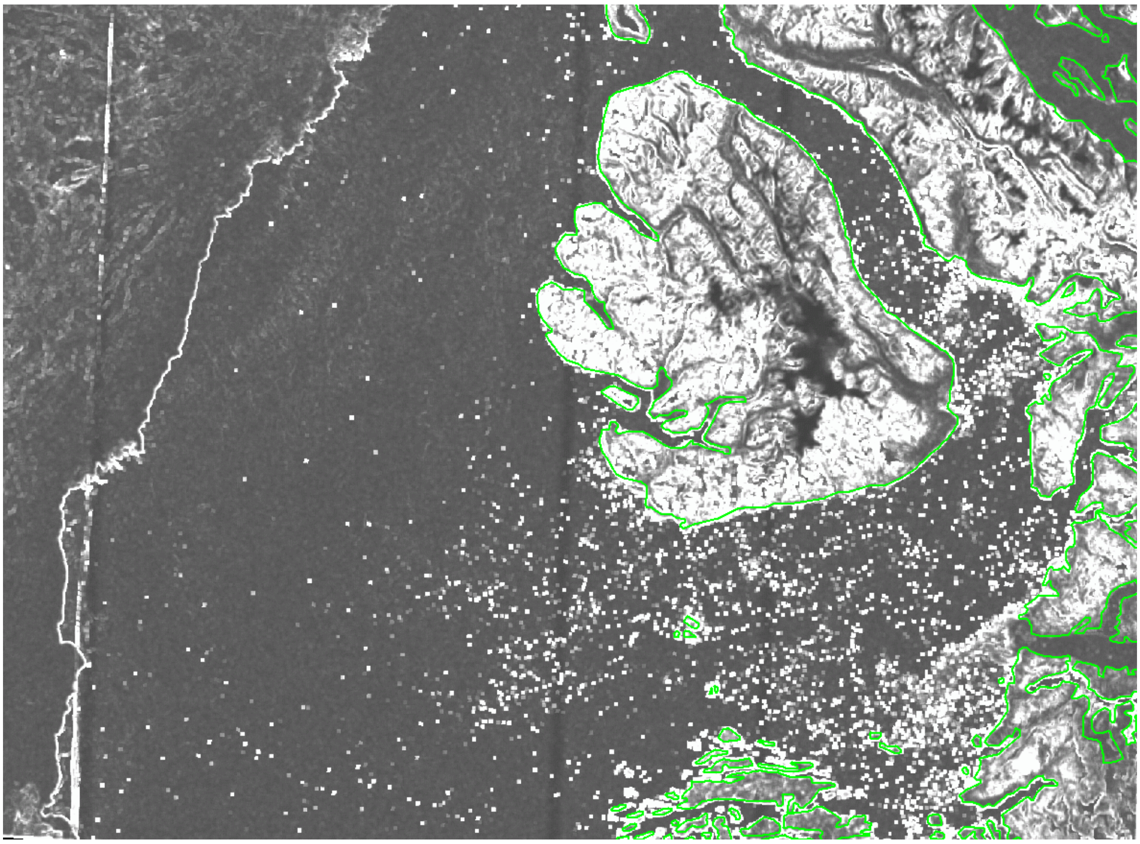


Figure 8.16. Radarsat PMR-filter image from June 14th 1999 20 UTC of the Disko Bay area showing the distribution of targets (icebergs). The edge of the 'West Ice' is found in the western part of the image (Source: Radarsat).

Figure 8.17. June 12th 1997. Glacial ice, primarily small icebergs and bergy bits, from one of the major sources in northeastern Disko Bay, Torsukattak, which produces about 16 km^3 ice per year (Photo: Keld Q. Hansen).

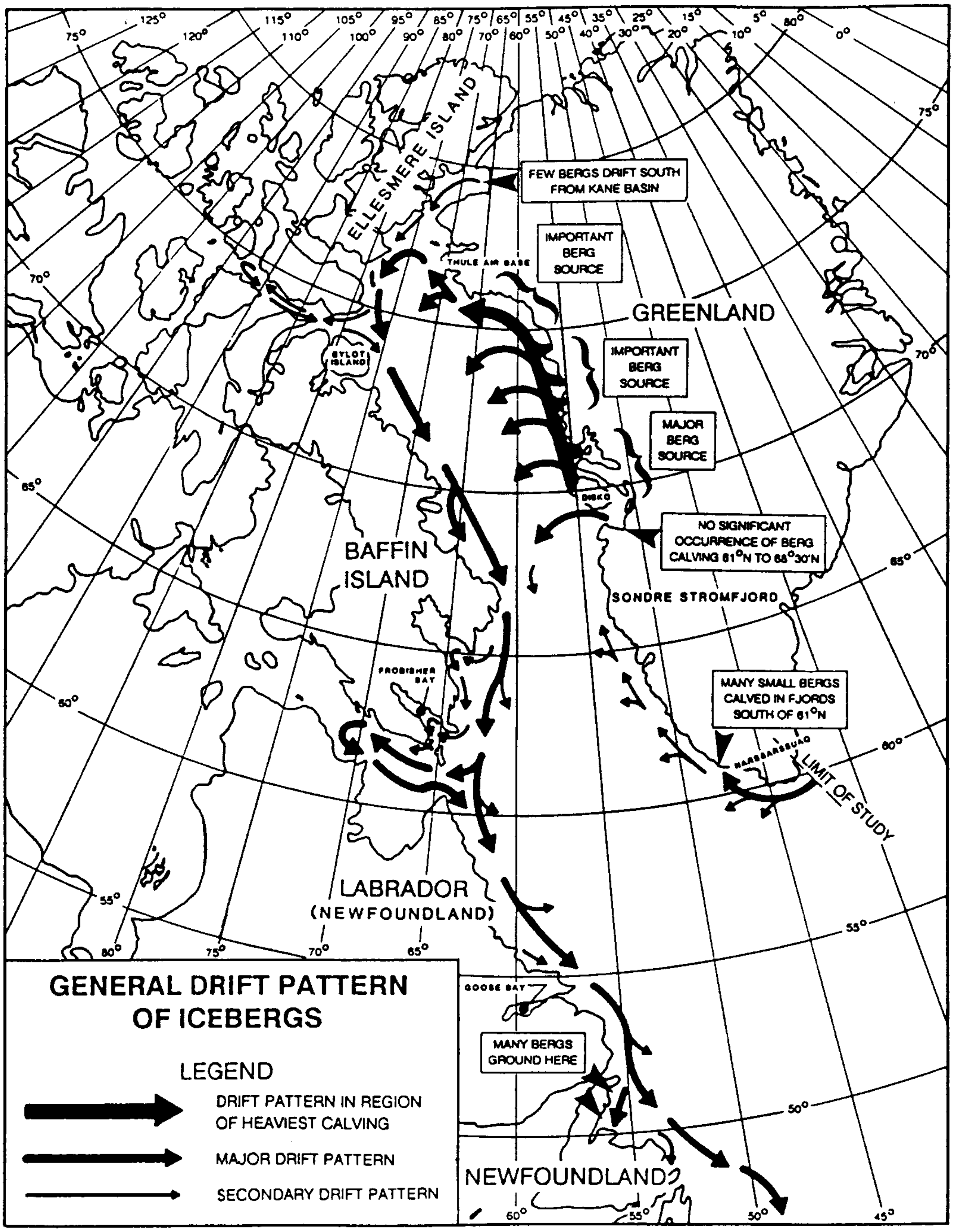


Figure 8.18. Major iceberg sources and general drift patterns in the West Greenland waters (US National Ice Center, Washington DC).

8.7.2 Iceberg drift and distribution

On a large scale the basic water currents and drift of icebergs in Baffin Bay and northern Davis Strait are fairly simple. There is a north-flowing current along the Greenland coast and a south-flowing current along Baffin Island and the Labrador coast giving an anti-clockwise drift pattern. However, branching of the general currents cause variations, and these can have a significant impact on the iceberg population and their residence time. Although the majority of icebergs from Disko Bay are carried northward to northeastern Baffin Bay and Cape York before heading southward, icebergs have also been observed to be diverted into one of the west-branching eddies without passing north of 70° N. Most of the icebergs from Baffin Bay drift southward in western Davis Strait joining the Labrador Current further south, although some may enter the eastern Davis Strait area west of Disko Island instead. Icebergs produced in Disko Bay or Baffin Bay generally will never reach the Greenland shores south of 68° N. Many icebergs produced in the Disko Bay enter Davis Strait, partly through Vaigat and partly along the southern coast of Disko Island. Some icebergs manage to drift towards or into southern Disko Bay from the Davis Strait due to onshore component of the currents west of Aasiaat. Icebergs south of Sisimiut are of East Greenland origin. Occasionally many small icebergs and bergy bits calved in Southwest Greenland fjords are observed close to the coast in this area, however these ice masses normally melt quickly and only rarely affect ocean areas farther offshore.

In a study in the late 1970'es, DHI/GTO found the lowest iceberg densities in West Greenland at the northern part of Lille Hellefiskebanke and at the southern part of Store Hellefiskebanke between 65° and 66° N. Iceberg densities increased both towards north and south. The density of icebergs in Disko Bay was significantly higher than outside the bay, with maximum concentrations of icebergs occurring in the northeastern part of Disko Bay. The iceberg density generally was highest in early summer, except in the area near Disko Bay where the highest density was seen in late summer, probably due to higher calving activity of the glaciers during the summer months. A similar distribution can be derived from data from USCG International Ice Patrol and the Canadian Ice Service and can also be observed by shipping companies operating in the area.

Icebergs are only occasionally seen in eastern Davis Strait between Nuuk and 67° N as a result of the pattern of dominant currents, the bathymetry and the distance to calving glaciers. Growlers, bergy bits and a few icebergs usually do not drift out of Godthåb Fjord and could hardly ever affect the 'Fyllas Banke'. The seasonal maximum density of icebergs in this area is normally closely related to the actual distribution of 'Storis'. Thus, under normal conditions, the seasonal maximum occurs from late April until late July. Off the ice edge of the 'Storis' the deterioration of icebergs increase significantly, and therefore the seasonal minimum of glacial ice in the 'Fyllas Banke' area normally occurs during the fall months of September to November. Due to the observed westward branching of the West Greenland Current and the bathymetry south of 'Fyllas Banke', the largest icebergs will probably be observed on the western side of the 'Fyllas Banke' area, but some of these may manage to drift northeast into the deeper waters between 'Fyllas Banke' and 'Toqqussaq Banke'.

8.7.3 Icebergs from East Greenland glaciers

Every year thousands of large icebergs are calved from several glacier outlets on the east coast of Greenland. When the icebergs reach open sea, they drift southwards in the East Greenland Current, which most of the year also contains large amounts of sea ice from the Arctic Ocean. Even in winter most of the sea ice from high latitudes melts when it drifts southward off the southeast coast of Greenland. Many icebergs drift off the sea ice edge and melt quickly due to a higher water temperature here and to the wave/swell action. Within the sea ice edge in the cold East Greenland Current the deterioration of the icebergs is limited. The actual position of icebergs off Southwest Greenland is to a certain extent controlled by the occurrence and the distribution of multi year ice 1-2 months earlier. Under normal conditions sea ice occurs in the Cape Farewell area from early winter until late summer. During spring and early summer the sea ice sometimes drifts into the 'Fyllas Banke' area. Therefore, the maximum iceberg density off Southwest Greenland is expected to occur in early and mid-summer. This pattern was indirectly observed in the DHI/GTO study in the late 1970'es (Mangor & Zorn 1983). 'Storis' was observed off the southwest coast of Greenland for several weeks during each of both years, however the sea ice distribution and length of the sea ice season was close to normal conditions.

Large variations in the number and size of icebergs rounding Cape Farewell are to be expected because of the variability of the currents, the amounts of sea ice and the weather conditions. An important factor controlling the iceberg environment off Southwest Greenland is the input of icebergs to the East Greenland Current at high latitudes during summer. It is well known that sea ice is present off the east coast most of the year, although there are large seasonal and inter-annual variations, especially during summer. In many cases the occurrence and drift of sea ice controls the movements of icebergs. If the fast ice in fjords with major iceberg sources, e.g. Scoresbysund or Kong Oscar Fjord, does not melt during summer, or if the East Greenland sea ice does not drift off the coast, this will probably reduce the input of icebergs to the East Greenland Current and cause a decrease in the number of icebergs at lower latitudes. However, this phenomenon has not been systematically investigated.

8.7.4 Iceberg dimensions

The characteristics of iceberg masses and dimensions off the southwest coast of Greenland are poorly investigated, and the following is mainly based on the DHI/GTO study in the late 1970'es.

In eastern Davis Strait the largest icebergs were most frequently found south of 64° N and north of 66° N. South of 64° N, the average mass of an iceberg near the 200 m depth contour varied between 1.4 and 4.1 million tons, with a maximum mass of 8.0 million tons. Average draft was 60-80 m and maximum draft was 138 m. Between 64° N and 66° N average masses were between 0.3 and 0.7 million tons. The maximum mass was 2.8 million tons. Average draft was 50-70 m and maximum draft is estimated to be 125 m.

The largest icebergs north of 66° N were found north and west of Store Hellefiskebanke. The average iceberg mass was about 2 million tons with a maximum mass of 15 million tons. In Disko Bay the average masses of icebergs were in the range 5-11 million tons with a maximum recorded mass of 32 million tons. Average draft was 80-125 m and maximum draft was 187 m. It is worth noting that many icebergs are deeply drafted and due to the bathymetry large icebergs will not drift into shallow water regions, e.g. at 'Fyllas Banke' where the water depth in large areas is only about 100 meters. Thus, large icebergs will ground before they drift into many offshore areas in Greenland.

Maximum draft can be evaluated by studying factors, which limit the dimension: glacier thickness, topographic factors which cause icebergs to be calved in 'small' pieces and thresholds in the mouths of the fjords with glaciers. The measurements of iceberg drafts north of 62° N indicate that an upper limit for a draft of 230 m will only be exceeded very rarely, however, no systematic 'maximum draft measurements' exist, and the extremes remain unknown. Several submarine cable crushes or breaks have occurred at water depths of about 150-200 meters. The maximum depth recorded was 208 meters southwest of Cape Farewell. These observations agree with the DHI/GTO conclusions, however larger drafts of icebergs of East Greenland origin cannot be excluded because observations are sparse. The large icebergs originating in Baffin Bay are expected to have a maximum draft of about 250-300 meters.

A field program, Berg Watch 97, carried out by the Danish Meteorological Institute, Danish Hydraulic Institute and ASIAQ/Greenland Field Investigations documented the presence of very large icebergs in eastern Baffin Bay characterised by a draft of more than 260 meters, or a mass of up to 90,000,000 tons, or a diameter of more than 1,400 meters. Due to the predominant currents in

Baffin Bay and Davis Strait, these icebergs will not reach the West Greenland shores south of 68° N. Surveys conducted by the USCG International Ice Patrol and other field studies of icebergs in the East Canadian waters have improved the knowledge on the iceberg environment in the western Davis Strait and the Labrador Sea. However, the amount of iceberg data relevant for the eastern Davis Strait are very sparse.

This page is intentionally left blank

Map legend

Base map

- Land
- Ice
- Lake
- Sea
- River
- Contour

Physical environment & logistics maps

Logistics

- Town
- Settlement
- Abandoned settlement
- Field station
- Abandoned station
- Harbour / Anchorage
- Boat harbour
- Airstrip
- Heliport
- Oilterminal
- Peak
- Safe haven
- Landing
- Inshore containment with length

100m

Shoretype

- Outside mapping area
- Rocky coast
- Archipelago
- Glacier coast
- Moraine
- Alluvial fan
- Talus
- Beach
- Barrier beach
- Salt marsh and/or tidal flat
- Pocket beach
- Delta
- Not classified (invisible)

Shoreline sensitivty maps

Shoreline species*

Al	Alcids breeding
An	Alcids nonbreeding
Ar	Arctic char
Ca	Capelin
De	Deep sea shrimp
Gu	Gulls
Ha	Harbour seals
Lu	Lumpsucker
Sb	Seaducks breeding
Sc	Scallop
Se	Seaducks spring
Sn	Snow crab
Tu	Tubenoses

*Icons only visible for species with a relative abundance = 3, 4 or 5

Site specific shoreline species

Al	Alcids breeding
Gu	Gulls
Sb	Seaducks breeding
Tu	Tubenoses

Shoreline resource use

- Resource use (Human use)
- Archaeological site

Shoreline areas sensivity ranking

- Extreme (> 45)
- High (33 - 45)
- Moderate (22 - 33)
- Low (< 22)

Selected areas

- Selected area

Mapscale 1:250.000
Projection: UTM, zone 23N, WGS84
Topographic base:
G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

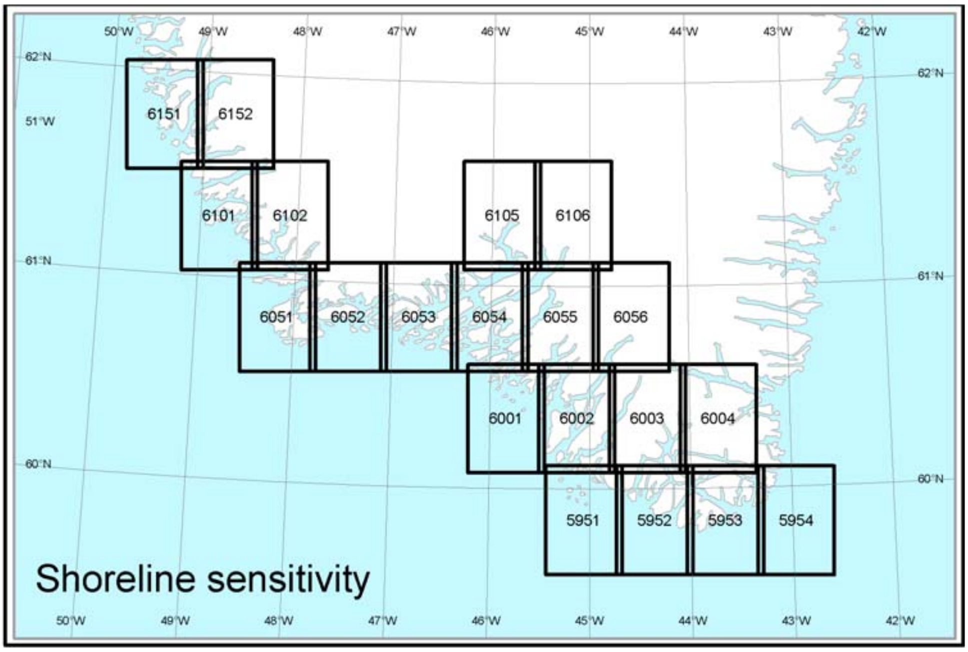
Maps produced by National Environmental Research Institute (NERI) and Geological Survey of Denmark and Greenland (GEUS), 2003

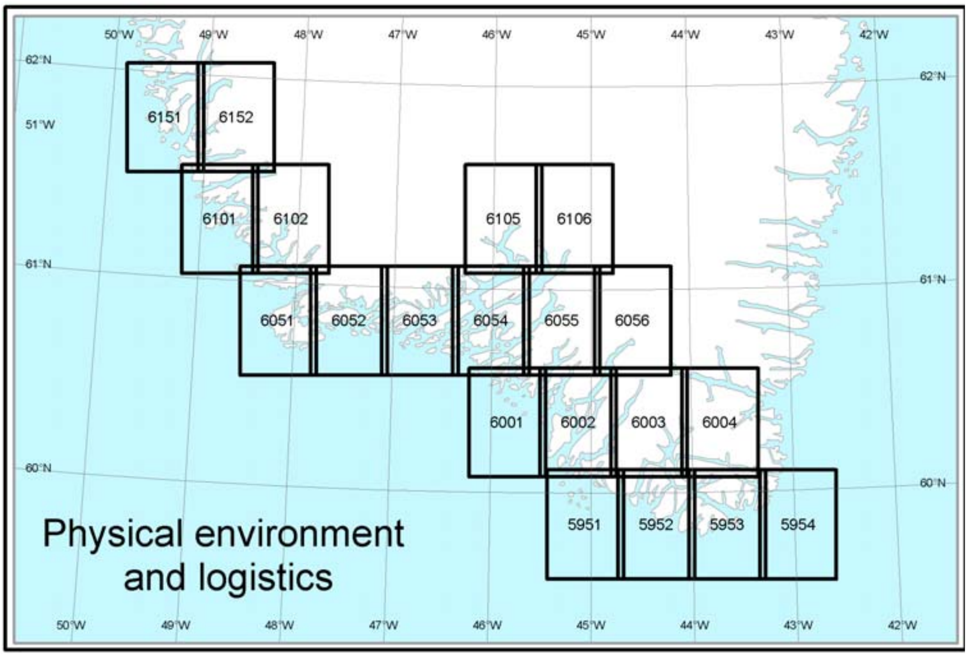
9 Operational shoreline information

This chapter contains two series of 20 detailed maps covering the area (see key map this page): **Shoreline sensitivity maps** and **physical environment and logistics maps**. The shoreline sensitivity maps are on left-hand side, and physical environment and logistics maps are on the right. Descriptive text appears on the pages in between. There is a common legend to the maps to be unfolded on the page facing this.

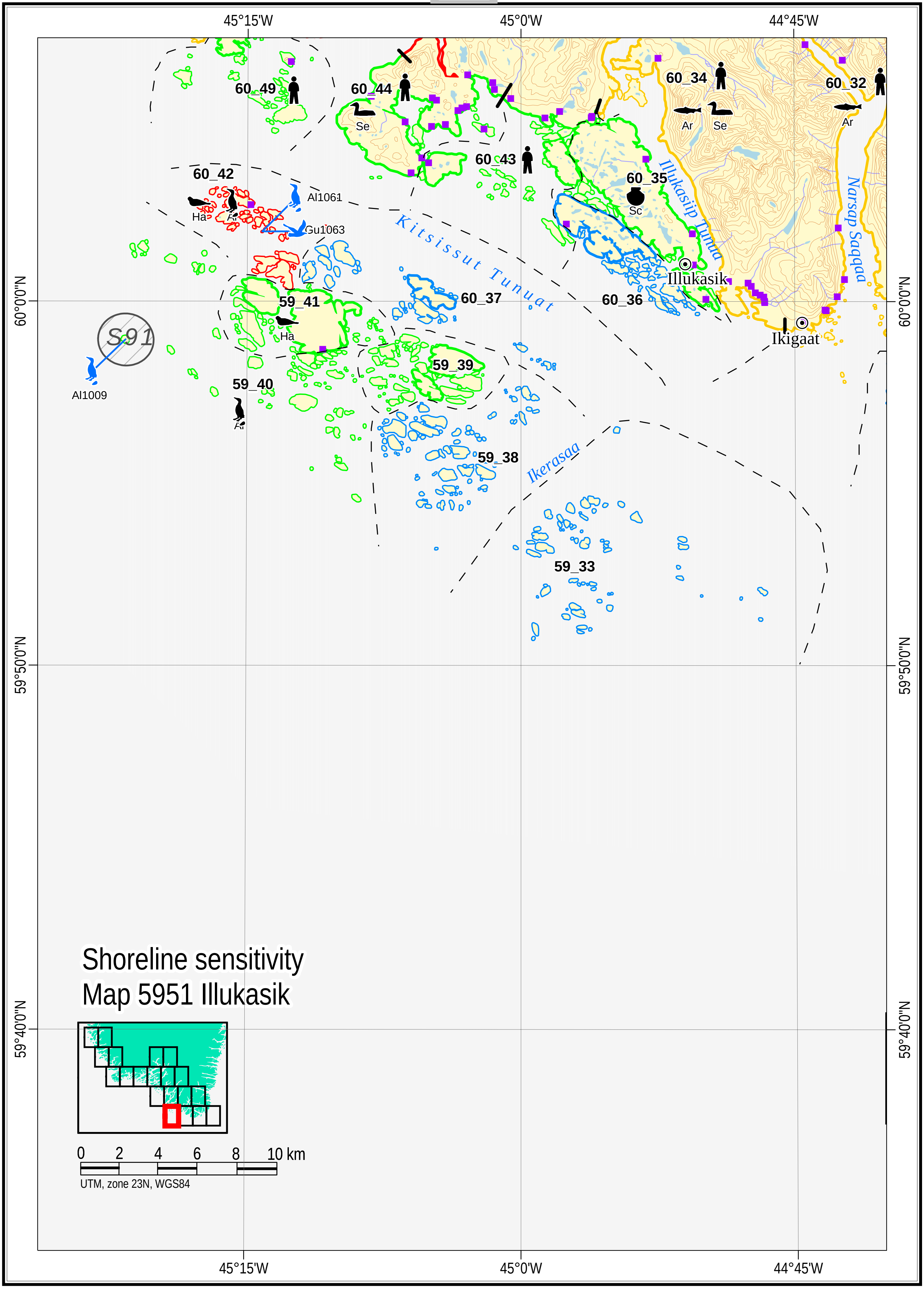
See Chapter 7, Users guide, for further information on map interpretation.

KEYMAPS:





Airphoto keymap   Map legend   Toggle maps   Keymaps



Shoreline sensitivity

Map 5951 - Illukasik

Environmental description

Resource use

R 60_34	Fishery for salmon and Arctic char at the coast and in 4 river outlets (all important). Hunting for guillemots and eiders. Tourist attraction at Ikigaat.
R 60_43	Fishery for salmon (important) and Arctic char in 1 river outlet (important). Hunting for guillemots, eiders and hooded seals.
R 60_44	Fishery for Greenland cod and salmon (important). Hunting for guillemots, eiders and hooded seals.

Species occurrence

Al59040	1 colony with breeding razorbills, black guillemots, Atlantic puffins and perhaps Brünnich's guillemots (**S91**).
Al60042	1 colony with breeding razorbills and black guillemots.
Ar60034	Arctic char in 4 rivers and fishery (important) in small coastal area.
Ha59041, Ha60042	Important area for harbour seal.
Sc60035	Important scallop fishing ground.
Se60034, Se60044	Eiders and long-tailed ducks in winter.

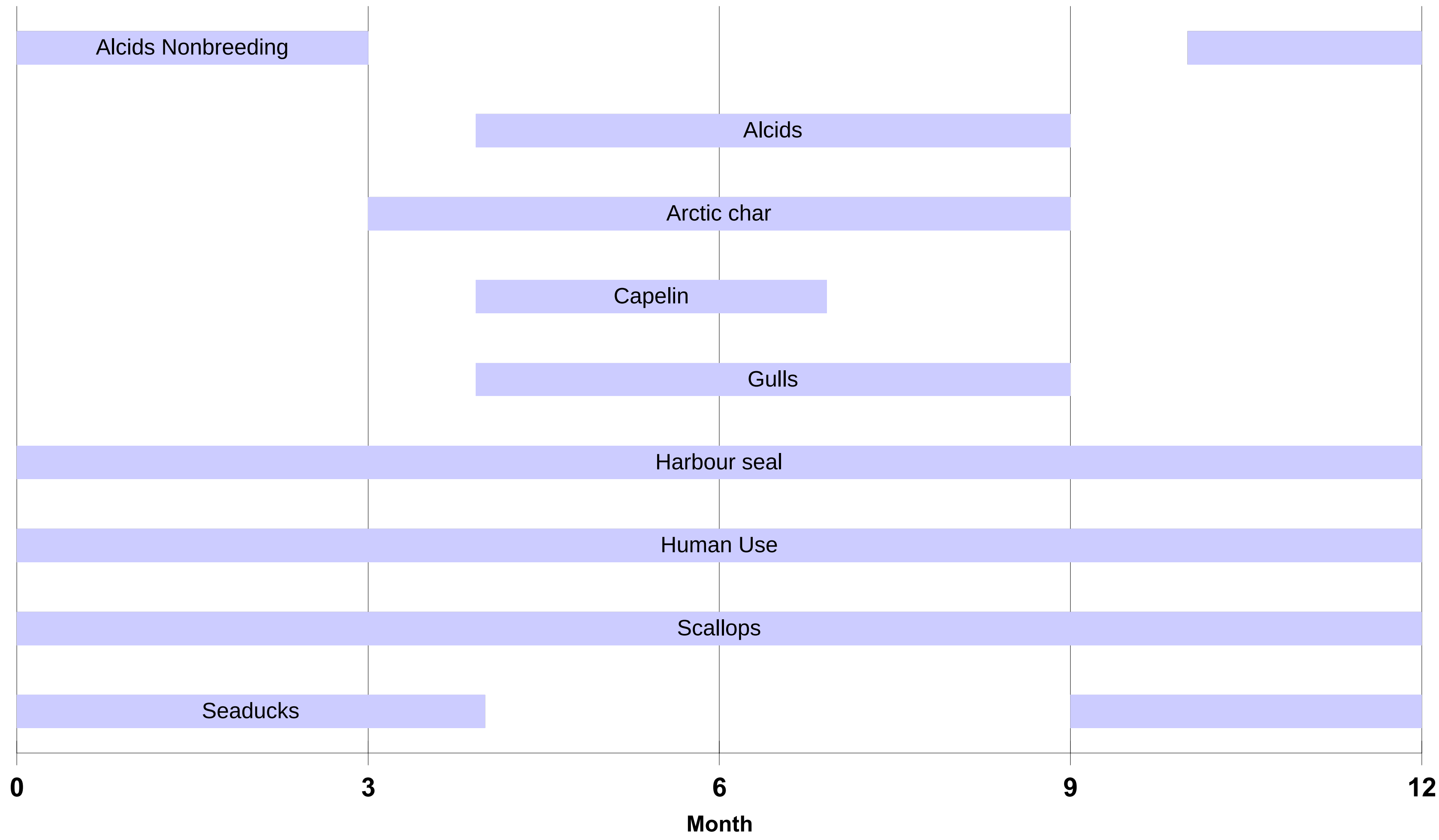
Site specific species occurrence (seabird breeding colonies); blue icons

Al1009	Breeding razorbills, black guillemots, Atlantic puffins and perhaps Brünnich's guillemots (**S91**).
Al1061	Breeding razorbills and black guillemots.
Gu1063	Breeding great black-backed gulls.

Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
59_33	8	Low
60_34	42	High
60_35	31	Moderate
60_36	12	Low
60_37	21	Low
59_38	11	Low
59_39	22	Low
59_40	24	Moderate
59_41	32	Moderate
60_42	45	High
60_43	24	Moderate
60_44	26	Moderate

Map 5951 Species and Resource Occurrences



This page is intentionally left blank

Physical environment and logistics

Map 5951 - Illukasik

Access

The nearshore waters in this area are largely uncharted, the inshore waters within fjords are not charted and therefore caution should be exercised. In general, the waters offshore, nearshore and within the fjords appear to be deep, however uncharted dangers may exist. Local knowledge is essential for navigation.

The coastline in this area is strewn with islets, rocks and shoals. Local knowledge is essential for navigation.

The relatively warm West Greenland Current prevents the formation of ice through this area, except for a band along the coast west of Cape Farewell (map 5953) and in some of the fjords.

Pack ice that enters the area from Cape Farewell may quickly scatter and dissipate in wind conditions. In some wind conditions ice may be concentrated and trapped in coastal areas, making navigation difficult. Conditions can change quickly and should be considered prior to inshore navigation. This ice is termed ‘Storis’.

The prevailing current sets to the NW waters along the coast. Tidal streams run SE/NW at rates up to 2 knots. There is no other information on tides or currents within fjords for this area.

Angissoq Havn, a bay on the east side of Angissoq, the largest island of Klapmydsøerne, has berthing for vessels up to 80 m length and 6.0 m draft. A small jetty in the SW corner of the harbour has depth alongside of 3.0 m and a height above mean water of 1.0 m. The tide attains a maximum height of 3.5 m and tidal streams are weak. The harbour is frequently blocked by ice so accessibility varies greatly with wind and tides.

Shorelines in this area are predominantly rock allowing little opportunity for marine access. There is no information to indicate the potential for beach landings.

There are no airports on this or adjoining maps. The nearest airport is at Narsarsuaq (map 6106) and there is a heliport in Nanortalik (map 6002).

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow nearshore waters, which may exist within the fjords and coastal islands on this map. The waters appear to be deep, but as they are uncharted, soundings should be taken to confirm their depth prior to using dispersants.

Offshore countermeasures represent the only practical method of protecting most shoreline areas, including the selected area shown on the map.

The main entrances to the fjords on this map are generally too wide to consider exclusion booming. Exclusion booming to reduce the extent of inshore contamination should be considered at two possible locations. The inlet at the entrance to Illukasip Tunua is 200 m wide, and the inlet at the head of Narsap Saqqaa is 700 m wide. Both have rock shorelines and appear to have deep water. Site surveys at the time of a spill will be required to confirm the feasibility of booming techniques. High tidal velocities are possible given the reported tidal range and may prevent successful booming.

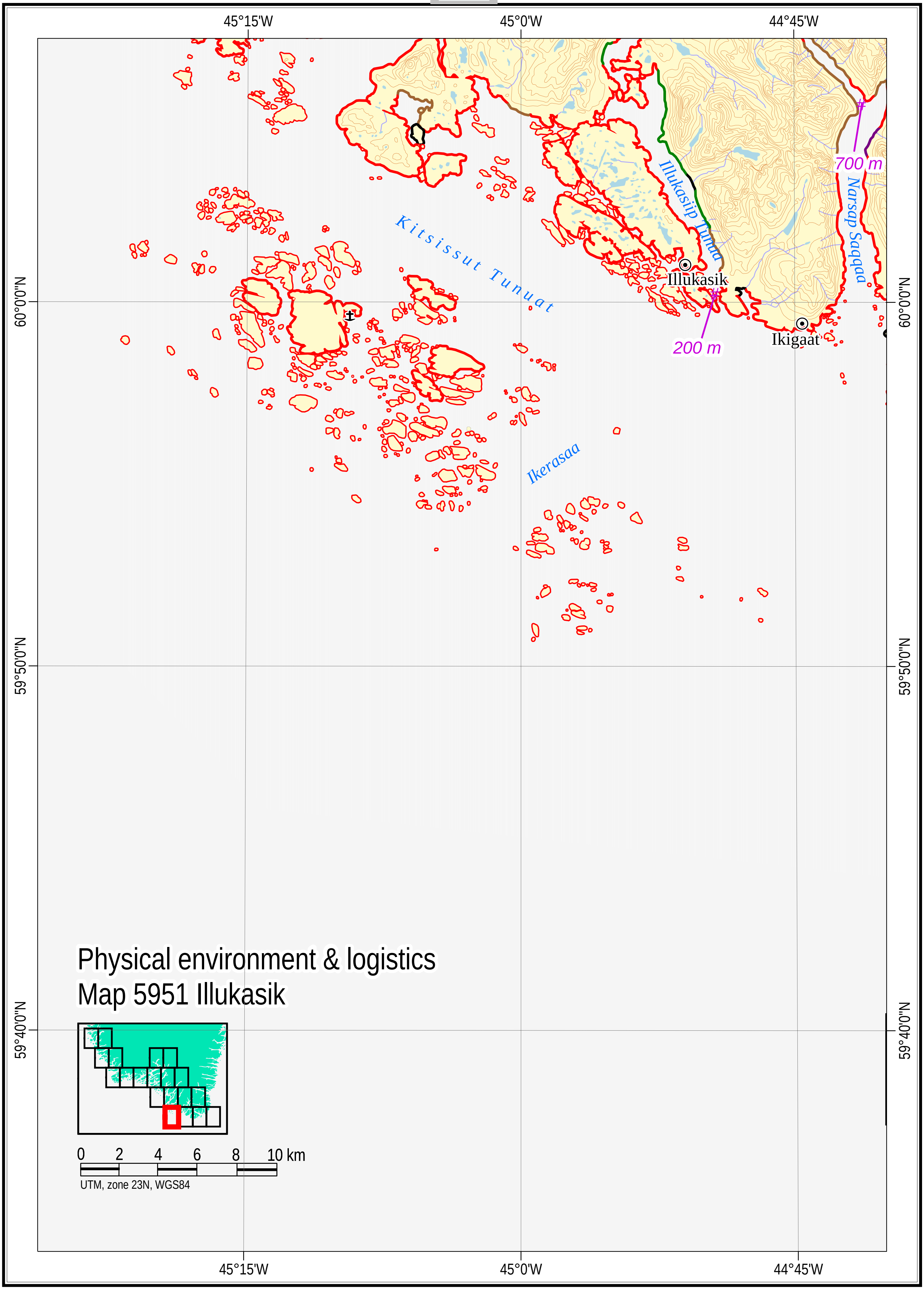
Shorelines shown on this map are predominantly exposed and semi-exposed rock and talus, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords and coastal islands. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marinebased given the likely nature of the shoreline.

Safe havens

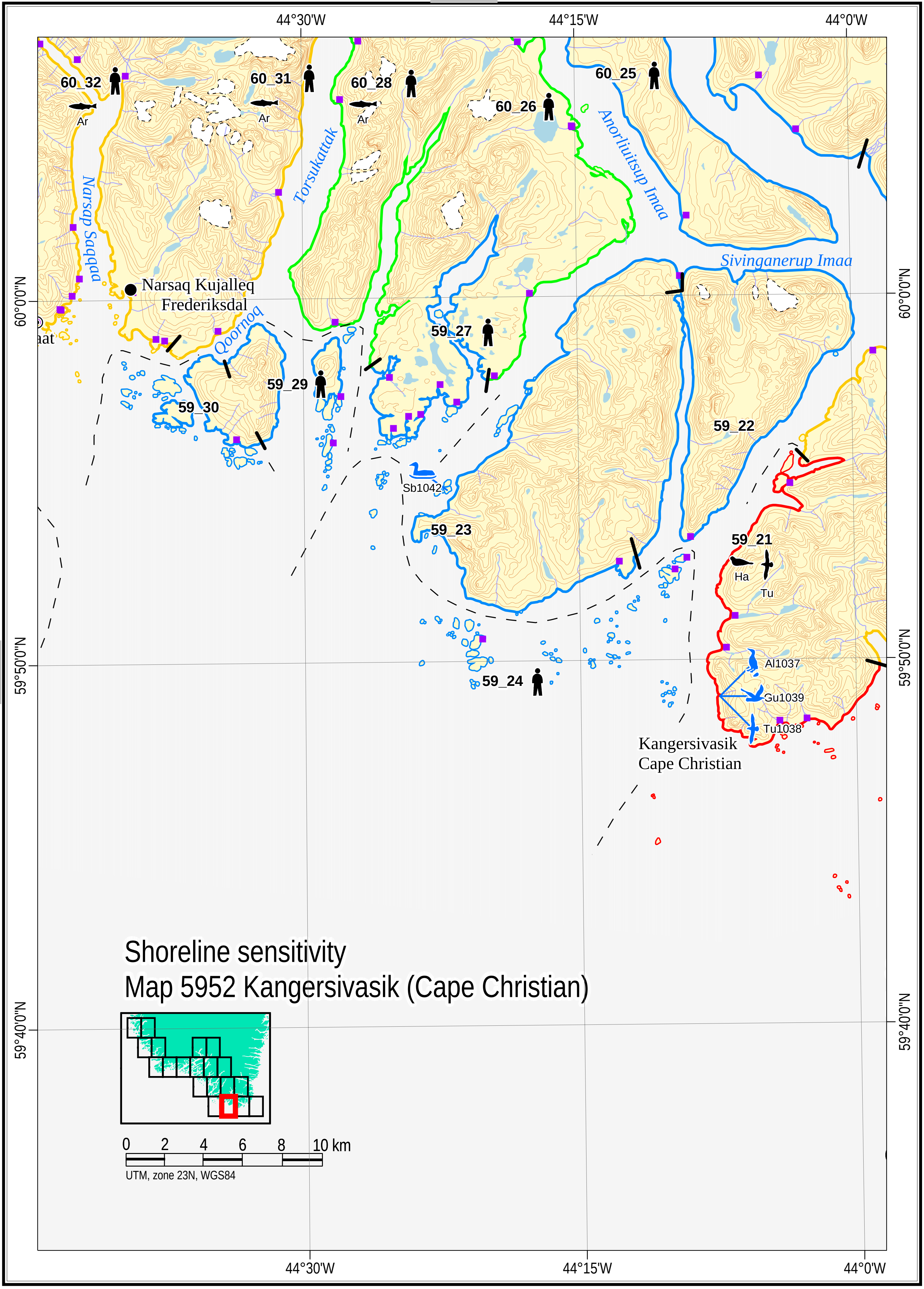
There are no potential safe havens identified on this map.

Maps

Danish Survey & Cadastre (KMS) topographical map: 59 V.1. Nautical charts: 1100, 1103,1113, 2100.


45°15'W
45°0'W
44°45'W
60°0'0"N
59°50'0"N
59°40'0"N
Kitsissut Tunuat
Illukasip Tunua
Narsap Saqqaa
Illukasik
Ikigaat
Ikerasaa
700 m
200 m
Physical environment & logistics
Map 5951 Illukasik
0 2 4 6 8 10 km
UTM, zone 23N, WGS84

Airphoto keymap
Map legend
Toggle maps
Keymaps



Shoreline sensitivity
Map 5952 Kangersivasik (Cape Christian)

Shoreline sensitivity

Map 5952 - Kangersivasik (Cape Christian)

Environmental description

Resource use

R 59_24	Fishery for Atlantic halibut. Hunting for guillemots and fin and minke whales.
R 60_25	Fishery for Greenland halibut (important) and wolffish. Hunting for guillemots, fin and minke whales and harp seals.
R 60_26	Fishery for Greenland halibut (important), wolffish and Arctic char in 1 river outlet (important). Hunting for guillemots, fin and minke whales. Tourism: climbing on coastal mountain.
R 59_27	Fishery for Atlantic halibut, salmon, redfish and Arctic char in 1 river outlet. Hunting for seals.
R 60_28	Fishery for Atlantic halibut, salmon, redfish and Arctic char at the coast and in 3 river outlets (all important). Hunting for seals and guillemots. Tourism: climbing on coastal mountains.
R 59_29	Fishery for Atlantic halibut, salmon (important) and redfish. Hunting for guillemots, seals and fin and minke whales.
R 60_32	Fishery for salmon (important), capelin, lumpsucker, Arctic char at the coast and in 3 (2 important) river outlets. Hunting for polar bear, seals and guillemots. Tourist attraction at Ikigaat and Narsamijit and climbing on coastal mountain.

Species occurrence

Ar60028	3 rivers with Arctic char and small important coastal fishing area.
Ar60032	3 rivers with Arctic char and important coastal fishing area.
Ha59021	Harbour seal habitat, all year incl. whelping.
Tu59021	1 colony with breeding northern fulmars.

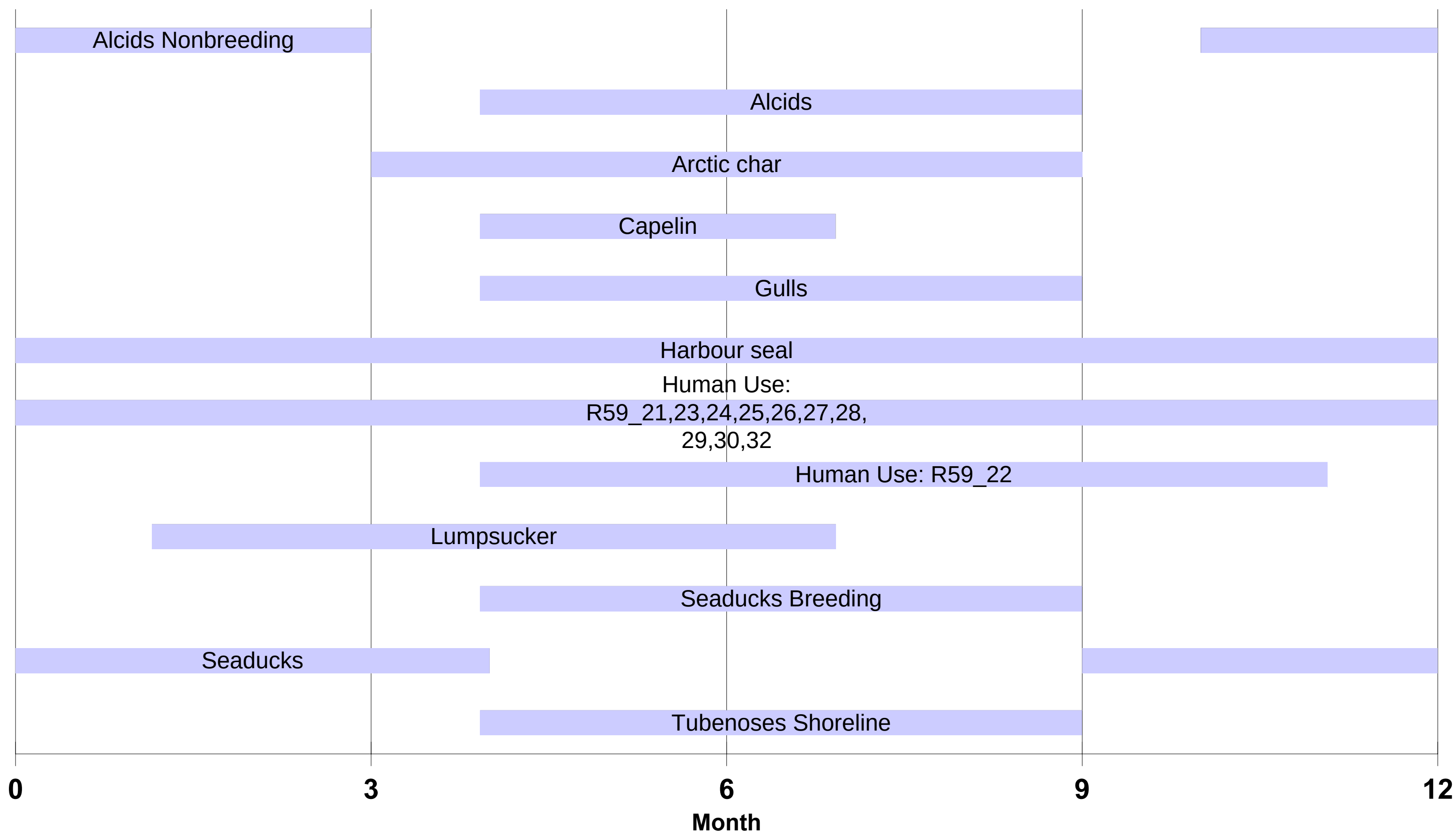
Site specific species occurrence (seabird breeding colonies); blue icons

Al1037	Breeding black guillemots.
Gu1039	Breeding Iceland gulls.
Sb1042	Breeding common eiders.
Tu1038	Breeding northern fulmars.

Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
59_21	45	High
59_22	12	Low
59_23	14	Low
59_24	16	Low
60_25	16	Low
60_26	25	Moderate
59_27	18	Low
60_28	28	Moderate
59_29	13	Low
59_30	18	Low
60_32	44	High

Map 5952 Species and Resource Occurrences



This page is intentionally left blank

Physical environment and logistics

Map 5952 - Kangersivasik (Cape Christian)

Access

The nearshore waters in this area are largely uncharted, the inshore waters within fjords are not charted and therefore caution should be exercised. In general, the waters offshore, nearshore and within the fjords appear to be deep, however uncharted dangers may exist. Local knowledge is essential for navigation.

The coastline in this area is strewn with islets, rocks and shoals. Local knowledge is essential for navigation.

The relatively warm West Greenland Current prevents the formation of ice through this area, except for a band along the coast west of Cape Farewell (map 5953) and in some of the fjords.

Pack ice that enters the area from Cape Farewell (February-July) may quickly scatter and dissipate in wind conditions. In some wind conditions ice may be concentrated and trapped in coastal areas, making navigation difficult. Conditions can change quickly and should be considered prior to inshore navigation. This ice is termed ‘Storis’.

The prevailing current sets to the NW waters along the coast. Tidal streams run SE/NW at rates up to 2 knots.

There is no other information on tides or currents within fjords for this area.

The settlement of Narsaq Kujalleq (Frederiksdal) has general depths of 3.5 m. Several anchorages with depths to 26 m are available. There is a small pier with depths alongside of 1.0 m and a height above mean water of 1 m. Small mobile cranes, fuel and fresh water are available in the port. Ice can be carried in by wind and tidal streams and block the harbour.

Shorelines in this area are exclusively rock allowing little opportunity for marine access. There is no information to indicate the potential for beach landings.

There are no airports on this or adjoining maps. The nearest airport is at Narsarsuaq (map 6106), and there is a heliport at Nanortalik (map 6002).

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow, nearshore waters, which may exist within the fjords and coastal islands on this map. The waters appear to be deep, but as they are uncharted, soundings should be taken to confirm their depth prior to using dispersants.

Offshore countermeasures represent the only practical method of protecting most shoreline areas.

The main entrances to the fjords on this map are generally too wide to consider exclusion booming. Exclusion booming to reduce the extent of inshore contamination should be considered at three possible locations. The inlet at the head of Narsap Saqqaa is 700 m wide, and the two inlets east of Torsukattak have widths of 400 and 700 m respectively. All three locations have rock shorelines and appear to have deep water. Site surveys at the time of a spill will be required to confirm the feasibility of booming techniques. Although there is no information on currents for this area, high tidal velocities are possible given the reported tidal range and may prevent successful booming.

Shorelines shown on this map are predominantly exposed and semi-exposed rock, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marinebased given the likely nature of the shoreline.

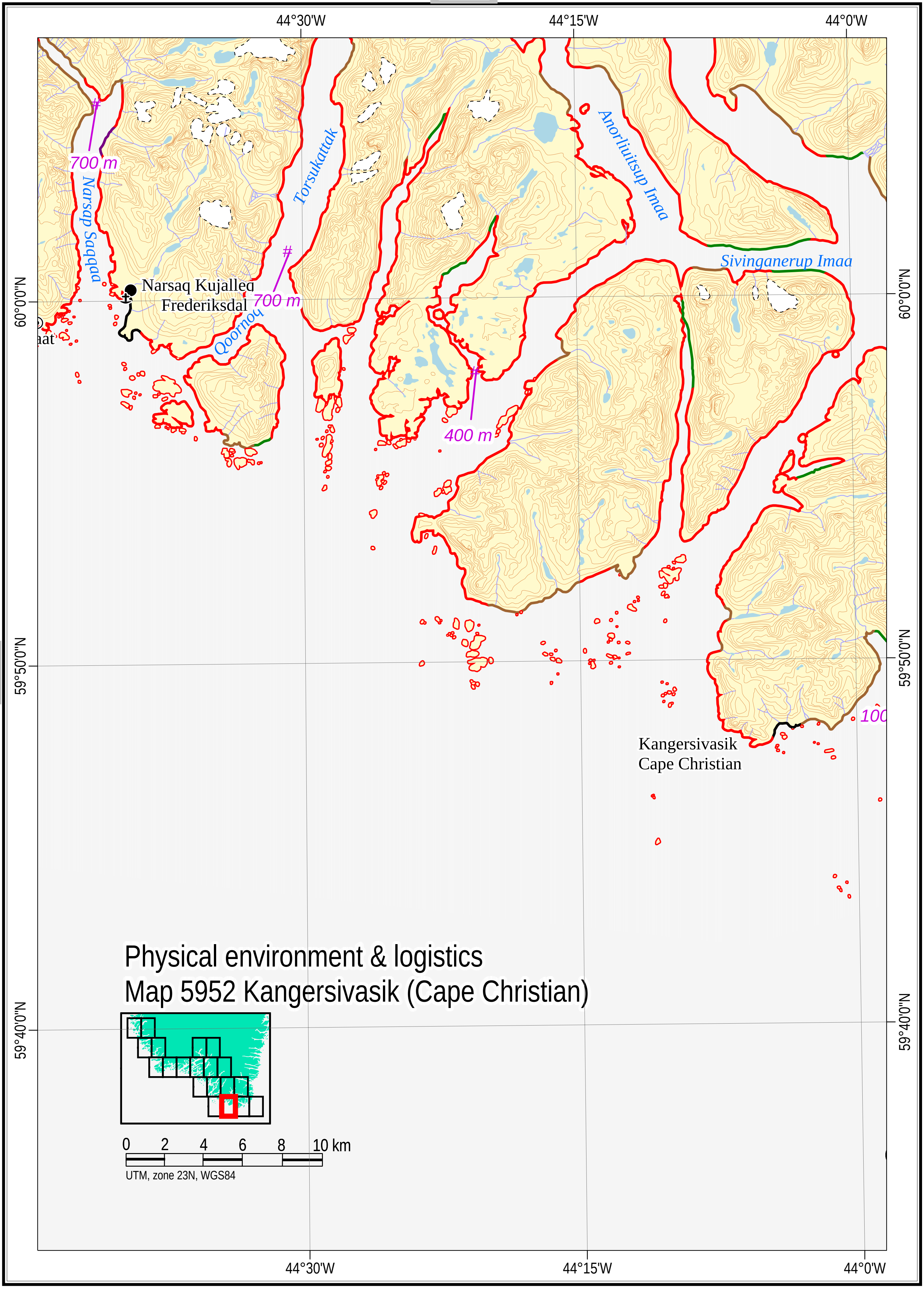
Safe havens

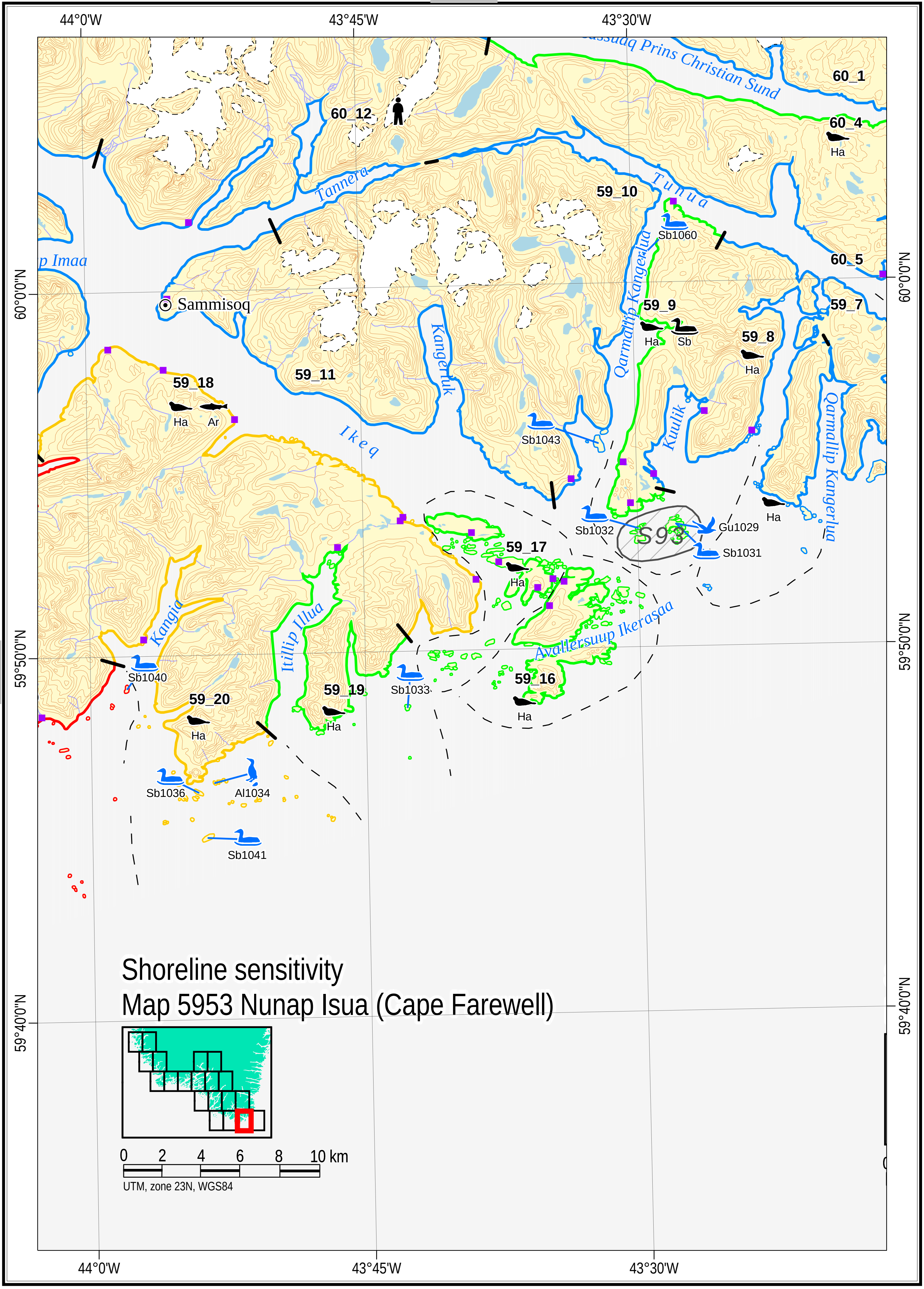
The first inlet to the east of Torsukattaq could be investigated for its suitability as a safe haven for vessel lightering operations given its moderate sensitivity and good shelter. The inlet appears to be deep, however only a single track of mid-channel soundings is known: local knowledge and reconnaissance at the time of a spill would be required. If tidal currents are sufficiently low, booms could be deployed across the inner portions of the bay to contain any further release of oil.

Maps

Danish Survey & Cadastre (KMS) topographical map: 59 V.1. Nautical charts: 1100, 1103, 2100.

Airphoto keymap
Map legend
Toggle maps
Keymaps




44°0'W
43°45'W
43°30'W
60°0'0"N
59°50'0"N
59°40'0"N
Prins Christian Sund
60_1
60_4
60_5
60_12
59_10
59_9
59_7
59_8
59_11
59_18
59_17
59_16
59_19
59_20
Tannera
Tunua
Sammisoq
Kangerluk
Qarmalip Kangerlua
Kuulik
Qarmallip Kangerlua
Ikeq
Kangia
Itillip Illua
Avallersuup Ikerasaa
Ha
Sb
Ar
Sb1060
Sb1043
Sb1032
Gu1029
Sb1031
Sb1040
Sb1033
Sb1036
Al1034
Sb1041
S93
Shoreline sensitivity
Map 5953 Nunap Isua (Cape Farewell)
0 2 4 6 8 10 km
UTM, zone 23N, WGS84

Shoreline sensitivity

Map 5953 - Nunap Isua (Cape farewell)

Environmental description

Resource use

R 60_12	Fishery for Greenland halibut, redfish and Arctic char in 1 river outlet (important). Hunting for harp seals.

Species occurrence

Ar59018	2 rivers with Arctic char.
Ha59007, Ha59016	Harbour seal habitat all year incl. whelping.
Ha59008, Ha59009	Harbour seal habitat.
Ha59017, Ha59018	Habour seal habitat, all year incl. whelping.
Ha59019, Ha59020	Habour seal habitat, all year incl. whelping.
Sb59009	One colony with breeding common eiders (**S93**).

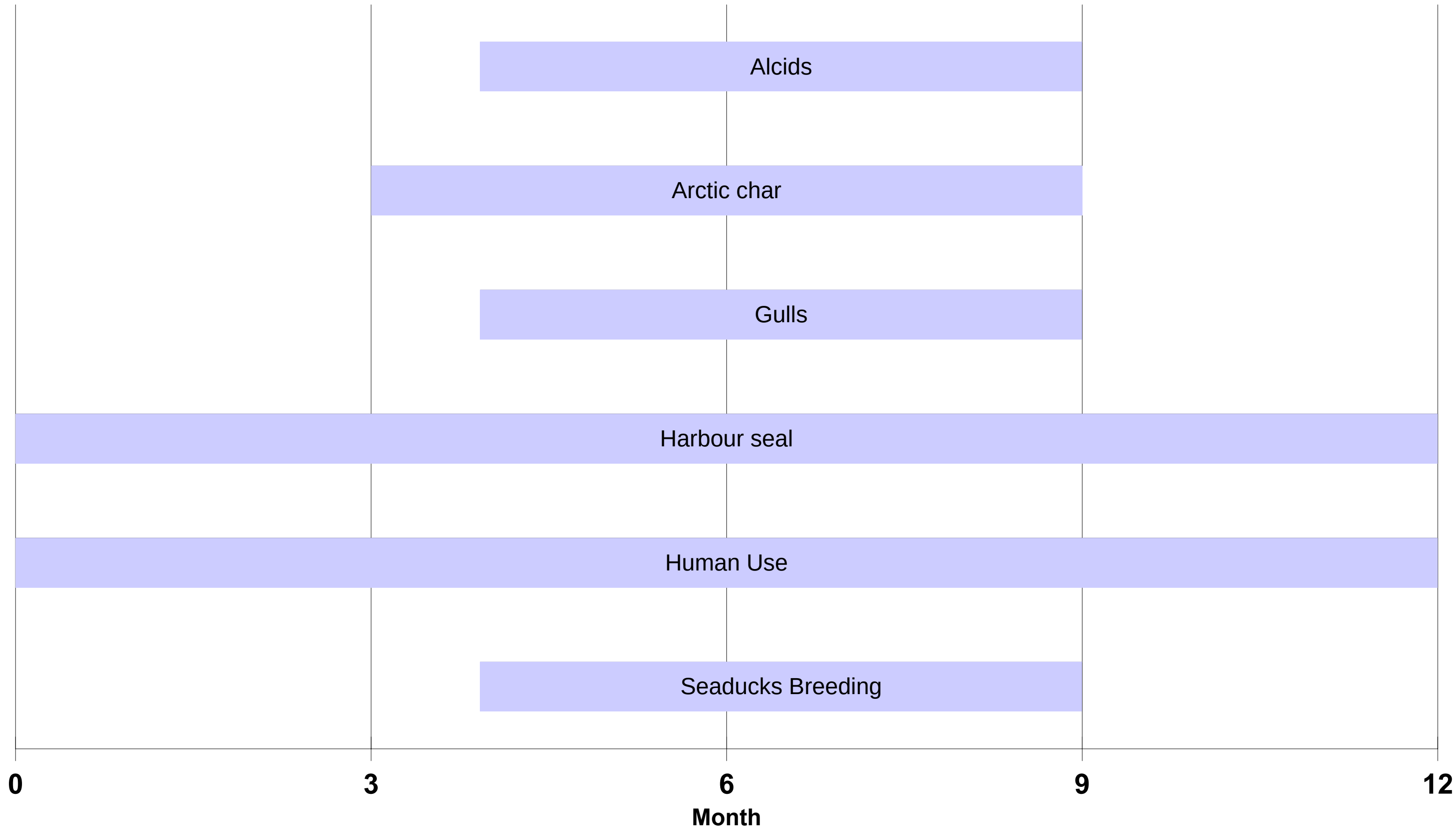
Site specific species occurrence (seabird breeding colonies); blue icons

Al1034	Breeding razorbills and black guillemots.
Gu1029	Breeding glaucous gulls and great black-backed gulls.
Sb1031, Sb1032	Breeding common eiders (**S93**).
Sb1033, Sb1036	Breeding common eiders.
Sb1040, Sb1041	Breeding common eiders.
Sb1043, Sb1060	Breeding common eiders.

Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
60_5	12	Low
59_7	21	Low
59_8	17	Low
59_9	23	Moderate
59_10	12	Low
59_11	7	Low
60_12	15	Low
59_16	25	Moderate
59_17	31	Moderate
59_18	44	High
59_19	32	Moderate
59_20	35	High

Map 5953 Species and Resource Occurrences



This page is intentionally left blank

Physical environment and logistics Map 5953 - Nunap Isua (Cape Farewell)

Access

The nearshore waters in this area are largely uncharted, the inshore waters within fjords are not charted and therefore caution should be exercised. In general the waters offshore, nearshore and within the fjords appear to be deep, however uncharted dangers may exist. Local knowledge is essential for navigation.

The coastline in this area is strewn with islets, rocks and shoals. Local knowledge is essential for navigation.

The relatively warm West Greenland Current prevents the formation of ice through this area, except for a band along the coast west of Cape Farewell and in some of the fjords.

Pack ice that enters the area from Cape Farewell (February-July) may quickly scatter and dissipate in wind conditions. In some wind conditions ice may be concentrated and trapped in coastal areas, making navigation difficult. Conditions can change quickly and should be considered prior to inshore navigation. This ice is termed ‘Storis’.

There is no information on tides or currents within fjords for this area.

No anchorages are reported for this map area.

Shorelines in this area are almost exclusively rock allowing little opportunity for marine access. There is no information to indicate the potential for beach landings.

There are no airports on this or adjoining maps. The nearest airport is at Narsarsuaq (map 6106), and there is a heliport at Nanortalik (map 6002).

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl, and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow, nearshore waters, which may exist within the fjords and coastal islands on this map. The waters appear to be deep, but as they are uncharted, soundings should be taken to confirm their depth prior to using dispersants.

Offshore countermeasures represent the only practical method of protecting most shoreline areas, including the selected area shown on the map.

The main entrances to the fjords on this map are generally too wide to consider exclusion booming. Exclusion booming to reduce the extent of inshore contamination should be considered at three possible locations. The inlet east of Sammisoq has a width of 500 m, Kangerluk inlet has a width of 900 m and Kangia one of 1,000 m. All three locations have rock shorelines and appear to have deep water. Site surveys at the time of a spill will be required to confirm the feasibility of booming techniques. High tidal velocities are possible given the reported tidal range and may prevent successful booming.

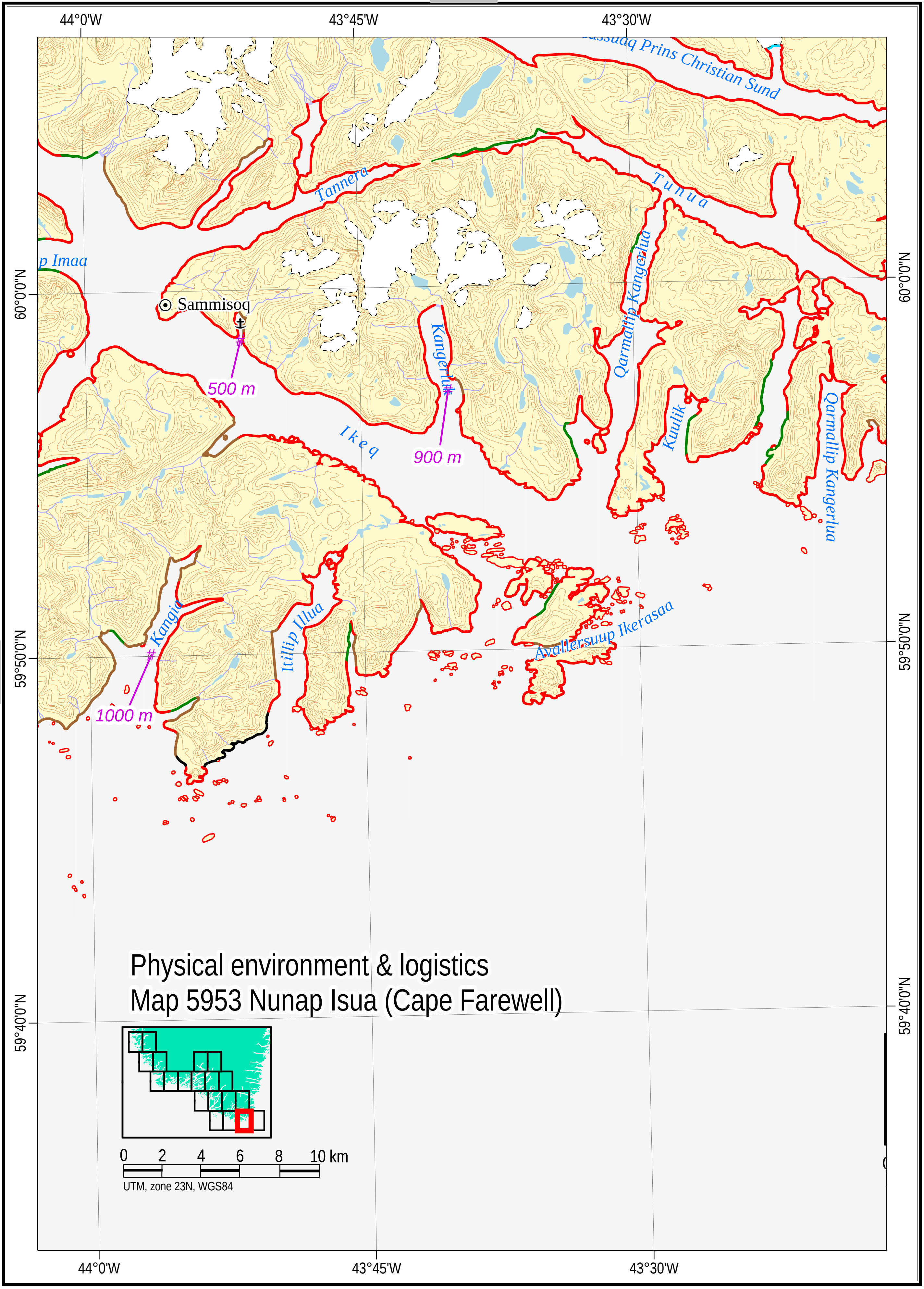
Shorelines shown on this map are predominantly exposed and semi-exposed rock, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marinebased given the likely nature of the shoreline.

Safe havens

The inlet (Kangerlutsiaq) 5 km east of Sammisoq is in an area of low sensitivity, and could be investigated for its suitability as a safe haven for vessel lightering operations. The fjord is not charted: site surveys would be required at the time of a spill to assess its suitability. If local knowledge suggests that tidal currents are sufficiently low, booms could be deployed across its entrance (500 m width) to contain any further release of oil.

Maps

Danish Survey & Cadastre (KMS) topographical map: 59 V.1. Nautical charts: 1100, 1103, 2100.



Physical environment & logistics
Map 5953 Nunap Isua (Cape Farewell)

0 2 4 6 8 10 km

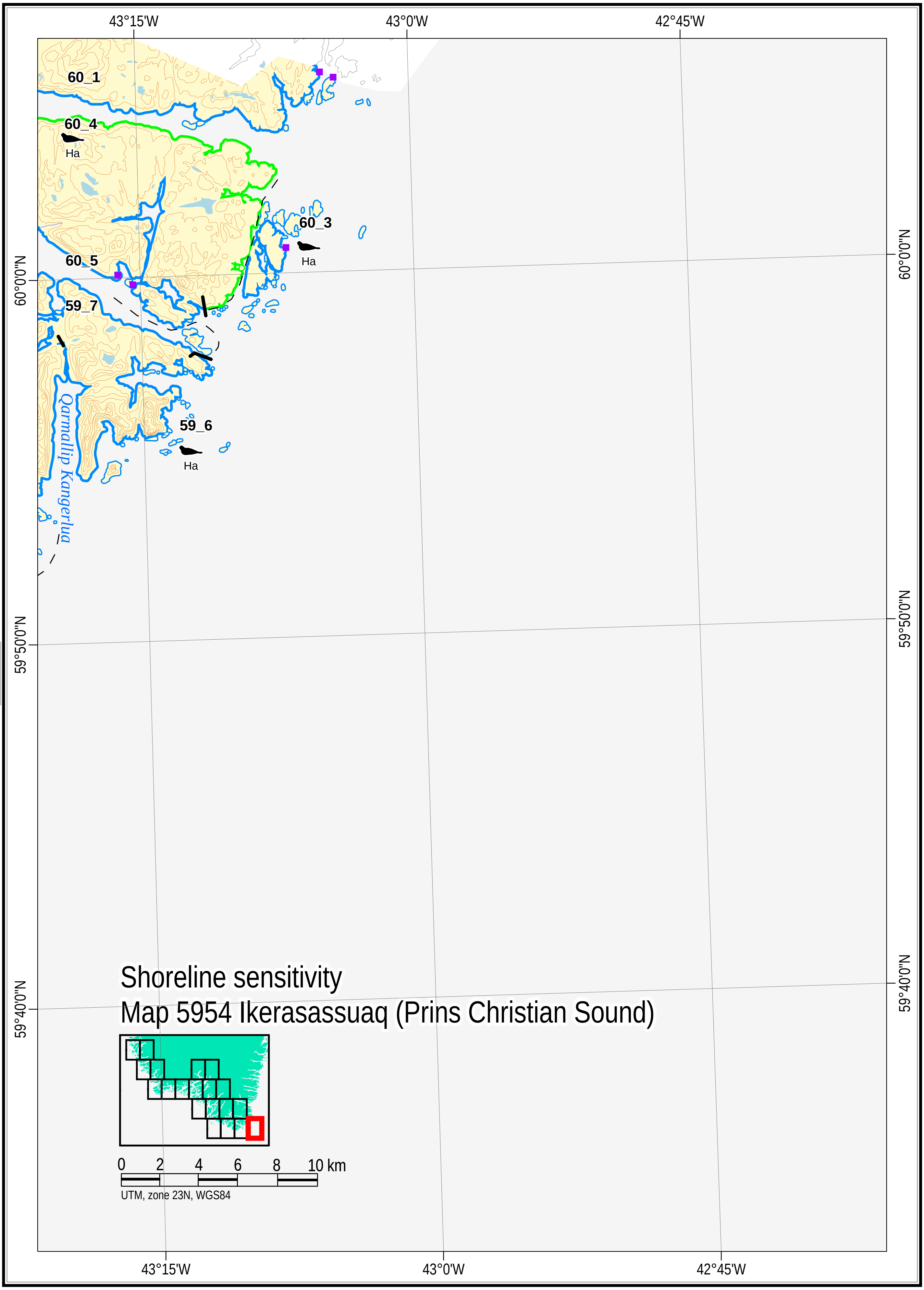
UTM, zone 23N, WGS84

Airphoto keymap

Map legend

Toggle maps

Keymaps



Shoreline sensitivity
Map 5954 Ikerasassuaq (Prins Christian Sound)

Shoreline sensitivity

Map 5954 - Ikerasassuaq (Prins Christian Sound)

Environmental description

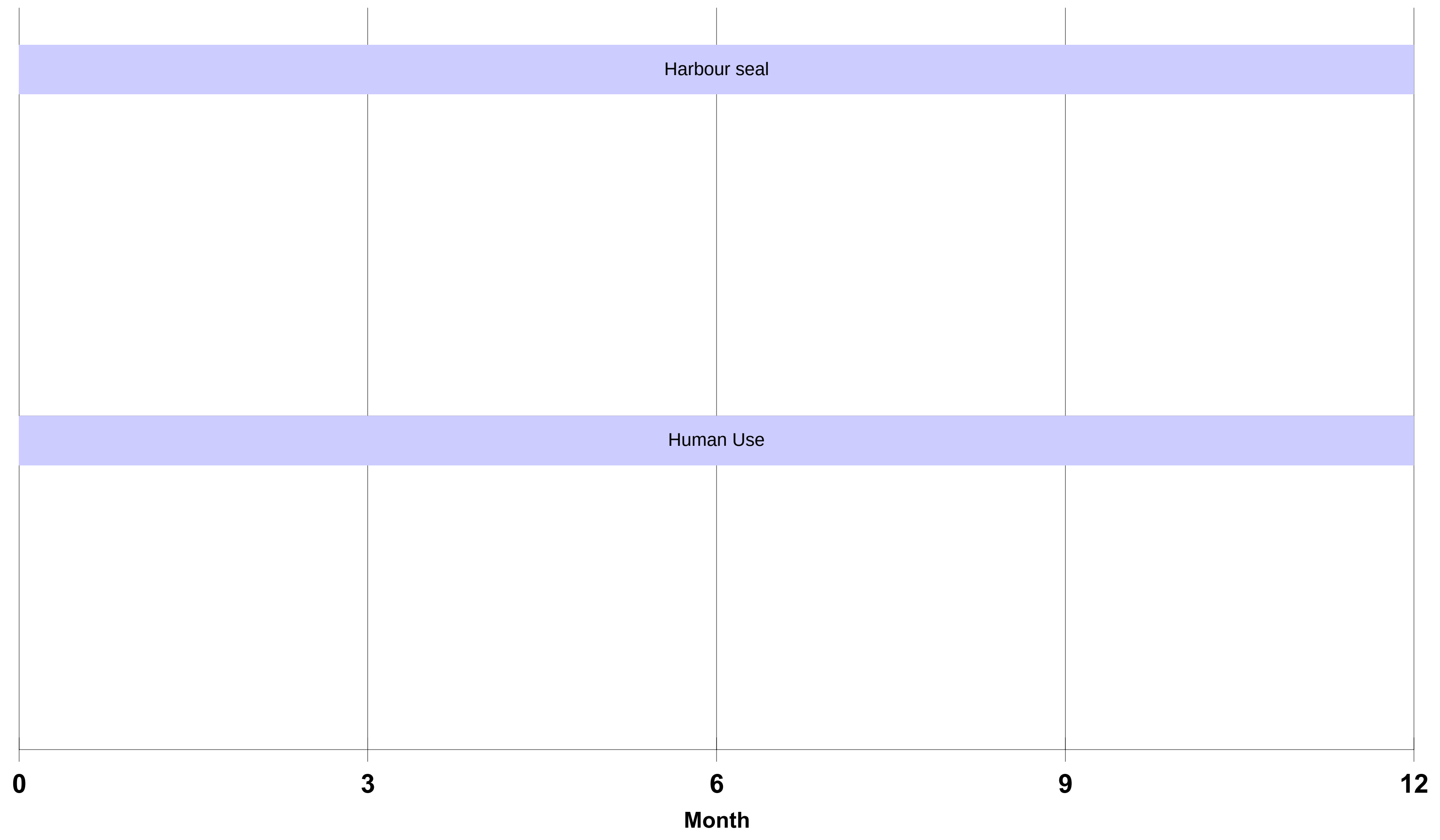
Species occurrence

Ha59006	Harbour seal habitat, all year and whelping.
Ha60003	Harbour seal habitat, all year and whelping.
Ha60004	Harbour seal habitat, all year and whelping.

Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
60_3	21	Low
60_4	25	Moderate
59_6	20	Low

Map 5954 Species and Resource Occurrences



This page is intentionally left blank

Physical environment and logistics Map 5954 - Ikerasassuaq (Prins Christian Sound)

Access

The nearshore waters in this area are largely uncharted, the inshore waters within fjords are not charted and therefore caution should be exercised. In general the waters offshore, nearshore and within the fjords appear to be deep, however uncharted dangers may exist. Local knowledge is essential for navigation.

The coastline in this area is strewn with islets, rocks and shoals. Local knowledge is essential for navigation.

The relatively warm West Greenland Current prevents the formation of ice through this area, except for a band along the coast west of Cape Farewell and in some of the fjords.

Pack ice that enters the area from Cape Farewell (February-July) may quickly scatter and dissipate in wind conditions. In some wind conditions ice may be concentrated and trapped in coastal areas, making navigation difficult. Conditions can change quickly and should be considered prior to inshore navigation. This ice is termed 'Storis'.

There is no information on tides or currents within fjords for this area.

No anchorages are reported for this map area.

Shorelines in this area are almost exclusively rock allowing little opportunity for marine access. There is no information to indicate the potential for beach landings.

There are no airports on this or adjoining maps. The nearest airport is at Narsarsuaq (map 6106), and there is a heliport at Nanortalik.

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl, and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow nearshore waters, which may exist within the fjords and coastal islands on this map. The waters appear to be deep, but as they are uncharted soundings should be taken to confirm their depth prior to using dispersants.

Offshore countermeasures represent the only practical method of protecting most shoreline areas.

Exclusion booming to reduce the extent of inshore contamination should be considered at two possible locations. The entrance to Prins Christian Sound has a width of 800 m and the fjord 12 km to the south has two channels, each with a width of 400 m. Both locations have rock shorelines and appear to have deep water. Site surveys at the time of a spill will be required to confirm the feasibility of booming techniques. High tidal velocities are possible given the reported tidal range and may prevent successful booming.

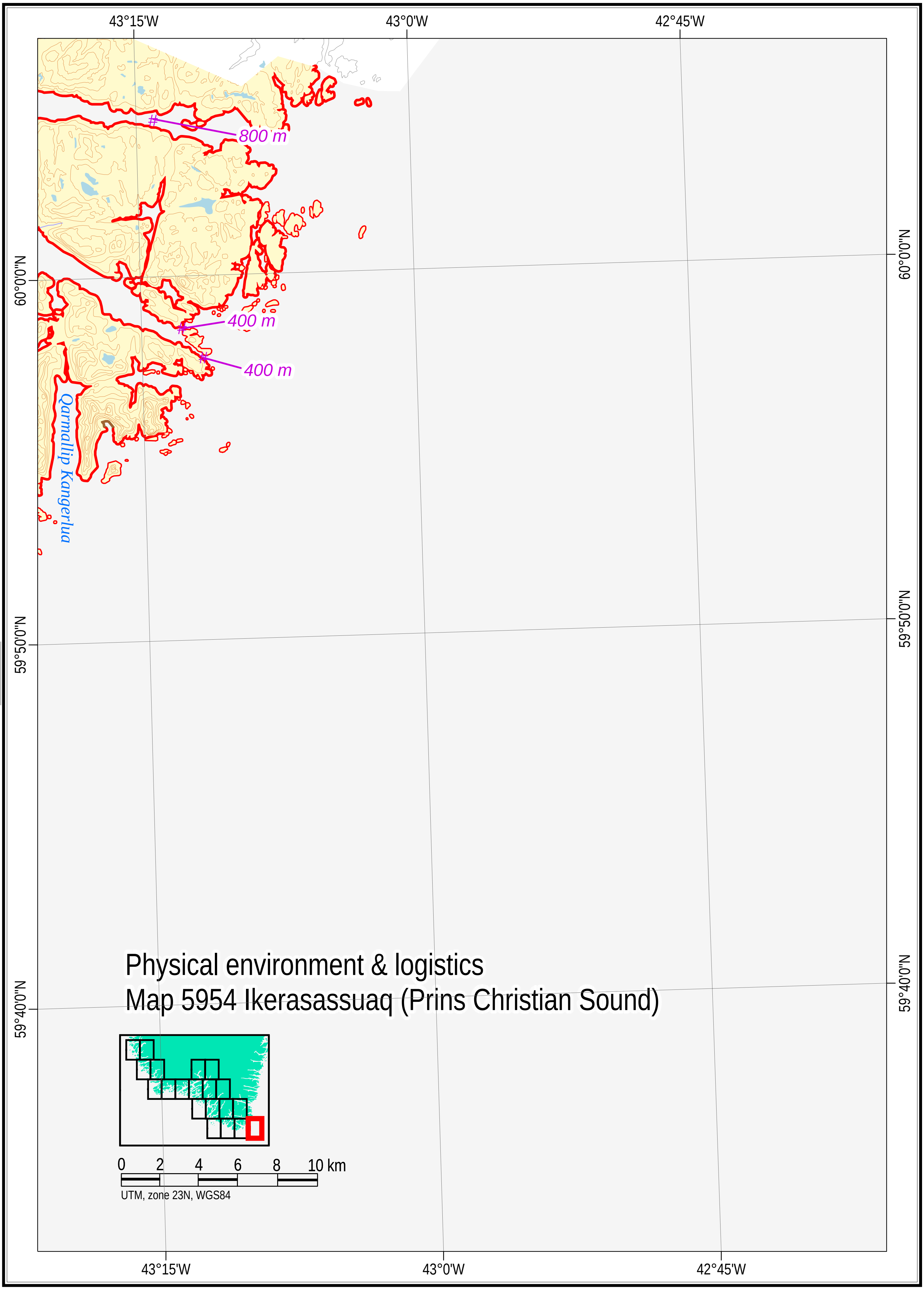
Shorelines shown on this map are exposed and semi-exposed rock, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marine-based given the likely nature of the shoreline.

Safe havens

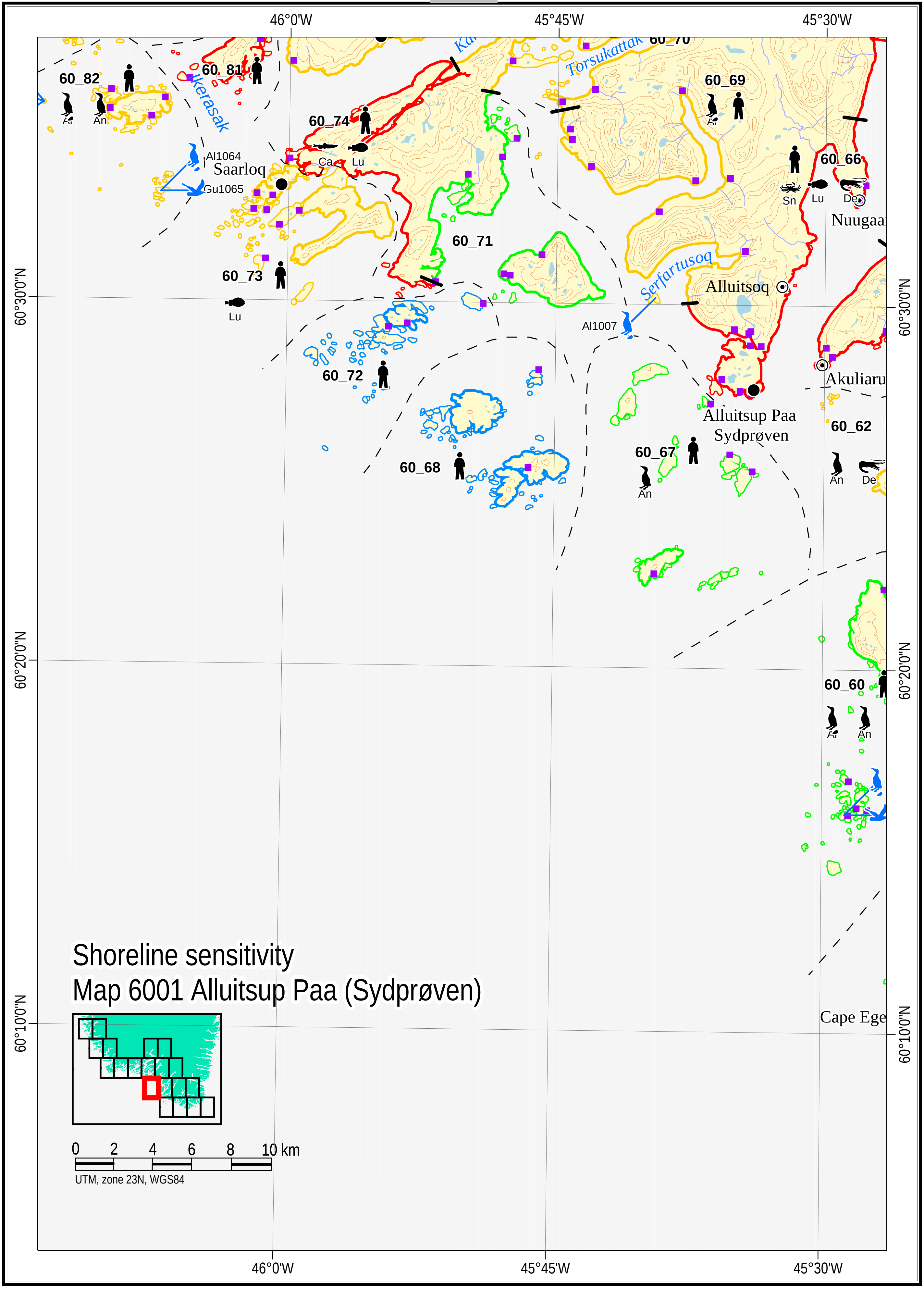
There are no potential safe havens identified on this map.

Maps

Danish Survey & Cadastre (KMS) topographical map: 59 V.1. Nautical charts: 1103, 2100, 2130.



Physical environment & logistics
Map 5954 Ikerasassuaq (Prins Christian Sound)


46°0'W
45°45'W
45°30'W
60°30'0"N
60°20'0"N
60°10'0"N
60_82
60_81
60_74
60_73
60_72
60_71
60_70
60_69
60_68
60_67
60_66
60_62
60_60
Kerasak
Torsukattak
Serfartusoq
Saarloq
Al1064
Gu1065
Al1007
Ca
Lu
An
Sn
De
Nuugaa
Alluitsoq
Akuliaru
Alluitsup Paa
Sydprøven
Cape Ege
Shoreline sensitivity
Map 6001 Alluitsup Paa (Sydprøven)
0 2 4 6 8 10 km
UTM, zone 23N, WGS84

Shoreline sensitivity

Map 6001 - Alluitsup Paa (Sydprøven)

Environmental description

Resource use

R 60_66	Fishery for salmon (important), wolffish, Greenland cod, Greenland halibut, deep sea shrimp, snow crab, capelin, lumpsucker (important), redfish and Arctic char in 1 river outlet. Hunting for eiders, fin and minke whales, harp seals, guillemots and polar bears. Tourist attractions at Alluitsup Paa and Lichtenau.
R 60_67	Fishery for salmon (important), Greenland cod, deep sea shrimp and snow crab. Hunting for fin and minke whales (important), harp seals and hooded seals. Tourist recreational area.
R 60_68	Fishery for Greenland cod, salmon and snow crab. Hunting for fin and minke whales, hooded seals (important) and harp seals.
R 60_69	Fishery for deep sea shrimp, snow crab, Greenland cod and salmon (important). Hunting for harp seals.
R 60_72	Fishery for Greenland cod, Atlantic cod and snow crab. Hunting for hooded seals and harp seals.
R 60_73	Fishery for lumpsucker and Atlantic cod. Hunting for fin and minke whales, hooded seals and harp seals.
R 60_74	Fishery for deep sea shrimp, capelin, lumpsucker and Atlantic cod. Hunting for fin and minke whales and harp seals.
R 60_82	Fishery for Atlantic cod and redfish. Hunting for fin and minke whales, hooded seals and harp seals.

Species occurrence

Al60069	1 colony with breeding black guillemots.
Al60082	1 colony with breeding razorbills, black guillemots and Atlantic puffins and 1 with black guillemots.
An60067, An60082	Black and Brünnich's guillemots in winter.
Ca60074	Capelin spawning and fishing area in narrow fjord and east of Saarloq.
De60066	Important fishery for deep sea shrimp.
Lu60066	Lumpsucker spawning and important fishing grounds along most of the coast.
Lu60073	Lumpsucker spawning and important fishing grounds along many coasts.
Lu60074	Lumpsucker spawning and important fishing grounds at Kangerluarsorujuk coast.
Sn60066	Snow crab fishing area.

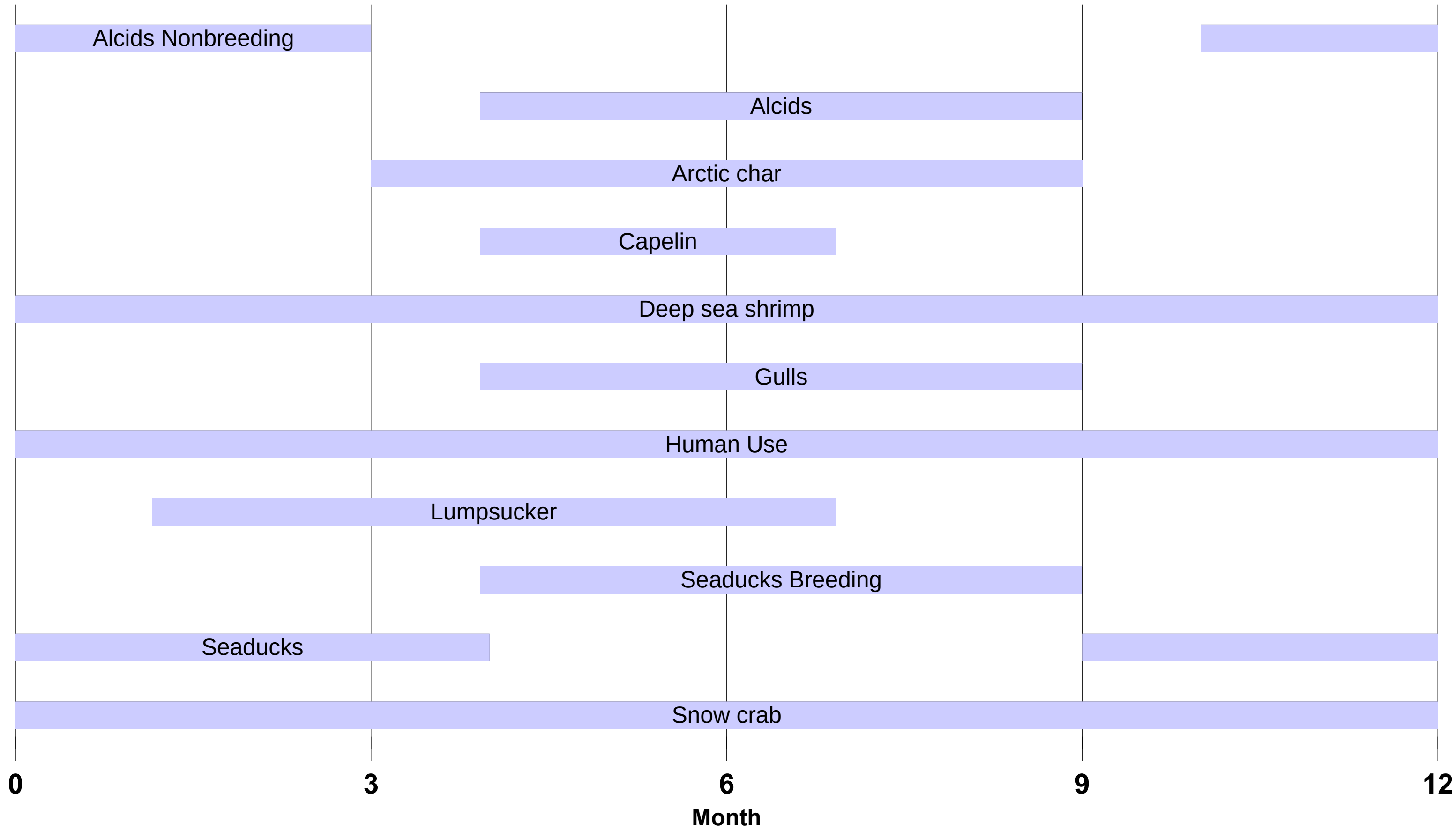
Site specific species occurrence (seabird breeding colonies); blue icons

Al1007, Al1064	Breeding black guillemots.
Gu1065	Breeding lesser black-backed gulls, great black-backed gulls and Arctic terns.

Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
60_66	46	Extreme
60_67	28	Moderate
60_68	14	Low
60_69	41	High
60_71	26	Moderate
60_72	20	Low
60_73	40	High
60_74	46	Extreme
60_82	43	High

Map 6001 Species and Resource Occurrences



This page is intentionally left blank

Physical environment and logistics

Map 6001 - Alluitsup Paa (Sydprøven)

Access

The nearshore waters in this area are largely uncharted and caution should be exercised. Reported depths in fjords are unknown except for a single track of mid-channel soundings. In general the waters offshore, nearshore and within the fjords appear to be deep, however uncharted dangers may exist. Local knowledge is essential for navigation.
The relatively warm West Greenland Current prevents the formation of ice through this area, except for a band along the coast west of Cape Farewell (map 5953) and in some of the fjords.

Pack ice that enters the area from Cape Farewell may quickly scatter and dissipate in wind conditions. In some wind conditions, ice may be concentrated and trapped in coastal areas, making navigation difficult. Conditions can change quickly and should be considered prior to inshore navigation. This ice is termed ‘ Storis’.

The prevailing current sets to the NW waters along the coast. Tidal streams run SE/NW at rates up to 2 knots. There is no other information on tides or currents within fjords for this area.

Tides at Alluitsup Paa and Saarloq have a maximum height of 3.0 to 3.5 m.

Alluitsup Paa, the largest settlement in the area, has anchorage for vessels to 40 m length and 3.0 m draft. A jetty at Qarsorsat has depths alongside of 2.0 to 3.0 m and a height above mean water of 1.0 m.

Anchorage can be made in Zakarias Havn, the narrow inlet 3 km NNW of Alluitsup Paa/ with depths of 12 to 14 m. Fresh water can be obtained from the river north of the anchorage.

The settlement of Saarloq has a jetty with depths alongside of 2.0 m and a height above mean water of 1.0 m. Shorelines in this area are almost exclusively rock allowing little opportunity for marine access. There is no information to indicate the potential for beach landings.

The possibility of beach landings could be explored within smaller fjords where beach and moraine shorelines exist; reconnaissance would be required to confirm access.

There are no airports on this or adjoining maps. The nearest airport is at Narsarsuaq (map 6106), and there are heliports at Nanortalik (map 6002) and Qaqortoq (map 6054).

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl, and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow nearshore waters, which may exist within the fjords and coastal islands on this map. The waters appear to be deep, but as they are uncharted, soundings should be taken to confirm their depth prior to using dispersants.

Offshore countermeasures represent the only practical method of protecting most shoreline areas.

The main entrances to the fjords on this map are generally too wide to consider exclusion booming. Exclusion booming to reduce the extent of inshore contamination should be considered at three possible locations. At Akulleq north of Alluitsup Paa/ the inlet width is 800 m. At Umannarsuup Tunua just east of Saarloq the south entrance has a width of 600 m and the west entrance has two channels each 100 m wide. Both locations have rock shorelines and appear to have deep water. Site surveys at the time of a spill will be required to confirm the feasibility of booming techniques. High tidal velocities are possible given the reported tidal range and may prevent successful booming.

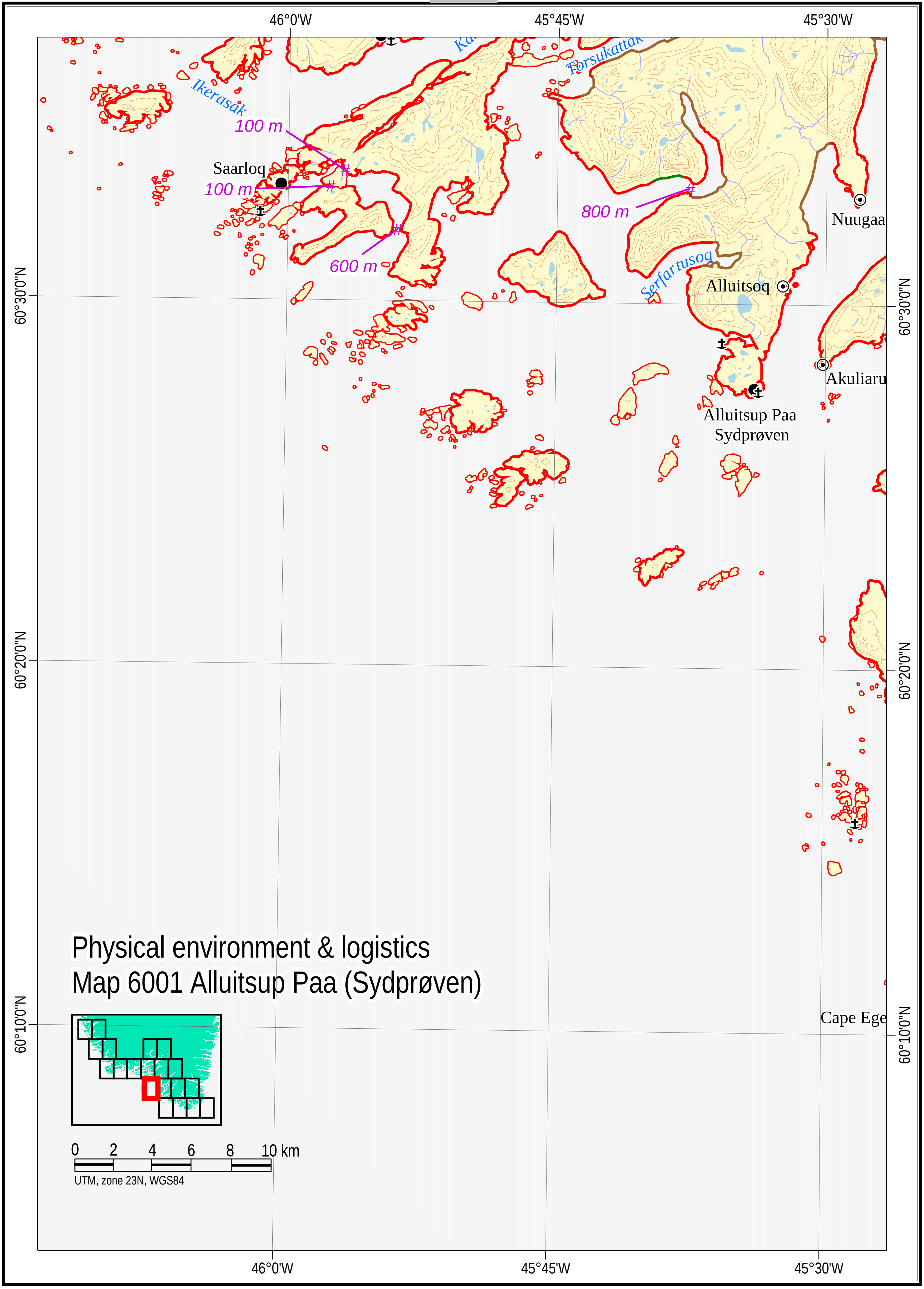
Shorelines shown on this map are predominantly exposed and semi-exposed rock, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marinebased given the likely nature of the shoreline.

Safe havens

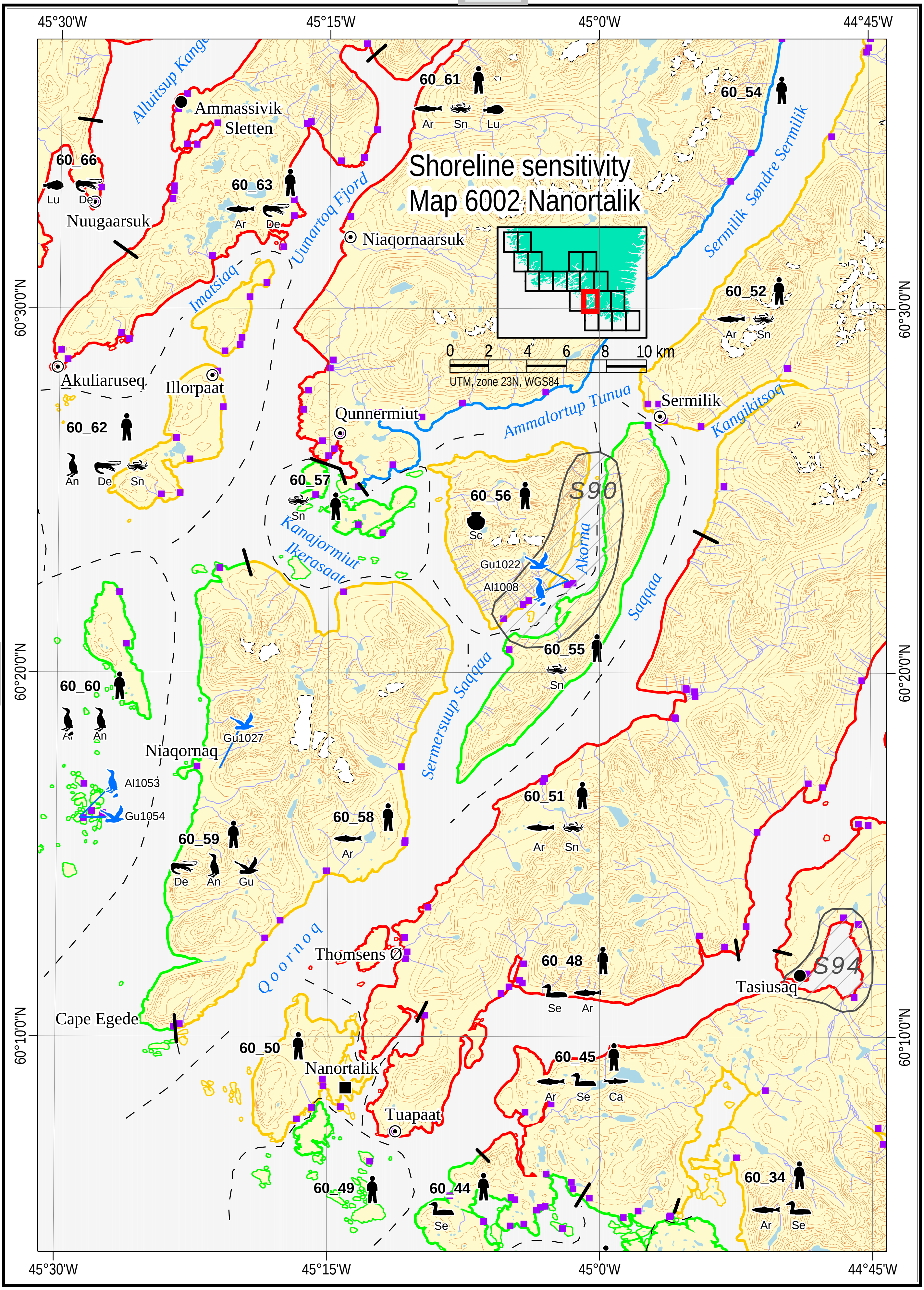
There are no potential safe havens identified on this map. The anchorage at Umannarsuup Tunua could be considered as a potential safe haven but the inlet has a moderate to high sensitivity rating.

Maps

Danish Survey & Cadastre (KMS) topographical maps: 60 V.1and V.2. Nautical charts: 1100,1113, 1114.



Physical environment & logistics
Map 6001 Alluitsup Paa (Sydprøven)


Shoreline sensitivity
Map 6002 Nanortalik
45°30'W
45°15'W
45°0'W
44°45'W
60°30'0"N
60°20'0"N
60°10'0"N
0 2 4 6 8 10 km
UTM, zone 23N, WGS84
Alluitsup Kangerlua
Ammassivik
Sletten
60_66
Lu
De
Nuugaarsuk
60_63
Ar
De
Unartoq Fjord
Niaqornaarsuk
60_61
Ar
Sn
Lu
60_54
Sermilik Søndre Sermilik
Imatsiaq
60_52
Ar
Sn
Akuliaruseq
Illorpaat
Qunnermiut
Ammalortup Tunua
Sermilik
Kangikitsoq
60_62
An
De
Sn
60_57
Sn
60_56
Sc
S90
Kanajormiut
Ikerasaat
Gu1022
Al1008
Akorna
Saqqaa
60_55
Sn
60_60
Ar
An
Niaqornaq
Gu1027
Sermersuup Saqqaa
Al1053
Gu1054
60_51
Ar
Sn
60_58
Ar
60_59
De
An
Gu
Qoornoq
Thomsens Ø
60_48
Se
Ar
S94
Tasiusaq
Cape Egede
60_50
Nanortalik
60_45
Ar
Se
Ca
Tuapaat
60_49
60_44
Se
60_34
Ar
Se

Environmental description

Resource use

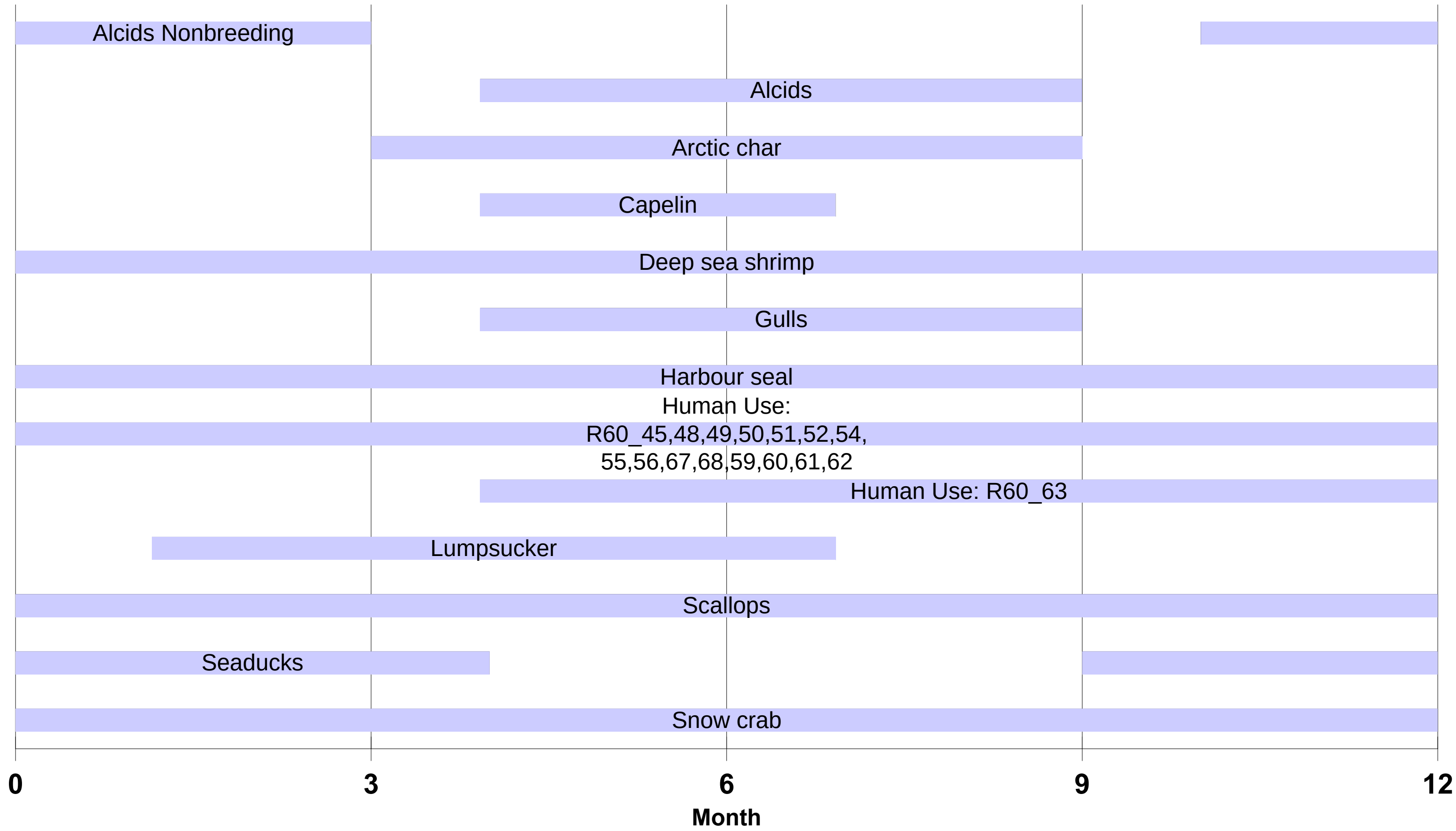
R 60_45	Fishery for salmon, wolffish (important), Atlantic cod, Greenland cod, Greenland halibut, capelin, lumpsucker and Arctic char at the coast and in 4 river outlets (all important) (**S94**). Hunting for harp seals. Tourist attraction at Tasiusaq (**S94**).
R 60_48	Fishery for wolffish (important), Greenland halibut, salmon, Greenland cod, lumpsucker, deep sea shrimp and Arctic char in 2 river outlets (important). Hunting for polar bears, harp seals, eiders and guillemots.
R 60_49	Fishery for Atlantic halibut and salmon (important). Hunting for guillemots, eiders, polar bears and hooded seals.
R 60_50	Fishery for salmon (important), Greenland cod, wolffish and Atlantic halibut. Hunting for guillemots, eiders and polar bears. Tourist attractions in town.
R 60_51	Fishery for salmon, Atlantic halibut, wolffish, Atlantic cod, Greenland cod, scallop, snow crab, lumpsucker and Arctic char at the coast and in 3 river outlets (all important). Hunting for guillemots, eiders and harp seals. Tourist attraction and angling at and near Nalunaq Gold Mine.
R 60_52	Fishery for Atlantic halibut, capelin, Greenland halibut (important), Atlantic cod, Greenland cod, snow crab, Arctic char at the coast and in 3 river outlets (2 important). Hunting for guillemots, eiders and harp seals. Tourist angling site in Kangikitsoq.
R 60_54	Fishery for Greenland halibut (important), Greenland cod and Arctic char at coast and snow crab. Hunting for guillemots, eiders and harp seals.
R 60_55	Fishery for scallop, salmon, Atlantic halibut, Atlantic cod, Greenland cod, snow crab and coastal Arctic char. Hunting for guillemots, eiders and harp seals. Tourist attraction at Amitsoq.
R 60_56	Fishery for Greenland cod, scallop and snow crab. Hunting for guillemots, eiders, harp seals.
R 60_57	Fishery for scallop, wolffish, salmon, Greenland cod, snow crab and deep sea shrimp. Hunting for polar bears.
R 60_58	Fishery for salmon, wolffish, Atlantic cod, Greenland cod, deep sea shrimp, snow crab and Arctic char at the coast and in 3 river outlets (1 important). Hunting for guillemots, harp seals and hooded seals. Tourist angling site.
R 60_59	Fishery for snow crab, scallop, deep sea shrimp (important), wolffish, Atlantic halibut, salmon and Arctic char in 1 river outlet. Hunting for eiders and hooded seals.
R 60_60	Fishery for salmon, Atlantic halibut and snow crab. Hunting for fin and minke whales, eiders, guillemots, hooded seals (important) and harp seals.
R 60_61	Fishery for salmon, wolffish (important), Greenland cod, Greenland halibut (important), snow crab (important), deep sea shrimp and Arctic char at the coast and in 4 river outlets (2 important). Hunting for eiders, guillemots, fin and minke whales, bearded seals, harp seals and ringed seals (important).
R 60_62	Fishery for salmon (important), Greenland halibut, wolffish, Greenland cod, deep sea shrimp and snow crab. Hunting for eiders, harp seals, fin and minke whales. Tourist attraction at Uunartoq (important).
R 60_63	Fishery for salmon (important), wolffish, Greenland cod, Greenland halibut, deep sea shrimp, snow crab and Arctic char at the coast and in 2 river outlets (both important). Hunting for eiders, guillemots, bearded seals, fin and minke whales, harp seals and ringed seals (important).

Species occurrence

Al60060	1 colony with breeding black guillemots.
An60059, An60060	Black and Brünnich's guillemots in winter.
An60062	Black and Brünnich's guillemots in winter.
Ar60045	4 rivers with Arctic char and important coastal fishing area (**S94**).
Ar60048	2 rivers with Arctic char and small important coastal fishing area.
Ar60051	3 rivers with Arctic char and important coastal fishing area.
Ar60052	3 rivers with Arctic char and important coastal fishing area.

(Continued on page 9-35)

Map 6002 Species and Resource Occurrences



Shoreline sensitivity

Map 6002 - Nanortalik

(Continued from page 9-33)

Ar60058	3 rivers with Arctic char and small, important coastal fishing area.
Ar60061	4 rivers with Arctic char and important coastal fishing areas.
Ar60063	2 rivers with Arctic char and important coastal fishing areas.
Ca60045	Capelin spawning and fishing area in Tasiusaq (**S94**)) and in fjord at Sallera.
De60059, De60062	Important deep sea shrimp fishery.
De60603	Important deep sea shrimp fishery.
Gu60059	1 colony with breeding Iceland gulls, glaucous gulls and great black-backed gulls.
Lu60061	Lumpsucker spawning grounds along almost all coasts.
Sc60056	Important scallop fishing ground.
Se60045, Se60048	Eiders in winter.
Sn60051, Sn60052	Snow crab fishing area.
Sn60055, Sn60057	Snow crab fishing area.
Sn60061, Sn60062	Snow crab fishing area.

Site specific species occurrence (seabird breeding colonies); blue icons

Al1008, Al1053	Breeding black guillemots.
Gu1022	Breeding kittiwakes, Iceland gulls and great black-backed gulls.
Gu1027	Breeding Iceland gulls, glaucous gulls and great black-backed gulls.
Gu1054	Breeding great black-backed gulls.

Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
60_45	54	Extreme
60_48	52	Extreme
60_49	27	Moderate
60_50	33	Moderate
60_51	57	Extreme
60_52	43	High
60_54	20	Low
60_55	31	Moderate
60_56	40	High
60_57	26	Moderate
60_58	40	High
60_59	28	Moderate
60_60	29	Moderate
60_61	65	Extreme
60_62	44	High
60_63	58	Extreme

Access

The nearshore waters in this area are largely uncharted and caution should be exercised. Reported depths in fjords are unknown except for a single track of mid-channel soundings. In general the waters offshore, nearshore and within the fjords appear to be deep, however uncharted dangers may exist. Local knowledge is essential for navigation.

The relatively warm West Greenland Current prevents the formation of ice through this area, except for a band along the coast west of Cape Farewell (map 5953) and in some of the fjords.
Pack ice that enters the area from Cape Farewell (February-July) may quickly scatter and dissipate in wind conditions. In some wind conditions ice may be concentrated and trapped in coastal areas, making navigation difficult. Conditions can change quickly and should be considered prior to inshore navigation.
Tides at Illorpaat have a mean high water height of 3.0 m, but can vary by up to 1 m depending on wind direction. It increase in north winds and decrease in south winds. There is no other information on currents within fjords for this area.

The harbour at the town of Nanortalik has berthing for vessels to 40 m length and 4.0 m draft, and vessels to 100 m length and 6 m draft can anchor in the bay. There is a wharf with depths alongside of 4.0 m and a height above mean water of 1.5 m. Mobile cranes, fuel and fresh water are available. Ice can block the entrance, particularly during south winds.
Sheltered anchorage is available at the north end of the channel between Thomsens Ø and the mainland.
Anchorage can be made on either side of Niaqornaq, a small peninsula 12 km north of Cape Egede on the west coast of Sermersoq. Here depths are from 7 to 14 m. Anchorage is available on the north end of Sermersoq in the bay marked Kangerlua with depths of 12 m. Fresh water is available from several rivers. Anchorage can be found among Sallit, the chain of islets west of Sermersoq, and at Qeqetarsuatsiaq, the island 3 km west of Sermersoq.

Anchorage is available at the abandoned settlement of Qunnermiut, with depths of 15 to 20 m.
Anchorage can be made at the abandoned settlement of Illorpaat at the north end of Tuttutuarsuk in depths to 12 m. A jetty has depths of 1.0 m alongside and a height above mean water of 0.8 m. There are ringbolts for stern moorings.
Anchorage is available off the settlement of Ammassivik in depths of 10 m. A jetty has depths alongside of 1.0 m and a height above mean water of 0.8 m. The jetty may be awash in NW winds. Water can be obtained from a well northeast of the settlement.

Shorelines in this area are almost exclusively rock allowing little opportunity for marine access. There is no information to indicate the potential for beach landings.
The possibility of beach landings could be explored within smaller fjords where beach and moraine shorelines exist. Reconnaissance would be required to confirm access.
There are no airports on this or adjoining maps. The nearest airport is at Narsarsuaq (map 6106), and there is a heliport at Nanortalik.

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl, and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow, nearshore waters, which may exist within the fjords on this map. The waters appear to be deep, but as they are uncharted, soundings should be taken to confirm their depth prior to using dispersants.
Offshore countermeasures represent the only practical method of protecting most shoreline areas, including the selected area shown on the map.
The main entrances to the fjords on this map are generally too wide to consider exclusion booming. Exclusion booming to reduce the extent of inshore contamination should be considered at Tasiusaq, which has an inlet width of 200 m. The entrance has a rock shoreline and appears to have deep water. Site surveys at the time of a spill will be required to confirm the feasibility of booming techniques. High tidal velocities are possible given the reported tidal range and may prevent successful booming.
Shorelines shown on this map are predominantly semi-exposed rock and moraine, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marine-based given the likely nature of the shoreline.

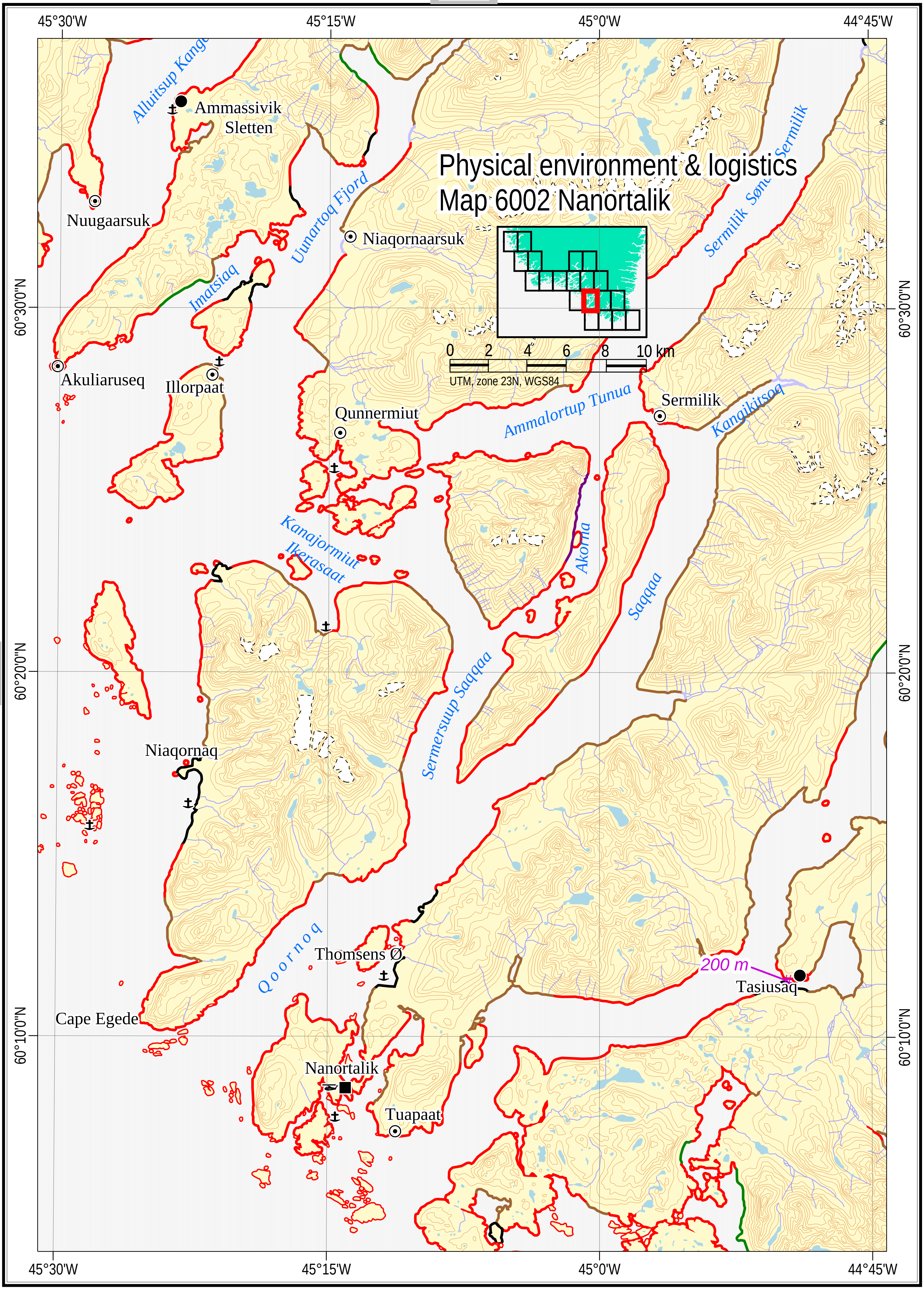
Safe havens

There are no potential safe havens identified on this map.

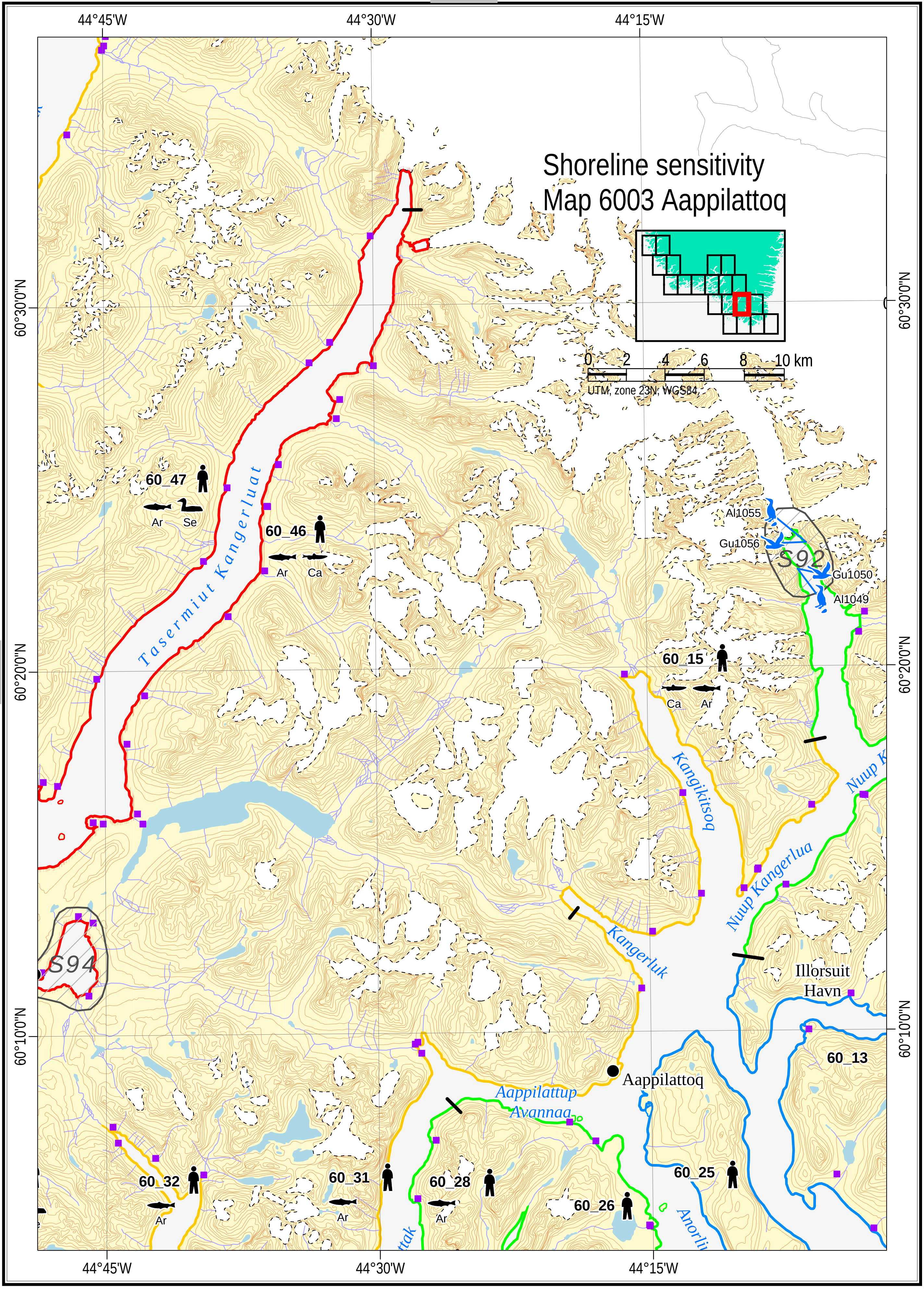
Maps

Danish Survey & Cadastre (KMS) topographical map: 60 V.2. Nautical charts: 1103, 1113, 2100.

Airphoto keymap Map legend Toggle maps Keymaps



Airphoto keymap
Map legend
Toggle maps
Keymaps



Shoreline sensitivity

Map 6003 - Aappilattoq

Environmental description

Resource use

R 60_15	Fishery for capelin (important), Greenland halibut, wolffish and Arctic char at coasts and in 2 river outlets (both important). Hunting for harp seals. Tourist hiking along coast.
R 60_31	Fishery for Greenland halibut, wolffish, redfish and Arctic char at coasts and in 3 river outlets (2 important). Hunting for fin and minke whales and guillemots. Tourist attraction at Aappilattoq.
R 60_46	Fishery for salmon, Greenland cod, Greenland halibut (important), capelin, lumpsucker, snow crab and Arctic char at coasts and in 5 river outlets (all important). Hunting for eiders, polar bears, harp seals and ringed seals (important). Tourist attractions and angling sites (important).
R 60_47	Fishery for salmon, Greenland cod, Greenland halibut (important), capelin, lumpsucker, snow crab and Arctic char at the coast and in 3 river outlets (all important). Hunting for eiders, guillemots, polar bears, harp seals and ringed seals (important). Tourist attractions at glaciers.

Species occurrence

Ar60015	2 rivers with Arctic char and small important coastal fishing areas.
Ar60031	3 rivers with Arctic char and small important coastal fishing areas.
Ar60046	6 rivers with Arctic char and important coastal fishing areas.
Ar60047	3 rivers with Arctic char and important coastal fishing areas.
Ca60015	Capelin spawning area and important fishing area in almost the entire fjord.
Ca60046	Capelin spawning areas (some also fishing areas) along most of the shores.
Se60047	Eiders in winter.

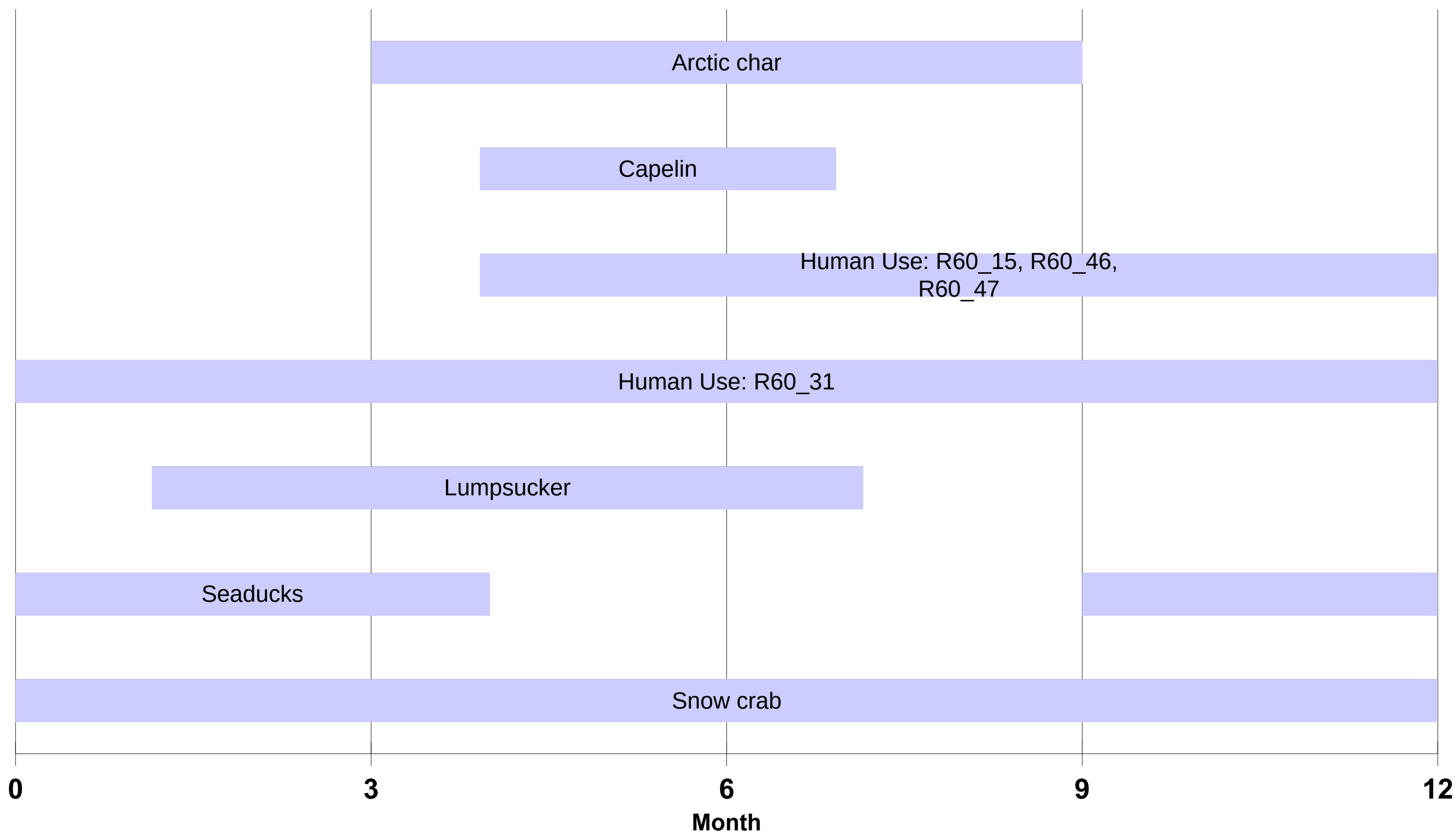
Site specific species occurrence (seabird breeding colonies); blue icons

Al1049, Al1055	Breeding black guillemots.
Gu1050	Breeding Iceland gulls, glaucous gulls and kittiwakes (**S92**).
Gu1056	Breeding Iceland gulls, glaucous gulls, kittiwakes and great black-backed gulls (**S92**).

Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
60_15	35	High
60_31	35	High
60_46	63	Extreme
60_47	49	Extreme

Map 6003 Species and Resource Occurrences



This page is intentionally left blank

Physical environment and logistics

Map 6003 - Aappilattoq

Access

There is little information on the marine areas within this map.

The nearshore waters in this area are largely uncharted and caution should be exercised. In general the waters offshore, nearshore and within the fjords appear to be deep, however uncharted dangers may exist. Local knowledge is essential for navigation.

There is no information on tides or currents within fjords for this area.

Pack ice that enters the area from Cape Farewell (February-July) may quickly scatter and dissipate in wind conditions. In some wind conditions, ice may be concentrated and trapped in coastal areas, making navigation difficult. Conditions can change quickly and should be considered prior to inshore navigation.

No anchorages are reported for this map area.

Charts indicate anchorages at the head of Kangerluk and Kangikitsoq fjords and in two other locations, but no other informations are available on these.

Shorelines in this area are predominantly rock allowing little opportunity for marine access. There is no information to indicate the potential for beach landings. Landings may be possible near the inner end of the fjords but would require reconnaissance to confirm.

There are no airports on this or adjoining maps. The nearest airport is at Narsarsuaq (map 6106), and there is a heliport at Nanortalik (map 6002).

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl, and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow, nearshore waters, which may exist within the fjords on this map. The waters appear to be deep, but as they are uncharted, soundings should be taken to confirm their depth prior to using dispersants.

Offshore countermeasures represent the only practical method of protecting most shoreline areas, including the selected area shown on the map.

The fjords on this map are generally too wide to consider exclusion booming. Exclusion booming to reduce the extent of inshore contamination should be considered at two possible locations. At both Kangerluk and at Stordalens Havn 12 km to the southwest the inlets are 800 m wide. Both locations have moraine shorelines and appear to have deep water. Site surveys at the time of a spill will be required to confirm the feasibility of booming techniques. High tidal velocities are possible given the reported tidal range and may prevent successful booming.

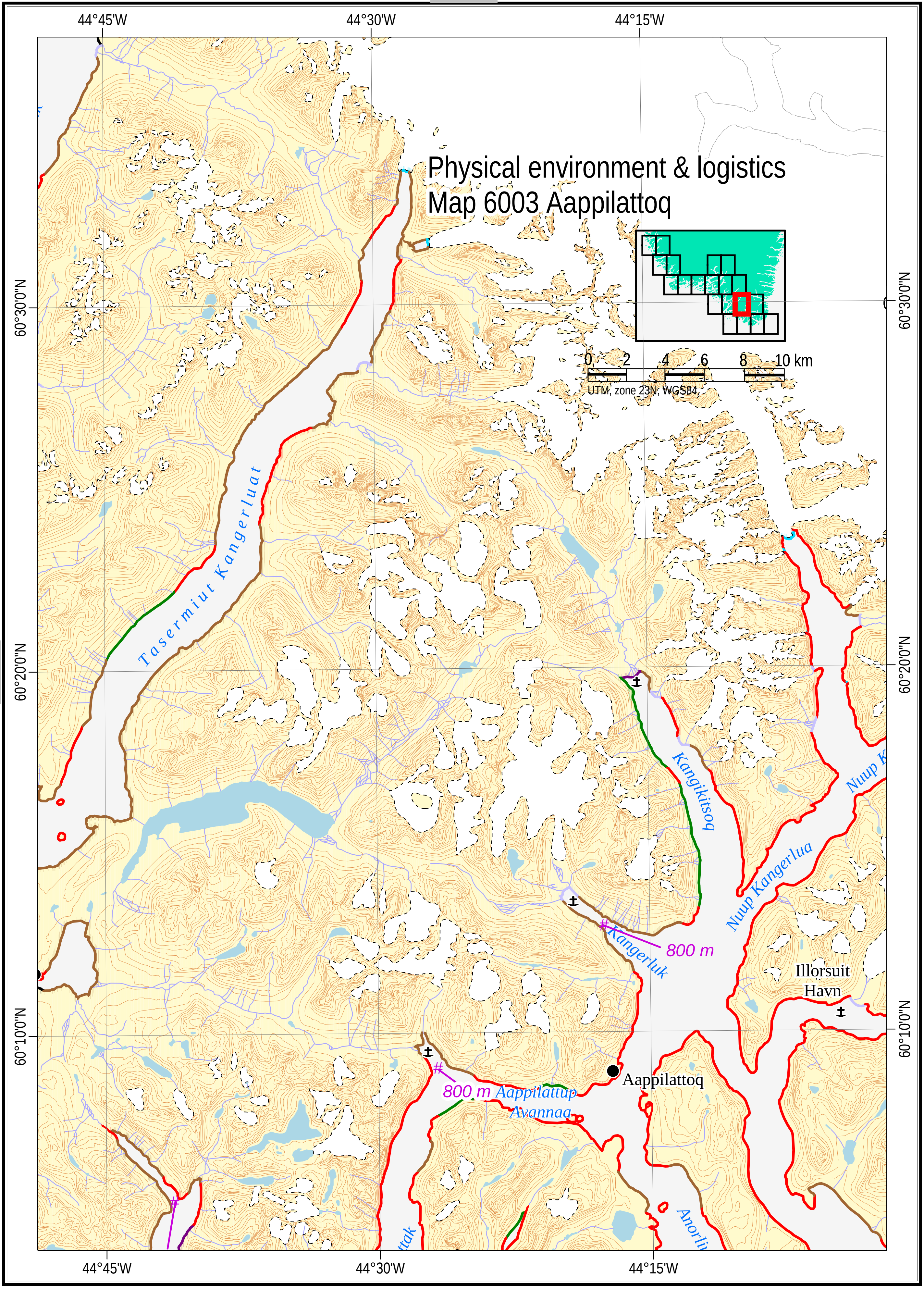
Shorelines shown on this map are predominantly semi-exposed rock and moraine, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marinebased given the likely nature of the shoreline.

Safe havens

Illorsuit (Igdlorsuit) Havn within Prins Christian Sound i is an area of relatively low sensitivity and could be investigated for its suitability as a safe haven for vessel lightering operations. The waters in the area appear to be deep, however the inlet is uncharted: local knowledge and reconnaissance at the time of a spill would be required. If local knowledge suggests that tidal currents are sufficiently low, booms could be deployed across the channel on each side of the anchorage (widths 1000 m) to contain any further release of oil. Other anchorages on this map could be considered as potential safe havens but all are in areas of high sensitivity.

Maps

Danish Survey & Cadastre (KMS) topographical map: 60 V.2. Nautical charts: 1103, 1113.

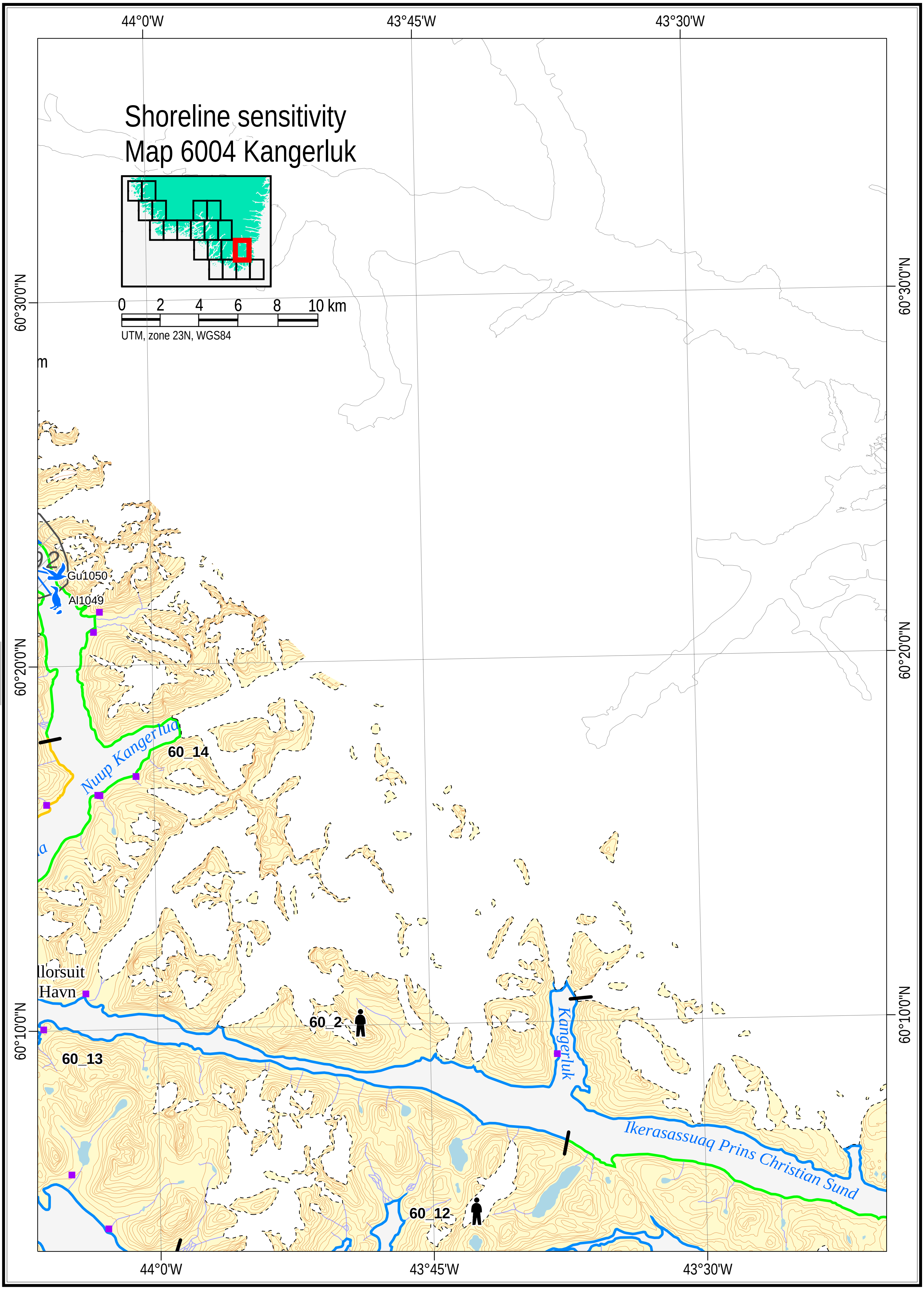

Physical environment & logistics
Map 6003 Aappilattoq
44°45'W
44°30'W
44°15'W
60°30'0"N
60°20'0"N
60°10'0"N
0 2 4 6 8 10 km
UTM, zone 23N, WGS84
Tasermiut Kangerluat
Kangilitsoq
Nuup Kangerlua
Kangerluk
800 m
Illorsuit Havn
Aappilattoq
Aappilattup Avannaa
Anorliu
ttak

Airphoto keymap

Map legend

Toggle maps

Keymaps



Environmental Oil Spill Sensitivity Atlas for the South Greenland Coastal Zone

Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Shoreline sensitivity

Map 6004 - Kangerluk

Environmental description

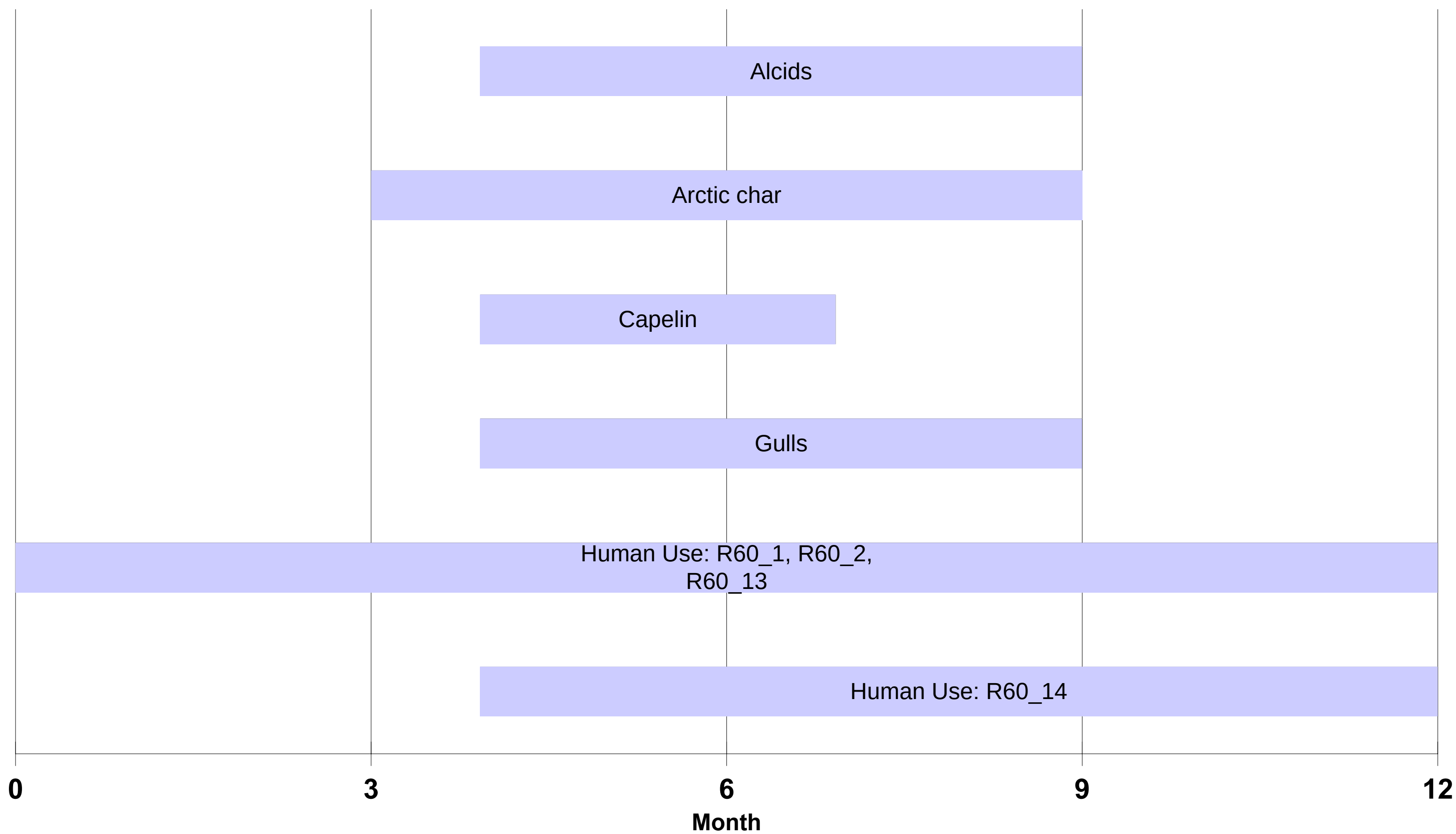
Resource use

R 60_2 Fishery for Greenland halibut, redfish and wolffish. Hunting for harp seals. Tourist climbing on coastal mountain.

Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
60_1	9	Low
60_2	14	Low
60_13	12	Low
60_14	22	Moderate

Map 6004 Species and Resource Occurrences



This page is intentionally left blank

Physical environment and logistics

Map 6004 - Kangerluk

Access

There is little information on the marine areas within this map.

The nearshore waters in this area are largely uncharted and caution should be exercised. In general the waters appear to be deep, however uncharted dangers may exist. Local knowledge is essential for navigation.

There is no information on tides or currents within fjords for this area.

Pack ice that enters the area from the east coast (February-July) may quickly scatter and dissipate in wind conditions. In some wind conditions ice may be concentrated and trapped in coastal areas making navigation difficult. Conditions can change quickly and should be considered prior to inshore navigation.

No anchorages are reported for this map area.

Charts indicate an anchorage within Prins Christian Sound, but no other information is available on this location.

Shorelines in this area are predominantly rock allowing little opportunity for marine access. There is no information to indicate the potential for beach landings.

There are no airports on this or adjoining maps. The nearest airport is at Narsarsuaq (map 6106), and there is a heliport at Nanortalik (6002).

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow nearshore waters, which may exist within the inlets of the fjords on this map. The waters appear to be deep, but as they are uncharted, soundings should be taken to confirm their depth prior to using dispersants.

Offshore countermeasures represent the only practical method of protecting most shoreline areas.

Prins Christian Sound is generally too wide to consider exclusion booming. Exclusion booming to reduce the extent of inshore contamination could be considered where the fjord narrows to 400 m. The location has rock and talus shoreline and appears to have deep water. Site surveys at the time of a spill will be required to confirm the feasibility of booming techniques. Although there is no information on currents for this area, high tidal velocities are possible given the reported tidal range and may prevent successful booming.

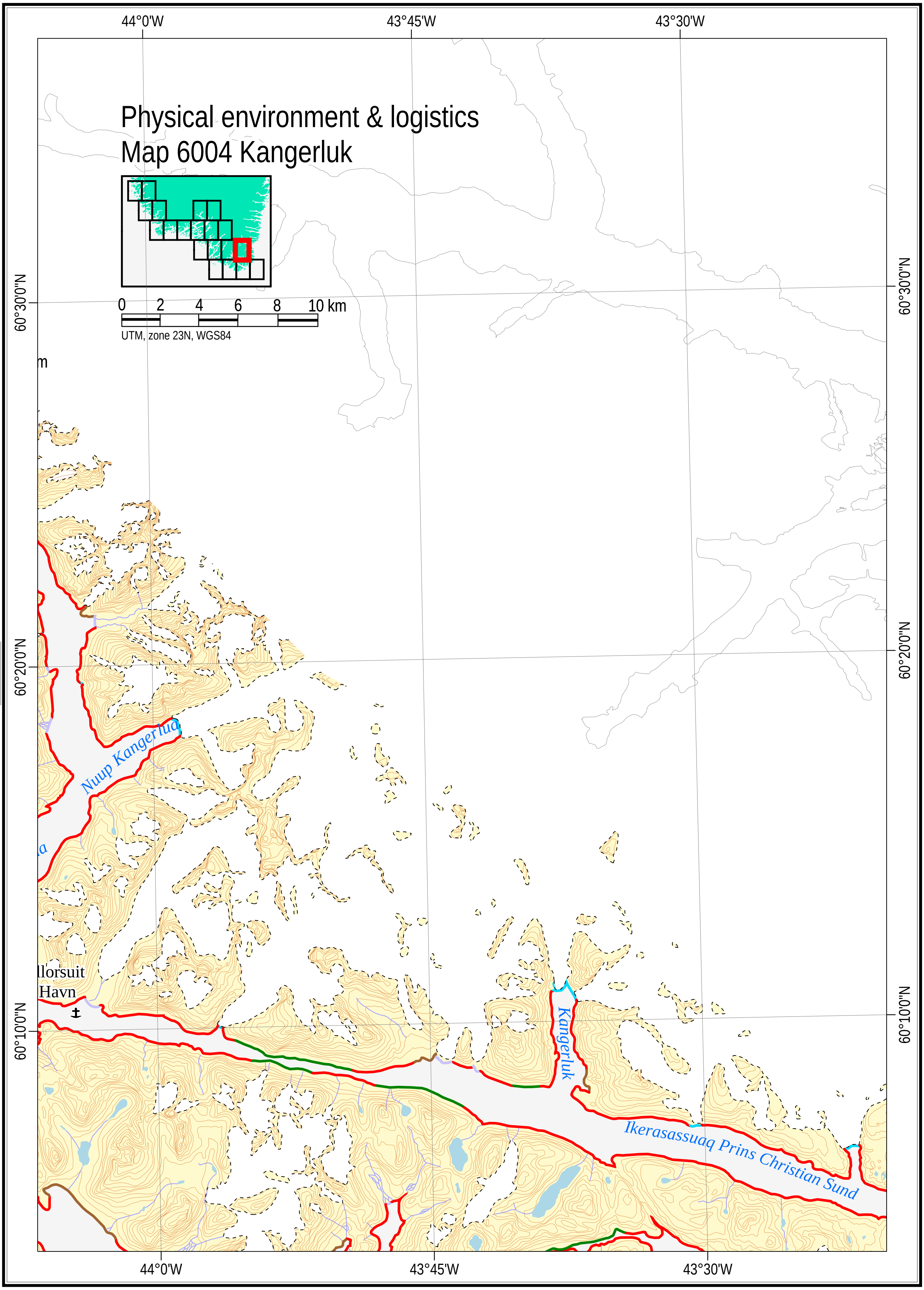
Shorelines shown on this map are predominantly rock, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marine-based given the likely nature of the shoreline.

Safe havens

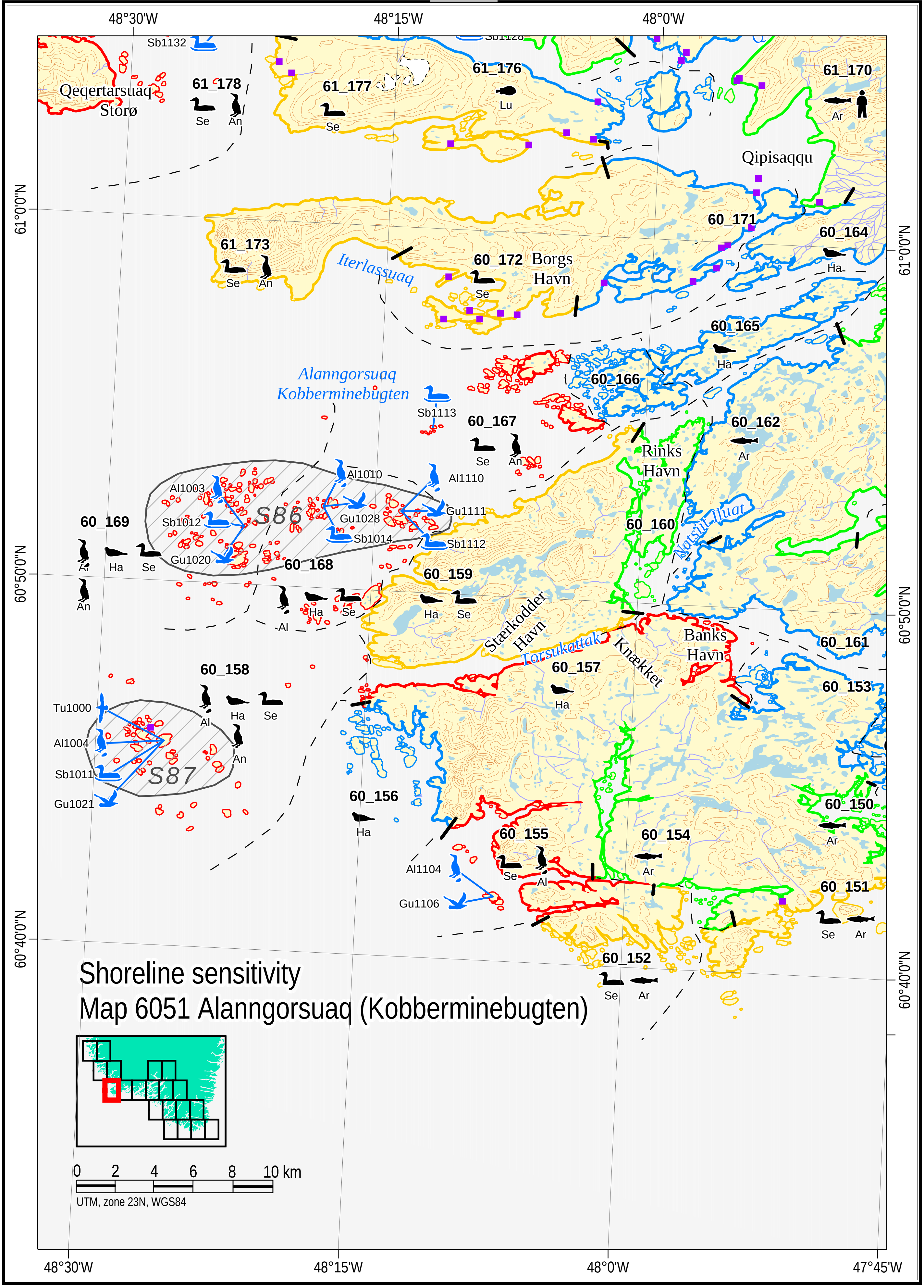
Illorsuit (Igdlorsuit) Havn within Prins Christian Sound is an area of relatively low sensitivity and could be investigated for its suitability as a safe haven for vessel lightering operations. The waters in the area appear to be deep, however the inlet is uncharted: local knowledge and reconnaissance at the time of a spill would be required. If local knowledge suggests that tidal currents are sufficiently low, booms could be deployed across the channel on each side of the anchorage (widths 1000 m) to contain any further release of oil. Other anchorages on this map could be considered as potential safe havens but all are in areas of high sensitivity.

Maps

Danish Survey & Cadastre (KMS) topographical map: 60 Ø.1. Nautical chart: 1103.


Physical environment & logistics
Map 6004 Kangerluk
0 2 4 6 8 10 km
UTM, zone 23N, WGS84
44°0'W
43°45'W
43°30'W
60°30'0"N
60°20'0"N
60°10'0"N
Nuup Kangerlua
Ilorsuit Havn
Kangerluk
Ikerasassuaq Prins Christian Sund

Airphoto keymap | Map legend | Toggle maps | Keymaps



Shoreline sensitivity
Map 6051 Alanngorsuaq (Kobberminebugten)

Shoreline sensitivity **Map 6051 - Alanngorsuaq (Kobberminebugt)**

Environmental description

Species occurrence

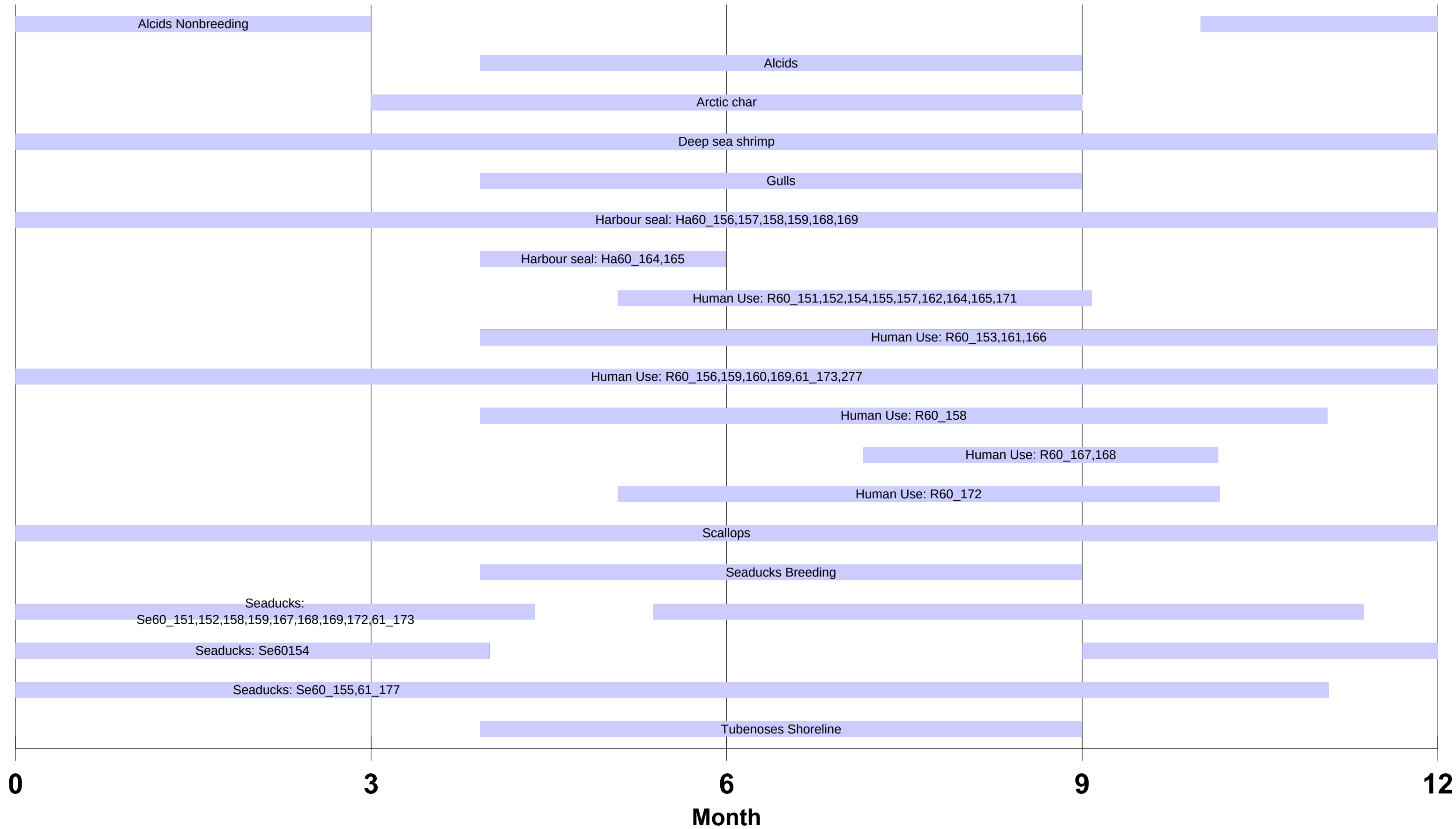
Al60155	1 colony with breeding razorbills and black guillemots.
Al60158	1 colony with breeding Brünnich's guillemots, common guillemots, razorbills, Atlantic puffins and black guillemots (**S87**).
Al60168	1 colony with breeding razorbills, black guillemots and Atlantic puffins, and 1 with black guillemots (**S86**).
Al60169	1 colony with breeding razorbills and black guillemots (**S86**).
An60158, An60167	Black and Brünnich's guillemots in winter.
An60169, An61173	Black and Brünnich's guillemots in winter.
Ar60151, Ar60152	Important coastal fishing areas for Arctic char.
Ar60154	6 rivers with Arctic char and important coastal fishing areas.
Ar60162	2 rivers with Arctic char and important coastal fishing areas.
Ha60156, Ha60157	Harbour seal habitat, all year and during whelping.
Ha60158, Ha60159	Harbour seal habitat, all year and during whelping (**S87**).
Ha60164, Ha60165	Harbour seal whelping area.
Ha60168, Ha60169	Harbour seal habitat, all year and during whelping (**S86**).
Se60151, Se60152	Eiders, long-tailed ducks and harlequin ducks in winter and harlequin ducks moulting in summer
Se60155, Se60158	Eiders, long-tailed ducks and harlequin ducks in winter and harlequin ducks moulting in summer (**S87**).
Se60159, Se60167	Eiders, long-tailed ducks and harlequin ducks in winter and harlequin ducks moulting in summer.
Se60168, Se60169	Eiders, long-tailed ducks and harlequin ducks in winter and harlequin ducks moulting in summer (**S87**).
Se60172, Se61173	Eiders, long-tailed ducks and harlequin ducks in winter and harlequin ducks moulting in summer.
Se61177	Eiders, long-tailed ducks and harlequin ducks in winter and harlequin ducks moulting in summer.

Site specific species occurrence (seabird breeding colonies); blue icons

Al1003	Breeding razorbills and black guillemots.
Al1004	Breeding Brünnich's guillemots, common guillemots, razorbills, Atlantic puffins and black guillemots (**S87**).
Al1010	Breeding razorbills, black guillemots and Atlantic puffins (**S86**).
Al1104	Breeding razorbills and black guillemots.
Al1110	Breeding black guillemots.
Gu1020	Breeding Iceland gulls and glaucous gulls.
Gu1021	Breeding kittiwakes, glaucous gulls and great black-backed gulls.
Gu1028	Breeding Iceland gulls, glaucous gulls and great black-backed gulls
Gu1106	Breeding glaucous or Iceland gulls.
Gu1111	Breeding great black-backed gulls.
Sb1011, Sb1012	Breeding common eiders.
Sb1014, Sb1112	Breeding common eiders.
Sb1113	Breeding common eiders.
Tu1000	Breeding northern fulmars.

(Continued on page 55)

Map 6051 Species and Resource Occurrences



Shoreline sensitivity — Map 6051 - Alanngorsuaq (Kobberminebugt)

(Continued from page 53)

Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
60_151	33	High
60_152	33	High
60_153	8	Low
60_154	26	Moderate
60_155	44	High
60_156	15	Low
60_157	46	Extreme
60_158	59	Extreme
60_159	42	High
60_160	22	Moderate
60_161	7	Low
60_162	21	Low
60_164	17	Low
60_165	18	Low
60_166	7	Low
60_167	52	Extreme
60_168	67	Extreme
60_169	81	Extreme
60_171	13	Low
60_172	41	High
61_173	33	High
61_177	41	High

Physical environment and logistics — Map 6051 - Alanngorsuaq (Kobberminebugt)

Access

The nearshore waters in this area are largely uncharted and caution should be exercised. In general the waters offshore, nearshore and within the fjords are deep, however uncharted dangers may exist. Local knowledge is essential for navigation.

The south side of Kobberminebugt/Alanngorsuaq is encumbered with islands, islets and rocks. Large icebergs frequently ground in these hazards.

The relatively warm West Greenland Current prevents the formation of ice through this area, except for a band along the coast west of Cape Farewell (map 5953) and in some of the fjords.

Pack ice that enters the area from Cape Farewell (February-July) may quickly scatter and dissipate in wind conditions. In some wind conditions ice may be concentrated and trapped in coastal areas making navigation difficult. The outflow of water from Sermilik usually prevents ice from entering fjords near its entrance. Conditions can change quickly and should be considered prior to inshore navigation.

Tidal streams in Ikerasassuaq and Torsukattak set to west on the flood and east on the ebb at rates up to 4 knots in the narrowest parts and about 1 knot elsewhere.

Physical environment and logistics Map 6051 - Alanngorsuaq (Kobberminebugt)

Access

(Continued from previous page)
The prevailing current sets to the NW waters along the coast. Tidal streams run SE/NW at rates up to 2 knots. There is no other information on tides or currents within fjords for this area.

Anchorage is available at Borgs Havn on the northern coast of Alanngorsuaq, depths of 13 to 27 m, and at Rinks Havn on the southern coast of Alanngorsuaq . At Rinks Havn there is good shelter.

Stærkodder Havn, 5 km within the north entrance to Torsukattaq, has anchorage in depths from 18 to 22 m.

Well-protected anchorage with depths of 5.6 to 22 m is available at Bangs Havn on the southern side of Ikerasarsuaq], 5 km east of Knækket, ,. Caution is recommended as charts are reported to be inaccurate.

Anchorage is available at depths of 15 m at Naajartalik, 3 km north of Cape Desolation. It is open to the south and vulnerable to pack ice. Islets and below-water rocks lie near the entrance.

In this area shorelines are exclusively rock allowing little opportunity for marine access. There is no information to indicate the potential for beach landings.

There are no airports on this or adjoining maps. The nearest airport is at Narsarsuaq (map 6106), and there is a heliport at Qaqortoq (map 6054).

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow nearshore waters, which may exist within the fjords and coastal islands on this map. The waters appear to be deep, but as they are uncharted, soundings should be taken to confirm their depth prior to using dispersants.

Offshore countermeasures represent the only practical method of protecting most shoreline areas, including the selected area shown on the map.

The main entrances to the fjords on this map are generally too wide to consider exclusion booming. Exclusion booming to reduce the extent of inshore contamination should be considered at three possible locations. At Stærkodder Havn in Torsukattaq the inlet width is approximately 500 m, and the two inlets to the south have inlet widths of approximately 500 m. All three locations have rock shorelines and appear to have deep water. Site surveys at the time of a spill will be required to confirm the feasibility of booming techniques. High tidal velocities are possible given the reported tidal range and may prevent successful booming.

Shorelines shown on this map are exposed and semi-exposed rock, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marine-based given the likely nature of the shoreline.

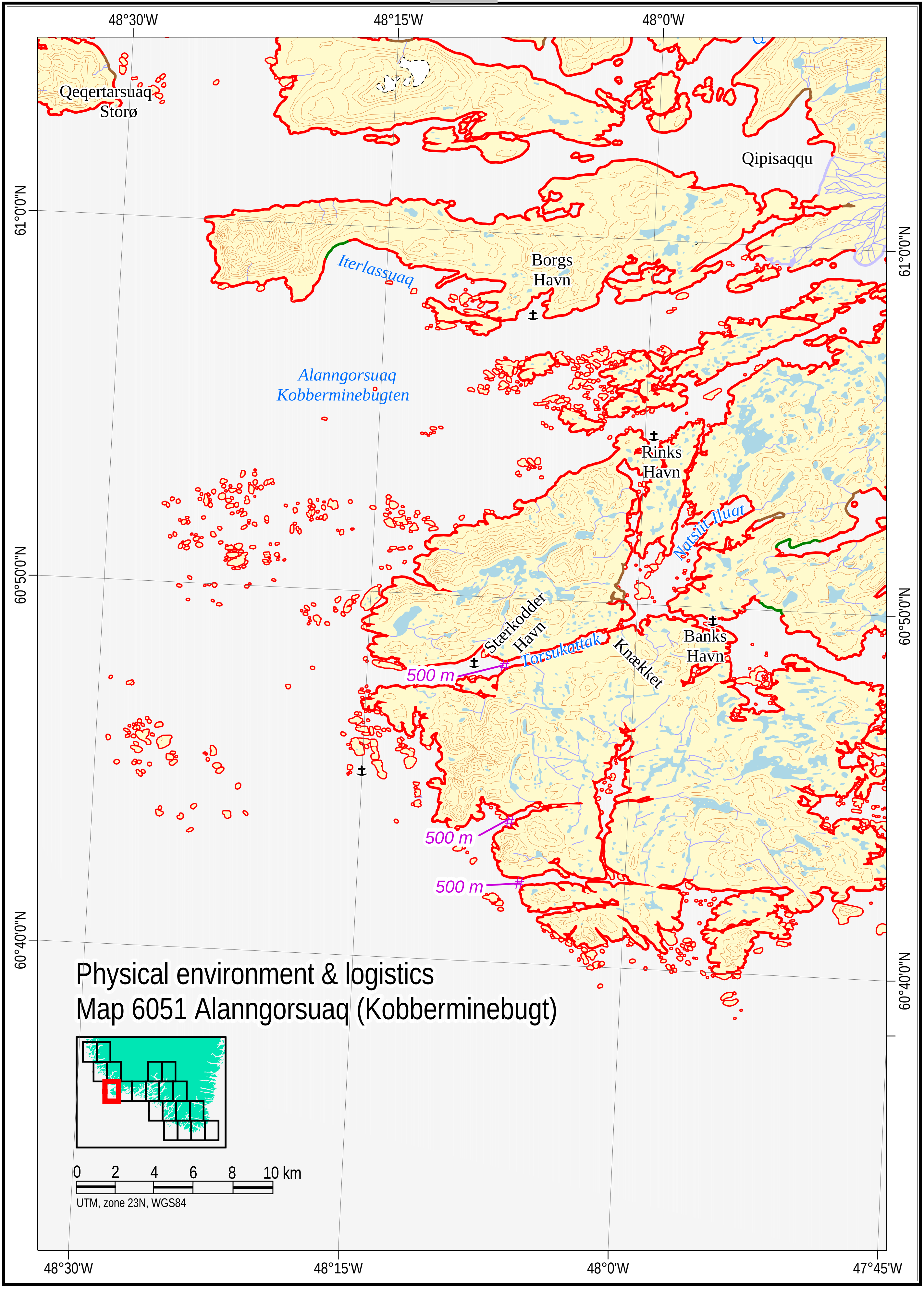
Safe havens

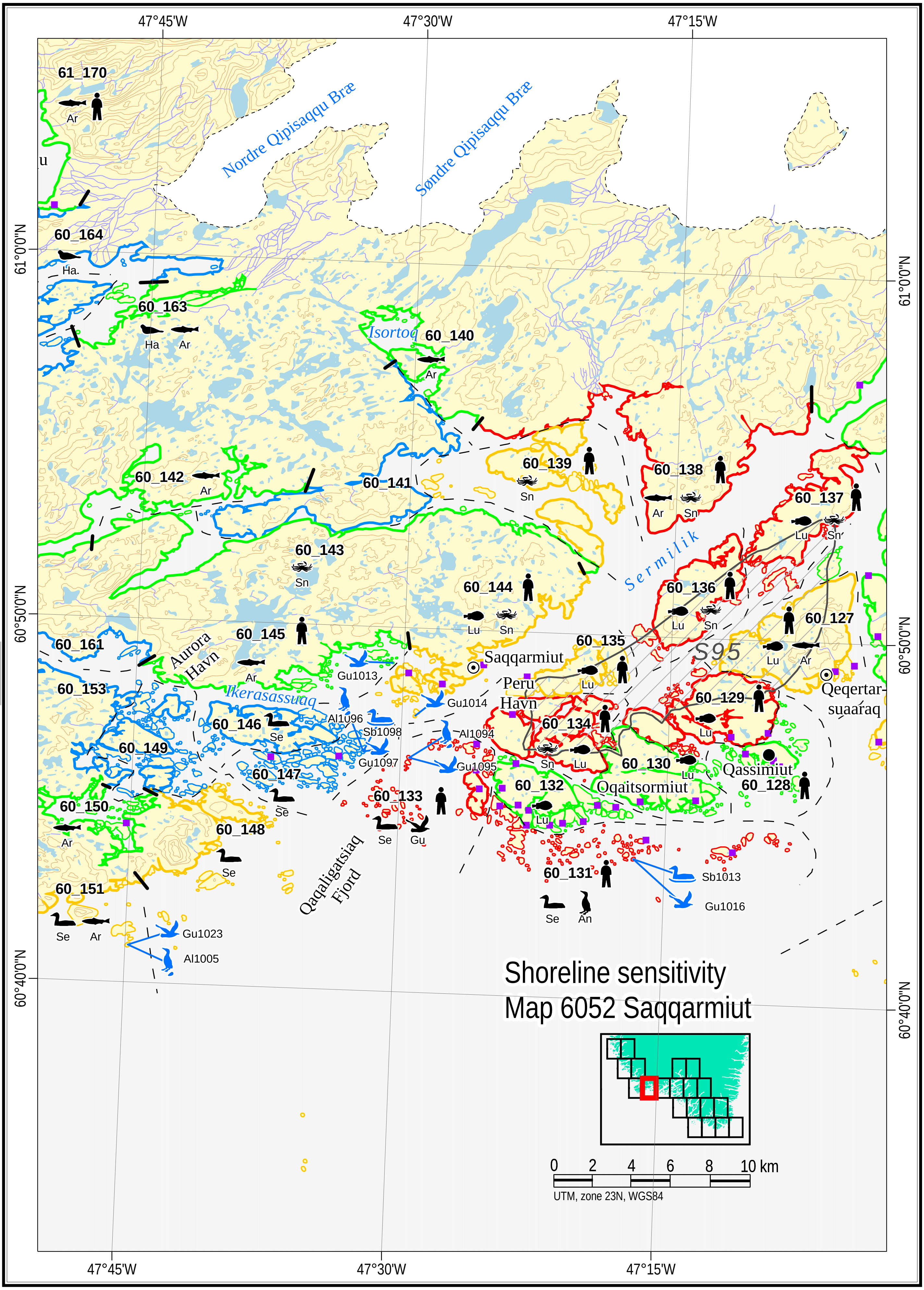
A potential safe haven for vessel lightering operations is at Stærkodder Havn within Torsukattaq, which has low to moderate sensitivity. If local knowledge suggests that tidal currents are sufficiently low, booms could be deployed across its entrance to contain any further release of oil.

Maps

Danish Survey & Cadastre (KMS) topographical map: 60 V.1. Nautical charts: 1100, 1117.

Physical environment & logistics
Map 6051 Alanngorsuaq (Kobberminebugt)




47°45'W
47°30'W
47°15'W
61°0'0"N
60°50'0"N
60°40'0"N
Nordre Qipisaqqu Bræ
Søndre Qipisaqqu Bræ
Isortoq
Sermilik
Aurora Havn
Ikerasassuaq
Qaqaligatsiaq Fjord
Saqqarmiut
Peru Havn
Qeqertarsuaraq
Qassimiut
Oqaitsormiut
S95
61_170
60_164
60_163
60_140
60_139
60_138
60_137
60_142
60_141
60_143
60_144
60_136
60_127
60_161
60_145
60_135
60_153
60_129
60_146
60_134
60_149
60_130
60_147
60_132
60_128
60_133
60_150
60_148
60_131
60_151
Gu1013
Gu1014
Al1096
Sb1098
Al1094
Gu1097
Gu1095
Sb1013
Gu1016
Gu1023
Al1005
Shoreline sensitivity
Map 6052 Saqqarmiut
0 2 4 6 8 10 km
UTM, zone 23N, WGS84

Environmental description

Resource use

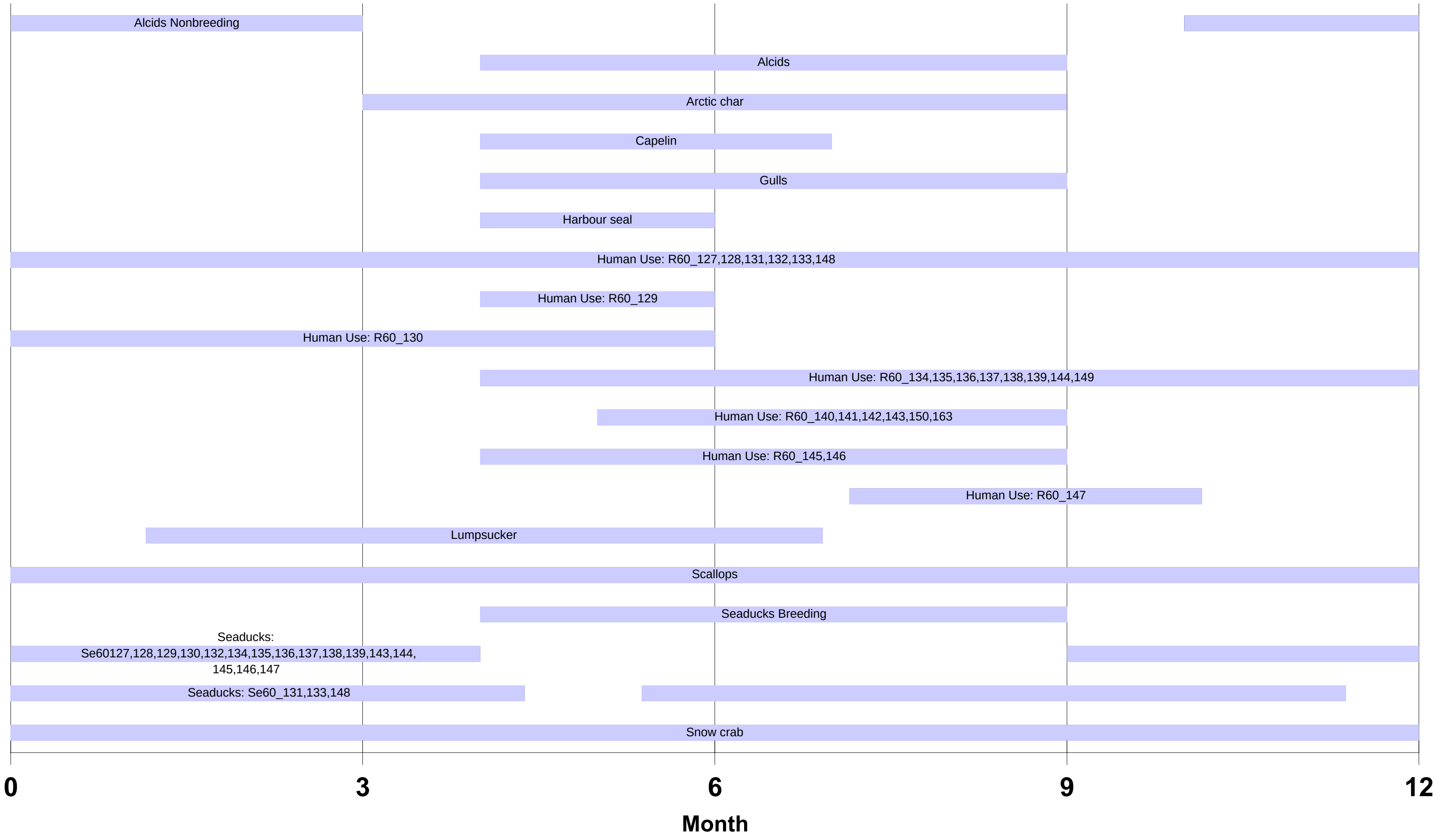
R 60_127	Fishery for snow crab, lumpsucker (important), Atlantic cod, salmon and Arctic char in 2 river outlets (both important). Hunting for seals, eiders and guillemots (**S95**).
R 60_128	Fishery for lumpsucker, salmon and Atlantic cod. Hunting for seals and eiders.
R 60_129	Fishery for snow crab, lumpsucker (important) and Atlantic cod. Hunting for seals and eiders (**S95**).
R 60_131	Fishery for salmon and Atlantic cod. Hunting for fin and minke whales, harbour porpoises, hooded seals, harp seals, guillemots and eiders.
R 60_133	Fishery for snow crab and salmon. Hunting for guillemots, seals and eiders.
R 60_134	Fishery for snow crab (important), lumpsucker (important), Atlantic cod, Greenland halibut and salmon. Hunting for seals and eiders (**S95**).
R 60_135	Fishery for lumpsucker (important), Greenland halibut, Atlantic cod and salmon. Hunting for seals and eiders (**S95**).
R 60_136	Fishery for snow crab (important), lumpsucker (important), Greenland halibut, Atlantic cod and salmon. Hunting for seals, eiders and guillemots (**S95**).
R 60_137	Fishery for snow crab, scallop, capelin, lumpsucker (important), Atlantic cod and Greenland halibut. Hunting for seals and guillemots (**S95**).
R 60_138	Fishery for snow crab (important), Atlantic cod, Greenland halibut and Arctic char at coast and in 5 rivers (all important). Hunting for seals.
R 60_139	Fishery for snow crab (important), Greenland halibut, Atlantic cod and salmon. Hunting for seals.
R 60_144	Fishery for snow crab (important), lumpsucker (important), Atlantic cod, Greenland halibut, salmon and Arctic char at coast and in 1 river outlet (important).
R 60_145	Fishery for lumpsucker and Arctic char at coast and in 3 river outlets (2 important).

Species occurrence

An60131	Black guillemots and Brünnich's guillemots in winter.
Ar60127	2 rivers with Arctic char (**S95**).
Ar60138	5 rivers with Arctic char and important coastal fishing area.
Ar60140	4 rivers with Arctic char and important coastal fishing areas.
Ar60142	2 rivers with Arctic char and important coastal fishing area.
Ar60145	3 rivers with Arctic char and small important coastal fishing area.
Ar60150	2 rivers with Arctic char and important coastal fishing areas.
Ar60163	1 river with Arctic char and important coastal fishing area.
Gu60133	1 colony with breeding Arctic terns.
Ha60163	Harbour seal whelping area.
Lu60127	Lumpsucker spawning and important fishing ground along all of the coasts (**S95**).
Lu60129	Lumpsucker spawning and important fishing ground along most of the coasts (**S95**).
Lu60130, Lu60132	Lumpsucker spawning and important fishing ground along almost all the coasts (**S95**).
Lu60134, Lu60135	Lumpsucker spawning and important fishing ground along almost all the coasts (**S95**).
Lu60136, Lu60137	Lumpsucker spawning and important fishing ground along almost all the coasts (**S95**).
Lu60144	Lumpsucker spawning and important fishing ground along all coasts.
Se60131, Se60133	Eiders, long-tailed ducks and harlequin ducks in winter and harlequin ducks moulting in summer.
Se60146, Se60147	Eiders and long-tailed ducks in winter.
Se60148	Eiders, long-tailed ducks and harlequin ducks in winter and harlequin ducks moulting in summer.
Sn60134, Sn60136	Snow crab fishing area (**S95**).
Sn60137, Sn60138	Snow crab fishing area (**S95**).
Sn60139, Sn60143	Snow crab fishing area.
Sn60144	Snow crab fishing area.

(Continued on page 9-61)

Map 6052 Species and Resource Occurrences



Shoreline sensitivity

Map 6052 - Saqqarmiut

(Continued from page 9-59)

Site specific species occurrence (seabird breeding colonies); blue icons

Al1005	Breeding razorbills.
Al1094, Al1096	Breeding black guillemots.
Gu1013, Gu1014	Breeding Arctic terns.
Gu1016, Gu1095	Breeding Arctic terns.
Gu1023	Breeding Iceland gulls and glaucous gulls.
Gu1097	Breeding great black-backed gulls.
Sb1013, Sb1098	Breeding common eiders.

Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
60_127	41	High
60_128	28	Moderate
60_129	46	Extreme
60_130	32	Moderate
60_131	54	Extreme
60_132	29	Moderate
60_133	54	Extreme
60_134	55	Extreme
60_135	36	High
60_136	49	Extreme
60_137	47	Extreme
60_138	49	Extreme
60_139	34	High
60_140	26	Moderate
60_141	13	Low
60_142	23	Moderate
60_143	25	Moderate
60_144	41	High
60_145	28	Moderate
60_146	20	Low
60_147	20	Low
60_148	34	High
60_149	8	Low
60_150	28	Moderate
60_163	29	Moderate

Physical environment and logistics

Map 6052 - Saqqarmiut

Access

The nearshore waters in this area are largely uncharted and the inshore waters within fjords are not charted. Therefore caution should be exercised. In general the waters offshore, nearshore and within the fjords appear to be deep, however uncharted dangers may exist. Local knowledge is essential for navigation.

The approaches to Sermilik are strewn with islets, rocks and shoals. Local knowledge is essential for navigation.

The relatively warm West Greenland Current prevents the formation of ice through this area, except for a band along the coast west of Cape Farewell (map 5953) and in some of the fjords.

Physical environment and logistics

Map 6052 - Saqqarmiut

Access

(Continued from previous page)
Pack ice that enters the area from Cape Farewell (February-July) may quickly scatter and dissipate in wind conditions. In some wind conditions ice may be concentrated and trapped in coastal areas making navigation difficult. The outflow of water from Sermilik usually prevents ice from entering fjords near its entrance. Conditions can change quickly and should be considered prior to inshore navigation.

The prevailing current sets to the NW waters along the coast. Tidal streams run SE/NW at rates up to 2 knots. There is no other information on tides or currents within fjords for this area.

Within the islands that form the east side of the entrance to Qaqaligatsiaq Fjord, tidal currents may set to the east on a rising tide and west on a falling tide, counter to that expected.

Anchorages are available on the south side of the island of Oqaitsormiut, depths of 26 m, and in Peru Havn, a large bay on the north side of Nordlige Mågeløb with depths of 13 to 18 m.

The anchorage at Aurora Havn on the north shore of Ikerasassuaq, has good shelter from south winds and depths of 13 to 15 m. Water can be obtained from a bay at the head of the harbour. Caution is advised as several islets near the entrance.

Shorelines in this area are exclusively rock allowing little opportunity for marine access. There is no information to indicate the potential for beach landings.

There are no airports on this or adjoining maps. The nearest airport is at Narsarsuaq (map 6106), and there is a heliport at Qaqortoq.

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow nearshore waters, which may exist within the fjords and coastal islands on this map. The waters appear to be deep, but as they are uncharted, soundings should be taken to confirm their depth prior to using dispersants.

Offshore countermeasures represent the only practical method of protecting most shoreline areas.

The main entrances to the fjords on this map are generally too wide to consider exclusion booming. Exclusion booming to reduce the extent of inshore contamination could be considered at any of the numerous inter-island channels. However both the tidal range (3 to 4 m) and the high reported tidal velocities in the vicinity suggest that exclusion booming (applicable in currents up to 0.4 m/s, 0.75 knots) in these areas would not likely be successful, and is not recommended.

Shorelines shown on this map are predominantly exposed and semi-exposed rock, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords and coastal islands. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marine-based given the likely nature of the shoreline.

Safe havens

There are no potential safe havens identified on this map. Aurora Havn, which is in an area of low to moderate sensitivity, could be considered as it offers good shelter. However depths are limited (depths in the Greenland Pilot (1966) not reliable), it would be difficult to boom given the width of its entrance and should be used only when local knowledge is at hand.

Maps

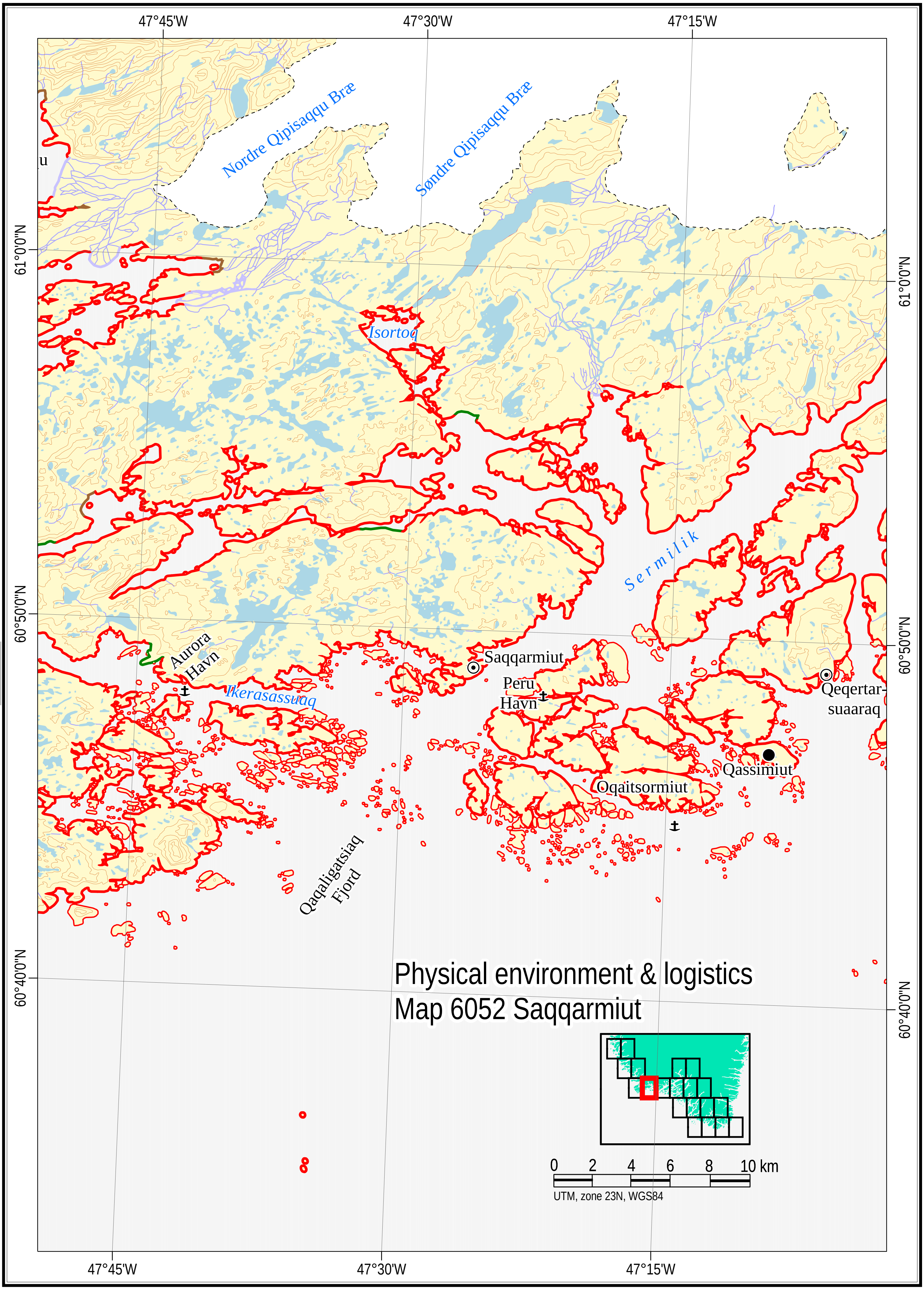
Danish Survey & Cadastre (KMS) topographical map: 60 V.1. Nautical charts: 1100, 1116, 1117.

Airphoto keymap

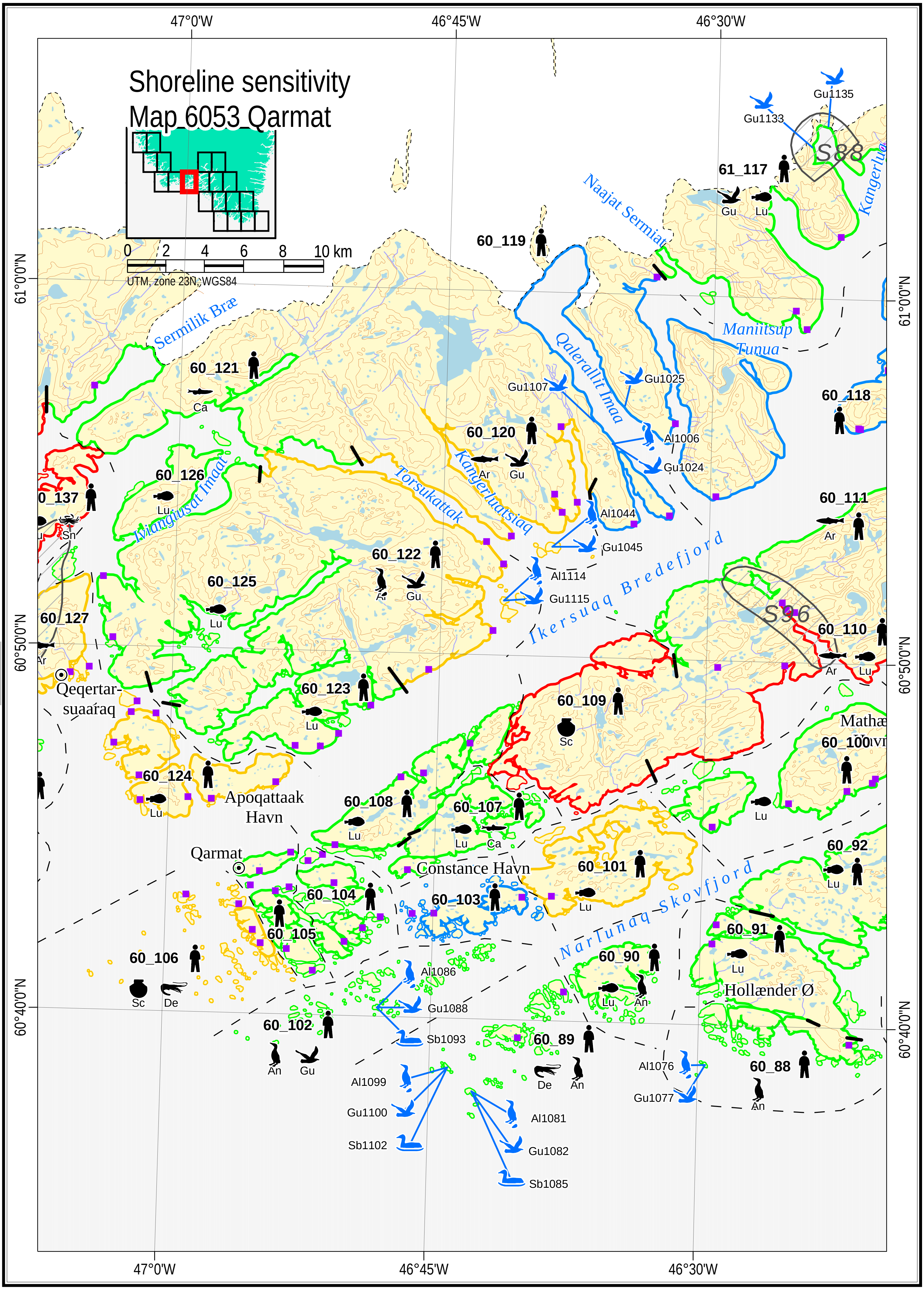
Map legend

Toggle maps

Keymaps



Physical environment & logistics
Map 6052 Saqqarmiut


Shoreline sensitivity
Map 6053 Qarmat
0 2 4 6 8 10 km
UTM, zone 23N, WGS84
47°0'W
46°45'W
46°30'W
61°0'0"N
60°50'0"N
60°40'0"N
Sermilik Bræ
Naajat Sermiat
Qaleralliit Imaa
Maniitsup Tunua
Kangerluatsiaq
Torsukattak
Iviangiusat Imaat
Ikersuaq Bredefjord
Narluunaq Skovfjord
Qeqertar-suaaraq
Apoqattaak Havn
Qarmat
Constance Havn
Hollænder Ø
S88
S86
61_117
60_119
60_121
60_120
60_118
60_126
0_137
60_122
60_125
60_111
60_127
60_110
60_123
60_109
60_100
60_124
60_108
60_107
60_101
60_92
60_104
60_103
60_105
60_91
60_106
60_90
60_102
60_89
60_88
Gu1133
Gu1135
Gu1107
Gu1025
Al1006
Gu1024
Al1044
Gu1045
Al1114
Gu1115
Al1086
Gu1088
Sb1093
Al1099
Gu1100
Sb1102
Al1081
Gu1082
Sb1085
Al1076
Gu1077

Environmental description

Resource use

R 60_88	Fishery for deep sea shrimp, Atlantic cod and salmon. Hunting for guillemots, fin and minke whales, harbour porpoises, hooded seals and harp seals.
R 60_89	Fishery for deep sea shrimp (important), snow crab, Atlantic cod, redfish and salmon. Hunting for guillemots, hooded seals, harp seals and harbour porpoises.
R 60_90	Fishery for lumpsucker (important), wolffish, Atlantic halibut, Atlantic cod, redfish, salmon and snow crab. Hunting for fin and minke whales, harbour porpoises, seals and guillemots.
R 60_91	Fishery for lumpsucker (important), wolffish, Atlantic halibut, Atlantic cod and salmon. Hunting for fin and minke whales, seals, harbour porpoises and guillemots.
R 60_100	Fishery for snow crab (important), lumpsucker (important), wolffish, Atlantic cod and salmon. Hunting for seals, guillemots and eiders.
R 60_101	Fishery for snow crab, lumpsucker (important), Atlantic cod, salmon, Atlantic halibut and redfish. Hunting for fin and minke whales, harbour porpoises, seals, guillemots and eiders.
R 60_102	Fishery for deep sea shrimp, snow crab, wolffish, Atlantic cod, salmon and redfish. Hunting for harbour porpoises, seals, guillemots and eiders.
R 60_103	Fishery for snow crab, lumpsucker, wolffish, Atlantic cod, salmon and redfish. Hunting for harbour porpoises and seals.
R 60_104	Fishery for snow crab, lumpsucker, salmon, Atlantic cod and wolffish. Hunting for harbour porpoises, seals and eiders.
R 60_105	Fishery for Greenland halibut, redfish, salmon, Atlantic cod, Atlantic halibut and wolffish. Hunting for seals, harbour porpoises, guillemots and eiders.
R 60_106	Fishery for deep sea shrimp, scallop (important), salmon, Atlantic cod and wolffish. Hunting for seals, fin and minke whales, harbour porpoises, guillemots and eiders.
R 60_107	Fishery for lumpsucker (important), wolffish, Atlantic cod and salmon. Hunting for harbour porpoises, seals and eiders.
R 60_108	Fishery for lumpsucker, Greenland halibut, wolffish, redfish, Atlantic cod, salmon, Atlantic halibut, and Arctic char in 1 river outlet (important). Hunting for harbour porpoises, seals, guillemots and eiders.
R 60_109	Fishery for scallop (important), lumpsucker, Greenland halibut, redfish, Atlantic cod, salmon and wolffish. Hunting for seals, guillemots and eiders.
R 60_111	Fishery for Atlantic cod, Greenland halibut, wolffish, redfish, salmon and Arctic char at coast and in 5 river outlets (3 important). Hunting for seals, guillemots and eiders (**S96**). Tourist attraction at Stephensens Harbour.
R 61_117	Fishery for capelin, lumpsucker, wolffish, redfish and Arctic char in 1 river outlet (important). Hunting for ringed seals and harp seals. Tourist attraction in glacier fjords (important).
R 60_118	Fishery for lumpsucker, Greenland halibut, Atlantic cod, wolffish and redfish. Hunting for seals and guillemots.
R 60_119	Fishery for capelin, Greenland halibut, redfish, Atlantic cod and salmon. Hunting for seals and guillemots.
R 60_120	Fishery for lumpsucker, Atlantic cod, wolffish, redfish, salmon and Arctic char at coast and in 3 river outlets (1 important). Hunting for seals and guillemots.
R 60_121	Fishery for capelin, lumpsucker (important), Atlantic cod and Arctic char in 1 river outlet (important). Hunting for seals.
R 60_122	Fishery for lumpsucker, Arctic char at coast, Atlantic cod, Greenland halibut, wolffish, redfish, salmon and Atlantic halibut. Hunting for seals and guillemots.
R 60_123	Fishery for lumpsucker (important), Atlantic cod, Greenland halibut, redfish, salmon, Atlantic halibut and Arctic char at coast and in 1 river. Hunting for seals and guillemots.
R 60_124	Fishery for scallop, lumpsucker (important), Atlantic cod, redfish, salmon and Atlantic halibut. Hunting for fin and minke whales, harbour porpoises, seals, guillemots and eiders.

(Continued on next page)

Shoreline sensitivity

Map 6053 - Qarmat

(Continued from previous page)

Species occurrence

Al60122	1 colony with breeding black guillemots.
An60088, An60089	Black guillemots and Brünnich's guillemots in winter.
An60090, An60102	Black guillemots and Brünnich's guillemots in winter.
Ar60111	5 rivers with Arctic char and small important coastal fishing area (**S96**).
Ar60120	3 rivers with Arctic char and important coastal fishing area.
Ca60107	Capelin spawning areas along many coasts.
Ca60121	Capelin spawning area and partly also fishing area in eastern and central part.
De60089	Important deep sea shrimp fishery.
De60106	Important deep sea shrimp fishery.
Gu60102	1 colony with breeding lesser black-backed gulls, herring gulls, Iceland gulls, great black-backed gulls and glaucous gulls.
Gu60120	1 colony with breeding lesser black-backed gulls, Iceland gulls, great black-backed gulls and herring gulls.
Gu60122	1 colony with breeding lesser black-backed gulls, herring gulls, great black-backed gulls, Iceland gulls and glaucous gulls.
Gu61117	2 colonies with breeding gulls and kittiwakes.
Lu60090, Lu60091	Lumpsucker spawning and important fishing grounds along almost all coasts.
Lu60100	Lumpsucker spawning and important fishing grounds along almost all coasts.
Lu60101	Lumpsucker spawning and important fishing grounds along almost all coasts.
Lu60107	Lumpsucker spawning and important fishing grounds along all coasts.
Lu60108	Lumpsucker spawning and important fishing grounds along south coast.
Lu60123	Lumpsucker spawning and important fishing grounds along most of the coasts except the coasts in Ikersuaq/Bredefjord.
Lu60124, Lu60125	Lumpsucker spawning and important fishing grounds along all of the coasts.
Lu60126	Lumpsucker spawning and important fishing grounds along all of the coasts.
Sc60106	Important scallop fishing ground.
Sc60109	Important scallop fishing ground.

Site specific species occurrence (seabird breeding colonies); blue icons

Al1006, Al1044, Al1076	Breeding black guillemots.
Al1081, Al1086, Al1099	Breeding black guillemots.
Al1114	Breeding black guillemots.
Gu1024, Gu1025	Breeding Iceland gulls and kittiwakes.
Gu1045	Breeding lesser black-backed gulls, Iceland gulls, great black-backed gulls and herring gulls.
Gu1077	Breeding lesser black-backed gulls, glaucous gulls, great black-backed gulls and arctic terns.
Gu1082	Breeding lesser black-backed gulls, glaucous gulls and great black-backed gulls.
Gu1088	Breeding lesser black-backed gulls, herring gulls, Iceland gulls, great black-backed gulls and glaucous gulls.
Gu1100	Breeding lesser black-backed gull, great black-backed gulls and Arctic terns.
Gu1107	Breeding Iceland gulls, glaucous gulls and kittiwakes.
Gu1115	Breeding lesser black-backed gulls, herring gulls, great black-backed gulls, Iceland gulls and glaucous gulls.
Gu1133, Gu1135	Breeding Iceland gulls, glaucous gulls and kittiwakes (**S88**).
Sb1085, Sb1093	Breeding common eiders.
Sb1102	Breeding common eiders.

(Continued on next page)

Shoreline sensitivity

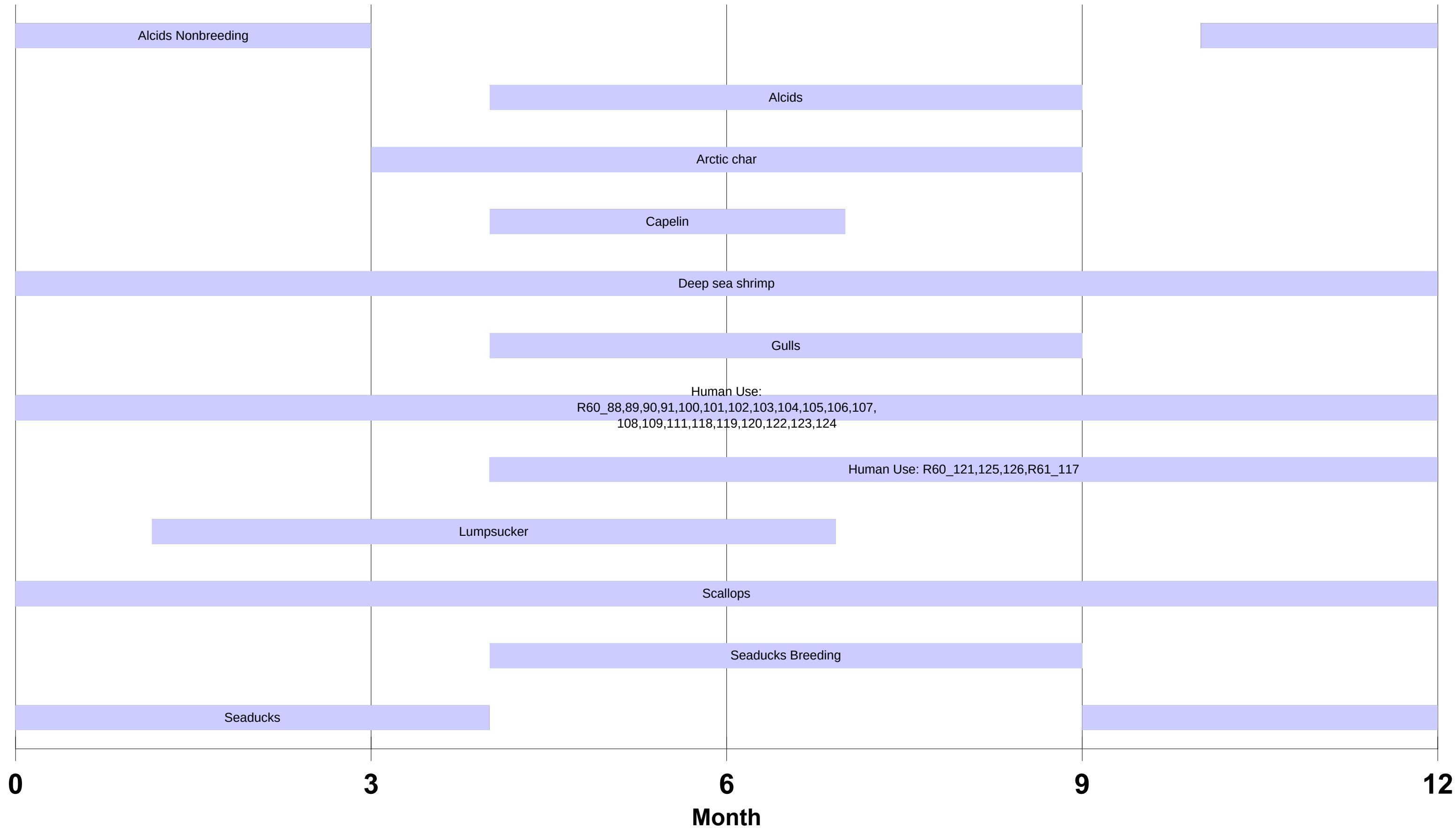
Map 6053 - Qarmat

(Continued from previous page)

Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
60_88	23	Moderate
60_89	25	Moderate
60_90	22	Moderate
60_91	22	Moderate
60_100	29	Moderate
60_101	37	High
60_102	27	Moderate
60_103	20	Low
60_104	25	Moderate
60_105	22	Moderate
60_106	36	High
60_107	28	Moderate
60_108	28	Moderate
60_109	45	Extreme
60_111	28	Moderate
61_117	24	Moderate
60_118	13	Low
60_119	20	Low
60_120	38	High
60_121	23	Moderate
60_122	33	Moderate
60_123	25	Moderate
60_124	41	High
60_125	30	Moderate
60_126	24	Moderate

Map 6053 Species and Resource Occurrences



Physical environment and logistics

Map 6053 - Qarmat

Access

The nearshore waters in this area are largely uncharted and the inshore waters within fjords are not charted. Therefore caution should be exercised. In general the waters offshore, nearshore and within the fjords appear to be deep, however uncharted dangers may exist. Local knowledge is essential for navigation.

Access

(Continued from previous page)

The approaches to Ikersuaq/Bredefjord are strewn with islets, rocks and shoals. Local knowledge is essential for navigation.

The relatively warm West Greenland Current prevents the formation of ice through this area, except for a band along the coast west of Cape Farewell (map 5953) and in some of the fjords.

When pack ice enters the area from Cape Farewell the entrance to Narlunaq/Skovfjord fills rapidly, but only in south winds does it enter the fjord beyond Hollænderø. Conditions can change quickly and should be considered prior to inshore navigation.

The prevailing current sets to the NW waters along the coast. Tidal streams run SE/NW at rates up to 2 knots. During the summer, a weak surface current sets almost constantly out of Narlunaq/Skovfjord.

At the entrance to Ikersuaq/Bredefjord, anchorage can be obtained at Høyers Havn on the north side of Qarmat and at 31 to 33 m in Apoqataaq Havn on the north side of Ikersuaq/Bredefjord. To the east a well-protected anchorage is available at Constance Havn with depths of 20 m. There are several islets and below-water rocks in the vicinity.

Anchorage can be made at 30 m in Hollænderø Havn, a small inlet on the south side of Hollænderø. The inlet is exposed to the entry of ice.

Shorelines in this area are exclusively rock allowing little opportunity for marine access. There is no information to indicate the potential for beach landings.

There are no airports on this or adjoining maps. The nearest airport is at Narsarsuaq (map 6106), and there is a heliport at Qaqortoq (map 6054).

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow nearshore waters, which may exist within the fjords and coastal islands on this map. The waters appear to be deep, but as they are uncharted, soundings should be taken to confirm their depth prior to using dispersants.

Offshore countermeasures represent the only practical method of protecting most shoreline areas.

The main entrances to the fjords on this map are generally too wide to consider exclusion booming. Exclusion booming to reduce the extent of inshore contamination should be considered at two possible locations. At Kangerluatsiaq the inlet width is approximately 600 m, and the inlet close east has an inlet width of approximately 700 m. Both have rock shorelines and appear to have deep water. Site surveys at the time of a spill will be required to confirm the feasibility of booming techniques. High tidal velocities are possible given the reported tidal range and may prevent successful booming.

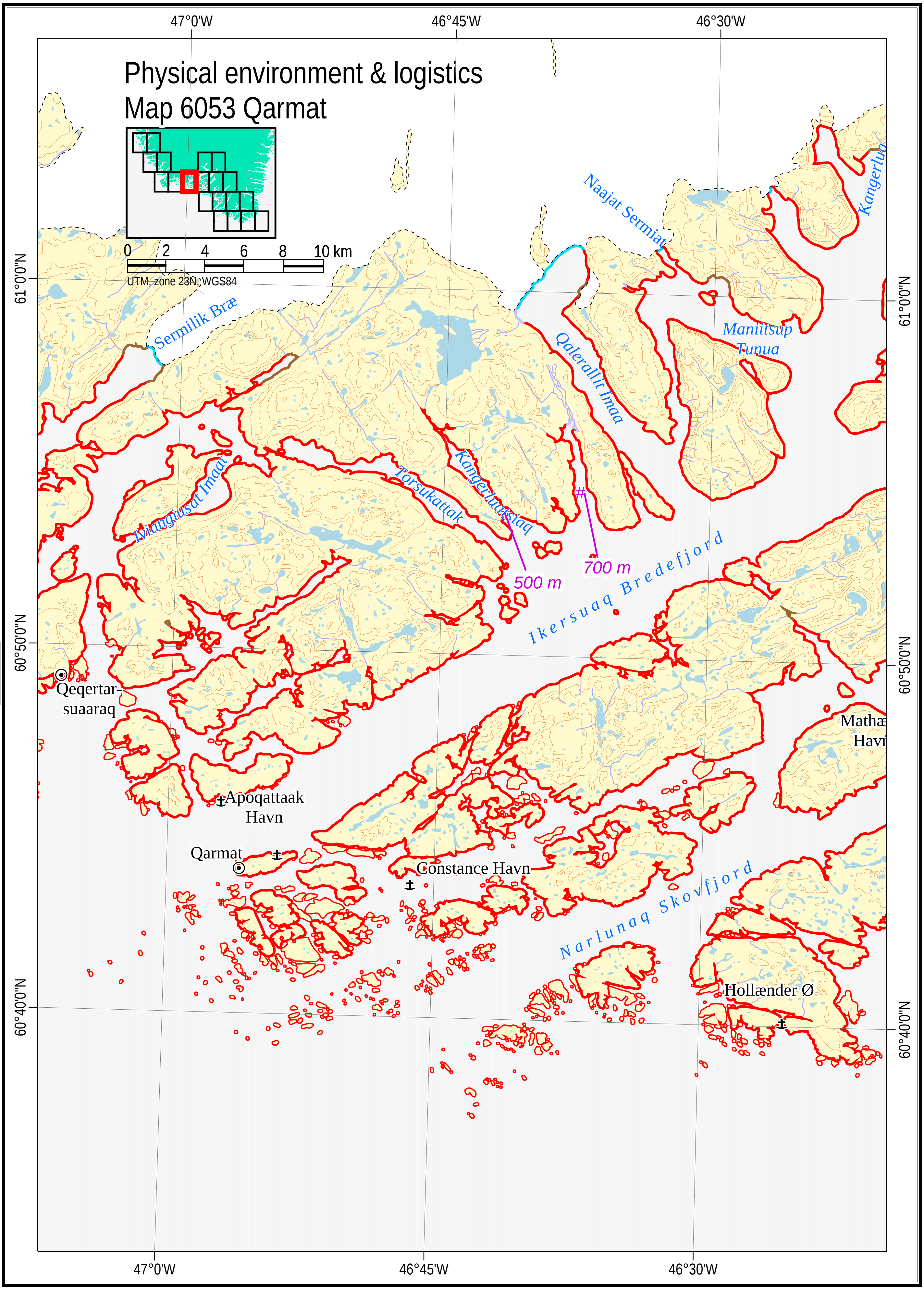
Shorelines shown on this map are exposed and semi-exposed rock, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marine-based given the likely nature of the shoreline.

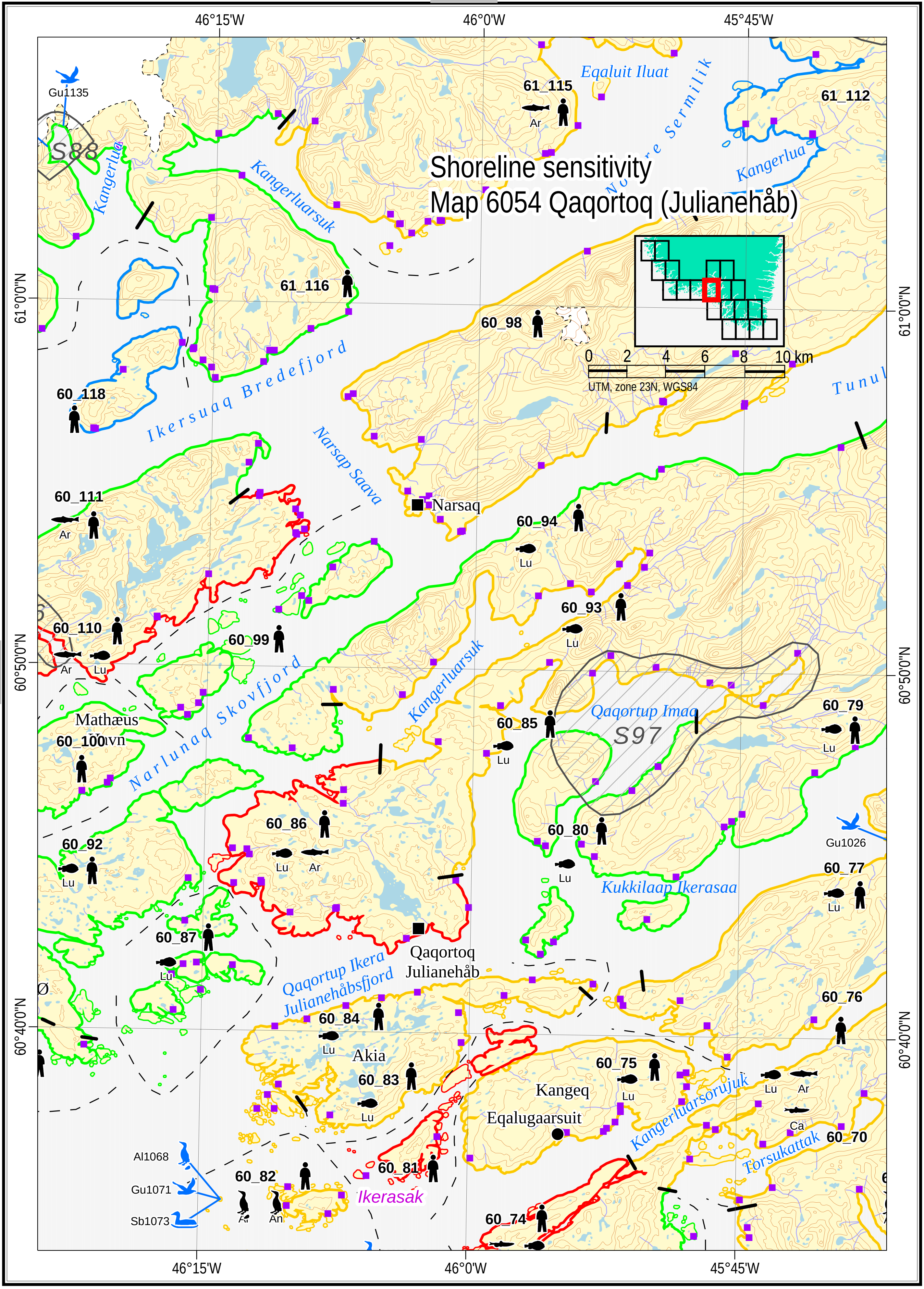
Safe havens

There are no potential safe havens identified on this map. Consideration could be given to the three anchorages near the entrance to Ikersuaq/Bredefjord, each of which is in an area of low to moderate sensitivity. However, they offer limited shelter and would be difficult to boom given their entrance widths. Other inlets along the north side of Ikersuaq/Bredefjord have the same limitations.

Maps

Danish Survey & Cadastre (KMS) topographical map: 60 V.1. Nautical charts: 1100, 1116.


47°0'W
46°45'W
46°30'W
Physical environment & logistics
Map 6053 Qarmat
0 2 4 6 8 10 km
UTM, zone 23N, WGS84
61°0'0"N
60°50'0"N
60°40'0"N
Naajat Sermiat
Sermilik Bræ
Maniitsup Tunua
Qerralllit Imaa
Kangerluarsiaq
Torsukattak
Iviangiusat Imaat
500 m
700 m
Ikersuaq Bredefjord
Qeqertar-suaaraq
Apoqattaak Havn
Qarmat
Constance Havn
Narlunaq Skovfjord
Hollænder Ø


Shoreline sensitivity
Map 6054 Qaqortoq (Julianehåb)
46°15'W
46°0'W
45°45'W
61°0'0"N
60°50'0"N
60°40'0"N
0 2 4 6 8 10 km
UTM, zone 23N, WGS84
Eqaluit Iluat
Nordre Sermilik
Kangerlua
Kangerluarsuk
Ikersuaq Bredefjord
Narsap Saava
Narsaq
Tunul
Kangerluarsuk
Narlunaq Skovfjord
Mathæus
Qaqortup Imaa
S97
S88
Kukkilaap Ikerasaa
Qaqortoq
Julianehåb
Qaqortup Ikera
Julianehåbsfjord
Akia
Kangeq
Eqalugaarsuit
Kangerluarsorujuk
Torsukattak
Ikerasak
61_115
61_112
61_116
60_98
60_118
60_111
60_94
60_93
60_110
60_99
60_85
60_79
60_100
60_86
60_80
60_92
60_77
60_87
60_84
60_76
60_83
60_75
60_81
60_82
60_74
60_70
Gu1135
Gu1026
Al1068
Gu1071
Sb1073
Ar
Lu
Ca
An

Environmental description

Resource use

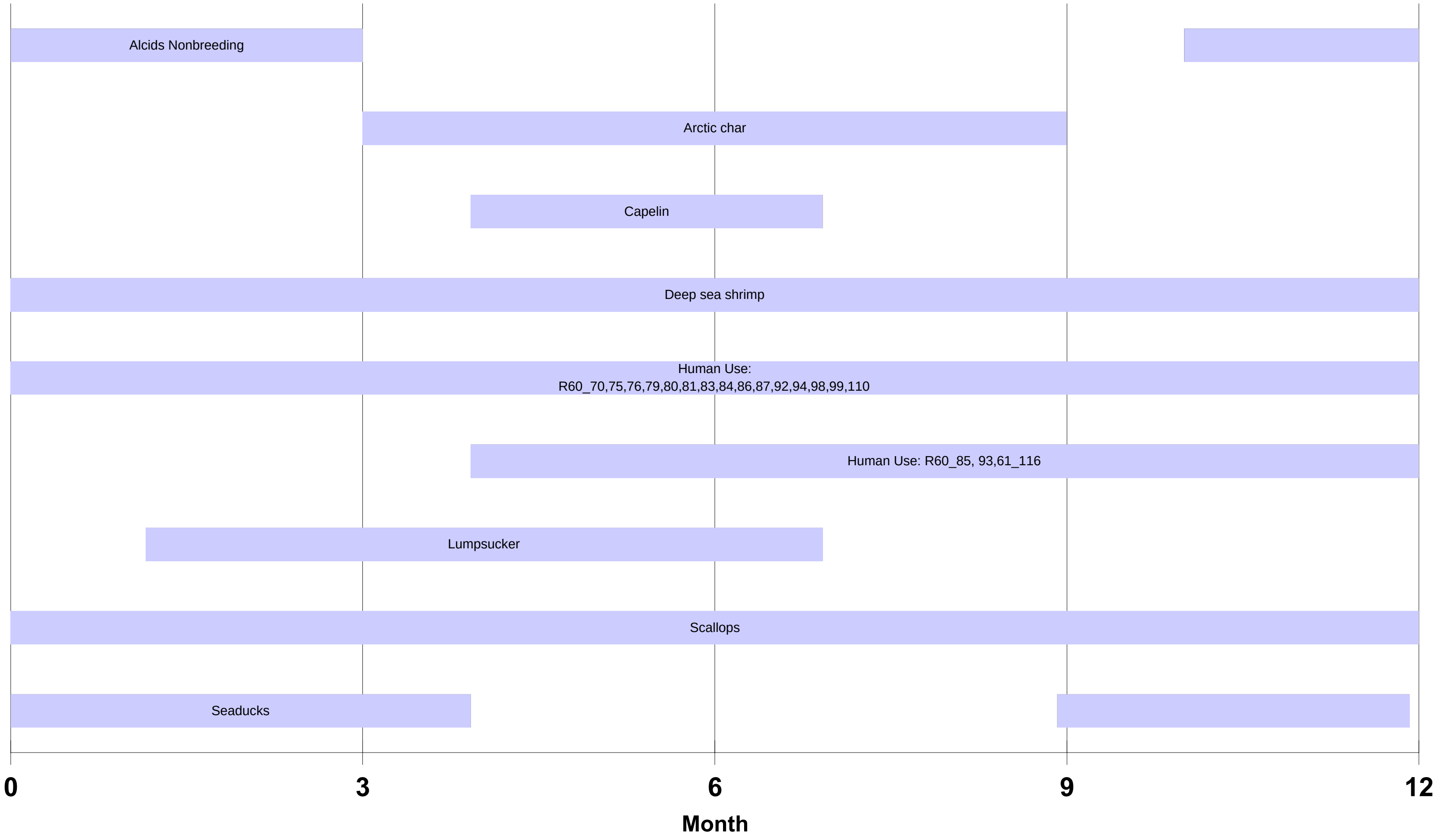
R 60_75	Fishery for lumpsucker and Atlantic cod. Hunting for seals. Tourist attractions along coast (important).
R 60_76	Fishery for capelin, lumpsucker (important), Atlantic cod and Arctic char in 2 river outlets (both important). Hunting for seals. Tourist attractions along coast.
R 60_79	Fishery for lumpsucker (important), Greenland halibut and Atlantic cod. Hunting for seals. Tourist attraction at Upernaviarsuk **(S97)**.
R 60_80	Fishery for lumpsucker (important), Atlantic cod and Greenland halibut. Hunting for fin and minke whales and seals (**S95**).
R 60_81	Fishery for scallop, lumpsucker and Atlantic cod. Hunting for fin and minke whales and seals.
R 60_83	Fishery for scallop, lumpsucker and Atlantic cod. Hunting for fin and minke whales and seals.
R 60_84	Fishery for lumpsucker (important), Atlantic cod and salmon. Hunting for fin and minke whales, harbour porpoises and seals.
R 60_85	Fishery for capelin, lumpsucker (important), Atlantic cod and Arctic char in 1 river outlet. Hunting for fin and minke whales and seals. Tourist attraction at Hvalsøy (important) (**S95**).
R 60_86	Fishery for scallop, lumpsucker (important), wolffish, salmon, Atlantic cod and Arctic char in 2 river outlets (both important). Hunting for fin and minke whales, harbour porpoises and seals. Tourist attraction in town.
R 60_87	Fishery for lumpsucker (important), wolffish, Atlantic cod and salmon. Hunting for fin and minke whales, harbour porpoises and seals.
R 60_92	Fishery for scallop, snow crab (important), lumpsucker (important), wolffish, salmon and Atlantic cod. Hunting for fin and minke whales, seals, harbour porpoises and guillemots.
R 60_93	Fishery for capelin, lumpsucker (important), wolffish, Atlantic cod (pound net), salmon and Arctic char in 1 river outlet. Hunting for seals.
R 60_94	Fishery for capelin, lumpsucker, snow crab, wolffish, Arctic char at coast, Atlantic cod (pound net), Greenland halibut, redfish and salmon. Hunting for seals and guillemots.
R 60_98	Fishery for capelin, lumpsucker, Atlantic cod (pound net), wolffish, redfish and Arctic char at coast and in 1 river outlet. Hunting for fin and minke whales, seals and guillemots. Tourist angling and hiking along coasts.
R 60_99	Fishery for snow crab, lumpsucker, Atlantic cod (pound net), wolffish, redfish and salmon. Hunting for fin and minke whales, seals, guillemots and eiders.
R 60_110	Fishery for scallop, capelin, deep sea shrimp, lumpsucker (important), Atlantic cod, wolffish and Arctic char at coast and in 3 river outlets (all important). Hunting for seals, guillemots and eiders.
R 61_116	Fishery for capelin, lumpsucker, Greenland halibut, wolffish, redfish and Arctic char at coast and in 2 river outlets (1 important). Hunting for seals and guillemots. Tourist attraction at Niaqornat.

Species occurrence

Ar60076, Ar60086	2 rivers with Arctic char.
Ar60110	3 rivers with Arctic char and small important coastal fishing area.
Ca60070	Capelin spawning and fishing area along almost all coasts.
Lu60075	Lumpsucker spawning and important fishing grounds along northern and southern coasts.
Lu60076	Lumpsucker spawning and important fishing grounds along almost all coasts.
Lu60079	Lumpsucker spawning and important fishing grounds along all coasts (**S95**).
Lu60080	Lumpsucker spawning and important fishing grounds along almost all coasts (**S95**).
Lu60083	Lumpsucker spawning and important fishing grounds in the eastern part.
Lu60084, Lu60086	Lumpsucker spawning and important fishing grounds along all coasts.
Lu60085	Lumpsucker spawning and important fishing grounds along all coasts (**S95**)
Lu60087	Lumpsucker spawning and important fishing grounds along almost all coasts.
Lu60092, Lu60093	Lumpsucker spawning and important fishing grounds along all coasts.

(Cont. on page 9-75)

Map 6054 Species and Resource Occurrences



Shoreline sensitivity

Map 6054 - Qaqortoq (Julianehåb)

Environmental description

(Continued from page 9-73)

Lu60094	Lumpsucker spawning and important fishing grounds along most of the coasts.
Lu60110	Lumpsucker spawning and important fishing grounds along all coasts.

Site specific species occurrence (seabird breeding colonies); blue icons

Al1068	Breeding razorbills, black guillemots and Atlantic puffins.
Gu1071	Breeding lesser black-backed gulls, great black-backed gulls and Arctic terns.
Sb1073	Beeding common eiders.

Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
60_70	33	High
60_75	39	High
60_76	41	High
60_79	32	Moderate
60_80	31	Moderate
60_81	46	Extreme
60_83	38	High
60_84	37	High
60_85	39	High
60_86	51	Extreme
60_87	25	Moderate
60_92	26	Moderate
60_93	36	High
60_94	30	Moderate
60_98	37	High
60_99	24	Moderate
60_110	52	Extreme
61_116	29	Moderate

Physical environment and logistics

Map 6054 - Qaqortoq (Julianehåb)

Access

The nearshore waters in this area are largely uncharted and caution should be exercised. In general the waters offshore, nearshore and within the fjords appear to be deep, however uncharted dangers may exist. Local knowledge is essential for navigation.

When pack ice enters the area from Cape Farewell (February-July) the entrance to Narlunaq/Skovfjord fills rapidly, but only in south winds does it enter the fjord beyond Hollænderø. Conditions can change quickly and should be considered prior to inshore navigation.

in winter ice can form locally within the fjords, and its movement can hamper navigation from early March to early August.

There is no information on tides or currents within fjords for this area.

Qaqortoq is a commercial harbour and the principal settlement of south Greenland. It has several good anchorages that is generally open day and night throughout the year. There are several jetties. The largest has depths alongside of 6 m, and they all have a height above mean water of 1.3 m. Facilities include a hospital, boatyard and mobile cranes. Fuel, fresh water and provisions are available. Icebergs do not generally enter the harbour, but pack ice is common from January to July. Tidal streams are negligible.

Anchorage is available off the pebble beach below Qaqortoq Fjeld with depths of 37 m. Caution is advised to avoid foul ground east and south of the anchorage.

Access

(Continued from previous page)
Mathæus Havn at the northeastern end of Illukasik is the only anchorage in Narlunaq suitable for a large vessel, depths to 40 m. Ice may fill the harbour in southern and southeastern winds.

Anchorage is available at the small settlement of Eqalugaarsuit, depths of 2.8 to 6.6 m. Tidal streams are weak in the harbour. Off the harbour it can run strongly. Mean high water of spring tides is 2.8 m.

The bay close southeast of the town of Narsaq provides anchorage for large vessels and a berth for vessels to 40 m length and 3.0 m draft. The mean high water of spring tides is 3.0 m and the tidal stream is weak.

Landings may be possible at the pebble beach below Qaqortoq Fjeld but would require reconnaissance to confirm.

In all other areas shorelines are almost exclusively rock allowing little opportunity for marine access. There is no information to indicate the potential for beach landings.

There are heliports at Qaqortoq and Narsaq. The nearest airport is at Narsarsuaq (map 6106).

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow nearshore waters, which may exist within the fjords and inter-island channels on this map. The waters appear to be deep, but as they are uncharted, soundings should be taken to confirm their depth prior to using dispersants.

Offshore countermeasures represent the only practical method of protecting most shoreline areas, including the selected area shown on the map.

The main entrances to the fjords on this map are generally too wide to consider exclusion booming. Exclusion booming to reduce the extent of inshore contamination of sensitive areas should be considered at four possible locations. Between the islands of Akia and Kangeq the two channels have inlet widths of 100 and 500 m. At the eastern extremity of Akia the two channels have widths of 700 and 500 m. Both locations have rock shorelines and appear to have deep water. Site surveys at the time of a spill will be required to confirm the feasibility of booming techniques. High tidal velocities are possible given the reported tidal range and may prevent successful booming.

Shorelines shown on this map are almost exclusively exposed and semi-exposed rock, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marine-based given the likely nature of the shoreline.

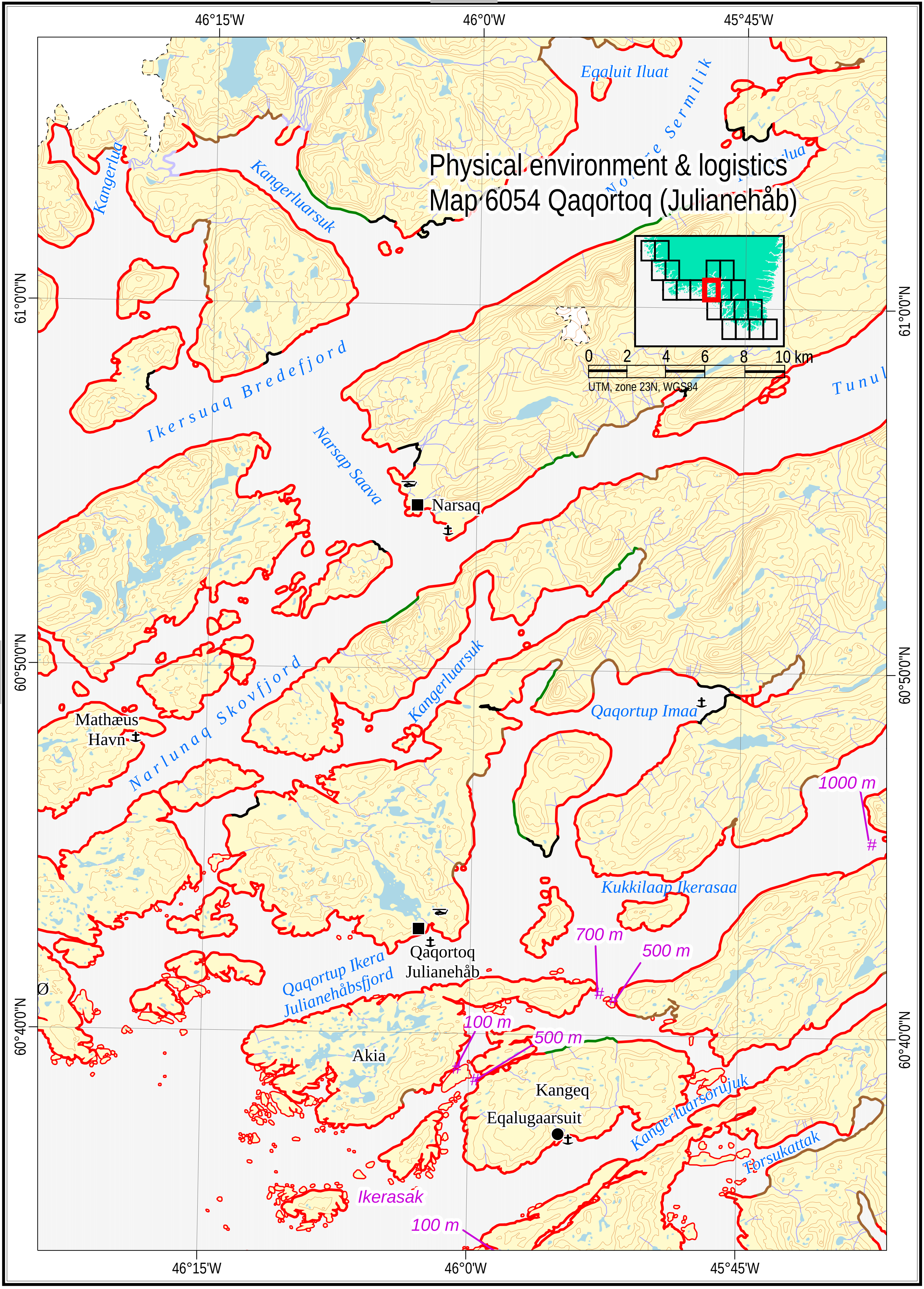
Several beaches are located on the north side of Ikersuaq/Bredefjord, at Kangerlua, in Qaqortup Imaa and close north of Narsaq. These beaches have protected or semi-protected coastal exposure. If oiled, these areas may require cleaning using sediment removal techniques along with the temporary stockpiling and subsequent removal for disposal of collected materials. In each of these areas marine access and beach trafficability are unknown, necessitating site surveys at the time of the cleanup.

Safe havens

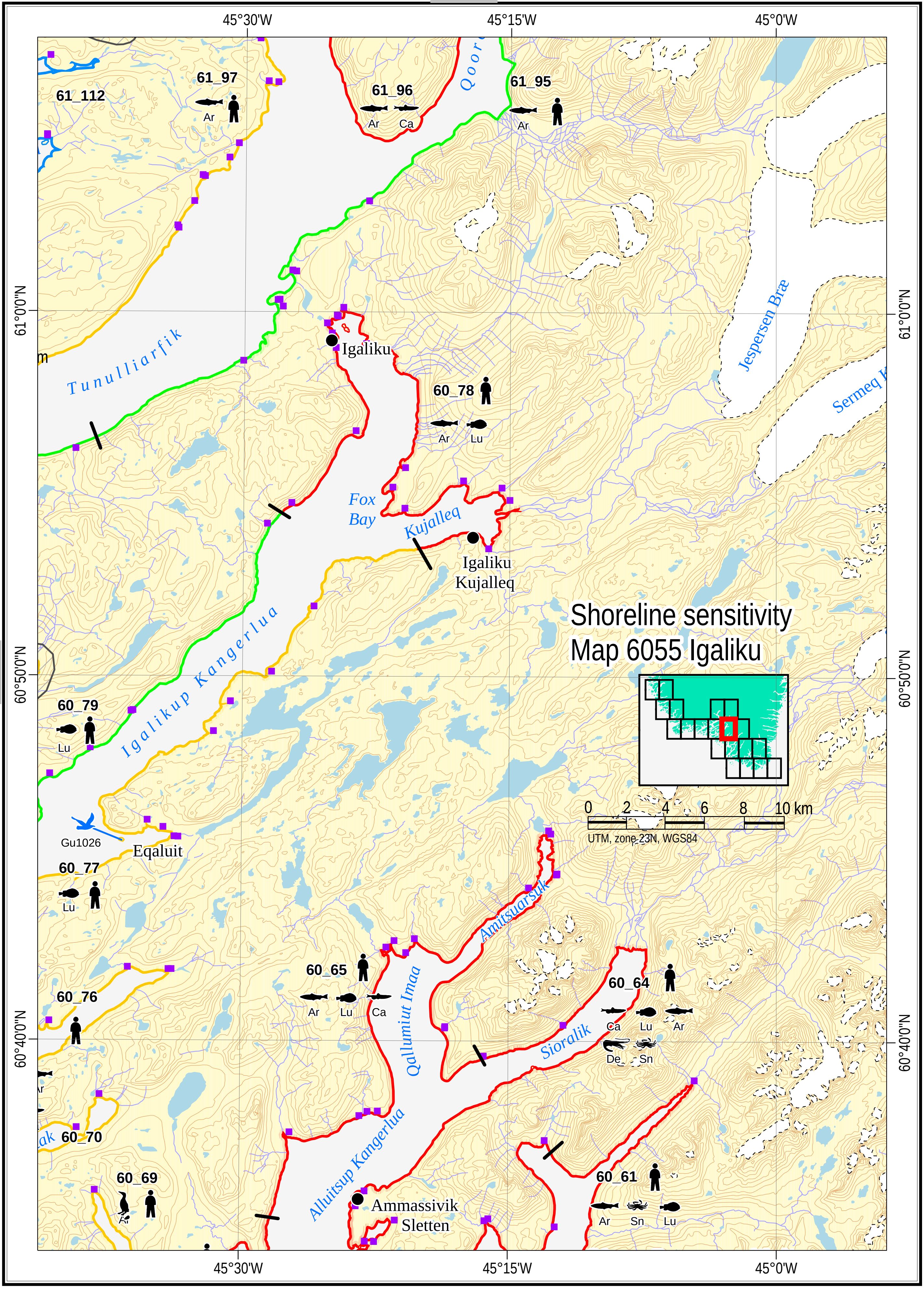
There are no potential safe havens identified on this map.

Maps

Danish Survey & Cadastre (KMS) topographical maps: 60 V.1 and V.2. Nautical charts: 1100, 1114, 1115, 1116.


Physical environment & logistics
Map 6054 Qaqortoq (Julianehåb)
46°15'W
46°0'W
45°45'W
61°0'0"N
60°50'0"N
60°40'0"N
0 2 4 6 8 10 km
UTM, zone 23N, WGS84
Eqaluit Iluat
Kangerlua
Kangerluarsuk
Ikersuaq Bredefjord
Narsap Saava
Narsaq
Tunul
Mathæus Havn
Narlunaq Skovfjord
Kangerluarsuk
Qaqortup Imaa
1000 m
Kukkilaap Ikerasaa
700 m
500 m
Qaqortoq
Julianehåb
Qaqortup Ikera
Julianehåbsfjord
Ø
100 m
500 m
Akia
Kangeq
Eqalugaarsuit
Kangerluarsorujuk
Torsukattak
Ikerasak
100 m

Airphoto keymap | Map legend | Toggle maps | Keymaps



Shoreline sensitivity

Map 6055 - Igaliku

Environmental description

Resource use

R 60_64	Fishery for salmon, Greenland halibut (important), wolffish, Atlantic cod, Greenland cod, deep sea shrimp, snow crab, capelin (important) lumpsucker and Arctic char at coast and at 1 river outlet (important). Hunting for eiders, fin and minke whales, polar bears and harp seals.
R 60_65	Fishery for salmon, wolffish, Atlantic cod, Greenland cod, Greenland halibut, deep sea shrimp, snow crab, capelin (important), lumpsucker, redfish and Arctic char at coast and at 3 river outlets. Hunting for eiders, fin and minke whales and harp seals. Tourist attraction at Qollortorsuaq.
R 60_77	Fishery for lumpsucker (important), Atlantic cod, Greenland halibut. and Arctic char at coast and at 1 river outlet (important). Hunting for seals. Tourist attractions along coast.
R 60_78	Fishery for capelin 1 lumpsucker (important) Atlantic cod, Greenland halibut and Arctic char at 4 river outlets (3 important). Hunting for seals. Tourist attractions along coast (important).
R 61_95	Fishery for Greenland halibut and Arctic char at 3 river outlets (2 important). Tourist attractions along the coast (important).
R 61_97	Fishery for lumpsucker, Greenland halibut, redfish and Arctic char at coast and in 1 river outlet (important). Tourist angling and hiking along the coast, and important attraction at Qassiarsuk.

Species occurrence

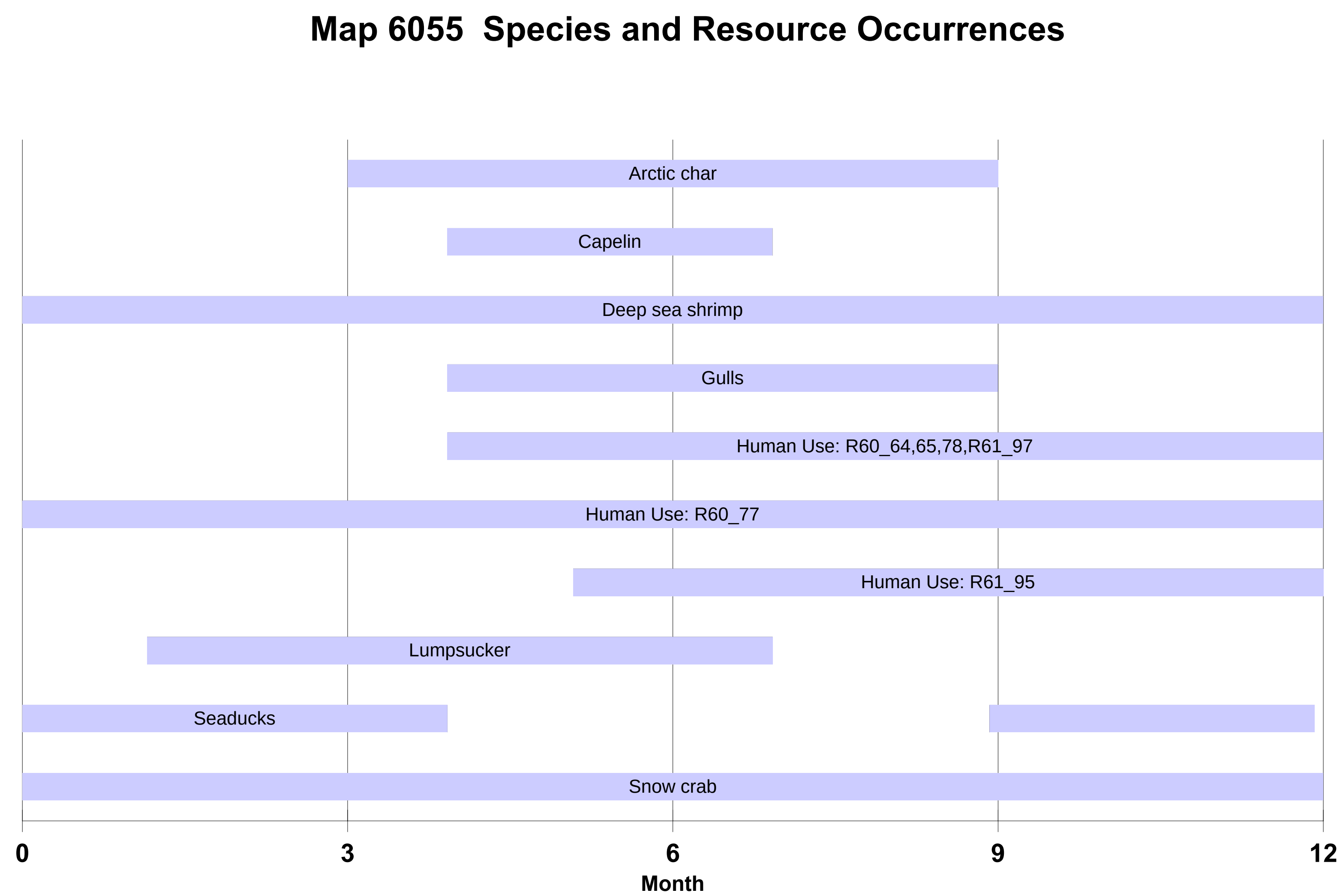
Ar60064	1 river with Arctic char and important coastal fishing areas.
Ar60065	3 rivers with Arctic char and important coastal fishing areas.
Ar60078	4 rivers with Arctic char.
Ar61095	3 rivers with Arctic char.
Ar61097	1 river with Arctic char and important coastal fishing areas.
Ca60064	Capelin spawning along the entire coast of Sioralik.
Ca60065	Capelin spawning area in Qallumiut Imaa and Amituiarsuk.
De60064	Important fishery for deep sea shrimp.
Lu60064	Lumpsucker spawning grounds along most of the coasts, a few important fishing sites.
Lu60065	Lumpsucker spawning grounds along the entire coast, a few important fishing sites.
Lu60077, Lu60078	Lumpsucker spawning and important fishing grounds along almost all coasts.
Sn60064	Snow crab fishing area.

Site specific species occurrence (seabird breeding colonies); blue icons

Gu1026	Breeding Iceland gulls, or glaucous gulls, great black-backed gulls, lesser black-backed gulls and kittiwakes.

Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
60_64	64	Extreme
60_65	63	Extreme
60_77	40	High
60_78	63	Extreme
61_95	32	Moderate
61_97	37	High


Map 6055 Species and Resource Occurrences
Arctic char
Capelin
Deep sea shrimp
Gulls
Human Use: R60_64,65,78,R61_97
Human Use: R60_77
Human Use: R61_95
Lumpsucker
Seaducks
Snow crab
0
3
6
9
12
Month

This page is intentionally left blank

Physical environment and logistics

Map 6055 - Igaliku

Access

There is little information on the marine areas within this map.

The nearshore waters in this area are largely uncharted and caution should be exercised. In general the waters offshore, nearshore and within the fjords appear to be deep, however uncharted dangers may exist. Local knowledge is essential for navigation.

There is no information on tides or currents within fjords for this area.

Anchorage is available on depths to 15 m at Qallumiut on the east side of Qallumiut Imaa, 6 km within the entrance. Water can be obtained from a river at the head of the cove.

Shorelines in this area are almost exclusively rock allowing little opportunity for marine access. There is no information to indicate the potential for beach landings. Landings may be possible near the beach and moraine shorelines at the inner end of the fjords but would require reconnaissance to confirm.

There are no airports on this or adjoining maps. The nearest airport is at Narsarsuaq (map 6106), and there are heliports at Qaqortoq (map 6054) and Nanortalik (map 6002).

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow nearshore waters, which may exist within the fjords and inlets on this map. The waters appear to be deep, but as they are uncharted, soundings should be taken to confirm their depth prior to using dispersants.

Offshore countermeasures represent the only practical method of protecting most shoreline areas.

The fjords on this map are generally too wide to consider exclusion booming. Exclusion booming to reduce the extent of inshore contamination should be considered at two possible locations. At Eqaluit and at Amitsuarsuk the inlets widths are 1,000 m. Both have rock shorelines and appear to have deep water. Site surveys at the time of a spill will be required to confirm the feasibility of booming techniques. High tidal velocities are possible given the reported tidal range and may prevent successful booming.

Shorelines shown on this map are predominantly semi-exposed rock and moraine, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marine-based given the likely nature of the shoreline.

Beaches located at the heads of the fjords on this map have protected or semi-protected coastal exposure. If oiled, these areas may require cleaning using sediment removal techniques along with the temporary stockpiling and subsequent removal for disposal of collected materials. In each of these areas marine access and beach trafficability are unknown, necessitating site surveys at the time of the cleanup.

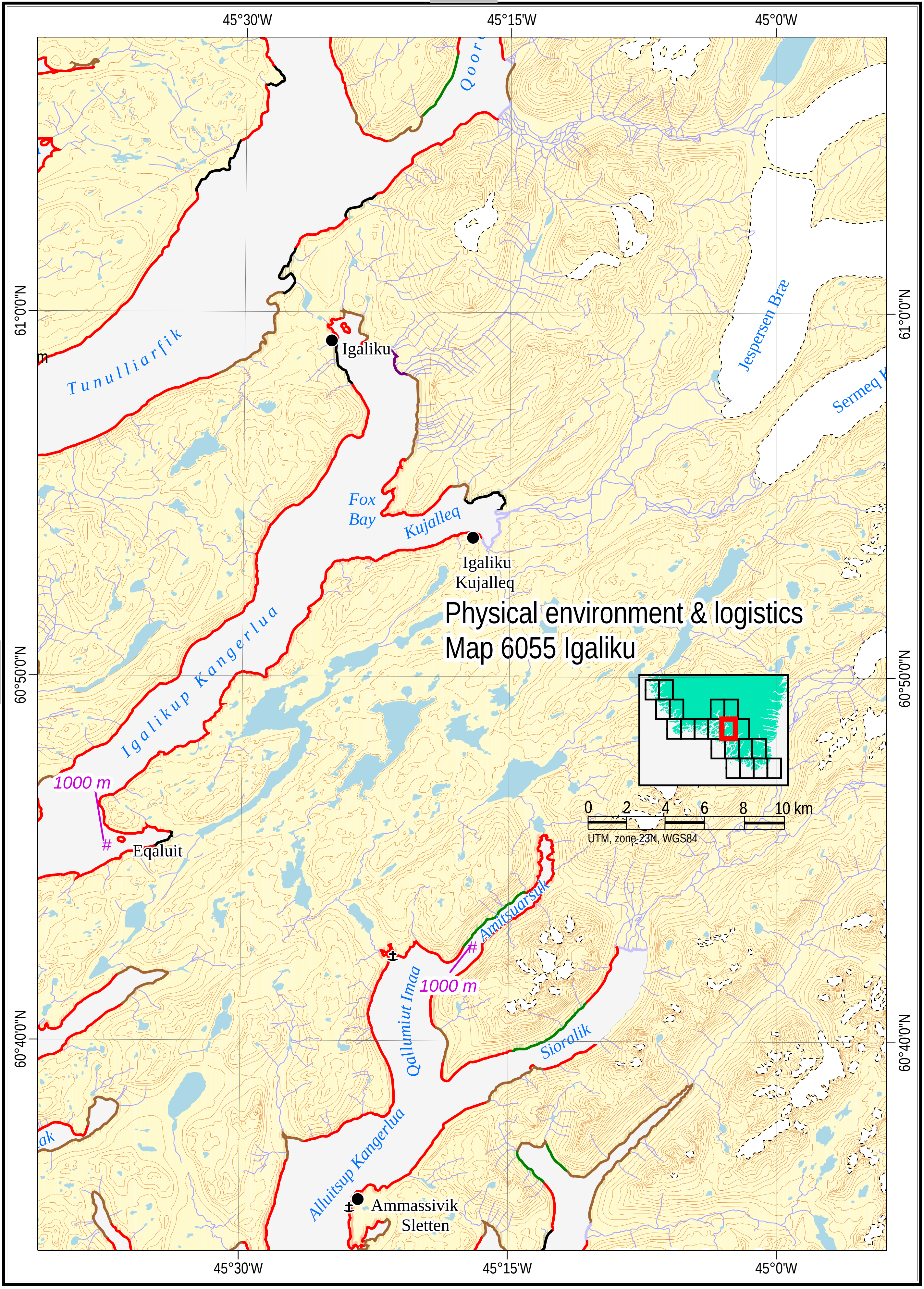
Safe havens

There are no potential safe havens identified on this map.

Maps

Danish Survey & Cadastre (KMS) topographical map: 60 V.2. Nautical chart: 1115.

Airphoto keymap
Map legend
Toggle maps
Keymaps



Environmental Oil Spill Sensitivity Atlas for the South Greenland Coastal Zone

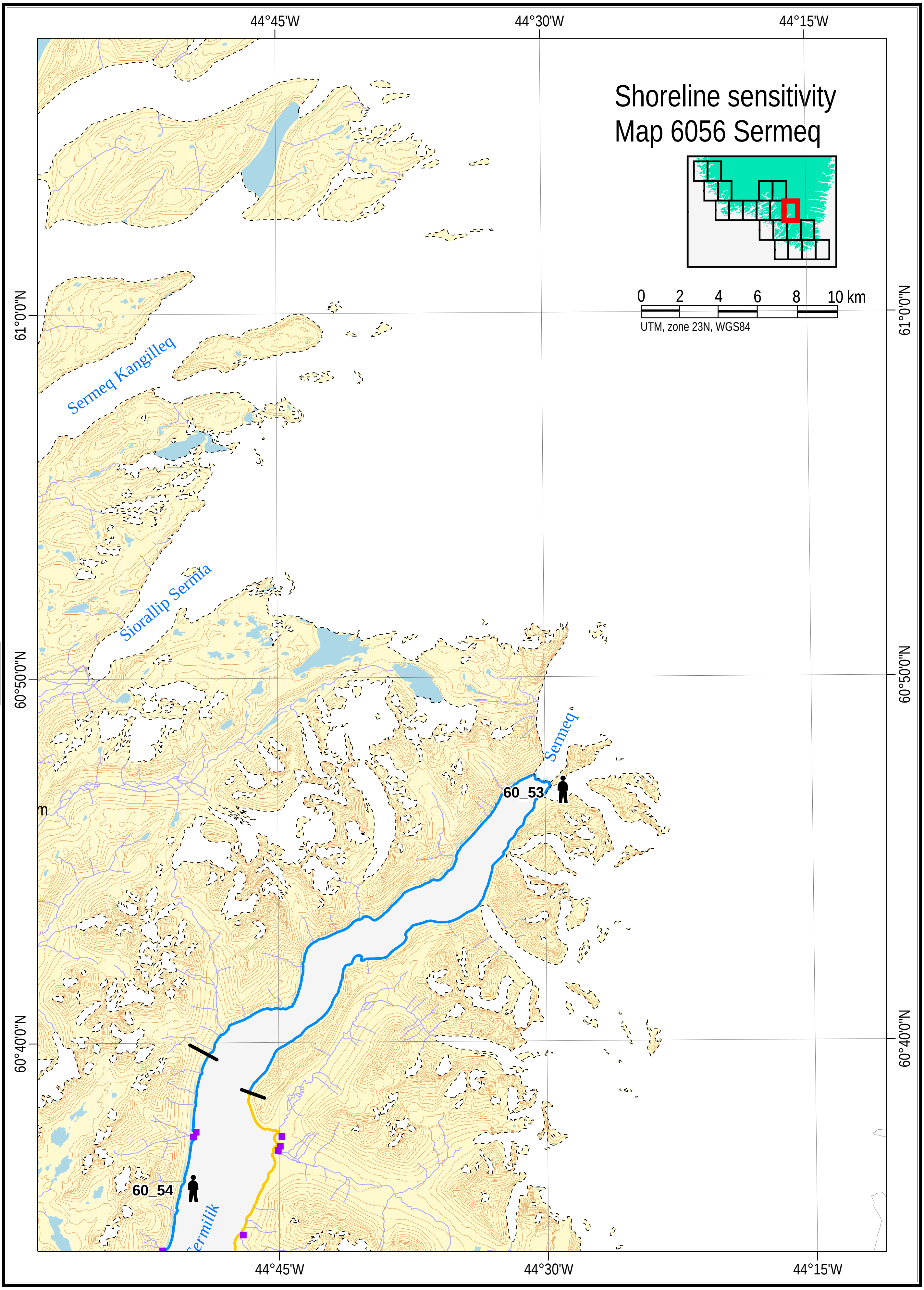
Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Airphoto keymap

Map legend

Toggle maps

Keymaps



Shoreline sensitivity

Map 6056 - Sermeq

Environmental description

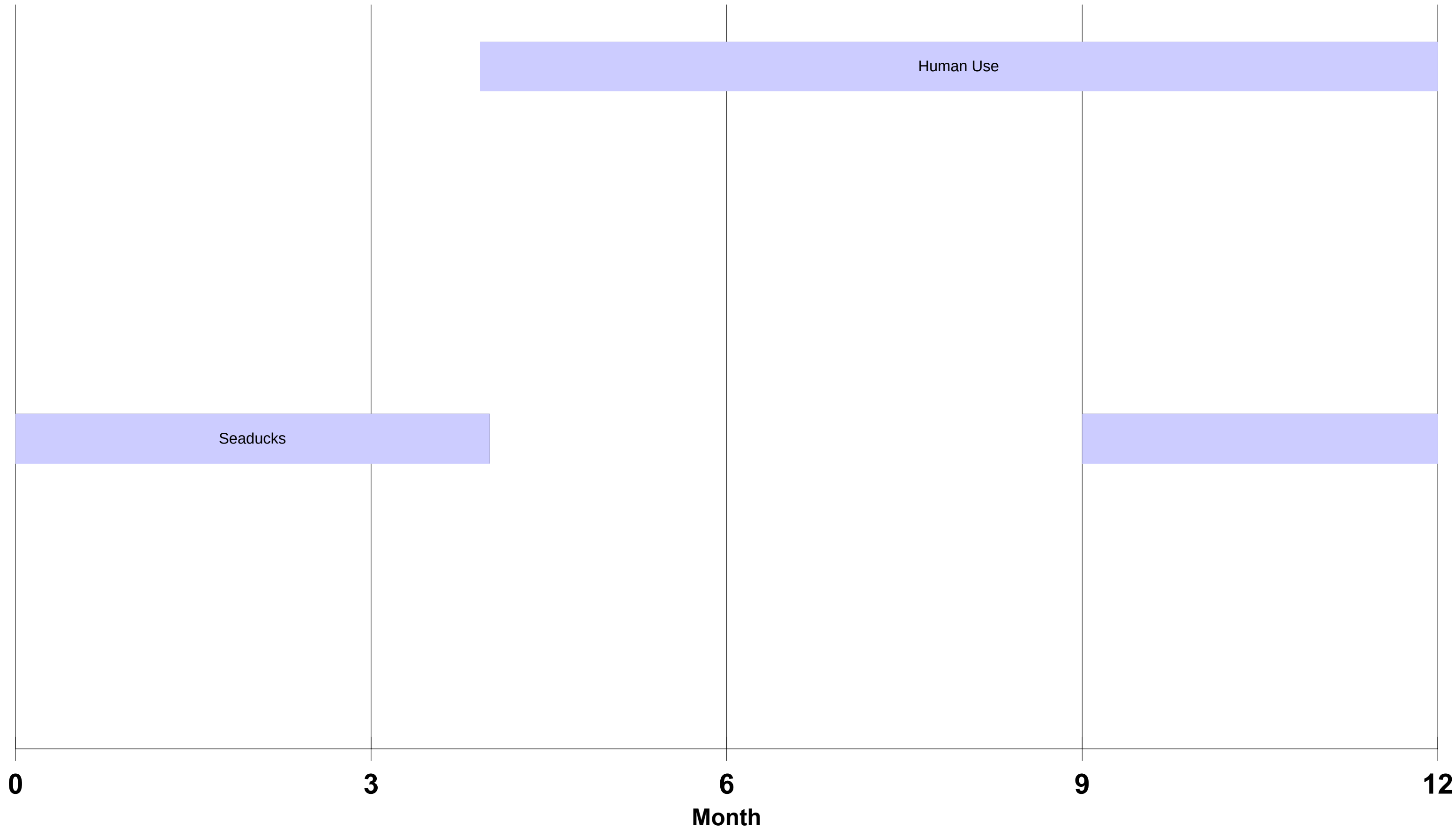
Resource use

R 60_53 Fishery for Arctic char at coast (important), Greenland halibut (important) and Greenland cod. Hunting for eiders, guillemots, bearded seals, harp seals and ringed seals (important).

Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
60_53	11	Low

Map 6056 Species and Resource Occurrences



This page is intentionally left blank

Physical environment and logistics

Map 6056 - Sermeq

Access

Little information is available on the limited marine areas in this map.

The nearshore waters in this area are largely uncharted and caution should be exercised. In general the waters offshore, nearshore and within the fjords appear to be deep, however uncharted dangers may exist. Local knowledge is essential for navigation.

There is no information on tides or currents within fjords for this area.

No anchorages are reported for this map area

Shorelines in this area are predominantly rock allowing little opportunity for marine access. There is no information to indicate the potential for beach landings.

There are no airports on this map. The nearest airport is at Narsarsuaq (map 6106), and there are heliports at Nanortalik (map 6002) and Narsaq (map 6054).

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow nearshore waters, which may exist within this fjord. The waters appear to be deep, but as they are uncharted, soundings should be taken to confirm their depth prior to using dispersants.

Offshore countermeasures represent the only practical method of protecting most shoreline areas.

There are no opportunities for exclusion booming in the area shown on this map due to the width of the fjord and the deep nearshore waters.

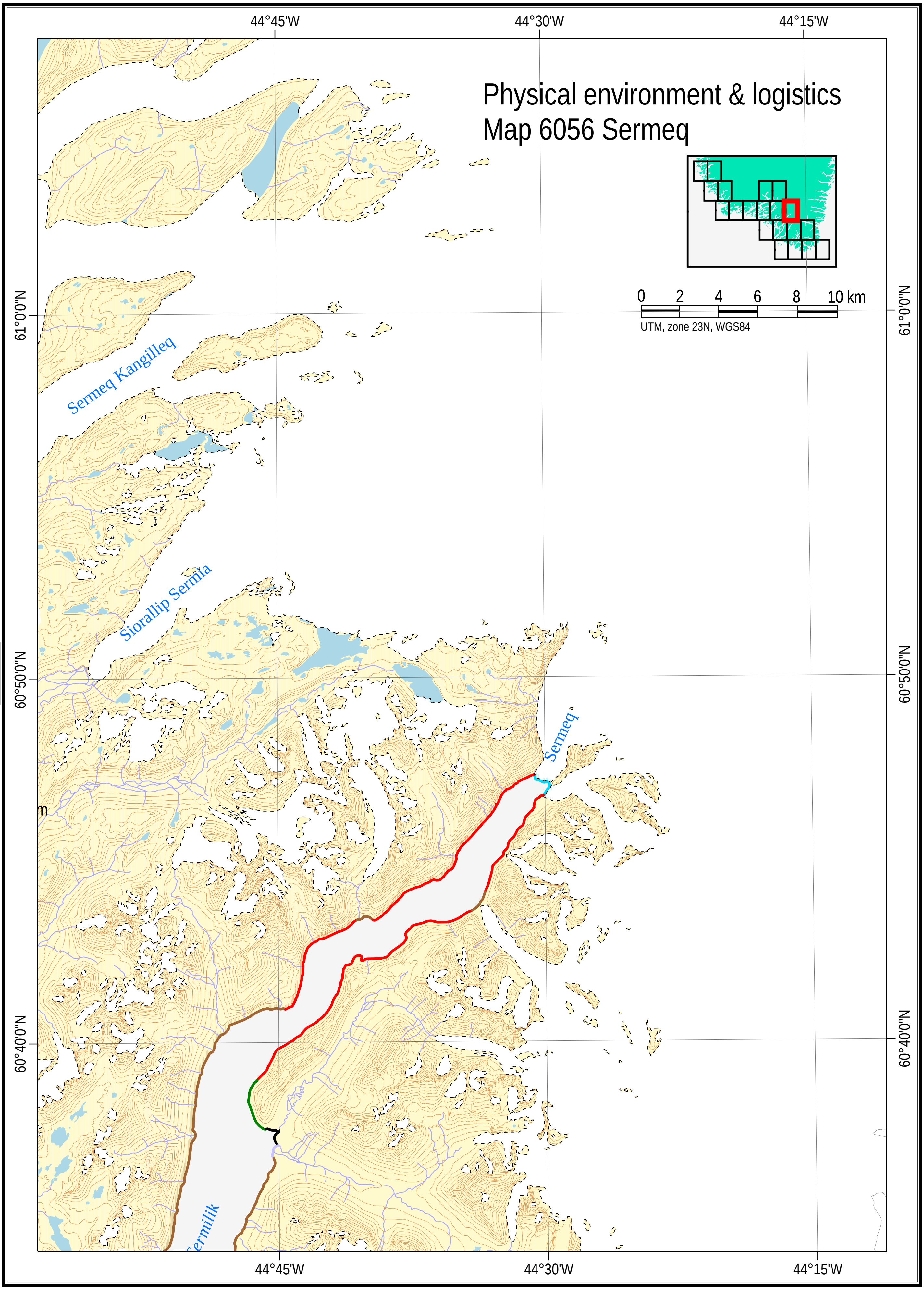
Shorelines shown on this map are semi-exposed rock and moraine, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marine-based given the likely nature of the shoreline.

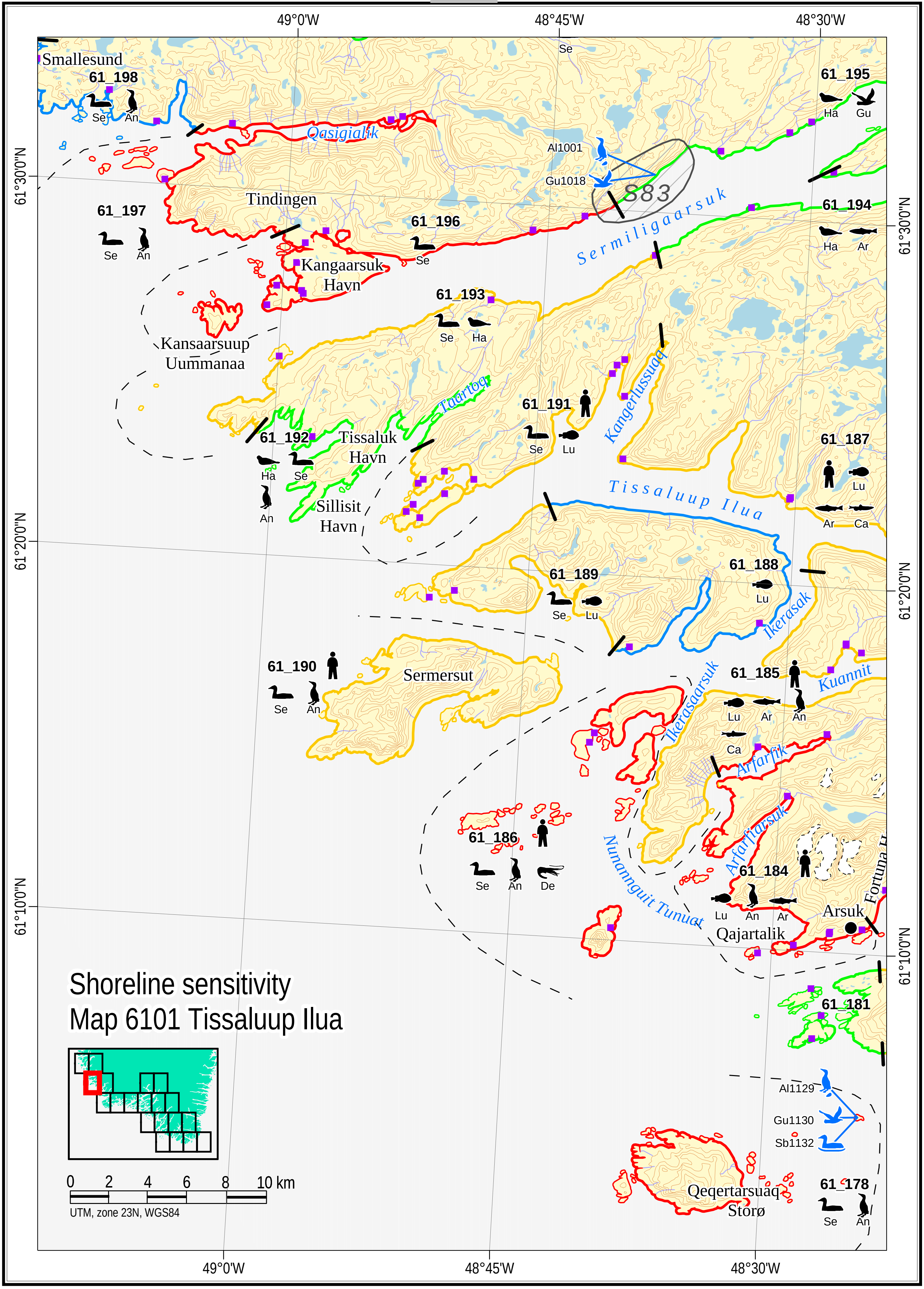
Safe havens

There are no potential safe havens identified on this map.

Maps

Danish Survey & Cadastre (KMS) topographical map: 60 V.2. Nautical charts: none.


Physical environment & logistics
Map 6056 Sermeq
0 2 4 6 8 10 km
UTM, zone 23N, WGS84
44°45'W
44°30'W
44°15'W
61°0'0"N
60°50'0"N
60°40'0"N
Sermeq Kangilleq
Siorallip Sermia
Sermeq



Shoreline sensitivity
Map 6101 Tissaluup Ilua

Shoreline sensitivity Map 6101 - Tissaluup Ilua

Environmental description

Resource use

R 61_184	Fishery for lumpsucker (important), capelin, wolffish, salmon and Arctic char at coast and in 1 river outlet (important). Hunting for eiders.
R 61_185	Fishery for lumpsucker (important), capelin, wolffish and Arctic char at coast and in 2 river outlets. Hunting for eiders.
R 61_186	Fishery for deep sea shrimp (important), Atlantic cod (pound net), wolffish and salmon. Hunting for fin and minke whales and eiders.
R 61_187	Fishery for lumpsucker (important), capelin, Atlantic cod (pound net) and Arctic char at coast and in 2 river outlets. Hunting for fin and minke whales and ringed seals.
R 61_190	Fishery for deep sea shrimp Atlantic cod (pound net), wolffish, salmon and Arctic char at 1 river outlet.
R 61_191	Fishery for lumpsucker, capelin, Atlantic cod (pound net), Greenland halibut and wolffish.

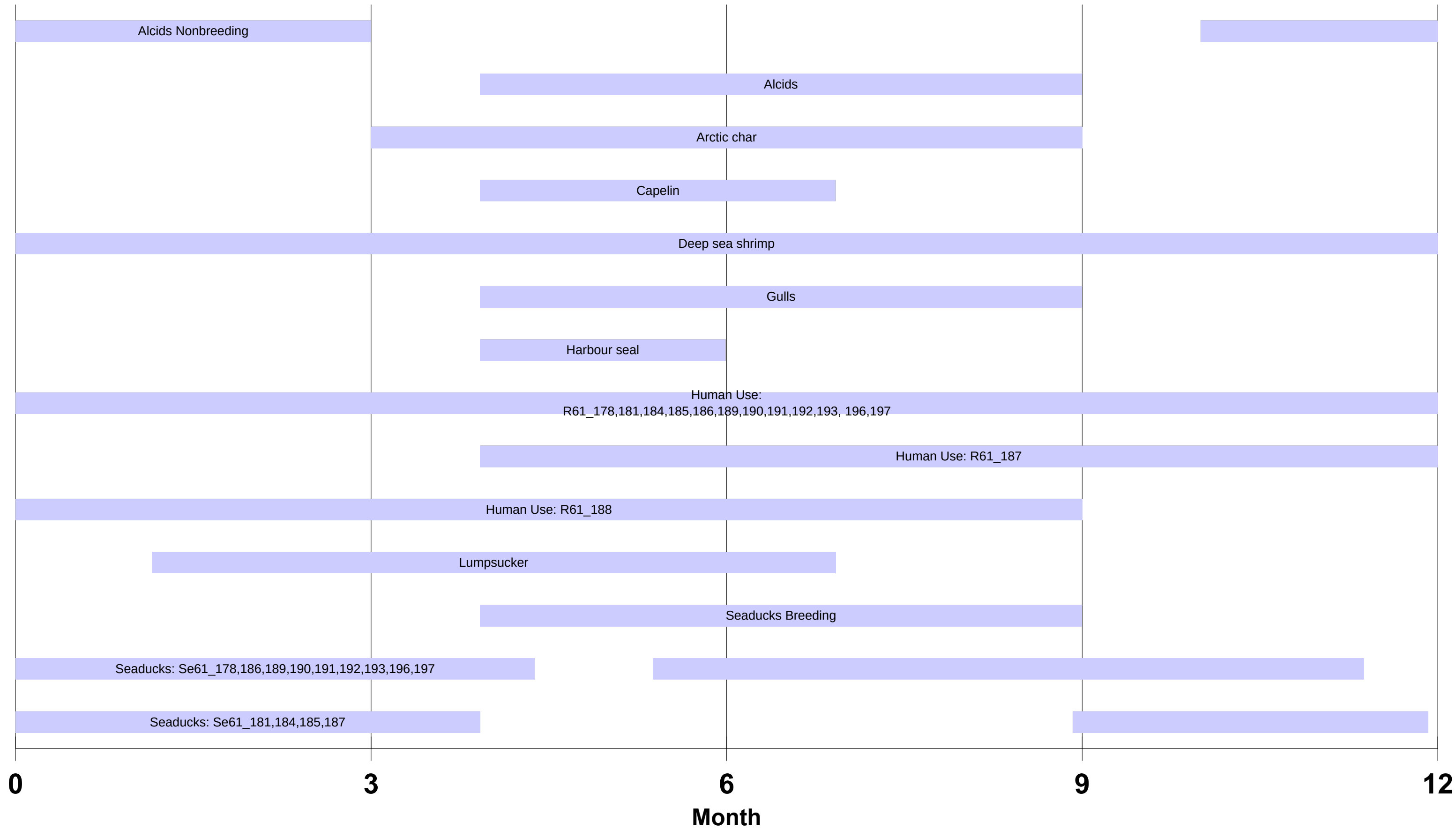
Species occurrence

An61178, An61184	Important area for Brünnich's guillemots in winter.
An61185, An61190	Black guillemots and Brünnich's guillemots in winter.
An61186	Important area for Brünnich's guillemots.
An61192, An61197	Black guillemots and Brünnich's guillemots in winter.
Ar61184	1 river with Arctic char and small important coastal fishing area.
Ar61185	2 rivers and coastal fishing areas (some important) for Arctic char.
Ar61187	3 rivers and coastal fishing areas for Arctic char.
Ca61185	Capelin fishing area in the eastern and central part.
Ca61187	Capelin fishing area in the western and central part.
De61186	Important fishery for deep sea shrimp.
Ha61192, Ha61193	Whelping area for harbour seals.
Lu61184, Lu61185	Lumpsucker spawning and important fishing grounds along all coasts.
Lu61187, Lu61188	Lumpsucker spawning and important fishing grounds along all coasts.
Lu61189	Lumpsucker spawning and important fishing grounds along south coasts.
Lu61191	Lumpsucker spawning and important fishing grounds in the eastern part.
Se61178, Se61186	Eiders, long-tailed ducks and harlequin ducks in winter and harlequin ducks moulting in summer.
Se61189	Harlequin duck winter and moulting area.
Se61190, Se61192	Eiders, long-tailed ducks and harlequin ducks in winter and harlequin ducks moulting in summer.
Se61191	Harlequin duck winter and moulting area
Se61193, Se61196	Eiders, long-tailed ducks and harlequin ducks in winter and harlequin ducks moulting in summer.
Se61197	Eiders, long-tailed ducks and harlequin ducks in winter and harlequin ducks moulting in summer.

Site specific species occurrence (seabird breeding colonies); blue icons

Al1001	Breeding razorbills and black guillemots (**S83**).
Al1129	Breeding black guillemots.
Gu1018	Breeding kittiwakes and Iceland gulls (**S83**).
Gu1130	Breeding lesser black-backed gulls and great black-backed gulls.
Sb1132	Breeding common eiders.

Map 6101 Species and Resource Occurrences



Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
61_178	50	Extreme
61_181	23	Moderate
61_184	51	Extreme
61_185	42	High
61_186	52	Extreme
61_187	37	High
61_188	15	Low
61_189	41	High
61_190	35	High
61_191	43	High
61_192	32	Moderate
61_193	36	High
61_196	49	Extreme
61_197	51	Extreme

Physical environment and logistics

Map 6101 - Tissaluup Ilua

Access

The nearshore waters in this area are largely uncharted and caution should be exercised. The waters within the fjords have only a single track of mid-channel soundings. In general the waters offshore, nearshore and within the fjords are deep, however uncharted dangers may exist. Local knowledge is essential for navigation.
The coast north of Ilorput/Arsuk Fjord is fringed with islands, islets and rocks. These are generally situated in the inshore area, allowing safe navigation at a distance of 8 km of the coast, except for areas southeast of Sermersut.

In Ilorput/Arsuk Fjord, anchorage is available in a harbour with depths of 13 m on the south side of Qajartalik. Islets and below-water rocks are situated at the entrance, and south winds send a heavy sea into the harbour.

Anchorage is available at depths of 11 to 18 m in Fortuna Havn 5 km east northeast of Qajartalik,.
Between Ilorput/Arsuk Fjord and Grædefjord (further north outside map) the coast may occasionally be blocked by pack ice for several weeks after break-up (February-June), after which a shore lead generally opens from the north. There are many fjords in this area which only produce little ice.

The prevailing current is 0.5 knots setting to the NW in waters along the coast.

There is no other information on tides or currents within fjords for this area.

Anchorage is available in depths of 22 m in Sillisit (Sitdlisit) Havn 3 km northeast of Søndre Kangeq,. Fresh water can be obtained from a stream at the north end of the harbour. Anchorage is available at depths of 21 m in Tissaluk Havn 4 km northeast of Søndre Kangeq.

Anchorage is available at the abandoned settlement of Kangaarsuk Havn at the head of a bay between Kangaarsup Uummanna and Tindingen. Water can be obtained from a lake on the north side of the harbour.

Shorelines in this area are almost exclusively rock allowing little opportunity for marine access. There is no information to indicate the potential for beach landings.

There are no airports on this or adjoining maps. The nearest airfields are the heliport at Paamiut (map 6151) and the international airport at Narsarsuaq (map 6106).

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow nearshore waters, which may exist within fjords and coastal islands. Tthe waters appear to be deep, but as they are largely uncharted, soundings should be taken to confirm their depth prior to using dispersants.

Offshore countermeasures represent the only practical method of protecting most shoreline areas including the selected area shown on the map.

The main entrances to the fjords on this map are generally too wide to consider exclusion booming. Exclusion booming to reduce the extent of inshore contamination should be considered at three possible locations. The width of the inlet at Qasigialik, is approximately 400 m, at Taartoq it is 500 m and at Arfarik the inlet is 800 m wide. All three have rock shorelines and appear to have deep water. Site surveys at the time of a spill will be required to confirm the feasibility of booming techniques.

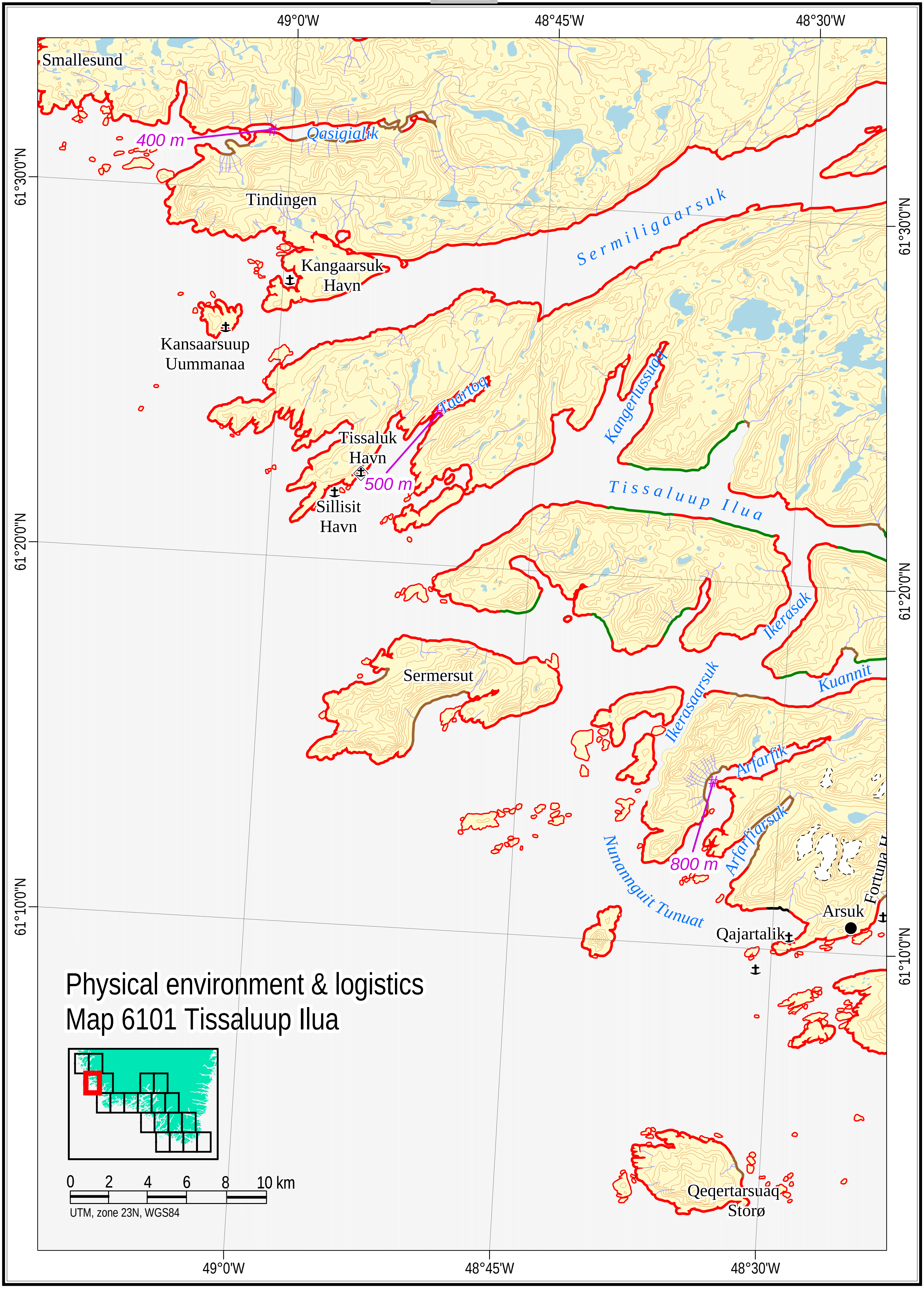
Shorelines shown on this map are predominantly and semi-exposed exposed rock, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marine-based given the likely nature of the shoreline.

Safe havens

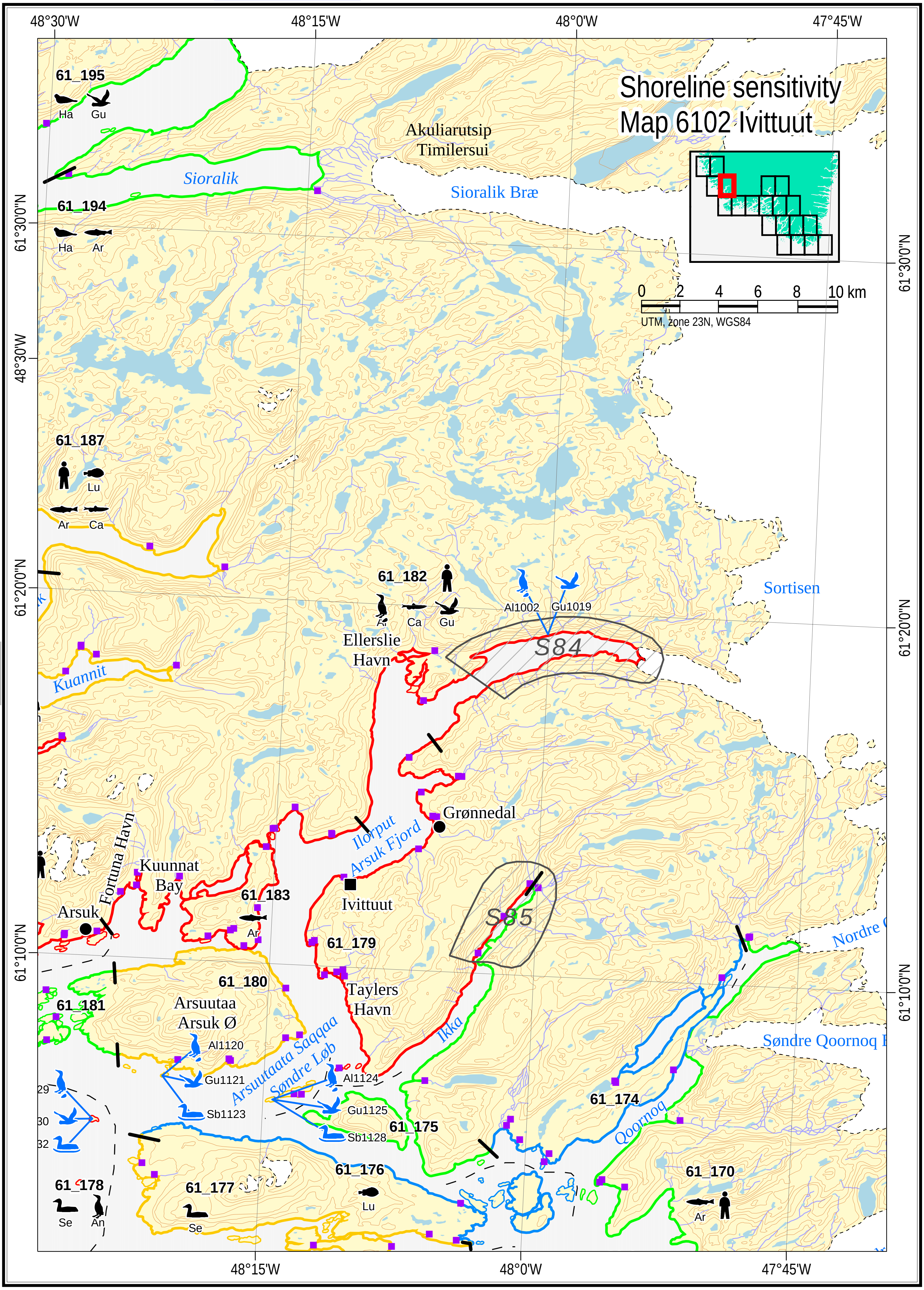
The anchorage at Tissaluk Havn is in an area of moderate sensitivity and therefore a potential safe haven for vessel lightering operations. If local knowledge suggests that tidal currents are sufficiently low, booms could be deployed across the 300 m wide entrance to contain any further release of oil. An alternative potential safe haven is in Taartoq to the northeast, but site surveys would be required to assess its suitability as the waters are uncharted.

Maps

Danish Survey & Cadastre (KMS) topographical map: 61 V.1. Nautical charts: 1100, 1118, 1200, 1210, 1251.



49°0'W
48°45'W
48°30'W
61°30'0"N
61°20'0"N
61°10'0"N
Smallesund
400 m
Qasigialik
Tindingen
Sermiligaarsuk
Kangaarsuk Havn
Kansaarsuup Uummanaa
Taartoq
Kangerlussuaq
Tissaluk Havn
500 m
Sillisit Havn
Tissaluup Ilua
Ikerasak
Sermersut
Kuannit
Ikerasaarsuk
Arfarfik
800 m
Arfarfiarsuk
Nunannguit Tunuat
Fortuna H.
Arsuk
Qajartalik
Physical environment & logistics
Map 6101 Tissaluup Ilua
0 2 4 6 8 10 km
UTM, zone 23N, WGS84
Qeqertarsuaq Storø


Shoreline sensitivity
Map 6102 Ivittuut
48°30'W
48°15'W
48°0'W
47°45'W
61°30'0"N
61°20'0"N
61°10'0"N
48°30'W
0 2 4 6 8 10 km
UTM, zone 23N, WGS84
61_195
Ha
Gu
61_194
Ar
Sioralik
Akuliarutsip
Timilersui
Sioralik Bræ
61_187
Lu
Ca
61_182
Ellerslie
Havn
Al1002
Gu1019
S84
Sortisen
Kuannit
Grønnedal
Ilorput
Arsuk Fjord
Fortuna Havn
Kuunnat
Bay
Arsuk
61_183
Ivittuut
61_179
S85
Nordre
61_180
61_181
Arsuutaa
Arsuk Ø
Taylers
Havn
Ikka
Søndre Qoornoq
Al1120
Gu1121
Sb1123
Arsuutaata Saqqaa
Søndre Løb
Al1124
Gu1125
Sb1128
61_175
61_174
Qoornoq
61_176
61_178
Se
An
61_177
61_170

Shoreline sensitivity

Map 6102 - Ivittuut

Environmental description

Resource use

R 61_170	Fishery for Arctic char at the coast and in 3 river outlets (all important). Hunting for ringed seals.
R 61_182	Fishery for Arctic char at the coast, capelin, Atlantic cod (pound net) and Greenland halibut. Hunting for ringed seals (**S84**).

Species occurrence

Al61182	1 colony with breeding Brünnich's guillemots, common guillemots and razorbills (**S84**).
Ar61170	3 rivers with Arctic char and small important coastal fishing area.
Ar61183	2 rivers and coastal fishing area for Arctic char.
Ar61194	2 rivers with Arctic char.
Ca61182	Capelin spawning and partly also important fishing area along most of the coasts (**S84**).
Gu61182	1 colony with breeding kittiwakes, Iceland gulls and glaucous gulls (**S84**).
Ha61194	Whelping area for harbour seals.
Lu61176	Lumpsucker spawning and important fishing ground in eastern part.

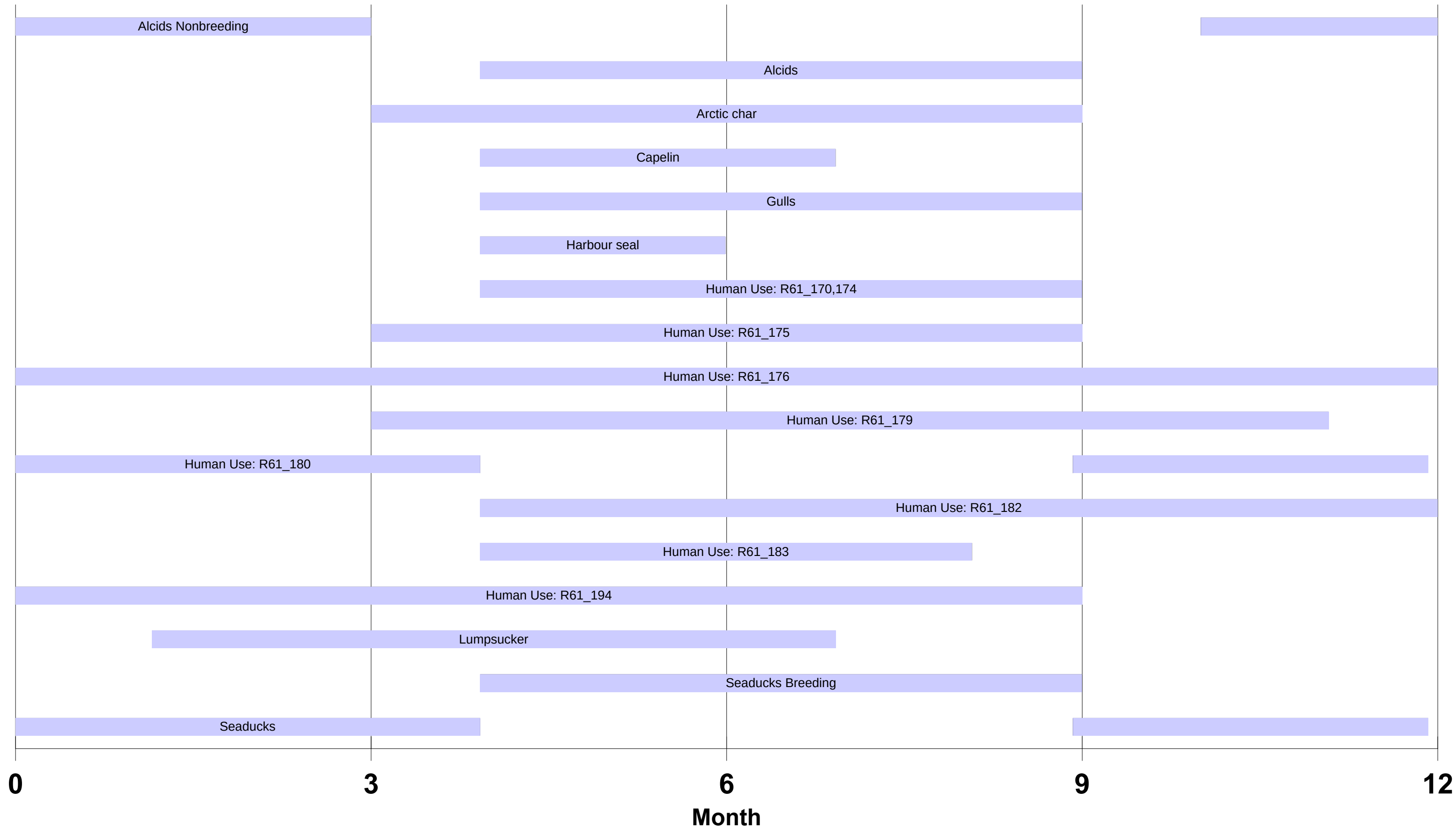
Site specific species occurrence (seabird breeding colonies); blue icons

Al1002	Breeding Brünnich's guillemots, common guillemots and razorbills.
Al1120, Al1124	Breeding black guillemots.
Gu1019	Breeding kittiwakes, Iceland gulls and glaucous gulls.
Gu1121	Breeding lesser black-backed gulls and great black-backed gulls.
Gu1125	Breeding lesser black-backed gulls, glaucous gulls and great black-backed gulls.
Sb1123, Sb1128	Breeding common eiders.

Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
61_170	27	Moderate
61_174	20	Low
61_175	27	Moderate
61_176	19	Low
61_179	45	Extreme
61_180	34	High
61_182	53	Extreme
61_183	56	Extreme
61_194	23	Moderate

Map 6102 Species and Resource Occurrences



Physical environment and logistics Map 6102 - Ivittuut

Access

The nearshore waters in this area are largely uncharted and caution should be exercised. In general the waters offshore, nearshore and within the fjords are deep, however uncharted dangers may exist. Local knowledge is essential for navigation.

Ilorput /Arsuk Fjord is deep and largely free of hazards throughout. Permission to enter Ilorput /Arsuk Fjord must be obtained immediately prior to entry from Greenland Command Naval Station, Grønnedal.

The West Greenland Current normally carries the drift ice from Cape Farewell away from Ilorput/Arsuk Fjord, but southwestern winds may blow ice towards land. From April to June the approaches may be filled with pack ice. Usually there is a shore lead between the mainland and the pack ice, which is sufficiently scattered to permit navigation.

There is no information on tides or currents within fjords for this area.

Two jetties are available at the settlement of Arsuk, with depths alongside of 2.1 m and a height above mean water of 1.5 m. A small crane is available, and fresh water can be obtained. Ice blown in on southwestern winds may hinder navigation.

Anchorage is available at Kuunnat Bay with depths of 11 to 33 m. The bay is well sheltered from the west and northwest.

Within Ilorput/Arsuk Fjord anchorages are available at Taylers Havn 3 km NNE of Iganak on the east side of Ilorput/Arsuk Fjord, depths of 11 m, and at Webers Havn 2 km to the NW, depths of 13 to 15 m. The latter is well sheltered, and kept free of ice most of the year by a rapid ebb tidal stream.

Physical environment and logistics

Map 6102 - Ivittuut

Access

(Continued from previous page)
Ivittuut is an abandoned mine site on the south side of the inner part of Ilorput/Arsuk Fjord. Ivittuut is usually open through the year with 122 m of berthing space and with depths alongside of 4.0 to 4.6 m and a height above mean water of 2 m.

Anchorage off Ivittuut has depths of 37 to 55 m but protection and holding are both poor. Christians Havn, 3 km northwest of Ivittuut, has depths of 11 to 16 m, and better shelter from northern winds.

Grønnedal is the location of a Danish Naval Station. A pier with 90 m of berthing space has depths alongside of 11.0 m. Facilities include a small hospital, and fuel and fresh water are available. Ellerslie Havn, 5 km north of Grønnedal, provides good shelter and depths of 9 to 15 m.

Beach landing is possible in the western part of the harbour at Ellerslie Havn.

The rest of the shorelines in this area are almost exclusively rock allowing little opportunity for marine access. The possibility of beach landings could be explored at the few beach shorelines within Ilorput/Arsuk Fjord, but reconnaissance would be required to confirm access.

There are no airports on this or adjoining maps. The nearest airfields are the heliport at Paamiut (map 6151) and the airport at Narsarsuaq (map 6106).

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow nearshore waters, which may exist within the fjords on this map. The waters appear to be deep, but as they are uncharted, soundings should be taken to confirm their depth prior to using dispersants.

Offshore countermeasures represent the only practical method of protecting most shoreline areas, including the selected area shown on the map.

The main entrances to the fjords on this map are generally too wide to consider exclusion booming. Exclusion booming to reduce the extent of inshore contamination should be considered at two possible locations. At Ikka, the inlet width is approximately 400 m and fronts a selected area. The channel on the north side of Arsuutaa/Arsuk Ø is approximately 100 m wide. Both locations have rock shorelines and appear to have deep water. Site surveys at the time of a spill will be required to confirm the feasibility of booming techniques.

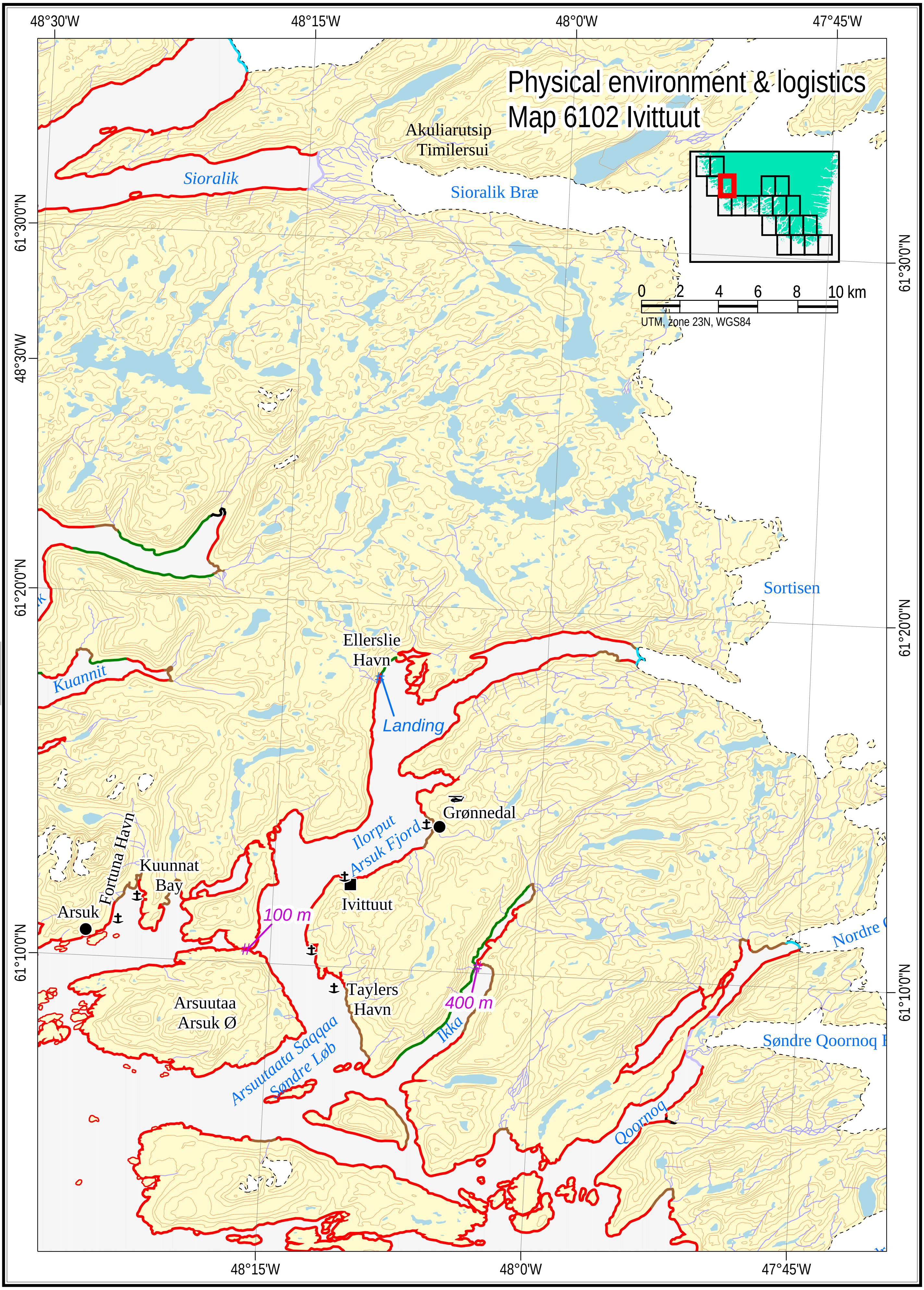
Shorelines shown on this map are predominantly exposed and semi-exposed rock, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marine-based given the likely nature of the shoreline.

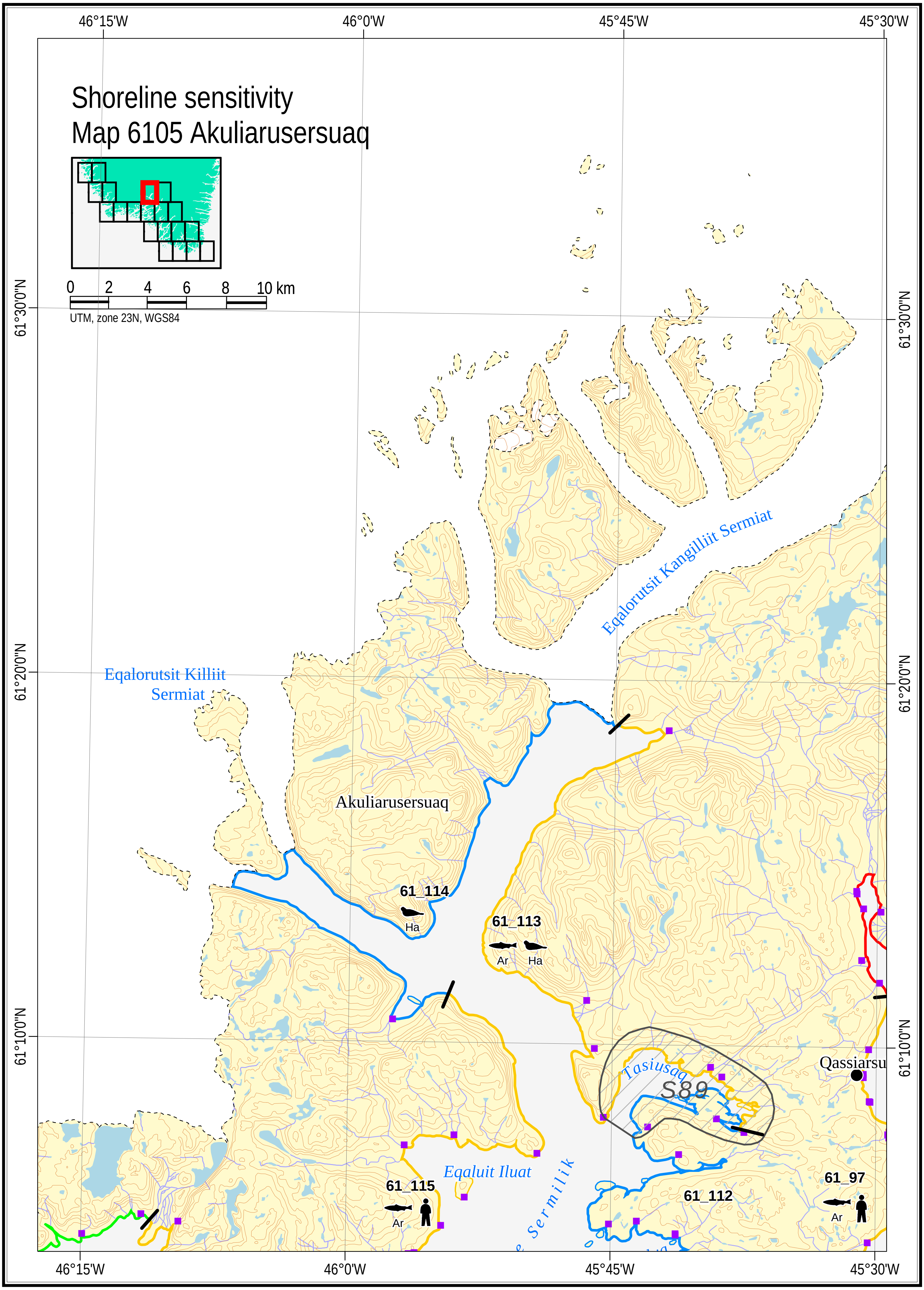
Safe havens

There are no potential safe havens identified on this map. Qoornoq Fjord could be investigated as a potential safe haven. It has a low to moderate sensitivity, but it is not charted. Site surveys would be required to assess its suitability. Its width means that exclusion booming would be impractical but its shape may provide natural containment.

Maps

Danish Survey & Cadastre (KMS) topographical maps: 61 V.1 and V.2. Nautical charts: 1100, 1118.


Physical environment & logistics
Map 6102 Ivittuut
48°30'W
48°15'W
48°0'W
47°45'W
61°30'0"N
61°20'0"N
61°10'0"N
48°30'W
Akuliarutsip
Timilersui
Sioralik
Sioralik Bræ
0 2 4 6 8 10 km
UTM, zone 23N, WGS84
Sortisen
Kuannit
Ellerslie
Havn
Landing
Grønnedal
Ilorput
Arsuk Fjord
Fortuna Havn
Kuunnat
Bay
Arsuk
100 m
Ivittuut
Taylers
Havn
400 m
Ikka
Arsuutaa
Arsuk Ø
Arsuutaata Saqqaa
Søndre Løb
Nordre Q
Søndre Qoornoq F
Qoornoq


Shoreline sensitivity
Map 6105 Akuliarusersuaq
0 2 4 6 8 10 km
UTM, zone 23N, WGS84
46°15'W
46°0'W
45°45'W
45°30'W
61°30'0"N
61°20'0"N
61°10'0"N
Eqalorutsit Kangilliit Sermiat
Eqalorutsit Killiit Sermiat
Akuliarusersuaq
61_114
Ha
61_113
Ar
Ha
Tasiusaq
S89
Qassiarsu
Eqaluit Iluat
Sermilik
61_115
Ar
61_112
61_97
Ar

Shoreline sensitivity

Map 6105 - Akuliarusersuaq

Environmental description

Resource use

R 61_115	Fishery for capelin, Greenland halibut, wolffish, redfish and Arctic char at the coast and in 4 river outlets (2 important). Hunting for seals.

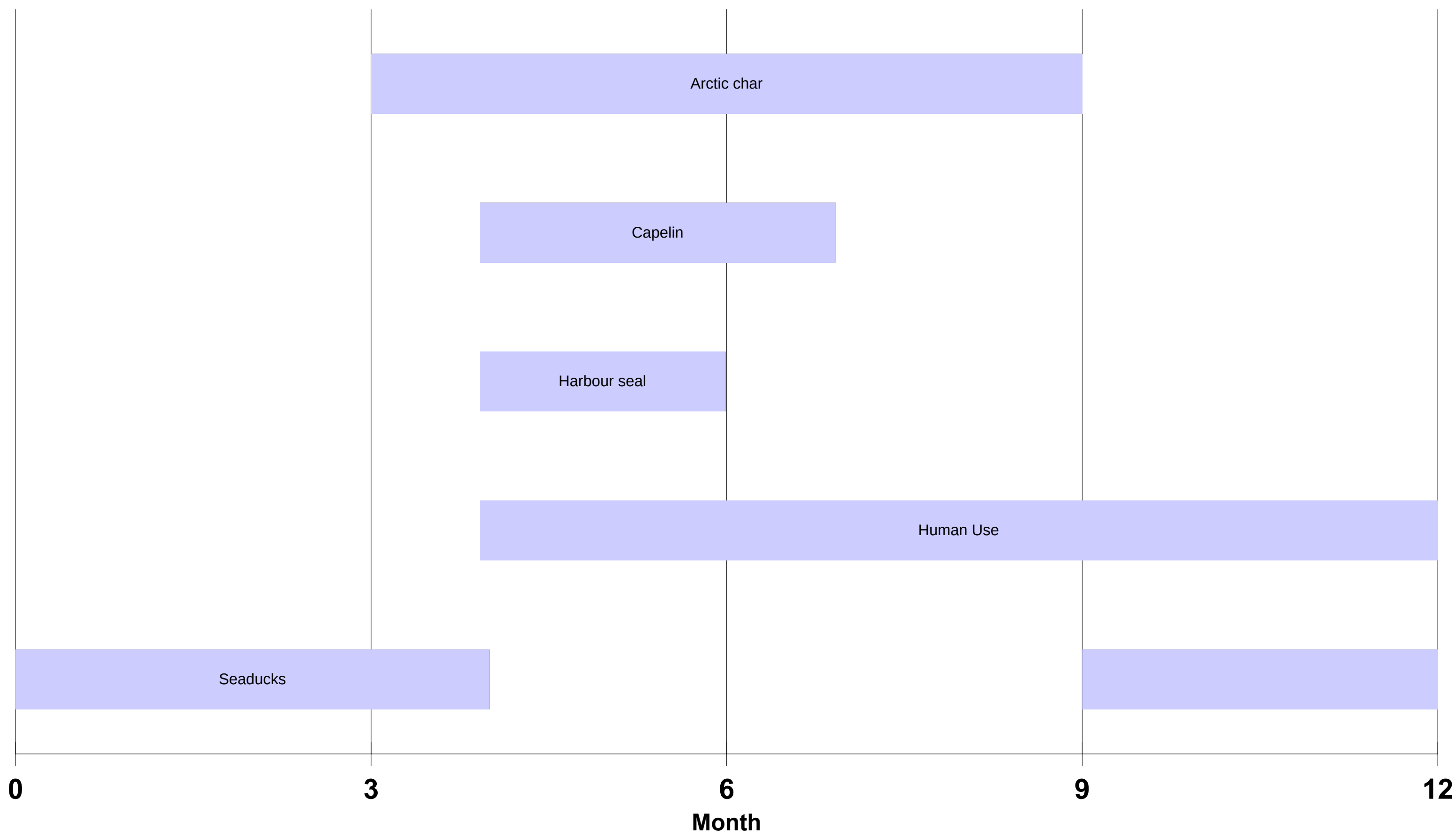
Species occurrence

Ar61113	5 rivers with Arctic char.
Ar61115	4 rivers with Arctic char and small important coastal fishing areas.
Ha61113, Ha61114	Whelping area for harbour seals.

Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
61_112	18	Low
61_113	37	High
61_114	17	Low
61_115	36	High

Map 6105 Species and Resource Occurrences



This page is intentionally left blank

Physical environment and logistics

Map 6105 - Akuliarusersuaq

Access

There is little information on the marine areas within this map.

The waters in this area are not charted and caution should be exercised. In general the waters appear to be deep, however uncharted dangers may exist. Local knowledge is essential for navigation.

Nordre Sermilik usually freezes over from early October to May. The northwestern of the two glaciers at the head of the fjord produces icebergs as large as 200 m length and 30 m height, seriously inconveniencing navigation after the winter ice has broken up.

There is no information on tides or currents within fjords for this area.

No anchorages are reported for this map area, although Eqaluit Iluat and Tasiusaq appear to be possible locations for anchorage.

Shorelines in this area are predominantly rock allowing little opportunity for marine access. There is no information to indicate the potential for beach landings. The possibility of beach landings could be explored in the vicinity of Eqaluit Iluat and Tasiusaq but there are no soundings in these areas and reconnaissance would be required to confirm access.

There are no airports on this map. The nearest airport is at Narsarsuaq (map 6106).

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow nearshore waters, which may exist at the head and in the inlets of the fjord. The waters appear to be deep, but as they are uncharted, soundings should be taken to confirm their depth prior to using dispersants.

Offshore countermeasures represent the only practical method of protecting most shoreline areas, including the selected area shown on the map.

There are no opportunities for exclusion booming in the area shown on this map due to the width of the inlets and the deep nearshore waters.

Shorelines shown on this map are predominantly semi-exposed rock, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marine-based given the likely nature of the shoreline.

Beaches within and south of Tasiusaq have protected or semi-protected coastal exposure. If oiled, these areas may require cleaning using sediment removal techniques along with the temporary stockpiling and subsequent removal for disposal of collected materials. In each of these areas, marine access and beach trafficability are unknown, necessitating site surveys at the time of the cleanup.

Safe havens

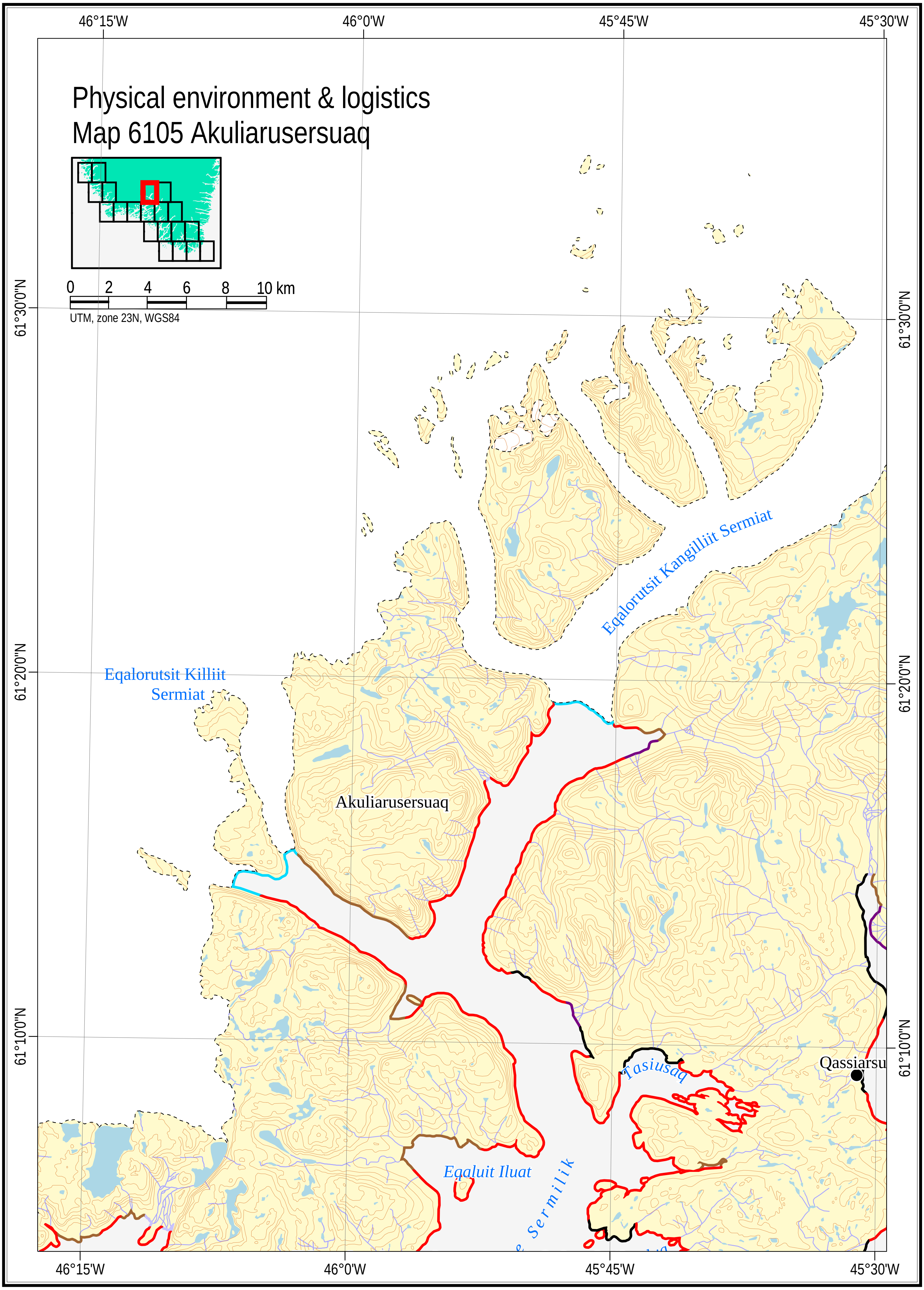
There are no potential safe havens identified on this map. Tasiusaq Fjord could be investigated as a potential safe haven. It has a low to moderate sensitivity, but it is poorly charted. Site surveys would be required to assess its suitability. Its width means that exclusion booming would be impractical but its shape may provide natural containment.

Maps

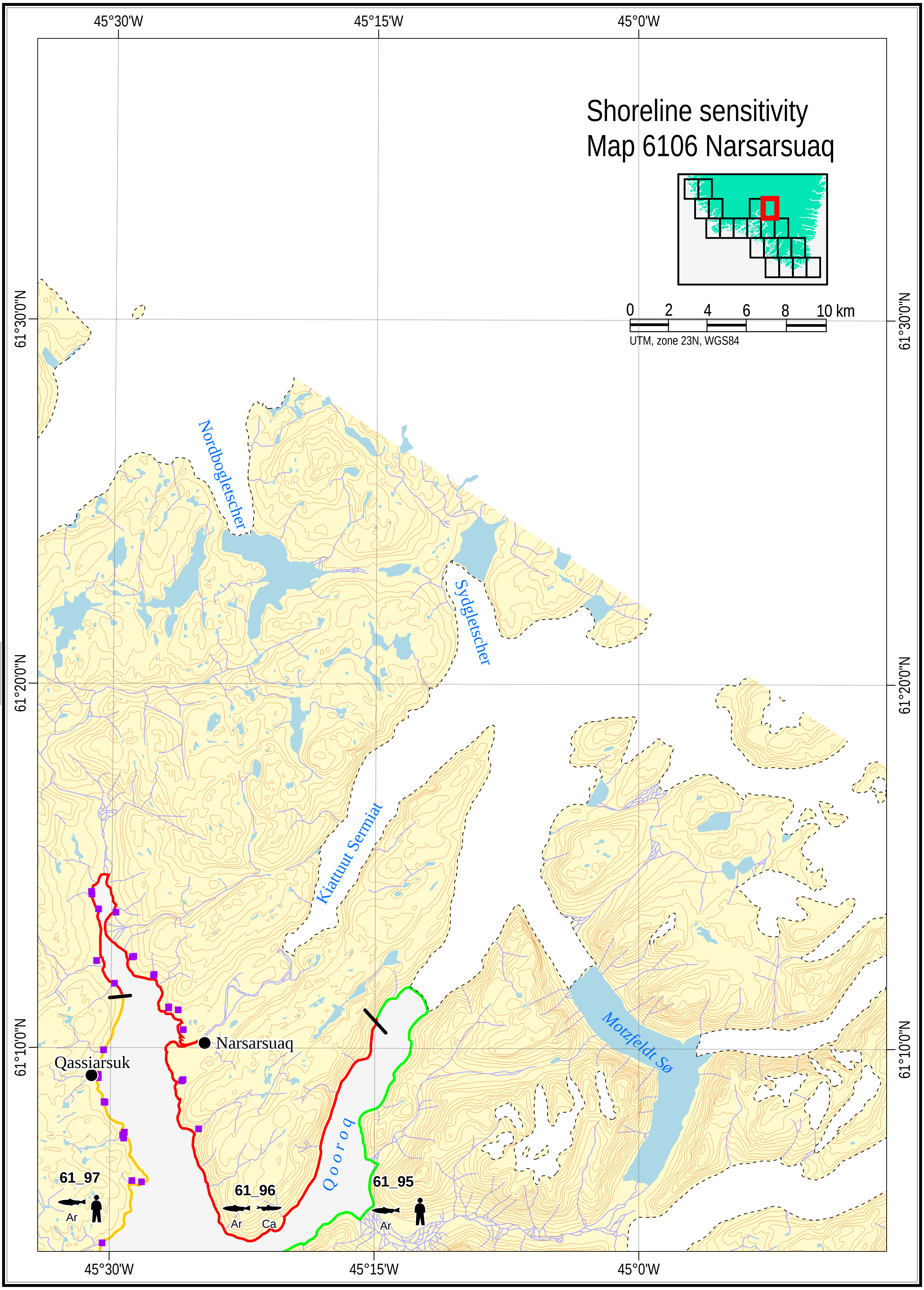
Danish Survey & Cadastre (KMS) topographical maps: 61 V.2 and V.3. Nautical chart: 1115.

Airphoto keymap
Map legend
Toggle maps
Keymaps

Physical environment & logistics
Map 6105 Akuliarusersuaq



Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998


Shoreline sensitivity
Map 6106 Narsarsuaq
0 2 4 6 8 10 km
UTM, zone 23N, WGS84
45°30'W
45°15'W
45°0'W
61°30'0"N
61°20'0"N
61°10'0"N
Nordbogletscher
Sydgletscher
Kiattuut Sermiat
Motzfeldt Sø
Qooroq
Narsarsuaq
Qassiarsuk
61_97
61_96
61_95
Ar
Ca

Shoreline sensitivity

Map 6106 - Narsarsuaq

Environmental description

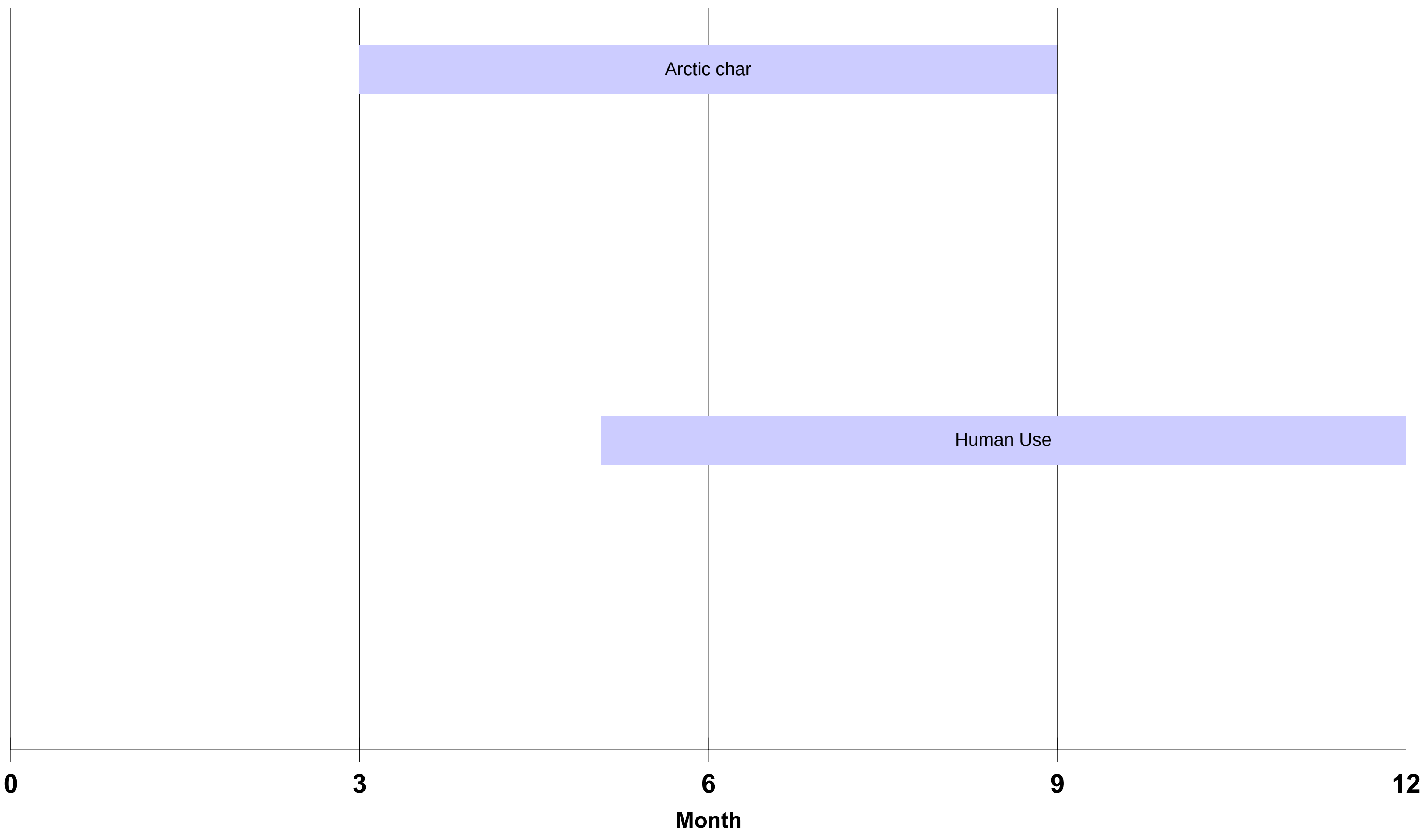
Species occurrence

Ar61096 4 rivers with Arctic char.

Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
61_96	52	Extreme

Map 6106 Species and Resource Occurrences



This page is intentionally left blank

Physical environment and logistics

Map 6106 - Narsarsuaq

Access

There is little information on the marine areas within this map.

The waters in this area are not charted and caution should be exercised. In general the waters appear to be deep, however uncharted dangers may exist. Local knowledge is essential for navigation.

There is no information on tides or currents within fjords for this area.

Vessels up to 130 m length and 8 m draft can berth at Narsarsuaq alongside a jetty. The tide has a maximum height of approximately 3.6 m. Facilities include mobile cranes and machine workshop, and fresh water is available.

Shorelines in this area are predominantly rock allowing little opportunity for marine access. There is no information to indicate the potential for beach landings.

An all season, concrete-surface airport (1830 x 45 m) is available at Narsarsuaq. There is road access from the airport to the town and the shoreline.

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow nearshore waters, which may exist at the head of the two fjords on this map. The waters appear to be deep, but as they are uncharted, soundings should be taken to confirm their depth prior to using dispersants.

Offshore countermeasures represent the only practical method of protecting most shoreline areas.

There are no opportunities for exclusion booming in the area shown on this map due to the width of the inlets and the deep nearshore waters.

Shorelines shown on this map are predominantly semi-exposed rock, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marine-based given the likely nature of the shoreline.

Beaches in the vicinity of Narsarsuaq have protected or semi-protected coastal exposure. If oiled, these areas may require cleaning using sediment removal techniques along with the temporary stockpiling and subsequent removal for disposal of collected materials. In each of these areas, marine access and beach trafficability are unknown, necessitating site surveys at the time of the cleanup.

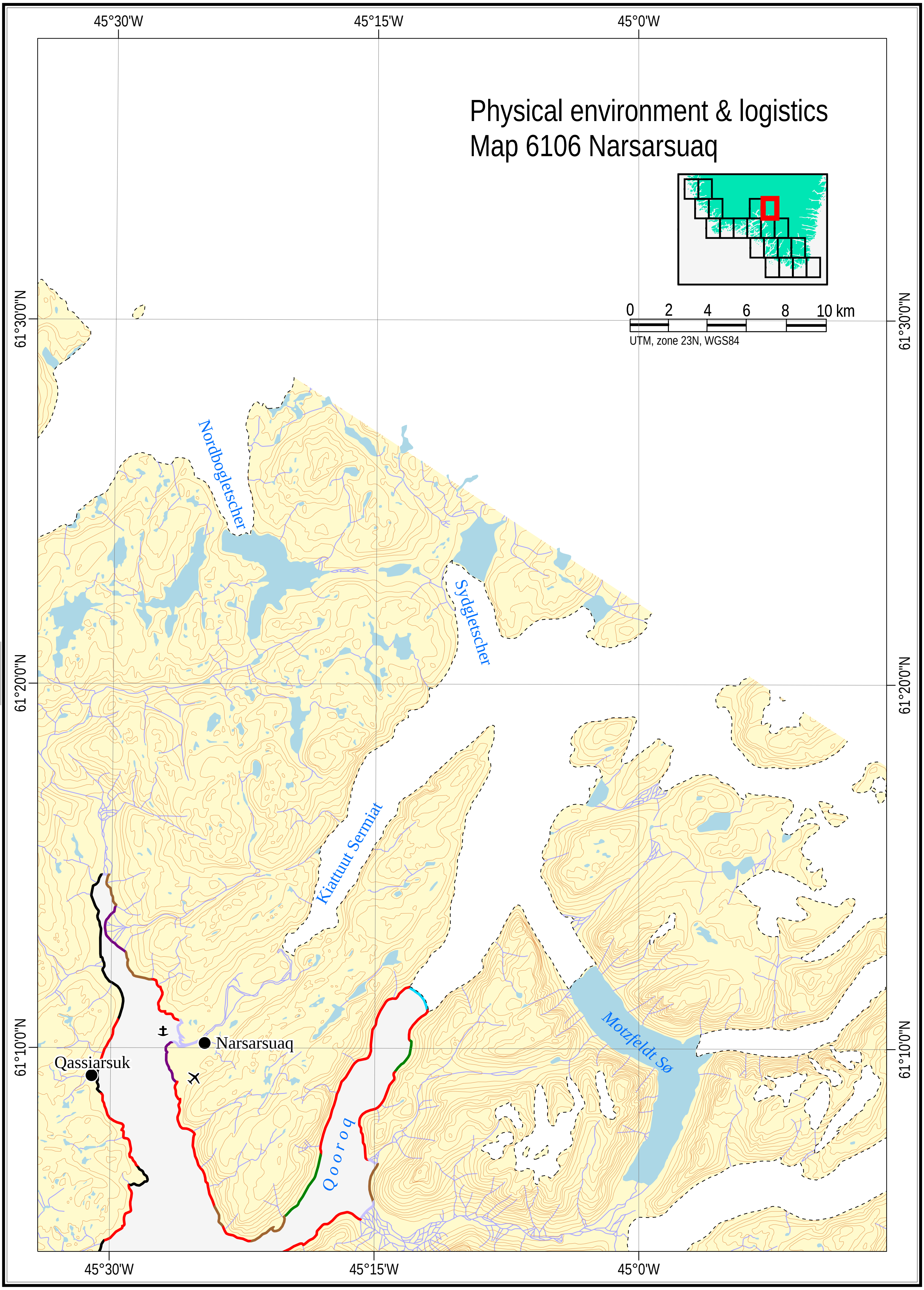
Safe havens

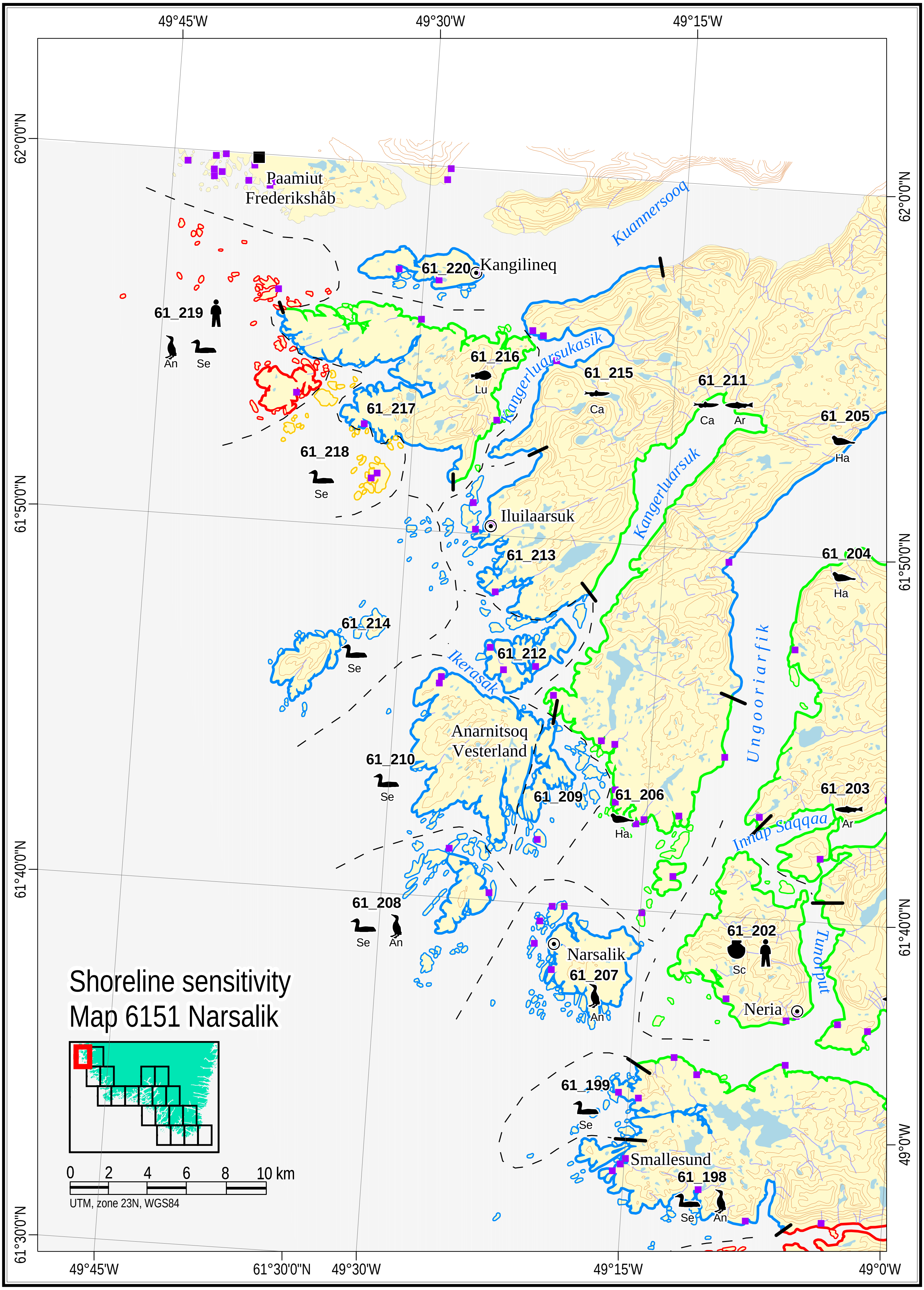
There are no potential safe havens identified on this map.

Maps

Danish Survey & Cadastre (KMS) topographical maps: 61 V.3. Nautical chart: 1115.

Airphoto keymap
Map legend
Toggle maps
Keymaps




49°45'W
49°30'W
49°15'W
62°0'0"N
61°50'0"N
61°40'0"N
61°30'0"N
49°0'W
61°30'0"N
Paamiut
Frederikshåb
Kuannersooq
Kangilineq
61_220
61_219
An
Se
61_216
Lu
Kangerluarsukasik
61_215
Ca
61_211
Ca
Ar
61_205
Ha
61_217
61_218
Se
Iluilaarsuk
Kangerluarsuk
61_213
61_204
Ha
61_214
Se
61_212
Ikerasak
Ungooriarfik
Anarnitsoq
Vesterland
61_210
Se
61_209
61_206
Ha
61_203
Ar
Innap Saqqaa
61_208
Se
An
61_202
Sc
Tunorput
Narsalik
61_207
An
Neria
61_199
Se
Smallesund
61_198
Se
An
Shoreline sensitivity
Map 6151 Narsalik
0
2
4
6
8
10 km
UTM, zone 23N, WGS84

Shoreline sensitivity

Map 6151 - Paamiut (Frederikshåb)

Environmental description

R 61_202	Fishery for scallop, lumpsucker, Atlantic cod (pound net), redfish and salmon.
R 61_219	Fishery for deep sea shrimp, Greenland halibut, wolffish, redfish and salmon. Hunting for fin and minke whales and eiders.

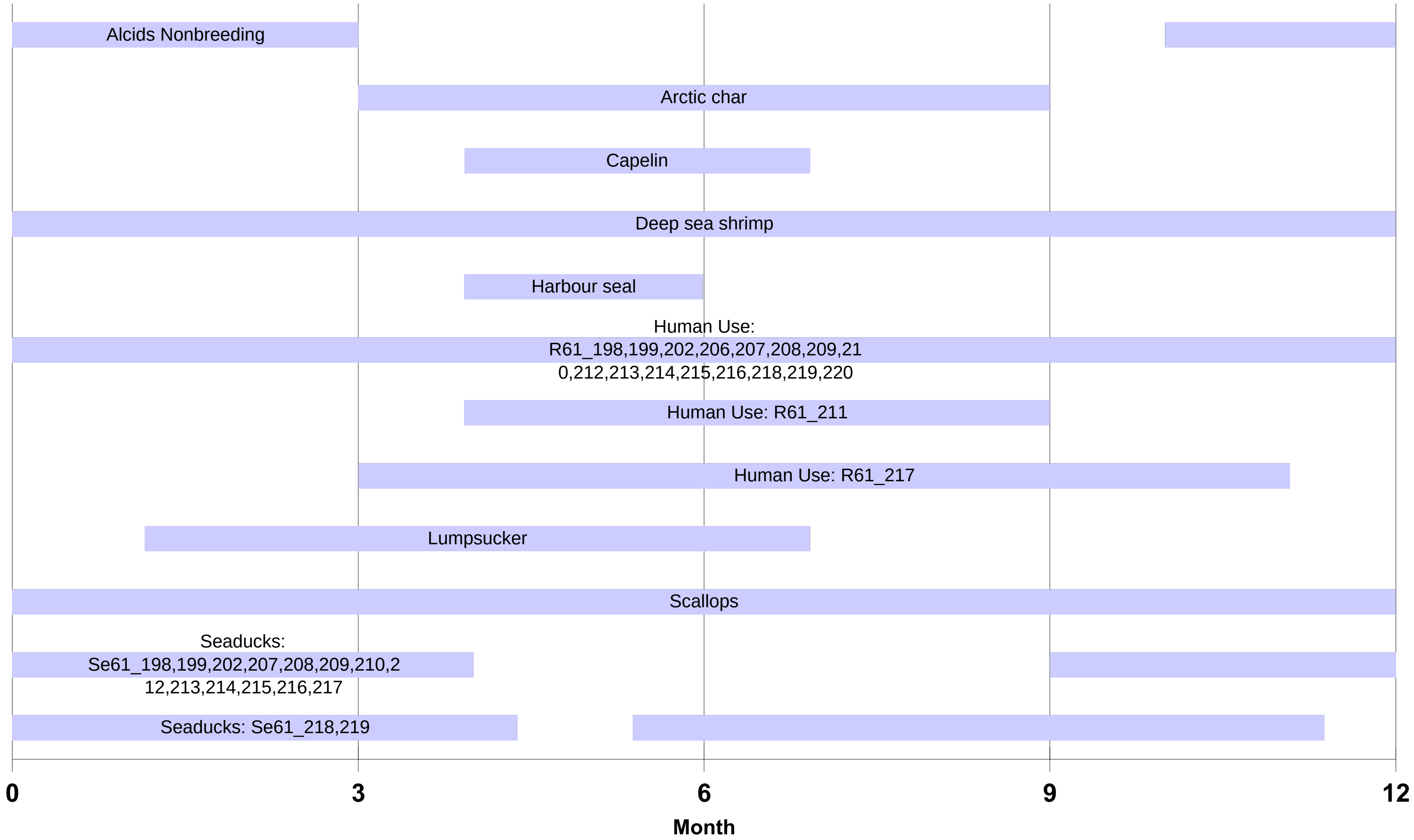
Species occurrence

An61198, An61207	Black guillemots and Brünnich's guillemots in winter.
An61208	Black guillemots and Brünnich's guillemots in winter.
An61219	Important area for Brünnich's guillemots in winter.
Ar61211	2 rivers with Arctic char.
Ca61211	Capelin spawning areas.
Ca61215	Capelin spawning and fishing areas (Kangerluarsukasik).
Ha61206	Whelping area for harbour seals.
Lu61216	Lumpsucker important fishing grounds.
Sc61202	Important scallop fishing ground.
Se61198, Se61199	Long-tailed ducks and eiders in winter.
Se61208, Se61210	Long-tailed ducks and eiders in winter.
Se61214	Long-tailed ducks and eiders in winter.
Se61218, Se61219	Eiders, long-tailed ducks and harlequin ducks in winter and harlequin ducks moulting in summer.

Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
61_198	20	Low
61_199	13	Low
61_202	30	Moderate
61_206	28	Moderate
61_207	21	Low
61_208	15	Low
61_209	8	Low
61_210	13	Low
61_211	22	Moderate
61_212	10	Low
61_213	14	Low
61_214	10	Low
61_215	17	Low
61_216	24	Moderate
61_217	15	Low
61_218	36	High
61_219	50	Extreme
61_220	11	Low

Map 6151 Species and Resource Occurrences



Physical environment and logistics Map 6151 - Paamiut (Frederikshåb)

Access

The nearshore waters in this area are largely uncharted and caution should be exercised. In general the waters offshore, nearshore and within the fjords are deep, however uncharted dangers may exist. Local knowledge is essential for navigation.

Numerous islands and hazards extend from the mainland coast and encumber the entrances to most fjords. Soundings are sparse in most fjords and caution is advised.

The coast through this area is fringed with islands, islets and rocks. These hazards are generally close to the main land, allowing safe navigation at a distance of 8 km of the coast, except for portions southeast of Sermersut (map 6101).

Between Ilorput/Arsuk Fjord and Grædefjord (further north outside map) the coast may be blocked by pack ice for several weeks after break-up after which a shore lead generally opens from the north. There are many fjords in this area, into most of which flow glaciers. This means that the entrances to fjords are often blocked with glacier ice through the open water
season.

At Paamiut pack ice and bergs from the south may make navigation difficult between April and August. Usually a shore lead several miles wide is formed, and pack ice is sufficiently scattered to permit navigation. Ice can form locally between December and March but it frequently breaks up. The area is generally regarded as navigable throughout the year.

The prevailing current is 0.5 knots setting to the NW in waters along the coast.

There is no other information on tides or currents within fjords for this area.

Access

(Continued from previous page)

Anchorage can be made in Smallesund south of the entrance to Neria Fjord, depths of 18 to 20 m. The east end of the harbour is encumbered with islets and below-water rocks.

Narsalik Harbour, an inlet on the northwestern side of the island of Narsalik, has anchorage for vessels to 35 m in length.

Paamiut is a relatively large town and has berthing for vessels up to 100 m length and 6 m draft. Anchorage can be made at several locations in the harbour and approaches in depths from 18 to 22 m.

Shorelines in this area are almost exclusively rock allowing little opportunity for marine access. There is no information to indicate the potential for beach landings.

There are no airports on this or adjoining maps. There is a heliport at Paamiut. An airport is reported to be planned for 2004. The nearest airport is at Narsarsuaq (map 6106).

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow nearshore waters, which may exist within fjords and coastal islands. The waters appear to be deep, but as they are uncharted, soundings should be taken to confirm their depth prior to using dispersants.

Offshore countermeasures represent the only practical method of protecting most shoreline areas.

Although there is no information on water currents for the many inter-island channels and entrances to fjords on this map, the tidal range (3 to 4 m), the width of the inlets, and the likely high tidal velocities suggest that exclusion booming (applicable in currents up to 0.4 m/s, 0.75 knots) in these areas would not likely be successful, and is not recommended.

If there is local knowledge to suggest that tidal velocities are less than a knot, exclusion booming could be attempted across fjords or inlets that are one kilometre or less in width. Alternatively, diversion booming could be attempted to protect sensitive areas, but this will not likely succeed in currents exceeding 1.5 m/s (3 knots) due to the excessive lengths of boom and the number of intermediate anchors required to maintain the required angle of the boom to the current. The requirement to constantly change boom angle with changing tidal stream direction would further complicate diversion booming operations.

Shorelines shown on this map are almost exclusively exposed and semi-exposed rock, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marine-based given the likely nature of the shoreline.

Safe havens

There are no potential safe havens identified on this map. Kangerluarsuk fjord could be investigated for its suitability as a safe haven given its moderate sensitivity and good shelter, but the fjord is not charted: site surveys would be required to assess its suitability. Its width means that exclusion booming would be impractical but its shape may provide natural containment.

Maps

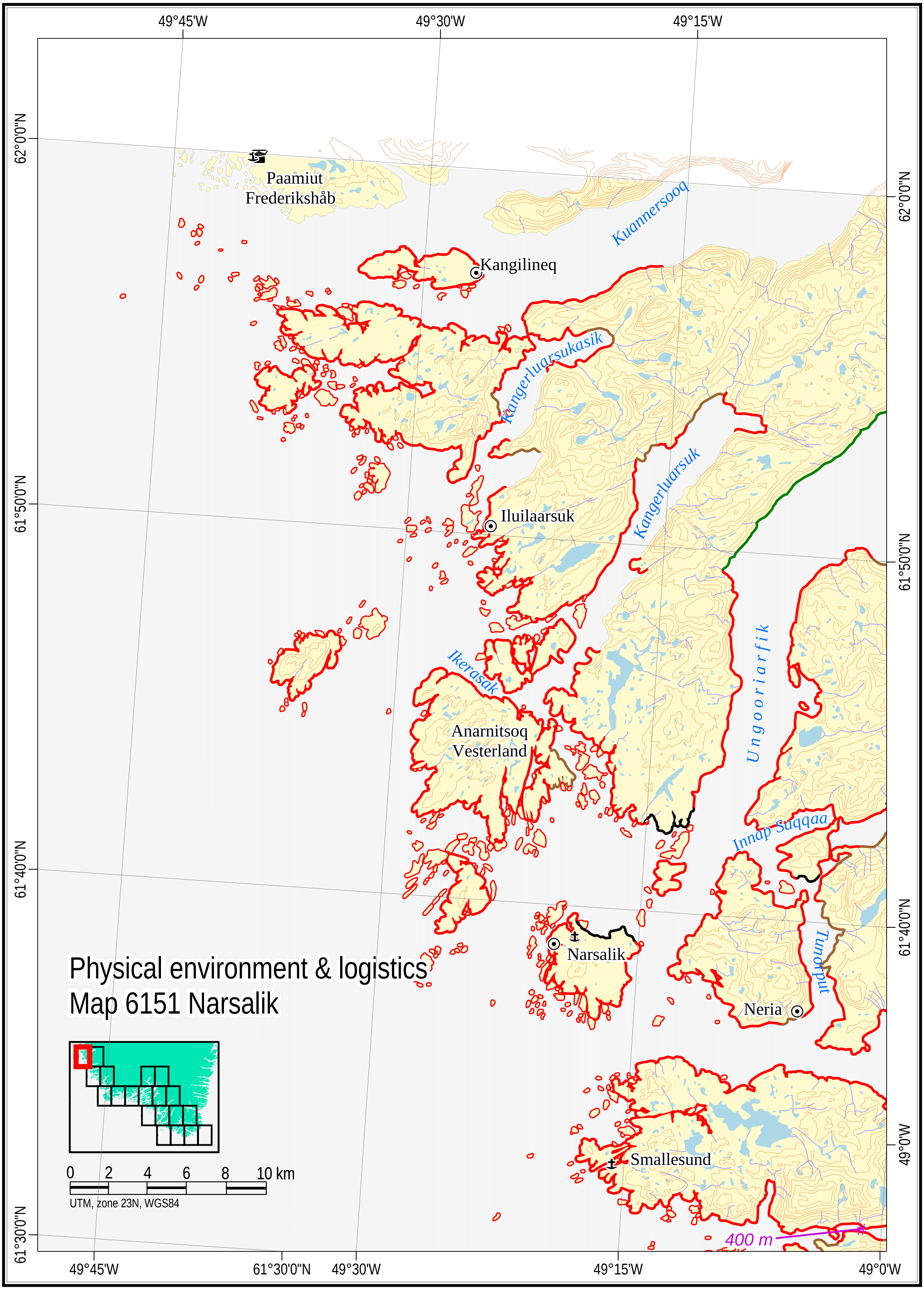
Danish Survey & Cadastre (KMS) topographical map: 61 V.1. Nautical charts: 1200, 1210, 1211, 1230, 1250, 1251.

Airphoto keymap

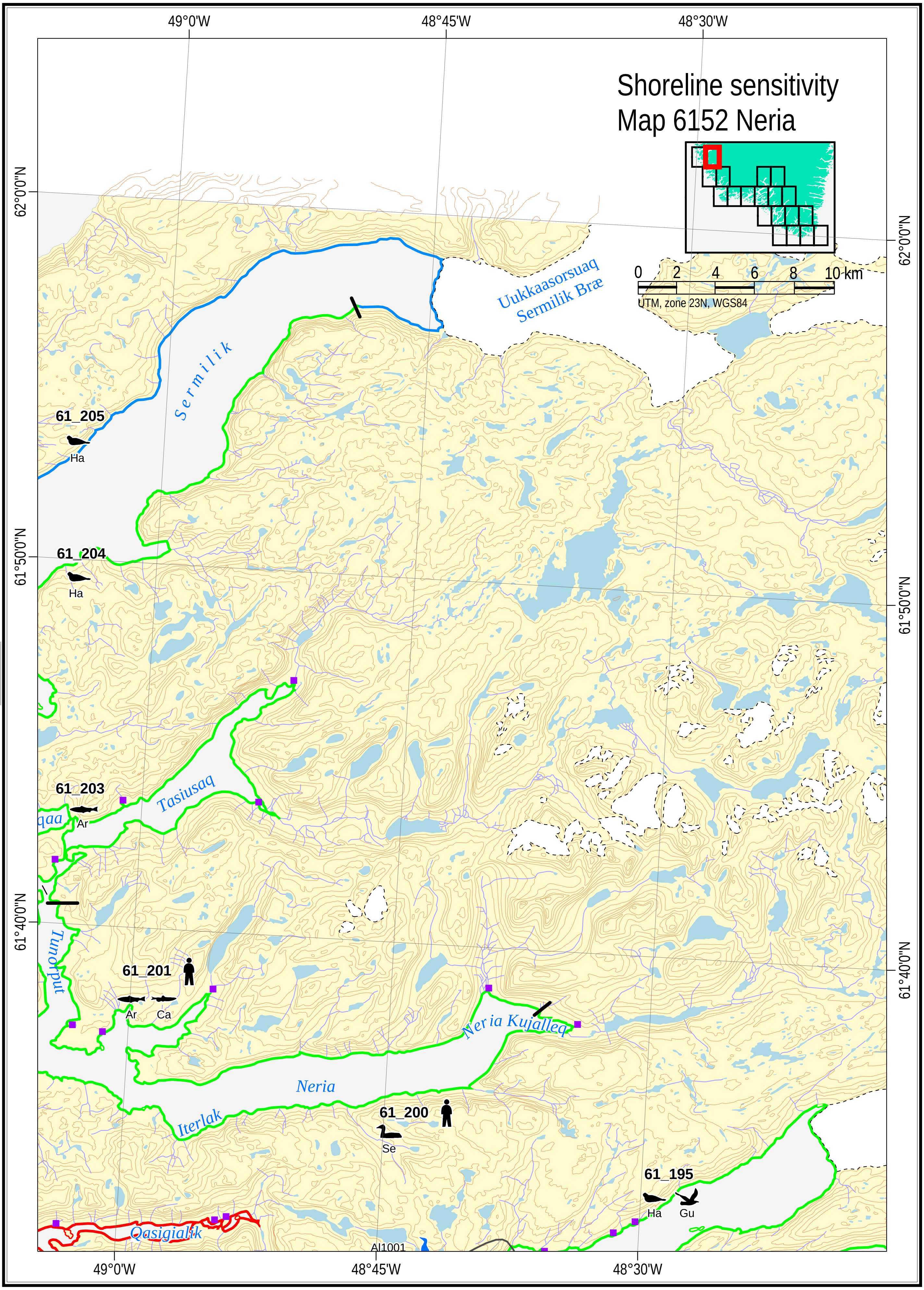
Map legend

Toggle maps

Keymaps



Airphoto keymap
Map legend
Toggle maps
Keymaps



Shoreline sensitivity — Map 6152 - Neria

Environmental description

Resource use

R 61_200	Fishery for capelin, Atlantic cod (pound net), redfish, salmon and Arctic char in 1 river outlet (important).
R 61_201	Fishery for lumpsucker, capelin, Atlantic cod (pound net), redfish, salmon and Arctic char in 2 rivers (both important).

Species occurrence

Ar61201	2 rivers with Arctic char.
Ar61203	3 rivers with Arctic char.
Ca61201	Fishing areas (some important) for capelin.
Gu61195	1 colony with breeding kittiwakes and Iceland gulls.
Ha61195, Ha61204	Whelping area for harbour seals.
Ha61205	Whelping area for harbour seals.
Se61200	Long-tailed ducks and eiders in winter.

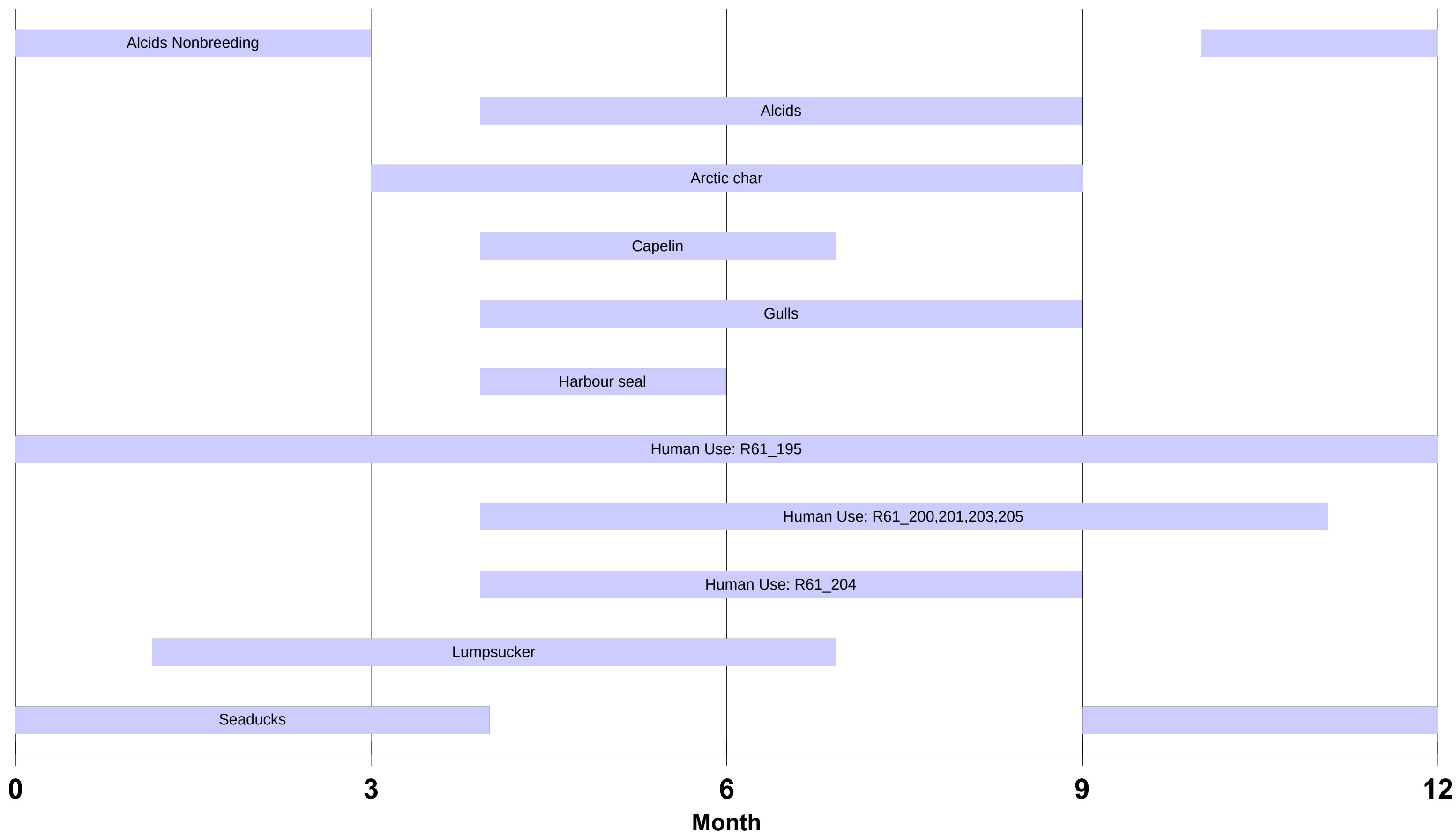
Site specific species occurrence (seabird breeding colonies); blue icons

Al1001	Breeding razorbills and black guillemots.
Gu1018	Breeding kittiwakes and Iceland gulls.

Shoreline sensitivity summary

SEG_ID	Sensitivity	Ranking
61_195	22	Low
61_200	23	Moderate
61_201	26	Moderate
61_203	22	Moderate
61_204	23	Moderate
61_205	16	Low

Map 6152 Species and Resource Occurrences



This page is intentionally left blank

Physical environment and logistics

Map 6152 - Neria

Access

Little information is available for the limited marine areas in this map.

No soundings are available for the portions of Sermilik and Neria shown on this map. These waters appear to be deep, however uncharted dangers may exist. Local knowledge is essential for navigation.

There is no information on tides or currents within fjords for this area.

No anchorages are reported for this map area.

Shorelines in this area are almost exclusively rock allowing little opportunity for marine access. There is no information to indicate the potential for beach landings.

There are no airports on this or adjoining maps. The nearest airfields are the heliport at Paamiut (map 6151) and the international airport at Narsarsuaq (map 6106).

Countermeasures

In situ burning of oil in conjunction with tracking oiled ice is recommended in ice concentrations down to six tenths. In open water conditions in offshore and nearshore areas, containment for recovery or burning is recommended. Dispersant application should be considered in offshore and nearshore waters to protect waterfowl and to prevent oil from entering inshore areas. Use of dispersants is cautioned against in shallow nearshore waters, which may exist within the fjords and inlets on this map. The waters appear to be deep, but as they are uncharted, soundings should be taken to confirm their depth prior to using dispersants.

Offshore countermeasures represent the only practical method of protecting most shoreline areas.

There are no opportunities for exclusion booming in the area shown on this map due to the width of the inlets and the deep nearshore waters.

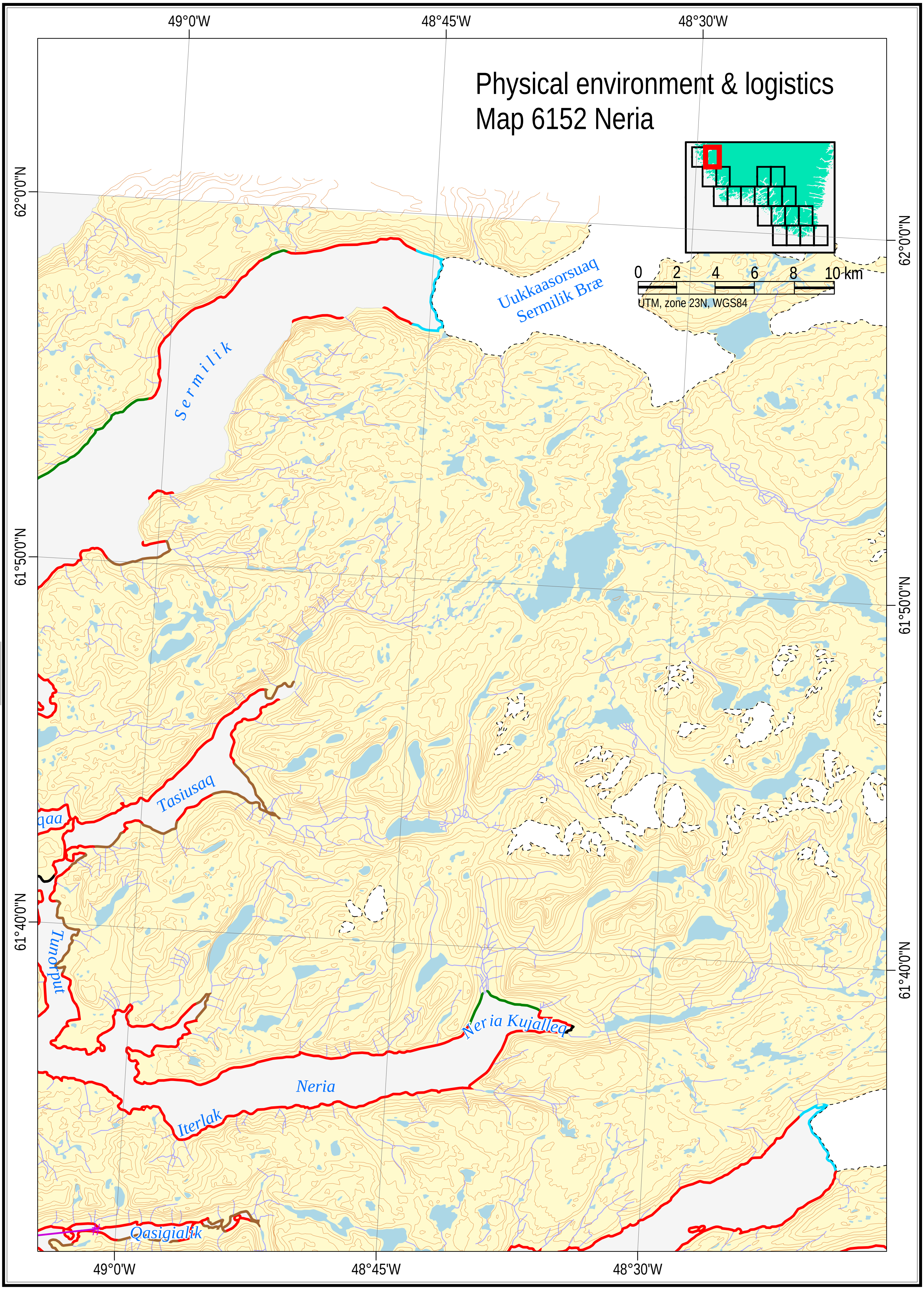
Shorelines shown on this map are predominantly semi-exposed rock, which may not require active cleaning efforts unless heavily contaminated with heavy oils. Consideration should be given to flushing operations in the protected waters within the fjords. Access and trafficability of these areas are unknown, but it is probable that any cleanup operations would be marine-based given the likely nature of the shoreline.

Safe havens

There are no potential safe havens identified on this map. The heads of the several fjords on this map could be investigated for their suitability as safe havens, offering good shelter and having low to moderate sensitivity ratings. None of these fjords is charted: site surveys would be required to assess their suitability. Their width means that exclusion booming would be impractical.

Maps

Danish Survey & Cadastre (KMS) topographical map: 61 V.1. Nautical chart: 1210.


Physical environment & logistics
Map 6152 Neria
49°0'W
48°45'W
48°30'W
62°0'0"N
61°50'0"N
61°40'0"N
0 2 4 6 8 10 km
UTM, zone 23N, WGS84
Uukkaasorsuaq Sermilik Bræ
Sermilik
Tasiusaq
Tunorput
Neria Kujalleq
Neria
Iterlak
Qasigialik

This page is intentionally left blank

10 References

Anker-Nilssen, T. 1994. Identifikasjon og prioritering av miljøressurser ved akutte oljeutslipp langs norskekysten og på Svalbard. – Norsk Institutt for Naturforskning, oppdragsmelding 310.

Anonymous 1998. Physical environment of eastern Davis Strait and northeastern Labrador Sea. An overview. – Mineral Resources Administration for Greenland. 34 pp.

Boertmann, D. 2003. Seabird colonies and moulting harlequin ducks in South Greenland - results of a survey in 2003. - NERI Research Notes 191.

Boertmann, D., A. Mosbech, K. Falk & K. Kampp 1996. Seabird colonies in western Greenland. - NERI Technical Report No. 170. 148 pp.

Boertmann, D., A. Mosbech & P. Johansen 1998. A review of biological resources in West Greenland sensitive to oil spills during winter. - NERI Technical Report No. 246. 72 pp.

Boertmann, D. & A. Mosbech 2001a. Important summer concentrations of seaducks in West Greenland. An input to oil spill sensitivity mapping. - National Environmental Research Institute, Denmark, NERI Technical Report No. 345: 1-48.

Boertmann, D. & A. Mosbech 2001b. Offshore seabird distributions during summer and autumn at West Greenland. Ship based surveys 1977 and 1992-2000. National Environmental Research Institute, Denmark. Technical Report No. 370.

Danish Hydraulic Institute/Greenland Technical Organization 1979. Icebergs. - Environmental conditions offshore West Greenland Vol. 4.

Dickins, D., I. Bjerkelund, P. Vonk, S. Potter, K. Finley, R. Stephen, C. Holdsworth, D. Reimer, A. Godon, W. Duval, I Buist & A. Sekerak 1990. Lancaster Sound region. A coastal atlas for environmental protection. – DF. Dickins Assosiates Ltd., Vancouver.

Egevang, C. & D. Boertmann 2001. The Greenland Ramsar sites. A status report. - National Environmental Research Institute, Denmark, NERI Technical Report No. 346: 1-96.

Horsted, S.A. 2000. A review of the cod fisheries at Greenland, 1910-1995. Journal of Northwest Atlantic Fishery Science 28 (speciel issue): 1-112.

IUCN 1996. IUCN Red List of Threatened Animals. - IUCN, Gland, Switzerland and Cambridge, UK. 448 pp.

Mangor, K. & R. Zorn 1983. Iceberg conditions offshore Greenland. – Iceberg Research 4.

Mosbech, A., R. Dietz, D. Boertmann & P. Johansen 1996. Oil exploration in the Fylla Area. - NERI Technical Report No. 156. 90 pp.

Mosbech, A., D. Boertmann, J. Nymand, F. Riget & M. Acquarone 1998. The marine environment in Southwest Greenland. Biological resources, resource use and sensitivity to oil spill. - NERI Technical Report No. 236. 202 pp.

Mosbech, A., K.L. Anthonsen, A. Blyth, D. Boertmann, E. Buch, D. Cake, L. Grøndahl, K.Q. Hansen, H. Kapel, S. Nielsen, N. Nielsen, F. Von Platen, S. Potter & M. Rasch 2000. Environmental Oil Spill Sensitivity Atlas for the West Greenland Coastal Zone. - Ministry of Environment and Energy, The Danish Energy Agency. 279 pp.

Nielsen, S.S., A. Mosbech & J. Hinkler 2000. Fiskeriressourcer på det lave vand i Vestgrønland. – Arbejdsrapport fra DMU Nr. 118.

Olsvig, S, & A. Mosbech 2003. Fiskeriressourcer på det lave vand i det nordlige Vestgrønland. En interviewundersøgelse om forekomsten og udnyttelsen af lodde, stenbider og ørred /Kalaallit Nunaata Kitaani immami ikkattumi aalisakkat peqqumaatit. Ammassat nipisat eqauillu qanoq nalliusimaartarneri iluaqutiginiarneqarnerilu pillugit apersuinertalimmik misissuineq. - NERI-Research Note No. 180. 74. pp.

Petersen, H.C. 1993a. Registrering af levende ressourcer og naturværdier i Grønland. Hæfte 1. Nanortalik Kommune. Grønlands Hjemmestyre (unpublished).

Petersen, H.C. 1993b. Registrering af levende ressourcer og naturværdier i Grønland. Hæfte 2. Qaqortoq Kommune. Grønlands Hjemmestyre (unpublished).

Petersen, H.C. 1993c. Registrering af levende ressourcer og naturværdier i Grønland. Hæfte 3. Narsaq Kommune. Grønlands Hjemmestyre (unpublished).

Petersen, H.C. 1993d. Registrering af levende ressourcer og naturværdier i Grønland. Hæfte 4. Paamiut Kommune og Ivittuut Kommune. Grønlands Hjemmestyre (unpublished).
Rätz, H-J. 1999. Structure and changes of the demersal fish assemblage off Greenland, 1982-96. NAFO Scientific Council Studies 32: 1-15.
Valeur, H.H., C. Hansen, K.Q. Hansen, L. Rasmussen & N. Thingvad 1997. Physical environment of eastern Davis Strait and northeastern Labrador Sea. - Danish Meteorological Institute Technical Report 97-9 (2 vols).

National Environmental Research Institute

The National Environmental Research Institute, NERI, is a research institute of the Ministry of the Environment.
In Danish, NERI is called Danmarks Miljøundersøgelser (DMU).
NERI's tasks are primarily to conduct research, collect data, and give advice on problems related to the environment and nature.

Addresses:

URL: http://www.dmu.dk

National Environmental Research Institute
Frederiksborgvej 399
PO Box 358
DK-4000 Roskilde
Denmark
Tel: +45 46 30 12 00
Fax: +45 46 30 11 14

Management
Personnel and Economy Secretariat
Monitoring, Research and Advice Secretariat
Department of Policy Analysis
Department of Atmospheric Environment
Department of Marine Ecology
Department of Environmental Chemistry and Microbiology
Department of Arctic Environment

National Environmental Research Institute
Vejlsøvej 25
PO Box 314
DK-8600 Silkeborg
Denmark
Tel: +45 89 20 14 00
Fax: +45 89 20 14 14

Monitoring, Research and Advice Secretariat
Department of Marine Ecology
Department of Terrestrial Ecology
Department of Freshwater Ecology

National Environmental Research Institute
Grenåvej 12-14, Kalø
DK-8410 Rønde
Denmark
Tel: +45 89 20 17 00
Fax: +45 89 20 15 15

Department of Wildlife Ecology and Biodiversity

Publications:
NERI publishes professional reports, technical instructions, and an annual report in Danish.
A R&D projects' catalogue is available in an electronic version on the World Wide Web.
Included in the annual report is a list of the publications from the current year.

This oil spill sensitivity atlas covers the shoreline and the offshore areas of South Greenland between 56º30′ N and 62º N. The coastal zone is divided into 220 areas and the offshore zone into 6 areas. For each area a sensitivity index value is calculated, and each area is subsequently ranked according to four degrees of sensitivity. Besides this general ranking a number of smaller sites are especially selected because they are of particular significance, they are particularly vulnerable to oil spill and effective oil spill response may be performed. The shoreline sensitivity ranking is shown on 20 maps (in scale 1:250,000), which also show the different elements included. These maps also show the selected areas. Coast types, logistics and proposed response methods along the coasts are shown on another 20 maps. The sensitivities of the offshore zones are depicted on 4 maps, one for each season. Based on all the information, appropriate oil spill response methods have been assessed for each area.

National Environmental Research Institute
Ministry of the Environment

ISBN 87-7772-806-8

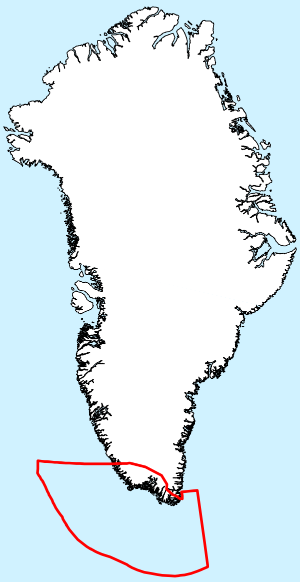
493 Environmental Oil Spill Sensitivity Atlas for the South Greenland Coastal Zone

National Environmental Research Institute
Ministry of the Environment · Denmark

Appendices

Environmental Oil Spill Sensitivity Atlas for the South Greenland Coastal Zone

NERI Techical Report, No. 493



Contents - Appendices

This page is intentionally left blank

11. Appendix A

Shoreline sensitivity ranking.

Explanation to calculations used in the table

Assigned value x Weighting factor = **Prority index**   **Sensitivity value =** sum of Prioty Indices

For biological elements:

(**Relative sensitivity** x **Relative abundance** x **Temporal modifier** x Oil recidence index)/ Constant = **Assigned value**

Formula for calculation of the sensitivity value of shoreline areas. Bold abbreviations indicate factors wich appear in the column headlines for the Shoreline Sensitivity ranking table. The Oil Residence Value (ORI) is a row heading. The For further explanation see Chapter 6.3 and Chapter 14.

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_1	6004	Human use				2..00	4..00		
		Archaeological sites				1..00	2..00		
		Special status areas				0..00	0..00		
		Communities				0..00	0..00		
		Oil residency index				1..88	2..82		
								9	Low
60_2	6004	Human use				3..00	6..00		
		Archaeological sites				1..00	2..00		
		Special status areas				0..00	0..00		
		Communities				1..15	2..30		
		Oil residency index				2..26	3..39		
								14	Low
60_3	5954	Human use				1..00	2..00		
		Archaeological sites				1..00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.75	2.63		
		Harbour seals	18	4	1	8.42	14.73		
								21	Low
60_4	5954	Human use				2.00	4.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.78	2.67		
		Harbour seals	18	5	1	10.69	18.70		
								25	Moderate
60_5	5953	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.32	3.47		
		Harbour seals	18	1	1	2.78	4.86		
								12	Low

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
59_6	5954	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.47	2.21		
		Harbour seals	18	5	1	8.84	15.47		
								20	Low
59_7	5953	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.60	2.39		
		Harbour seals	18	5	1	9.57	16.75		
								21	Low
59_8	5953	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.72	2.58		
		Harbour seals	18	3	1	6.20	10.85		
								17	Low
59_9	5953	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.89	2.83		
		Gulls	17	1	0.5	1.07	1.87		
		Harbour seals	18	3	1	6.80	11.90		
		Seaducks breeding	23	1	0.5	1.45	2.53		
								23	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
59_10	5953	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.96	2.93		
		Seaducks breeding	23	2	0.5	3.00	5.25		
								12	Low
59_11	5953	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.26	3.38		
								7	Low
60_12	5953	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.31	3.47		
		Arctic char	14	2	0.5	2.16	3.78		
								15	Low
60_13	6004	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.65	1.30		
		Oil residency index				2.11	3.17		
		Arctic char	14	1	0.5	0.99	1.73		
								12	Low

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_14	6004	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.15	0.30		
		Oil residency index				2.91	4.37		
		Alcids	25	1	0.5	2.43	4.25		
		Capelin	21	1	0.25	1.02	1.79		
		Gulls	17	2	0.5	3.30	5.78		
								22	Moderate
60_15	6003	Human use				4.00	8.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				1.10	2.20		
		Oil residency index				2.95	4.43		
		Arctic char	14	3	0.5	4.13	7.23		
		Capelin	21	4	0.25	4.13	7.23		
								35	High
59_16	5953	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.74	2.61		
		Harbour seals	18	5	1	10.46	18.30		
								25	Moderate
59_17	5953	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.29	3.43		
		Harbour seals	18	5	1	13.71	23.99		
								31	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
59_18	5953	Human use				2.00	4.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.34	3.51		
		Arctic char	14	3	0.5	3.28	5.74		
		Harbour seals	18	5	1	14.05	24.59		
								44	High
59_19	5953	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.85	2.78		
		Arctic char	14	2	0.5	1.73	3.02		
		Harbour seals	18	5	1	11.10	19.43		
		Seaducks breeding	23	1	0.5	1.42	2.48		
								32	Moderate
59_20	5953	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.61	2.41		
		Alcids	25	2	0.5	2.68	4.69		
		Arctic char	14	2	0.5	1.50	2.63		
		Harbour seals	18	5	1	9.65	16.88		
		Seaducks breeding	23	1	0.5	1.23	2.16		
								35	High

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
59_21	5952	Human use				2.00	4.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.55	2.32		
		Alcids	25	1	0.5	1.29	2.26		
		Alcids nonbreeding	21	2	0.5	2.17	3.79		
		Gulls	17	1	0.5	0.88	1.54		
		Harbour seals	18	5	1	9.29	16.25		
		Seaducks breeding	23	1	0.5	1.19	2.08		
		Tubenoses shoreline	18	4	0.5	3.72	6.50		
								45	High
59_22	5952	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.91	2.87		
		Alcids nonbreeding	21	2	0.5	2.68	4.68		
								12	Low
59_23	5952	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.52	2.29		
		Alcids nonbreeding	21	2	0.5	2.13	3.73		
		Seaducks breeding	23	1	0.5	1.17	2.04		
								14	Low

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
59_24	5952	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.12	3.18		
		Alcids nonbreeding	21	2	0.5	2.96	5.19		
								16	Low
60_25	5952	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				2.60	5.20		
		Oil residency index				2.16	3.24		
								16	Low
60_26	5952	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				2.40	4.80		
		Oil residency index				2.74	4.12		
		Arctic char	14	2	0.5	2.56	4.48		
								25	Moderate
59_27	5952	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.68	4.02		
		Arctic char	14	1	0.5	1.25	2.19		
								18	Low

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_28	5952	Human use				5.00	10.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				1.15	2.30		
		Oil residency index				2.12	3.18		
		Arctic char	14	4	0.5	3.95	6.92		
								28	Moderate
59_29	5952	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				1.20	2.40		
		Oil residency index				1.63	2.44		
								13	Low
59_30	5952	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				4.10	8.20		
		Oil residency index				1.41	2.11		
		Alcids nonbreeding	21	1	0.5	0.99	1.73		
								18	Low
60_31	6003	Human use				5.00	10.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				3.95	7.90		
		Oil residency index				2.14	3.22		
		Arctic char	14	3	0.5	3.00	5.25		
		Capelin	21	2	0.25	1.50	2.63		
								35	High

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_32	5952	Human use				5.00	10.00		
		Archaeological sites				5.00	10.00		
		Special status areas				0.00	0.00		
		Communities				4.05	8.10		
		Oil residency index				1.96	2.93		
		Alcids nonbreeding	21	1	0.5	1.37	2.39		
		Arctic char	14	4	0.5	3.65	6.39		
		Capelin	21	2	0.25	1.37	2.39		
		Lumpsucker	15	1	0.5	0.98	1.71		
								44	High
59_33	5951	Human use				2.00	4.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.00	1.51		
		Alcids nonbreeding	21	2	0.5	1.41	2.46		
								8	Low
60_34	5951	Human use				4.00	8.00		
		Archaeological sites				5.00	10.00		
		Special status areas				0.00	0.00		
		Communities				2.50	5.00		
		Oil residency index				2.52	3.78		
		Alcids nonbreeding	21	1	0.5	1.76	3.09		
		Arctic char	14	5	0.5	5.88	10.29		
		Capelin	21	1	0.25	0.88	1.54		
								42	High

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_35	5951	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.55	1.10		
		Oil residency index				2.62	3.93		
		Alcids nonbreeding	21	1	0.5	1.83	3.21		
		Scallop	18	3	1	9.42	16.49		
								31	Moderate
60_36	5951	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.31	3.47		
		Alcids nonbreeding	21	1	0.5	1.62	2.83		
								12	Low
60_37	5951	Human use				2.00	4.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.68	2.53		
		Alcids nonbreeding	21	2	0.5	2.36	4.13		
		Harbour seals	18	2	1	4.04	7.08		
		Scallop	18	1	1	2.02	3.54		
								21	Low
59_38	5951	Human use				2.00	4.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.86	2.79		
		Alcids nonbreeding	21	2	0.5	2.61	4.56		
								11	Low

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
59_39	5951	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.29	4.93		
		Alcids nonbreeding	21	2	0.5	4.60	8.06		
		Scallop	18	1	1	3.95	6.90		
								22	Low
59_40	5951	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.62	2.43		
		Alcids	25	5	0.5	6.76	11.83		
		Alcids nonbreeding	21	2	0.5	2.27	3.97		
		Harbour seals	18	1	1	1.95	3.41		
								24	Moderate
59_41	5951	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.81	2.72		
		Alcids nonbreeding	21	2	0.5	2.54	4.44		
		Harbour seals	18	4	1	8.71	15.24		
		Scallop	18	1	1	2.18	3.81		
								32	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_42	5951	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.82	2.74		
		Alcids	25	4	0.5	6.08	10.64		
		Alcids nonbreeding	21	2	0.5	2.55	4.47		
		Gulls	17	1	0.5	1.03	1.81		
		Harbour seals	18	5	1	10.94	19.15		
								45	High
60_43	5951	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.23	3.35		
		Alcids nonbreeding	21	2	0.5	3.13	5.47		
		Arctic char	14	2	0.5	2.09	3.65		
								24	Moderate
60_44	5951	Human use				3.00	6.00		
		Archaeological sites				5.00	10.00		
		Special status areas				0.00	0.00		
		Communities				1.80	3.60		
		Oil residency index				2.51	3.76		
		Alcids nonbreeding	21	1	0.5	1.75	3.07		
								26	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_45	6002	Human use				5.00	10.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				3.95	7.90		
		Oil residency index				2.83	4.24		
		Arctic char	14	5	0.5	6.60	11.56		
		Capelin	21	4	0.25	3.96	6.93		
		Harbour seals	18	1	1	3.40	5.94		
		Lumpsucker	15	2	0.5	2.83	4.95		
								54	Extreme
60_46	6003	Human use				5.00	10.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				1.20	2.40		
		Oil residency index				3.83	5.75		
		Arctic char	14	5	0.5	8.94	15.64		
		Capelin	21	5	0.25	6.70	11.73		
		Lumpsucker	15	1	0.5	1.92	3.35		
		Snow crab	9	2	1	4.60	8.05		
								63	Extreme
60_47	6003	Human use				5.00	10.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				1.25	2.50		
		Oil residency index				3.33	4.99		
		Arctic char	14	5	0.5	7.76	13.58		
		Capelin	21	1	0.25	1.16	2.04		
		Lumpsucker	15	1	0.5	1.66	2.91		
		Snow crab	9	2	1	3.99	6.98		
								49	Extreme

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_48	6002	Human use				5.00	10.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				4.20	8.40		
		Oil residency index				2.36	3.54		
		Alcids nonbreeding	21	1	0.5	1.65	2.89		
		Arctic char	14	3	0.5	3.31	5.79		
		Capelin	21	1	0.25	0.83	1.45		
		Deep sea shrimp	7	1	1	1.10	1.93		
		Harbour seals	18	2	1	5.67	9.92		
		Lumpsucker	15	1	0.5	1.18	2.07		
								52	Extreme
60_49	6002	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				4.95	9.90		
		Oil residency index				2.37	3.56		
		Alcids nonbreeding	21	2	0.5	3.32	5.81		
								27	Moderate
60_50	6002	Human use				4.00	8.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				5.05	10.10		
		Oil residency index				2.24	3.37		
		Alcids nonbreeding	21	2	0.5	3.14	5.50		
								33	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_51	6002	Human use				5.00	10.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				2.50	5.00		
		Oil residency index				2.76	4.14		
		Arctic char	14	5	0.5	6.45	11.28		
		Capelin	21	2	0.25	1.93	3.38		
		Lumpsucker	15	1	0.5	1.38	2.42		
		Scallop	18	1	1	3.32	5.80		
		Snow crab	9	3	1	4.97	8.70		
								57	Extreme
60_52	6002	Human use				5.00	10.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.70	4.05		
		Arctic char	14	5	0.5	6.30	11.03		
		Capelin	21	2	0.25	1.89	3.31		
		Snow crab	9	3	1	4.86	8.51		
								43	High
60_53	6056	Human use				4.00	8.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.24	3.37		
								11	Low
60_54	6002	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.12	3.18		
		Snow crab	9	2	1	2.55	4.45		
								20	Low

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_55	6002	Human use				5.00	10.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.25	3.38		
		Arctic char	14	2	0.5	2.10	3.68		
		Scallops	18	1	1	2.70	4.73		
		Snow crab	9	3	1	4.06	7.10		
								31	Moderate
60_56	6002	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.24	3.36		
		Alcids	25	1	0.5	1.87	3.27		
		Gulls	17	2	0.5	2.54	4.44		
		Scallop	18	4	1	10.76	18.82		
		Snow crab	9	1	1	1.34	2.35		
								40	High
60_57	6002	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.34	3.51		
		Deep sea shrimp	7	1	1	1.09	1.91		
		Scallop 18	1	1	2.81	4.92			
		Snow crab	9	3	1	4.21	7.37		
								26	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_58	6002	Human use				5.00	10.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				1.40	2.80		
		Oil residency index				1.91	2.87		
		Alcids nonbreeding	21	2	0.5	2.68	4.68		
		Arctic char	14	5	0.5	4.46	7.80		
		Deep sea shrimp	7	1	1	0.89	1.56		
		Snow crab	9	2	1	2.29	4.01		
								40	High
60_59	6002	Human useHuman use				4.00	8.00		
		Archaeological Sites				1.00	2.00		
		Special status areasSpecial status areas				0.00	0.00		
		Communities				0.70	1.40		
		Oil residency index				1.09	1.64		
		Alcids nonbreeding	21	3	0.5	2.29	4.01		
		Arctic char	14	1	0.5	0.51	0.89		
		Deep sea shrimp	7	4	1	2.04	3.56		
		Gulls	17	3	0.5	1.85	3.25		
		Scallop	18	1	1	1.31	2.29		
		Snow crab	9	1	1	0.65	1.15		
								28	Moderate
60_60	6002	Human use				4.00	8.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.45	2.18		
		Alcids	25	3	0.5	3.63	6.36		
		Alcids nonbreeding	21	3	0.5	3.05	5.34		
		Gulls	17	1	0.5	0.82	1.44		
								29	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_61	6002	Human use				5.00	10.00		
		Archaeological sites				5.00	10.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.63	3.94		
		Arctic char	14	5	0.5	6.13	10.73		
		Capelin	21	2	0.25	1.84	3.22		
		Deep sea shrimp	7	2	1	2.45	4.29		
		Lumpsucker	15	4	0.5	5.25	9.19		
		Snow crab	9	5	1	7.88	13.79		
								65	Extreme
60_62	6002	Human use				5.00	10.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				2.25	4.50		
		Oil residency index				1.98	2.97		
		Alcids nonbreeding	21	3	0.5	4.15	7.27		
		Deep sea shrimp	7	3	1	2.77	4.85		
		Lumpsucker	15	1	0.5	0.99	1.73		
		Snow crab	9	3	1	3.56	6.23		
								44	High
60_63	6002	Human use				5.00	10.00		
		Archaeological sites				5.00	10.00		
		Special status areas				0.00	0.00		
		Communities				5.05	10.10		
		Oil residency index				2.19	3.28		
		Alcids nonbreeding	21	1	0.5	1.53	2.68		
		Arctic char	14	3	0.5	3.06	5.36		
		Capelin	21	2	0.25	1.53	2.68		
		Deep sea shrimp	7	3	1	3.06	5.36		
		Lumpsucker	15	2	0.5	2.19	3.83		
		Snow crab	9	2	1	2.62	4.59		
								58	Extreme

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_64	6055	Human use				5.00	10.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				2.75	5.50		
		Oil residency index				2.74	4.11		
		Arctic char	14	3	0.5	3.83	6.71		
		Capelin	21	4	0.25	3.83	6.71		
		Deep sea shrimp	7	3	1	3.83	6.71		
		Lumpsucker	15	4	0.5	5.48	9.58		
		Snow crab	9	3	1	4.93	8.62		
								64	Extreme
60_65	6055	Human use				5.00	10.00		
		Archaeological sites				5.00	10.00		
		Special status areas				0.00	0.00		
		Communities				2.05	4.10		
		Oil residency index				2.49	3.73		
		Arctic char	14	5	0.5	5.81	10.16		
		Capelin	21	3	0.25	2.61	4.57		
		Deep sea shrimp	7	2	1	2.32	4.06		
		Lumpsucker	15	5	0.5	6.22	10.88		
		Snow crab	9	2	1	2.99	5.22		
								63	Extreme
60_66	6001	Human use				5.00	10.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				5.30	10.60		
		Oil residency index				1.44	2.16		
		Alcids nonbreeding	21	1	0.5	1.01	1.76		
		Arctic char	14	1	0.5	0.67	1.17		
		Capelin	21	1	0.25	0.50	0.88		
		Deep sea shrimp	7	3	1	2.01	3.52		
		Lumpsucker	15	4	0.5	2.87	5.03		
		Snow crab	9	3	1	2.59	4.53		
								46	Extreme

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_67	6001	Human use				4.00	8.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				4.10	8.20		
		Oil residency index				1.51	2.26		
		Alcids nonbreeding	21	3	0.5	3.17	5.55		
		Deep sea shrimp	7	2	1	1.41	2.47		
								28	Moderate
60_68	6001	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.46	2.19		
		Alcids nonbreeding	21	2	0.5	2.04	3.58		
								14	Low
60_69	6001	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				1.80	3.60		
		Oil residency index				2.44	3.66		
		Alcids	25	4	0.5	8.12	14.22		
		Alcids nonbreeding	21	1	0.5	1.71	2.99		
		Capelin	21	2	0.25	1.71	2.99		
		Deep sea shrimp	7	1	1	1.14	1.99		
								41	High
60_70	6054	Human use				2.00	4.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				2.85	5.70		
		Oil residency index				2.85	4.27		
		Arctic char	14	2	0.5	2.66	4.65		
		Capelin	21	5	0.25	4.98	8.72		
								33	High

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_71	6001	Human use				2.00	4.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				3.85	7.70		
		Oil residency index				2.12	3.18		
		Alcids nonbreeding	21	2	0.5	2.97	5.20		
								26	Moderate
60_72	6001	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				3.40	6.80		
		Oil residency index				1.25	1.88		
		Alcids nonbreeding	21	2	0.5	1.76	3.07		
								20	Low
60_73	6001	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				7.00	14.00		
		Oil residency index				1.90	2.85		
		Alcids nonbreeding	21	2	0.5	2.66	4.65		
		Capelin	21	1	0.25	0.66	1.16		
		Lumpsucker	15	3	0.5	2.85	4.98		
								40	High
60_74	6001	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				8.25	16.50		
		Oil residency index				2.37	3.55		
		Alcids nonbreeding	21	2	0.5	3.32	5.80		
		Capelin	21	3	0.25	2.49	4.35		
		Deep sea shrimp	7	1	1	1.11	1.93		
		Lumpsucker	15	3	0.5	3.55	6.22		
								46	Extreme

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_75	6054	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				7.25	14.50		
		Oil residency index				2.30	3.45		
		Alcids nonbreeding	21	1	0.5	1.61	2.81		
		Lumpsucker	15	3	0.5	3.45	6.03		
								39	High
60_76	6054	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				2.70	5.40		
		Oil residency index				2.48	3.72		
		Arctic char	14	3	0.5	3.47	6.07		
		Capelin	21	2	0.25	1.74	3.04		
		Lumpsucker	15	5	0.5	6.20	10.85		
								41	High
60_77	6055	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.20	0.40		
		Oil residency index				3.02	4.53		
		Arctic char	14	2	0.5	2.82	4.93		
		Capelin	21	1	0.25	1.06	1.85		
		Gulls	17	2	0.5	3.42	5.98		
		Lumpsucker	15	4	0.5	6.03	10.56		
								40	High

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_78	6055	Human use				3.00	6.00		
		Archaeological sites				5.00	10.00		
		Special status areas				0.00	0.00		
		Communities				3.70	7.40		
		Oil residency index				4.09	6.14		
		Arctic char	14	5	0.5	9.55	16.70		
		Capelin	21	1	0.25	1.43	2.51		
		Lumpsucker	15	4	0.5	8.18	14.32		
								63	Extreme
60_79	6054	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.55	1.10		
		Oil residency index				2.87	4.30		
		Capelin	21	1	0.25	1.00	1.76		
		Lumpsucker	15	5	0.5	7.17	12.55		
								32	Moderate
60_80	6054	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				3.05	6.10		
		Oil residency index				2.51	3.76		
		Lumpsucker	15	4	0.5	5.01	8.77		
								31	Moderate
60_81	6054	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				10.30	20.60		
		Oil residency indexOil residency index				2.51	3.76		
		Alcids nonbreeding	21	2	0.5	3.51	6.14		
		Lumpsucker	15	1	0.5	1.25	2.19		
		Scallop	18	1	1	3.01	5.27		
								46	Extreme

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_82	6001	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				4.35	8.70		
		Oil residency index				1.52	2.28		
		Alcids	25	4	0.5	5.07	8.87		
		Alcids nonbreeding	21	3	0.5	3.19	5.59		
		Gulls	17	2	0.5	1.72	3.02		
		Seaducks breeding	23	1	0.5	1.17	2.04		
								43	High
60_83	6054	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				7.05	14.10		
		Oil residency index				2.28	3.42		
		Capelin	21	1	0.25	0.80	1.40		
		Lumpsucker	15	3	0.5	3.42	5.98		
		Scallop	18	1	1	2.73	4.78		
								38	High
60_84	6054	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				3.40	6.80		
		Oil residency index				2.01	3.01		
		Alcids nonbreeding	21	2	0.5	2.81	4.92		
		Capelin	21	1	0.25	0.70	1.23		
		Lumpsucker	15	5	0.5	5.03	8.79		
								37	High

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_85	6054	Human use				4.00	8.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.90	1.80		
		Oil residency index				2.95	4.42		
		Arctic char	14	1	0.5	1.38	2.41		
		Capelin	21	2	0.25	2.06	3.61		
		Lumpsucker	15	5	0.5	7.37	12.90		
								39	High
60_86	6054	Human use				4.00	8.00		
		Archaeological sites				5.00	10.00		
		Special status areas				0.00	0.00		
		Communities				4.05	8.10		
		Oil residency index				2.39	3.59		
		Arctic char	14	3	0.5	3.35	5.86		
		Lumpsucker	15	5	0.5	5.98	10.47		
		Scallop	18	1	1	2.87	5.02		
								51	Extreme
60_87	6054	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.80	1.60		
		Oil residency index				1.91	2.87		
		Alcids nonbreeding	21	1	0.5	1.34	2.34		
		Lumpsucker	15	4	0.5	3.82	6.68		
								25	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_88	6053	Human use				4.00	8.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.43	2.14		
		Alcids	25	1	0.5	1.19	2.08		
		Alcids nonbreeding	21	3	0.5	3.00	5.25		
		Deep sea shrimp	7	1	1	0.67	1.17		
		Gulls	17	2	0.5	1.62	2.83		
								23	Moderate
60_89	6053	Human use				4.00	8.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.04	1.56		
		Alcids	25	1	0.5	0.86	1.51		
		Alcids nonbreeding	21	3	0.5	2.18	3.81		
		Deep sea shrimp	7	5	1	2.42	4.23		
		Gulls	17	2	0.5	1.18	2.06		
		Seaducks breeding	23	1	0.5	0.80	1.39		
								25	Moderate
60_90	6053	Human use				5.00	10.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.27	1.90		
		Alcids nonbreeding	21	3	0.5	2.66	4.66		
		Lumpsucker	15	5	0.5	3.17	5.55		
								22	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_91	6053	Human use				4.00	8.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.99	2.99		
		Alcids nonbreeding	21	1	0.5	1.39	2.44		
		Lumpsucker	15	4	0.5	3.98	6.97		
								22	Moderate
60_92	6054	Human use				4.00	8.00		
		Archaeological sites				1.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.23	3.34		
		Lumpsucker	15	5	0.5	5.57	9.74		
		Scallop	18	1	1	2.67	4.67		
								26	Moderate
60_93	6054	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				3.25	6.50		
		Oil residency index				2.26	3.39		
		Arctic char	14	1	0.5	1.06	1.85		
		Capelin	21	2	0.25	1.58	2.77		
		Lumpsucker	15	5	0.5	5.66	9.90		
								36	High
60_94	6054	Human use				5.00	10.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				1.95	3.90		
		Oil residency index				2.62	3.93		
		Arctic char	14	1	0.5	1.22	2.14		
		Capelin	21	1	0.25	0.92	1.61		
		Lumpsucker	15	3	0.5	3.93	6.88		
								30	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
61_95	6055	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				3.05	6.10		
		Oil residency index				3.56	5.33		
		Arctic char	14	3	0.5	4.98	8.71		
								32	Moderate
61_96	6106	Human use				2.00	4.00		
		Archaeological sites				5.00	10.00		
		Special status areas				0.00	0.00		
		Communities				7.90	15.80		
		Oil residency index				3.90	5.85		
		Arctic char	14	5	0.5	9.10	15.93		
								52	Extreme
61_97	6055	Human use				4.00	8.00		
		Archaeological sites				5.00	10.00		
		Special status areas				0.00	0.00		
		Communities				3.25	6.50		
		Oil residency index				3.21	4.82		
		Arctic char	14	3	0.5	4.50	7.87		
								37	High
60_98	6054	Human use				5.00	10.00		
		Archaeological sites				5.00	10.00		
		Special status areas				0.00	0.00		
		Communities				3.70	7.40		
		Oil residency index				2.42	3.63		
		Arctic char	14	1	0.5	1.13	1.98		
		Capelin	21	1	0.25	0.85	1.48		
		Lumpsucker	15	1	0.5	1.21	2.12		
								37	High

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_99	6054	Human use				4.00	8.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				2.15	4.30		
		Oil residency index				2.27	3.40		
		Lumpsucker	15	1	0.5	1.13	1.99		
								24	Moderate
60_100	6053	Human use				4.00	8.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.50	3.75		
		Lumpsucker	15	5	0.5	6.25	10.93		
								29	Moderate
60_101	6053	Human use				5.00	10.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.76	4.13		
		Alcids nonbreeding	21	2	0.5	3.86	6.75		
		Capelin	21	1	0.25	0.96	1.69		
		Lumpsucker	15	5	0.5	6.89	12.05		
								37	High
60_102	6053	Human use				5.00	10.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.14	1.71		
		Alcids	25	2	0.5	1.90	3.33		
		Alcids nonbreeding	21	3	0.5	2.40	4.19		
		Deep sea shrimp	7	1	1	0.53	0.93		
		Gulls	17	3	0.5	1.94	3.39		
		Lumpsucker	15	2	0.5	1.14	2.00		
		Seaducks breeding	23	1	0.5	0.87	1.53		
								27	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_103	6053	Human use				4.00	8.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.32	3.47		
		Alcids nonbreeding	21	1	0.5	1.62	2.84		
		Lumpsucker	15	2	0.5	2.32	4.05		
								20	Low
60_104	6053	Human use				4.00	8.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.71	4.06		
		Alcids nonbreeding	21	2	0.5	3.79	6.63		
								25	Moderate
60_105	6053	Human use				4.00	8.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.13	3.19		
		Alcids nonbreeding	21	2	0.5	2.98	5.21		
								22	Moderate
60_106	6053	Human use				4.00	8.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.52	2.28		
		Alcids nonbreeding	21	2	0.5	2.13	3.72		
		Deep sea shrimp	7	3	1	2.13	3.72		
		Scallop	18	5	1	9.12	15.96		
								36	High

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_107	6053	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.55	3.83		
		Capelin	21	3	0.25	2.68	4.69		
		Lumpsucker	15	5	0.5	6.38	11.17		
								28	Moderate
60_108	6053	Human use				5.00	10.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.28	3.42		
		Arctic char	14	2	0.5	2.13	3.72		
		Capelin	21	2	0.25	1.59	2.79		
		Lumpsucker	15	3	0.5	3.42	5.98		
								28	Moderate
60_109	6053	Human use				5.00	10.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.76	4.14		
		Capelin	21	2	0.25	1.93	3.38		
		Lumpsucker	15	2	0.5	2.76	4.82		
		Scallop	18	4	1	13.23	23.16		
								45	Extreme

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_110	6054	Human use				5.00	10.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				1.35	2.70		
		Oil residency index				2.48	3.72		
		Arctic char	14	5	0.5	5.78	10.12		
		Capelin	21	1	0.25	0.87	1.52		
		Deep sea shrimp	7	1	1	1.16	2.02		
		Lumpsucker	15	5	0.5	6.20	10.85		
		Scallop	18	1	1	2.97	5.21		
								52	Extreme
60_111	6053	Human use				5.00	10.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.75	1.50		
		Oil residency index				2.54	3.80		
		Arctic char	14	5	0.5	5.92	10.35		
								28	Moderate
61_112	6105	Human use				2.00	4.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				1.75	3.50		
		Oil residency index				2.84	4.27		
								18	Low
61_113	6105	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				1.25	2.50		
		Oil residency index				3.52	5.28		
		Arctic char	14	5	0.5	8.21	14.37		
		Harbour seals	18	5	0.25	5.28	9.24		
								37	High

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
61_114	6105	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.69	4.04		
		Arctic char	14	1	0.5	1.26	2.20		
		Harbour seals	18	5	0.25	4.04	7.07		
								17	Low
61_115	6105	Human use				4.00	8.00		
		Archaeological sites				5.00	10.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.88	4.32		
		Arctic char	14	5	0.5	6.71	11.75		
		Capelin	21	1	0.25	1.01	1.76		
								36	High
61_116	6054	Human use				4.00	8.00		
		Archaeological sites				5.00	10.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.62	3.94		
		Arctic char	14	2	0.5	2.45	4.29		
		Capelin	21	2	0.25	1.84	3.21		
								29	Moderate
61_117	6053	Human use				4.00	8.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.06	3.08		
		Arctic char	14	2	0.5	1.92	3.36		
		Capelin	21	1	0.25	0.72	1.26		
		Gulls	17	3	0.5	3.50	6.12		
								24	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_118	6053	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.19	3.28		
		Lumpsucker	15	1	0.5	1.09	1.91		
								13	Low
60_119	6053	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.12	3.18		
		Alcids	25	1	0.5	1.76	3.09		
		Capelin	21	1	0.25	0.74	1.30		
		Gulls	17	2	0.5	2.40	4.20		
								20	Low
60_120	6053	Human use				5.00	10.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.28	3.42		
		Alcids	25	2	0.5	3.80	6.65		
		Arctic char	14	3	0.5	3.19	5.59		
		Gulls	17	3	0.5	3.88	6.78		
		Lumpsucker	15	2	0.5	2.28	3.99		
								38	High
60_121	6053	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.10	4.65		
		Arctic char	14	2	0.5	2.89	5.06		
		Capelin	21	3	0.25	3.25	5.70		
								23	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_122	6053	Human use				4.00	8.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.33	3.49		
		Alcids	25	3	0.5	5.82	10.19		
		Gulls	17	3	0.5	3.96	6.93		
		Lumpsucker	15	1	0.5	1.16	2.04		
								33	Moderate
60_123	6053	Human use				4.00	8.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.15	0.30		
		Oil residency index				2.47	3.71		
		Arctic char	14	1	0.5	1.15	2.02		
		Lumpsucker	15	4	0.5	4.95	8.66		
								25	Moderate
60_124	6053	Human use				5.00	10.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				3.55	7.10		
		Oil residency index				1.90	2.85		
		Alcids nonbreeding	21	1	0.5	1.33	2.33		
		Lumpsucker	15	5	0.5	4.75	8.32		
		Scallop	18	1	1	2.28	3.99		
								41	High
60_125	6053	Human use				2.00	4.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.65	1.30		
		Oil residency index				3.31	4.97		
		Arctic char	14	2	0.5	3.09	5.41		
		Lumpsucker	15	5	0.5	8.28	14.49		
								30	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_126	6053	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				1.05	2.10		
		Oil residency index				2.27	3.41		
		Capelin	21	2	0.25	1.59	2.78		
		Lumpsucker	15	5	0.5	5.68	9.94		
								24	Moderate
60_127	6052	Human use				4.00	8.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				4.95	9.90		
		Oil residency index				2.28	3.41		
		Arctic char	14	3	0.5	3.19	5.58		
		Lumpsucker	15	5	0.5	5.69	9.96		
		Snow crab	9	1	1	1.37	2.39		
								41	High
60_128	6052	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				5.15	10.30		
		Oil residency index				2.14	3.21		
		Alcids nonbreeding	21	1	0.5	1.50	2.62		
		Lumpsucker	15	2	0.5	2.14	3.74		
								28	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_129	6052	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				4.65	9.30		
		Oil residency index				3.44	5.16		
		Alcids nonbreeding	21	1	0.5	2.41	4.21		
		Lumpsucker	15	4	0.5	6.88	12.04		
		Snow crab	9	2	1	4.13	7.22		
								46	Extreme
60_130	6052	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				4.70	9.40		
		Oil residency index				2.38	3.56		
		Alcids nonbreeding	21	1	0.5	1.66	2.91		
		Lumpsucker	15	5	0.5	5.94	10.39		
								32	Moderate
60_131	6052	Human use				4.00	8.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				2.00	4.00		
		Oil residency index				1.90	2.85		
		Alcids nonbreeding	21	3	0.5	3.99	6.98		
		Gulls	17	1	0.5	1.08	1.88		
		Seaducks	23	5	1	14.55	25.46		
		Seaducks breeding	23	1	0.5	1.46	2.55		
								54	Extreme

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_132	6052	Human use				2.00	4.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				1.25	2.50		
		Oil residency index				2.20	3.31		
		Alcids nonbreeding	21	2	0.5	3.09	5.40		
		Lumpsucker	15	4	0.5	4.41	7.71		
								29	Moderate
60_133	6052	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.02	3.03		
		Alcids	25	1	0.5	1.68	2.95		
		Alcids nonbreeding	21	2	0.5	2.83	4.95		
		Gulls	17	3	0.5	3.43	6.01		
		Seaducks	23	5	1	15.49	27.10		
		Snow crab	9	1	1	1.21	2.12		
								54	Extreme
60_134	6052	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				1.75	3.50		
		Oil residency index				3.44	5.16		
		Alcids nonbreeding	21	2	0.5	4.82	8.43		
		Lumpsucker	15	4	0.5	6.88	12.04		
		Snow crab	9	5	1	10.32	18.07		
								55	Extreme

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_135	6052	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				1.90	3.80		
		Oil residency index				3.42	5.13		
		Alcids nonbreeding	21	1	0.5	2.39	4.19		
		Lumpsucker	15	5	0.5	8.55	14.97		
								36	High
60_136	6052	Human use				4.00	8.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				3.20	6.40		
		Oil residency index				3.13	4.70		
		Lumpsucker	15	5	0.5	7.83	13.69		
		Snow crab	9	5	1	9.39	16.43		
								49	Extreme
60_137	6052	Human use				4.00	8.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				1.05	2.10		
		Oil residency index				2.99	4.48		
		Capelin	21	2	0.25	2.09	3.66		
		Lumpsucker	15	5	0.5	7.47	13.07		
		Scallop	18	1	1	3.59	6.27		
		Snow crab	9	3	1	5.38	9.41		
								47	Extreme

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_138	6052	Human use				4.00	8.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.55	5.32		
		Arctic char	14	5	0.5	8.27	14.48		
		Capelin	21	1	0.25	1.24	2.17		
		Snow crab	9	5	1	10.64	18.61		
								49	Extreme
60_139	6052	Human use				3.00	6.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.66	5.49		
		Lumpsucker	15	1	0.5	1.83	3.20		
		Snow crab	9	5	1	10.97	19.20		
								34	High
60_140	6052	Human use				2.00	4.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.96	5.94		
		Arctic char	14	5	0.5	9.24	16.17		
								26	Moderate
60_141	6052	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.63	5.45		
		Arctic char	14	2	0.5	3.39	5.93		
								13	Low

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_142	6052	Human use				2.00	4.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.49	5.23		
		Arctic char	14	5	0.5	8.14	14.25		
								23	Moderate
60_143	6052	Human use				2.00	4.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.09	4.63		
		Alcids nonbreeding	21	1	0.5	2.16	3.78		
		Arctic char	14	1	0.5	1.44	2.52		
		Snow crab	9	3	1	5.55	9.72		
								25	Moderate
60_144	6052	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.35	3.52		
		Alcids nonbreeding	21	1	0.5	1.64	2.88		
		Arctic char	14	2	0.5	2.19	3.83		
		Gulls	17	1	0.5	1.33	2.33		
		Lumpsucker	15	5	0.5	5.87	10.27		
		Snow crab	9	4	1	5.63	9.86		
								41	High

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_145	6052	Human use				3.00	6.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.75	4.12		
		Alcids nonbreeding	21	1	0.5	1.92	3.37		
		Arctic char	14	3	0.5	3.85	6.73		
		Gulls	17	1	0.5	1.56	2.72		
		Lumpsucker	15	2	0.5	2.75	4.81		
								28	Moderate
60_146	6052	Human use				2.00	4.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.10	4.65		
		Alcids nonbreeding	21	1	0.5	2.17	3.80		
		Arctic char	14	2	0.5	2.89	5.06		
		Lumpsucker	15	1	0.5	1.55	2.71		
								20	Low
60_147	6052	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.47	3.71		
		Alcids	25	1	0.5	2.06	3.61		
		Alcids nonbreeding	21	1	0.5	1.73	3.03		
		Gulls	17	1	0.5	1.40	2.45		
		Seaducks breeding	23	1	0.5	1.90	3.32		
								20	Low

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_148	6052	Human use				2.00	4.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.75	2.62		
		Alcids nonbreeding	21	2	0.5	2.45	4.29		
		Seaducks	23	5	1	13.41	23.47		
								34	High
60_149	6052	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				4.32	6.49		
								8	Low
60_150	6052	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				4.33	6.50		
		Arctic char	14	5	0.5	10.11	17.69		
								28	Moderate
60_151	6051	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.38	2.07		
		Alcids	25	1	0.5	1.15	2.02		
		Alcids nonbreeding	21	1	0.5	0.97	1.69		
		Arctic char	14	3	0.5	1.94	3.39		
		Gulls	17	1	0.5	0.78	1.37		
		Seaducks	23	5	1	10.60	18.56		
								33	High

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_152	6051	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.61	2.42		
		Alcids nonbreeding	21	1	0.5	1.13	1.97		
		Arctic char	14	4	0.5	3.01	5.27		
		Seaducks	23	5	1	12.36	21.63		
								33	High
60_153	6051	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				4.04	6.05		
								8	Low
60_154	6051	Human use				2.00	4.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.29	4.93		
		Alcids nonbreeding	21	1	0.5	2.30	4.03		
		Arctic char	14	5	0.5	7.67	13.43		
								26	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_155	6051	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.83	2.74		
		Alcids	25	3	0.5	4.57	7.99		
		Alcids nonbreeding	21	1	0.5	1.28	2.24		
		Arctic char	14	2	0.5	1.71	2.98		
		Gulls	17	1	0.5	1.04	1.81		
		Seaducks	23	5	1	14.01	24.51		
								44	High
60_156	6051	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.12	1.68		
		Harbour seals	18	5	1	6.73	11.77		
								15	Low
60_157	6051	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.97	4.46		
		Alcids nonbreeding	21	1	0.5	2.08	3.64		
		Arctic char	14	2	0.5	2.78	4.86		
		Harbour seals	18	5	1	17.85	31.24		
								46	Extreme

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_158	6051	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				10.00	15.00		
		Communities				0.00	0.00		
		Oil residency index				0.99	1.49		
		Alcids	25	5	0.5	4.13	7.23		
		Alcids nonbreeding	21	3	0.5	2.08	3.65		
		Gulls	17	1	0.5	0.56	0.98		
		Harbour seals	18	5	1	5.95	10.42		
		Seaducks	23	5	1	7.61	13.31		
		Seaducks breeding	23	1	0.5	0.76	1.33		
		Tubenoses shoreline	18	2	0.5	1.19	2.08		
								59	Extreme
60_159	6051	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.48	2.22		
		Alcids nonbreeding	21	1	0.5	1.04	1.82		
		Harbour seals	18	5	1	8.90	15.57		
		Seaducks	23	5	1	11.37	19.90		
								42	High
60_160	6051	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.89	5.83		
		Arctic char	14	2	0.5	3.63	6.35		
		Scallop	18	1	1	4.66	8.16		
								22	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_161	6051	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.50	5.26		
								7	Low
60_162	6051	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.46	5.20		
		Arctic char	14	5	0.5	8.09	14.15		
								21	Low
60_163	6052	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				4.52	6.78		
		Arctic char	14	3	0.5	6.33	11.08		
		Harbour seals	18	4	0.25	5.43	9.49		
								29	Moderate
60_164	6051	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.43	5.14		
		Arctic char	14	1	0.5	1.60	2.80		
		Harbour seals	18	4	0.25	4.11	7.20		
								17	Low

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_165	6051	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.08	4.62		
		Arctic char	14	2	0.5	2.87	5.03		
		Harbour seals	18	4	0.25	3.69	6.46		
								18	Low
60_166	6051	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.52	5.28		
								7	Low
60_167	6051	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.49	3.74		
		Alcids nonbreeding	21	3	0.5	5.23	9.15		
		Seaducks	23	5	1	19.10	33.42		
		Seaducks breeding	23	1	0.5	1.91	3.34		
								52	Extreme

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_168	6051	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.73	2.59		
		Alcids	25	5	0.5	7.20	12.60		
		Alcids nonbreeding	21	2	0.5	2.42	4.23		
		Gulls	17	1	0.5	0.98	1.71		
		Harbour seals	18	5	1	10.37	18.14		
		Seaducks	23	5	1	13.25	23.18		
		Seaducks breeding	23	1	0.5	1.32	2.32		
								67	Extreme
60_169	6051	Human use				1.00	2.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.00	3.00		
		Alcids	25	5	0.5	8.34	14.60		
		Alcids nonbreeding	21	3	0.5	4.20	7.36		
		Deep sea shrimp	7	1	1	0.93	1.63		
		Gulls	17	1	0.5	1.13	1.99		
		Harbour seals	18	5	1	12.01	21.02		
		Seaducks	23	5	1	15.35	26.86		
		Seaducks breeding	23	1	0.5	1.53	2.69		
								81	Extreme
61_170	6102	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.04	4.57		
		Arctic char	14	4	0.5	5.68	9.94		
								27	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
60_171	6051	Human use				1.00	2.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.07	4.60		
								13	Low
60_172	6051	Human use				1.00	2.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.89	2.84		
		Alcids nonbreeding	21	2	0.5	2.65	4.63		
		Seaducks	23	5	1	14.49	25.36		
								41	High
61_173	6051	Human use				2.00	4.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.57	2.36		
		Alcids nonbreeding	21	3	0.5	3.30	5.77		
		Seaducks	23	5	1	12.04	21.08		
								33	High
61_174	6102	Human use				2.00	4.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.33	4.99		
		Arctic char	14	2	0.5	3.11	5.43		
								20	Low

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
61_175	6102	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				3.00	6.00		
		Oil residency index				3.05	4.57		
		Arctic char	14	2	0.5	2.84	4.98		
		Lumpsucker	15	2	0.5	3.05	5.33		
								27	Moderate
61_176	6102	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.52	3.77		
		Alcids nonbreeding	21	1	0.5	1.76	3.08		
		Lumpsucker	15	3	0.5	3.77	6.60		
								19	Low
61_177	6051	Human use				1.00	2.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.04	3.06		
		Alcids nonbreeding	21	1	0.5	1.43	2.50		
		Seaducks	23	5	1	15.63	27.36		
								41	High

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
61_178	6101	Human use				2.00	4.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				5.00	10.00		
		Oil residency index				1.48	2.22		
		Alcids	25	1	0.5	1.23	2.16		
		Alcids nonbreeding	21	4	0.5	4.14	7.24		
		Deep sea shrimp	7	1	1	0.69	1.21		
		Gulls	17	1	0.5	0.84	1.47		
		Seaducks	23	5	1	11.33	19.83		
		Seaducks breeding	23	1	0.5	1.13	1.98		
								50	Extreme
61_179	6102	Human use				2.00	4.00		
		Archaeological sites				5.00	10.00		
		Special status areas				0.00	0.00		
		Communities				8.85	17.70		
		Oil residency index				2.93	4.40		
		Arctic char	14	1	0.5	1.37	2.40		
		Capelin	21	1	0.25	1.03	1.80		
		Lumpsucker	15	2	0.5	2.93	5.14		
								45	Extreme
61_180	6102	Human use				1.00	2.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				5.15	10.30		
		Oil residency index				1.99	2.99		
		Alcids	25	1	0.5	1.66	2.90		
		Alcids nonbreeding	21	2	0.5	2.79	4.88		
		Gulls	17	1	0.5	1.13	1.97		
		Seaducks breeding	23	1	0.5	1.53	2.67		
								34	High

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
61_181	6101	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				5.00	10.00		
		Oil residency index				2.17	3.26		
		Alcids nonbreeding	21	2	0.5	3.04	5.32		
								23	Moderate
61_182	6102	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				4.55	9.10		
		Oil residency index				2.42	3.63		
		Alcids	25	5	0.5	10.07	17.63		
		Arctic char	14	1	0.5	1.13	1.97		
		Capelin	21	4	0.25	3.39	5.92		
		Gulls	17	3	0.5	4.11	7.19		
								53	Extreme
61_183	6102	Human use				2.00	4.00		
		Archaeological sites				5.00	10.00		
		Special status areas				0.00	0.00		
		Communities				9.80	19.60		
		Oil residency index				2.93	4.39		
		Alcids nonbreeding	21	1	0.5	2.05	3.59		
		Arctic char	14	4	0.5	5.47	9.57		
		Lumpsucker	15	2	0.5	2.93	5.13		
								56	Extreme

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
61_184	6101	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				4.45	8.90		
		Oil residency index				2.08	3.13		
		Alcids nonbreeding	21	4	0.5	5.84	10.21		
		Arctic char	14	3	0.5	2.92	5.11		
		Capelin	21	2	0.25	1.46	2.55		
		Lumpsucker	15	5	0.5	5.21	9.12		
								51	Extreme
61_185	6101	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.15	0.30		
		Oil residency index				2.33	3.50		
		Alcids nonbreeding	21	3	0.5	4.90	8.57		
		Arctic char	14	4	0.5	4.35	7.62		
		Capelin	21	3	0.25	2.45	4.29		
		Lumpsucker	15	5	0.5	5.83	10.20		
								42	High
61_186	6101	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.89	2.83		
		Alcids nonbreeding	21	4	0.5	5.28	9.25		
		Deep sea shrimp	7	4	1	3.52	6.16		
		Seaducks	23	5	1	14.47	25.32		
								52	Extreme

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
61_187	6101	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.31	3.46		
		Arctic char	14	4	0.5	4.31	7.54		
		Capelin	21	3	0.25	2.42	4.24		
		Lumpsucker	15	5	0.5	5.77	10.10		
								37	High
61_188	6101	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.50	2.25		
		Lumpsucker	15	5	0.5	3.75	6.57		
								15	Low
61_189	6101	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.92	2.88		
		Capelin	21	1	0.25	0.67	1.18		
		Lumpsucker	15	3	0.5	2.88	5.05		
		Seaducks	23	5	1	14.74	25.80		
								41	High

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
61_190	6101	Human use				3.00	6.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.43	2.15		
		Alcids nonbreeding	21	3	0.5	3.01	5.27		
		Arctic char	14	1	0.5	0.67	1.17		
		Deep sea shrimp	7	1	1	0.67	1.17		
		Seaducks	23	5	1	10.99	19.23		
								35	High
61_191	6101	Human use				3.00	6.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.03	3.05		
		Capelin	21	1	0.25	0.71	1.24		
		Lumpsucker	15	3	0.5	3.04	5.33		
		Seaducks	23	4	1	12.45	21.79		
								43	High
61_192	6101	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.29	1.94		
		Alcids nonbreeding	21	3	0.5	2.72	4.76		
		Capelin	21	1	0.25	0.45	0.79		
		Harbour seals	18	4	0.25	1.55	2.72		
		Lumpsucker	15	2	0.5	1.29	2.26		
		Seaducks	23	4	1	7.94	13.89		
								32	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
61_193	6101	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.63	2.45		
		Alcids nonbreeding	21	2	0.5	2.29	4.00		
		Harbour seals	18	4	0.25	1.96	3.43		
		Seaducks	23	5	1	12.52	21.91		
								36	High
61_194	6102	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.35	3.53		
		Arctic char	14	3	0.5	3.29	5.76		
		Capelin	21	2	0.25	1.65	2.88		
		Harbour seals	18	4	0.25	2.82	4.94		
								23	Moderate
61_195	6152	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.87	2.81		
		Alcids	25	2	0.5	3.12	5.47		
		Gulls	17	3	0.5	3.19	5.58		
		Harbour seals	18	4	0.25	2.25	3.94		
								22	Low

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
61_196	6101	Human use				2.00	4.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.15	3.23		
		Alcids nonbreeding	21	2	0.5	3.02	5.28		
		Capelin	21	1	0.25	0.75	1.32		
		Seaducks	23	5	1	16.52	28.91		
								49	Extreme
61_197	6101	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.42	3.63		
		Alcids nonbreeding	21	3	0.5	5.08	8.90		
		Arctic char	14	2	0.5	2.26	3.95		
		Capelin	21	2	0.25	1.69	2.97		
		Seaducks	23	4	1	14.85	25.99		
								51	Extreme
61_198	6151	Human use				2.00	4.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.70	2.55		
		Alcids nonbreeding	21	3	0.5	3.57	6.24		
		Lumpsucker	15	1	0.5	0.85	1.49		
								20	Low

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
61_199	6151	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.60	3.89		
		Alcids nonbreeding	21	1	0.5	1.82	3.18		
								13	Low
61_200	6152	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.65	3.97		
		Alcids nonbreeding	21	1	0.5	1.85	3.25		
		Arctic char	14	2	0.5	2.47	4.33		
		Capelin	21	2	0.25	1.85	3.25		
								23	Moderate
61_201	6152	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.75	4.12		
		Arctic char	14	3	0.5	3.85	6.73		
		Capelin	21	3	0.25	2.89	5.05		
		Lumpsucker	15	1	0.5	1.37	2.40		
								26	Moderate

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
61_202	6151	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.26	3.39		
		Alcids nonbreeding	21	1	0.5	1.58	2.76		
		Lumpsucker	15	1	0.5	1.13	1.97		
		Scallops	18	3	1	8.13	14.22		
								30	Moderate
61_203	6152	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.42	5.14		
		Arctic char	14	4	0.5	6.39	11.19		
								22	Moderate
61_204	6152	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				3.17	4.76		
		Arctic char	14	2	0.5	2.96	5.18		
		Harbour seals	18	4	0.25	3.81	6.66		
								23	Moderate
61_205	6152	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.65	3.98		
		Harbour sealn	18	4	0.25	3.19	5.58		
								16	Low

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
61_206	6151	Human use				2.00	4.00		
		Archaeological sites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.47	3.70		
		Arctic char	14	2	0.5	2.30	4.03		
		Harbour seals	18	4	0.25	2.96	5.18		
		Scallop	18	1	1	2.96	5.18		
								28	Moderate
61_207	6151	Human use				2.00	4.00		
		Archaeological nites				3.00	6.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.19	3.28		
		Alcids nonbreeding	21	3	0.5	4.59	8.04		
								21	Low
61_208	6151	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.73	2.59		
		Alcids nonbreeding	21	3	0.5	3.62	6.34		
								15	Low
61_209	6151	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.84	4.26		
								8	Low

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
61_210	6151	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.74	2.61		
		Alcids nonbreeding	21	2	0.5	2.43	4.26		
								13	Low
61_211	6151	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.29	3.43		
		Arctic char	14	3	0.5	3.20	5.60		
		Capelin	21	5	0.25	4.00	7.00		
		Lumpsucker	15	1	0.5	1.14	2.00		
								22	Moderate
61_212	6151	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.24	3.36		
		Alcids nonbreeding	21	1	0.5	1.57	2.75		
								10	Low
61_213	6151	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.56	2.34		
		Alcids nonbreeding	21	2	0.5	2.19	3.83		
		Capelin	21	1	0.25	0.55	0.96		
		Lumpsucker	15	1	0.5	0.78	1.37		
								14	Low

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
61_214	6151	Human use				2.00	4.00		
		Archaeological sites				0.00	0.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				1.48	2.22		
		Alcids nonbreeding	21	2	0.5	2.07	3.63		
								10	Low
61_215	6151	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.07	3.11		
		Alcids nonbreeding	21	1	0.5	1.45	2.54		
		Capelin	21	3	0.25	2.18	3.81		
		Lumpsucker	15	1	0.5	1.04	1.81		
								17	Low
61_216	6151	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				1.50	3.00		
		Oil residency index				2.02	3.02		
		Alcids nonbreeding	21	1	0.5	1.41	2.47		
		Lumpsucker	15	3	0.5	3.02	5.29		
		Scallop	18	1	1	2.42	4.23		
								24	Moderate
61_217	6151	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.65	1.30		
		Oil residency index				1.92	2.88		
		Alcids nonbreeding	21	2	0.5	2.69	4.71		
		Lumpsucker	15	1	0.5	0.96	1.68		
								15	Low

Area	Map number	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
61_218	6151	Human use				2.00	4.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				0.00	0.00		
		Oil residency index				2.04	3.05		
		Alcids nonbreeding	21	2	0.5	2.85	4.99		
		Seaducks	23	4	1	12.49	21.85		
								36	High
61_219	6151	Human use				3.00	6.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				2.40	4.80		
		Oil residency index				1.70	2.56		
		Alcids nonbreeding	21	5	0.5	5.96	10.44		
		Deep sea shrimp	7	1	1	0.80	1.39		
		Seaducks	23	5	1	13.06	22.86		
								50	Extreme
61_220	6151	Human use				1.00	2.00		
		Archaeological sites				1.00	2.00		
		Special status areas				0.00	0.00		
		Communities				2.45	4.90		
		Oil residency index				1.66	2.49		
								11	Low

12. Appendix B

Offshore sensitivity ranking

Area	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
Scenario/Season	**Autumn**							
OS 13	Marine oil residency index				3	4..5		
	Special status areas				0	0		
	Human use				1	2		
	Baleen whales	9	1	1	0.77	1.35		
	Tubenoses offshore	17	1	1	1.46	2.55		
							10	Low
OS 14	Marine oil residency index				3	4.5		
	Special status areas				0	0		
	Human use				1	2		
	Tubenoses offshore	17	1	1	1.46	2.55		
							9	Low
OS 15	Marine oil residency index				3	4.5		
	Special status areas				0	0		
	Human use				1	2		
	Tubenoses offshore	17	1	1	1.46	2.55		
							9	Low
OS 16	Marine oil residency index				5	7.5		
	Special status areas				0	0		
	Human use				5	10		
	Baleen whales	9	3	1	3.86	6.75		
	Deep sea shrimp	7	3	1	3.00	5.25		
	Tubenoses offshore	17	2	1	4.86	8.50		
							38	High

Area	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
OS 17	Marine oil residency index				5	7.5		
	Special status areas				0	0		
	Human use				5	10		
	Alcids nonbreeding	21	5	1	15.00	26.25		
	Baleen whales	9	4	1	5.14	9.00		
	Deep sea shrimp	7	5	1	5.00	8.75		
	Tubenoses offshore	17	2	1	4.86	8.50		
							70	Extreme
OS 18	Marine oil residency index				5	7.5		
	Special status areas				0	0		
	Human use				3	6		
	Alcids nonbreeding	21	3	1	9.00	15.75		
	Baleen whales	9	3	1	3.86	6.75		
	Deep sea shrimp	7	5	1	5.00	8.75		
	Tubenoses offshore	17	2	1	4.86	8.50		
							53	Extreme
Scenario	**Spring**							
OS 13	Marine oil residency index				5	7.5		
	Special status areas				0	0		
	Human use				1	2		
							10	Low

Area	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
OS 14	Marine oil residency index				3	4.5		
	Special status areas				0	0		
	Human use				1	2		
	Tubenoses offshore	17	2	1	2.91	5.10		
							12	Low
OS 15	Marine oil residency index				3	4.5		
	Special status areas				0	0		
	Human use				1	2		
	Tubenoses offshore	17	1	1	1.46	2.55		
							9	Low
OS 16	Marine oil residency index				5	7.5		
	Special status areas				0	0		
	Human use				5	10		
	Deep sea shrimp	7	3	1	3.00	5.25		
	Tubenoses offshore	17	2	1	4.86	8.50		
							31	Moderate
OS 17	Marine oil residency index				5	7.5		
	Special status areas				0	0		
	Human use				5	10		
	Alcids nonbreeding	21	5	1	15.00	26.25		
	Deep sea shrimp	7	5	1	5.00	8.75		
							53	Extreme

Area	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
OS 18	Marine oil residency index				5	7.5		
	Special status areas				0	0		
	Human use				3	6		
	Alcids nonbreeding	21	5	1	15.00	26.25		
	Baleen whales	9	1	1	1.29	2.25		
	Deep sea shrimp	7	5	1	5.00	8.75		
	Tubenoses offshore	17	1	1	2.43	4.25		
							55	Extreme
Scenario	**Summer**							
OS 13	Marine oil residency index				3	4.5		
	Special status areas				0	0		
	Human use				1	2		
	Baleen whales	9	1	1	0.77	1.35		
	Tubenoses offshore	17	2	1	2.91	5.10		
							13	Low
OS 14	Marine oil residency index				3	4.5		
	Special status areas				0	0		
	Human use				1	2		
	Tubenoses offshore	17	2	1	2.91	5.10		
							12	Low

Area	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
OS 15	Marine oil residency index				3	4.5		
	Special status areas				0	0		
	Human use				1	2		
	Tubenoses offshore	17	1	1	1.46	2.55		
							9	Low
OS 16	Marine oil residency index				5	7.5		
	Special status areas				0	0		
	Human use				5	10		
	Baleen whales	9	4	1	5.14	9.00		
	Deep sea shrimp	7	3	1	3.00	5.25		
	Tubenoses offshore	17	3	1	7.29	12.75		
							45	High
OS 17	Marine oil residency index				5	7.5		
	Special status areas				0	0		
	Human use				5	10		
	Baleen whales	9	4	1	5.14	9.00		
	Deep sea shrimp	7	5	1	5.00	8.75		
	Tubenoses offshore	17	2	1	4.86	8.50		
							44	High
OS 18	Marine oil residency index				5	7.5		
	Special status areas				0	0		
	Human use				3	6		
	Baleen whales	9	4	1	5.14	9.00		
	Deep sea shrimp	7	5	1	5.00	8.75		
	Tubenoses offshore	17	3	1	7.29	12.75		
							44	High

Area	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
Scenario	**Winter**							
OS 13	Marine oil residency index				5	7.5		
	Special status areas				0	0		
	Human use				1	2		
							10	Low
OS 14	Marine oil residency index				3	4.5		
	Special status areas				0	0		
	Human use				1	2		
	Tubenoses offshore	17	2	1	2.91	5.10		
							12	Low
OS 15	Marine oil residency index				3	4.5		
	Special status areas				0	0		
	Human use				1	2		
	Tubenoses offshore	17	1	1	1.46	2.55		
							9	Low
OS 16	Marine oil residency index				5	7.5		
	Special status areas				0	0		
	Human use				5	10		
	Deep sea shrimp	7	3	1	3.00	5.25		
	Tubenoses offshore	17	2	1	4.86	8.50		
							31	Moderate

Area	Element	Relative sensitivity	Relative abundance	Temporal modifier	Assigned value	Priority index	Sensitivity value	Final ranking
OS 17	Marine oil residency index				5	7.5		
	Special status areas				0	0		
	Human use				5	10		
	Alcids nonbreeding	21	5	1	15.00	26.25		
	Deep sea shrimp	7	5	1	5.00	8.75		
							53	Extreme
OS 18	Marine oil residency index				5	7.5		
	Special status areas				0	0		
	Human use				3	6		
	Alcids nonbreeding	21	5	1	15.00	26.25		
	Deep sea shrimp	7	5	1	5.00	8.75		
	Tubenoses offshore	17	1	1	2.43	4.25		
							53	Extreme

13 Appendix C, Climatic data for logistics

The following descriptions apply to entire West Greenland, between Cape Farewell at 60º N and Upernavik at 73º N.

13.1 **West Greenland meteorology**

13.1.1

Surrounded by steep coasts, Davis Strait/Baffin Bay forms a channel that provides ideal conditions for outbreaks of cold air southward, as well as for the injection of warm subtropical air deep into the Arctic Basin. Both patterns are driven by disturbances of the polar front zone. This exchange of air masses within the lower part of the troposphere largely determines the weather and climate of the area. Another essential feature is the all year round low sea surface temperatures causing the West Greenland waters to be part of the arctic zone with summer temperatures below 10° C.

The upper flow of the troposphere largely controls the movement of surface weather phenomena, such as migrating cyclones and anticyclones.

13.1.2 Sea level pressure

The sea level pressure (slp) pattern is strongly influenced by the distribution of cold and warm surfaces (Figure 13.1), although in an opposite direction. The slp pattern is essentially different from the upper level pattern, particularly during *winter*, when an area of high pressure occurs over the northernmost part of Greenland and northerly winds (a winter monsoon) prevail in the West Greenland waters. A low pressure area extending from Newfoundland via Iceland to the Norwegian Sea with a trough northward along the west coast of Greenland reflects the main zone of cyclonic activity. It appears that Greenland generally receives its weather from the southwest. About 60-70 percent of all cyclones approaching South Greenland arrives from between west and south-southeast.

In *summer*, the mean slp gradient around Greenland is slack, and no prevailing wind direction is discernible. Cyclonic activity may occur anywhere in the Greenland area. During the year, atmospheric pressure is highest (most settled weather) and normally occur around April. Atmospheric pressure is lowest in September/October over Canada and in December/January over Greenland.

13.1.3 Surface winds

Three main factors affect wind speeds:

1. The pressure gradient associated with cyclones and anticyclones

The intensity of pressure systems (particularly cyclones) is greatest in winter. Southern Greenland in particular is influenced by severe weather that is connected with the North Atlantic winter cyclones. The northern part of the Davis Strait has the lightest winds due to the moderating effect of high pressure systems. Although the main track of cyclones is south of Greenland in summer, cyclonic activity may occur anywhere in Greenland.

2. The static stability of the air near the surface
Stable layering or inversions impede vertical motions. In the coastal area orographic influences on the direction and speed of low level airflow are reinforced. On the open sea the surface wind speed is reduced under stable conditions. With the movement of cold and stable air over snow/pack ice to open water, there is a rapid destabilisation taking place due to warming from below. Vertical exchange (convection) results in an increase in the speed and gustiness of the surface wind.

3. Influence of topography (local winds)
Surface winds and pressure patterns are also substantially modified by the steep coasts surrounding the Davis Strait, particularly that of Greenland.

Down directed (katabatic) offshore winds may reach the sea level as outbursts of dry and (due to compression) relatively warm air (a *foehn wind*) accompanied by falling pressure, causing a *trough of low pressure* to develop. Foehn winds are rather frequent in southern Greenland, however, their frequency declines northward along the coast. In the fjords and in the inner part of Disko Bay (e.g. Ilulissat/Jakobshavn) the foehn winds may be very strong with gusts of hurricane force. Their occurrence is not known in detail. At sea (or the outer coast, e.g. Aasiaat/Egedesminde) the warm wind is usually insufficient to supersede the cold air near the sea surface, resulting in the formation of a pronounced low level inversion (and a wind minimum).

Onshore winds are diverted along the coast towards lower pressure and are reinforced. A *ridge of high pressure* develops. Maximum winds occur in the coastal areas, particularly around the protruding coastline (e.g. Cape Farewell, Nunarsuit). The *coastal jet* or *barrier wind* propagates more or less northwards along the coast (like a surge), causing a rapid and often dramatic change from ’foehn conditions’ (broken clouds and good visibility) to ’barrier wind conditions’ (strong wind, snow or rain with poor visibility and low clouds). The surge also propagates seawards, although in a weakened form.

With cold air aloft (in an unstable air mass) the orographic influence upon flow patterns are less evident. Most essential, katabatic winds from the ice cap are likely to be of the *bora* type. In defiance of the warming by compression a still cold and strong easterly wind, which, contrary to foehn winds, will spread far out over the sea. Strong winds of the bora type are infrequent in the West Greenland area. Their occurrence in the form of a cold northeasterly gale or storm is known from Disko Bay and the Nuuk/Godthåb area. At present, there is no model available to explain the extremely high winds that occur very locally in the fjords and over the archipelago, or the high winds that occur for short periods of time and extend (e.g. in heavy showers) out to the open sea.

In the northern part of West Greenland, north of lat. 65° N, the annual mean wind speed is 5-6 m/s, increasing south of lat. 65° N to 7-8 m/s and south of Cape Farewell to almost 10 m/s. It appears that maximum wind speeds occur in the northernmost part of West Greenland as early as October/November and in midwinter for other areas. The minimum wind speeds occur in midsummer all over the area.

Gale force winds
The geographical distribution of gale force winds (above 13.8 m/s) in winter and summer is shown in Figure 13.2. The percentage of gale force winds is relatively low in the northern part of the area, less than 5 % in winter and 1 % in summer increasing southward to a maximum of 30 % in winter and 4 % in summer in the southernmost part.

Most of the cyclones affecting West Greenland arrive from between south and west. Weather systems approaching from directions between northeast and southeast are essentially modified by the passage of the ice cap, however, they may regenerate over the Davis Strait.

In winter, southern Greenland in particular is influenced by severe weather connected with the North Atlantic cyclones. Figure 13.3 outlines typical tracks for major cyclones. Cyclones approaching southern Greenland from southwest or south usually split in the vicinity of Cape Farewell with one part moving northward along the west coast, while the other moves off toward Iceland. In summer, eastward moving cyclones often develop along the boundary line between the cold Canadian archipelago and the warm continent to the south of it, affecting the Davis Strait region. Therefore, West Greenland weather, although less severe, often appears more unsettled in summer than in winter.

Cyclones may develop locally on a small scale any time of the year. Often they will be the result of topographic influence, i.e. *lee lows*. Another type is the *polar low.* In this case the cyclone develops over open water with very cold air aloft. The diameter of a polar low is generally 200-300 km. Wind speeds exceed (as per definition) gale force, 15 m/s, and the system is accompanied by heavy snow showers. Occasionally, polar lows can be rather intense with a structure in their mature stage resembling that of a tropical cyclone. The lifetime of a polar low is limited, usually less than 24 hours, and it dies rapidly when making landfall.

13.1.4 Air temperature

The sea west of Greenland belongs to the Arctic region with mean air temperatures two meters above the sea surface of below 10° C all year round. The coldest month is February and the warmest month August (in the coastal area: July). The distribution of mean air temperatures for the two months is shown in Figure 13.4.

To the north (with sea ice occurring much of the year) the pattern is of the *continental* or *high arctic* type (cool summers and very cold winters) with temperatures ranging by as much as 30° C between the coldest and warmest month. To the south (over open water) the pattern is *oceanic* (cool summers and relatively mild winters) with a temperature range of less than 10° C.

In *summer*, temperatures close to the sea surface will deviate little from those of the seawater. Freezing temperatures may occur over sea ice and/or within fog. In *winter*, very low temperatures occur over snow covered areas due to radiation cooling of the surface. Over open water air temperatures are normally below those of the sea surface due to advection of cold air. In the coastal zone temperatures may reach 15° C or more in summer and, under foehn conditions, even in winter. Away from the coast the warm air mass is generally incapable of displacing the cool air nearest to the surface.

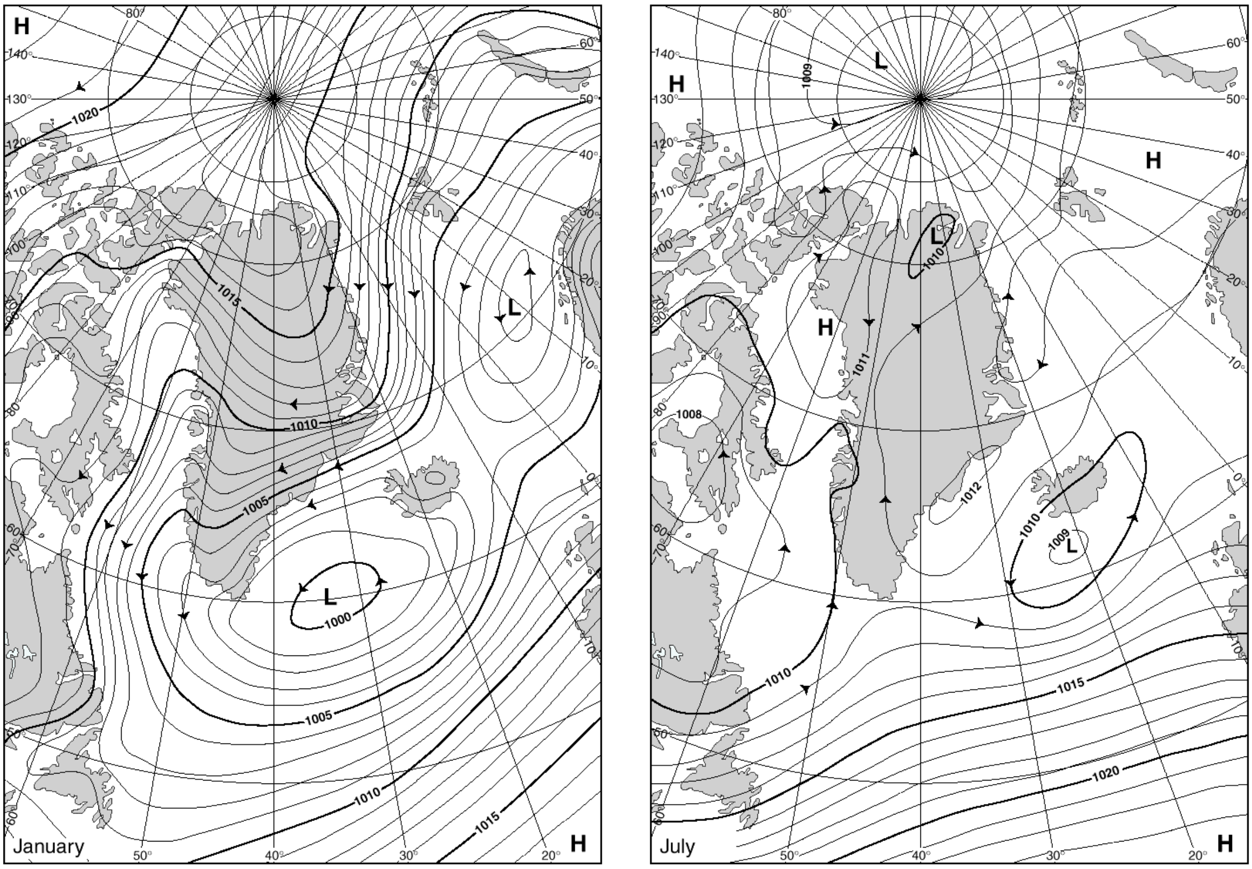


Figure 13.1. Mean atmospheric pressure (hPa) at sea level in winter (left) and summer (right).

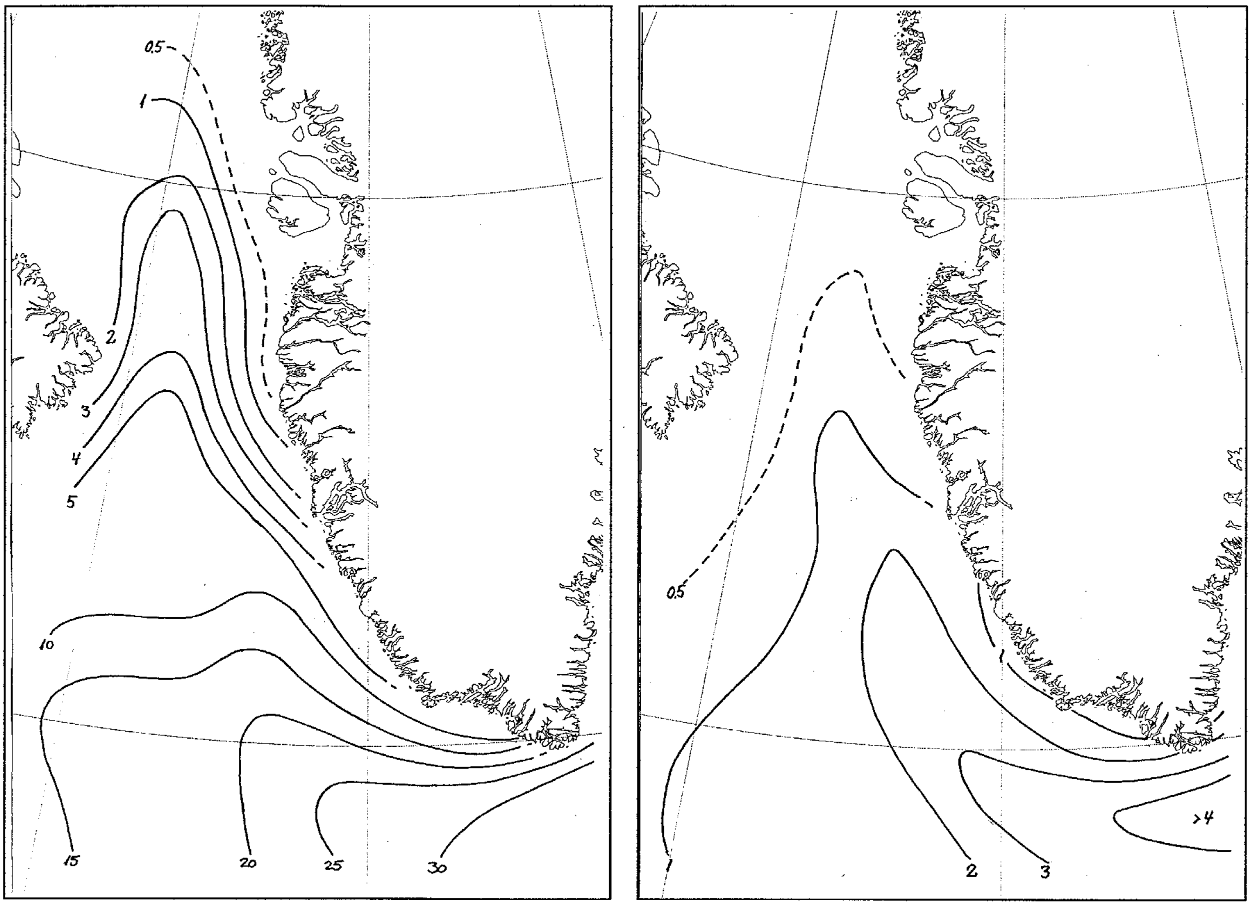


Figure 13.2. Geographical distribution in percentages of gale force winds (above 13.8 m/s).
Left: winter. Right: summer (ECMWF-data, 1980-93).

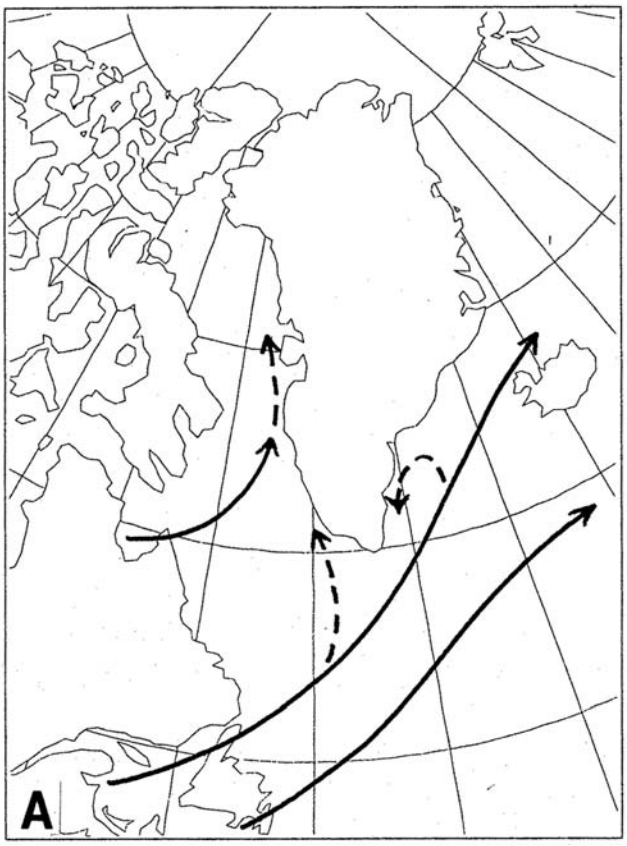


Figure 13.3. Typical tracks for major cyclones, (A) in winter and (B) in summer.

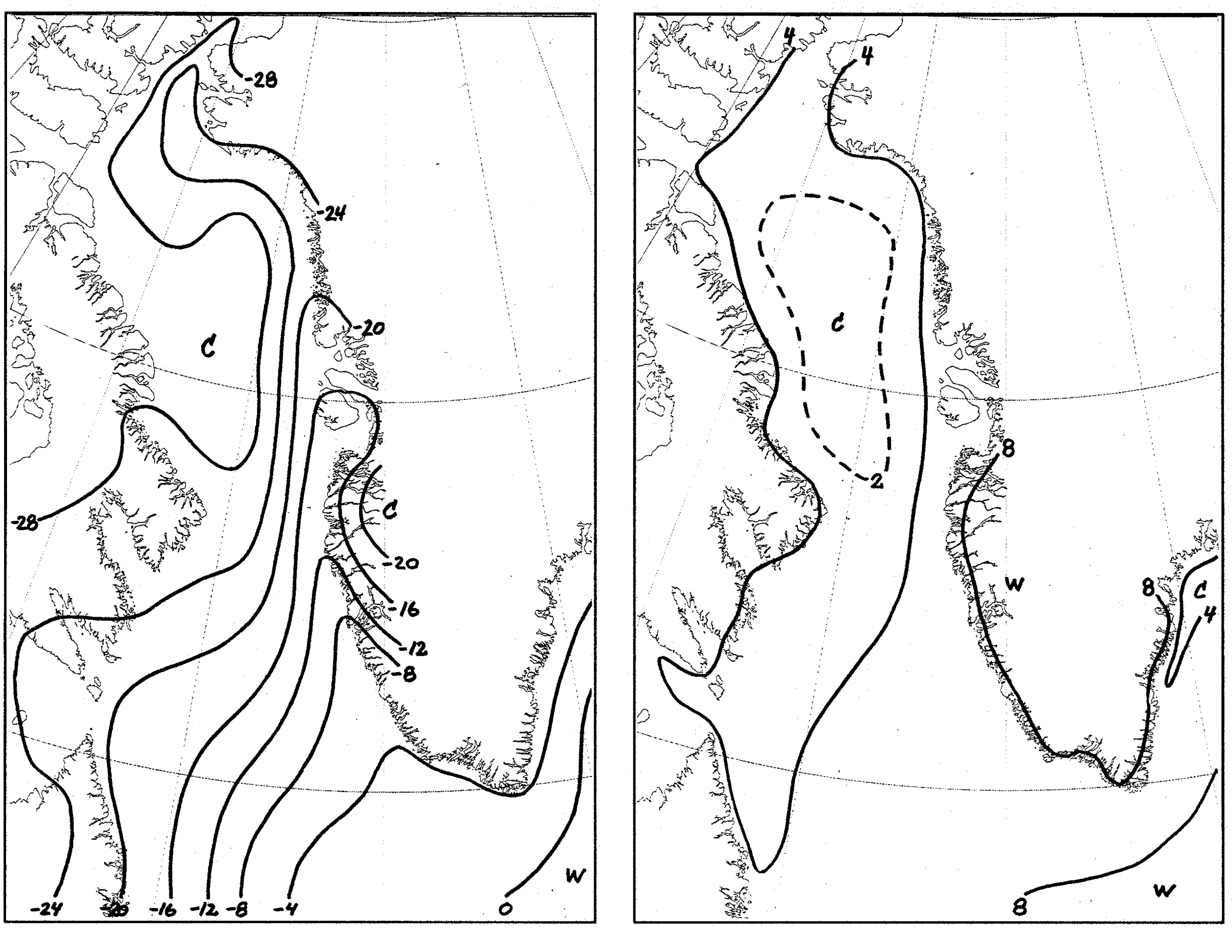


Figure 13.4. Mean temperatures for February (left) and August (right) (partly based on ECMWF-data).

13.1.5 Fog and precipitation

Visibility is reduced mainly by the occurrence of *fog*, although *precipitation*, *snow* in particular, is another important cause. Fog (visibility less than 1 km) is primarily a *summer* phenomenon. The frequency of fog increases during May and peaks in June/July, when the temperature contrast between the cool sea surface and the relatively warm atmosphere is at a maximum. It fades out in late August. The frequency of fog in July is 20-30 % of the total time over the coldest parts of the sea area (Figure 13.5).

Fog is less frequent over the coastland. It is often within sight when facing west from the inhabited places of West Greenland. Summerfog is of the advection type. It typically develops with moist air drifting slowly across a water surface with (not necessarily large) temperature variations, which occur almost everywhere in the West Greenland waters. The sun will often be visible through the fog. Once formed, fog may persist even with increasing wind, however, it will gradually become patchy. Advection of an air mass to a warmer surface causes the fog to evaporate or lift to low clouds.

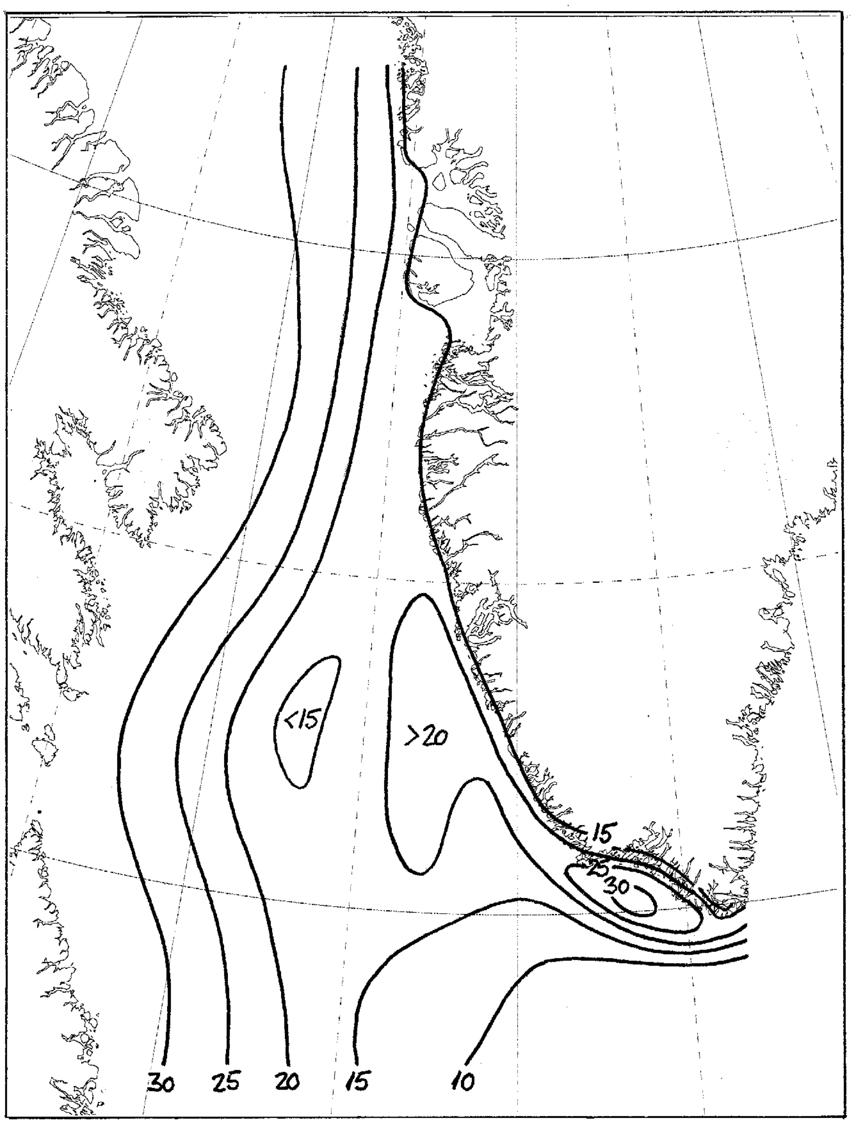


Figure 13.5. Geographical distribution of fog in July (percentage of time).

When there are clear skies above, temperatures within fog are often a few degrees below that of the sea surface due to radiation cooling. Freezing temperatures within fog over a cold water surface are not unusual, and icing with rime ice or clear ice may occur. In *winter*, advection fog may occasionally form within a warm and moist air mass advected from the south. Fog may even form with a warm foehn wind blowing aloft. Radiation fog may develop under clear calm conditions over snow covered and solid pack ice. However, the air will often be too dry for the fog formation, unless there is a source of moisture (an open lead in the ice) nearby, due to sublimation of rime on the cold surface. Steam fog (sea smoke) forms within cold air flowing from pack ice or from cold land out over open water. The occurrence of steam fog is often very localised, however, it may be more widespread in a very cold air mass.

Visibility may also be reduced more or less by precipitation (particularly snow) and drifting snow. In winter, snow showers are present much of the time over open water causing moderate or poor visibility. The amount of precipitation is known only from coastal stations. It is high in the south due to open water and frequent cyclonic activity. Precipitation is low in the north, where the moisture content of the air is low, particularly in winter and spring. The annual precipitation ranges from 200-300 mm in the Disko area to more than 1,000 mm in southernmost Greenland. In Nuuk/Godthåb it is about 600 mm.

With winds blowing onshore orographic intensification takes place in the outer coastal areas. On the other hand offshore winds tend to reduce precipitation. Winterly showers over open water are very frequent; often kept away from the coast by the land breeze they contribute to the amount of precipitation at sea. Most of the precipitation falls in late summer or in autumn, due to maximum occurrence of open water combined with high cyclonic activity. In winter, precipitation is usually in the form of snow.

13.2 West Greenland oceanography

13.2.1 Introduction

Along the West Greenland fishing banks two current components are dominating. Closest to the shore the East Greenland Current component is found bringing water of polar origin northward along the West Greenland coast. On it's way this water is diluted by run-off water from the various fjord systems. the East Greenland Current component looses its momentum on the way northward and at the latitude of Fyllas Banke it turns westward towards Canada where it joins the Labrador Current. West and below the Polar Water a current component is found originating from the Irminger Sea and the North Atlantic Current. This relatively warm and salty water can be traced all the way along West Greenland from Cape Farewell to Thule.

The oceanographic conditions in the West Greenland Waters are dominated by the following water masses:

- *Polar Water,* originating from the Arctic Ocean and carried to West Greenland by the East Greenland Current
- *Irminger Water, Irminger Mode Water and North Atlantic Mode Water,* all originating from the North Atlantic Current.

The inflow of Polar Water is strongest during spring and early summer (May-July), and since the East Greenland Current carry large amount of Polar Ice with it, the distribution of Polar Ice (Storis) along the coasts of West Greenland will attain its maximum during the same period. The inflow of water masses of Atlantic origin is strongest during autumn and winter explaining why the waters of Southwest Greenland normally are ice-free during wintertime.

A fifty year long time-series of temperature and salinity from West Greenland oceanographic observation points reveal strong inter-annual variability in the oceanographic conditions off West Greenland as well as some distinct climatic events of which three cold periods within the recent thirty years are the most dominant. The inter-annual variability is caused by changes in the atmospheric circulation or by variations in the strength of the ocean currents transporting water to the West Greenland area, and both seem to be related to the North Atlantic Oscillation Index (NAO-index) reflecting the difference in mean sea level air pressure between the Icelandic Low and the Azores High.

13.2.2 Circulation

The ocean currents around Greenland is an integral part of the circulation and water mass balance of the North Atlantic and the arctic regions, where the bottom topography is of vital importance to the circulation and the distribution of water masses (Figure 13.6).

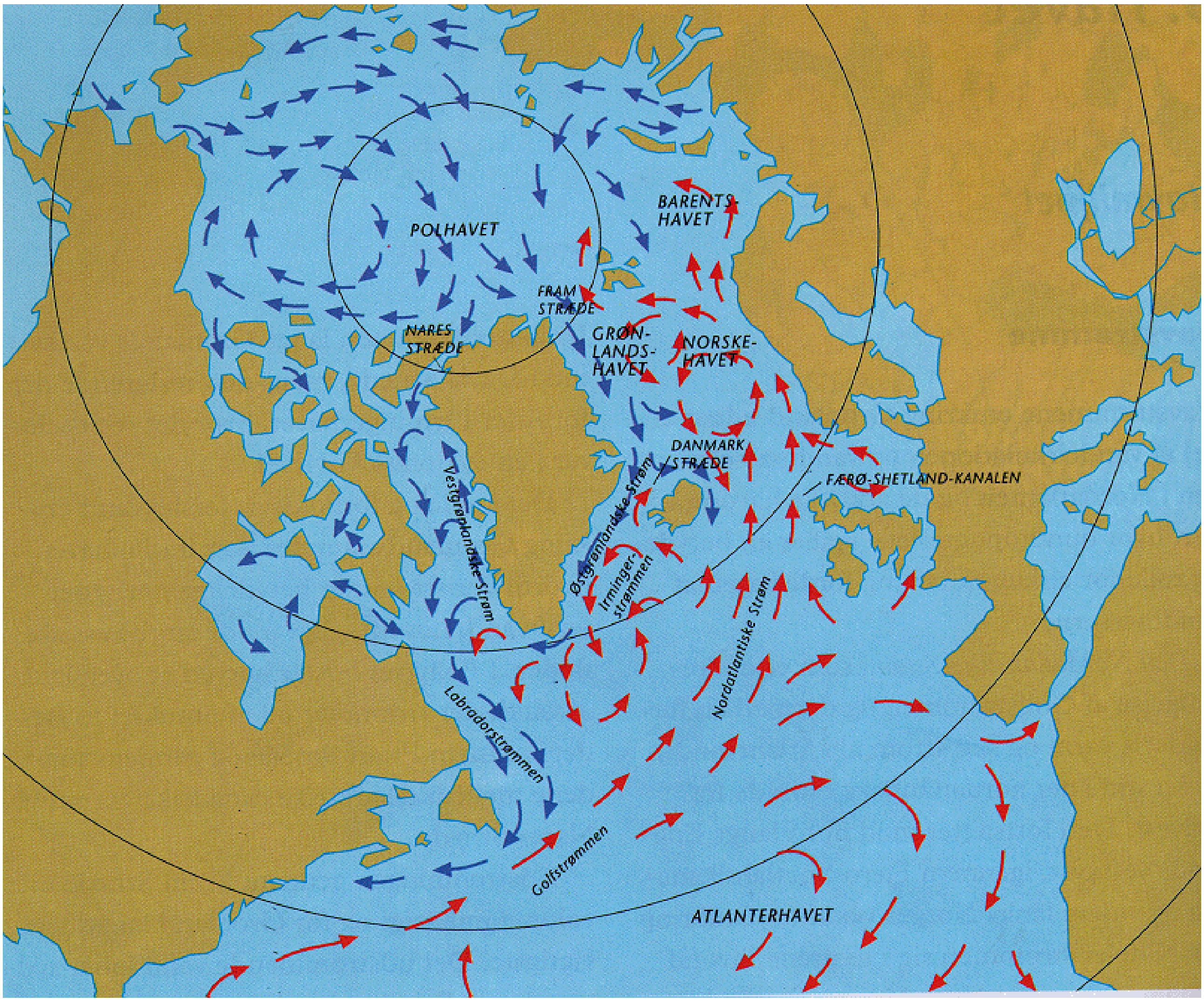


Figure 13.6. Surface currents in the northern North Atlantic. Blue arrows = cold water. Red arrows = warm water.

From southwest the North Atlantic Current, which is a continuation of the Gulf Stream, enters the area. It flows northward along the westcoast of Great Britain, through the Faeroe-Shetland Channel and continues along the continental slope off Norway. At around 70° N the current splits up into two components. One of them continuing along the west coast of Norway into the Barents Sea, the other following the continental slope northwards to the Spitsbergen region. Here it converges with the colder, less saline arctic surface water, sinks and continues as a subsurface current into the Arctic Ocean. Part of the North Atlantic Current branches off westwards into the East Greenland Current, where it underlies the Polar Water from 150 m to approximately 800 m.

Before entering the Faeroe-Shetland Channel, part of the North Atlantic Current turns westward as the Irminger Current, which occupies the ocean area south of Iceland. Part of this current follows the Icelandic coastline to the north through the Denmark Strait and continues along the north coast of Iceland, where it meets the cold, less saline East Icelandic Current. The other part of the Irminger Current turns towards Greenland south of the Denmark Strait, where it flows southward along the east coast of Greenland. Some of this water rounds Cape Farewell, while a second portion remains within the Irminger Sea, where it recirculates in a cyclonical gyre.

Turning our attention to the cold water, it originates from the Arctic Ocean, which throughout the year is supplied with fresh water primarily from the large Russian rivers. This surplus of water leaves the area mainly at two locations:

a. Through the Fram Strait i.e. the area between Greenland and Spitsbergen.

b. Through the Canadian Arctic Archipelago i.e. the area between Greenland and Canada.

The Fram Strait is by far the most important of the two outflow regions, making up about 75 % of the water outflow from the Arctic basin. The water is transported southward along the east coast of Greenland and constitutes the East Greenland Current. This current flows on top of the Greenlandic shelf from the Fram Strait to Cape Farewell and continues northward along the west coast of Greenland up to a latitude of about 65-66°N, where it turns westward and unites with the south flowing current off the Canadian east coast. This current, called the Baffin Current, also transports water from the Arctic Ocean, leaving the area through the second major outflow region, the Canadian Arctic archipelago. It follows the Canadian coast and continues into the Labrador Current, which meets the North Atlantic Current at around 40-45°N.

The water in the Cape Farewell area is relatively stagnant. In the southern part of the area water from the Labrador Current is swept east- to northeast by the North Atlantic Current. It flows side by side and gradually mix with the North Atlantic Current and later the Irminger Current in the Irminger Sea and returns to the area south of Cape Farewell. Therefore the current system in this area can be regarded as a great cyclonic gyre, in which the velocities are relatively small.

Along the West Greenland fishing banks two current components are dominating. Closest to the shore the East Greenland Current component is found bringing the water of polar origin northward along the West Greenland coast. On it's way the water is diluted by run-off water from the various fjord systems. The East Greenland Current component looses its momentum on the way northward, and at the latitude of Fyllas Bank it turns westward towards Canada where it joins the Labrador Current. West and below the Polar Water a current component is found originating from the Irminger Sea and the North Atlantic Current. This relatively warm and salty water can be traced all the way along West Greenland from Cape Farewell to Thule.

It has recently been shown (Pickart et al. 2001) that the East Greenland Current component undergoes a major change from one side of Greenland to the other. On the eastern side the current is tightly trapped to the shelf break, while it on the western side extends far offshore over the deep basin, Figure 13.7. This is a year-round phenomenon.

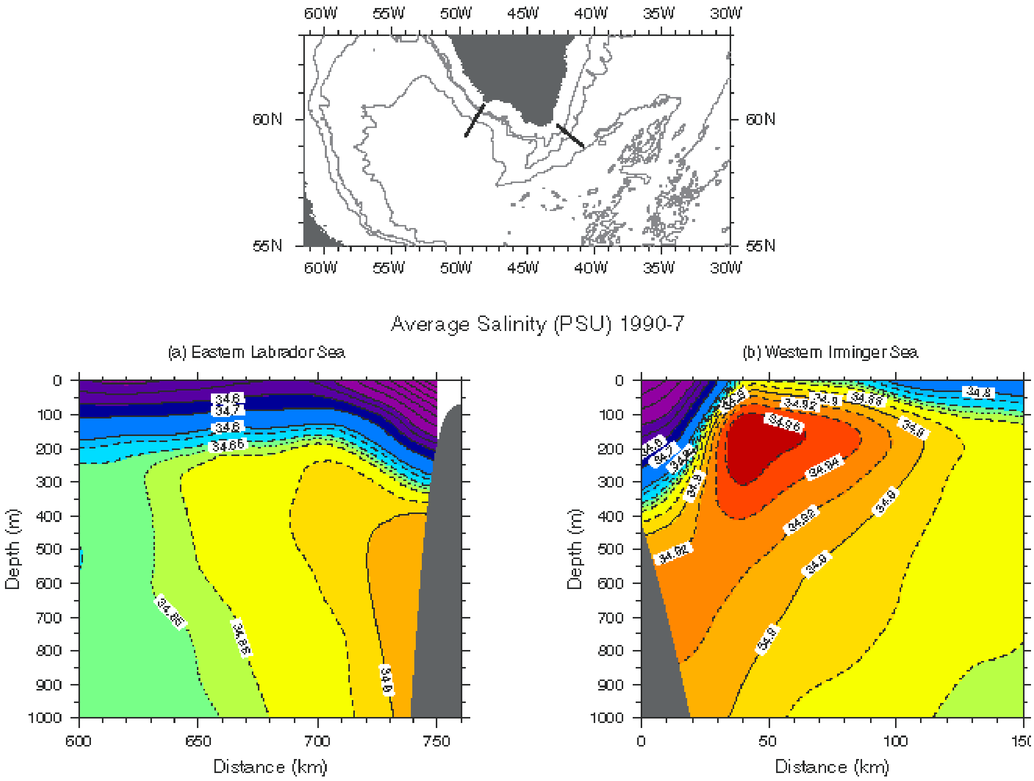


Figure 13.7. Mean upper-layer salinity for the period 1990-97. a) Eastern Labrador Sea. b) Western Irminger Sea (source: Pickart et al. 2001).

Several processes could explain this phenomenon:

- The East Greenland Current has trouble negotiating the "sharp corner" of Cape Farewell.
- Winds, which are predominantly northwesterly in this region. This implies onshore Ekman transport on the east side of Greenland and offshore on the west side.
- Fluctuations in the Irminger Current component.

The first two are not regarded as likely explanations, since annual oceanographic surveys show that polar water still is close to the coast just west of Cape Farewell (Buch & Nielsen 2001) and the wind influence has large annual variability.

The most likely candidate therefore is fluctuations in the Irminger Current. Recent analysis of Topex-Poseidon altimetry data (Prater 2000) as well as data from surface drifters and subsurface floats (Fratantoni et al. 1999, Lavander 2000, Cuny et al. 2001) has revealed interesting support for this theory, all showing the presence of a localised source of high eddy variability off West Greenland, Figure13.10.

The reason for the formation of eddies in this particular region is believed to be due to baroclinic instability of the Irminger Current as a result of the underlying bathymetry, with the continental slope being particularly steep in this area.

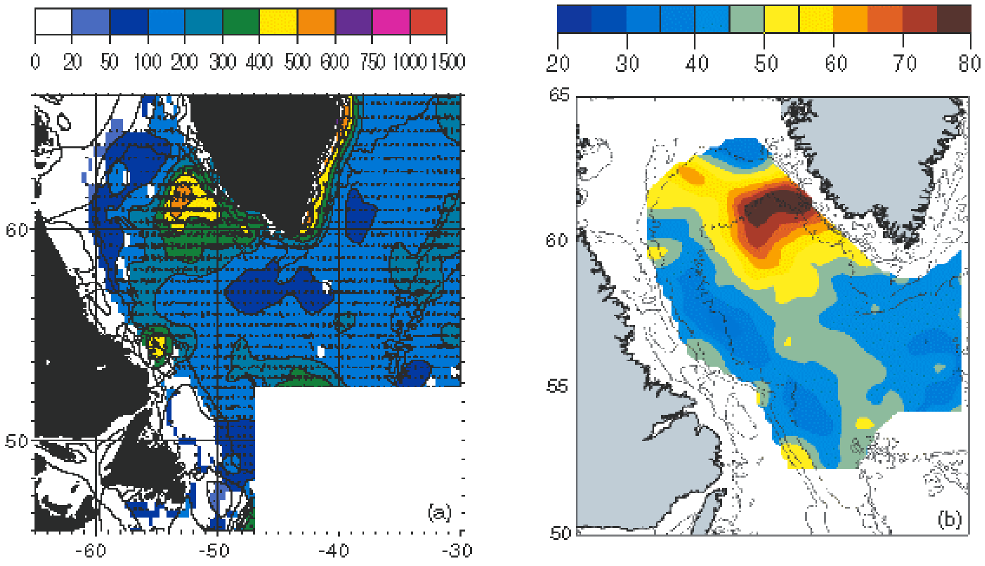


Figure 13.8. a) EKE from WOCE surface drifters (from Fratantoni et al. 1999). b) Sea-surface height variability from POPEX (from Prater 2000).

This picture of the surface circulation in the ocean off Greenland only reflects the average condition, and great seasonal and inter-annual variations do, however, occur. Recent research has demonstrated that the North Atlantic Oscillation (NAO) is the major source of inter-annual variability of weather and climate in the North Atlantic region and thereby also to variations in the ocean circulation and the oceanic environment (see Section 3).

13.2.3 North Atlantic Oscillation (NAO)

The NAO, which is associated with changes in the surface westerlies across the Atlantic onto Europe, refers to a meridional oscillation in the atmospheric mass with centres of action near the Iceland Low and the Azores High (van Loon & Rogers 1978). Although it is evident throughout the year, it is most pronounced during winter and accounts for more than one-third of the total variance of the Sea Level Pressure (SLP) field over the North Atlantic. Because the signature of the NAO is strongly regional, a simple index of NAO was defined by Hurrell (1995) as the difference between the normalised mean winter (December-March) SLP anomalies at Lisbon, Portugal and Stykkisholmur, Iceland. The SLP anomalies at each station were normalised by dividing each seasonal pressure by the long-term mean (1964-1995) standard deviation. The variability of the NAO index since 1864 is shown in Figure 13.9 (Hurrell & van Loon 1997), where the heavy solid line represents the low pass filtered meridional pressure gradient. Positive values of the index indicate stronger than average westerlies over the middle latitudes associated with low-pressure anomalies over the region of the Icelandic Low and anomalous high pressures across the subtropical Atlantic.

In addition to a large amount of inter-annual variability, there have been several periods when the NAO index persisted in one phase over many winters (van Loon & Rogers 1978, Barnett 1985, Hurrell & van Loon 1997).

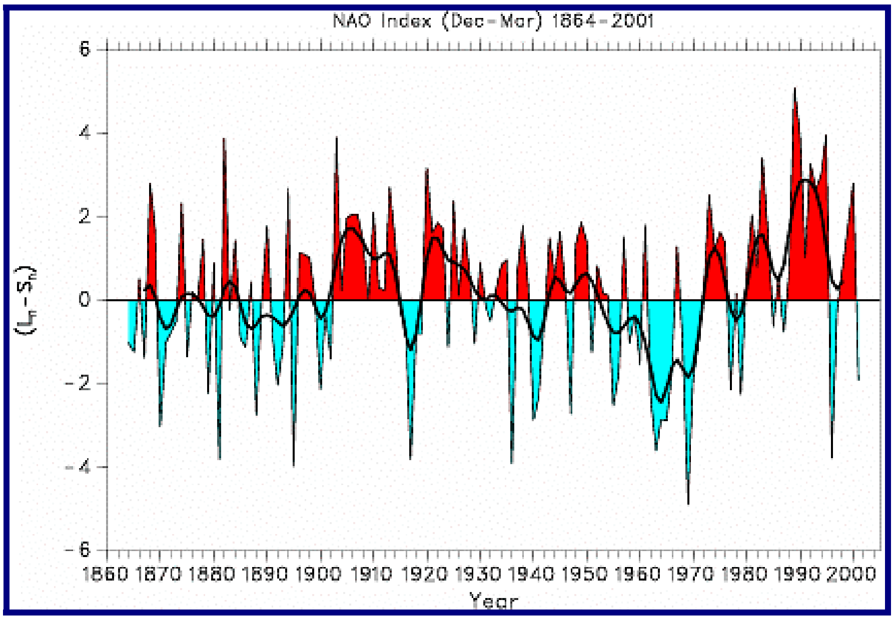


Figure 13.9. Time series of the winter (December-March) index of the NAO (as defined in the text) from 1864-1995. The heavy solid line represents the meridional pressure gradient smoothed with low pass filter to remove. Fluctuations with periods less than 4 years (update from Hurrell & van Loon 1997).

Over the region of the Icelandic Low seasonal pressures were anomalously low during winter from the turn of the century until about 1930 (with exception of the 1916-1919 winters), while pressures were higher than average at lower latitudes. Consequently, the wind onto Europe had a strong westerly component and the moderating influence of the ocean contributed to higher than normal temperatures over much of Europe (Parker & Folland 1988). From the early 1940's until the early 1970's the NAO index exhibited a downward trend and this period was marked by European wintertime temperatures that were frequently lower than normal (van Loon & Williams 1976, Moses et al. 1987). A sharp reversal has occurred over the past 30 years and, since 1980, the NAO has remained in a highly positive phase with SLP anomalies of more than 3 mb in magnitude over both the subpolar and the subtropical Atlantic. The 1983 and 1989-1995 winters were marked by some the highest positive values of the NAO index recorded since 1864 (Figure 13.11).

A detailed analysis by Hurrell (2000) shows that the NAO exerts a dominant influence on wintertime temperatures across much of the Northern Hemisphere. Surface air temperature and sea surface temperature (SST) across wide regions of the North Atlantic Ocean, North America, the Arctic, Eurasia and the Mediterranean are significantly correlated with NAO variability. Such changes in surface temperature (and related changes in rainfall and storminess) can have significant impacts on a wide range of human activities as well as on marine and terrestrial ecosystems.

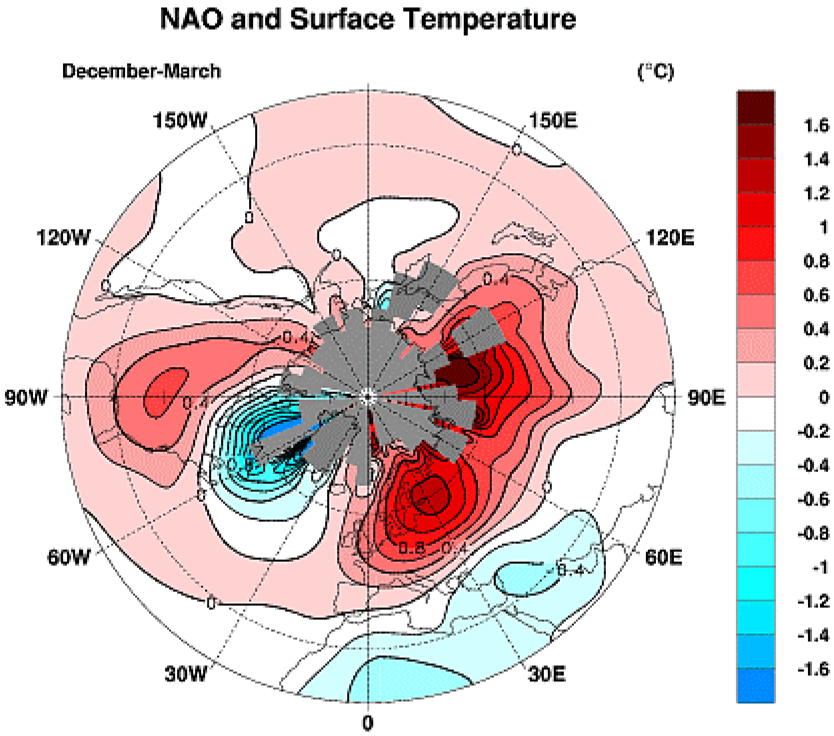


Figure 13.10. Changes in land surface and sea surface temperature (° C) corresponding to a unit deviation of the NAO index for the winter months (December-March) from 1935-1999. The contour increment is 0.2° C. Regions of insufficient data are not contoured (after Hurrell 2000).

When the NAO index is positive, enhanced westerly flow across the North Atlantic during winter moves relatively warm (and moist) maritime air over much of Europe and far downstream across Asia, while stronger northerlies over Greenland and northeastern Canada carry cold air southward and decrease land temperatures and SST over the northwest Atlantic (Figure 13.10).

This can be illustrated further by comparing the temperature over Greenland from a low NAO period (1960-69) to a high NAO period (1990-99), Figure13.13. It is noticed that especially offshore West Greenland was significantly warmer in the 1960's than in the 1990's.

Changes in the wind pattern in the Greenland area are minor as illustrated in Figure 13.12. A more detailed analysis using wind observations (6 hour intervals) from a number of observation sites in Greenland confirms this statement.

The influence of the changing NAO-index on the atmosphere naturally is reflected to the ocean and the ocean circulation. In Figure 13.13 the general ocean circulation of the North Atlantic is show under NAO^+ and NAO^- - conditions.

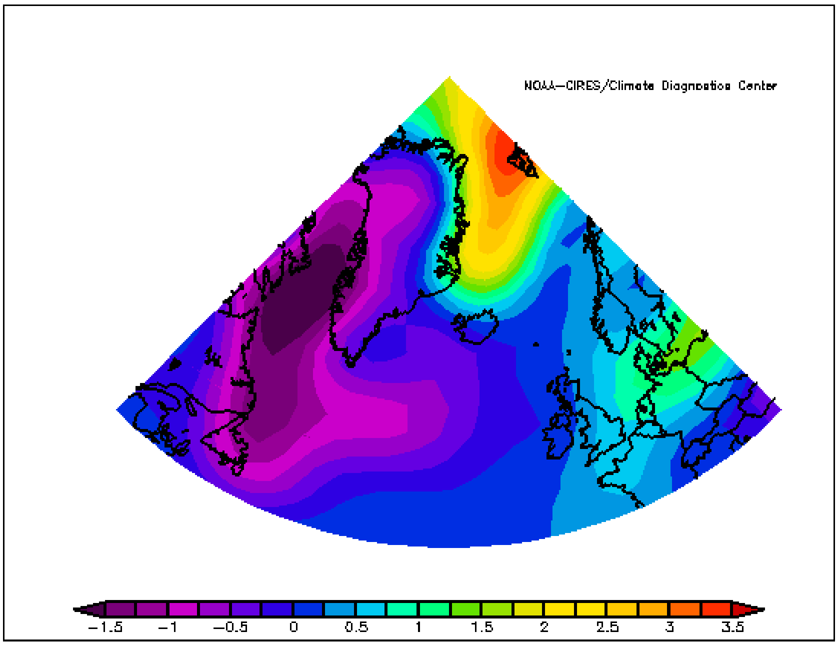


Figure 13.11. Difference in air temperatures at the 1,000 mb level between 1960-69 and 1990-99 . Calculated using the NCEP/NCAR reanalysis database.

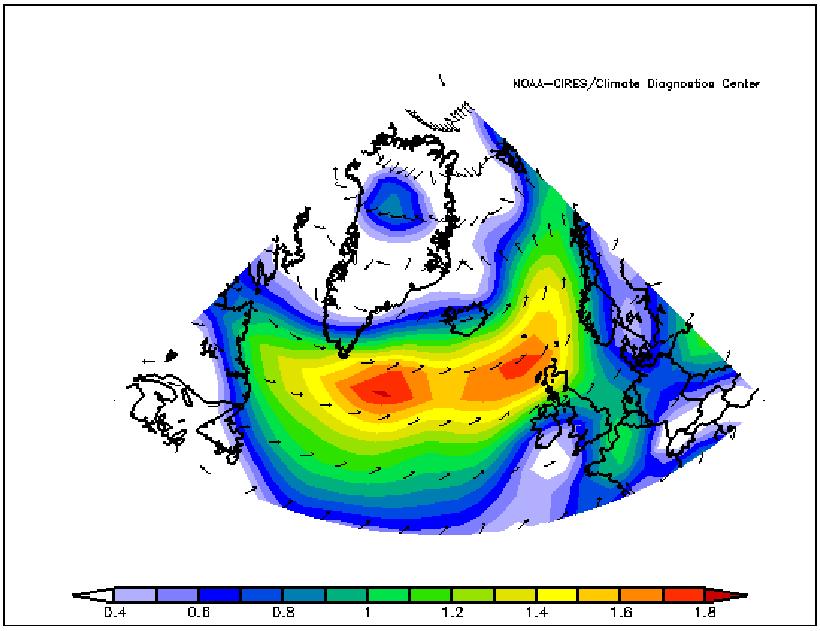


Figure 13.12. Changes in the 1,000 mb winds between the 1960-69 and 1990-99. Calculated using the NCEP/NCAR reanalysis database.

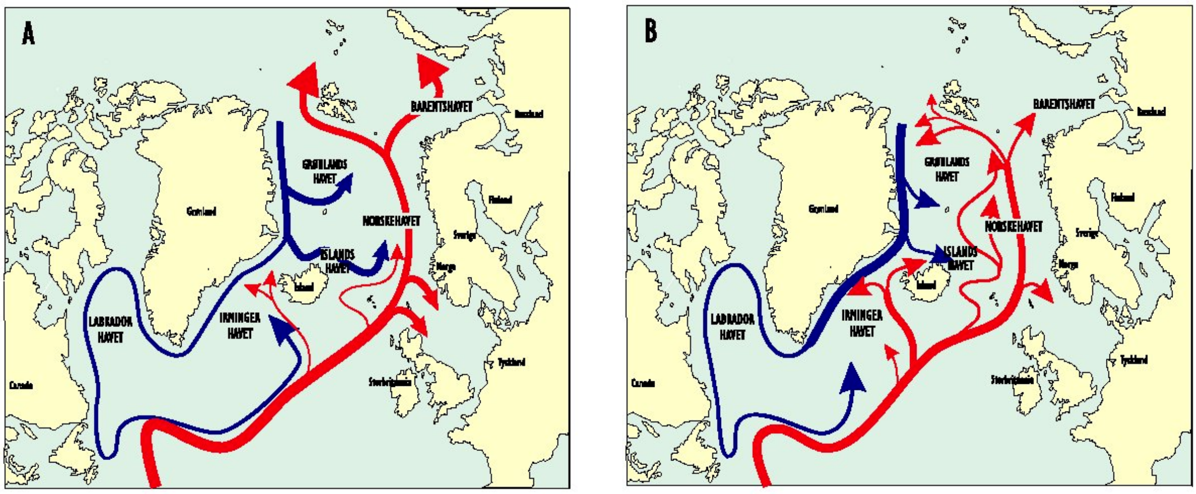


Figure 13.13. Ocean circulation under high (A) and low (B) NAO-index conditions (after Blindheim et al. 2001).

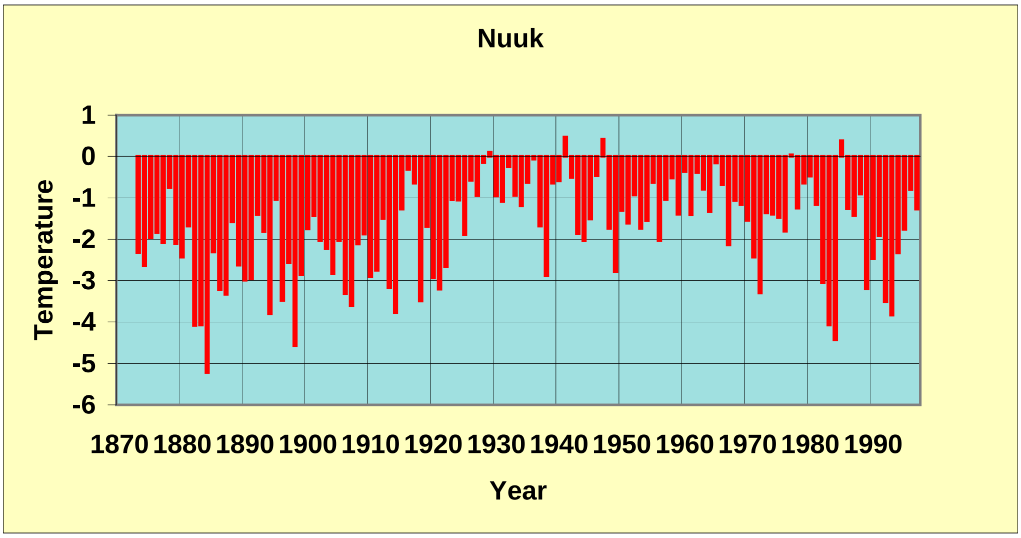
Positive values of NAO result in an intensification of the North Atlantic Current, which is deflected towards the east having the result that the Irminger Current has low intensity, while the inflow to the North Sea and the Arctic Ocean are strong. This results in warm conditions in Europe and the Arctic region. The East Greenland Current has high intensity north of the Denmark Strait but low intensity south of the strait, because water is flowing into the Greenland Sea and the Iceland Sea via the Jan Mayen- and the East Icelandic Currents.

During negative NAO conditions the intensity of the North Atlantic Ocean circulation is almost quite opposite. The intensity of the North Atlantic Current is weaker resulting in several side branches, strong Irminger Current, reduced inflow to the North Sea and the Arctic Ocean. The East Greenland Current has a high intensity all the way to Cape Farewell with weak inflows to the Greenland- and Iceland Seas.

The above given description of the NAO index clearly illustrates the strong correlation between the strength of the westerlies across the North Atlantic - the NAO index - and the climate in Greenland and Europe. It also shows that the climate in Greenland and Europe are negatively correlated to each other, a phenomenon named Seesaw in the literature.

Conditions over Greenland

Time series of annual mean air temperatures from Nuuk in West Greenland and Tasiilaq in East Greenland is shown in Figure 13.14. In addition to the inter-annual variability all stations reflects the general picture of variability outlined above in the description of the NAO index (Figure 13.11, 13.12), i.e. high NAO conditions normally reflect in cold condition in Greenland. The late 1990'es are however an exception from this pattern, since both NAO and Nuuk air temperatures show relatively high values. This was due to a slight displacement of the NAO pattern towards the East or Northeast (ICES 2000).



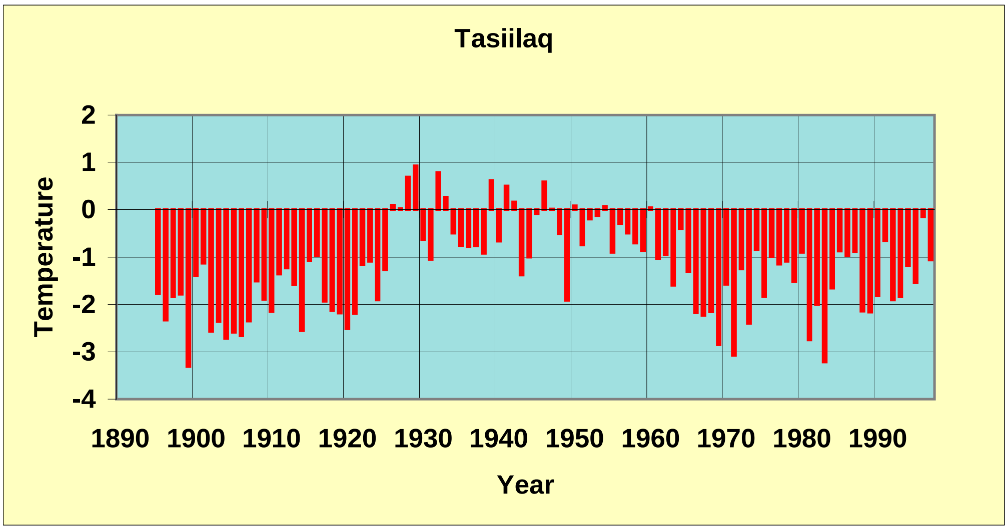
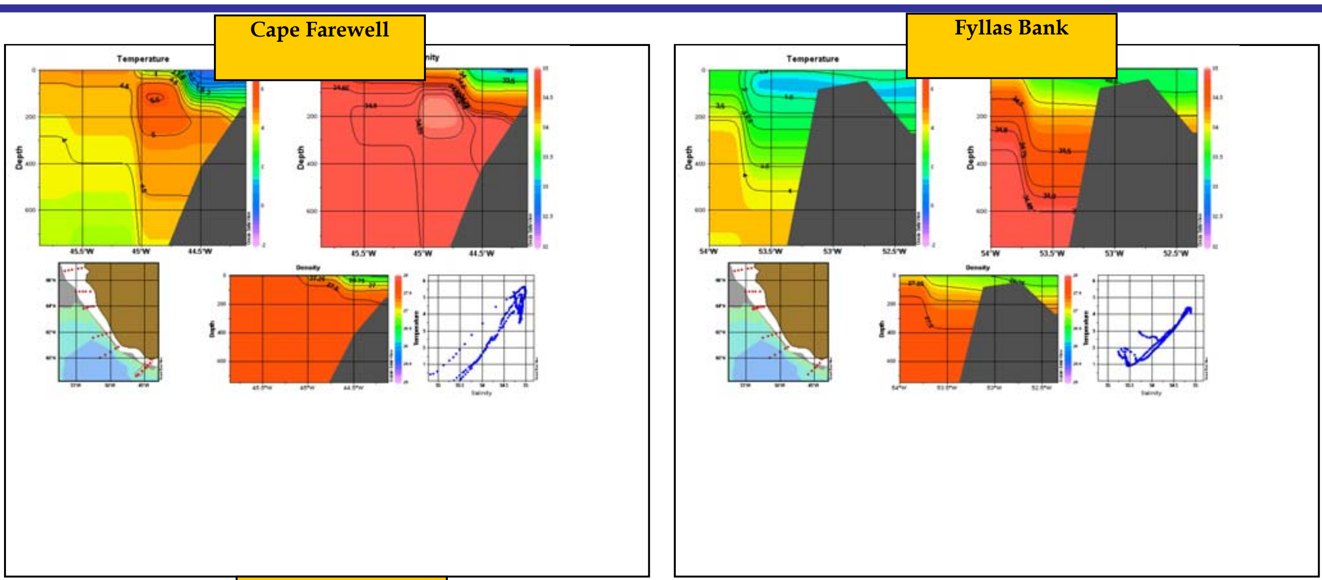


Figure 13.14. Annual mean air temperatures from Nuuk and Tasiilaq.

Some geographical differences can be recognised of which one of the most significant is the relatively long cold period experienced in Tasiilaq, East Greenland in the late 1960'es and early 1970's. These cold conditions can also be traced at the southernmost West Greenland stations around 1970. The cause for the cold conditions at East- and West Greenland around 1970 has been thoroughly discussed in the literature as the well known "Mid-seventies anomaly" or the "Great salinity anomaly", which was traced all over the North Atlantic area during the 1970'es and early 1980'es. It was a result of a period of extremely high frequency of northerly winds over the Arctic Ocean and northern North Atlantic in the 1960'es (Dickson et al. 1988). The northerly winds caused a greater than normal outflow of cold and relatively fresh Polar Water from the Arctic Ocean. This water together with large amounts of polar ice was carried along the east coast of Greenland to the West Greenland area by the East Greenland Current. It is therefore logical that the most extreme air temperature conditions was experienced at Tasiilaq

Focusing on the 1981-1995 period attention must be paid to two remarkably cold periods: 1982-1984 and 1989-1994. These two cold periods coincide well in time with the occurrence of the highest positive values of NAO index (1983, 1989 and 1990) as shown in Figure 13.11.

The 1982–1984 period has been discussed by Rosenørn et al. (1985) who showed that the cold conditions was due to the inflow of an extremely cold air mass from arctic Canada to the Davis Strait region with the centre in the vicinity of Aasiaat. Judging from the annual mean temperatures given in Figure 13.14, it is seen that the 1982-1984 period is one of the coldest ever recorded at Greenland although not the coldest. Rosenørn et al. (1985) showed that negative temperature anomalies were observed every month from February 1982 to November 1984, but especially the winter months were extremely cold. The mean temperatures for the winter months December, January and February was in 1984 the coldest ever recorded (-15.2° C in Nuuk) and that we shall 99 years back in time to find similar conditions (-15.1° C in 1885).



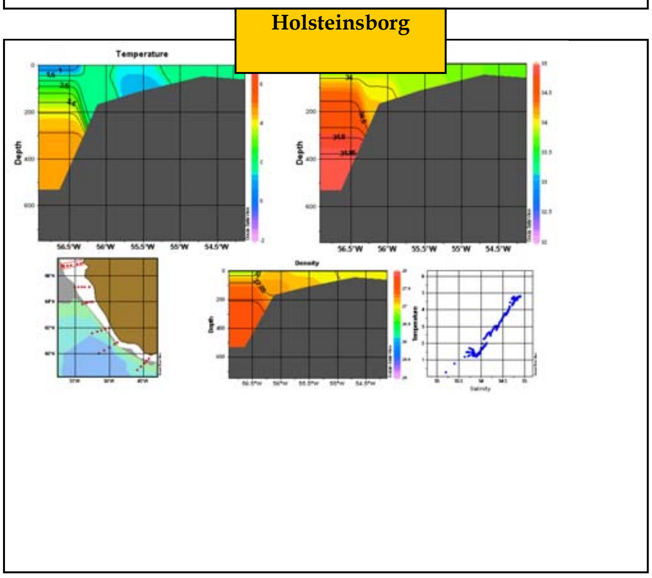


Figure 13.15. Vertical distribution of temperature, salinity and density medio June 2001 at three NAFO standard sections – Cape Farewell, Fyllas Bank and Holsteinsborg – along the west coast of Greenland.

13.2.4 Water masses

The waters off West Greenland are dominated by four water masses all formed outside the Davis Strait (Buch 1990/2000):

- In the surface layer close to the coast cold and low saline Polar Water is found. It is carried to West Greenland by the East Greenland Current.
- Below and west of the Polar Water we find water originating from the North Atlantic Current
- North East Atlantic Deep Water and Northwest Atlantic Bottom Water are found at great depths.

The two deep water masses are not discussed in the present context since they are found at great depths.

In Figure 13.15 the vertical distribution of temperature, salinity and density is shown on three NAFO standard sections off West Greenland. At the southernmost section at Cape Farewell the front between the Polar Water and the Atlantic Water is clear and sharp. Further north the front is much more diffuse - as discussed in section 2 - and the core of the Polar Water is here located at a depth of around 100 m.

The T/S-characteristics of Polar Water as it is found in the East Greenland Current are temperatures generally below 0° C but they may rise to 3-5° C in the surface layer during the summer. Salinity is below 34.4. Buch (1990/2000) however showed that the T/S-characteristics of Polar Water are altered on its way to West Greenland due to mixing with surrounding water masses. Along the West Greenland fishing banks Polar Water therefore is characterised by temperatures below 1° C, which may rise to 3-5° C during summer, salinities are below 33.75-34.0. This classification is quite similar to the one given by Kiilerich (1943).

The Atlantic water component has until recently been referred to as Irminger Water, but a more detailed analysis questions this statement. Lee (1968) and Clarke (1984) have defined Irminger Water as a mixture of Irminger Sea Water, formed in the Irminger Sea during winter, and North Atlantic Water and they characterised Irminger Water to have temperatures between 4 and 6° C and salinities between 34.95 and 35.1.

In order to study the water masses of Atlantic origin in more detail, all available observational data from West Greenland as published in World Ocean Atlas 1994 are used for a T/S-plot analysis. Due to the seasonal variability of the inflow of Atlantic Water T/S-diagrams have been prepared using the Ocean Data View Software for each of the four seasons (Figure 13.16. a-d, $S < 34.0$ has been disregarded).

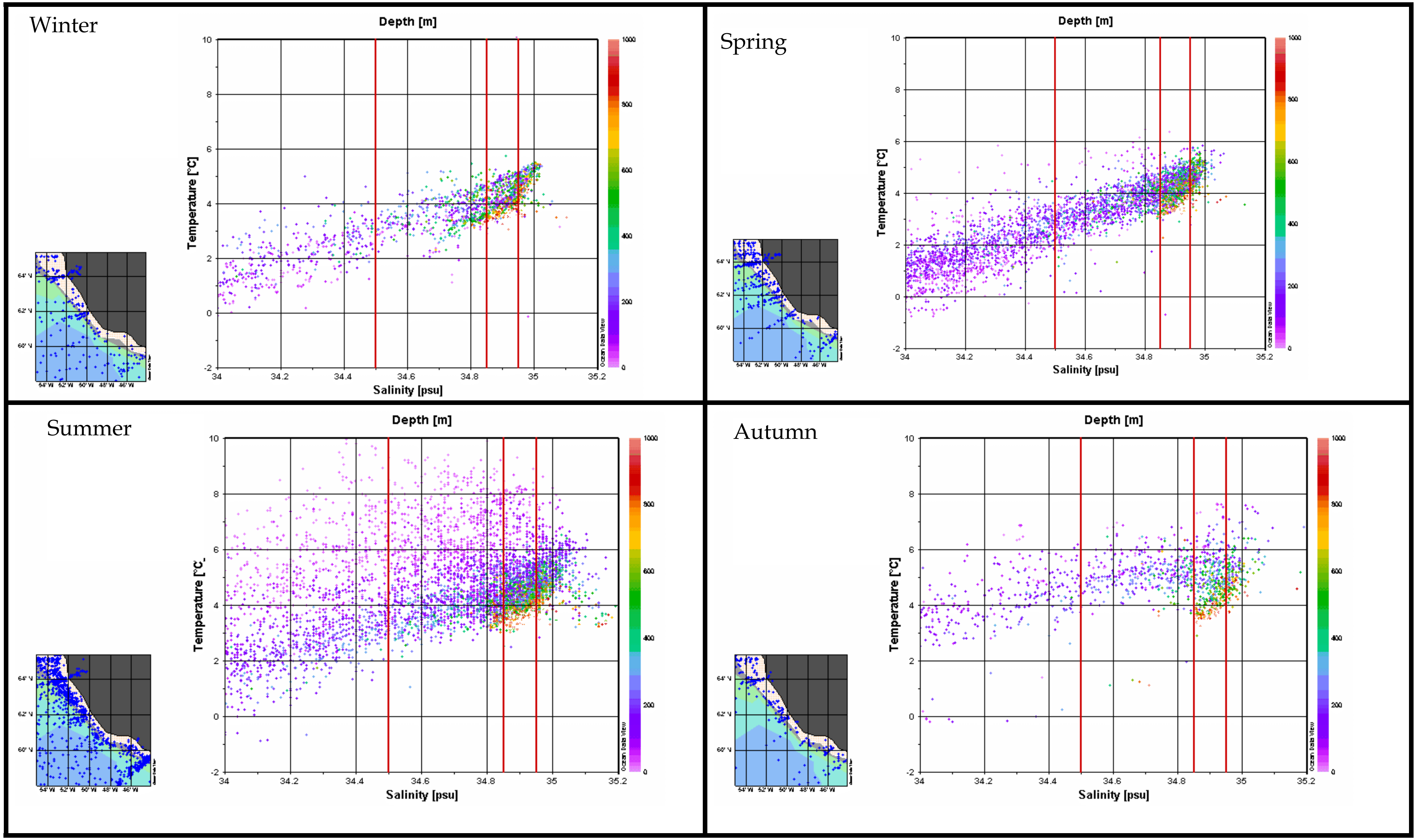


Figure 13.16. Seasonal T-S-plots from the West Greenland area using all available data in the World Ocean Atlas 1994. The colour indicates the observation depth.

These T/S-diagrams clearly indicate the presence of Irminger Water (T~4.5° C, S > 34.95) during all seasons. A more detailed analysis producing T/S-plot for each decade shows great decadal variability in the inflow of Irminger Water to the West Greenland area. It can for instance be seen in Figure 13.17 that the inflows during the 1960'es were much higher than during the 1980'es.

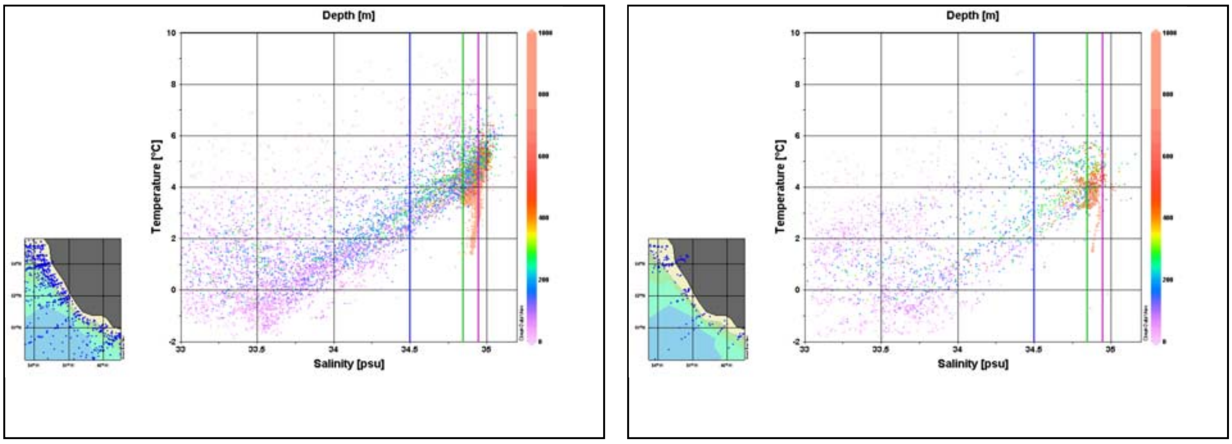


Figure 13.17. TS-plots from the West Greenland area using all available data in the World Ocean Atlas 1994 for the 1960'es (left) and the 1980'es (right).

Figure 13.16 additionally shows that throughout the year there is a body of water in the West Greenland area with salinities above 34.85 and temperatures around 4° C. This body of water most likely have been formed by the Irminger Water mixing with the surrounding water as it flows towards West Greenland resulting in a decrease in temperature and salinity. Water off West Greenland with temperatures above 4° C and salinities between 34.85 and 34.95 is therefore named ***Irminger Mode Water***. This water mass can always be observed off West Greenland, while pure Irminger Water (T around 4.5° C; S > 34.95) only occasionally is observed in the area and then primarily in the southernmost part.

The T/S-plots in Figure 13.16 and the example of a vertical temperature and salinity distribution plot in Figure 13.15 show that there exists a huge volume of water with temperatures above 2.5° C and salinities in the interval 34.50-34.85. Additionally it is seen in Figure 13.16 that the temperature increases during autumn. Water with salinities above 34.5 is found at depths excluding the possibility of a temperature rise due to atmospheric heating (see Figure 13.16 where the colour coding indicates the observation depth). The high temperatures, especially during autumn, support the assumption that water with salinities in the interval 34.5-34.85 are originating from the North Atlantic Current.

Along the Cape Farewell sections of the NORWESTLANT surveys (Lee 1968) a rather thick layer (200 to 250 metres) with salinities between 34.6-34.85 was observed at a distance of around 100 nm south of Cape Farewell. The temperatures were around 2.5° C during the first two NORWESTLANT surveys and increased to above 4.5° C during the third survey. Clarke (1984) reported observations from a section between Cape Farewell and Flemish Cap taken in early 1978. North of the North Atlantic Current to about 100 nm south of Cape Farewell a 200-300 thick layer with temperatures above 2.5° C and salinities below 34.85 was observed, Figure 13.18.

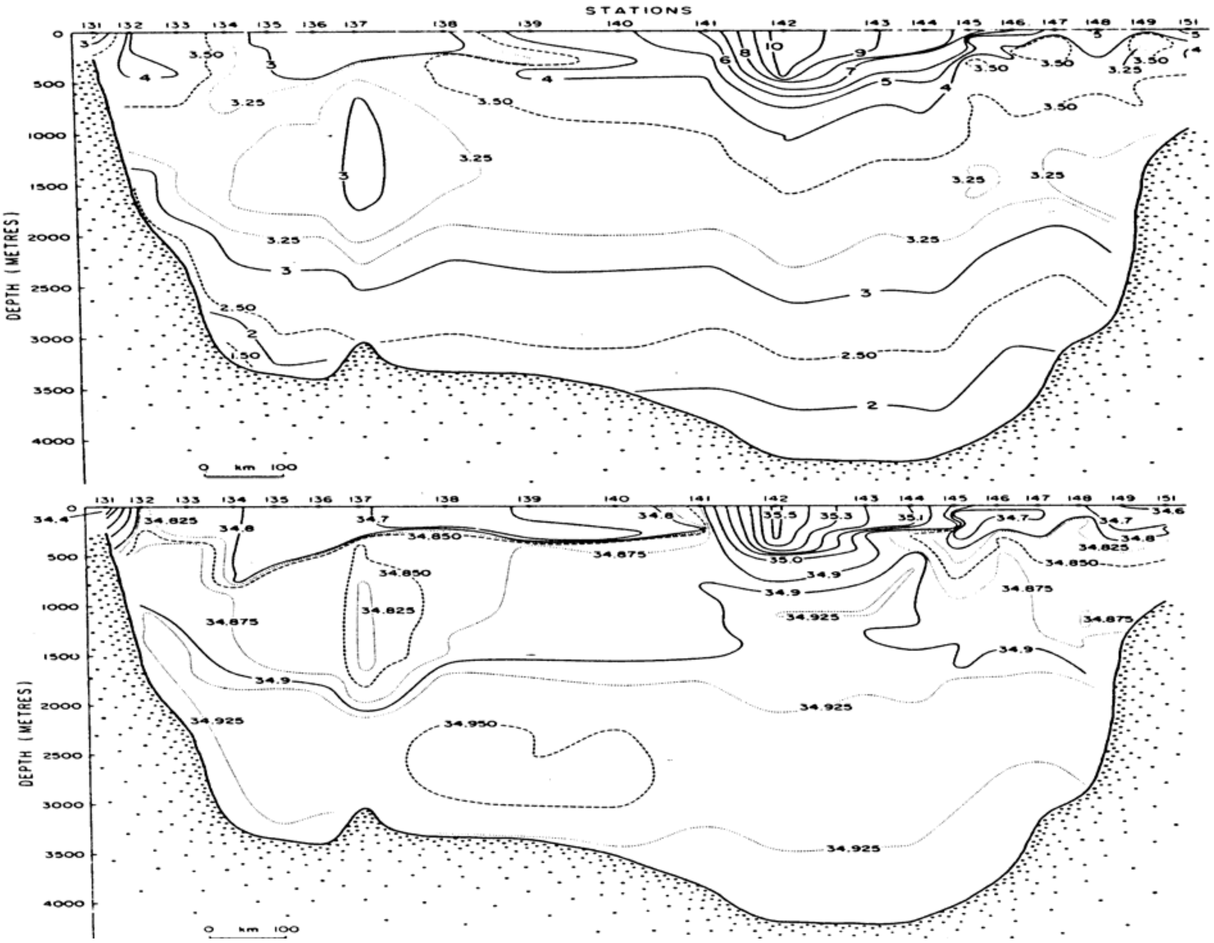


Figure 13.18. Potential temperature and salinity fields along the Cape Farewell to Flemish Cap Section, 1978. After Clarke (1984).

There is therefore reason to believe that the water mass observed off West Greenland characterised by salinities between 34.5 and 34.85 and temperatures above 2° C –(late in the year often above 5° C) has its origin in the northern part of the North Atlantic Current. The relatively low salinities most likely are due to influence from the Labrador Current. This water mass was named "***Northwest Atlantic Mode Water*",** by Buch (2000). A possible path towards West Greenland can be seen in Figure 13.6, where water from the northern rim of the North Atlantic Current turns north at around 40° W flowing towards the area off Southeast Greenland. Here it turns southward flowing towards the Cape Farewell area, where it turns northward again. In the Davis Strait at around 63-65° N the water flows towards west until it reaches the Labrador Current.

The analysis of T/S-data from West Greenland therefore indicates the presence of three water masses of Atlantic origin:

- ***Irminger Water*** - temperature around 4.5° C and salinity above 34.95 psu,
- ***Irminger Mode Water*** - Irminger Water mixed with surrounding water masses on it way to West Greenland - temperature around 4° C and salinities between 34.85 and 34.95 psu,
- ***Northwest Atlantic Mode Water*** - Temperature above 2.5° C and salinities between 34.5 and 34.85 psu. In late autumn the temperatures rise to above 5° C.

13.2.5 Fronts

Along the westcoast of Greenland a front between the low saline Polar Water (mixed with fresh water from land runoff) and the saline water of Atlantic origin is found in the surface layer just west of the West Greenland fishing banks.

In Figure 13.19 it is seen that the front is very sharp at the southernmost sections and becoming increasingly diffuse further north. At the Sisimiut/Holsteinsborg section the front seen further south has almost vanished, while another front at the westernmost part of the section has revealed itself reflecting the presence of newly melted Westice (drift ice from Baffin Bay and Davis Strait).

A more detailed study of temperature and salinity observations throughout the year shows that the front between the two water masses is weak from January to May and relatively strong the remaining part of the year with maximum strength in September and October, see Figure 13.20.

The weak stratification during the winter months is a combined effect of the upper layer being homogenised by vertical overturning due to atmospheric cooling and the fact that the inflow of Polar Water is relative low in this part of the year.

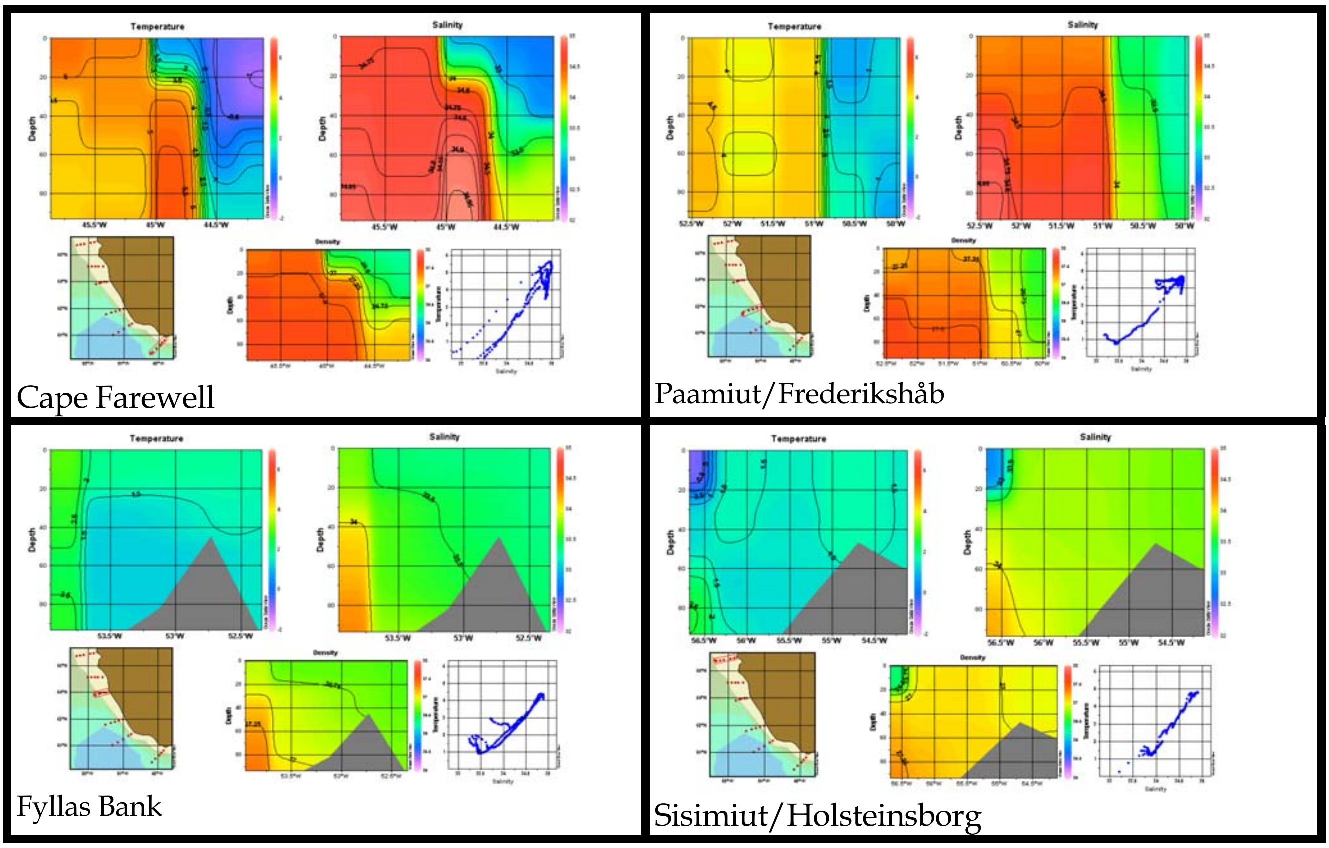


Figure 13.19. Vertical distribution of temperature, salinity and density in June 2001 in the upper100 m at the NAFO standard sections Cape Farewell, Paamiut/Frederikshåb, Fyllas Bank and Sisimiut/Holsteinsborg.

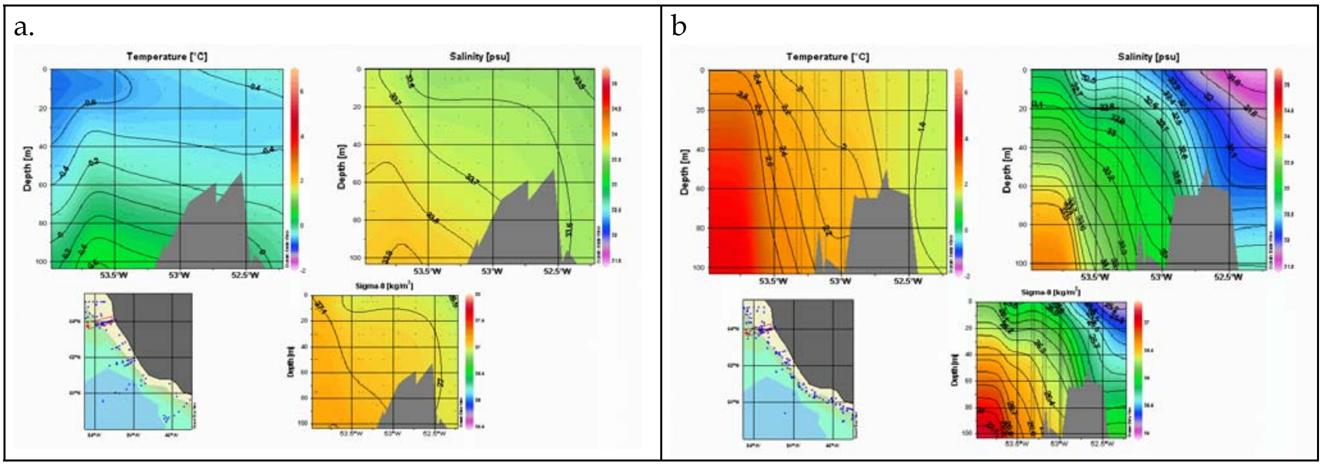


Figure 13.20. Vertical distribution of temperature, salinity and density in the upper 100 m at Fyllas Bank in a) March and b) October. Mean Values for the period 1950-1999.

It shall also be noticed that strength of the front is primarily governed by the differences in salinity.

From the perspective of biological productivity the vertical velocities across the front transporting nutrient rich water from greater depth to the surface layer is of interest. Upwelling is generally found west of the West Greenland fishing grounds and to a lesser extent in the deep channels separating the banks, and it is highest from the Fyllas Bank to the Disko Bay in the area of strongest tides, Figure 13.21. Model calculations reveal that the vertical velocities can reach values of 7×10^{-5} m/s and the simulations additionally show that there is – as could be expected – good correlation between northerly winds and positive (upward) vertical velocities.

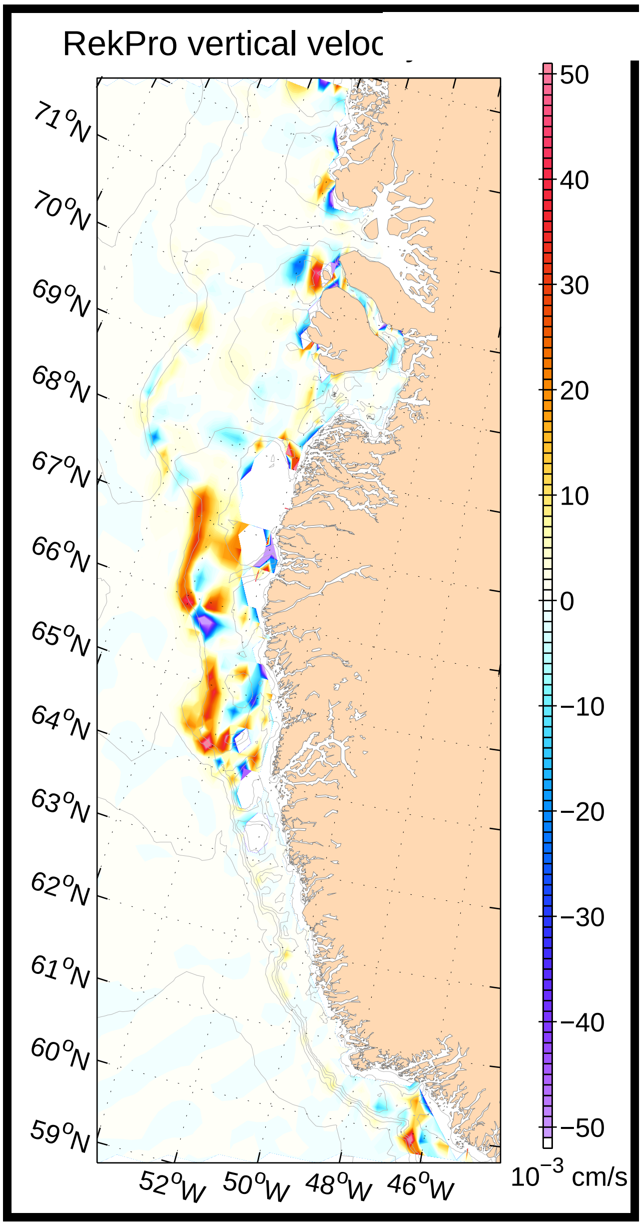


Figure 13.21. Mean vertical velocity at 50 m modelled in 2000 (April to November). Only the barotropic component is included. Red is upwelling and blue is downwelling. Bathymetry lines drawn with grey.

13.2.6 Inter-annual variability

Surface conditions

The most well known oceanographic time series from West Greenland is the mid-June mean temperature on top of Fyllas Bank (Fyllas Bank St. 2, 0-40 m), Figure 13.22.

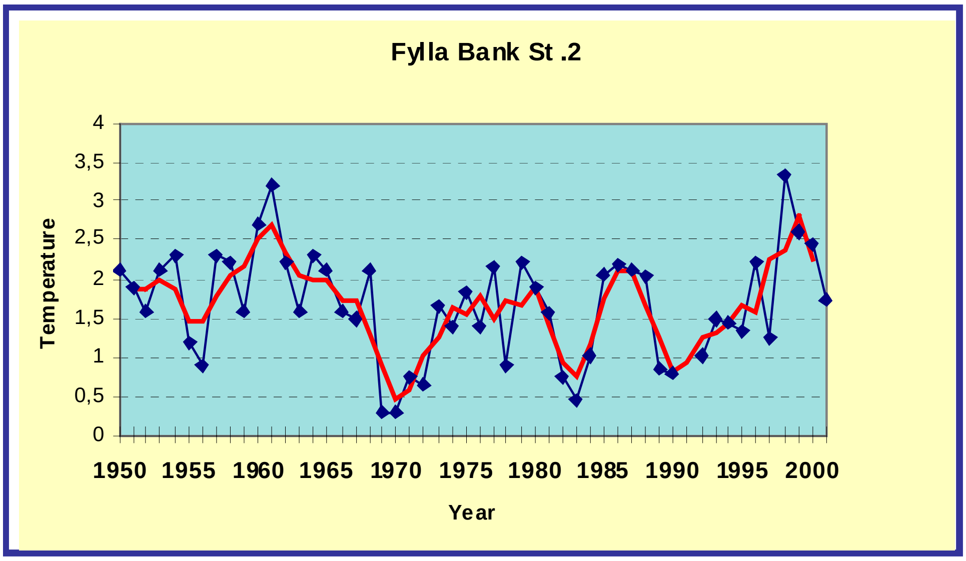


Figure 13.22. Mean temperatures of the upper 40 m on Fyllas Bank St. 2, medio June 1950-1997. Blue line = observations; red line = 3 year running mean.

The temperature may vary quite drastically from one year to the next, often more than 1° C, reflecting the variability of both the atmospheric influence and the inflow of Polar Water. The curve showing the 3-year running mean values naturally smoothens out the variations and reflects therefore better the large scale climatic variability.

The almost 50 year long temperature time-series reveal some very distinct climatic events:

- The 1950-1968 period generally showed high temperatures around 2° C.
- Around 1970 a cold period - the coldest - was experienced. The cold climate of this period was due to an anomalous high inflow of Polar Water (Buch 1990/2000), which was closely linked to the "Great Salinity Anomaly", Dickson et al. (1988).
- The early 1980'es and early 1990'es, two extremely cold periods, were observed reflecting the cold atmospheric conditions in the Davis Strait area as discussed above.
- A remarkably low temperature was observed in 1997 although the atmospheric conditions were quite warm, Figure 13.14, which could indicate a high inflow of Polar Water.
- During recent years temperatures have been rather high most likely due to increased inflow of Irminger Water, se below.

Figure 13.23 shows the time-series of the mid-June salinity on top of Fyllas Bank (actual observations as well as a 3 years running mean). The "Great Salinity Anomaly" around 1970 is clearly reflected in this data set, while the climatic anomalies in the early 1980'es and 1990'es do not expose themselves in any significant way in the surface salinities at Fyllas Bank, which of course was not to be expected because these cold periods was due to atmospheric cooling.

Relatively low salinities were observed in 1996 and 1997 indicating that the inflow of Polar Water have been above normal in these years.

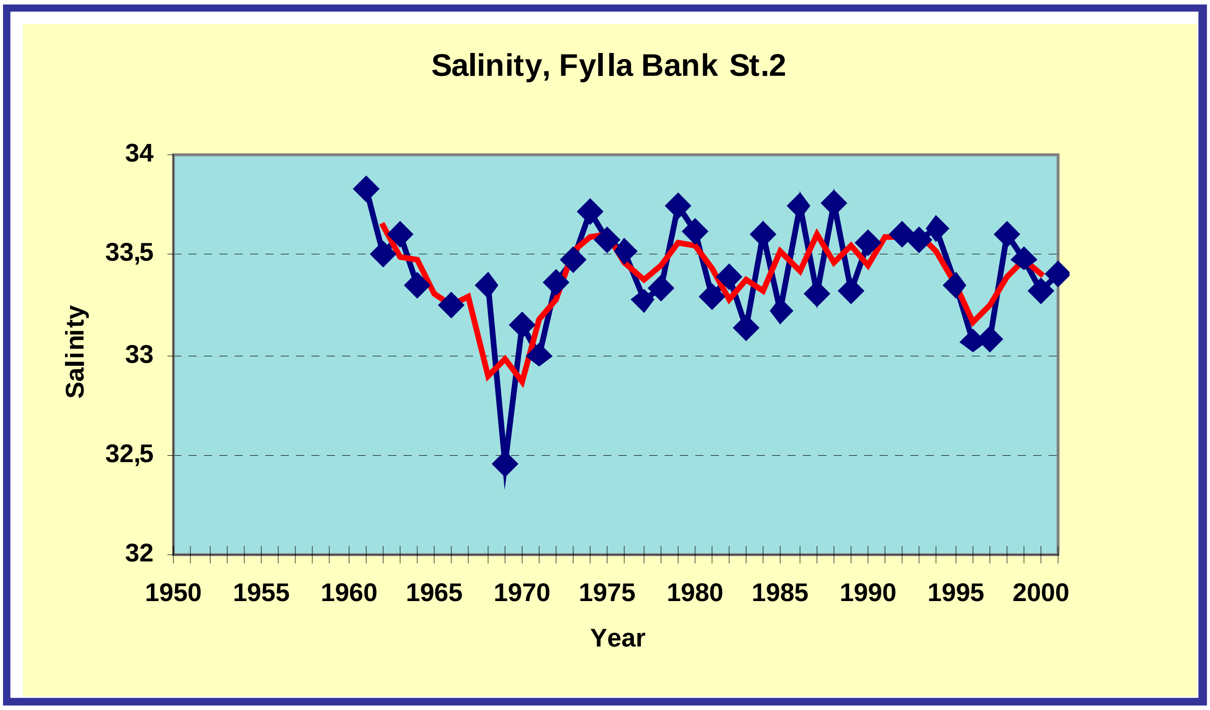


Figure 13.23. Mean salinity of the upper 40 m on Fyllas Bank St. 2, medio June 1961 - 1997. Blue line = observations; red line = 3 year running mean.

Further offshore - just west of the fishing banks there exists relatively long time series of July temperatures and salinities from the following sections and stations:

- Fyllas Bank St. 4, start 1952
- Maniitsoq/Sukkertoppen St. 5, start 1970
- Sisimiut/Holsteinsborg St. 5, start 1970

The mean temperatures and salinities of the upper 50 metres from the three stations are shown in Figure 13.24.

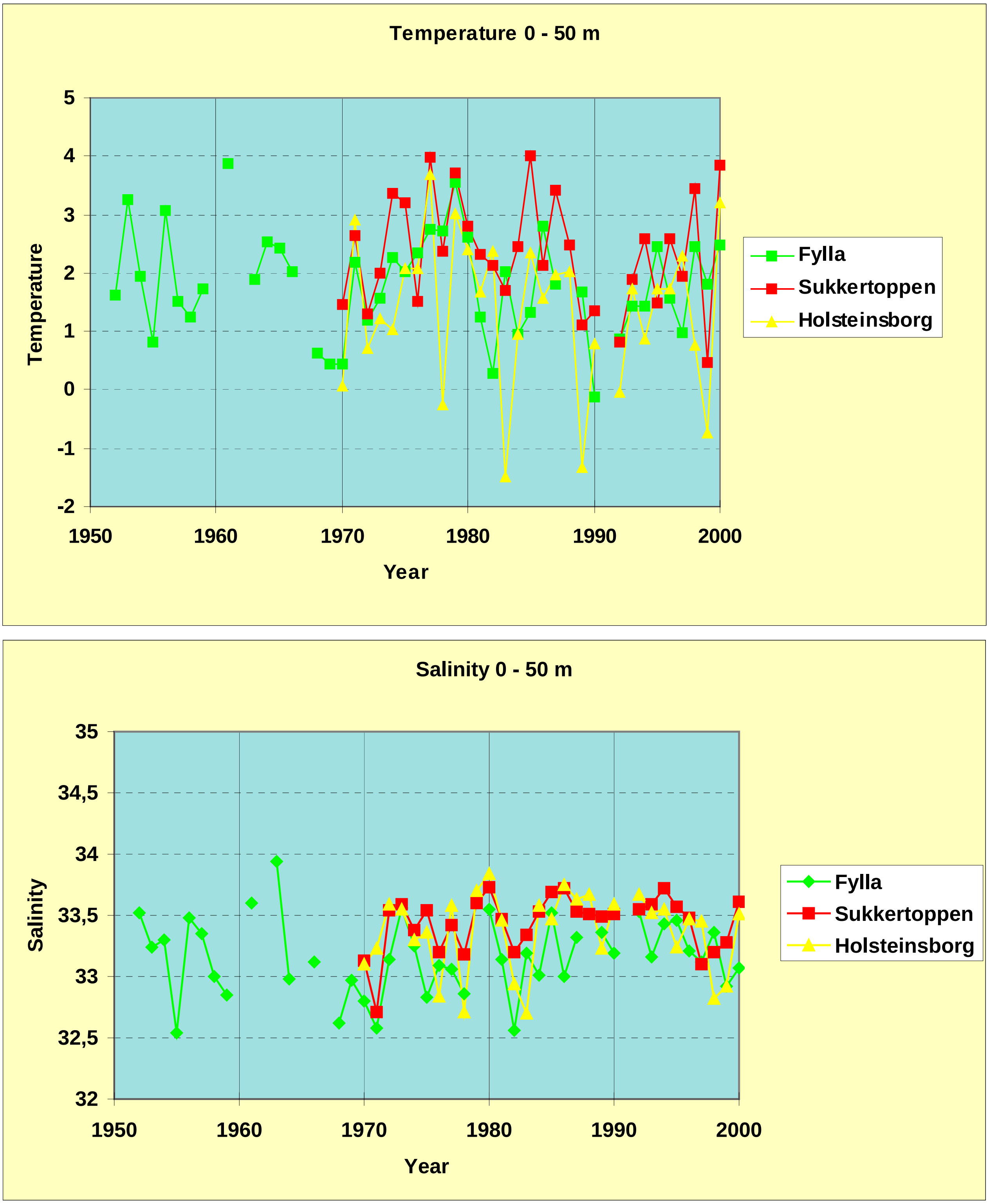


Figure 13.24. Mean temperature and salinity in the upper 50 m at Fyllas Bank St. 4, Maniitsoq/Sukkertoppen St. 5 and Sisimiut/Holsteinsborg St. 5.

The time series reveal that

- The overall tendency in the inter-annual variability at the three stations are comparable although individual years may show large differences in temperature and salinity as well as opposite signs in the development from the preceding year.
- Generally the highest temperatures and salinities are observed at the Maniitsoq/Sukkertoppen, while the lowest salinities most often are observed at Fyllas Bank. This is due to the fact that the Fyllas Bank area is influenced by Polar Water and the Sisimiut/Holsteinsborg station at this time of the year often is influenced by melting west ice and possibly also by cold, relatively fresh water of Polar origin flowing southward on the Canadian side of the Davis Strait; but none of these reach the Maniitsoq/Sukkertoppen area.
- The three cold periods mentioned above is also reflected in these time series. Opposite to the conditions at Fyllas Bank St. 2 a significant decrease in salinity was observed at all three stations during the 1982-84 period, especially in 1982, which was caused by a high inflow of polar ice to the West Greenland area in 1982 combined with the heavy formation of ice in the Davis Strait during the extremely cold winters in 1983 and 1984.
- Relatively warm and saline conditions were experienced in 1979-80.
- Some years extremely cold and low saline conditions were observed at the Sisimiut/Holsteinsborg station, which is due to the presence of ice at the time of observation.

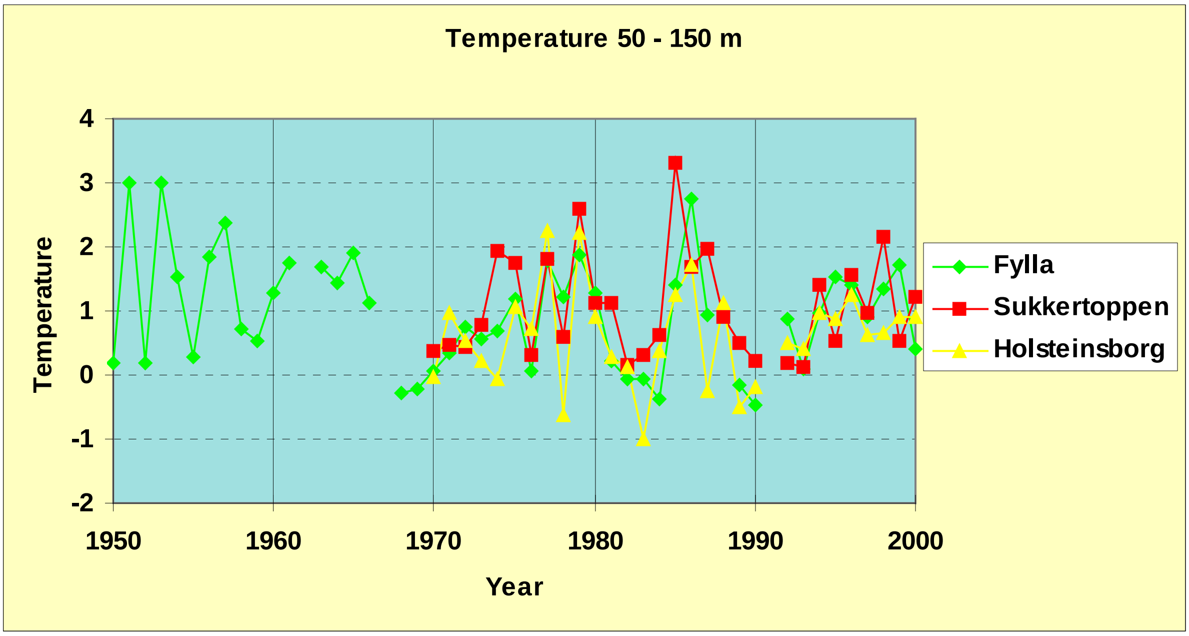
Deeper layers

The variability in the deeper layers are illustrated by the July time series of temperature and salinity from the same three stations just west of the fishing banks that were used above. In Figures 13.20, 13.21 and 13.22 the mean values of temperature and salinity is given for the 50-150 m, 150-400 m and 400-600 m water column. This layering has been chosen for the following reason:

I. The 50-150 m layer is mainly influenced by Polar Water
II. The 150-400 m layer is the transition zone between Polar Water and water of Atlantic Origin
III. The 400-600 m layer is occupied by Atlantic water masses.

It is seen from the three figures that there is great inter-annual variability at all depth levels, although the amplitude of the fluctuations naturally decreases with depth. This is a clear indication of the fact that the West Greenland waters are influenced by the dynamics of several currents having their origin in different parts of the North Atlantic. The variability of the oceanographic conditions in the West Greenland area therefore reflects the individual strengths of the various currents the particular year but also the climatic signal that the currents carry with them from their respective area of formation.

In the 50-150 m layer the temperature fluctuations in general follows the same pattern as was observed in the surface layer, i.e. the cold periods are clearly seen also in this layer, because vertical convection caused by the extreme atmospheric cooling during wintertime creates cold conditions in this layer and superimposed on this is the inflow of cold Polar Water (Figure 13.25). The fluctuations in the salinity signal have, as expected, decreased compared to the surface layer. In 1982 the salinity was extremely low at the Fyllas Bank station; actually it was even lower than during the period with the “Great Salinity Anomaly” around 1970. This is a clear sign of a great inflow of Polar Water, and as mentioned above 1982 was a year with a great inflow of Polar Ice to the West Greenland area, which is a clear reflection of a high transport rate in the East Greenland Current.



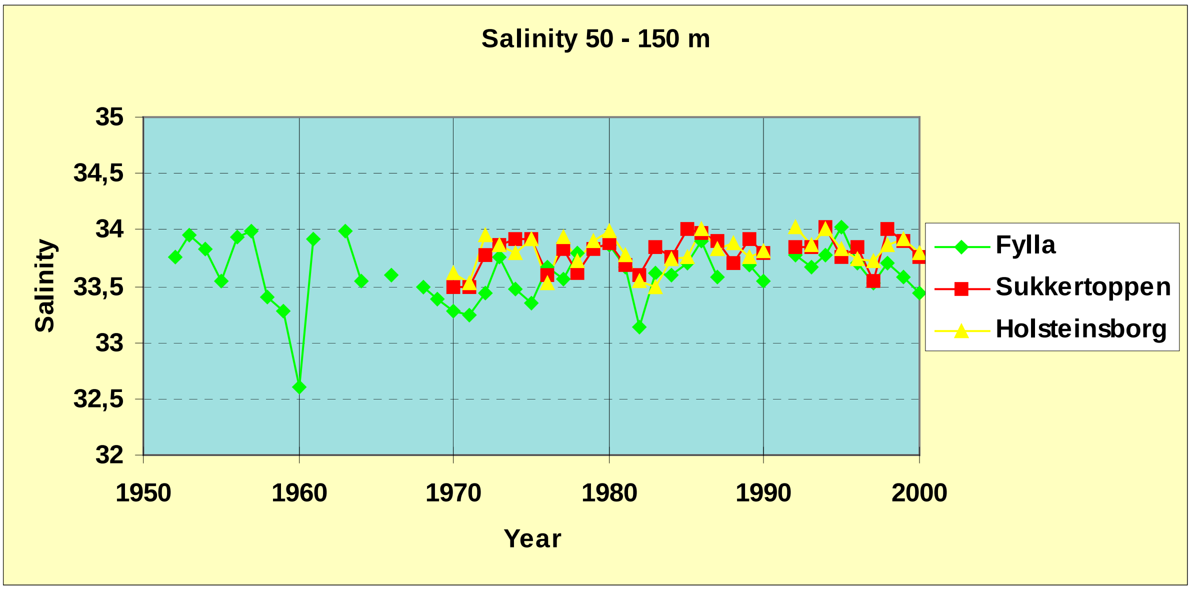
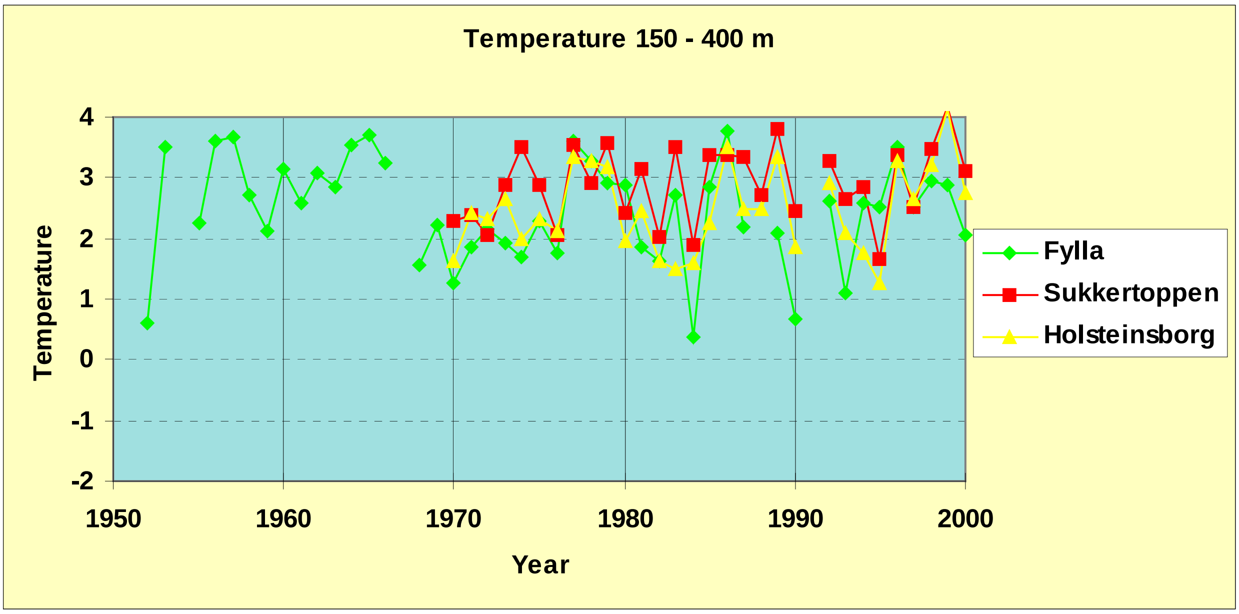


Figure 13.25. Mean temperature and salinity in the 50-150 m layer at Fyllas Bank St. 4, Maniitsoq/Sukkertoppen St. 5 and Sisimiut/Holsteinsborg St. 5.

In the 150-400 m layer the temperature fluctuations still are sizeable (Figure 13.26). The cold periods still can be recognised, but it is evident that other signals play a dominant role in this layer, which off course was to be expected in a layer forming the transition between two different current regimes.



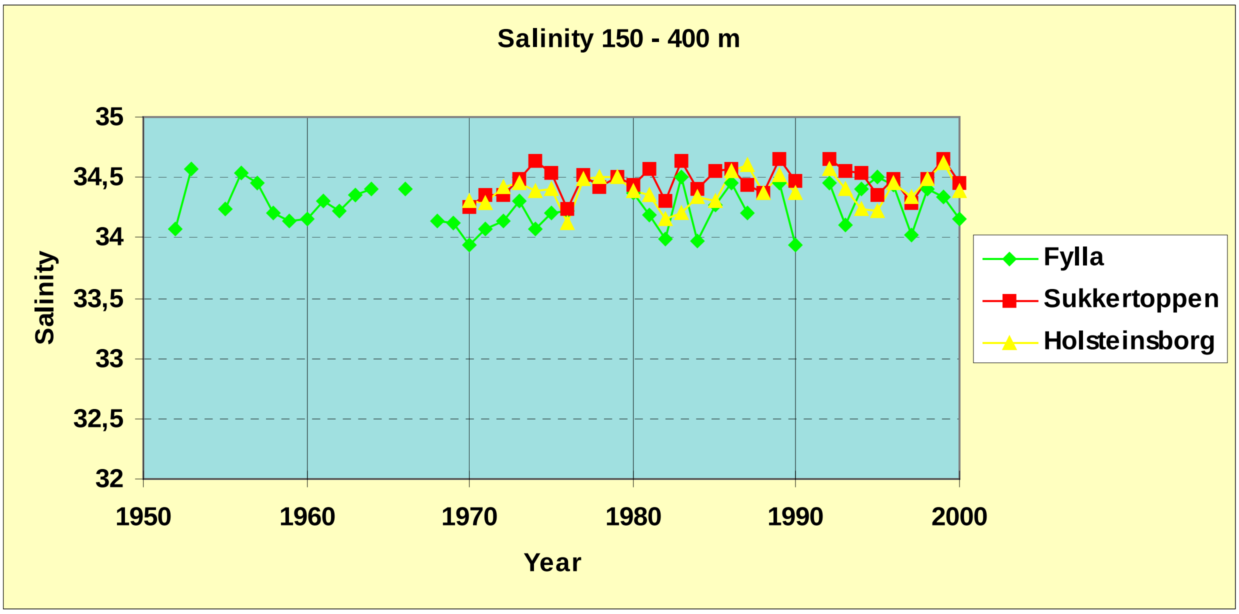
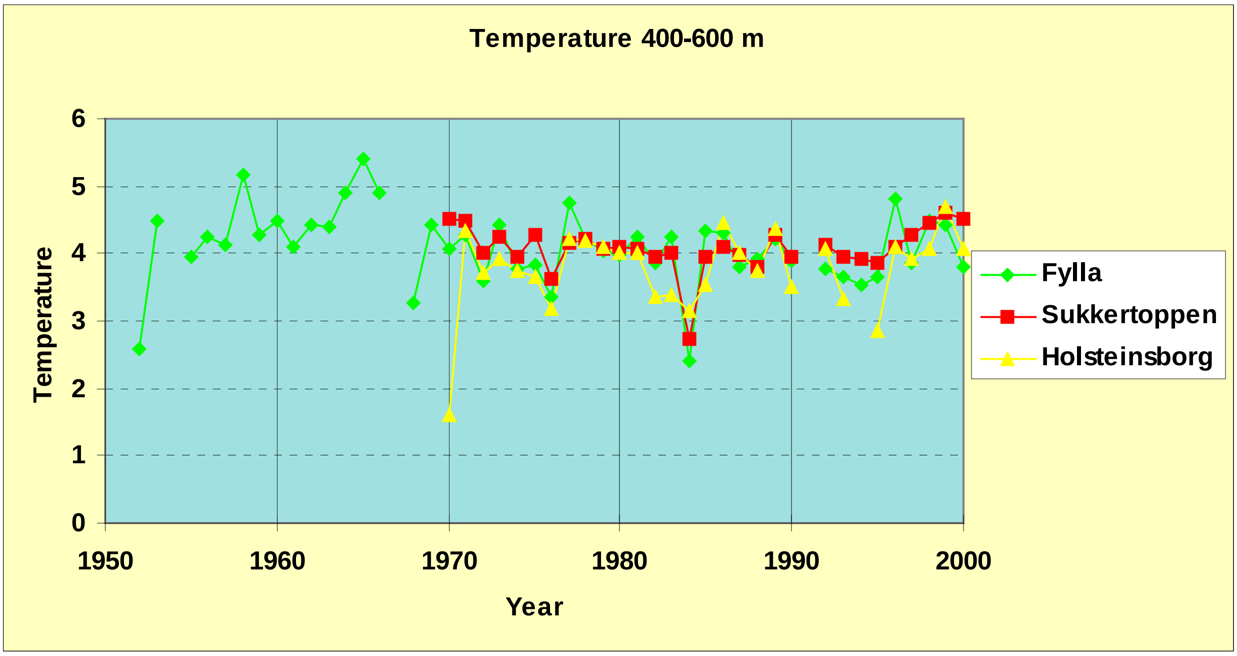


Figure 13.26. Mean temperature and salinity in the 150-400 m layer at Fyllas Bank St. 4, Maniitsoq/Sukkertoppen St. 5 and Sisimiut/Holsteinsborg St. 5.



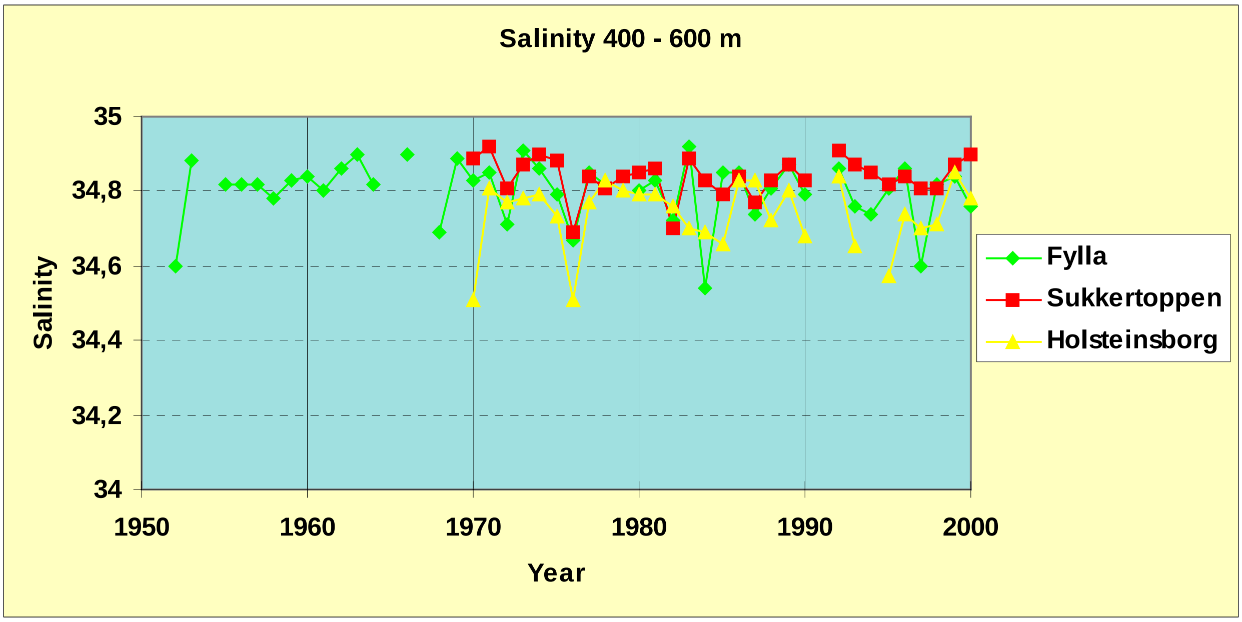


Figure 13.27. Mean temperature and salinity in the 400-600 m layer at Fyllas Bank St. 4, Maniitsoq/Sukkertoppen St. 5 and Sisimiut/Holsteinsborg St. 5.

The warm conditions, as experienced in the late 1970'es and late 1980'es, therefore reflect a dominance of water of Atlantic origin i.e. Sub-Atlantic Water. The salinity is generally highest at the Maniitsoq/Sukkertoppen, which properly is due to the fact that at this depth interval the Fyllas Bank and the Sisimiut/Holsteinsborg stations are more influenced by Polar Water than the Lille Hellefiske Station. Extremely low salinity values were observed at the Fyllas Bank station around 1970 and in 1982, 1984, 1990 and 1997, which can be interpreted as a sign of Polar Water dominance and confirms the trends observed in the shallower layer except for the 1984 situation. The low saline conditions at Fyllas Bank in 1984 was discussed by Buch (1990/2000), who argued that vertical convection during the previous extremely cold winter had caused huge amounts of low saline surface water to sink to great depth off West Greenland preventing inflow of Sub-Atlantic Water at normal rates.

The 400-600 m layer is characterised by temperatures around 4° C and salinities around 34.8 (Figure 13.27). Salinities higher than 34.8, and especially values close to 34.9, indicate high inflow rates of Irminger Water. The salinity at the Sisimiut/Holsteinsborg station is at this depth interval generally lower than on the other stations, which is because the Atlantic components, especially the Irminger component, do not in full strength reach as far north as the Sisimiut/Holsteinsborg area. The most extreme event was observed in 1984 at Fyllas Bank and in the temperature signal also at Maniitsoq/Sukkertoppen. The explanation to these low temperature and salinity conditions is believed to be the same as given above for the similar observations in the 150-400 m layer.

The observations performed during the summer cruises at the southernmost sections in recent years have not been incorporated into the time series discussed above because the series still are to short; but it can briefly be mentioned that the late 1990'es were characterised by a higher inflow of Irminger Water than normal. A tongue of high saline water (S > 34.95) was reaching as far north as to an area between the Paamiut/Frederikshåb- and the Fyllas Bank sections, and in 1997 water with salinities above 35 was observed at the Cape Farewell section.

Analysis of temperature and salinity data collected off West Greenland over the past 6-7 decades (Buch et al. 2002) are given in Figure 13.28 showing time series plot of temperature, salinity and density from stations just west of the shelf at the Cape Farewell- and Fyllas Bank sections, respectively. It is seen that the inflow of water of Atlantic Origin has changed. Before the 1970'es pure Irminger Water (S > 34.95) was present at the Cape Farewell St. 3 in large quantities at depths greater than 100-400 m, although the inflow was gradually decreasing. It is also noticed that the heat inflow was markedly greater at that time with temperatures above 4.5° C in the entire upper 600 m water column, the upper 200 m even had temperatures above 5.5° C. After 1970 Irminger Water has only been observed in smaller quantities after 1995, and a similar statement can be given for temperatures above 5.5° C. In the intermediate period the dominant water mass was Irminger Mode Water. The increased activity in the circulation of Irminger Water has also been observed in the interior of the Irminger Sea after 1995 (Mortensen & Valdimarsson 1999).

At the Fyllas Bank St. 4 we observe a similar trend in reduced inflow of salt and heat. The Irminger Mode Water was present in much higher quantities before mid 1970'es than after, and it is noticed that the three cold periods are clearly reflected in the temperatures of the upper 200 m. A weak freshening in the upper 150-200 m is additionally observed since 1965 resulting in a less dense water mass within this layer. This freshening, however, is most dominant in the upper 50-100 m. A similar freshening during the same period has also been observed in the Irminger Water component north of Iceland (Malmberg 1985), indicating a reduction of the strength of the Irminger Current after 1965 and/or a more dominant influence of Polar Water. From mid 1965'es to the early 1970'es, the freshening was caused by an anomalous high inflow of Polar Water closely linked to the "Great Salinity Anomaly", whereas afterwards it is believed to be caused by a high NAO anomaly reducing the strength of the Irminger Current.

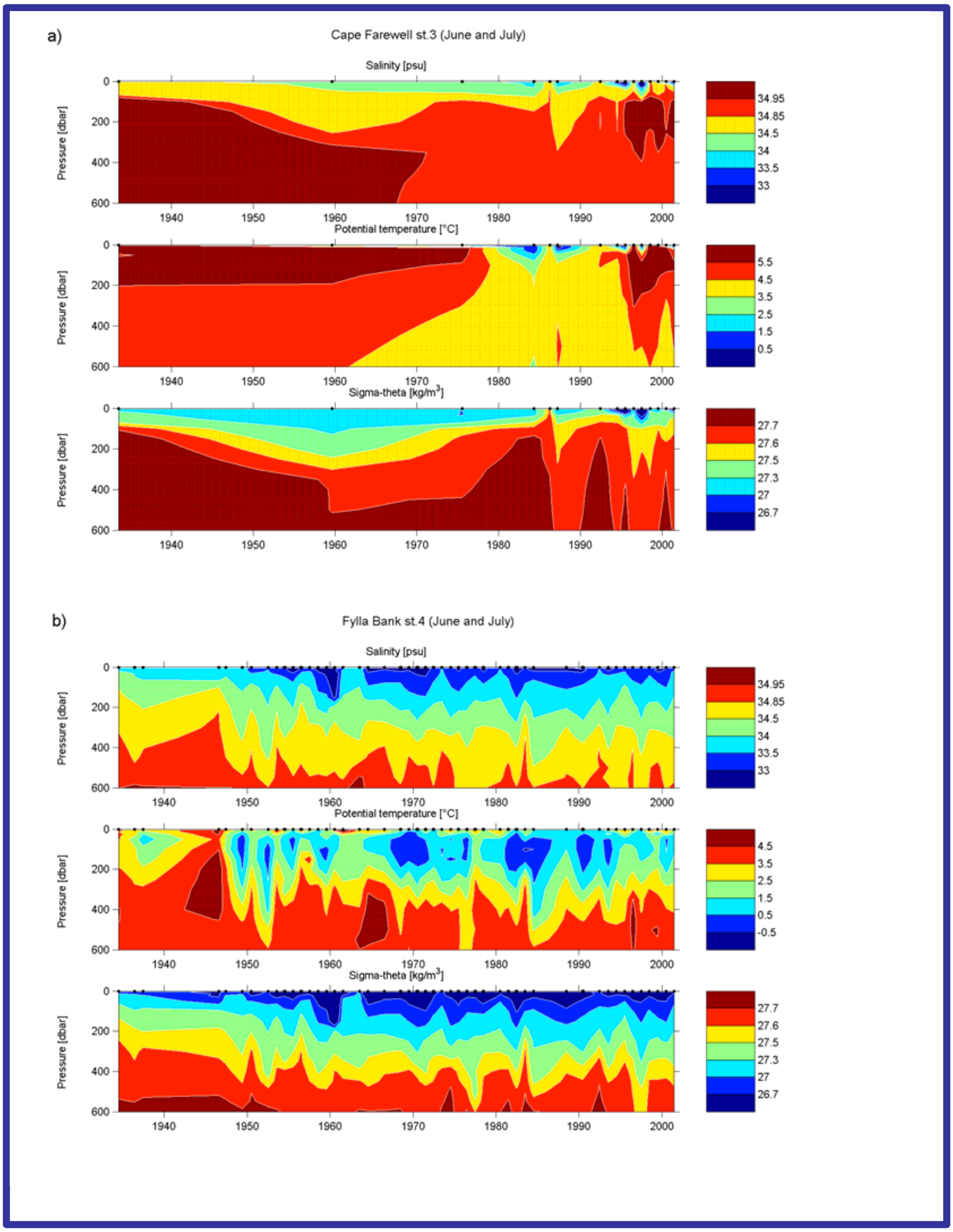


Figure 13.28. Time series of summer (June and July) salinity, temperature and density at: a) Cape Farewell St. 3, and b) Fyllas Bank St. 4. From Buch et al. (2002).

13.2.7 Tides

The tide is the name given to the alternate rise and fall of sea level with an average period of 12.4 h (24.8 h in some places). Locally, the periods varies by an hour or so on either side of the average figure and the rise and fall sequence shows an almost infinite variety around the globe. Tides are a consequence of the simultaneous action of the gravitational forces from the moon, sun and earth and the revolution about one another of the earth-moon and the earth-sun. The fact that the paths of the rotation of the sun and the moon about the earth are not circles but ellipses, and that the planes of rotation are not always in the equatorial plane but move north and south with the annual cycle for the sun and a monthly cycle for the moon, add further complications to the resultant tide producing forces. The motions of the sun and moon are known very exactly, and it is possible to express the resultant tide producing forces as the sum of a number of simple harmonic constituents, each of which has its own characteristic period, phase and amplitude - the most important is given in Table 13.1.

Table 13.1.

Name	Symbol	Period (solar hours)	Relative size
Semi-diurnal			
• Principal lunar	M_2	12.42	100
• Principal solar	S_2	12.00	47
• Large lunar elliptic	N_2	12.66	19
• Luni-solar	K_2	11.97	13
Diurnal			
• Luni-solar	K_1	23.93	58
• Principal lunar	O_1	25.82	42
• Principal solar	P_1	24.07	19
• Larger lunar elliptic	Q_1	26.87	8
Long period			
• Lunar fortnightly	M_f	327.9	17
• Lunar monthly	M_m	661.3	9
• Solar semi-annual	S_{sa}	4383	8

The most important tidal constituent in the Davis Strait-Baffin Bay area is the semidiurnal M_2 with a amphidromic[1] point at about 70° N almost in the middle of the Baffin Bay, Figure 13.29. Along West Greenland the greatest amplitude (120 cm) is found in the Nuuk area, decreasing to around 40 cm north of Disko Island.

The strongest tidal signal - *Spring tide* - is experienced when the sun, earth and moon are lying on a line, which happens every 14 days at new moon and full moon. The lowest tidal signal - *Nip tide* - is experienced 7 days after spring tide at half moon (when the line between the moon and earth is perpendicular to the line between the sun and earth). The difference between high and low water at a few location along the west coast of Greenland at spring tide and nip tide are given en the table below:

	Difference in water level between high- and low water	
Location	Spring tide	Nip tide
Nanortalik	2.7 m	0.9 m
Paamiut	3.3 m	1.0 m
Nuuk	4.6 m	1.5 m
Maniitsoq	4.3 m	1.2 m
Sisimiut	4.3 m	1.2 m
Aasiaat	2.5 m	0.8 m

[1] Amphidromic Point = point with no tidal amplitude around which cotidal lines rotate in anti-clockwise.

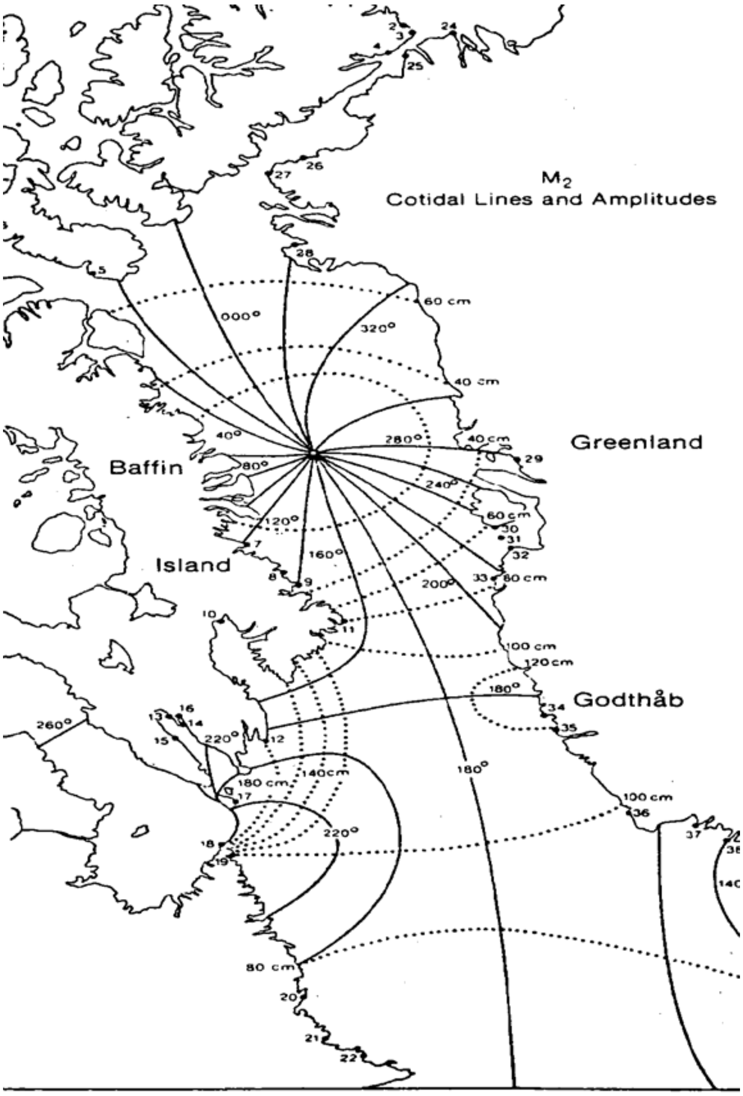


Figure 13.29. M_2-cotidal lines and amplitudes based on coastal observations.

13.2.8 Fjord oceanography

Most fjords in West Greenland are sill fjords i.e. resulting in strong limitations to the exchange of water between the deeper parts of the fjord and the open, Figure 13.30.

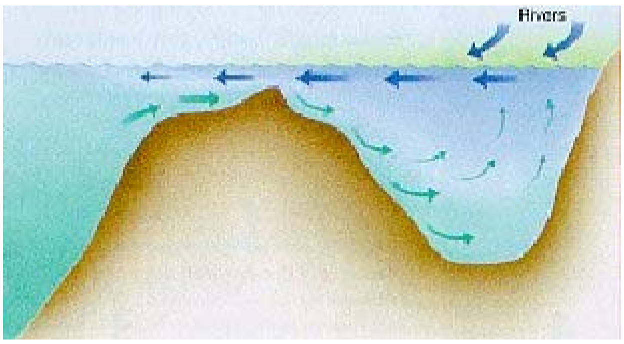


Figure13.30. Large-scale fjord circulation.

The large-scale circulation in a fjord depends on three factors: bottom conditions, water exchange with the open ocean and the supply of fresh water from land. Schematically, the circulation consists of a surface current with brackish water which flows out of the fjord, and a current in deeper layers with more saline water going in the opposite direction. The fresh water largely comes from rivers in the drainage area, an area that normally is several times larger than the fjord itself. Direct precipitation on the sea surface is of minor importance.

The inflow of fresh water to the fjord may be described as the engine which drives the large-scale circulation. The inflow generally causes a higher water level in the fjord than outside. This difference in water level forces the brackish surface water out of the fjord. On its way to the mouth of the fjord the brackish water becomes increasingly saline since the surface water mixes with the underlying water. In order to replace the water entrained into the surface current an undercurrent of more saline water is flowing into the fjord at intermediate depth levels. During the winter the fresh water inflow to Greenland fjords are reduced to almost zero because lakes and rivers freeze and the precipitation on land falls as snow. The surface salinity in the fjords will thereby increase to the level found in the coastal waters outside the fjord, and the circulation in the fjord will decrease to a minimum. These conditions will facilitate convection in the fjord.

The deep water in West Greenland fjords are renewed through two different mechanisms:

- Inflow of water from the open ocean with higher density than the deep water of the fjord. This process normally requires strong northerly winds along the west coast of Greenland, which will cause high density water to rise above sill level outside the fjord.
- Vertical convection during autumn and winter cooling and freezing of the surface water causing salt rejection from the freezing water.

The latter mechanism is functioning every winter and it is therefore seldom to observe anoxic conditions in the deep water of Greenland fjords.

13.2.9 References

Barnett, T.P. 1985. Variations in Near-Global Sea Level Pressure. J. Atmos. Sci., 42: 478-501.

Blindheim, J., R. Toresen & H. Loeng 2001. Fremtidige klimatiske endringer og betydningen for fiskeressursene. Havets miljø. 2001.

Buch, E. 1990/2000. A monograph on the Physical Oceanography of the Greenland Waters. Greenland Fisheries Research Institute Report, (reissued in 2000 as Danish Meteorological Institute, Scientific report, 00-12). 405 pp.

Buch, E. 2000. Air-Sea-Ice Conditions off Southwest Greenland, 1981-97. J. Northwest Atlantic Fishery Science, Vol. 26: 1-14.

Buch, E. & M.H. Nielsen 2001. Oceanographic Investigations off West Greenland 2000. NAFO Scr. Doc ½.

Buch, E., M.H. Nielsen & S.A. Pedersen 2002. On the coupling between Climate, Hydrography and Recruitment variability of Fishery Resources off West Greenland. Proceedings from ICES Decadal Symposium, Edinburg 2001.

Clarke, R.A. 1984. Transport through the Cape Farewell-Flemish Cap section. Rapp. P.v. Reun. Cons. int Explor. Mer. 185: 120-130.

Cuny, J., R.B. Rhines, P.P. Niiler & S. Bacon 2001. Labrador Sea boundary currents and the fate of the Irminger Sea Water. Journal of Physical Oceanography, accepted.

Dickson, R.R., J. Meincke, S.A. Malmberg & A.J. Lee 1988. The "Great Salinity Anomaly" in the Northern North Atlantic 1968-1982. Prog. Oceanog. Vol. 20: 103-151.

Fratantoni, D.M., P.L. Richardson & C. Wooding 1999. Circulation of the North Atlantic Ocean during the 1990's as determined by Lagrangian drifters. EOS, Transactions AGU, 80: 43.

Hurrell, J.W. 1995. Decadal Trends in the North Atlantic Oscillation Regional Temperatures and Precipitation. Science 269: 676-679.

Hurrell, J.W. & H. van Loon 1997. Decadal Variations in Climate associated with the North Atlantic Oscillation. Climate Change, 36: 301-326.

Hurrell, J.W. 2000. The North Atlantic Oscillation. Prepared for the National Academy of Sciences, 12th Annual Symposium on Frontiers of Science, Irvine, CA.

Kiilerich, A. 1943. The Hydrography of the West Greenland Fishing Banks. Medd. Komm. for Danmarks Fiskeri- og Havundersøgelser. Bind II.

Lavander, K.L. 2000. Float-based Observations of Convection and General Circulation in the Labrador Sea. Ph.D. Thesis, Scripps Institution of Oceanography, La Jolla, Ca.

Lee, A.J. 1968. NORWESTLANT Surveys: Physical Oceanography. ICNAF Special Publ. no. 7, Part 1: 31-54, Part II: 38-159.

Malmberg, S.A. 1985. The water masses between Iceland and Greenland. Rit. Fiskideildar, 9: 127-140.

Mortensen, J. & H. Valdimarsson 1999. Thermohaline changes in the Irminger Sea. ICES CM 1999/L:16

Moses, T., G.N. Kiladis, H.F. Diaz & R.G. Barry 1987. Characteristics and Frequency Reversals in Mean Sea Level Pressure in the North Atlantic Sector and Their Relationships to Long-Term Temperature Trends. J. of Climatology, 7: 13-30.

Parker, D.E. & C.K. Folland 1988. The nature of Climatic Variability. Met. Mag., 117: 201-210.

Pickart, R.S., D.J. Torres & R.A. Clarke 2001. Hydrography of the Labrador Sea during active convection. Jour. Of Phys. Oceanography. In press.

Prater, M.D. 2000. Eddies in the Labrador Sea as observed by profiling RAFOS floats and remote sensing. Jour. of Phys. Oceanography. In Press.

Rosenørn, S., J. Fabricius, E. Buch & S.A. Horsted 1985. Record-hard winters at West Greenland. NAFO SCR DOC. 85/61. 17 pp.

van Loon, H. & J. Williams 1976. The connection between Trends of Mean Temperature and Circulation at the surface: Part I. Winter. Mon. Wea. Rev., 104: 365-380.

van Loon, H. & J.C. Rogers 1978. The Seesaw in Winter Temperatures between Greenland and Northern Europe. Part I: General Description. Mon. Wea. Rev 106: 296-310.

14 Appendix D, Methods and documentation

14.1 Introduction

The methods and data used in the present atlas project have been described in the Chapters 6, 7 and 8. However, some technical details and data documentation was not included in these chapters and is therefore presented here. Appendix D should thus be seen as supplementary to the descriptions in Chapters 6, 7 and 8.

This chapter contains:

- the detailed settings used for calculating the sensitivity index values with the Greenland oil spill sensitivity application (Chapter 14.2),
- a description of the data and methods used in the geomorphologic coast classification (Chapter 14.3),
- a description of the data and methods used to assess abundance values for the biological occurrences for each area (Chapter 14.4),
- a description of the data and method used to assess assigned values for the archaeological sites for each shoreline area (Chapter 14.5),
- an account of the selected areas (Chapter 14.6).

14.2 The parameters of the Greenland oil spill sensitivity application

Below is a list of the parameter settings in the Greenland oil spill sensitivity application for the index calculations in this atlas.

Assigned Values to shoreline and offshore areas:

Score per community, range	0-10*
Special status area score	5
Resource (human) use, range**	0-5
Archaeological sites, range	0-5
Animal relative abundance, range	0-5

* Calculated in GIS using a 10 km buffer zone around each community. The value is proportional to the length of shoreline segments included within this buffer zone.
**Range from 0 (no importance) to 5 (extreme importance).

Shoreline exposure class modifier for shoreline ice cover
The exposure modifier is –1 less than 8 weeks for maximum open water periods.

Shoreline ORI modifiers
A few modifications to the basic classification of the ORI value (see Chapter 6) are made to account for shoreline slope and for a few geomorphologic coast types considered to have longer residence times. However the maximum ORI value is limited to 5 and the minimum to 1.

ORI slope modifiers

Steep	-1
Flat	+1

ORI shore type modifiers

Archipelagos	+1
Pocket beach	+1
Barrier beach	+1
Delta	+1

Offshore ORI

Offshore oil eesidence index values have been defined for the offshore areas to approximately correspond to the shoreline ORI values. However, the offshore ORI have been defined for each of the four seasons. In the Davis Strait the presence of the dynamic pack ice with floes and ice edges will act to restrict oil movement and thus significantly increase the potential oil exposure time. The offshore ORI values have been defined with values increasing from 3 to 5 for the open water period (period with less than 5/10th of ice) decreasing from more than 90 % to less than 50 % of the season.

Offshore ORI values (ORI for offshore areas)

0-50 % of season with open water	5
51-90 % of season with open water	4
91-100 % of season with open water	3

Weighing factors

Resource (human) use	2
Species occurrences	1.75
Special status areas (Ramsar sites)	1.5
Oil residence index	1.5

Application constants

Biological resource constant (shoreline)	14.7
Biological resource constant (offshore)	35
Maximum ORI value	5

With these settings the average contributions (PI-values) to the final sensitivity values for the shoreline areas are:

- biological occurrences 54 %,
- resource (human) use 17 %,
- oil residence index 11 %,
- archaeological sites 10 %,
- communities 8 %,
- special status areas (Ramsar sites) 0 %.

However, this is a simplification since the oil residence index value is a factor in the calculation of the PI-value for biological occurrences and thus has a higher relative contribution to the final sensitivity value.

14.3 Geomorphologic information

The geomorphology of the Southwest Greenland coast between c. 60° N and 62° N has been classified according to shore type, sediment type, slope and exposure. The classification covers the coastline from near Prins Christian Sound just east of Cape Farewell to Paamiut at 62° N. The total shoreline length is c. 11,367 km (Figure 14.1).

14.3.1 Methods

The classification is based on air photo interpretation of digital stereo images using a digital photogrammetric workstation (DPW). The images used were in scale 1:150,000 (taken in 1985). The pictures were scanned (pixel size 14 µm) imported and oriented by aero triangulation. A digital vector coastline was imported from G250-vector database of Kort & Matrikelstyrelsen (KMS) (= Danish Survey and Cadastre). The aerial stereo images and the coastline-vector were synchronised by the use of PRO600 Socet Set software. This facilitates an interactive assignment of attributes to the coastline while inspecting the stereo images.

To allow the calculation of oil spill sensitivity indices the coastal classification is mainly based on the methods outlined in the proposal 'West Greenland Coastal Atlas for Environmental Protection. A Proposal to the Danish Energy Agency' produced by AXYS in July 1999 (Mosbech et al. 2000). The classification has been changed a bit to suit Greenland coasts better when defining shore types.

In a few cases the images were supplemented with interpretations of air photos in a scale of c. 1:40,000 (taken in the period 1959-1968) using a manual stereoscope. In total c. 110 images were used for the classification. Furthermore, topographic maps (scale 1:250,000), quaternary geological maps (scale 1:500,000) and geological maps (scale 1:100,000) have been used for the classification.

The division of the shoreline into shore type segments is based on the geomorphology of the coast. A shore type is a repeatable category of coastal geomorphology which indirectly indicate the coastal sediment type. Seventeen different shore types have been used for the classification (Table 14.1). However, in the atlas the seventeen shore types have been reduced to twelve shore types for simplicity (Table 7.1). This has been done by lumping shore types with erosional cliffs together with the corresponding shore types without erosional cliffs.

A lower segment length of app. 2 km was applied. Therefore, shore segments with a shore extent less than app. 2 km were not categorised separately but were included in the neighbouring segments. Segments less than 2 km classified as deltas or glaciers are preserved.

For each segment the shore type (Table 14.1), the sediment type (Table 14.2), the slope (Table 14.3) and the exposure (Table 14.4) were classified.

All islands within archipelagos are classified with unique attributes concerning shore type, sediment type, slope and exposure.

Landscape elements of special geomorphologic interest (e.g. cuspate forelands and tombolos) have been classified where possible.

14.3.2 Statistics

The total number of segments identified is 7,384. Of these 1,282 segments (2,872 km) are on the mainland coast 1,298 segments (4,174 km) are on bigger islands (perimeter > 6 km) and 4,804 segments (320 km) are on smaller islands (perimeter < 6 km).

The distribution of segments on shore type, sediment type, slope and exposure categories respectively are given in Tables 14.5-14.8. In terms of shoreline length, the 'rocky coast' is the dominant shore type (64.8 %). 'Rock' is the dominant substrate (87.6 %). 'Inclined' is the dominant slope (50.5 %) and 'semi-protected' is the dominant exposure type (50.4 %). The majority of the coasts within the 'archipelago' shore type are rocky coasts. Together the 'archipelago' and 'rocky coast' shore types by length constitute 88.9 % of the total investigated shoreline.

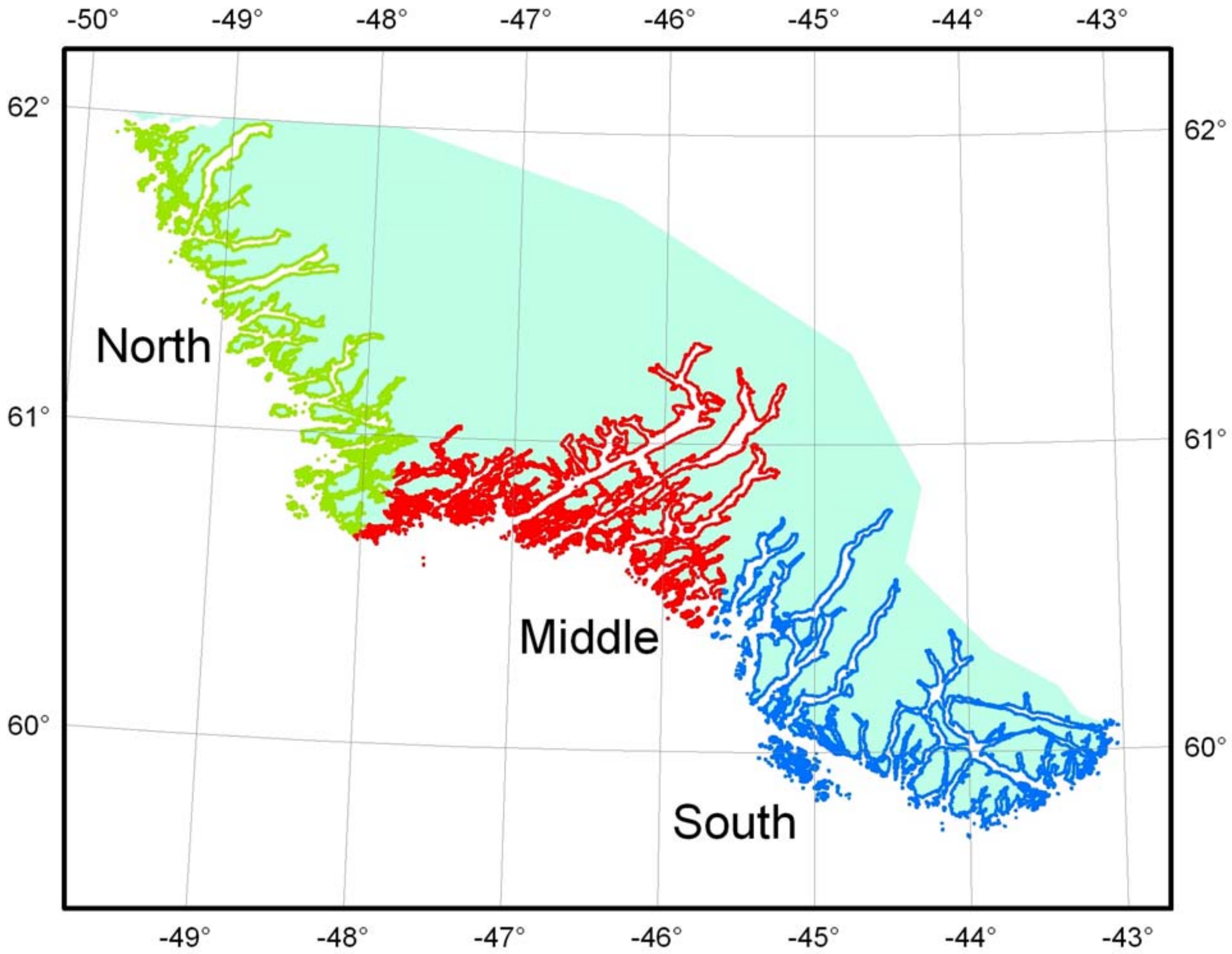


Figure 14.1. The study area in South Greenland. Length of coastline: South 3,448 km, Middle 4,527 km and North 3,391 km.

Table 14.1. Classification of shore types in South Greenland between 60° and 62° N.

Shores developed in solid rock

Shore type no.	Shore type	Segment type	Characteristics
1	Rocky coast	Line	- Coast developed in bedrock of varying morphology, elevation and gradient. - Narrow beach with coarse sediment consisting of boulders, cobbles and pebbles might occur. - The occurrence of abraded intertidal platforms is indicated by the gradient (Table 14.3).
2	Rocky coast with erosional cliff	Line	- As shore type 1, but with steep or vertical erosional cliff.
3	Archipelago	Polygon	- Several smaller islands, normally developed in solid rock. - Rocky coasts and pocket beaches might occur but have only been classified individually if the perimeter of the island exceeds 6 kilometres.
4	Glacier coast	Line	- Occurrence of a glacier in the intertidal zone.

Shores developed in sediments of glacial. alluvial or colluvial origin

Shore type no.	Shore type	Segment type	Characteristics
5	Moraine	Line	- Shore developed in unconsolidated glacial sediments. - Narrow beach with coarse sediment consisting of boulders, cobbles and pebbles might occur. - The occurrence of abraded intertidal platforms is indicated by the gradient (Table 14.3).
6	Moraine with erosional cliff	Line	- As shore type 5 but with steep or vertical erosional cliff.
7	Alluvial fan	Line	- Shore developed in alluvial fan. - Narrow beach with sediment consisting of boulders, cobbles, pebbles, gravel and sand might occur. - The occurrence of intertidal platforms is indicated by the gradient (Table 14.3).
8	Alluvial fan with erosional cliff	Line	- As shore type 7 but with steep or vertical erosional cliff.
9	Talus	Line	- Shore developed in talus (colluvial fan) of varying gradient. - Narrow beach with coarse sediment consisting of boulders, cobbles and pebbles might occur.
10	Talus with erosional cliff	Line	- As shore type 9 but with steep or vertical erosional cliff.

Shores developed in marine sediments

Shore type no.	Shore type	Segment type	Characteristics
11	Beach	Line	- Long, linear depositional beaches of wellsorted sand, gravel, pebbles, cobbles or boulders. - Beach ridge plains often occur landwards the beach.
12	Beach ridge plain with erosional cliff	Line	- Coastal cliff cut in beach ridge plain. - Narrow beach with well sorted sediment consisting of boulders, cobbles, pebbles, granules or sand might occur.
13	Barrier beach	Line	- Coastal environment consisting of coastal barriers and lagoons with beaches, dunes, salt marsh and tidal flats. - Spits often occur near tidal inlets. - Washover fans might occur on barriers. - Beaches consisting of wellsorted sand, gravel, pebbles or cobbles. - Tidal flats consisting of mud.
14	Salt marsh and/or tidal flat	Line	- Wide salt marshes with or without salt marsh cliff and/or wide intertidal flats. - Consisting of relatively fine sediments (mud, sand, silt and clay).
15	Pocket beach	Line	- Beach developed in the inner part of an embayment in solid rock. - No larger rivers run into the embayment. - Beaches normally consist of wellsorted sediments consisting of sand, gravel, pebble or cobbles.

Shores developed in deltaic sediments

Shore type no.	Shore type	Segment type	Characteristics
16	Delta	Line	- Low gradient intertidal platform developed by fluvial sediments in front of a river valley. - Braided river channels often occur within the intertidal zone. - Sediment normally fine grained ranging from clay to fine sand.

Others

Shore type no.	Shore type	Segment type	Characteristics
17	Not classified	Line	**-** The shore has not been classified due to lack of air photo information (cloud cover, shadow etc.)

Table 14.2. Sediment classification for South Greenland coasts between 60° and 62° N.

Substrate class	Substrate, general	Substrate, specific	Shore description
1	Ice	Ice	Glacial ice within the intertidal zone.
2	Rock	Rock	Bedrock within the intertidal zone.
3	Rock and sediment	Rock and coarse sediment	A combination of bedrock and coarse sediment including boulders, cobbles and pebbles, either as veneers over the bedrock or as small pocket beaches interspersed with bedrock.
4		Rock and fine sediment	A combination of bedrock and fine sediment including mud, sand or mixtures of sand and boulders, cobbles or pebbles. Sediments most likely to occur as small pocket beaches interspersed with bedrock.
5	Sediment	Coarse sediment	Boulders, cobbles and pebbles. Collectively referred to as 'gravel'. Includes 'shingle-type' beaches.
6		Fine sediment	Mud, sand and combinations of sand and gravel.

Table 14.3. Slope classification for South Greenland coasts between 60º and 62º N.

Slope class	Slope
1	Steep
2	Inclined
3	Flat

Table 14.4. Exposure classification for South Greenland coasts between 60º and 62º N.

Exposure class	Exposure
1	Protected
2	Semi-protected
3	Semi-exposed
4	Exposed

Table 14.5. Shore type statistics.

Shore type	No. of segments	Km	%
0	0	0	0
1	2,528	7,367	64.8
2	5	15	0.1
3	4,290	2,735	24.1
4	28	50	0.4
5	258	643	5.7
6	16	28	0.2
7	9	19	0.2
8	1	6	0.1
9	79	231	2.0
10	2	1	0.0
11	4	5	0.0
12	58	129	1.1
13	0	0	0.0
14	0	0	0.0
15	0	0	0.0
16	70	86	0.8
17	18	52	0.5
Total	**7,384**	**11,367**	**100.0**

Table 14.6. Sediment type statistics

Sediment type	No. of segments	Km	%
1	28	50	0.4
2	6,735	9,953	87.6
3	36	105	0.9
4	62	117	1.0
5	212	509	4.5
6	311	633	5.6

Table 14.7. Slope statistics

Slope type	No. of segments	Km	%
1	2,265	5,480	48.2
2	5,007	5,744	50.5
3	112	142	1.2

Table 14.8. Exposure statistics

Exposure type	No. of segments	Km	%
1	975	1,896	16.7
2	2,605	5,727	50.4
3	1,443	1,893	16.7
4	2,361	1,851	16.3

14.4 Biological and resource use information

14.4.1 Introduction

This section describes the different species/species groups included for calculation of shoreline sensitivities. It gives an overview of the different sources to the biological information. Moreover, a description of the behind the selection of seabird breeding colonies and behind the calculation of the relative abundance of seabirds in each shoreline area is given. Many more species of birds, marine mammals and fish/shellfish occur in the region. These are however of insignificant importance as hunting/fishing objects, they occur widespread without any concentration areas or they are not particularly exposed to oil in case of a spill in the region. Following acronyms are used: NERI-AE = National Environmental Research Institute, Denmark, Department of Arctic Environment and GINR = Greenland Institute of Natural Resources.

14.4.2 Marine mammals

Harbour seal

This seal species occur within the area throughout the year. All the presented information is retrieved from Petersen (1993a, b, c & d) and Teilmann & Dietz (1994) supplemented with more general information from Mosbech et al. (1998).

Baleen whales

This group comprise three species: Fin whale, minke whale and humpback whale. Fin whale and minke whale are both summer visitors to the area, and both are hunted under regulation by the International Whaling Commission. The presented data on these two species are from the Greenland catch statistics (Witting 2000). The humpback whale is also a summer visitor to the area, although a few may stay over winter. This species is protected from hunting.

14.4.3 Seabirds

The seabird species have been assembled in some seabird groups:

- Alcids, comprising breeding Brünnich’s guillemots (Thick-billed murre), common guillemots, razorbills, black guillemots and Atlantic puffins.
- Alcids winter, comprising wintering Brünnich’s guillemots (Thick-billed murre) and little auks (dovekies).
- Seaducks breeding, comprising common eiders.
- Seaducks, comprising non-breeding (mainly in winter buts also moulting birds in summer) common eiders, king eiders and harlequin ducks.
- Gulls, comprising Iceland gulls, glaucous gulls, great black-backed gulls, lesser black-backed gulls, herring gulls, kittiwakes and Arctic terns.
- Cormorants, comprising only great cormorants.
- Tubenoses offshore, comprising northern fulmars and great shearwaters in offshore waters.
- Tubenoses shoreline, comprising breeding northern fulmars.

Breeding seabirds at shorelines

Selection of seabird breeding colonies included in this atlas derive from NERI-AE’s database of seabird breeding colonies covering the entire Greenland (see Boertmann et al. 1996). The selection is based upon the geographical range between 60° N and 62° N and on the best available surveys, as many colonies have been surveyed several times. However, the most recent surveys are not necessarily the best, as for example aircraft based surveys are inferior to boat based surveys. In

July 2003 a specific seabird colony survey was carried out in South Greenland to improve the information to be included in the atlas (Boertmann 2003).

All numbers of birds are expressed individuals as many species can only be monitored as such. Survey results expressed in pairs or nests are therefor transformed to individuals in this context (No. of pair/nest x 2).

Species criteria for selection
The criteria for inclusion of colonies are listed in Table 14.9.

Table 14.9. Criteria for inclusion of seabird colonies.

Species	Criteria	No. of colonies meeting the criterion	No. of colonies included because other species meet their criterion (mixed colonies)
Northern fulmar	All colonies	2	-
Common eider	Colonies with ≥ 5 indvs.	19	2
Iceland gull	Colonies with ≥ 500 indvs.	1	14
Glaucous gull	Colonies with ≥ 500 indvs.	0	13
Unsp. glaucous/Iceland gull	Colonies with ≥ 500 indvs.	0	1
Lesser black-backed gull	Colonies with ≥ 50 indvs.	2	9
Black-legged kittiwake	Colonies with ≥ 50 indvs.	10	1
Arctic tern	Colonies with ≥ 30 indvs.	5	0
Common guillemot	All colonies	0	2
Brünnich's guillemot (thick-billed murre)	All colonies	2	-
Razorbill	Colonies with ≥ 5 indvs.	8	3
Black guillemot	Colonies with ≥ 250 indvs.	9	23
Atlantic puffin	All colonies	3	-

Taking into account that most colonies have a mixed species assemblage the total number of colonies (with different geographical position) selected is 49.

Comments to the criteria
The criteria take into account the sensitivity to oil spill of the bird species both on individual level and on population level. These sensitivities are dependent on the behaviour and ecology of the birds but also the distance to neighbouring colonies, which is a measure of the ability to re-colonise a colony. Moreover they take into account the status of the breeding population within the region, whether they are decreasing, increasing or stable, as well as their international conservation status.

There are only two breeding sites for northern fulmar in the region.

The breeding population of common eider in entire West Greenland has decreased seriously for a century, and within the study region the population of breeding common eiders is very small an dispersed. In 2003 a rather large and dense colony was discovered just east of Cape Farewell. To exclude sites with a few scattered nesting eiders the criteria for inclusion is ≥ 5 birds.

Iceland gull, glaucous gull (incl. unsp. Iceland/glaucous gull) are widespread breeders in South Greenland. As gulls are only moderately sensitive to oil spill only the largest colonies are included. A few large colonies situated very high on cliffs (> 500 m asl.) and in the inland are excluded.

A speciality for South Greenland is the lesser black-backed gull, which recently has immigrated, and the population is increasing strongly.

Black-legged kittiwakes breed exclusively in colonies usually on the lower part of steep cliff faces. They are widespread in West Greenland but rather few and generally small colonies are known in South Greenland (major part less than 500 pairs). Colonies with less than 50 individuals are excluded as they tend to be less stable over time.

Arctic terns breed usually in dense colonies on low islands. The population in Greenland is generally decreasing. A characteristic feature is that colonies in large areas are abandoned in certain years (with adverse weather in spring). Small colonies less than 30 pairs are excluded. Terns are moderately sensitive to oil spill, but colonies situated on low islands are very sensitive to disturbance e.g. from oil spill response activities.

All members of the family auks (alcids), that is common guillemots, Brünnich's guillemots, razorbills, black guillemots, little auks and Atlantic puffins, are very sensitive to oil spill. This is caused by their behaviour and also by their very low population turnover. Therefore protection of their breeding sites have high priority. Moreover the breeding population of Brünnich's guillemot in entire West Greenland is seriously decreasing due to a very high hunting pressure, and the very few breeding sites within the sensitivity mapping region are therefore all included. Common guillemots breed only in few numbers in colonies of Brünnich's guillemots, and all are included.

Razorbills breed in small colonies (max. a few tens of pairs) scattered throughout the study region. The colonies are difficult to monitor, because the nests are concealed. A few birds seen at a site may not be breeding birds, why sites with less than 5 birds are excluded.

The black guillemot is the most widespread and numerous alcid within the region, where colony size range from a few pairs to some hundred. The colonies are often very loose and difficult to delimit, and all in all only very large colonies with more than 250 individuals observed are included.

The population of Atlantic puffin is small in entire West Greenland. The largest colonies hold up to some hundred pairs. The population was moreover decreasing until hunting and egging was prohibited in 1960. The population seems now to be slowly increasing. All colonies are included.

In each shoreline segment the numbers of breeding seabirds for each of the species groups are added to calculate the input (relative abundance) to the sensitivity calculation:

Alcids			
	Black guillemot	1-100	1
		101-200	2
		201-500	3
		501-1,000	4
		> 1,001	5
	Razorbill	1-20	1
		21-50	2
		51-100	3
		101-200	4
		> 201	5

Puffin	1-5	1
	6-10	2
	11-20	3
	21-50	4
	> 51	5
Brünnich's guillemot	1-10	1
	11-50	2
	51-100	3
	101-200	5
	> 201	5

A colony/shoreline area, which otherwise only will reach a relative abundance of 3 or less, is added one point if three or more alcid species are present.

Seaducks breeding

Common eider	1-50	1
	51-100	2
	101-200	3
	201-500	4
	≥ 501	5

Gulls

Iceland gull	1-200	1
Glaucous gull	201-400	2
Great black-backed gull	401-1,000	3
	1,001-2,000	4
	≥ 2,001	5
Lesser black-backed gull	1-10	1
	11-25	2
	26-50	3
	51-100	4
	≥ 101	5
Kittiwake	1-100	1
	101-1,000	2
	1,001-2,000	3
	2,001-10,000	4
	≥ 10,001	5
Arctic tern	1-50	1
	51-200	2
	201-1,000	3
	1,001-2,000	4
	≥ 2,001	5

Colonies/shoreline areas with four or more gull species (not terns) only reach a relative abundance of 2 are added one point.

Tubenoses shoreline

Northern fulmar	1-200	1
	201-1,000	2
	1,001-2,000	3
	2,001-10,000	4
	> 10,001	5

Non-breeding coastal seabirds
Included in the shoreline sensitivity calculation are non-breeding seaducks and cormorants. Alcids are omitted and only related to offshore areas, as they are not dependent of the coast for resting as seaducks and cormorants are. Gulls are also included, however only very large aggregations. Gulls are omnipresent in the region, and their occurrence is highly variable, unpredictable and dependent of ice conditions and food availability.

The index values for seaducks (non-breeding) are:

Seaducks

Common eider		
	1-200:	1
	201-500:	2
	501-2,000:	3
	2,001-5,000:	4
	> 5,000:	5
Harlequin duck		
	1-20:	1
	21-100:	2
	101-250:	3
	251-400:	4
	> 400:	5
Long-tailed duck		
	300-500:	3
	501-1,000:	4
	> 1,000:	5

Offshore seabirds
The information regarding offshore occurrence of seabirds have been retrieved from Brown (1986), Mosbech et al. (1996, 1998), Durinck & Falk (1996), Boertmann & Mosbech (1997, 2001a, b), Mosbech & Johnson (1999), Merkel et al. (2002), Boertmann et al. (in print), Boertmann (2003) and is supplemented with unpublished information from NERI-AE.

14.4.4 Fish, shellfish and fisheries

Capelin, lumpsucker and Arctic char

The information on capelin, lumpsucker and Arctic char derive from an interview survey in South Greenland carried out in summer 2003 (NERI-AE unpubl.). The data mainly reflect areas where the resources are utilised, however the data is also used as an indicator of the presence of the species. Moreover is information from Petersen (1983a, b, c & d), Nielsen et al. (2000) and more general information from Mosbech et al. (1998) included.

Snow crab

GINR provided information from the fisheries in 2001, which is unpublished, limited and not complete. This is augmented with information from Glahder (2001), which however only covers Nanortalik municipality. As the snow crab fishery in entire West Greenland is of a new date (since mid-1990'es), and still in development, many new fishing grounds may be encountered in the future. On the other hand signs on over-fishing seem to be apparent now in some areas.

Scallop

GINR has supplied the data regarding scallop fishery. The data are distributed between the years 1991 to 1999 and each single catch is referred to a geographical position. More general information derives from Mosbech et al. (1998). According to GINR the fishing areas are fairly stable in time. However new fishing grounds may turn up and some may be overexploited and given up.

Deep sea shrimp

The data on the fisheries in South Greenland are provided by GINR and derive from 1999 and 2000.

14.4.5 Resource use

Data are extracted from the NERI-AE interview survey (unpubl.) regarding fishery for capelin, lumpsucker and Arctic char. From the large unpublished material collected by Petersen (1993a, b, c & d) more information on human use of living resources is derived mainly on fishery (capelin, lumpsucker, Arctic char, Atlantic cod (mainly pound net fishing in fjord areas), Atlantic halibut, wolffish (mainly spotted), redfish, snow crab and scallop) and hunting (seabirds mainly guillemots and eiders) seals and whales. An interview survey on hunting and fishing carried out in relation to the development of a gold mine in Nanortalik municipality (Glahder 2001) and a combined literature and interview survey on human use from Narsaq municipality (Dietz 1989) is also included. Data on the location of fin- and minke whales hunting sites were provided by GINR (Witting 2000). Finally unpublished material from NERI-AE is included.

Resource use also include the use of the coast as tourist attraction. In the region covered by this atlas adequate information has been obtained from interviews with relevant local people in most of the municipalities except Paamiut and Ivittuut (NERI-AE unpubl.).

The relative human use figures for each segment is based on the number of exploited resources (incl. tourism). Max. number of exploited resources in a segment = 16.

No. of resources exploited	No. of segments	Human use figure
10	23	5
8-9	29	4
5-7	7	3
3-4	8	2
0-2	3	1

If there are more than 3 important Arctic char rivers in a segment the figure is raised with 1.

14.4.6 References

Boertmann, D. 2003. Seabird colonies and moulting harlequin ducks in South Greenland - results of a survey in 2003. - NERI Research Notes 191.

Boertmann, D. & A. Mosbech. 1997. Breeding distribution and abundance of the great cormorant *Phalacrocorax carbo carbo* in Greenland. - Polar Research 16: 93-100.

Boertmann, D. & A. Mosbech 2001a. Important summer concentrations of seaducks in West Greenland. An input to oil spill sensitivity mapping. - National Environmental Research Institute, Denmark, NERI Technical Report No. 345: 1-48.

Boertmann, D. & A. Mosbech 2001b. Offshore seabird distributions during summer and autumn at West Greenland. Ship based surveys 1977 and 1992-2000. National Environmental Research Institute, Denmark. Technical Report No. 370.

Boertmann, D., A. Mosbech, K. Falk & K. Kampp 1996. Seabird colonies in western Greenland. - NERI Technical Report No. 170. 148 pp.

Boertmann, D., A. Mosbech & P. Johansen 1998. A review of biological resources in West Greenland sensitive to oil spills during winter. - NERI Technical Report No. 246. 72 pp.

Boertmann, D., P. Lyngs, F. Merkel & A. Mosbech in print. The significance of Southwest Greenland as winter quarters for seabirds. - Bird Conservation International.

Brown, R.G.B. 1986. Revised Atlas of Eastern Canadian Seabirds. 1 Shipboard Surveys. - Canadian Wildlife Service. 111 pp.

Dietz, R. 1989. Nuværende anvendelse af områder i og tilgrænsende Narsaq Kommune, 1988. - Greenland Environmental Research Institute.

Durinck, J. & K. Falk 1996. The distribution and abundance of seabirds off south-western Greenland in autumn and winter 1988-1989. - Polar Research 15 (1): 23-42.

Glahder, C.M. 2001. Natural resources in the Nanortalik District. - NERI Technical Report No. 384.

McLaren, P.L. & R.A. Davis 1983. Distribution of wintering marine mammals off West Greenland and in southern Baffin Bay and northern Davis Strait, March 1982. - LGL Ltd. Toronto. 92 pp.

Merkel, F.R., A. Mosbech, D. Boertmann & L. Grøndahl 2002. Winter seabird distribution and abundance off West Greenland, 1999. - Polar Research 21: 17–36.

Mosbech, A. & S. Johnson 1999. Late winter distribution and abundance of sea-associated birds in Southwest Greenland, Davis Strait and southern Baffin Bay. - Polar Research 18: 1-17.

Mosbech, A., R. Dietz, D. Boertmann & P. Johansen 1996. Oil exploration in the Fylla Area. - NERI Technical Report No. 156. 90 pp.

Mosbech, A., D. Boertmann, J. Nymand, F. Riget & M. Acquarone 1998. The marine environment in Southwest Greenland. Biological resources, resource use and sensitivity to oil spill. - NERI Technical Report No. 236. 202 pp.

Nielsen, S.S., A. Mosbech & J. Hinkler 2000. Fiskeriressourcer på det lave vand i Vestgrønland. – Arbejdsrapport fra DMU nr. 118.

Petersen, H.C. 1993a. Registrering af levende ressourcer og naturværdier i Grønland. Hæfte 1. Nanortalik Kommune. Grønlands Hjemmestyre (unpublished).

Petersen, H.C. 1993b. Registrering af levende ressourcer og naturværdier i Grønland. Hæfte 2. Qaqortoq Kommune. Grønlands Hjemmestyre(unpublished).

Petersen, H.C. 1993c. Registrering af levende ressourcer og naturværdier i Grønland. Hæfte 3 Narsaq Kommune. Grønlands Hjemmestyre(unpublished).

Petersen, H.C. 1993d. Registrering af levende ressourcer og naturværdier i Grønland. Hæfte 4. Paamiut Kommune og Ivittuut Kommune. Grønlands Hjemmestyre(unpublished).

Teilmann, J. & R. Dietz 1998. Status of the harbour porpoise in Greenland. - Polar Biology 19: 211-220.

Witting, L. 2000. Seasonal and geographical distribution of catches of minke and finwhales in West Greenland 1988-99. – Unpublished manuscript to the International Whaling Commission.

14.5 Archaeological and historic information

14.5.1 Introduction

Settlement in Greenland

Greenland has been populated for two long periods, which together span c. 4,400 years. The oldest period is c. 2400 BC-200 AD; the later period is c. 1000 AD until the present day.

The settlement strategy of the various cultures, the visibility of the features and the utilisation of the resources of the country have left their mark on the landscape. The area in question covers the west coast from 59º N to 62º N plus the east coast from Cape Farewell to Cape Discord at Danell Fjord.

As the crow flies this is about 500 km, but in practice it is much farther because of the long fjords. In this area there are at present some 1,500 archaeological sites, which are registered in the central database of the Greenland National Museum & Archives (NKA), and which are therefore subject to the terms of the Conservation Act (see below). Of the c. 1,500 individual sites c. 1,000 are coastal and included in this atlas.

The natural conditions within the mapped coastal stretch vary greatly from the outer coast to the inner fjords. Climatically, it is in the southern part of the Low Arctic zone, but in the inner fjords the climate is more Sub-boreal. In certain places the land between the inland ice sheet and the sea consists of bare, alpine, barren Archaean rock, while in other places there are deeply ramified fjord landscapes with the large vegetation-covered areas, which were among the preconditions for the Norse way of life.

In the summer the area is typified by the enormous quantities of drift ice that usually come with the sea currents from East Greenland. In the winter the fjords are closed by sea ice, while there is still open water out at sea. These conditions provide very different possibilities for settlement, for transport and for access to resources depending on the traditions and cultural preconditions that form the starting-point for the settlers.

All Inuit immigrations to Greenland came from Ellesmere Island over Smith Sound to the Thule (Avanersuaq) area. Around the year 1000 AD the immigration came from the east, as Icelandic farmers settled in South Greenland. In 1721 Hans Egede established the mission station "Håbets Koloni" ("Hope Colony") (the predecessor of present-day Nuuk), and the foundation was laid for the development of modern Greenland.

In South Greenland the oldest part of the Palaeo-eskimo period in the history of Greenland, which covered the cultural periods termed 'Saqqaq' and 'Early Dorset', i.e. c. 2400 BC-200 AD, is extremely poorly represented in the material. There are sporadic finds but no concrete settlement structures. Settlements and finds from these periods are known in large numbers from almost all areas outside the one in question: from Nuuk to Hall Land on the west coast and from Peary Land to Skjoldungen on the north, east and southeast coasts. This lack of material must be due to among other things:

- lack of awareness in former times of the Palaeo-Eskimo period
- inadequate reconnaissance in more recent times
- land subsidence/the rising of the sea level, which have left older low-lying sites under water or eroded them down to the beach level

Settlements from the Late Dorset period, c. 1000-1200 AD, are only known in the Thule area. Along the west coast a very small number of Late Dorset implements have been found, but no settlements. At the Norse farms in South Greenland the presence of a few Late Dorset implements suggests that the Norsemen met these people and exchanged tools and/or raw materials with them. This presumably happened during the Norsemen's journeys far to the north in the Thule area.

Around the same time as the Late Dorset people arrived in the Thule area, around 1000 AD, the Icelandic immigrants – the Norse Greenlanders – settled in Southwest Greenland. The relatively mild, fertile fjord areas in South Greenland – combined with the resources from the sea - permitted the Norsemen to sustain themselves for several centuries with a combination of farming, cattle breeding and hunting.

In the course of the thirteenth century, the last great Inuit wave came from Alaska. Via Canada the people of the Thule culture (Inuit) came over Smith Sound to Northwest Greenland. From there they quickly spread all over the country. The Thule people were whalers and sealers. The umiaq ('women's boat'), kayak and dog-sledges gave them great mobility and the potential for incorporating whaling in their hunting.

Around 1500 the Norse Greenlanders had gone, and the Thule people had settled along the coast all the way round Greenland. In the centuries after that there were both great migrations of people along the coasts and considerable local shifts in settlement between the outer coast and fjords in regions like Southwest Greenland as a result of the 'Little Ice Age' in the 16-1700's.

Southwestern Greenland is an area with a rich, exciting history from 1000 AD on, and a very obscure history for the oldest periods, where the few remains today are threatened by natural phenomena (sea rising/land sinking). The very scanty evidence of Palaeo-eskimo presence in coastal settlements will therefore quite naturally be given a higher risk assessment than the same features would have in other parts of the country.

Which items of archaeological and historical interest are included?

All known coastal archaeological and historical find-sites (minus colonial trading posts, villages and the like) are included in this atlas, but with a view to the protection of the antiquities only the basic site information is included.

If, in connection with an acute situation or for other reasons, it emerges that there is a need to establish a higher state of preparedness, detailed information about the individual sites can be obtained from the Greenland National Museum & Archives, Box 145, DK-3900 Nuuk, which can be contacted by telephone at (+299) 32 26 11 or e-mail: grnatmus@greennet.gl

The conservation act

If a man-made feature is from before 1900, it is protected by the terms of "Landstingslov nr. 5/1980 af 16. oktober 1980 om fredning af jordfaste fortidsminder og bygninger" ("The conservation act"). The Greenland National Museum & Archives administers this act and is responsible for the registration of antiquities.

14.5.2 Description of the data

History

For more than 200 years, information has been gathered about archaeological sites in Greenland. The oldest reports are from the beginning of the eighteenth century, when Denmark began the colonisation of Greenland, and the Christian mission entered the picture in earnest. The first missionaries were much preoccupied with the fate of the Norse Greenlanders and visited the ruins of their settlements. Thus throughout the 1800's a large body of material was submitted to shed light on the history of Norse settlement. But it was only after 1900 that serious interest in the indigenous population of the country arose. At the beginning of the 1930's, proper archaeological investigation of the prehistory of the Inuits began.

With the transfer of the conservation and museum acts to the Greenland Home Rule in 1981, the collected knowledge of antiquities in Greenland was systematised in the form of card indices, overview maps, conservation numbers etc. This knowledge has been regularly developed and updated by field surveys and other ways of gathering information about the antiquities. Most recently all this material has been entered in a database, which is subject to ongoing expansion and quality assurance.

The data

Information about the individual sites is a mixture of experts' inspections in older and more recent times and various kinds of information from past and present. It is a mixture of high quality site information, less good information and poor information. The latter categories may also include information that has not yet been verified by specialists. This atlas include information that sounds credible and can be localised. The settlement type has typically been inferred from the feature types. Place-names have been used to shed light on the activities in the area in question. An attempt has been made to update the information up to and including the summer of 2002.

Data quality

Much of the information comes from secondary sources, which have certain shortcomings in the present context. We may lack information on which and how many features are covered by the registration, on how old they are believed to be, how close to the present sea level they are, their state of preservation etc. – information which today is important for the assessment of their sensitivity in the event of a pollution threat. If surveys/maps from the last 20-30 years are available, the relevant information usually is at hand.

For most of the coastal sites we have no information on their position in terms of metres above sea level. In some cases this has been estimated on the basis of other available information and/or personal experience. All coastal sites with no information on altitude above sea level are treated in this atlas as being in the risk zone for oil spills, Group 2, until proved otherwise.

The more recent field surveys in the area have given rise to two typical comments in the database:

a. The site could no longer be found.
b. The site no longer exists.

The first of these indicates that the site is not at the place indicated, but that it may exist somewhere else nearby, or that it may have been eroded away. Sites with such information have been retained as fully valid items in this atlas since the littoral zone may have unverified remains, or there may be features/remains close by which have not yet been registered.

The second comment means that we have positive knowledge that there was once a feature or features at the place but that they have now disappeared. This may have happened for example as a result of coastal erosion or construction activities. Sites listed with such information have been retained as fully valid items in this atlas, since the beach zone may still have remains or traces of the features originally observed.

In a number of cases there is uncertainty about the precise geographical position of the site. On the original maps (not included here) of the antiquities each 'antiquity circle' covers an area with a diameter of 500 metres. The transfer of 'points' from paper maps to a digital map has only increased the precision if more recent GPS coordinates have been obtained.

In the section "Sensitivity assessment" there is an account of the principles underlying the assessment of the individual sites.

14.5.3 Geographical coverage

Besides the geographical conditions – and thus the presence of available resources – there are many factors which must be considered when one is assessing the representativity of the registered coastal sites. The following remarks should be noted with regard to the various municipalities:

Nanortalik municipality includes parts of the Norse *Eastern Settlement*. The area has been the object of extensive archaeological research for more than a century. In addition, comprehensive reconnaissances have been conducted in recent years – including 2002 –. There are still clear gaps in our information for the following areas:

- throughout Prins Christian Sound,
- on the east coast north and south of Prins Christian Sound,
- the whole archipelago Kitsissut off Nanortalik.

The municipality is considered fairly well covered. But many new archaeological sites may appear in the future.

Qaqortoq municipality includes parts of the Norse *Eastern Settlement*. Throughout the 1980's and to some extent in the 1990's there have been inspections of large parts of the area with special reference to the mapping of ruins and securing them against damage in the sheep-farming areas. The outer coast has been carefully surveyed in important areas, while we still lack a detailed archaeological mapping of:

- several islands along the sea coast,
- the region from Saqqarmiut (at Sermilik) via Nunarsuit up to and including Kobberminebugten (Copper Mine Bay)
- the southernmost part of the municipality at Alluitsup Paa (Sydprøven)

The material is considered more or less complete as far as the inner fjords and the Norse remains are concerned, but information about Inuit sites still has substantial deficiencies. Many new Inuit sites may appear in the future.

Narsaq municipality includes a large part of the Norse *Eastern Settlement*. It has been the object of intensive archaeological research for more than a century. In addition, extensive field surveys were carried out in the 1990's.

The municipality is considered fairly well covered. But we must constantly expect new sites to emerge.

Ivittuut municipality includes the Norse *Middle Settlement*. There has been a good deal of archaeological registration activity in the area since the 1980's.

The municipality is considered to be fairly well covered. We must constantly expect new sites to emerge.

Paamiut municipality has been the object of extensive archaeological reconnaissance in the 1980's, but a number of islands in the archipelago area have not been visited. Experience suggests that there is considerably potential for archaeological 'bonuses' on these islands. We lack archaeological mapping in the southern part of the area with the fjords Sermilik, Sermiligarsuk and Kvanefjord.

14.5.4 Explanations of the classification and terms

Identification

Fmnr.

Each archaeological site entered in the Greenland Archive of Antiquities (GFA) has a *fredningsnummer* ('conservation number'). All man-made remains from before 1900 are subject to the conservation act. When a report on a new find is received, the site is assigned a conservation number and entered in the GFA.

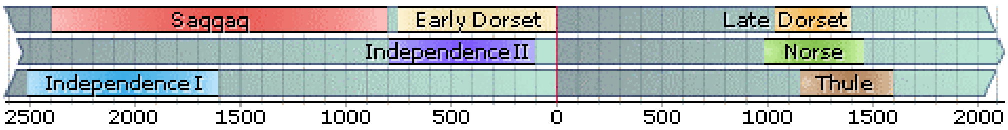
Datings

Periods of cultural history

For each site in GFA there is an account of when or in what periods the individual features were used – that is, which periods of cultural history are represented. Distinctions are made between Inuit, Norse and European origin. If we only know that there are ruins at the place with no dating, we use the overall category "Unknown".

Inuit

The table shows the Inuit cultural periods that are known in Greenland and their chronological placing. If no accurate dating has been possible, one must refer to the next level above. The Independence cultures belong in North West Greenland.



The Palaeo-eskimo period is considered as lasting until the end of "Late Dorset". With "Thule" begins the Neo-eskimo period, which lasts until 1900 AD.

Norse

The period from the *landnam* (pioneering settlement) of Eric the Red until the collapse of the Norse society, i.e. *c.* 985-1450 AD.

Whaling

European cultural traces dated within the period *c.* 1450-1721 AD, the latter being the year when Denmark's colonisation of Greenland began.

Colonial

The period from 1721 until 1900 AD.

Recent

All cultural traces that are more recent than 1900 AD, If there are recent features at an archaeological site, this is noted in GFA, even if they are not subject to the protection of the conservation act. No distinction is made here between Inuit and European features.

Site type The general terms for site types given below are used in GFA. More detailed information on the feature types and other traces of activity at the individual sites have been entered in the database if they are available.

14.5.5 Sensitivity assessment

General assessment

Most of the coastal Inuit settlements were established close to the sea and just above the present-day high-water line. Most of the Norse structures lie inland, but there are also many along the coast, where they have been subject to the same erosive forces as many of the Inuit remains.

Because of the sinking of the land and/or the rising of the sea, many sites may today lie very close to- or even below - the current high-water line. These will therefore be particularly sensitive in the event of an oil spill:

- Directly, because contamination will in several ways mean a deterioration of the scientific documentation value of the cultural deposits:
  - the preservation conditions for organic material will become considerably poorer
  - the possibility of conducting analyses and scientific datings will be destroyed.

- Indirectly, because emergency measures or land-based action would be difficult to implement without causing substantial physical damage to the coastal ruins and culture layers.

Many of the registered cultural remains are very difficult to recognise in the terrain, even for the trained eye. The sensitivity assessment of the archaeological sites must therefore only be regarded as providing guidelines. It is assumed that in the event of a spill, archaeological expertise will be involved in the planning of the emergency measures and in the practical implementation of the plan.

The assessment of sensitivity is based both on factual knowledge of the relevant local cultural history of the region and on qualified opinion.

Since the atlas covers all the known coastal sites, in principle they are all without exception at risk in the event of coastal land-based activities in connection with an oil spill.

Criteria for the assessment

The criteria applied are in principle the same as were used for the sensitivity assessment of the archaeological sites between 62° N and 68° N in the *Environmental Oil Spill Sensitivity Atlas for the West Greenland Coastal Zone*, 2000. The differences lie on the one hand in a more rigorous linguistic approach to the criteria and on the other in the transfer of all "coastal sites on which there is at present no more detailed information" from Group 1 to Group 2, until we have proof that a site should be in one of the other groups. The sensitivity of the items of archaeological interest is expressed on an ascending scale from 1 to 3:

1. Sites considered not likely to be affected by pollution.

2. Sites considered likely to be directly affected by pollution.

3. Sites of special importance which require special status in the event of an oil spill or other activities in connection with raw material exploration and extraction.

Group 1 comprises sites situated more than 20 metres above sea level, or traces of features considered to be of very little importance as historical documentation, because they are very poorly preserved.

In principle the features in this group could be threatened by land-based activities, for example in connection with oil spills.

Group 2 comprises a. all coastal archaeological sites deemed to represent historical source value, b. sites considered to have recreational value or sightseeing value, and c. sites which can be localised, but about which there is at present no further information.

In principle the features in this group could be threatened by land-based activities, for example in connection with oil spills.

Group 3 meets the criteria for Group 2 items a and b, but these sites are further considered to have quite special importance, especially in scientific respects. The basis of this evaluation may be the result of archaeological investigations, historical source material or the like.

The sightseeing value or the local population's use of the locality in question may also be included as criteria.

In principle the features in this group could be threatened by land-based activities, for example in connection with oil spills.

See also: Photos from archaeological sites.

14.6 Selected areas

14.6.1 Brief description of the areas

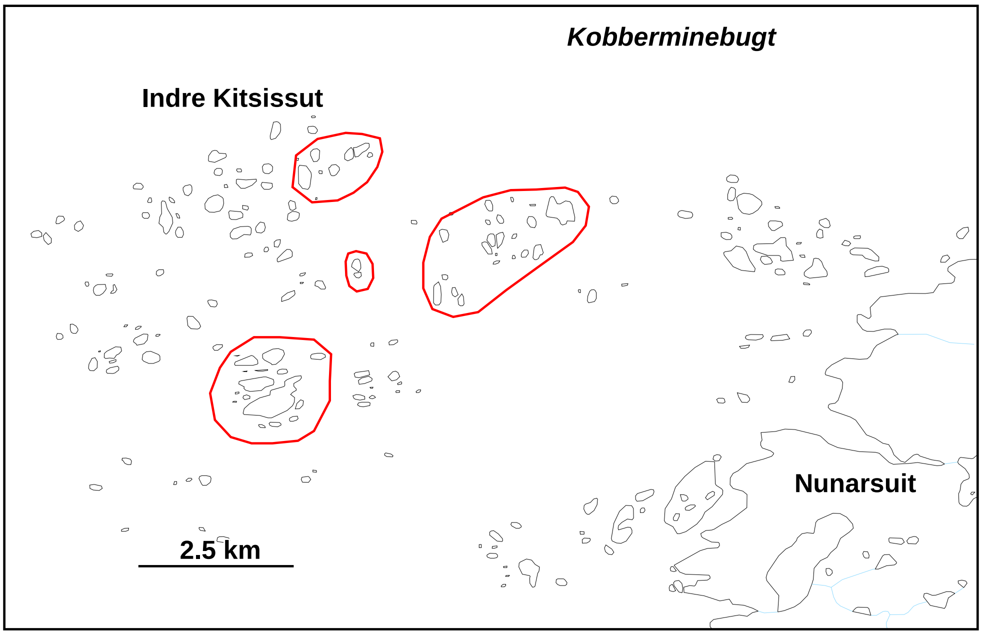
This is a summary of the selected areas in the South Greenland region, as referred to in chapter 6.4.

S83. A seabird breeding colony on a steep cliff. The seabirds include Iceland gulls, kittiwakes and razorbills.

S84. The head of Ilorput/Arsuk Fjord. The very important seabird breeding colony Fox Faldet is situated here. The birds on this steep cliff include Brünnich's guillemots, kittiwakes and Iceland gulls. The fjord is also an important fishing and hunting area.

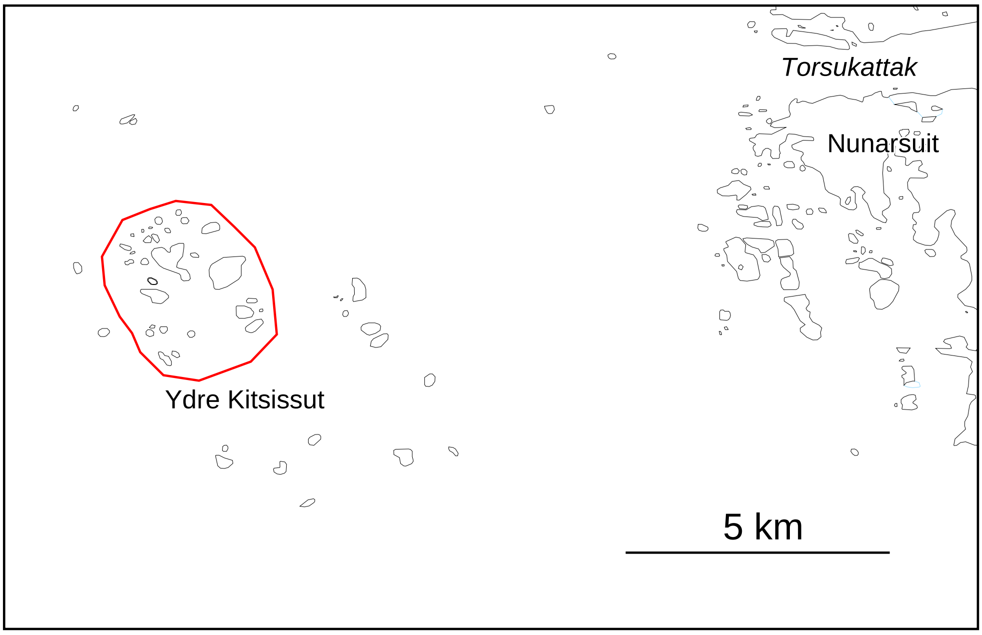
S85. The head of Ikka Fjord. From the sea bottom some very peculiar and unique columns raise towards the surface. They are made up from the mineral ikait, which is unstable in air. This part of the fjord is a nature protection area with restricted access for boats and ships.

S86. The archipelago Indre Kitsissut. There are many seabird breeding colonies among the islands. The species include Atlantic puffins, razorbills, white-tailed eagles, Iceland gulls etc. There are also many moulting and wintering harlequin ducks. The coasts are rocky (Figure 7.4). The most important islands are framed with red on this map:



S87. The archipelago Ydre Kitsissut. These islands hold the most diverse seabird breeding colony in Greenland. The most important species are Brünnich's guillemots, Atlantic puffins, razorbills, kittiwakes and northern fulmars. The coasts are rocky and the islands are extremely exposed to the ocean. The following map shows the most important islands framed with red. The islands are designated as a Ramsar-site (International convention for the protection of wetlands).

S88. Head of fjord (without name). On the steep cliffs there are several seabird breeding colonies with Iceland gulls and kittiwakes.



S89. Tasiusaq west of Qassiarsuk. This bay is an important area for Arctic char fishing. The shores is also an important hiking and angling area for tourists. There are archaeological sites along the coast.

S90. The strait of Akorna. There are two seabird breeding colonies on the islands. Breeding birds include Kittiwakes, Iceland gulls and black guillemots. The coasts are low cliffs, steep cliffs, talus and moraine.

S91. Najaat. A small, barren and smooth island. This extremely exposed rock house a seabird breeding colony with razorbills, black guillemots, Atlantic puffins and perhaps Brünnich's guillemots.

S92. Head of the fjord Kangersuneq Qinngorleq. On the steep cliffs there are several seabird breeding colonies with Iceland gulls and kittiwakes.

S93. The archipelago Qeqertat. These small and low rocky islands are extremely exposed to the ocean. They house a large colony of breeding common eiders.

S94. The bay of Tasiusaq. This shallow bay is an important area for Arctic char, capelin and lumpsucker fishery. The settlement and surroundings are a tourist excursion site. The coasts are made up from moraine with large boulders.

S95. Bay of Akulleq. This is an important fishing area for lumpsucker, scallop and Arctic char. It is also an important hunting area, particularly in winter.

S96. Bays on the island Tuttutooq. These two bays are important fishing and hunting areas. Fisheries are a.o. aimed at capelin, lumpsucker and Arctic char. There are some archaeological sites along the coasts.

S97. Qaqortup Imaa. In this area the famous archaeological site Hvalsøy is situated. This medieval church ruin is an important tourist attraction. There are also fisheries for capelin and lumpsucker.

14.6.2 Pinpointing "The selected areas" using a grid-based GIS-analysis

The selection of these areas is based on the principles from a Norwegian system (Anker-Nilssen 1994), which gives priorities to oil spill sensitive areas for oil spill contingency planning. While the Canadian index system covers the entire coast in 50-km units, and thus gives a general overview of the sensitivity, the selected areas system uses actual topographic borders and thus pinpoints the sensitive areas and leaves the rest unclassified.

The basis for their selection is, compared to the coastline in general, that they are:

1. of high value either environmentally or for resource use,
2. sensitive to oil spill, and
3. of a size and form that may allow effective protection in an oil spill situation with a manageable amount of manpower and equipment.

The last criterion is important because it elucidates the rather limited possibilities to protect all coastlines during a large oil spill.

The selection process was supported by a grid-based GIS analysis of biological, human use, cultural and geomorphological data. The GIS analysis was performed using ESRI's spatial analyser and a grid-cell size of 2.5 km.

Table 14.10. Overview of input data and data layers for the selected areas GIS-analysis.

Data type	Data layer	Potential range of grid cell values
Coastal morphology	Oil residence index (ORI), calculated layer based on exposure, shore type, substrate and slope (1 layer) Exposure Shore type Substrate Slope	1-5
Tourism	Hiking, angling, excursions, attractions and tours (1 layer)	0 or 10 or 20
Archaeological and historic sites	Coastal sites (class 2 and 3) (1 layer)	0-22
Birds	Birds colonies (13 species with a layer each) Winter seabirds (5 species with a layer each) Birds moulting (1 layer)	0-25 0-2.5 0-24
Shellfish	Snow crab (1 layer) Scallop (1 layer) Deep sea shrimp (1 layer)	0 or 9 0 -18 0 or 6
Fish	Arctic char (1 layer) Capelin (1 layer) Lumpsucker (1 layer) Greenland halibut (1 layer)	0-14 0-21 0-15 0-7

All data was gridded in 2.5 x 2.5 km cells and calculations of sensitivity index values for each cell followed largely the index calculation of assigned values for the 50-km segments. However, not only geographic resolution but also the resolution in number of species and relative abundance was higher in the "Selected area" GIS analysis. The GIS analysis was based on 29 data layers (Table 14.10).

A GIS layer with oil residence index (ORI) values was calculated based on exposure, shore type, substrate and slope. For biological occurrences, GIS layers with relative abundance (RA) x relative sensitivity (RS) values were produced. Abundance data were normalised to give the relative abundance on a scale from 0 to 1 for all species, except for winter seabirds which were so widespread that a scale from 0-0.1 was applied to balance their importance. Relative sensitivity values are given in Table 14.11. Layers with values representing value and sensitivity of archaeological and historic sites and areas important for tourism were also produced. Values in all layers (except ORI) were summed and multiplied by ORI to produce a priority index value layer.

Preparation of GIS layers
(References see 14.4.5)

Bird colonies, winter seabirds and moulting birds
Abundance data:
Data on bird colonies comes from the Seabird colony database NERI 2003.
Data on winter seabirds comes from Merkel et al. (2002) and NERI (unpubl.).
Data on moulting birds comes from Mosbech & Boertmann (1999), Boertmann & Mosbech (2002).

Fish
Abundance for each grid cell has been calculated by summation of values for spawning (10), fishing (5 or 10) and fishing sites (5 or 10). Data comes from GINR, Olsvig & Mosbech (2003) and Olsvig & Mosbech (in prep.).

Shellfish
Abundance of scallops was classified by the fishery intensity measured by numbers of hauls (0 to 1). The relative abundance of deep sea shrimps and snow crabs was classified as fishery present (1) or fishery not present (0). Data comes from GINR.

Tourism
For tourism data a buffer-zone of 1 km has been applied to the vector data before gridding, and the values 20, 10 and 0 have been applied to the grid cells with important tourism, some tourism, and no tourism respectively. Tourism input data comes from interviews in 2003.

Archaeological and historical sites
Archaeological and historical site data comes from the National Museum and Archives database 2003.

Oil residence index
A layer with oil residence index (ORI) grid cell values was calculated based on exposure, shore type, substrate and slope using the same algorithm as for the 50-km segments (see chapter 6.3 and 14.2). The full spatial resolution (approx. 2 km) of the geomorphologic data set has been used.

Priority index value layer
The priority index values were calculated for each grid cell by multiplying the sum of all the other layers with the ORI value.

Final selection
The final process of deciding on the “selected areas” was done based on a series of maps showing priority index values for different combinations of data layers (maps included on CD-version).

This process of pinpointing small areas using data with high spatial resolution is more sensitive to lack of data and imprecise data than the classification of the 50-km segments. This was taking into account in the final selection process were the results of the GIS analysis was used as support for a selection based on best professional judgement.

Site specific information already presented as site specific on the operational maps (bird colonies and archaeology) was toned down in the selection process to allow the other data to pinpoint the high value sites otherwise averaged out on the 50-km segments.

The assessment of the potential for oil spill protection was on a site by site basis for a number of preliminary selected sites. Some rather large sites were accepted although it will only be realistic to protect them partially in an oil spill situation. This was done because of the high importance of these sites and that protection of even a minor part will be valuable. Furthermore we do not have detailed data to reasonably split them up in a number of smaller selected areas representing zones of sensitivity.

Example 1
Example of GIS-analysis used in support of pinpointing "selected areas". The map shows grid-cells (2,5 x 2,5 km) with priority index values higher than 100 as black squares. The priority index values in this example are calculated including layers for tourism, bird colonies, bird moulting areas, seabird wintering areas, fish (including both spawning and fishing areas), shellfish fishing areas (including shrimp), coastal archaeological sites and coastal morphology (including wave exposure). The final "selected areas" used on the sensitivity maps are indicated with green borders. It is seen that some "selected areas" do not have grid-cells with high priority index values, and some grid-cells with high values are not included in "selected areas". The final selection has been based on professional judgement (including assessment of data limitations) and local consultation.

Example 2
Example of GIS-analysis used in support of pinpointing "selected areas". The map shows grid-cells (2,5 x 2,5 km) with priority index values higher than 124 as black squares. The priority index values in this example are calculated as above, but without layers for bird colonies and coastal archaeological sites. The final selected areas are indicated with green borders.
See text for further explanations.

Table 14.11. Relative sensitivity values of resources and species.

Species name	Vulnerability	Mortality potential	Sublethal potential	Recovery period	Relative sensitivity
Arctic char	Moderate	Low/ Short	Moderate	Moderate	14
Capelin	Very high/ No recovery	High/ Long	High/ Long	Moderate	21
Lumpsucker	Moderate	Moderate	High/ Long	Low/ Short	15
Greenland halibut	Very low/ Very short	Very low/ Very short	Low/ Short	Low/ Short	7
Snow crab	Very low/ Very short	Low/ Short	Moderate	Low/ Short	9
Deep sea shrimp	Very low/ Very short	Very low/ Very short	Low/ Short	Very low/ Very short	6
Scallop	High/ Long	Low/ Short	High/ Long	High/ Long	18
Breeding Arctic tern	Moderate	High/ Long	Very high/ No recovery	Very high/ No recovery	20
Breeding Atlantic puffin	Very high/ No recovery	Very high/ No recovery	Very high/ No recovery	High/ Long	24
Breeding black guillemot	High/ Long	Very high/ No recovery	Very high/ No recovery	Moderate	21
Breeding Brünninch's guillemot	Very high/ No recovery	Very high/ No recovery	Very high/ No recovery	Very high/ No recovery	25
Breeding common eider	Very high/ No recovery	Very high/ No recovery	Very high/ No recovery	High/ Long	24
Breeding glaucous gull	Moderate	High/ Long	Very high/ No recovery	Low/ Short	17
Breeding great black-backed gull	Moderate	High/ Long	Very high/ No recovery	Low/ Short	17
Breeding Iceland gull	Moderate	High/ Long	Very high/ No recovery	Low/ Short	17
Breeding kittiwake	High/Long	High/ Long	Very high/ No recovery	Low/ Short	19
Breeding lesser black-backed gull	Moderate	High/ Long	Very high/ No recovery	Low/ Short	17
Breeding little auk	Very high/ No recovery	Very high/ No recovery	Very high/ No recovery	High/ Long	24
Breeding northern fulmar	Moderate	High/ Long	High/ Long	High/ Long	18
Breeding razorbill	Very high/ No recovery	Very high/ No recovery	Very high/ No recovery	High/ Long	24
Wintering Brünninch's guillemot	Very high/ No recovery	Very high/ No recovery	Very high/ No recovery	Very high/ No recovery	25
Wintering king eider	Very high/ No recovery	Very high/ No recovery	Very high/ No recovery	Very high/ No recovery	25
Wintering black guillemot	High/ Long	Very high/ No recovery	Very high/ No recovery	Moderate	21
Wintering common eider	Very high/ No recovery	Very high/ No recovery	Very high/ No recovery	Very high/ No recovery	25
Wintering long tailed duck	Very high/ No recovery	Very high/ No recovery	Very high/ No recovery	Moderate	23
Moulting harlequin duck	Very high/ No recovery	Very high/ No recovery	Very high/ No recovery	High/ Long	24

14.7 Defining offshore areas for the sensitivity analysis

In order to map the sensitivity of the offshore habitat this has been divided into a suitable number of offshore areas for which the sensitivity index values has been calculated. Consideration has been given to the spatial resolution of available physical, biological and human use data when deciding on the size of the offshore areas and moreover should the areas be of a more or less similar size. For making it easier to use the Atlas it was decided to use the same offshore area boundaries for all seasons.

The available biological data from the offshore region are very unevenly distributed while some of the physical data (especially bathymetry and the satellite data) has a uniform coverage throughout the entire region. Therefore the delimitation of the offshore areas is based on the physical data.

A cluster analysis of oceanographic, bathymetric and climatic data was applied to support the definition of the single offshore areas, so their limits more or less would follow natural boundaries.

We performed cluster analyses using the statistical software SAS (PROC FASTCLUS and PROC CLUSTER). The aim of the cluster analyses was to support the definition of ecological meaningful offshore areas for the sensitivity mapping with a statistical robust procedure. The variables available for the cluster analysis are listed in Table 14.12a, b.

For the cluster analysis all data was resampled to a grid with a spatial resolution of 25 km x 25 km. The data coverage throughout the year of the environmental variables was quite different. E.g. there is a lack of many variables during winter month in areas mostly covered by ice. It was therefore decided to split the year into the seasons used in the sensitivity analysis (January – March, April – May, June – August and September to December). Cluster analyses were performed separately for each of these seasons and for the whole year. Furthermore, the number of environmental variables included in the analyses varied to test the sensibility of the results. Table 14.13 shows the environmental variables and seasons included in the cluster analyses performed.

Table 14.12a. The 12 variables included in the cluster analyses.

Variable	Description	Units
AirTemp (°C)	Air temperature	°C
Pressure (mb)	Air pressure	mb
SST (°C)	Sea surface temperature	°C
Wind (m/s)	Windspeed	m/s
Ice (%)	Ice coverage	%
Depth (m)	Sea depth	m
Slope (deg.)	Slope of seabottom	degrees
Dist2GL (Km)	Distance to Greenland coast	km
Temp0m (°C)	Temperature at surface (0 meter)	°C
Temp30m (°C)	Temperature at 30 meter depth	°C
Sal0m (psu)	Salinity at surface (0 meter)	psu
Sal30m (psu)	Salinity at 30 meter depth	psu

Table 14.12b. Technical information on the environmental variables included in the cluster analyses.

Environmental variable	Data source	Data product	Spatial resolution	Time period covered and time resolution
AirTemp	NOAA (satellite)	COADS	1x1 degree	Monthly mean 1988-1997
Pressure	NOAA (satellite)	COADS	1x1 degree	Monthly mean 1988-1997
SST	NOAA (satellite)	COADS	1x1 degree	Monthly mean 1988-1997
Wind	NOAA (satellite)	COADS	1x1 degree	Monthly mean 1988-1997
Ice	NSIDC (satellite)	DMSP SSM/I Monthly Polar Gridded Sea Ice Concentrations	25x25 km	Monthly averaged 1988-1997
Depth	NGDC (NOAA)	IBCAO	2,5x2,5 km	(2000)
Slope	Calculated from "Depth"	-	2,5x2,5 km	(2000)
Dist2GL	Calculated from "Depth"	-	2,5x2,5 km	(2000)
Temp0m	NODC (NOAA) (satellite)	WOD01	Point measurements	Sporadic coverage 1988-1997
Temp30m	NODC (NOAA) (satellite)	WOD01	Point measurements	Sporadic coverage 1988-1997
Sal0m	NODC (NOAA) (satellite)	WOD01	Point measurements	Sporadic coverage 1988-1997
Sal30m	NODC (NOAA) (satellite)	WOD01	Point measurements	Sporadic coverage 1988-1997

NOAA = National Oceanic and Atmospheric Administration
NSIDC = National Snow and Ice Data Center
NGDC = National Geophysical Data Center
NODC = National Oceanographic Data Center
COADS = Comprehensive Ocean-Atmosphere Data Set
DMSP SSM/I = Defence Meteorological Satellite Program's Special Sensor Microwave/Imager.
WOD01 = World Ocean Database 2001
IBCAO = International Bathymetric Chart of the Arctic Ocean

Links:

COADS: http://web1.cdc.noaa.gov/cdc/data.coads.1deg.html

DMSP SSM/I: http://nsidc.org/data/nsidc-0002.html

IBCAO: http://www.ngdc.noaa.gov/mgg/bathymetry/arctic/arctic.html

WOD01: http://www.nodc.noaa.gov/OC5/SELECT/dbsearch/dbsearch.html

Table 14.13. Environmental variables and seasons used in the cluster analyses.

Season	Environmental variables
January-March	Ice, Depth, Slope, Dist2GL, Airtemp Pressure, SST, Wind
April-May	Ice, Depth, Slope, Dist2GL, Airtemp Pressure, SST, Wind
June-August	Ice, Depth, Slope, Dist2GL, Airtemp Pressure, SST, Wind
June -August	All 12 environmental variables
September-December	Ice, Depth, Slope, Dist2GL, Airtemp Pressure, SST, Wind
September-December	All 12 environmental variables

The environmental variables were standardised to have the mean value zero and the standard deviation of one because the variable are measured in different units. In order to decide the appropriate number of clusters in each case a preliminary cluster analyses with a number of clusters of 30 were performed. Based on the cubic clustering criteria, the pseudo F statistic and the pseudo t^2 statistic the number of clusters was decided in each occasion. The selected number of clusters varied between 5 and 7. The method used to measure the distance between clusters were the centroid method, which is defined as the squared euclidean distance between their centroids.

After deciding on an appropriate number of clusters in the preliminary cluster analysis, the cluster analyses were performed with a fixed number of clusters and the resulting clusters were mapped in a GIS. By comparing the cluster maps for the different seasons general tendencies became apparent and the boundaries for the offshore areas were drawn on overlays of the cluster maps for the four seasons.

For the South Greenland region this method resulted in six offshore areas.

For the resulting offshore areas the monthly mean values for the environmental variables used in the cluster analysis are summarised in table 14.14.

Table 14.14. Average of available environmental data (1988-1997) by month for the offshore areas OS13-18.

		Offshore Area					
Month	Variable	OS 13	OS 14	OS 15	OS 16	OS 17	OS 18
01	AirTemp (°C)	-1.3	-2.2	1.0	-3.1	-3.4	-4.7
	Pressure (mb)	994.9	997.5	992.6	995.7	996.5	995.4
	SST (°C)	3.7	3.2	2.6	1.4	1.4	-0.2
	Wind (m/s)	14.4	11.8	14.3	11.8	10.3	9.8
	Ice (%)	2.4	0.4	2.3	0.8	7.1	8.0
02	AirTemp (°C)	-1.4	-1.7	-2.0	-4.5	-4.2	-6.6
	Pressure (mb)	996.5	1001.2	997.6	997.4	996.5	998.0
	SST (°C)	3.5	2.4	2.4	0.8	0.7	-0.8
	Wind (m/s)	13.4	12.6	14.0	12.0	10.7	10.3
	Ice (%)	2.5	0.1	4.1	1.4	10.2	15.3
03	AirTemp (°C)	-0.5	-1.0	-3.8	-3.4	-3.3	-4.0
	Pressure (mb)	1001.0	1003.0	1005.2	1002.9	1003.5	1002.8
	SST (°C)	3.2	2.8	1.9	0.9	0.5	0.0
	Wind (m/s)	14.6	14.1	9.2	11.4	9.3	10.0
	Ice (%)	3.7	0.3	5.1	2.5	12.7	13.1
04	AirTemp (°C)	1.0	-0.1	-1.2	-0.6	-0.1	-1.0
	Pressure (mb)	1011.3	1011.1	1012.5	1011.0	1011.1	1011.1
	SST (°C)	3.2	2.5	2.1	1.2	0.9	0.2
	Wind (m/s)	13.3	11.0	9.2	10.0	8.4	8.3
	Ice (%)	3.2	0.0	3.2	1.1	18.7	5.7
05	AirTemp (°C)	3.2	2.7	1.5	1.9	2.1	1.5
	Pressure (mb)	1014.2	1014.7	1014.7	1016.0	1016.4	1016.1
	SST (°C)	3.7	3.4	2.7	1.9	1.6	0.7
	Wind (m/s)	10.2	9.3	7.9	7.5	6.9	7.4
	Ice (%)	2.1	0.0*	0.3	0.7	18.4	6.2
06	AirTemp (°C)	5.0	4.6	3.6	3.8	4.2	3.6
	Pressure (mb)	1010.9	1009.9	1012.1	1010.3	1010.8	1010.9
	SST (°C)	5.0	4.2	3.7	3.2	3.0	2.1
	Wind (m/s)	8.6	8.4	6.8	7.0	5.1	6.1
	Ice (%)	2.3	0.6	0.3	1.5	21.7	9.3

Table 14.14 (cont.). Average of available environmental data (1988-1997) by month for the offshore areas OS13-18.

07	AirTemp (°C)	6.4	6.5	5.9	5.1	5.1	4.8
	Pressure (mb)	1009.8	1010.1	1010.1	1010.4	1011.0	1010.2
	SST (°C)	6.3	6.3	5.6	4.5	4.2	3.6
	Wind (m/s)	7.7	7.1	6.1	5.9	4.8	4.7
	Ice (%)	1.5	0.5	0.2	1.0	9.7	8.4
08	AirTemp (°C)	7.2	7.8	7.0	5.0	4.9	4.5
	Pressure (mb)	1007.0	1008.9	1007.1	1007.9	1008.4	1007.3
	SST (°C)	7.1	7.2	7.5	4.4	3.8	3.5
	Wind (m/s)	9.2	6.6	6.7	6.7	5.2	6.6
	Ice (%)	1.2	0.6	0.5	1.1	5.5	8.2
09	AirTemp (°C)	6.0	6.7	5.8	4.4	4.4	4.2
	Pressure (mb)	1006.3	1006.0	1005.3	1006.5	1007.8	1007.8
	SST (°C)	6.7	7.2	6.3	3.8	3.4	2.9
	Wind (m/s)	9.4	9.6	8.8	8.0	7.0	7.8
	Ice (%)	1.9	1.3	0.8	1.6	5.4	6.5
10	AirTemp (°C)	4.5	4.5	3.4	2.2	1.8	1.7
	Pressure (mb)	1007.5	1009.4	1009.2	1009.3	1009.5	1008.3
	SST (°C)	5.8	6.0	4.4	3.3	2.2	2.2
	Wind (m/s)	11.8	11.0	8.7	9.4	8.3	9.5
	Ice (%)	0.2	0.2	0.1	0.1	2.0	3.8
11	AirTemp (°C)	2.5	2.7	1.8	0.8	0.6	0.0
	Pressure (mb)	999.5	997.4	999.5	1001.7	999.8	1003.2
	SST (°C)	5.0	4.9	3.7	2.5	1.8	1.1
	Wind (m/s)	14.5	12.2	10.2	11.5	10.4	10.3
	Ice (%)	0.1	0.1	0.0	0.1	2.1	3.9
12	AirTemp (°C)	0.8	2.4	-1.2	-1.8	-1.5	-3.0
	Pressure (mb)	1001.4	994.8	1000.0	1000.0	999.9	1001.7
	SST (°C)	4.3	3.8	3.0	1.7	1.2	0.6
	Wind (m/s)	14.9	16.5	10.6	12.0	11.5	9.9
	Ice (%)	1.0	0.5	0.2	0.6	4.1	6.1
01-12	Depth (m)	1872	3149	3183	1657	81	119
	Slope (°)	0.91	0.27	0.14	1.91	0.47	0.62
	Dist2GL (Km)	137	233	260	88	40	29
06-07-08	Temp0m (°C)	6.53	4.02	3.75	2.25	0.52	1.07
	Temp30m (°C)	6.29	3.87	2.82	1.63	0.84	0.03
	Sal0m (psu)	34.22	34.23	34.01	33.81	33.42	33.18
	Sal30m (psu)	34.50	34.33	34.14	33.76	33.51	33.20
09-10-11-12	Temp0m (°C)	4.60	5.41	3.21	2.76	2.03	2.76
	Temp30m (°C)	4.42	4.99	4.05	3.73	2.47	3.53
	Sal0m (psu)	33.49	34.50	33.77	33.08	32.35	32.99
	Sal30m (psu)	34.09	34.52	34.21	33.71	32.72	33.49

--no data

** only data from one year*

Table 14.14 (cont.). Average of available environmental data (1988-1997) by month for the offshore areas OS13-18.

07	AirTemp (°C)	6.4	6.5	5.9	5.1	5.1	4.8
	Pressure (mb)	1009.8	1010.1	1010.1	1010.4	1011.0	1010.2
	SST (°C)	6.3	6.3	5.6	4.5	4.2	3.6
	Wind (m/s)	7.7	7.1	6.1	5.9	4.8	4.7
	Ice (%)	1.5	0.5	0.2	1.0	9.7	8.4
08	AirTemp (°C)	7.2	7.8	7.0	5.0	4.9	4.5
	Pressure (mb)	1007.0	1008.9	1007.1	1007.9	1008.4	1007.3
	SST (°C)	7.1	7.2	7.5	4.4	3.8	3.5
	Wind (m/s)	9.2	6.6	6.7	6.7	5.2	6.6
	Ice (%)	1.2	0.6	0.5	1.1	5.5	8.2
09	AirTemp (°C)	6.0	6.7	5.8	4.4	4.4	4.2
	Pressure (mb)	1006.3	1006.0	1005.3	1006.5	1007.8	1007.8
	SST (°C)	6.7	7.2	6.3	3.8	3.4	2.9
	Wind (m/s)	9.4	9.6	8.8	8.0	7.0	7.8
	Ice (%)	1.9	1.3	0.8	1.6	5.4	6.5
10	AirTemp (°C)	4.5	4.5	3.4	2.2	1.8	1.7
	Pressure (mb)	1007.5	1009.4	1009.2	1009.3	1009.5	1008.3
	SST (°C)	5.8	6.0	4.4	3.3	2.2	2.2
	Wind (m/s)	11.8	11.0	8.7	9.4	8.3	9.5
	Ice (%)	0.2	0.2	0.1	0.1	2.0	3.8
11	AirTemp (°C)	2.5	2.7	1.8	0.8	0.6	0.0
	Pressure (mb)	999.5	997.4	999.5	1001.7	999.8	1003.2
	SST (°C)	5.0	4.9	3.7	2.5	1.8	1.1
	Wind (m/s)	14.5	12.2	10.2	11.5	10.4	10.3
	Ice (%)	0.1	0.1	0.0	0.1	2.1	3.9
12	AirTemp (°C)	0.8	2.4	-1.2	-1.8	-1.5	-3.0
	Pressure (mb)	1001.4	994.8	1000.0	1000.0	999.9	1001.7
	SST (°C)	4.3	3.8	3.0	1.7	1.2	0.6
	Wind (m/s)	14.9	16.5	10.6	12.0	11.5	9.9
	Ice (%)	1.0	0.5	0.2	0.6	4.1	6.1
01-12	Depth (m)	1872	3149	3183	1657	81	119
	Slope (°)	0.91	0.27	0.14	1.91	0.47	0.62
	Dist2GL (Km)	137	233	260	88	40	29
06-07-08	Temp0m (°C)	6.53	4.02	3.75	2.25	0.52	1.07
	Temp30m (°C)	6.29	3.87	2.82	1.63	0.84	0.03
	Sal0m (psu)	34.22	34.23	34.01	33.81	33.42	33.18
	Sal30m (psu)	34.50	34.33	34.14	33.76	33.51	33.20
09-10-11-12	Temp0m (°C)	4.60	5.41	3.21	2.76	2.03	2.76
	Temp30m (°C)	4.42	4.99	4.05	3.73	2.47	3.53
	Sal0m (psu)	33.49	34.50	33.77	33.08	32.35	32.99
	Sal30m (psu)	34.09	34.52	34.21	33.71	32.72	33.49

--no data

** only data from one year*

15 Appendix E, Place names

This is an index to all the place names used on the maps in Chapter 8 and 9. Some place names also have a name in Danish, which are listed too. Some place names only have a name in Danish, and these are listed at the end of the index. The positions listed are the positions of the names on the maps. If the place name occurs on several map-sheets, it is listed once for each map-sheet. Please note that on older maps the pre-1973 orthography of the names in Greenlandic is used.

Greenlandic	Danish	Map sheet	Latitude	Longitude
Aappilattoq		6003	60°90'	44°17'
Aappilattup Avannaa		6003	60°80'	44°22'
Akorna		6002	60°23'	45°20'
Akuliaruseq		6001	60°28'	45°30'
Akuliaruseq		6002	60°28'	45°30'
Akuliarusersuaq		6105	61°17'	46°20'
Akuliarutsip Timilersui		6102	61°35'	48°50'
Alanngorsuaq	Kobberminebugten	6051	60°56'	48°20'
Alluitsoq		6001	60°31'	45°32'
Alluitsup Kangerlua		6002	60°35'	45°26'
Alluitsup Kangerlua		6055	60°35'	45°26'
Alluitsup Paa	Sydprøven	6001	60°28'	45°34'
Amitsuarsuk		6055	60°45'	45°13'
Ammalortup Tunua		6002	60°27'	45°60'
Ammassivik	Sletten	6002	60°36'	45°23'
Ammassivik	Sletten	6055	60°36'	45°23'
Anarnitsoq	Vesterland	6151	61°45'	49°26'
Anorliuitsup Imaa		5952	60°60'	44°14'
Anorliuitsup Imaa		6003	60°60'	44°14'
Arfarfiarsuk		6101	61°12'	48°33'
Arfarfik		6101	61°15'	48°33'
Arsuutaa	Arsuk Ø	6102	61°90'	48°21'
Arsuutaata Saqqaa	Søndre Løb	6102	61°60'	48°17'
Avallersuup Ikerasaa		5953	59°50'	43°36'
Eqalorutsit Kangilliit		6105	61°21'	45°46'
Eqalorutsit Killiit Sermiat		6105	61°17'	46°10'
Eqalugaarsuit		6054	60°37'	45°55'
Eqaluit		6055	60°46'	45°34'
Eqaluit Iluat		6054	61°70'	45°55'
Eqaluit Iluat		6105	61°70'	45°55'
Igaliku		6055	60°59'	45°25'
Igaliku Kujalleq		6055	60°54'	45°17'
Igalikup Kangerlua		6055	60°48'	45°37'
Ikeq		5953	59°56'	43°47'
Ikerasak		6054	60°36'	46°60'
Ikerasak		6151	61°47'	49°27'
Ikerasak		6001	60°36'	46°60'
Ikerasak		6101	61°18'	48°31'
Ikerasassuaq		6052	60°48'	47°41'
Ikerasassuaq	Prins Christian Sund	6004	60°70'	43°33'

Greenlandic	Danish	Map sheet	Latitude	Longitude
Ikerasassuaq	Prins Christian Sund	5954	60°40'	43°10'
Ikerasaa		5951	59°55'	44°59'
Ikerasaarsuk		6101	61°15'	48°37'
Ikersuaq	Bredefjord	6053	60°51'	46°39'
Ikersuaq	Bredefjord	6054	60°57'	46°18'
Ikigaat		5951	59°59'	44°45'
Ikka		6102	61°80'	48°50'
Illorpaat		6002	60°28'	45°22'
Illukasiip Tunua		5951	60°40'	44°52'
Illukasik		5951	60°10'	44°51'
Ilorput	Arsuk Fjord	6102	61°13'	48°11'
Iluilaarsuk		6151	61°50'	49°25'
Imatsiaq		6002	60°30'	45°23'
Innap Saqqaa		6151	61°42'	49°90'
Isortoq		6052	60°58'	47°33'
Iterlak		6152	61°35'	48°57'
Iterlak		6055	60°55'	45°17'
Iterlassuaq		6051	60°59'	48°18'
Itillip Illua		5953	59°50'	43°49'
Iviangiusat Imaat		6053	60°53'	47°30'
Ivittuut		6102	61°12'	48°11'
Kanajormiut Ikerasaat		6002	60°24'	45°18'
Kangerlua		6054	61°40'	45°46'
Kangerlua		6054	61°40'	46°21'
Kangerluarsorujuk		6054	60°37'	45°51'
Kangerluarsuk		6054	61°40'	46°13'
Kangerluarsuk		6151	61°50'	49°17'
Kangerluarsuk		6054	60°49'	46°50'
Kangerluarsukasik		6151	61°54'	49°25'
Kangerluatsiaq		6053	60°56'	46°45'
Kangerluk		6003	60°13'	44°18'
Kangerluk		5953	59°59'	43°41'
Kangerluk		6004	60°11'	43°38'
Kangerlussuaq		6101	61°24'	48°41'
Kangersivasik	Kap Christian	5952	59°48'	44°70'
Kangia		5953	59°50'	43°57'
Kangikitsoq		6003	60°17'	44°13'
Kangikitsoq		6002	60°27'	44°54'
Kangilineq		6151	61°57'	49°27'
Kiattuut Sermiat		6106	61°14'	45°18'
Kitsissut Tunuat		5951	60°20'	45°8'
Kuannersooq		6151	61°58'	49°19'
Kuannit		6101	61°17'	48°28'
Kuannit		6102	61°17'	48°28'
Kujalleq		6055	60°54'	45°21'
Kukkilaap Ikerasaa		6054	60°44'	45°53'
Kuulik		5953	59°57'	43°27'
Maniitsup Tunua		6053	60°59'	46°30'
Nanortalik		6002	60°90'	45°14'
Narlunaq	Skovfjord	6054	60°46'	46°20'
Narsalik		6151	61°39'	49°20'
Narsap Saqqaa		5952	60°00'	44°42'

Greenlandic	Danish	Map sheet	Latitude	Longitude
Narsap Saqqaa		5951	60°00'	44°42'
Narsap Saava		6054	60°56'	46°11'
Narsaq		6054	60°55'	46°30'
Narsaq Kujalleq	Frederiksdal	5952	60°00'	44°39'
Narsarsuaq		6106	61°10'	45°25'
Natsiit Iluat		6051	60°52'	47°58'
Neria		6152	61°36'	48°51'
Neria		6151	61°38'	49°60'
Neria Kujalleq		6152	61°38'	48°39'
Niaqornaarsuk		6002	60°32'	45°14'
Nunannguit Tunuat		6101	61°13'	48°40'
Nunap Isua	Kap Farvel	5953	59°47'	43°55'
Nuugaarsuk		6002	60°33'	45°28'
Nuugaarsuk		6001	60°33'	45°28'
Nuup Kangerlua		6004	60°16'	44°50'
Nuup Kangerlua		6003	60°16'	44°50'
Nuup Kangerlua		6003	60°13'	44°10'
Naajat Sermiat		6053	61°40'	46°38'
Paamiut	Frederikshåb	6151	61°59'	49°40'
Qalerallit Imaa		6053	60°59'	46°39'
Qallimiut		6055	60°42'	45°22'
Qallumiut Imaa		6055	60°39'	45°21'
Qanisartuut		6055	60°48'	45°33'
Qaqortoq	Julianehåb	6054	60°43'	46°30'
Qaqortup Ikera	Julianehåbsfjord	6054	60°41'	46°12'
Qaqortup Imaa		6054	60°49'	45°53'
Qarmallip Kangerlua		5953	59°57'	43°19'
Qarmallip Kangerlua		5954	59°57'	43°19'
Qarmallip Kangerlua		5953	60°20'	43°29'
Qarmat		6053	60°44'	46°56'
Qasigialik		6152	61°32'	48°59'
Qasigialik		6101	61°32'	48°59'
Qassersuannguaq		6051	60°48'	48°80'
Qassiarsuk		6106	61°90'	45°31'
Qassiarsuk		6105	61°90'	45°31'
Qassimiut		6052	60°47'	47°90'
Qeqertarsuaq	Storø	6051	61°40'	48°34'
Qeqertarsuaq	Storø	6101	61°40'	48°34'
Qeqertarsuaaraq		6052	60°49'	47°60'
Qeqertarsuaaraq		6053	60°49'	47°60'
Qipisaqqu		6051	61°20'	47°56'
Qoornoq		6002	60°11'	45°19'
Qoornoq		6102	61°50'	47°56'
Qoornoq		5952	59°59'	44°36'
Qooroq		6106	61°60'	45°18'
Qooroq		6055	61°60'	45°18'
Qunnermiut		6002	60°27'	45°14'
Sammisoq		5953	59°59'	43°56'
Saqqarmiut		6052	60°49'	47°26'
Saqqaa		6002	60°21'	44°58'
Serfartusoq		6001	60°30'	45°40'
Sermeq		6056	60°48'	44°30'

Greenlandic	Danish	Map sheet	Latitude	Longitude
Sermeq Kangilleq		6056	60°57'	44°57'
Sermeq Kangilleq		6055	60°57'	44°57'
Sermersuup Saqqaa		6002	60°17'	45°10'
Sermiligaarsuk		6101	61°29'	48°42'
Sermilik		6052	60°52'	47°18'
Sermilik		6152	61°54'	48°59'
Sermilik	Søndre Sermilik	6002	60°32'	44°54'
Sermilik		6002	60°27'	44°57'
Sermilik Bræ	Sermilik Bræ	6053	60°59'	47°10'
Sioralik		6055	60°40'	45°14'
Sioralik		6102	61°31'	48°24'
Sioralik Bræ	Sioralik Bræ	6102	61°32'	48°80'
Siorallip Sermia		6056	60°51'	44°54'
Sivinganerup Imaa		5952	60°10'	44°80'
Tannera		5953	60°20'	43°47'
Tasermiut Kangerluat		6003	60°20'	44°43'
Tasiluk		6054	60°41'	45°49'
Tasiusaq		6152	61°43'	48°59'
Tasiusaq		6105	61°90'	45°43'
Tasiusaq		6002	60°12'	44°49'
Tissaluup Ilua		6101	61°23'	48°41'
Torsukattak		6053	60°55'	46°49'
Torsukattak		6054	60°36'	45°45'
Torsukattak		6001	60°36'	45°45'
Torsukattak		5952	60°20'	44°30'
Tuapaat		6002	60°70'	45°11'
Tunorput		6151	61°40'	49°50'
Tunua		5953	60°30'	43°29'
Tunulliarfik		6054	60°57'	45°42'
Taartoq		6101	61°24'	48°50'
Ungooriarfik		6151	61°46'	49°10'
Uukkaasorsuaq	Sermilik Bræ	6152	61°58'	48°41'
Uunartoq Fjord	Uunartoq Fjord	6002	60°31'	45°17'
	Nordbogletscher	6106	61°27'	45°25'
	Nordre Sermilik	6054	61°40'	45°52'
	Nordre Qoornoq Bræ	6102	61°11'	47°44'
	Søndre Qipisaqqu Bræ	6052	61°20'	47°31'
	Grønnedal	6102	61°14'	48°60'
	Sydgletscher	6106	61°23'	45°10'
	Motzfeldt Sø	6106	61°11'	45°20'
	Sortisen	6102	61°21'	47°49'
	Jespersen Bræ	6055	60°58'	45°20'
	Nordre Qipisaqqu Bræ	6052	61°20'	47°41'
	Fox Bay	6055	60°55'	45°24'
	Søndre Qoornoq Bræ	6102	61°90'	47°48'

16 Appendix F, Names of animals in English, Danish and Greenlandic

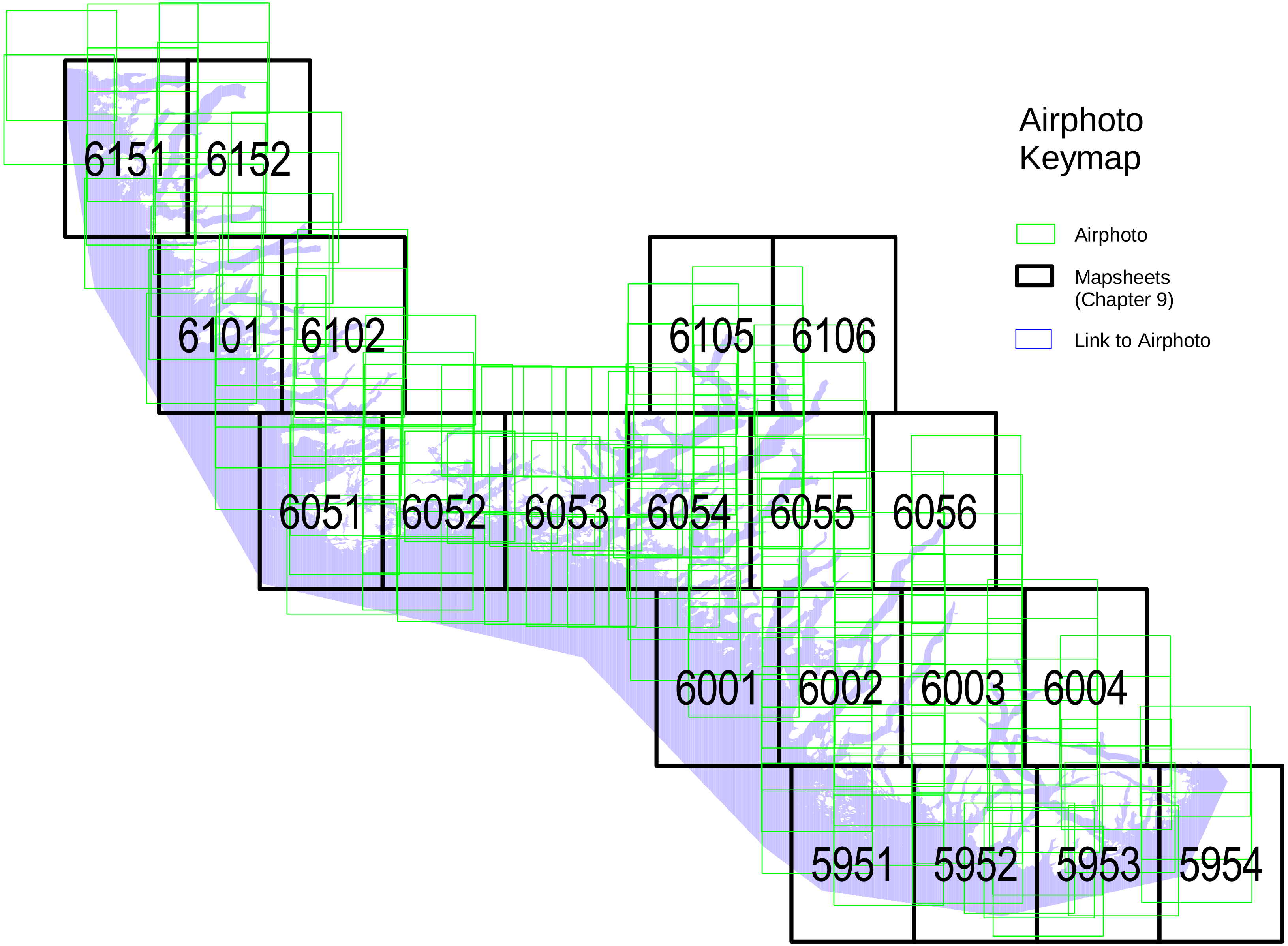
English and *scientific* name **Engelsk og *videnskabeligt* navn** **Tuluttut ilisimatuussutsik kullu taaguutaat**	**Danish name** **Dansk navn** **Qallunaatut taaguutaat**	**Greenlandic name** **Grønlandsk navn** **Kalaallisut taaguutaat**
Fish and shellfish **Fisk m.m.** **Aalisakkat il. il.**		
American plaice *Hippoglossoides platessoides*	Håising	Oquutaq
Arctic char *Salvelinus alpinus*	Fjeldørred	Eqaluk
Arctic cod *Arctogadus glacialis*	Istorsk	
Atlantic cod *Gadus morhua*	Torsk	Saarullik
Atlantic halibut *Hippoglossus hippoglossus*	Helleflynder	Nataarnaq
Atlantic salmon *Salmo salar*	Laks	Kapisilik
Atlantic wolffish *Anarichas lupus*	Havkat	Qeeraaraq
Beaked redfish *Sebastes mentella*	Dybhavsrødfisk	Suluppaagaq itisoormiu
Blue mussel *Mytilus edulis*	Blåmusling	Uiloq
Butterfish *Pholis gunnellus*	Tangspræl	Pilaatalik
Capelin *Mallotus villosus*	Lodde	Ammassak
Cutthroat trout *Salmo clarki*	Cutthroat ørred	-
Deep sea shrimp *Pandalus borealis*	Dybvandsreje	Kinguppak
Golden redfish *Sebastes marinus*	Stor rødfisk	Suluppaagaq
Greenland cod *Gadus ogac*	Uvak	Uugaq
Greenland halibut *Reinhardtius hippoglossoides*	Hellefisk	Qaleralik
Long rough dab *Hippoglossoides platessiodes*	Håsing	Oquutaq
Lumpsucker *Cyclopterus lumpus*	Stenbider	Nipisa

Fish and shellfish cont. **Fisk m.m.** **Aalisakkat il. il.**		
Polar cod *Boreogadus saida*	Polartorsk	Eqalugaq
Redfish *Sebastes spp.*	Rødfisk	Suluppaagaq
Sand eel *Ammodytes sp.*	Tobis	-
Scallop *Chlamys islandica*	Kammusling	Uiluiq
Shorthorn sculpin *Myoxocephalus scorpius*	Almindelig ulk	Kanajoq
Spottet wolffish *Anarhicas minor*	Plettet havkat	Qeeraq milattooq
Snow crab *Chionoecetes opilio*	Krabbe	Saattuaq
Starry skate *Raja radiata*	Tærbe	Allernaq
Three-spined stickleback *Gasterosteus aculeatus*	Trepigget hundestejle	Kakilisak pingasunik kapinartulik
Wolffish *Anarhicas sp.*	Havkat	

Birds Fugle Timmisat		
Arctic skua *Stercorarius parasiticus*	Almindelig kjove	Isunngaq
Arctic tern *Sterna paradisaea*	Havterne	Imeqqutaalaq
Atlantic puffin *Fratercula arctica*	Lunde	Qilanngaq
Black guillemot *Cepphus grylle*	Tejst	Serfaq
Black-legged kittiwake *Rissa tridactyla*	Ride	Taateraaq
Common eider *Somateria mollissima*	Ederfugl	Miteq siorartooq
Common guillemot (common murre) *Uria aalge*	Almindelig lomvie	Appa sigguttooq
Cormorant *Phalacrocorax sp.*	Skarv	Oqaatsoq
Glaucous gull *Larus hyperboreus*	Gråmåge	Naajarujussuaq
Great black-backed gull *Larus marinus*	Svartbag	Naajarluk
Great cormorant *Phalacrocorax carbo*	Skarv	Oqaatsoq
Great northern diver *Gavia immer*	Islom	Tuullik
Great shearwater *Puffinus gravis*	Storskråpe	Qaqullunnaq
Great skua *Stercorarius skua*	Storkjove	-
Grey phalarope *Phalaropus fulicarius*	Thorshane	Kajuaraq
Harlequin duck *Histrionicus histrionicus*	Strømand	Toornarviarsuk
Iceland gull *Larus glaucoides*	Hvidvinget måge	Naajarnaq
Ivory gull *Pagophila eburnea*	Ismåge	naajavaarsuk
King eider *Somateria spectabilis*	Kongeederfugl	miteq siorakitsoq
Lesser black-backed gull *Larus fuscus*	Sildemåge	-
Little auk (dovekie) *Alle alle*	Søkonge	Appaliarsuk
Long-tailed duck *Clangula hyemalis*	Havlit	Alleq
Long-tailed skua *Stercorarius longicaudus*	Lille kjove	Papikkaaq

Birds cont. **Fugle** **Timmisat**		
Mallard *Anas platyrhynchos*	Gråand	Qeerlutooq
Northern fulmar *Fulmarus glacialis*	Mallemuk	Qaqulluk
Pomarine skua *Stercocarius pomarinus*	Mellemkjove	Isunngarsuaq
Purple sandpiper *Calidris maritima*	Sortgrå ryle	Saarfaarsuk
Raven *Corvus corax*	Ravn	Tulugaq
Razorbill *Alca torda*	Alk	Apparluk
Red-breasted merganser *Mergus merganser*	Toppet skallesluger	Paaq
Red-necked phalarope *Phalaropus lobatus*	Odinshane	Naluumasortoq
Red-throated diver *Gavia stellata*	Rødstrubet lom	Qarsaaq
Sabine's gull *Larus sabini*	Sabinemåge	Taateraarnaq
Brünnich's guillemot (Thick-billed murre) *Uria lomvia*	Polarlomvie	Appa
White-tailed eagle *Haliaeetus albicilla*	Havørn	Nattoralik

Mammals **Pattedyr** **Uumasut miluumasut**		
Bearded seal *Erignathus barbatus*	Remmesæl	Ussuk
Bedlamer *Phoca groenlandica*	Blåside (ung grønlands-sæl)	Allatooq
Blue whale *Balaenoptera musculus*	Blåhval	Tunnulik
Bottlenose whale *Hyperoodon ampullatus*	Døgling	Anarnak
Bowhead whale *Balaena mysticetus*	Grønlandshval	Arfivik
Fin whale *Balaenoptera physalis*	Finhval	Tikaagulliusaaq
Harbour porpoise *Phocoena phocoena*	Marsvin	Niisa
Harbour seal *Phoca vitulina*	Spættet (spraglet) sæl	Qasigiaq
Harp seal *Phoca groenlandica*	Grønlandssæl (sortside)	Aataarsuaq
Hooded seal *Cystophora cristata*	Klapmyds	Natsersuaq
Humpback whale *Megaptera novaeangliae*	Pukkelhval	Qipoqqaq
Killer whale *Orcinus orca*	Spækhugger	Aarluk
Minke whale *Balaenoptera acutorostrata*	Vågehval (sildepisker)	Tikaagullik
Narwhal *Monodon monoceros*	Narhval	Qilalugaq qernertaq
Polar bear *Ursus maritimus*	Isbjørn	Nanoq
Ringed seal *Phoca hispida*	Ringsæl (netside)	Natseq
Sei whale *Balaenoptera borealis*	Sejhval	Tunnullit ilaat
Sperm whale *Physeter macrocephalus*	Kaskelot	Kigutilissuaq
Walrus *Odobenus rosmarus*	Hvalros	Aaveq
White whale (beluga) *Delphinapterus leucas*	Hvidhval (hvidfisk)	Qilalugaq qaqortaq



Airphoto Keymap

Airphoto

Mapsheets (Chapter 9)

Link to Airphoto

Seabird breeding colony no. 59001. Najaat in Nordlige Kitsissut. A small island very exposed to the ocean. Breeding birds include besides gulls, razorbill, Atlantic puffin, black guillemot and perhaps Brünnich's guillemot.

Seabird breeding colony no. 59004, Qeqertat. A group of small barren islands very exposed to the ocean. These islands hold a large colony of common eider, perhaps one of the largest in West Greenland.

Seabird breeding colony no. 59006, a small island off Pamialluussaq, exposed to the ocean. Breeding site for common eider.

Seabird breeding colony no. 59007, small island just east of Kap Farvel. The breeding birds include razorbills and black guillemots.

Seabird breeding colony no. 59010, Kap Christian near Kap Farvel. Steep and tall cliffs with breeding northern fulmars and Iceland gulls.

Seabird breeding colony no. 60011, Qiioqit, a small island exposed to the ocean. Breeding birds include razorbill, black guillemot and great black-backed gull. The island is also habitat for moulting harlequin ducks.

Seabird breeding colony no. 60012, Ydre Kitsissut. This is an archipelago situated far from the mainland coast. It holds one of the most important seabird breeding colonies in Greenland with northern fulmars, common eiders, Brünnich's guillemots, razorbills, Atlantic puffins, black guillemots and kittiwakes. It is also a habitat for moulting harlequin ducks. The picture was taken March 12, 1999.

Seabird breeding colony no. 60015, Qalerallit Imaa, a steep cliff in protected fjord. Breeding birds include kittiwake, Iceland gull and glaucous gull.

Seabird breeding colony no. 60016, a steep cliff in the fjord Qalerallit Imaa. Breeding birds include kittiwake, Iceland gull, glaucous gull and black guillemot.

Seabird breeding colony no. 60023, Qarsussat, a low island in protected waters,
Breeding birds include Arctic terns.

Seabird breeding colony no. 60027, A steep cliff in the fjord Kangersuneq Qingorleq. Breeding birds include kittiwake, Iceland gull, glaucous gull and black guillemot.

Seabird breeding colony no. 60032. Pukkitsut, a group of small and low islands in Qaqqaligaatsiaq Fjord. Breeding birds include Arctic tern, lesser black-backed gull and black guillemot.

Seabird breeding colony no. 60039, Sallit. A large archipelago at the outer coast. Black guillemots are numerous here.

Seabird breeding colony no. 60044. Steep cliff in the fjord Kangersuneq Qingorleq. Breeding birds include kittiwake, Iceland gull, glaucous gulls and black guillemot.

Seabird breeding colony no. 60051. An islet in the archipelago Nordlige Kitsissut off Nanortalik. This small rock holds a large colony of breeding razorbills.

Seabird breeding colony no. 60053. Siumiuttat an archipelago at the outer coast. Breeding birds include Arctic tern, lesser black-backed gull and black guillemot.

Seabird breeding colony no. 60057. Qiioqe, a small island exposed to the ocean. Breeding birds include Arctic tern, lesser black-backed gull and black guillemot.

Seabird breeding colony no. 60058. Angissit, a small and low island near the outer coast. Breeding birds include common eider, lesser black-backed gull and black guillemot.

Seabird breeding colony no. 60059, Serfatussut. A small island near the outer coast. Breeding birds include common eider, Iceland gull, lesser black-backed gull and black guillemot.

Seabird breeding colony no. 60060, Qeqernertut. Two low islands near the outer coast. The islands hold a large breeding colony of Arctic terns, and also black guillemots and Arctic skuas.

Seabird breeding colony no. 60063, a steep cliff on the island Umiissaaq near the outer coast. Breeding birds include common eiders and black guillemots.

Seabird breeding colony no. 60065, Uiguleriit. A low island and some skerries at the outer coast. Breeding birds include common eider, Arctic tern, lesser black-backed gull and black guillemot.

Seabird breeding colony no. 60087. A steep cliff in the fjord Qalerallit Imaa. Breeding birds include kittiwake and Iceland gull.

Seabird breeding colony no. 60089, Uummannguaq, a large archipelago near the outer coast. Breeding birds include common eider, great black backed gull and black guillemot.

Seabird breeding colony no. 60091, a group of low islands in Bredefjord. Breeding birds include lesser black-backed gull, great black-backed gull, Iceland gull, herring gull, glaucous gull and black guillemot.

Seabird breeding colony no. 61002, Fox Faldet. A steep cliff in Arsuk Fjord. This and the colony on Ydre Kitsissut are the most important and significant seabird breeding colonies in the region 60º - 62º N. Breeding birds include Brünnich’s guillemot, Iceland gull and kittiwake.

Seabird breeding colony No. 61032, Qeqertarsussuk. A low island with breeding common eiders, Arctic skuas, lesser and greater black-backed gulls and black guillemots.

Seabird breeding colony no. 61038, Akullit Nunaat. A steep cliff face in the head of a fjord. Breeding birds include Iceland gulls and kittiwakes.

Seabird breeding colony no. 61040, Akullit Nunaat. On this steep and barren cliff Iceland gulls, glaucous gulls and kittiwakes breed.

Photos from archaeological sites in West Greenland

Figure 1. The remains of a winterhouse very near the coast.

Figure 2. Endangered paleo-eskimo (Dorset) dwellings, Disko Bay.

Figure 3. Settlement-area from the Thule-period. Disko Bay.

Figure 4. Stone-and-turf winterhouse slowly sliding into the sea. Disko Bay.

Figure 5. Stone-and-turf winterhuse from the Thule-culture sliding slowy towards the sea.

Figure 6. Settlement-area with the most recent turfhouses still clearly visible.

Figure 7. Large winterhouse, with one wall still left.

Figure 8. Exposed midden layers covering almost 4.500 years of the past.

Figure 9. Coastal erosion on site with archaeological remains from several millennia.

Figure 10. Accelerated coastal erosion of very old midden remains due to modern activities.

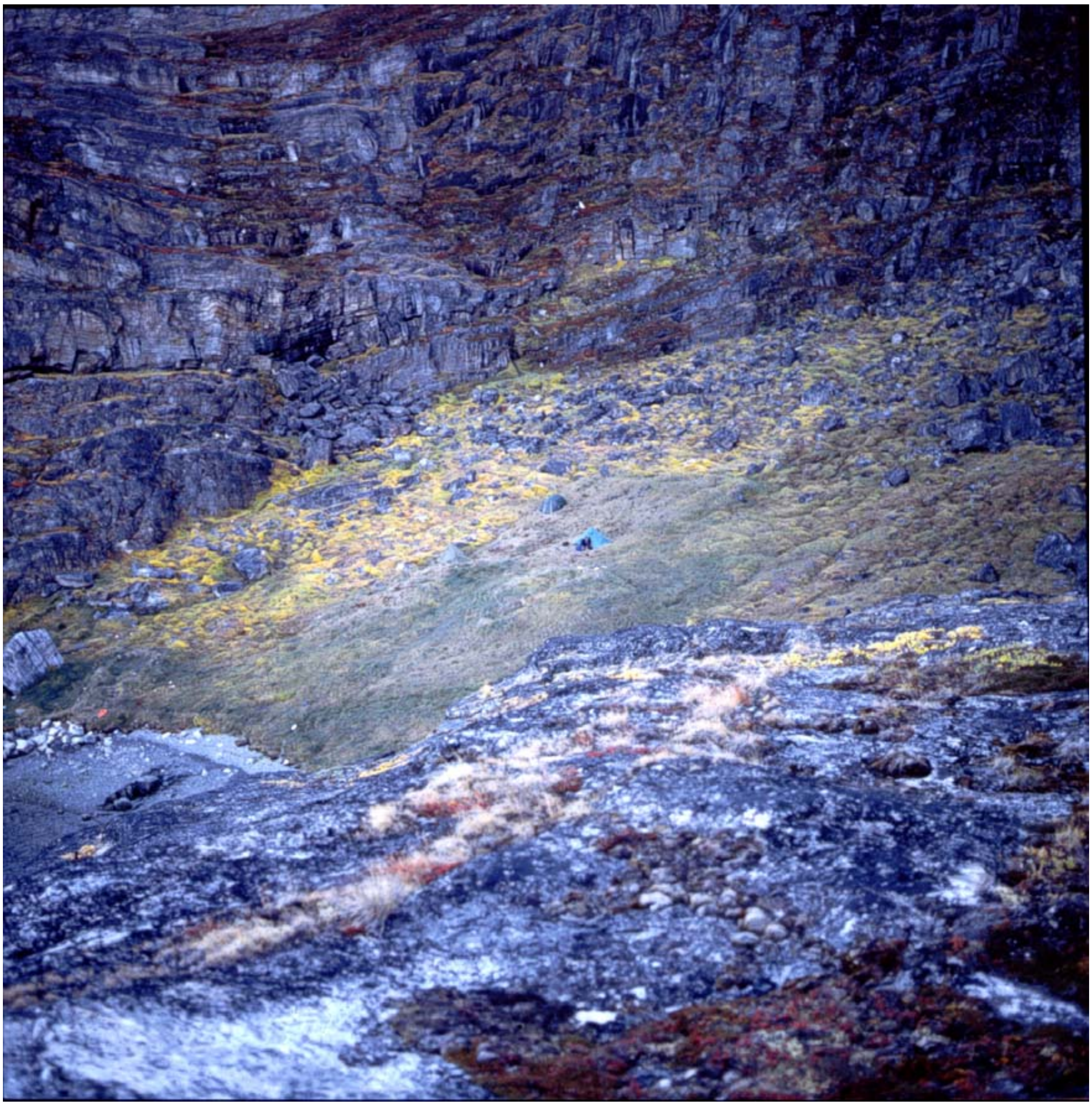


Figure 11. Grass-covered settlement area from 15th Century.

Figure 12. Strong wind erosion has exposed a paleo-eskimo site.

Figure 13. Remains of a large communal winter house.

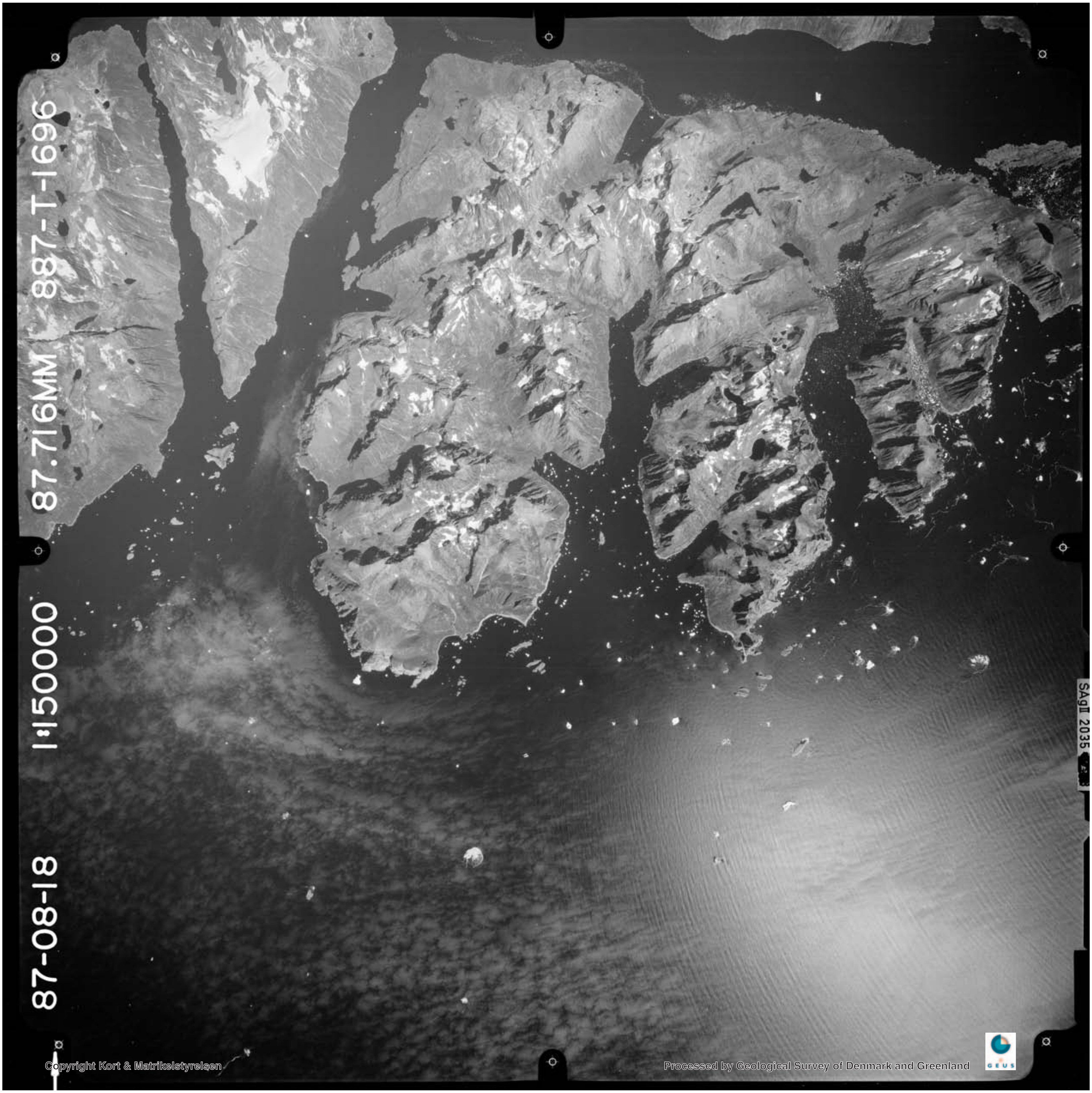
Figure 14. Ruin of the norse church at Ikigaat/Herjolfsnæs in Nanortalik municipality.

Figure 15. Ruin of a norse building at Pamialluk

Approximate scale 0 2 4 6 8 10 km

Contents

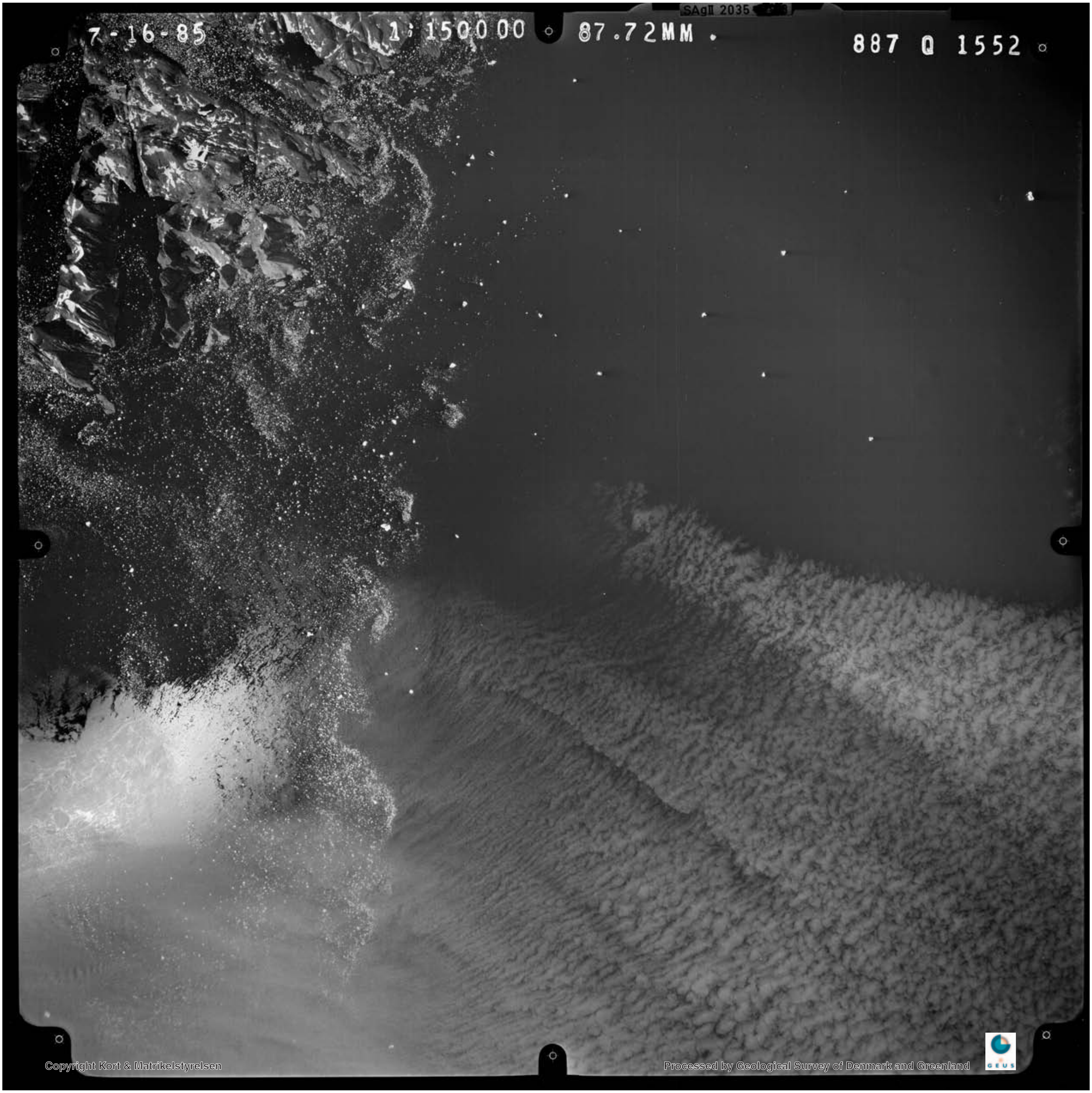
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

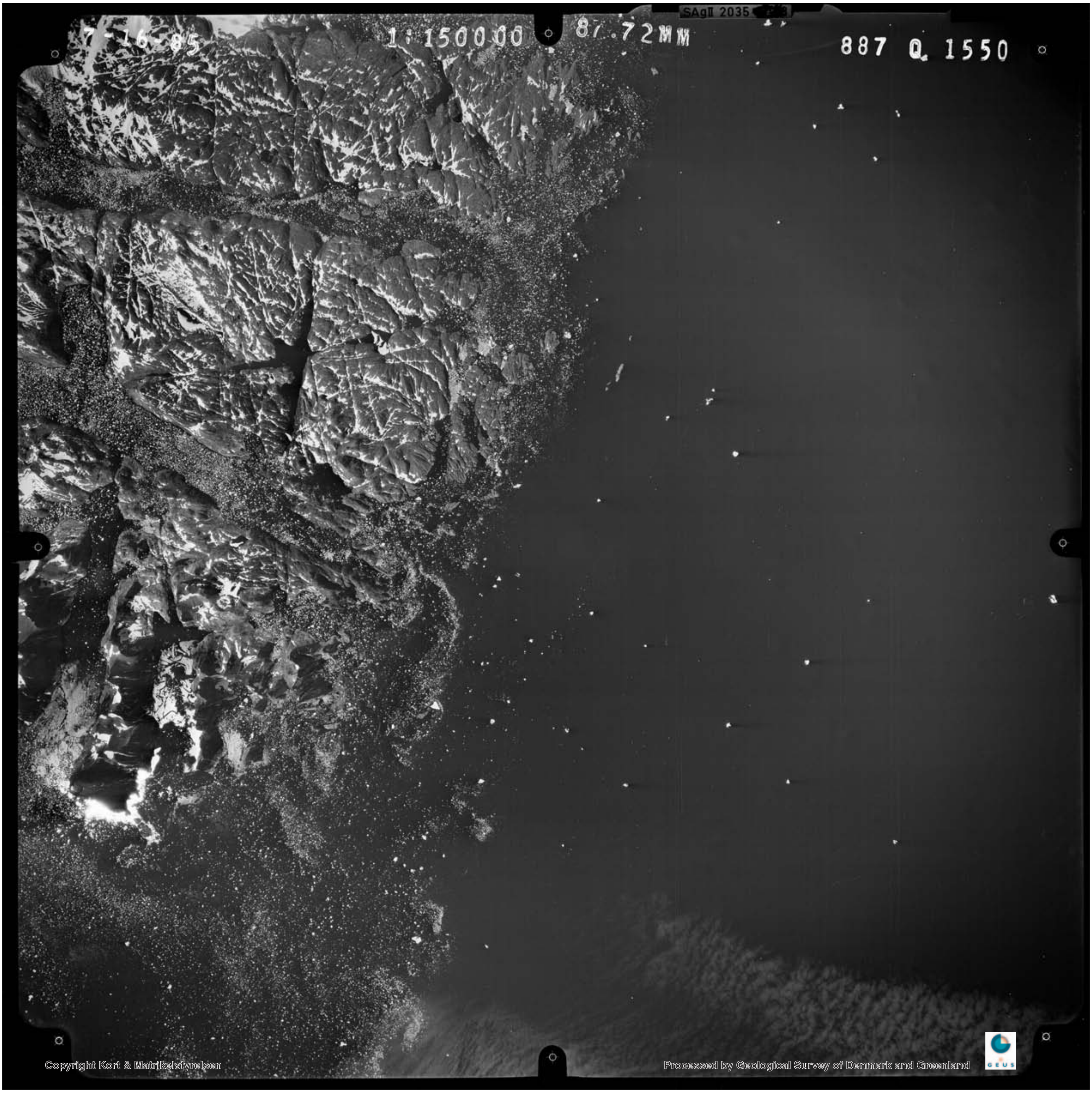
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

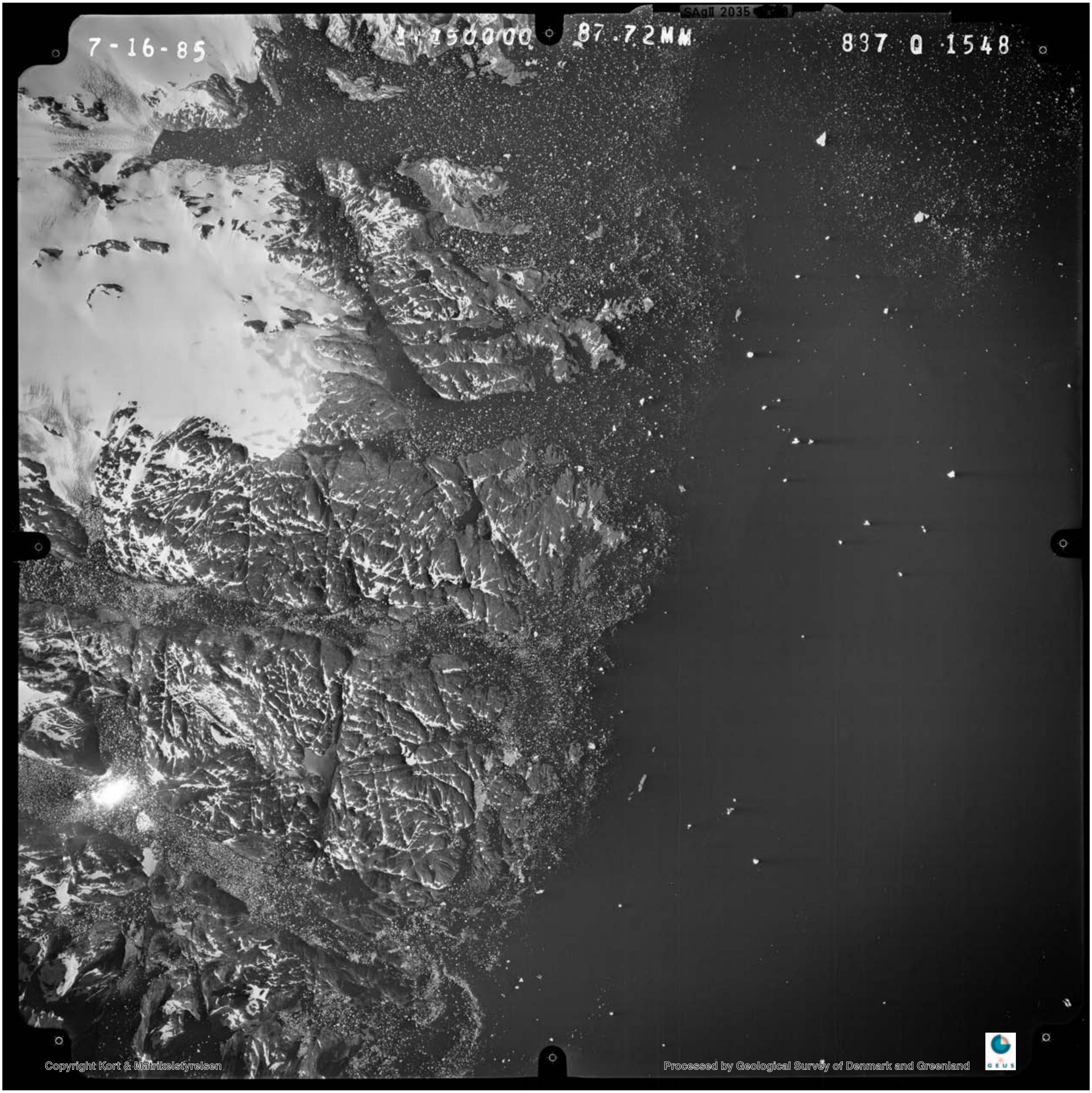
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Approximate scale 0 2 4 6 8 10 km

Approximate scale 0 2 4 6 8 10 km

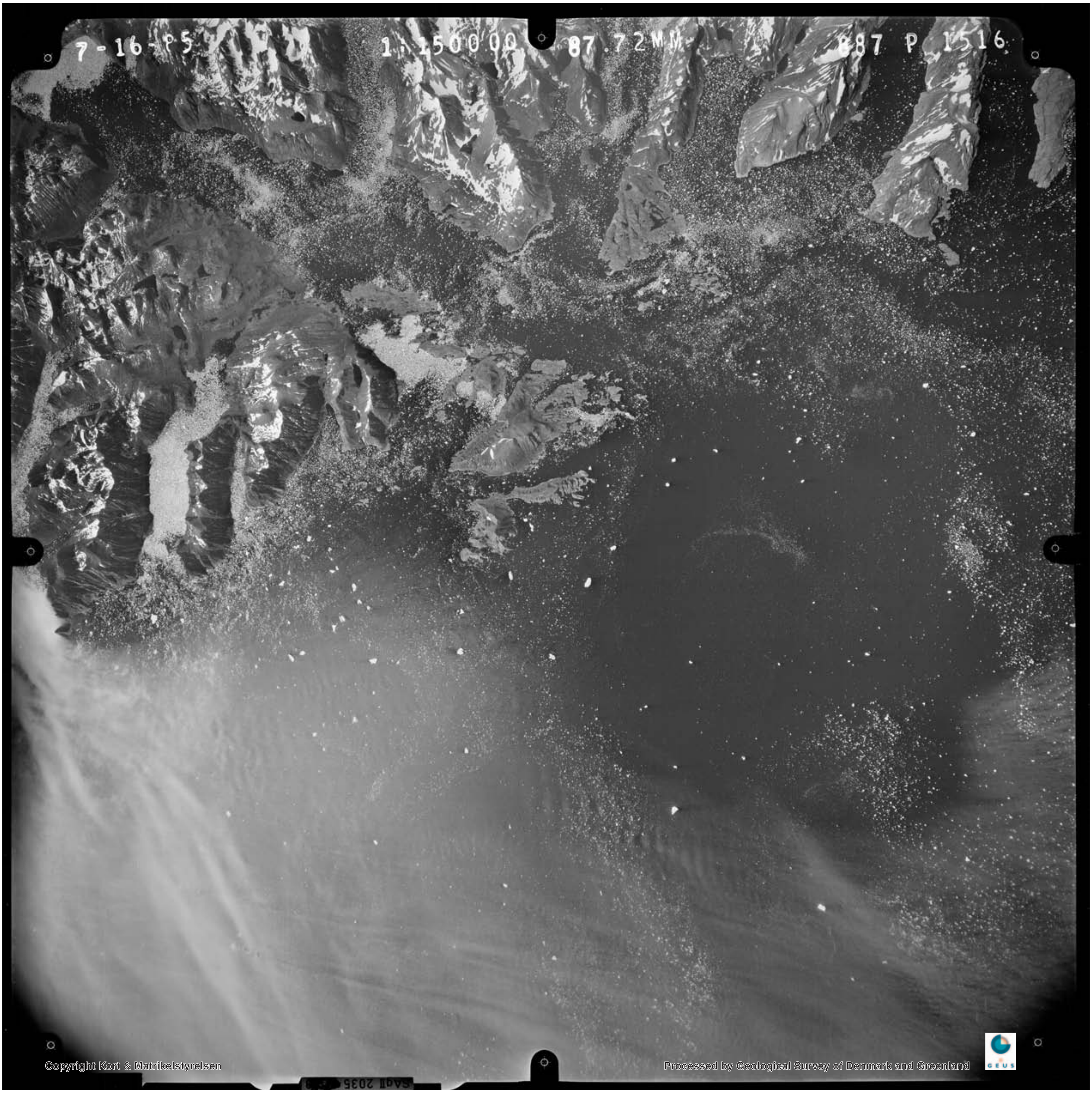
Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

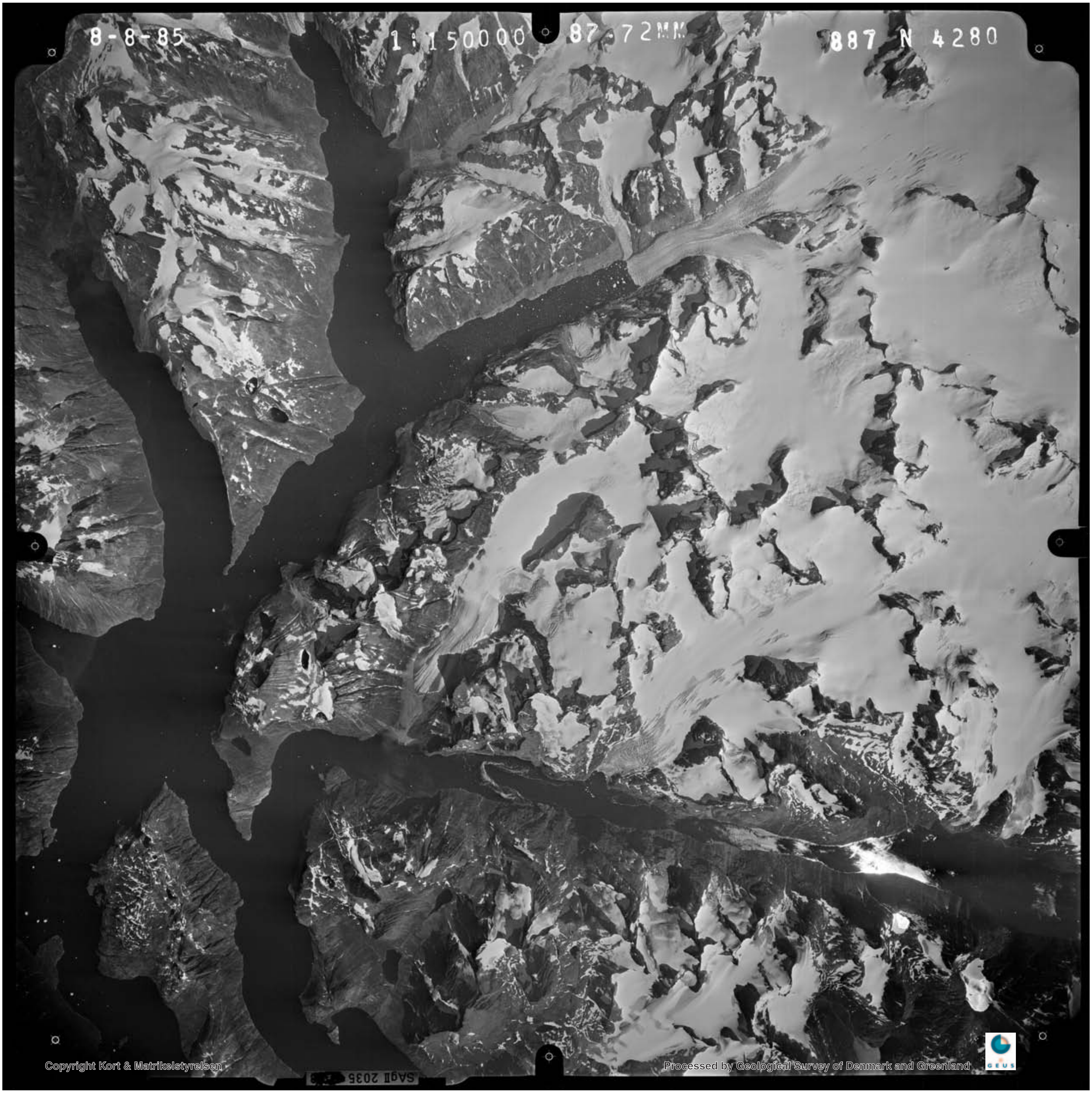
Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Contents

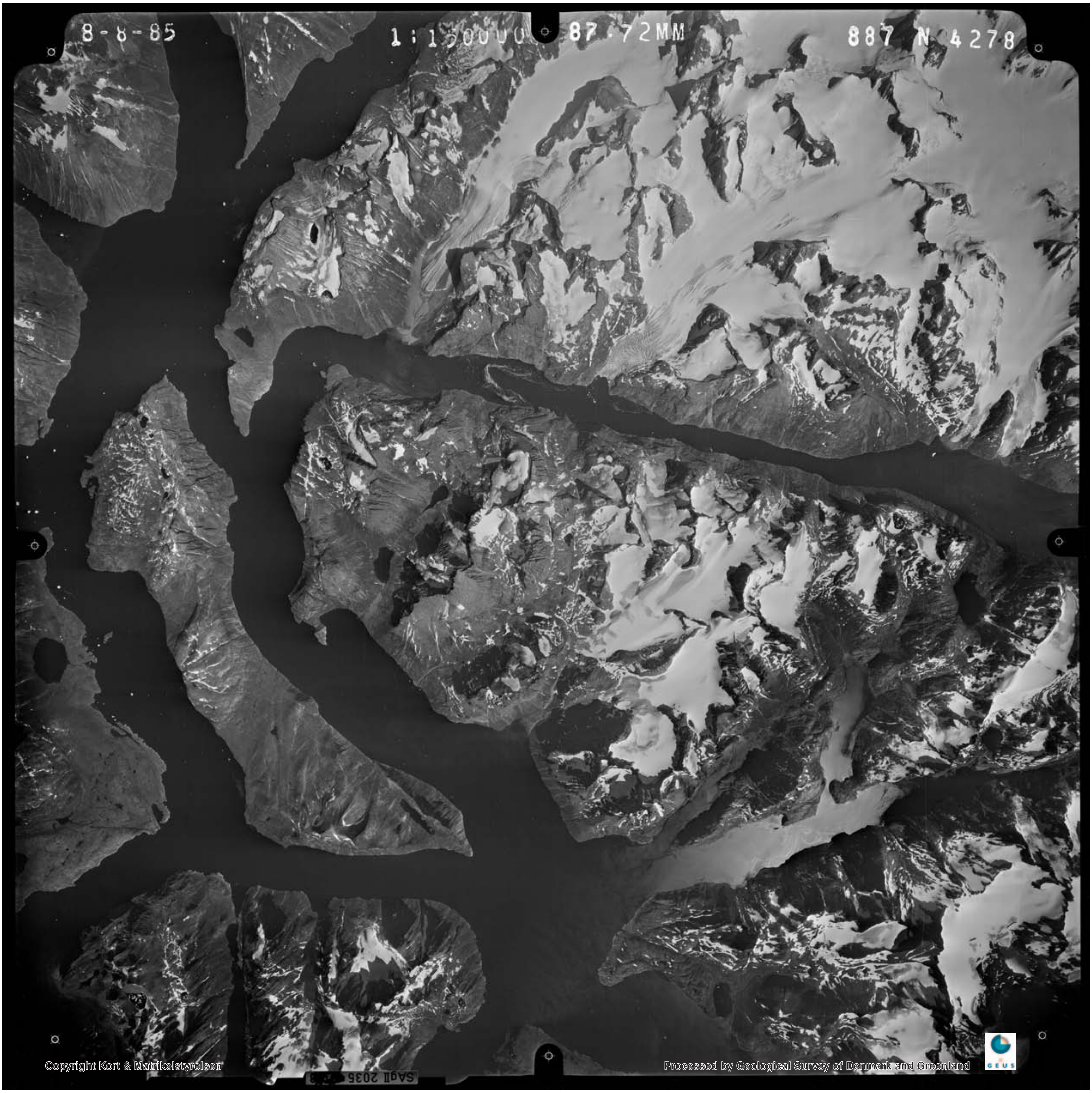
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



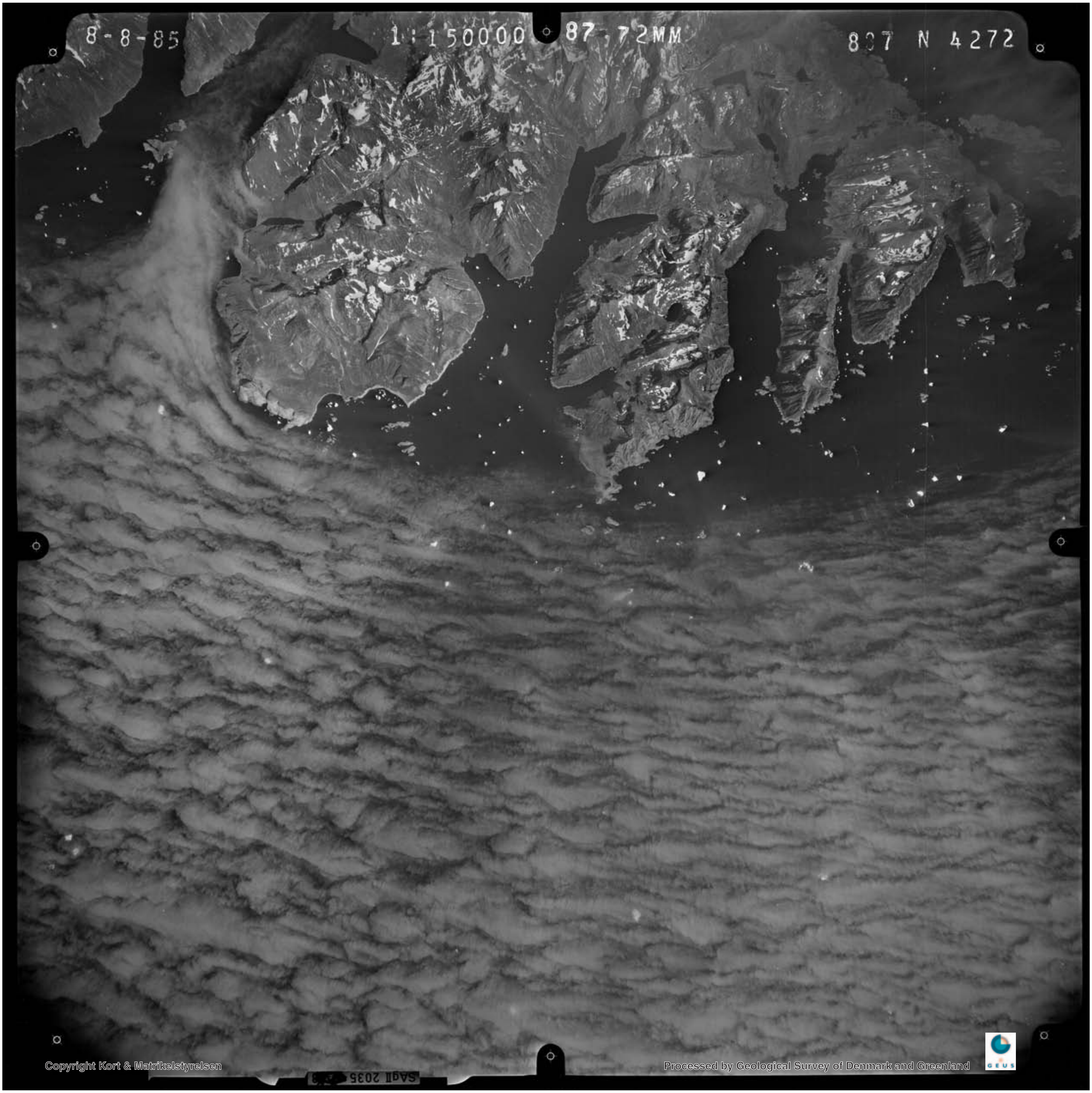
Approximate scale 0 2 4 6 8 10 km

Approximate scale 0 2 4 6 8 10 km

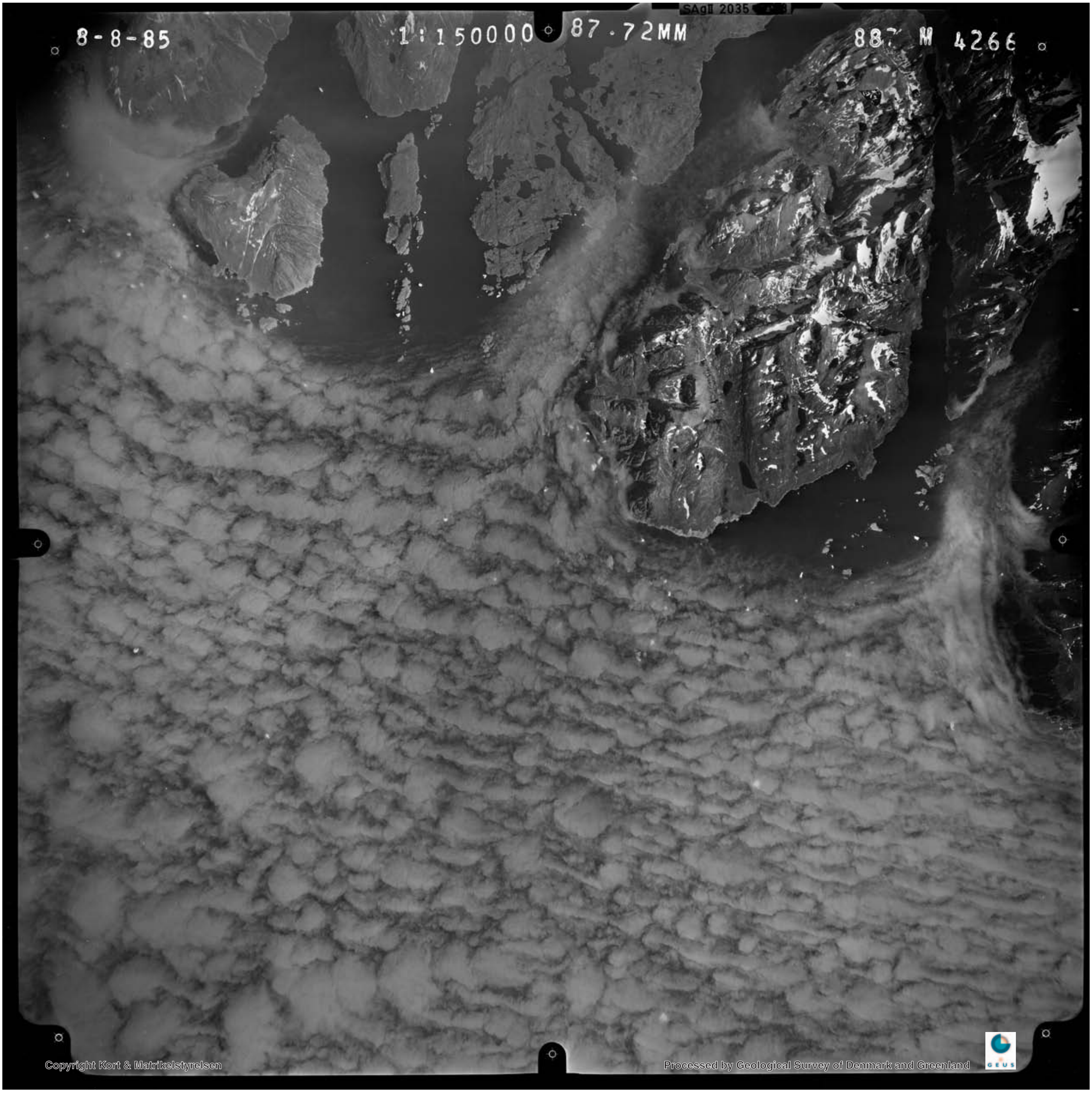
Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



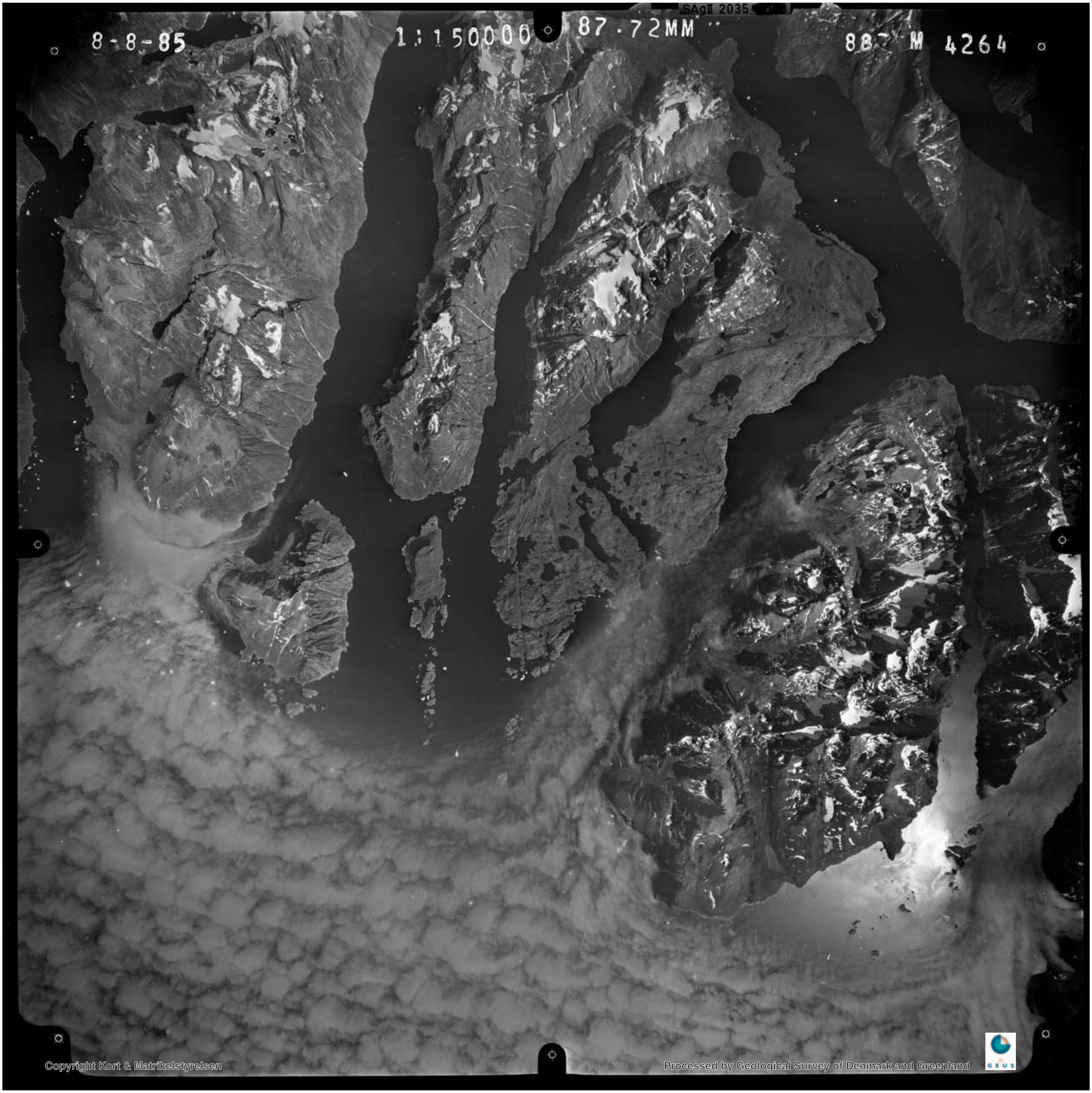
Approximate scale 0 2 4 6 8 10 km



Approximate scale 0 2 4 6 8 10 km

Contents

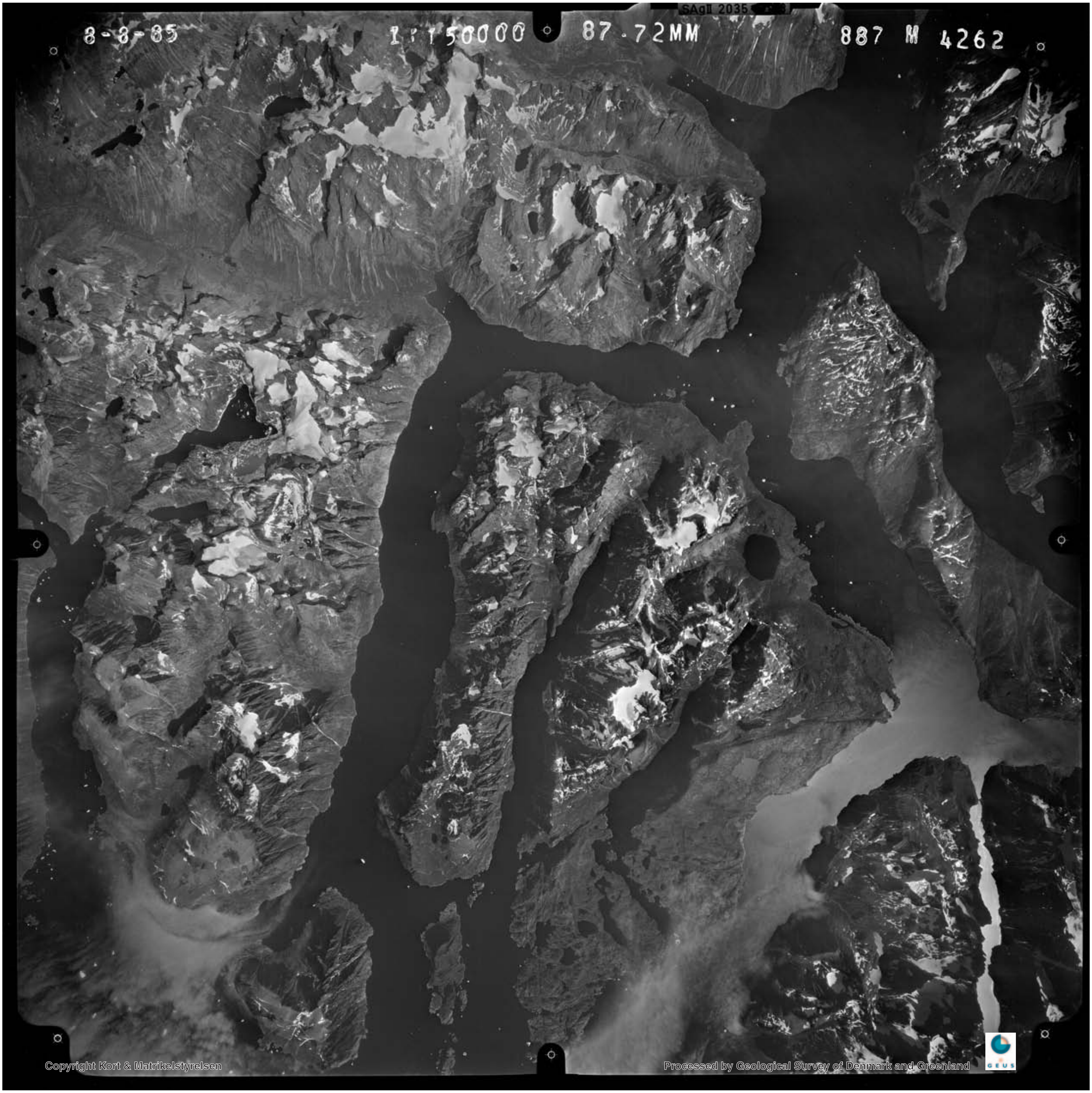
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

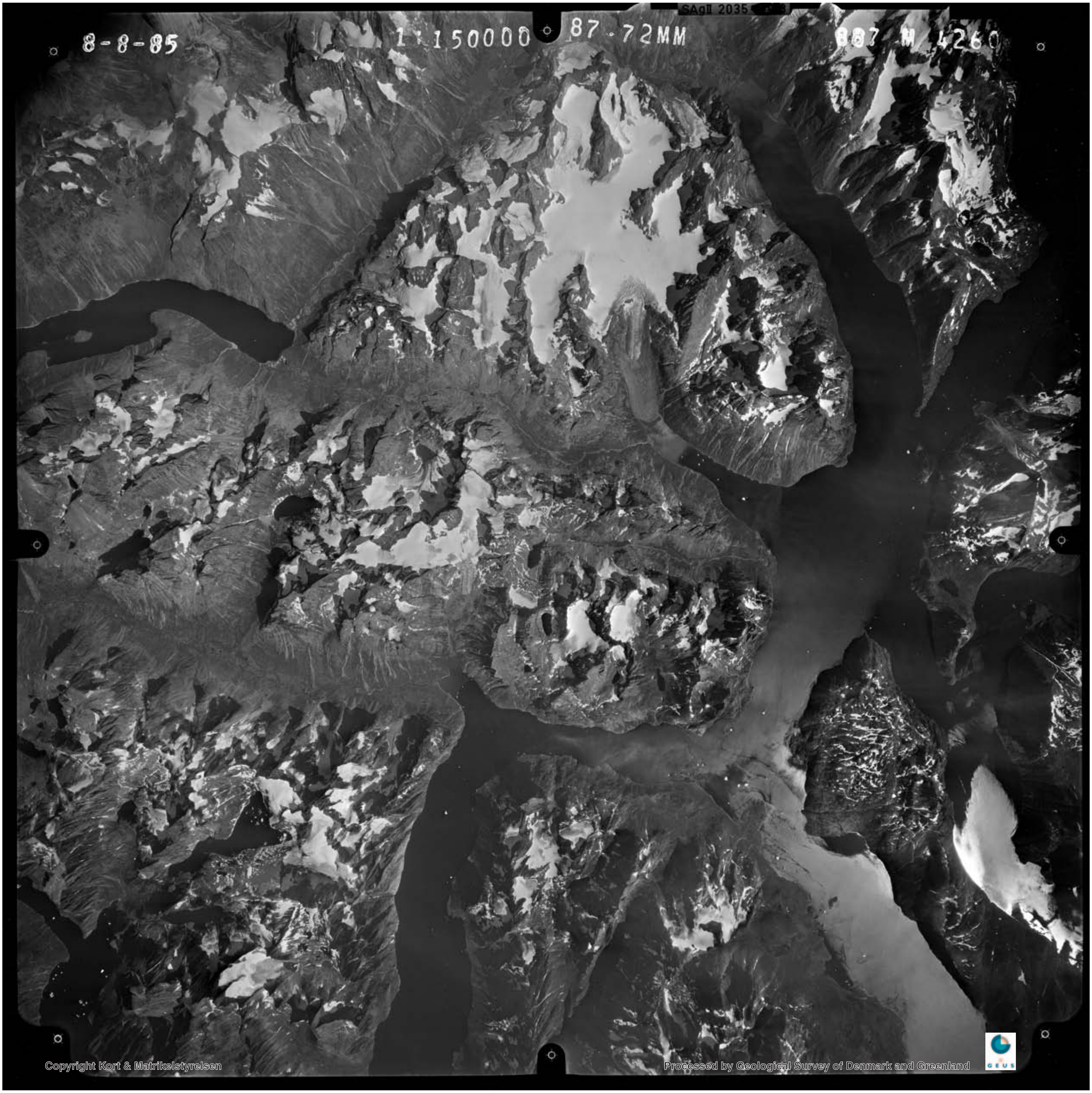
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

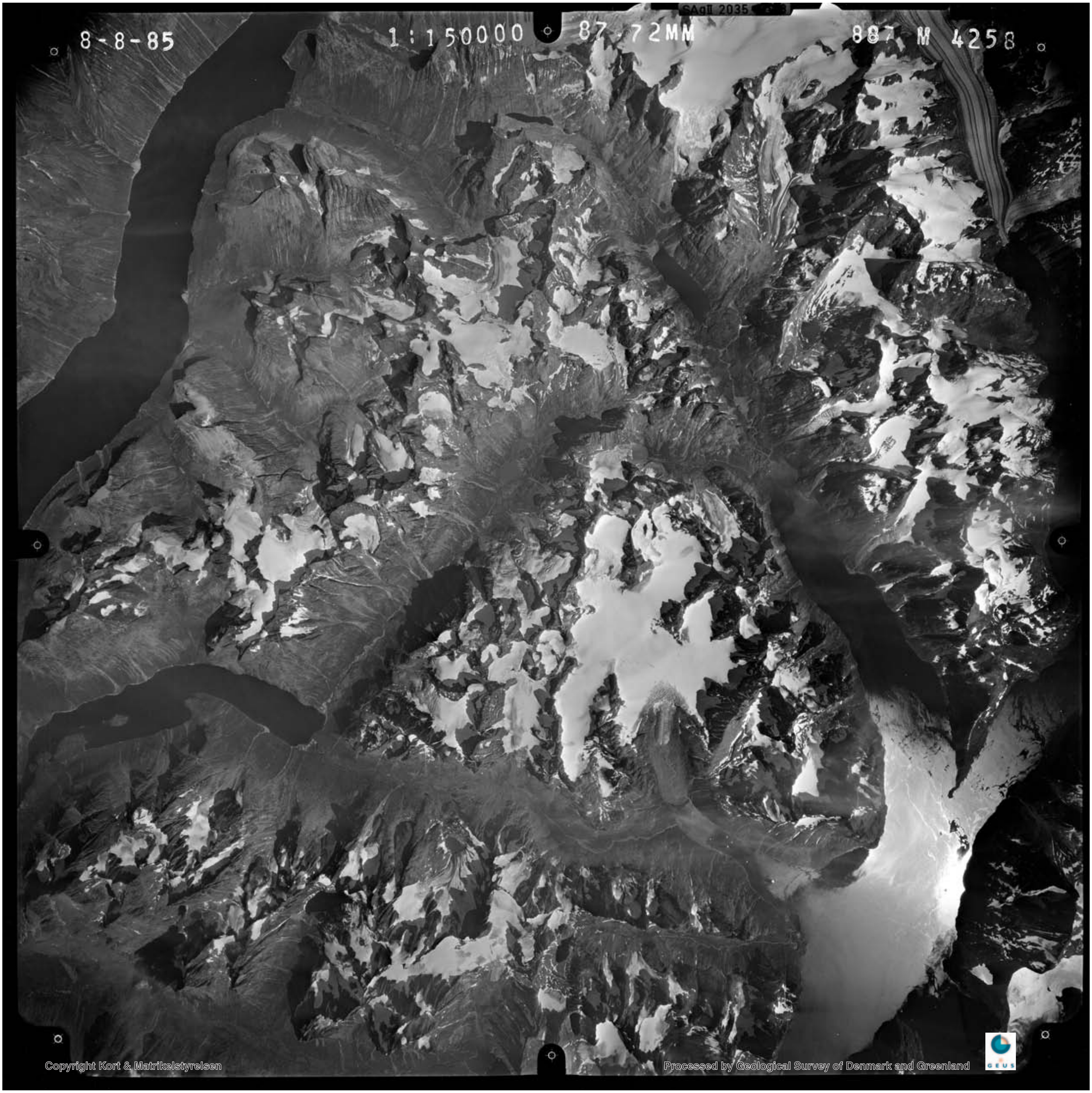
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

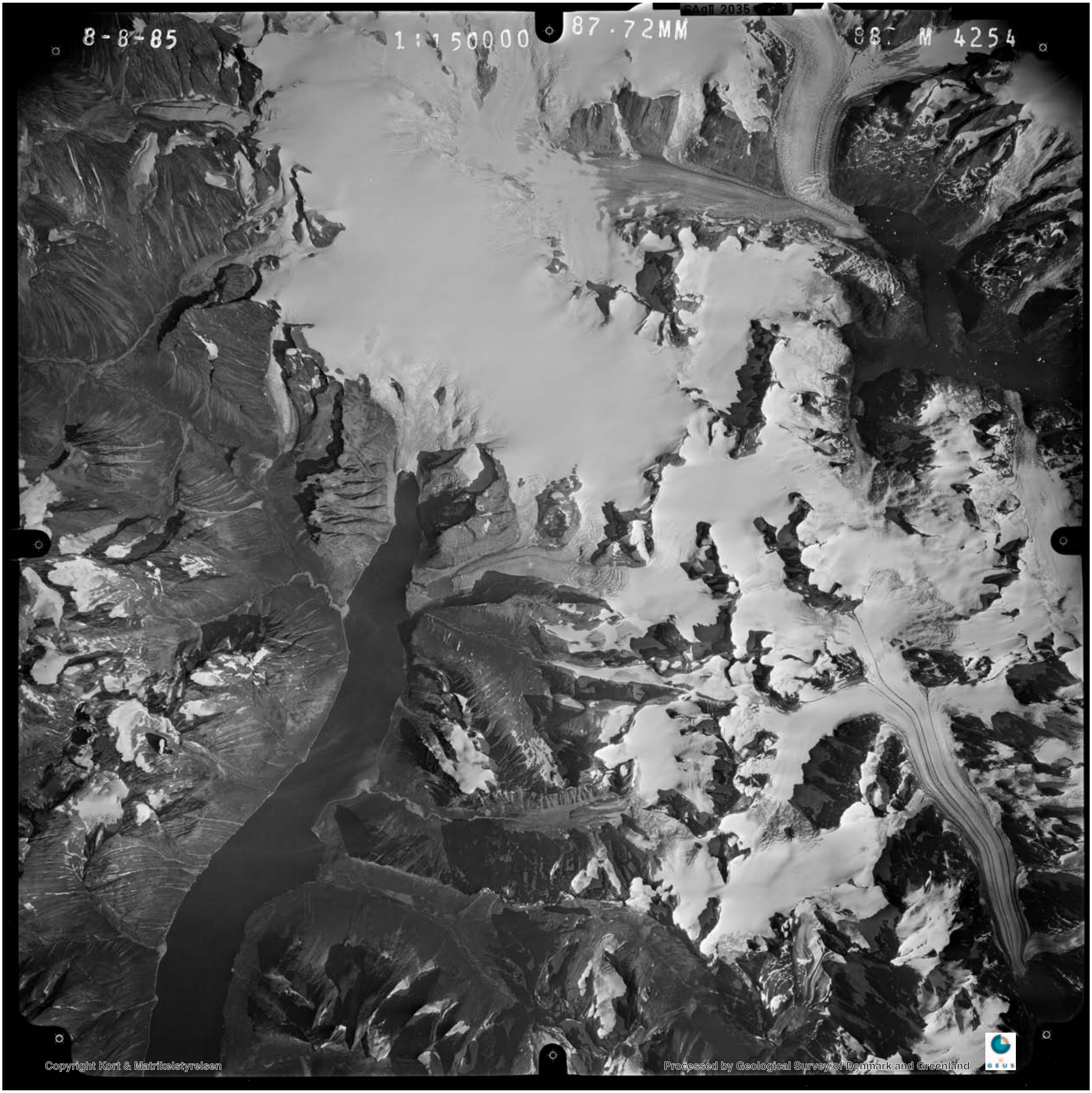
Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Contents

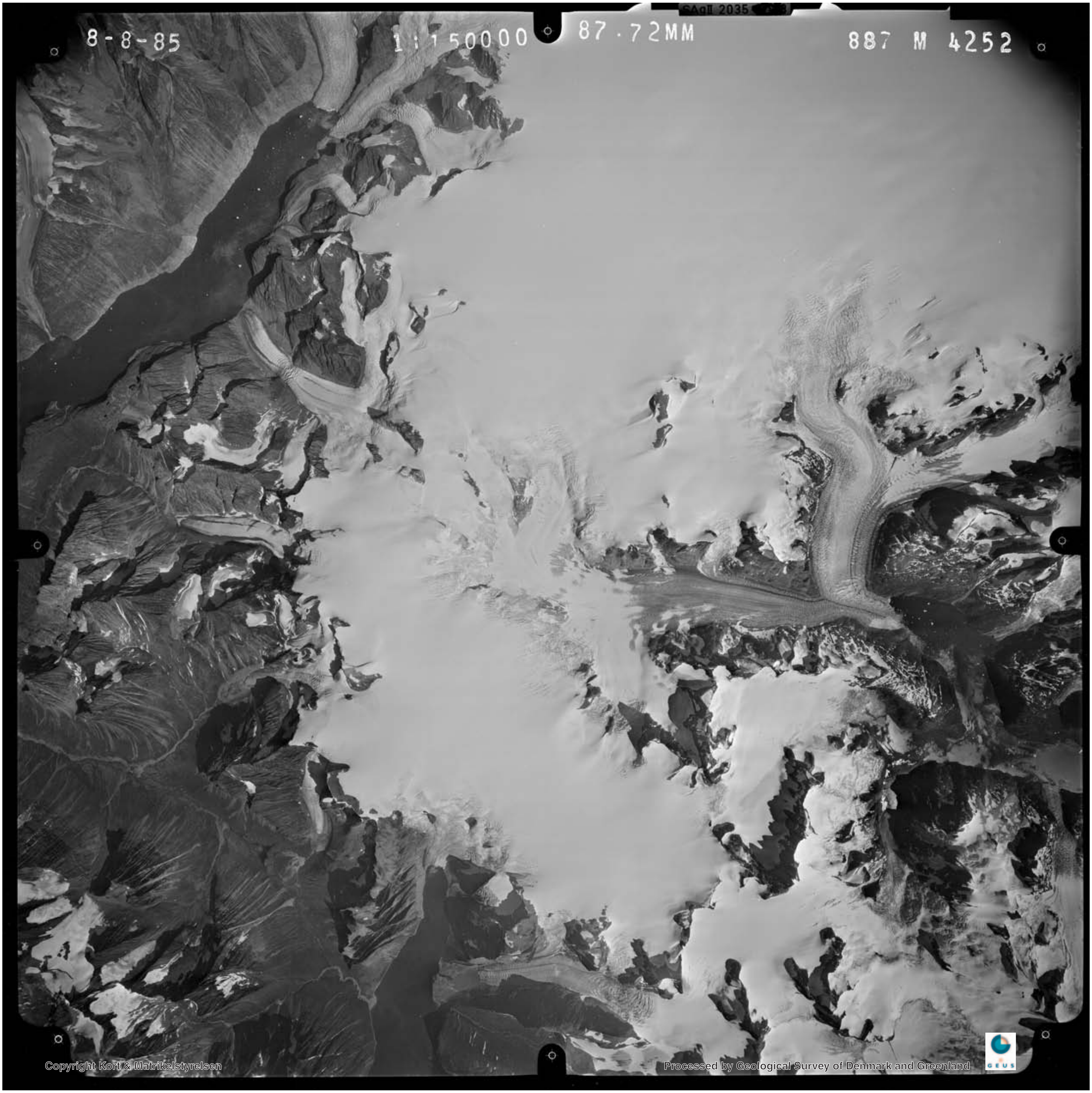
Airphoto Keymap



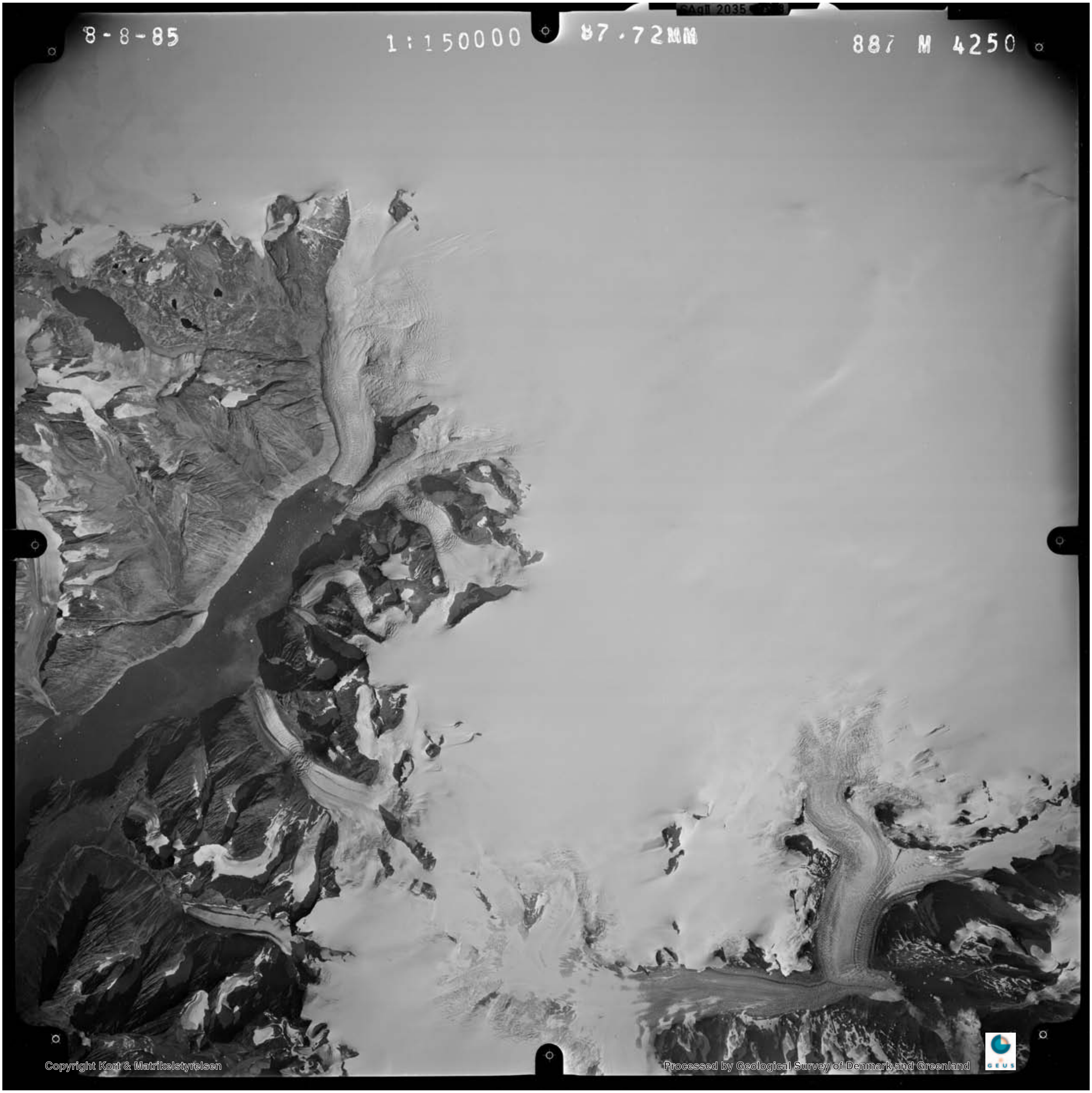
Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



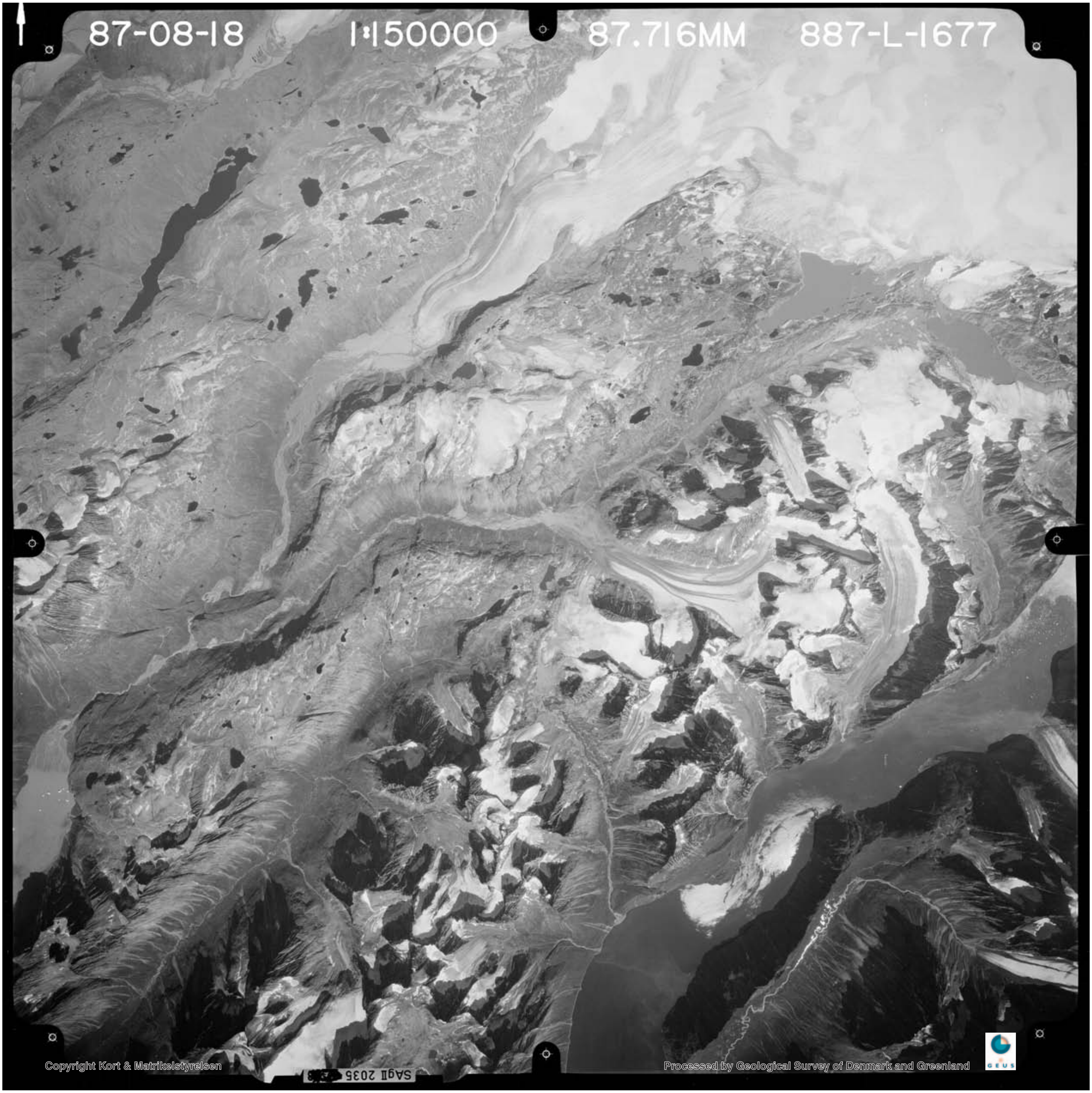
Approximate scale 0 2 4 6 8 10 km



Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Contents

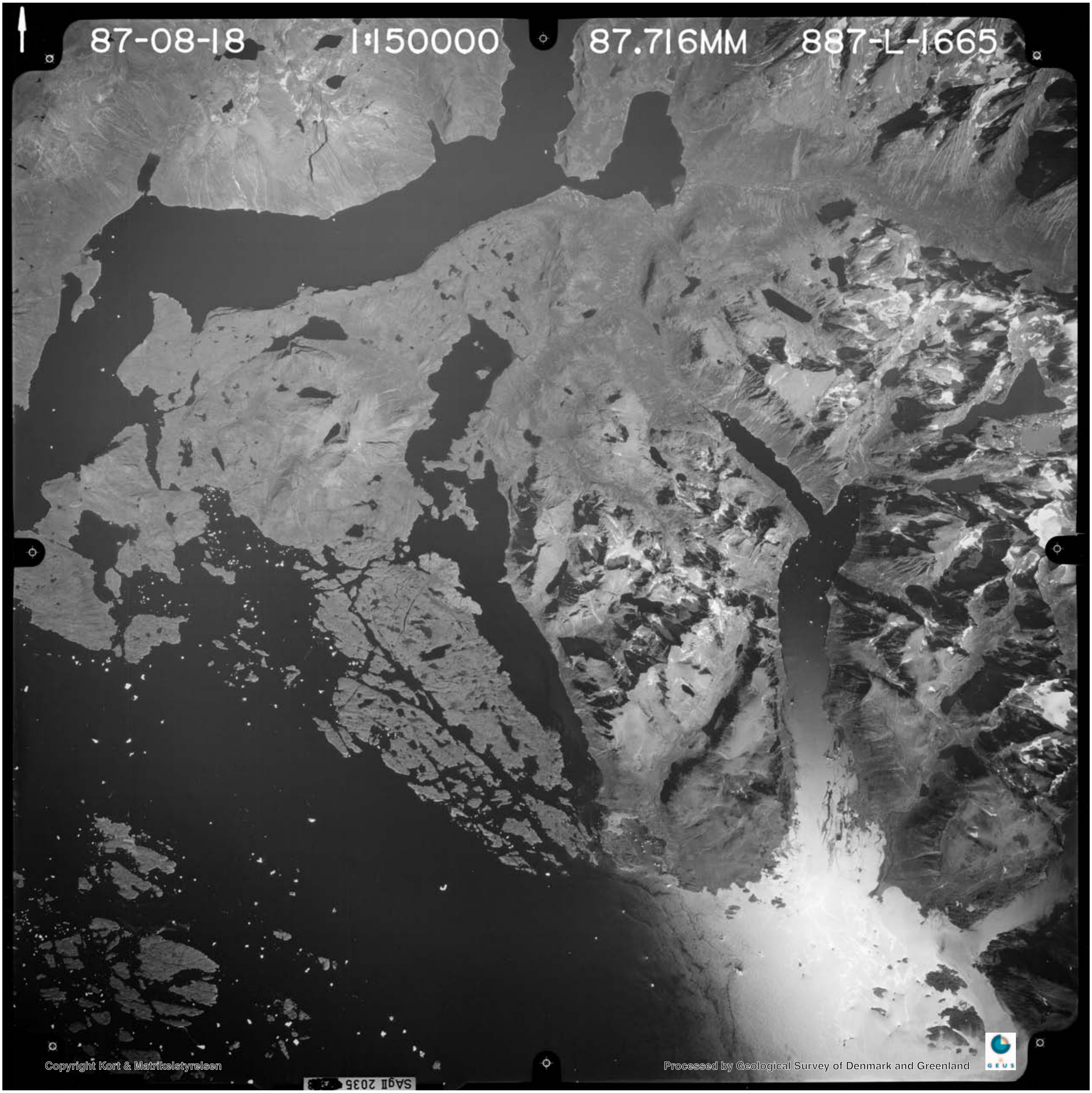
Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap

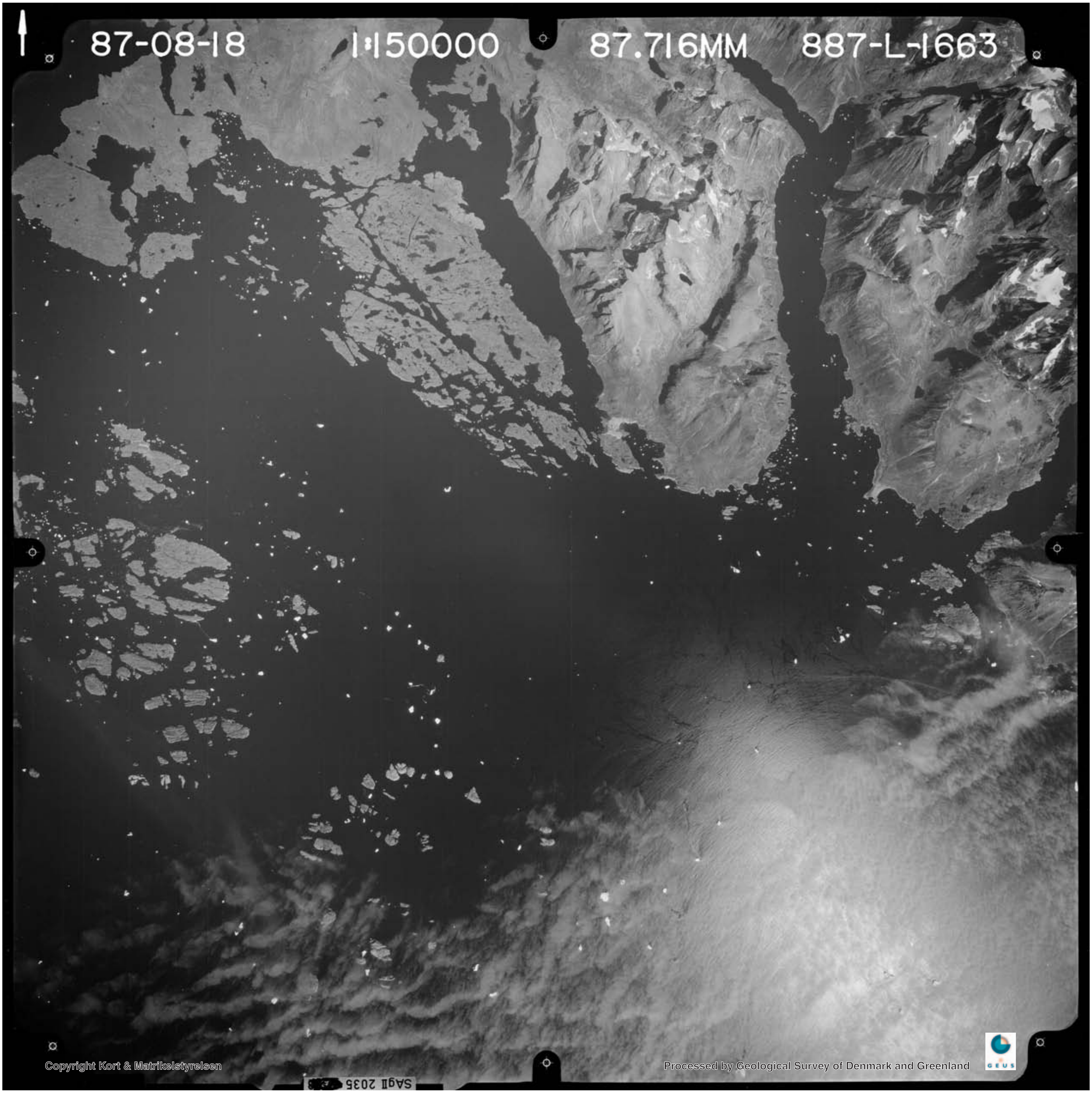
Approximate scale 0 2 4 6 8 10 km



Approximate scale 0 2 4 6 8 10 km

Contents

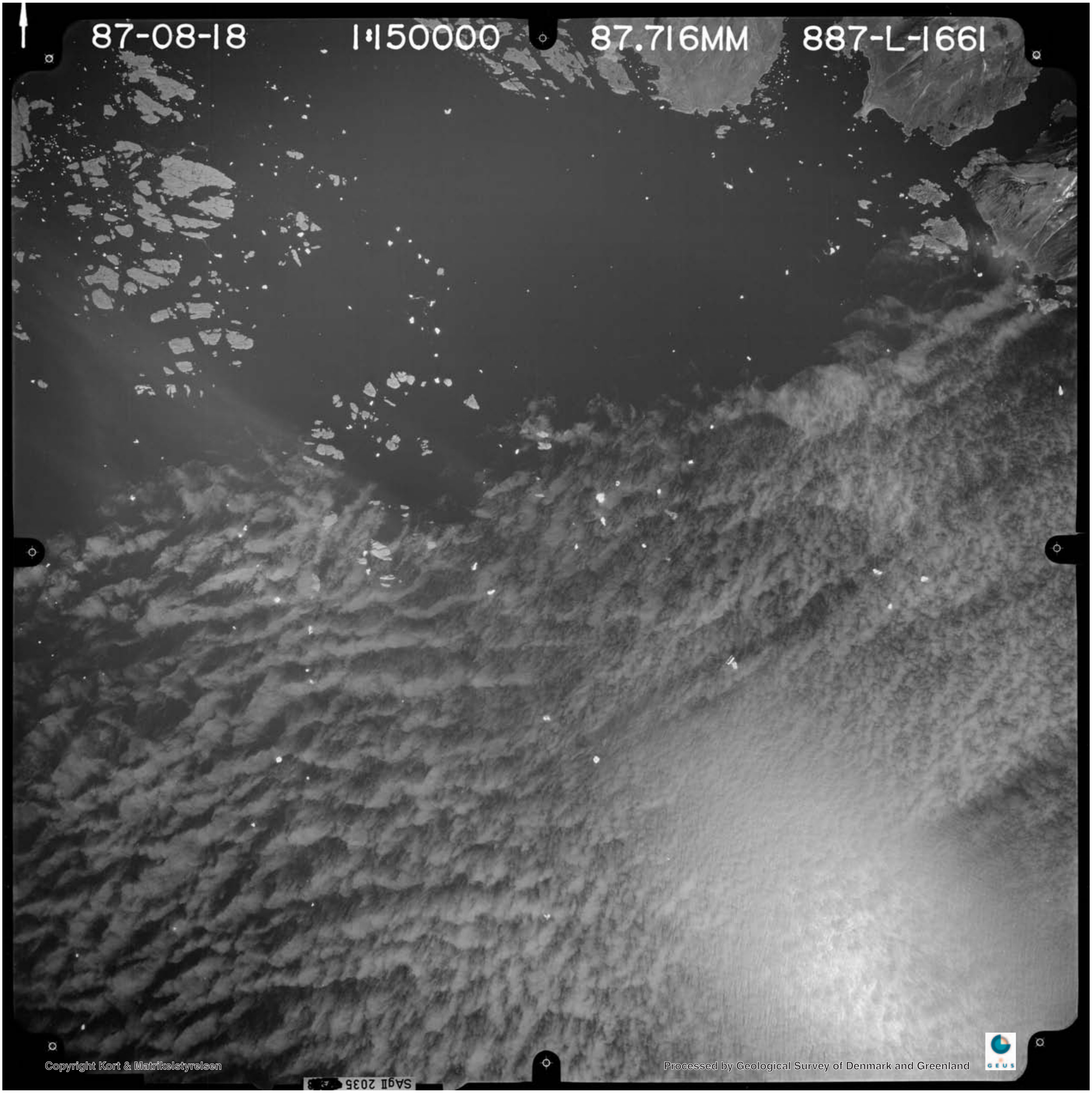
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

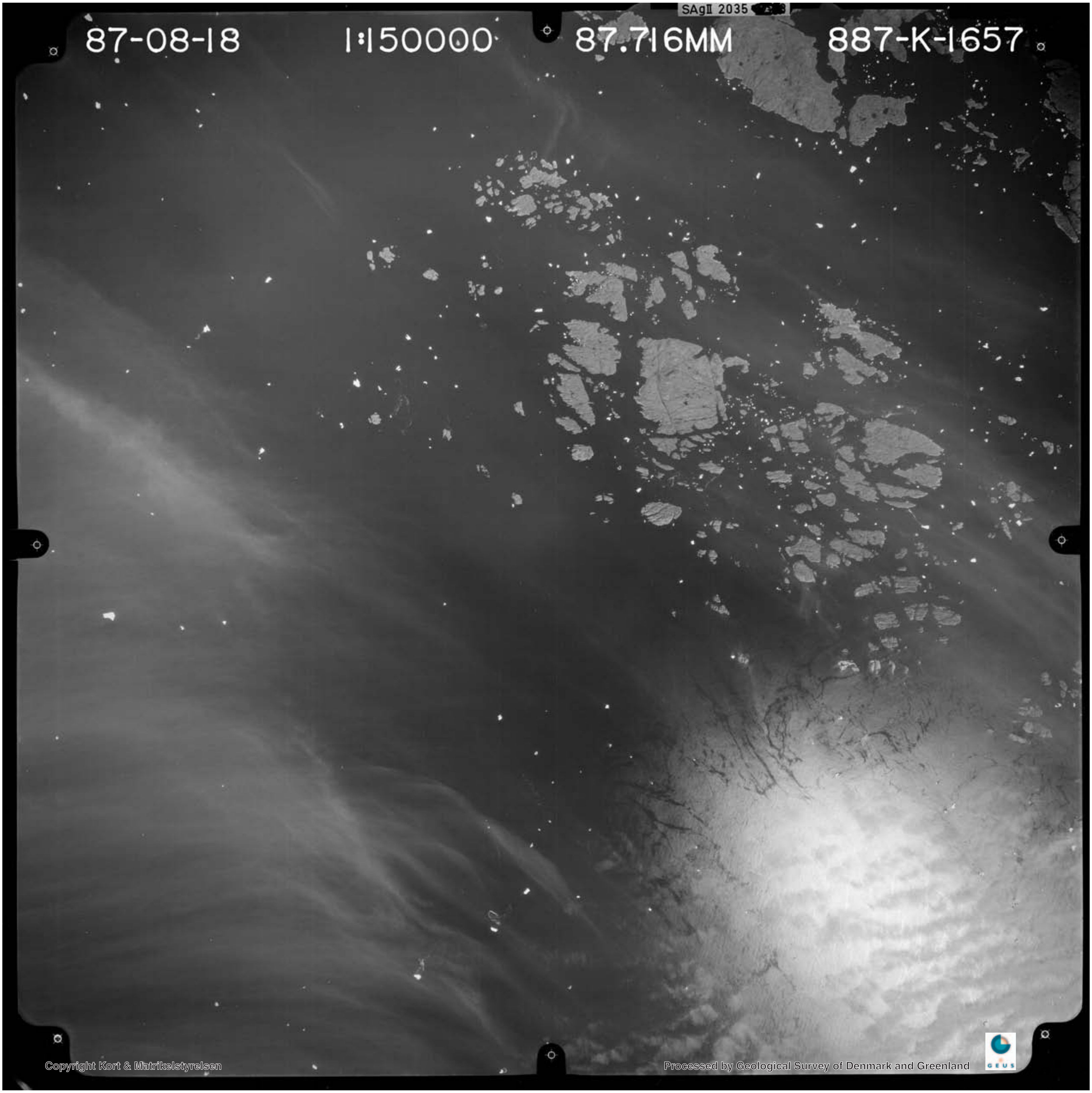
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

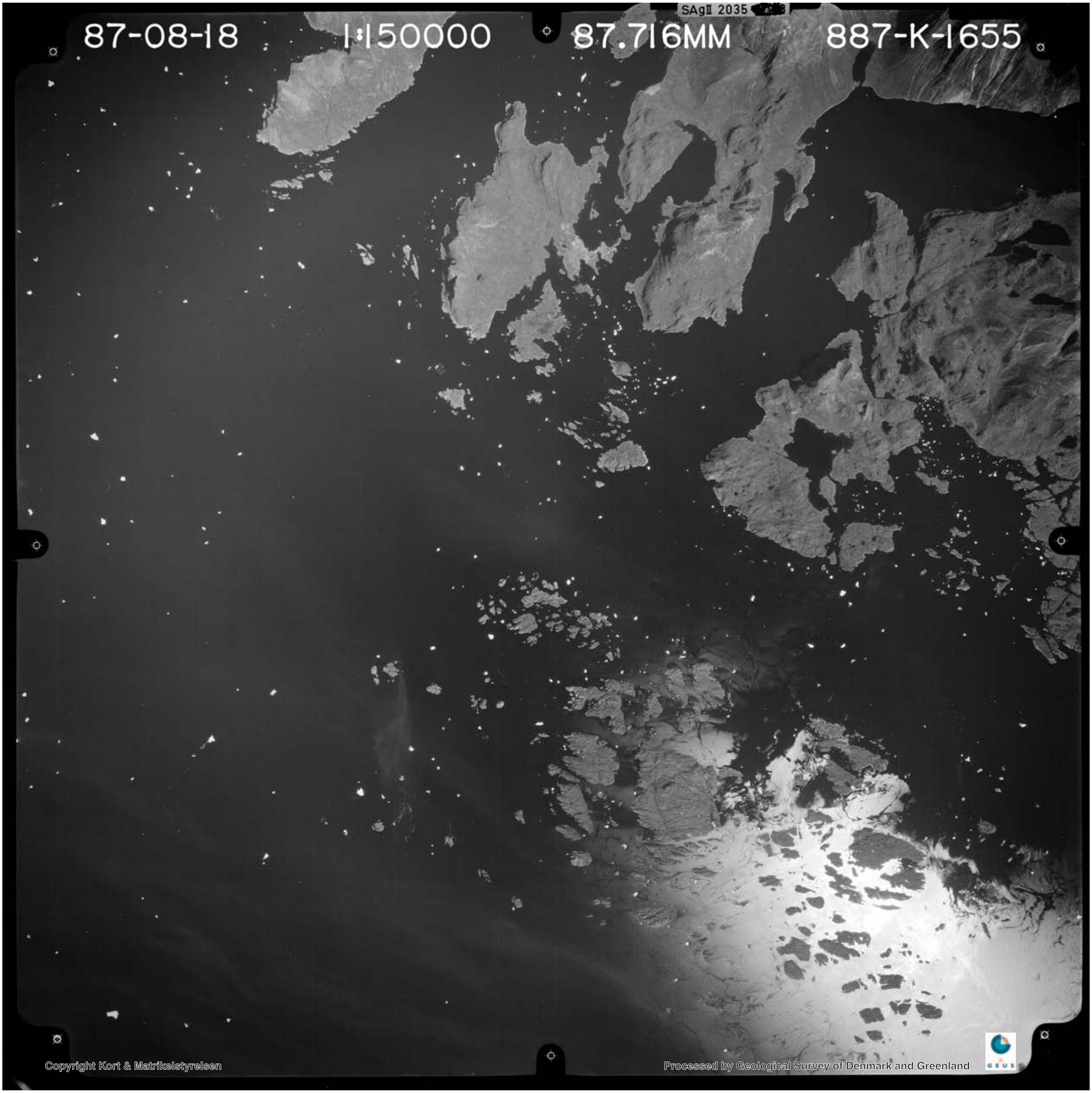
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

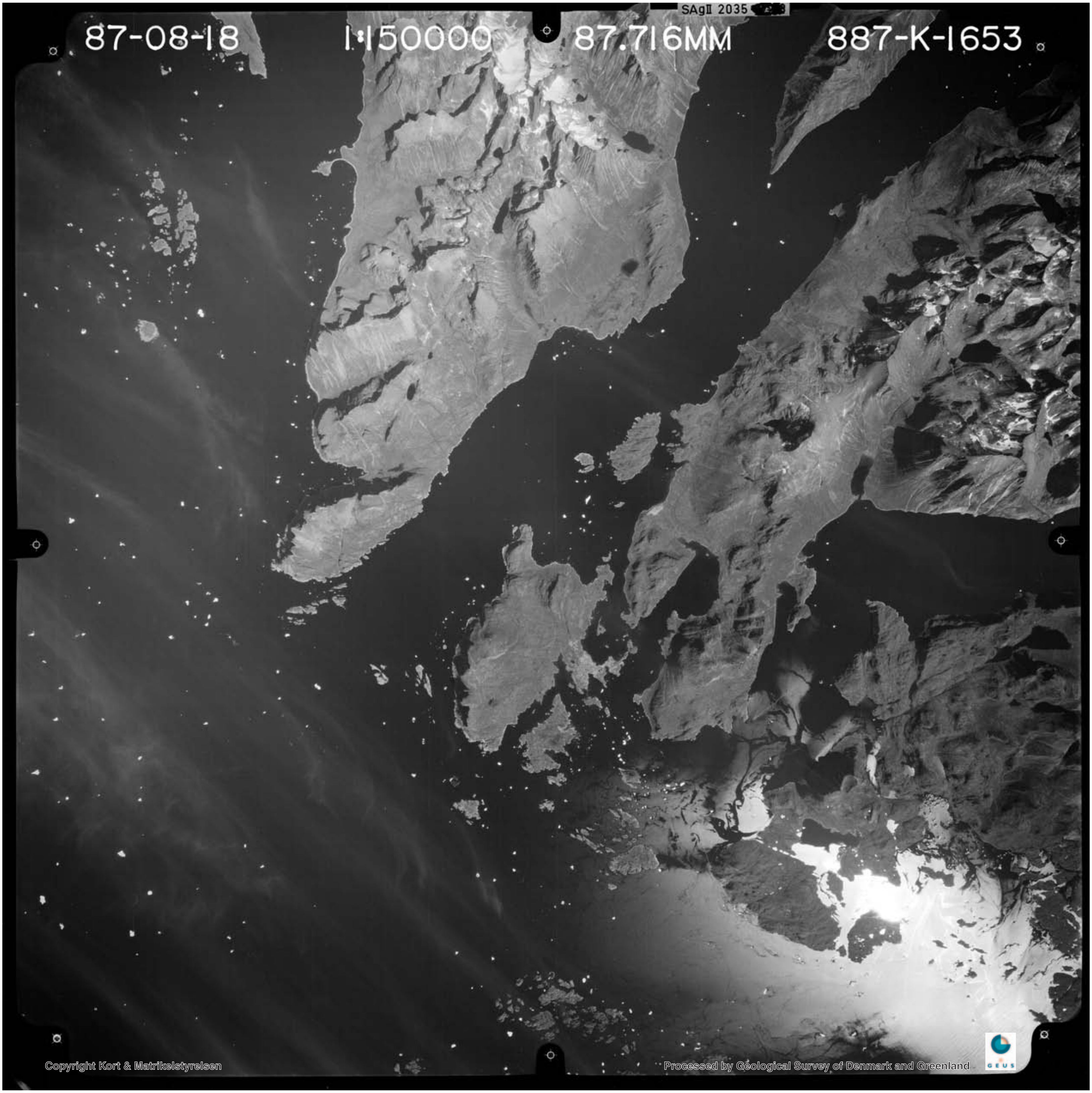
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

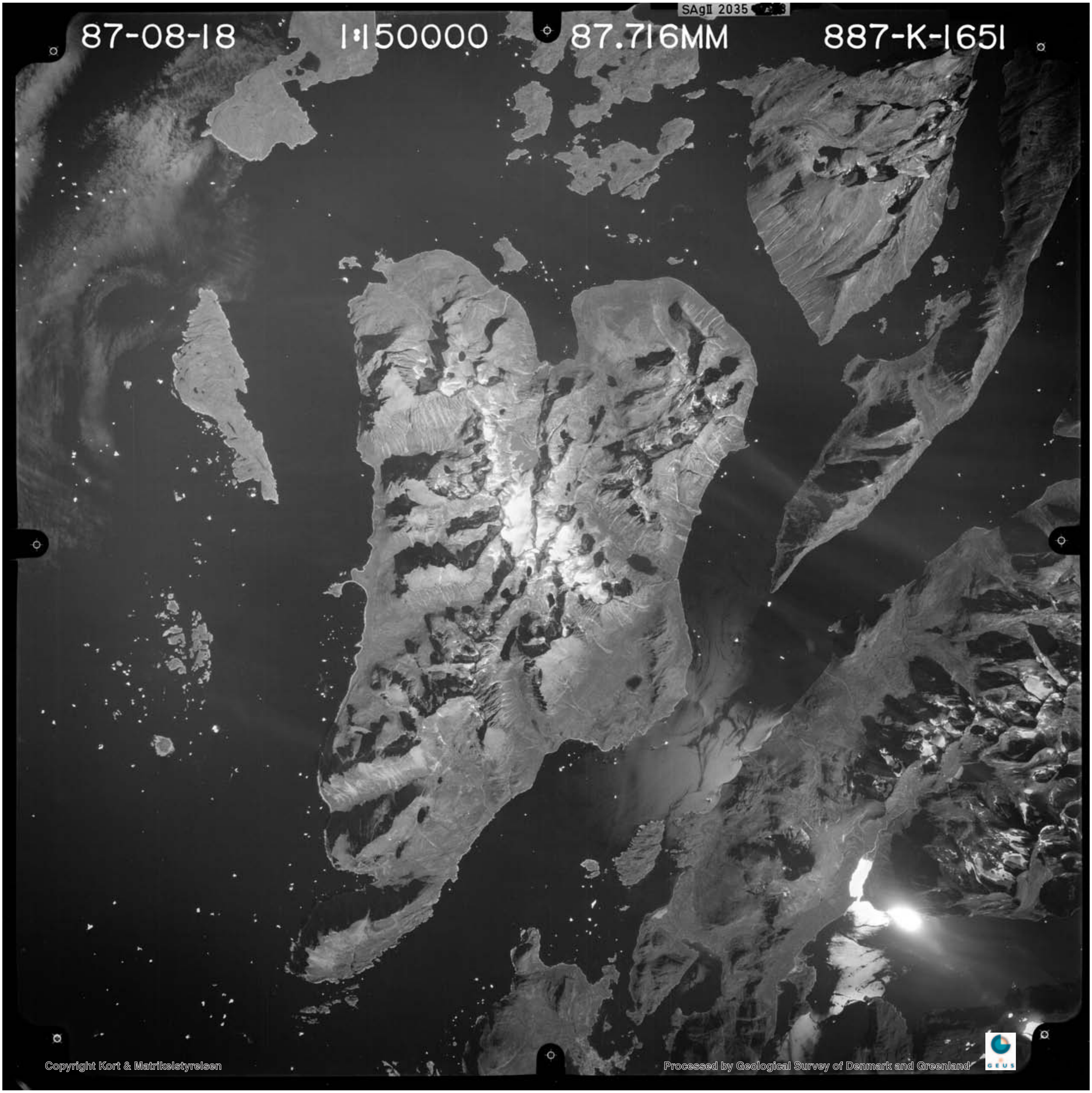
Contents

Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Contents

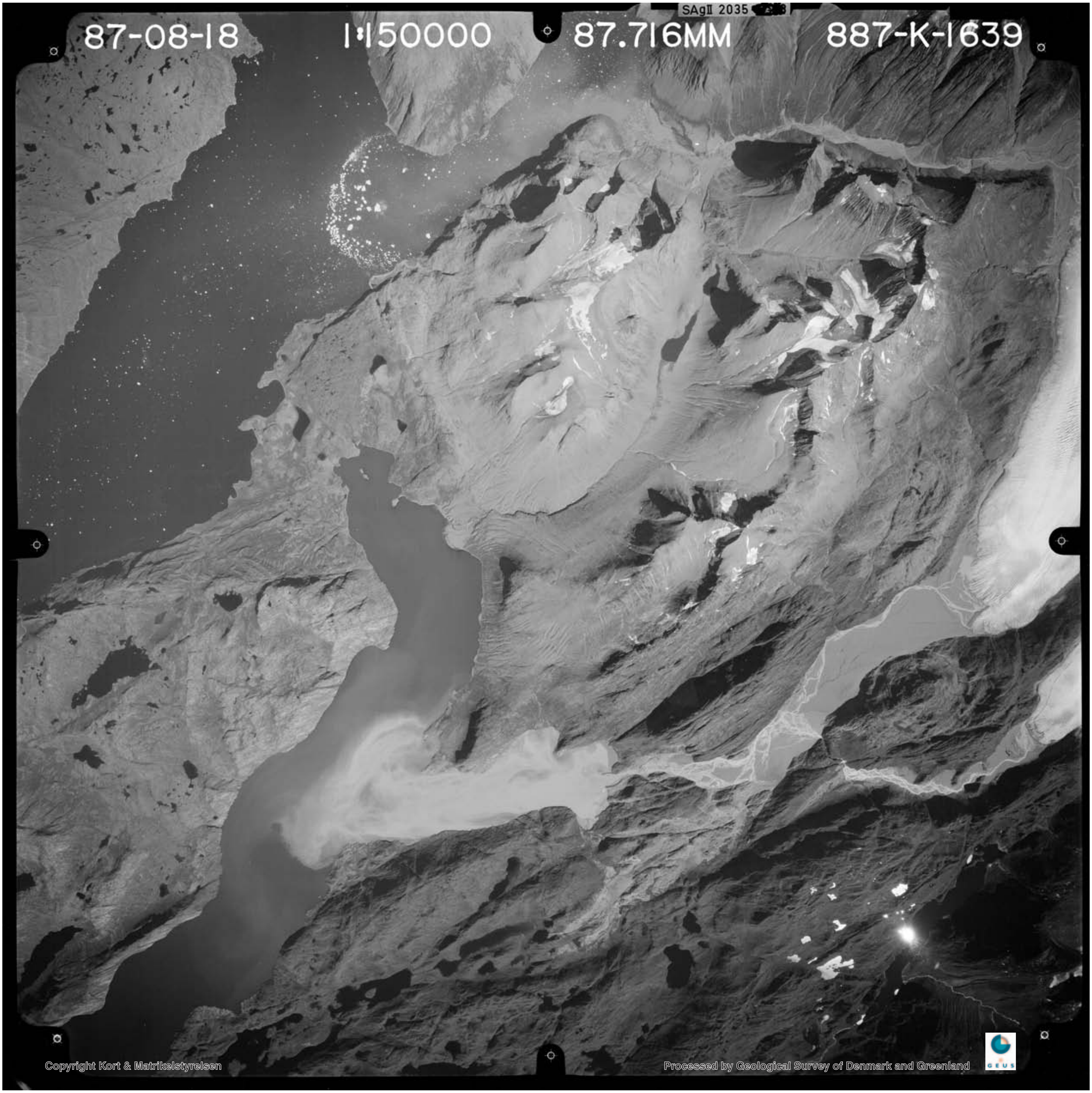
Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

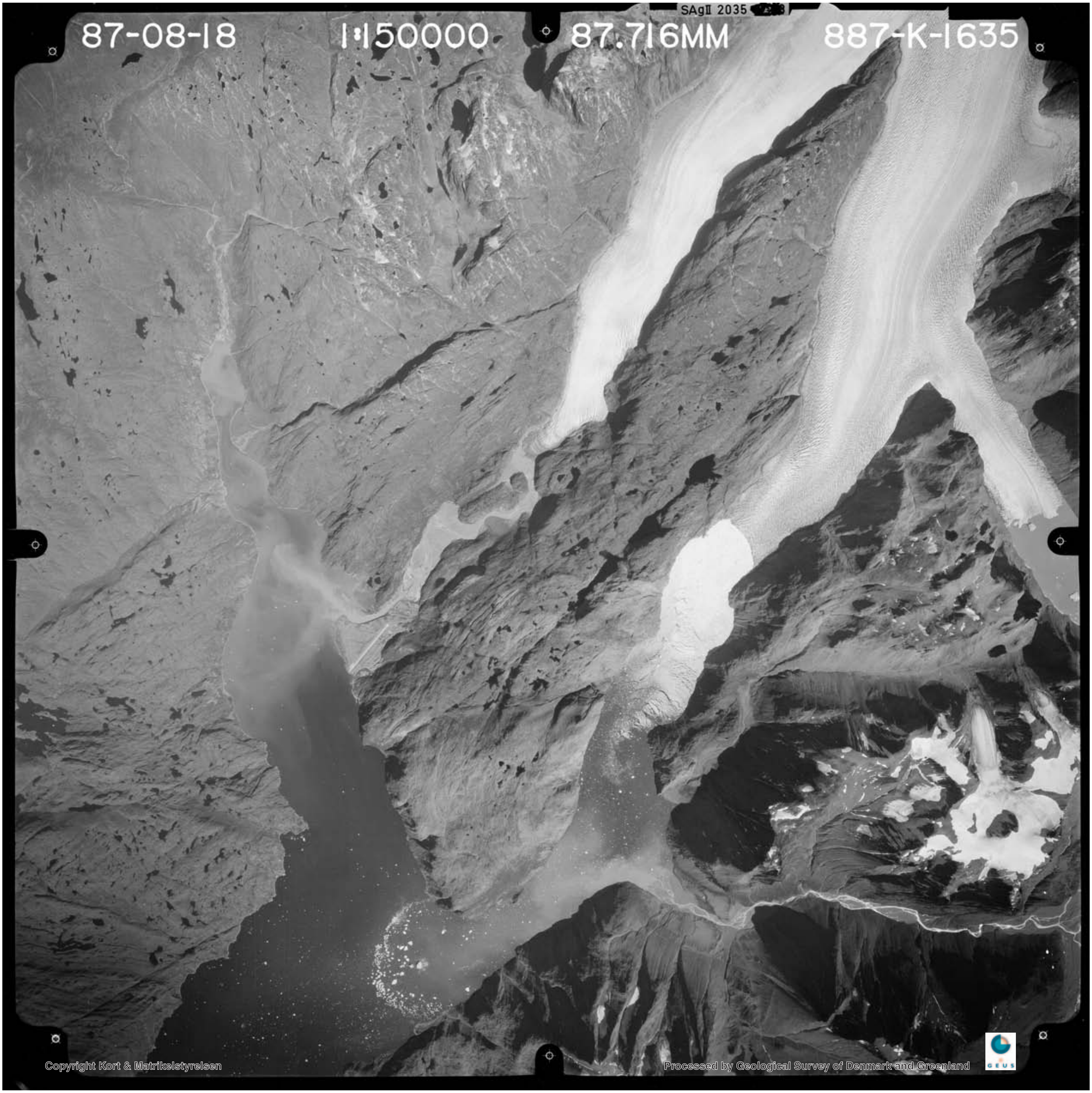
Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Contents

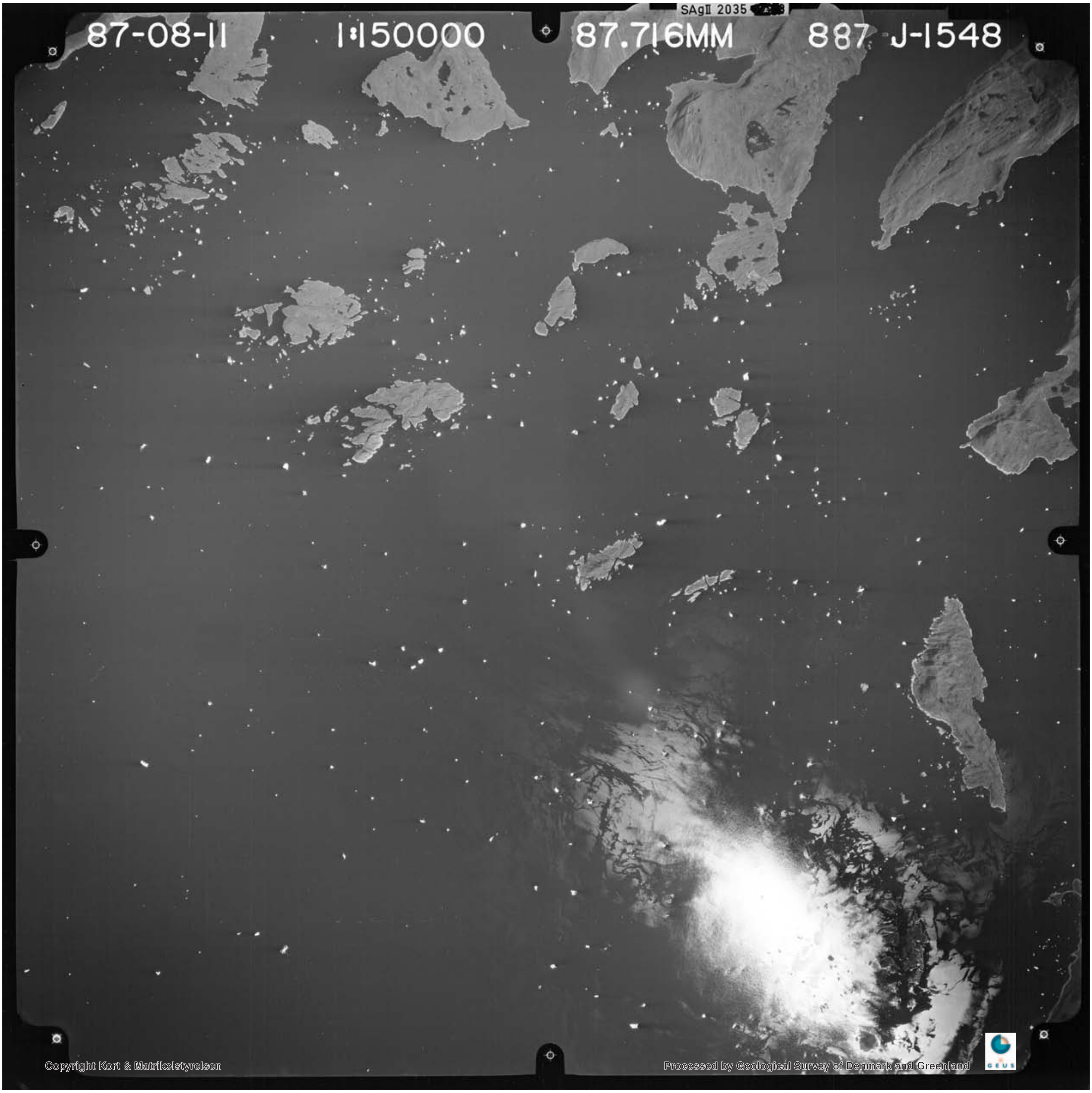
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

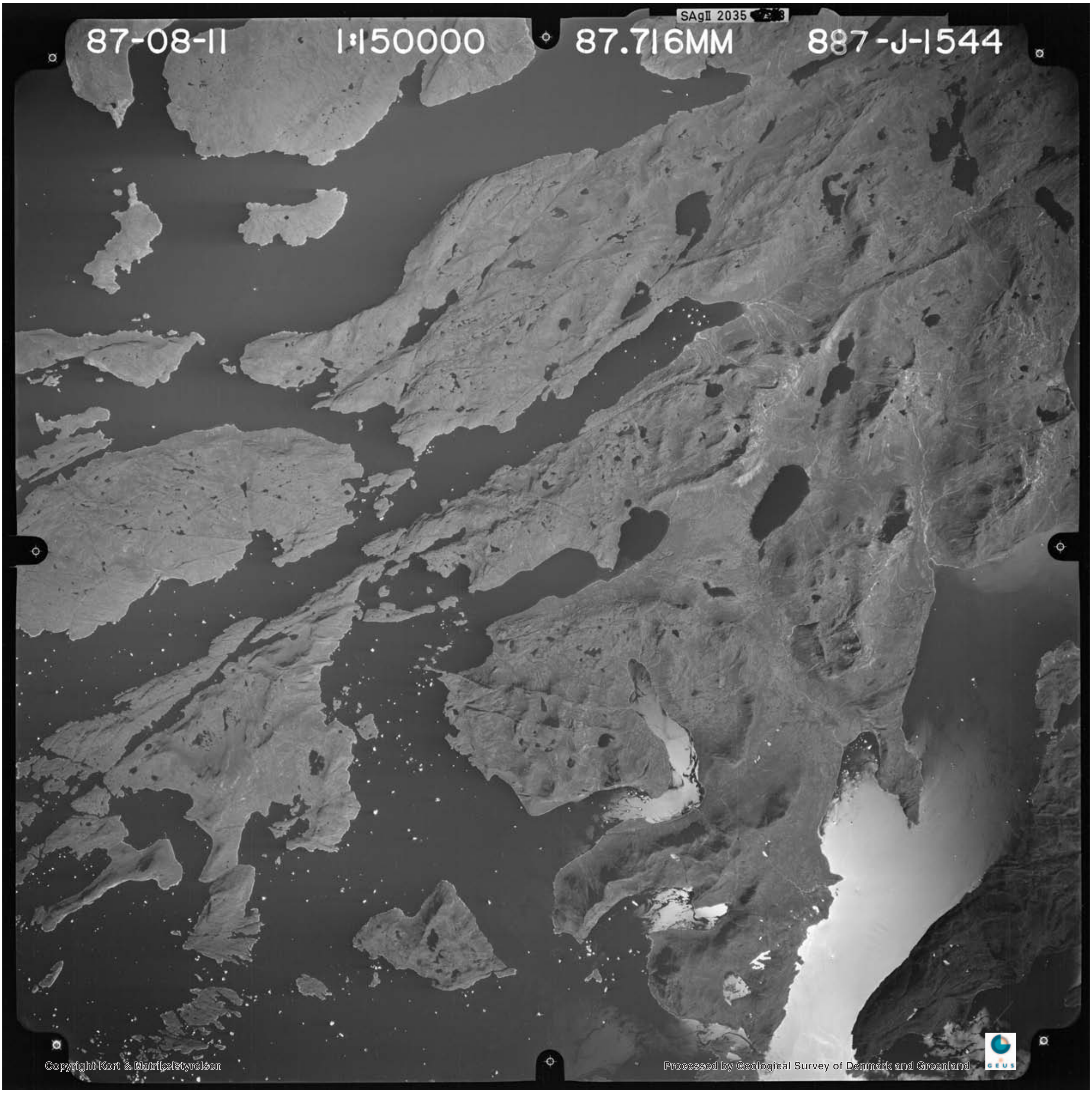
Contents

Airphoto Keymap

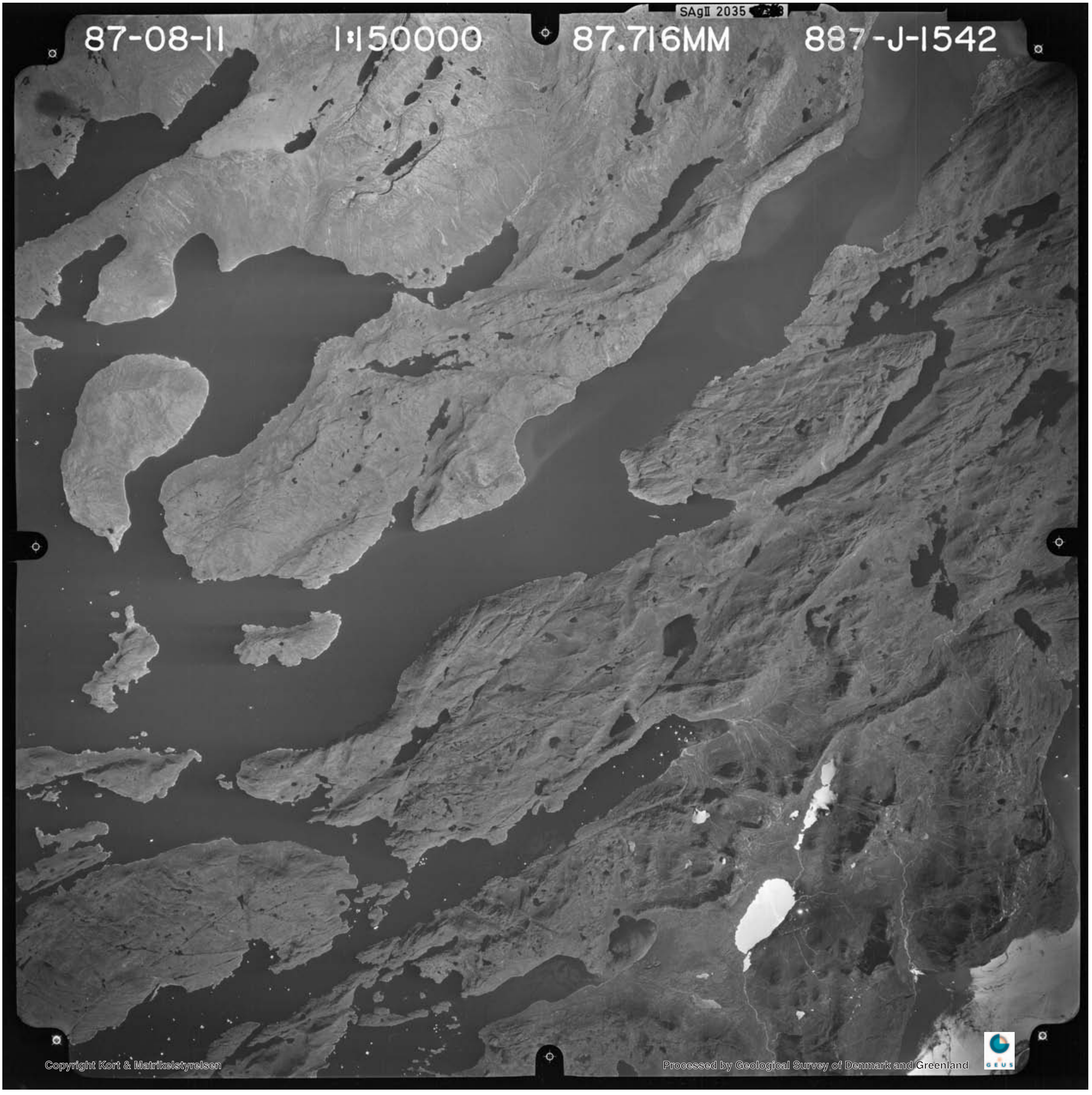
Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km



Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap

Contents

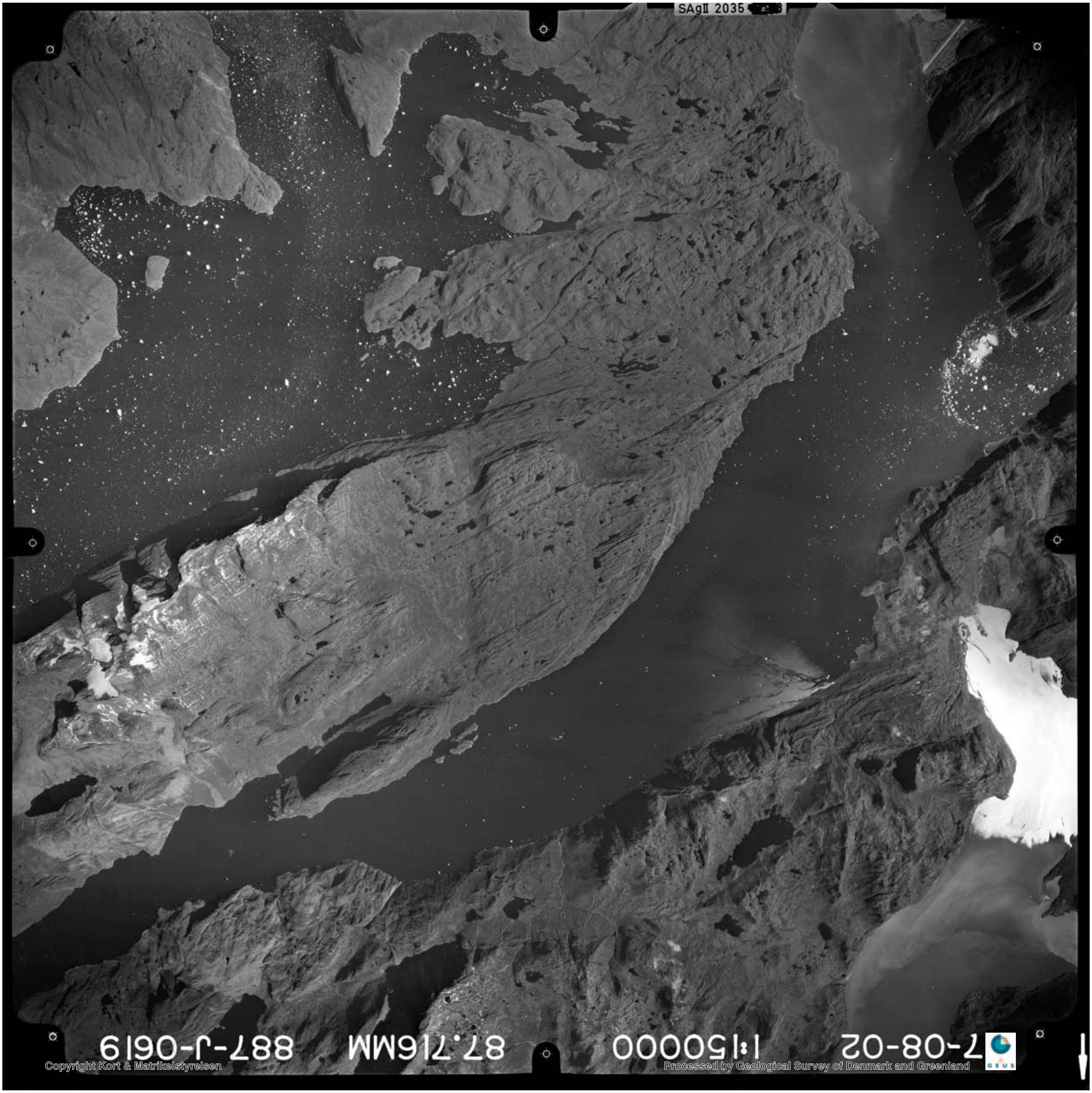
Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Approximate scale 0 2 4 6 8 10 km

Contents

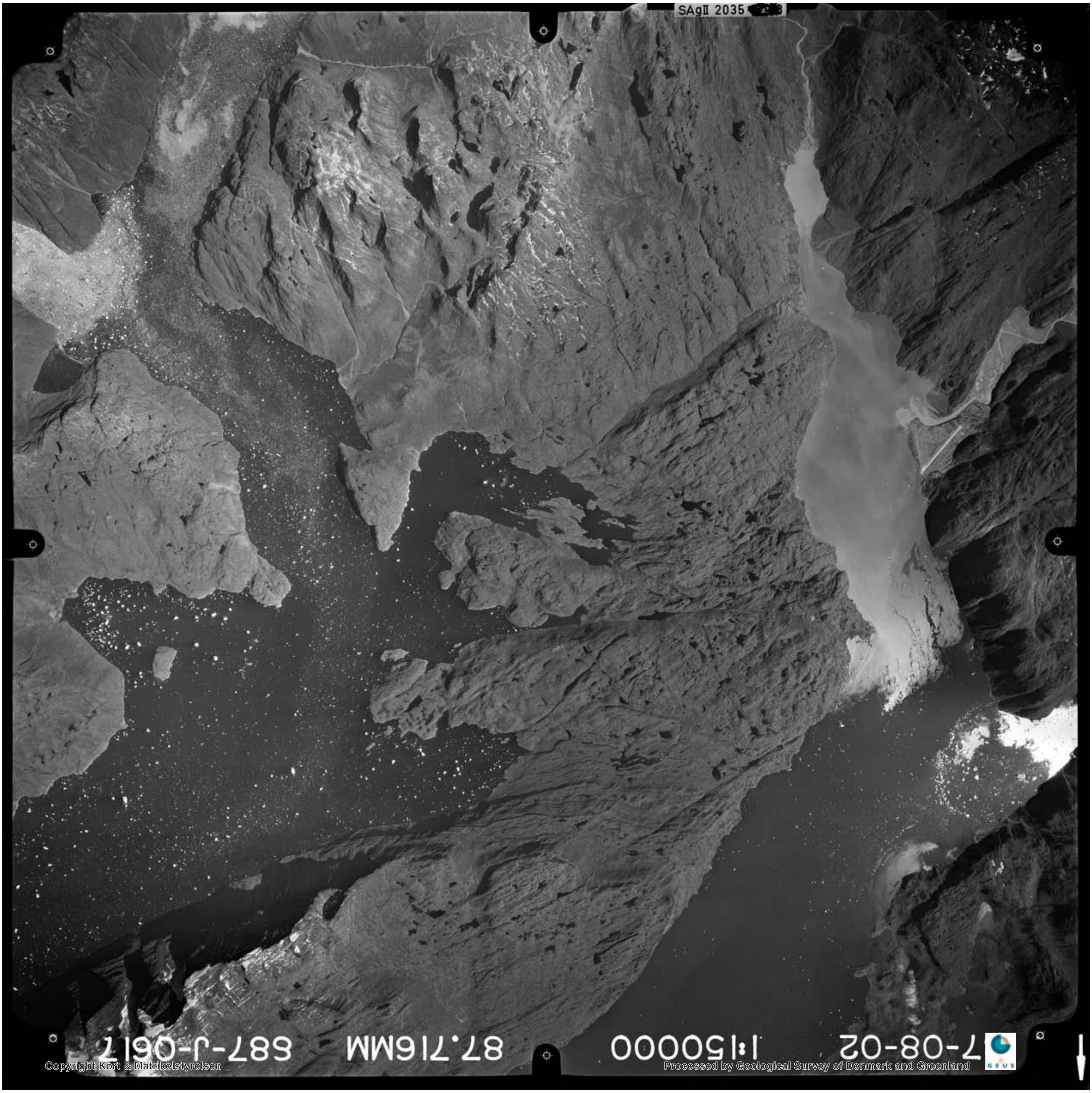
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

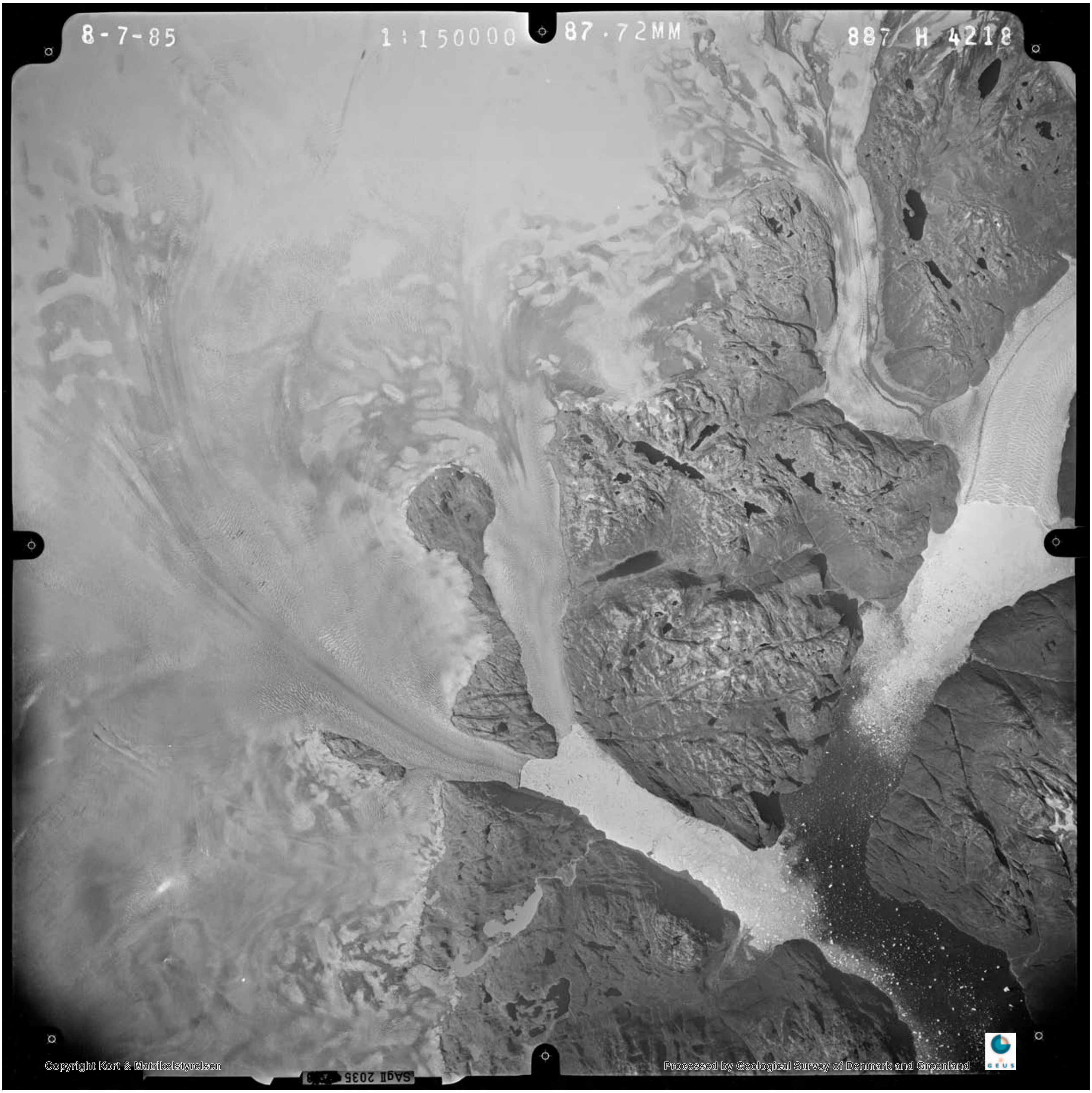
Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Contents

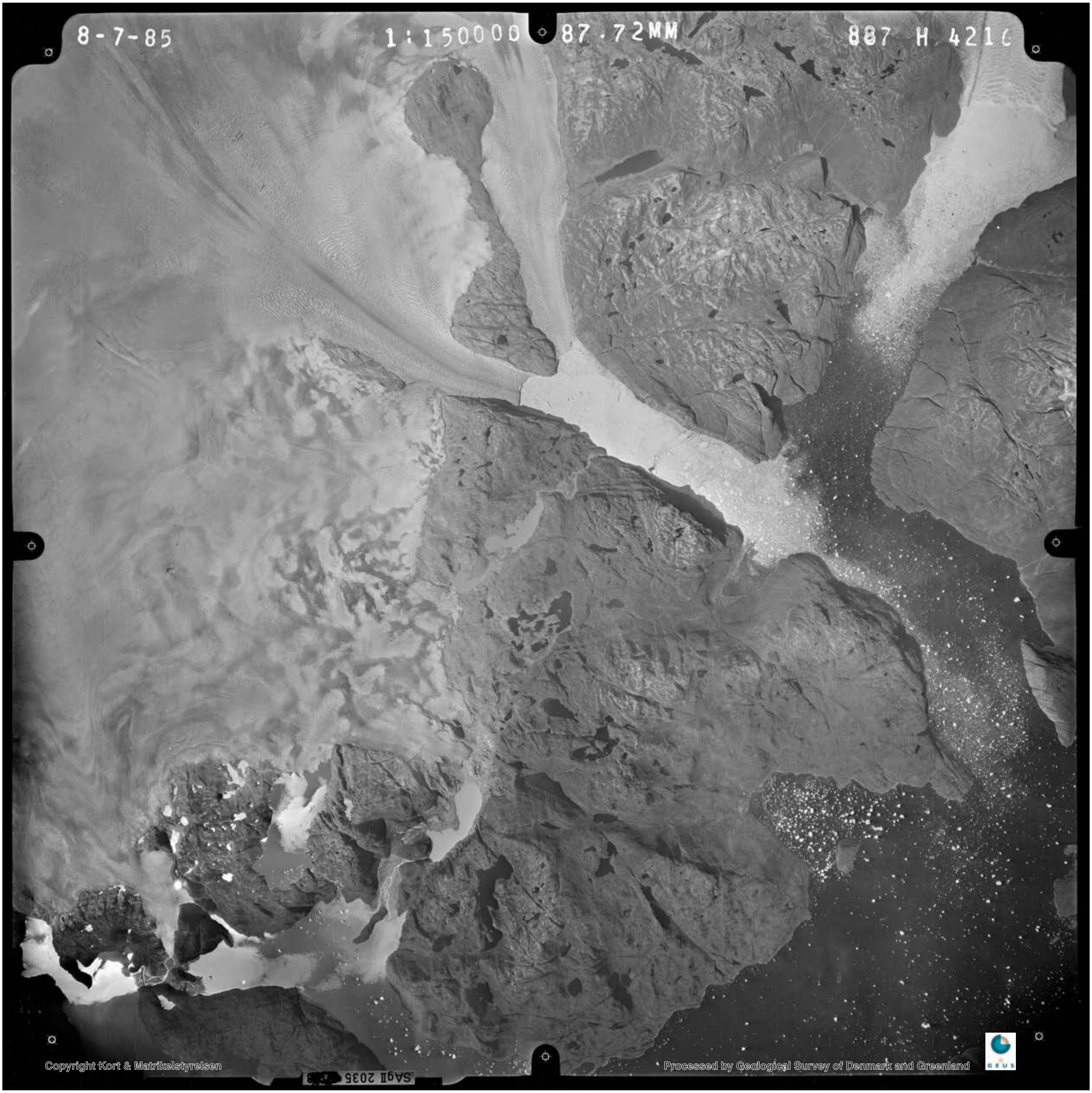
Airphoto Keymap



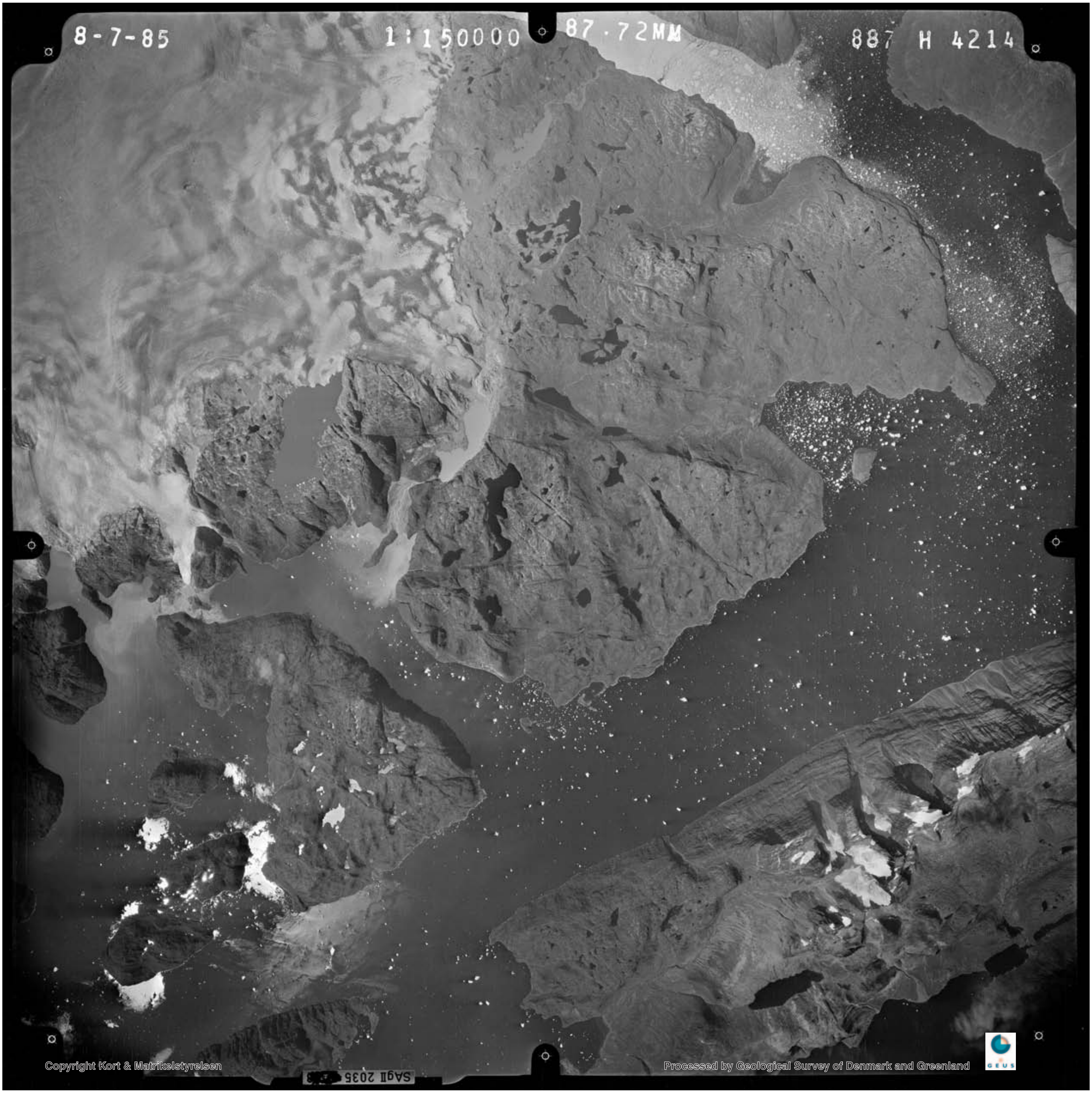
Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km



Approximate scale 0 2 4 6 8 10 km

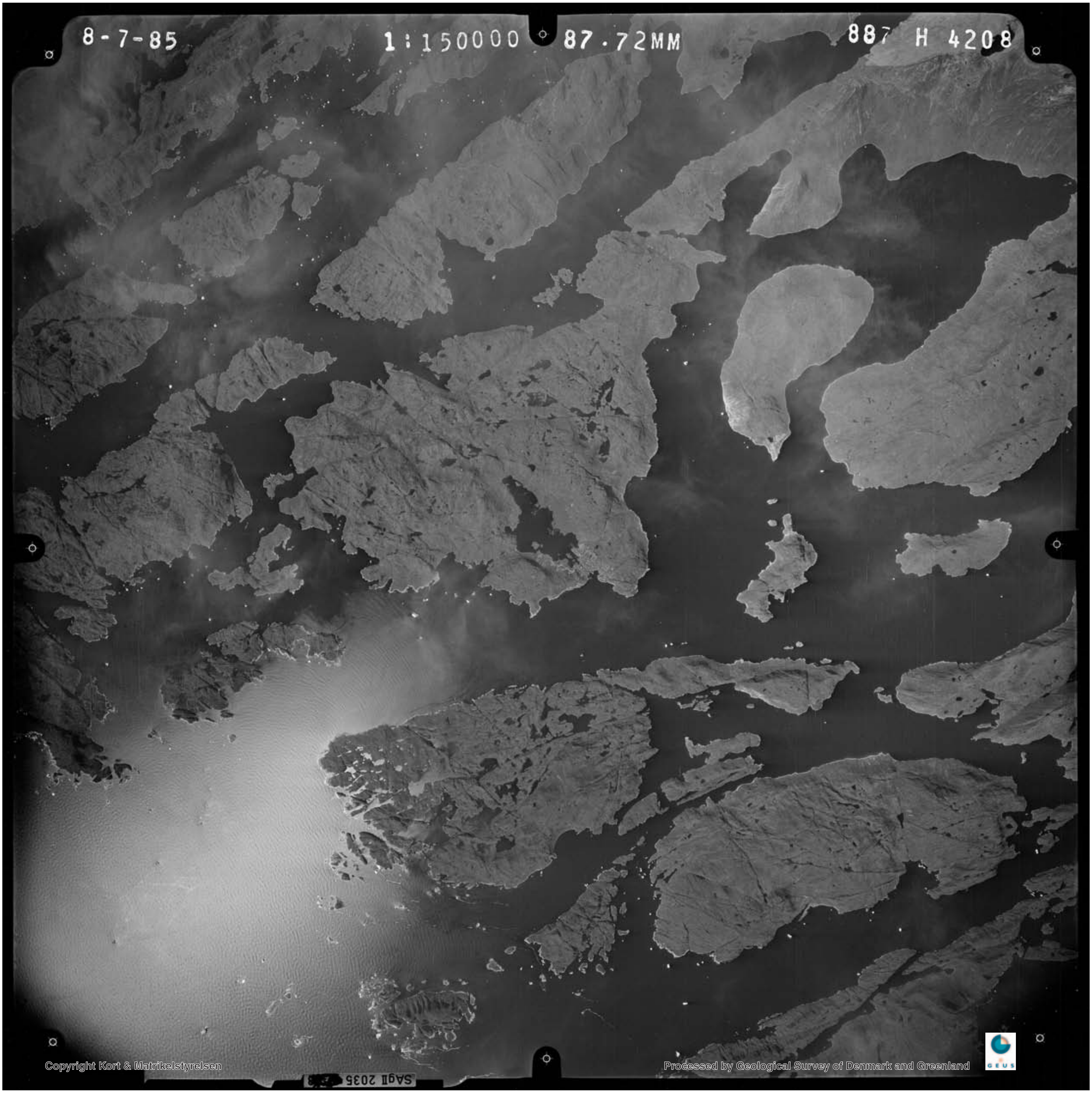
Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

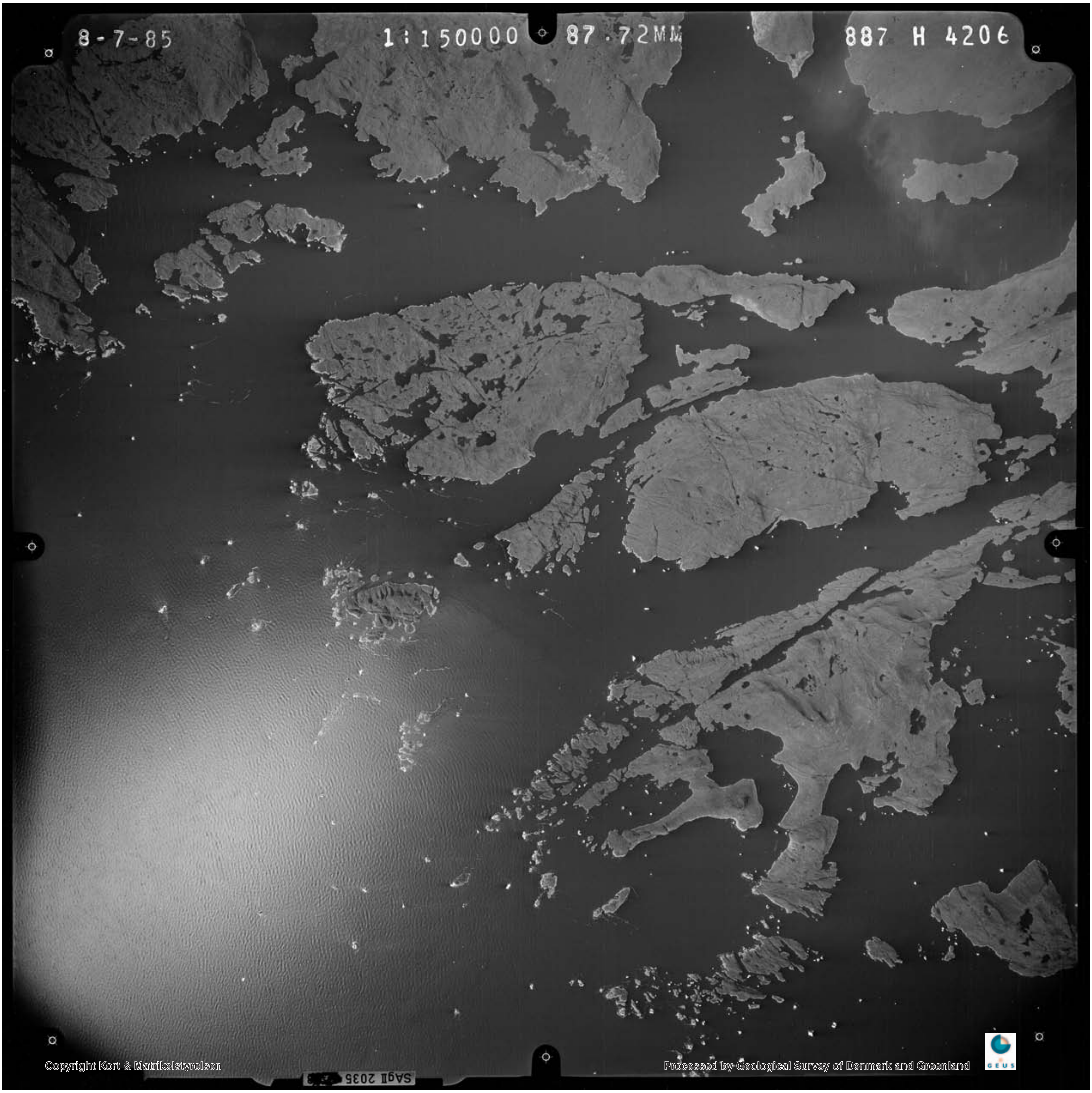
Contents   Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

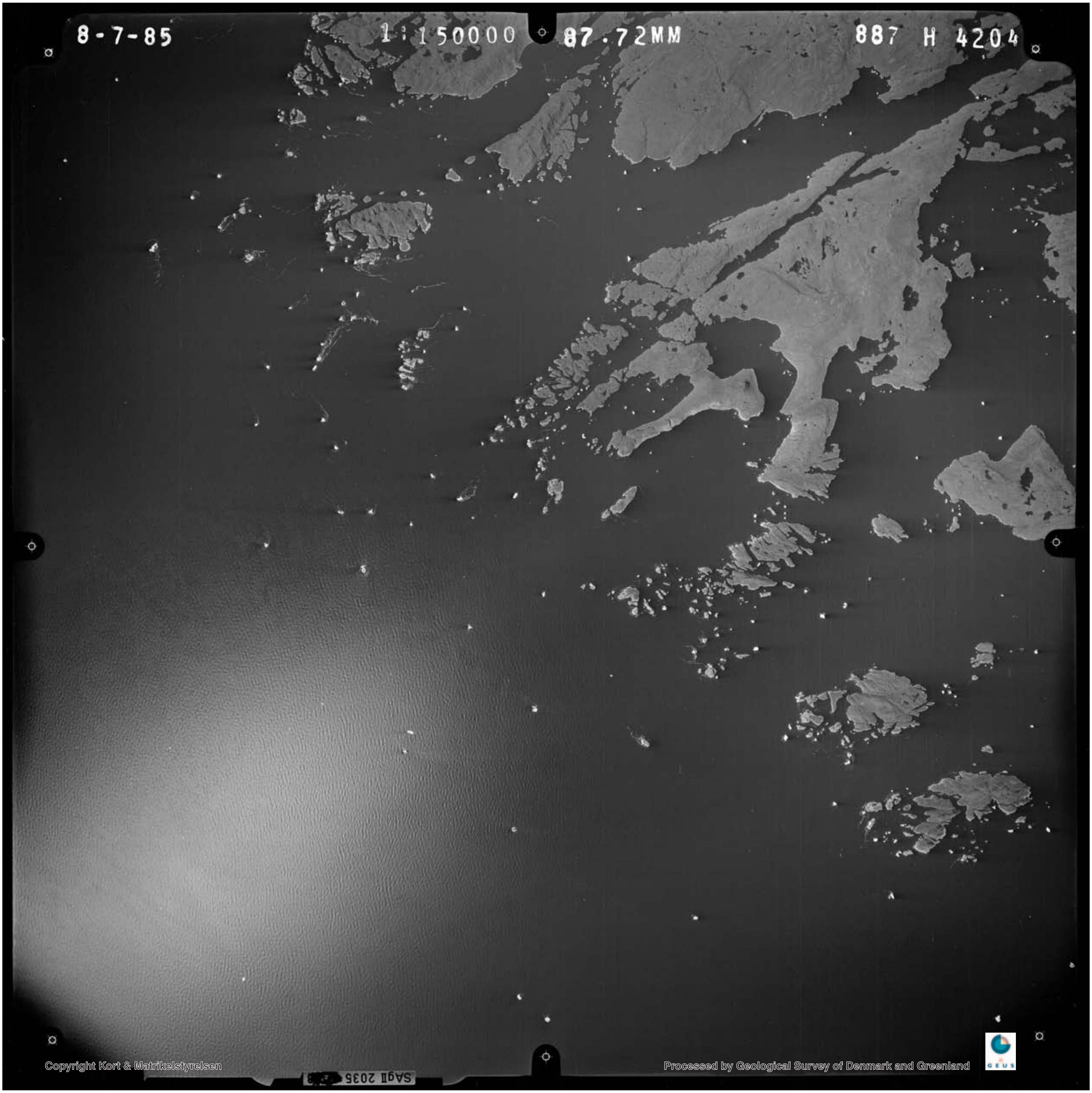
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

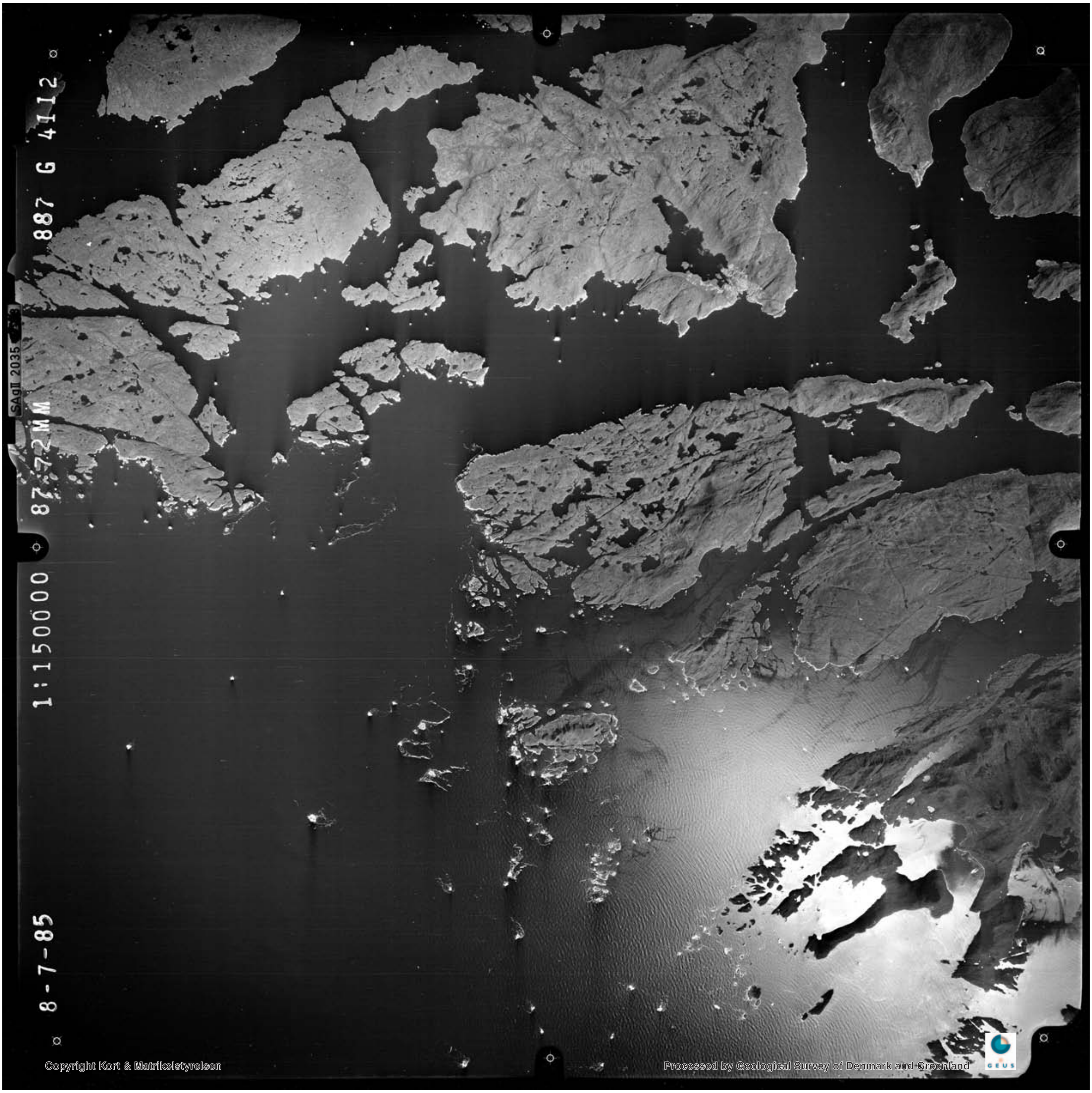
Airphoto Keymap



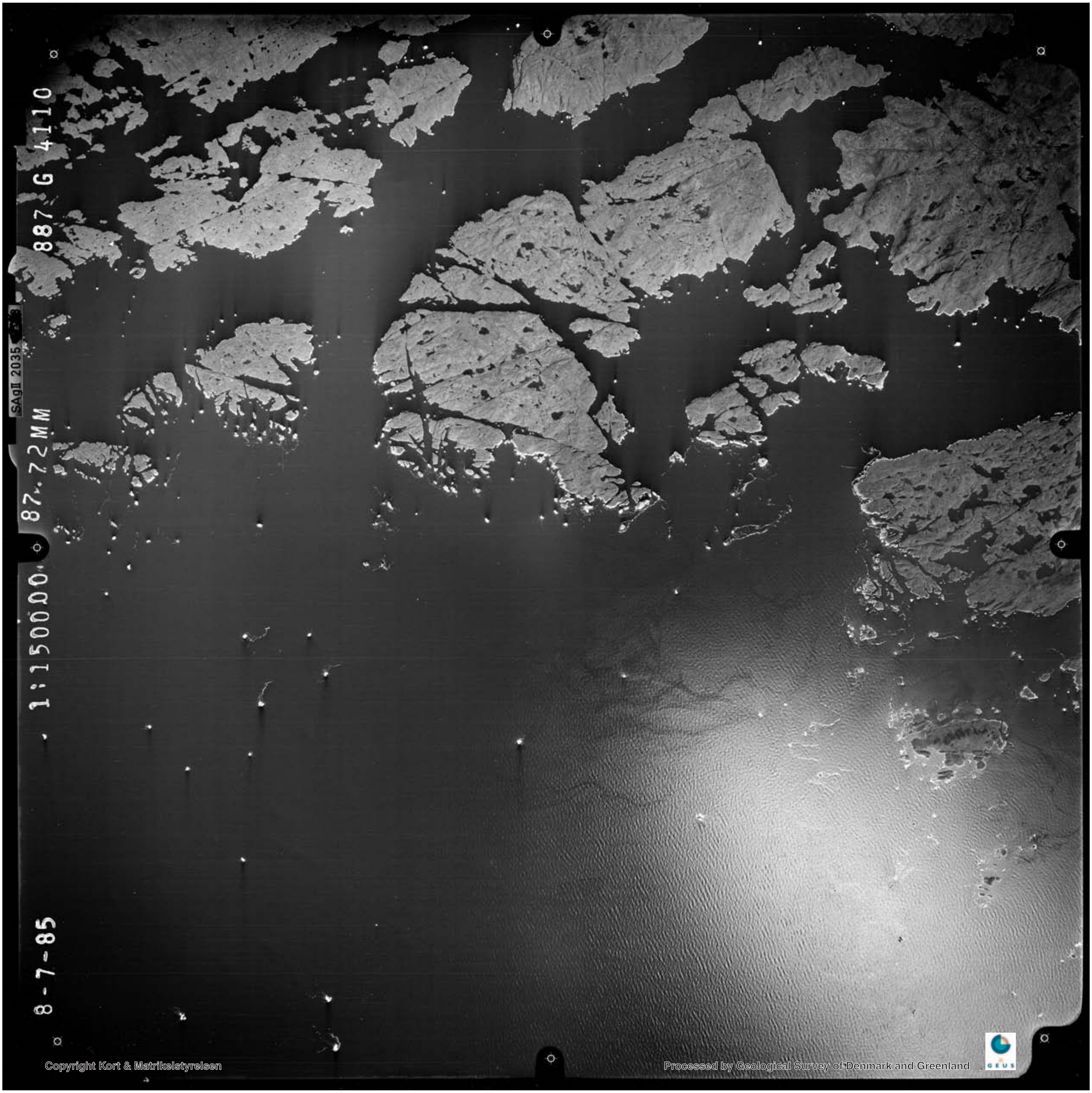
Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



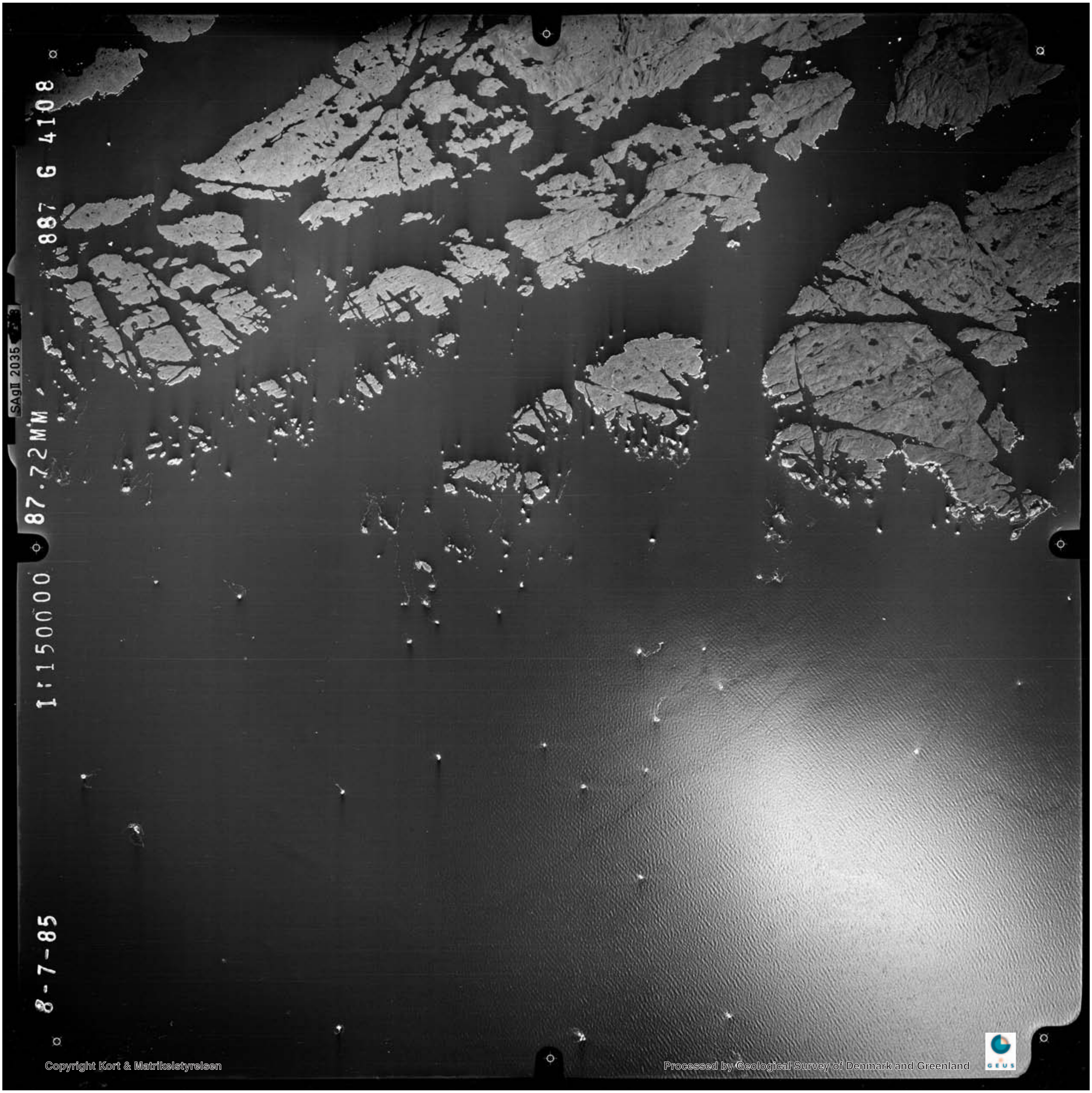
Approximate scale 0 2 4 6 8 10 km



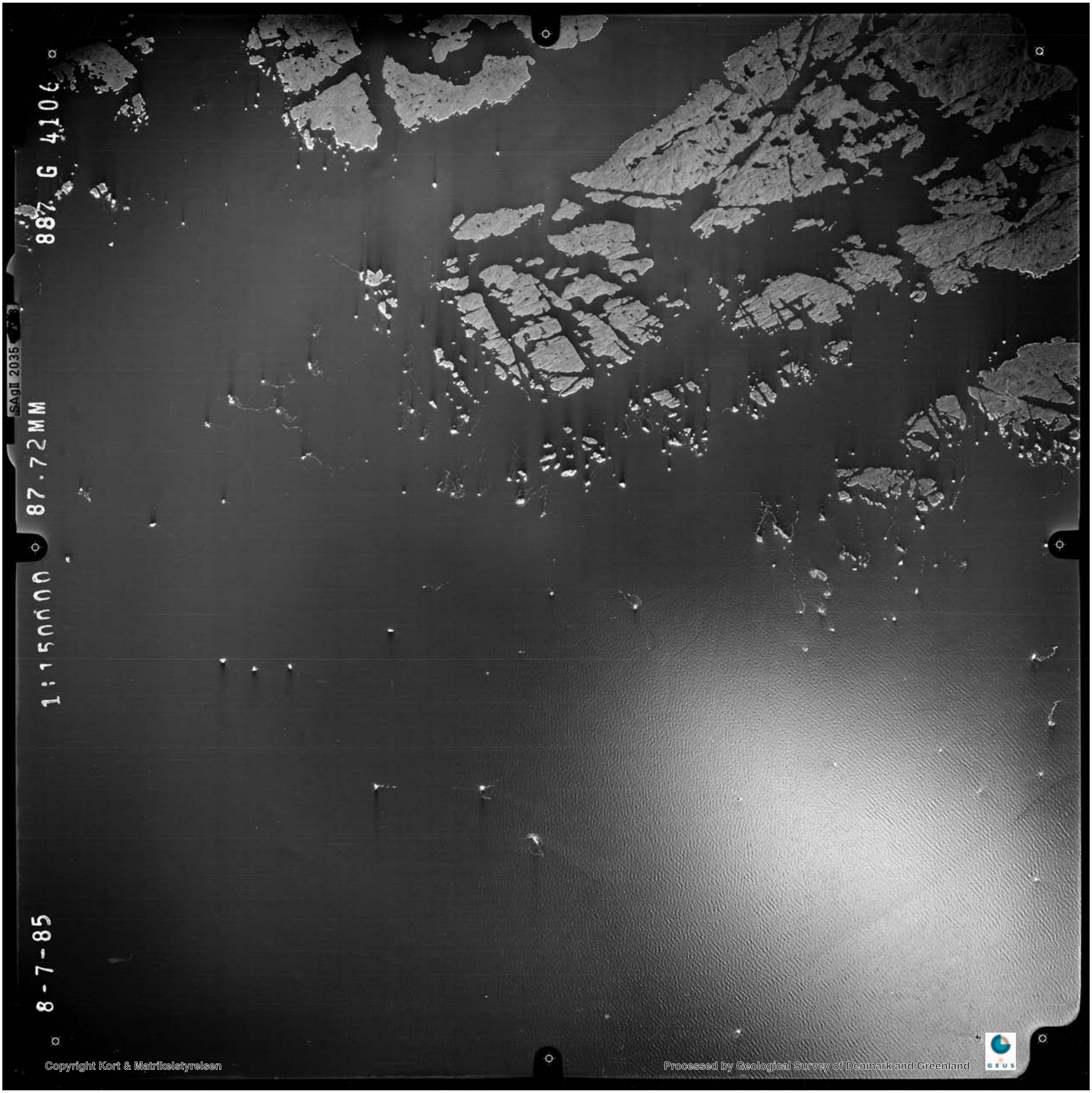
Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



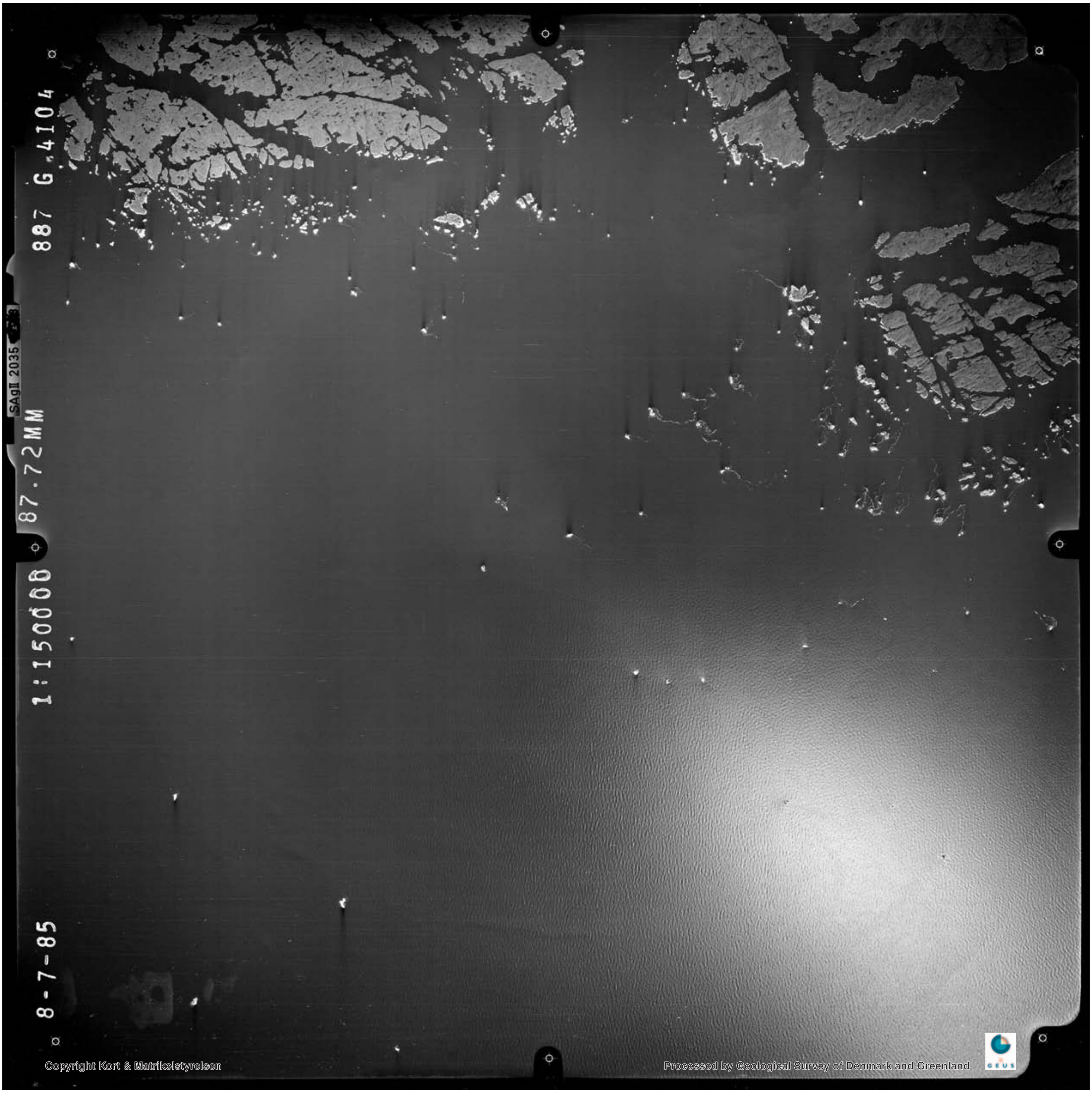
Approximate scale 0 2 4 6 8 10 km



Approximate scale 0 2 4 6 8 10 km

Contents

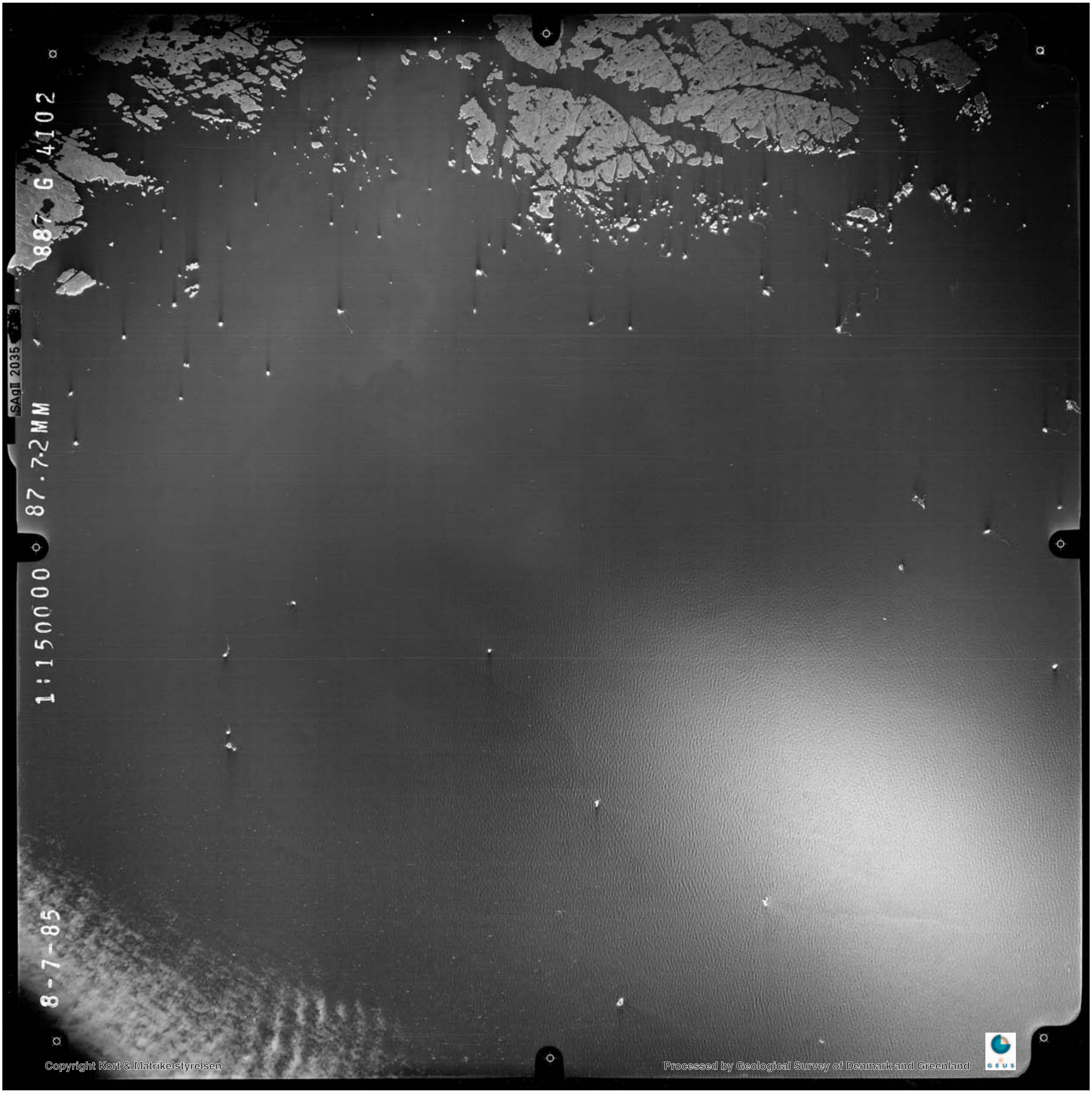
Airphoto Keymap



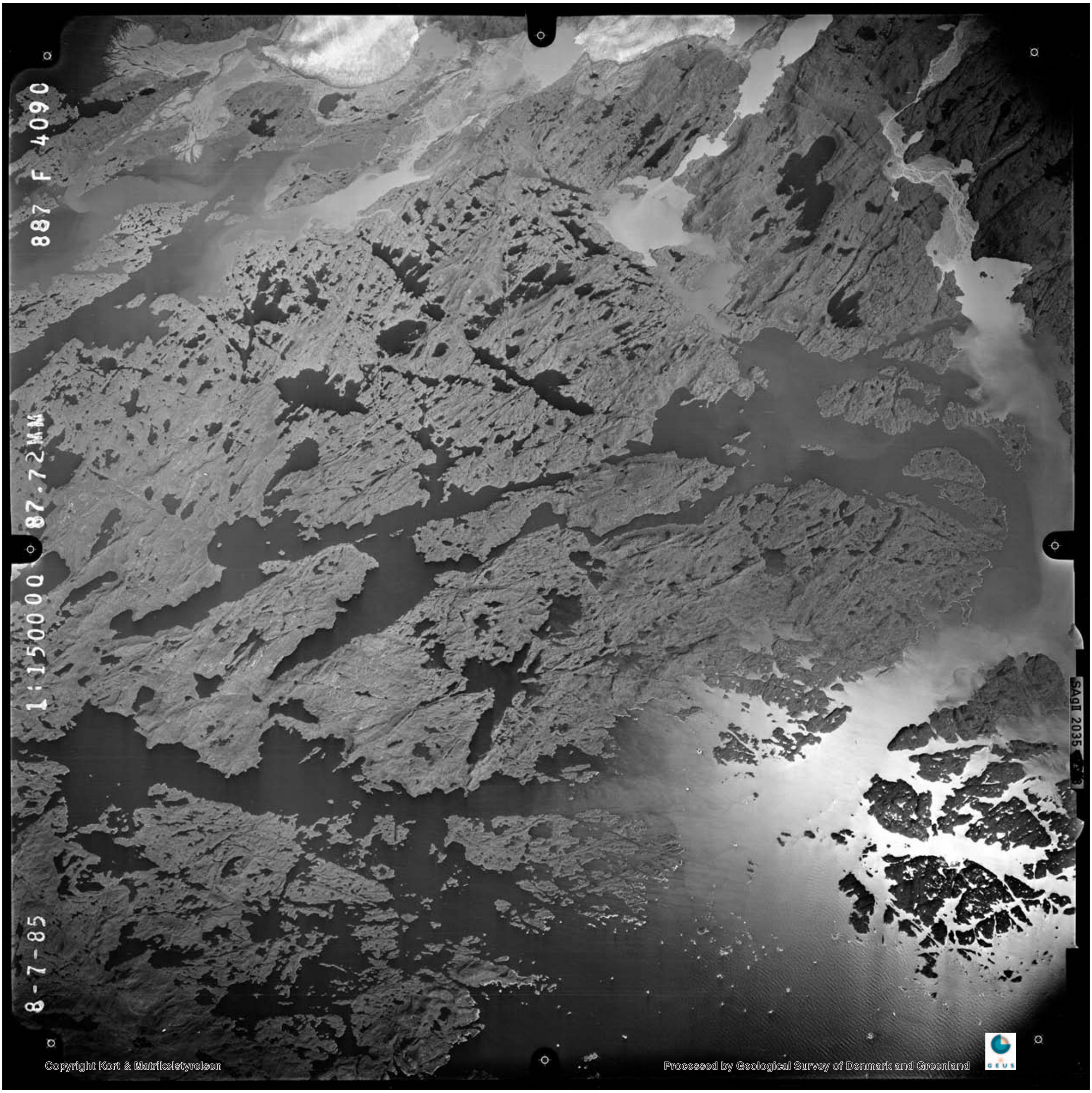
Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



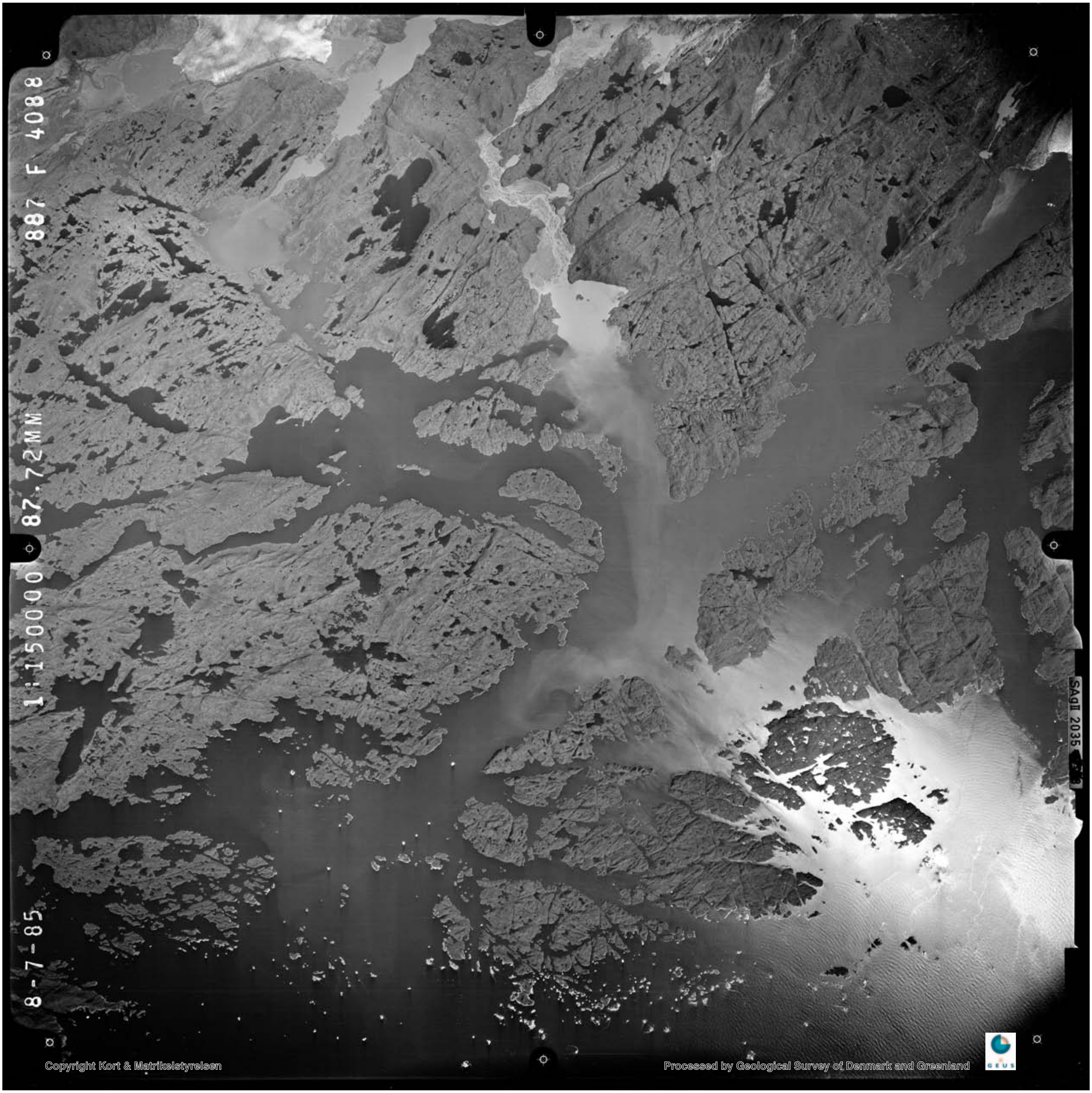
Approximate scale 0 2 4 6 8 10 km



Approximate scale 0 2 4 6 8 10 km

Contents

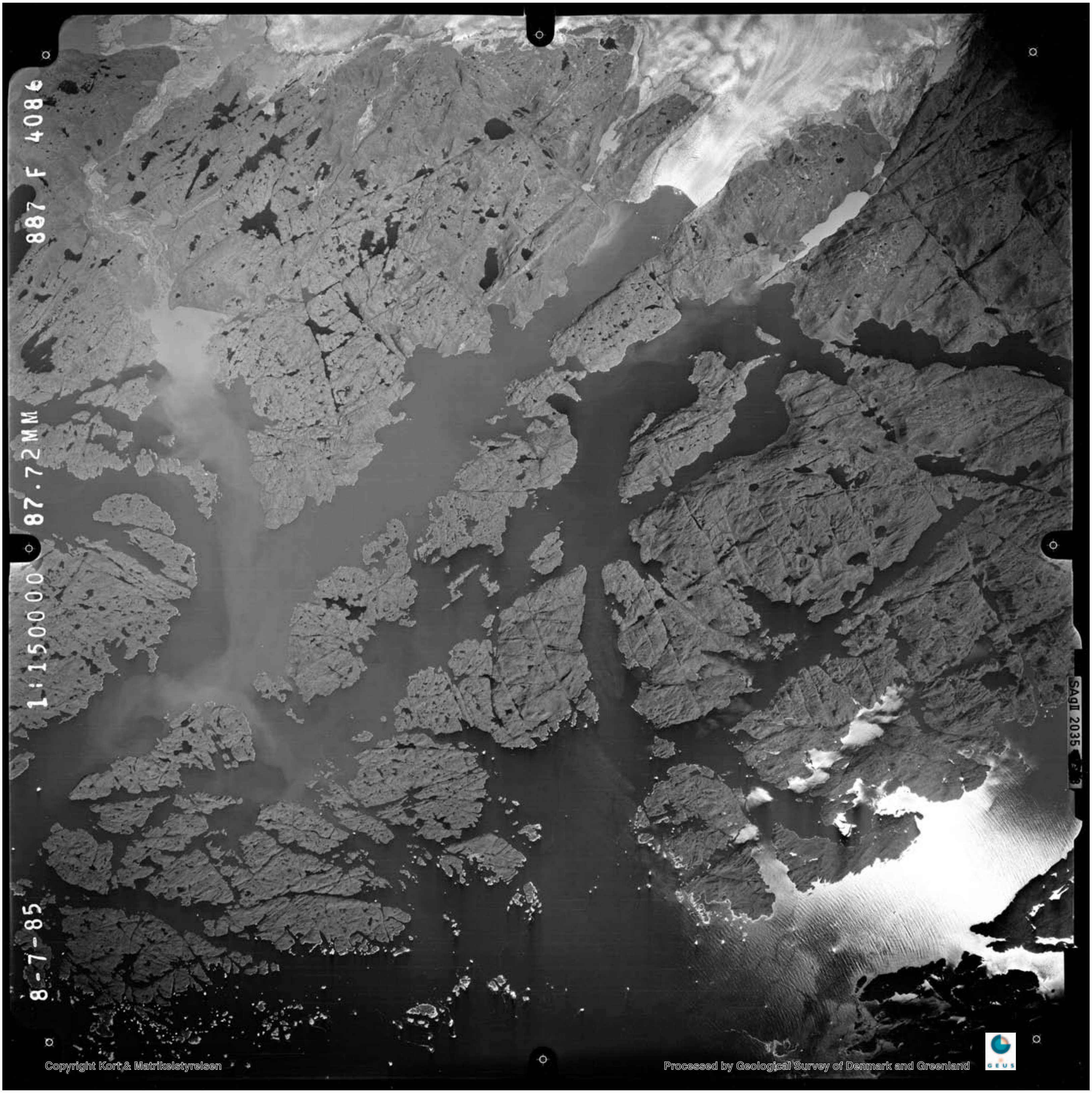
Airphoto Keymap



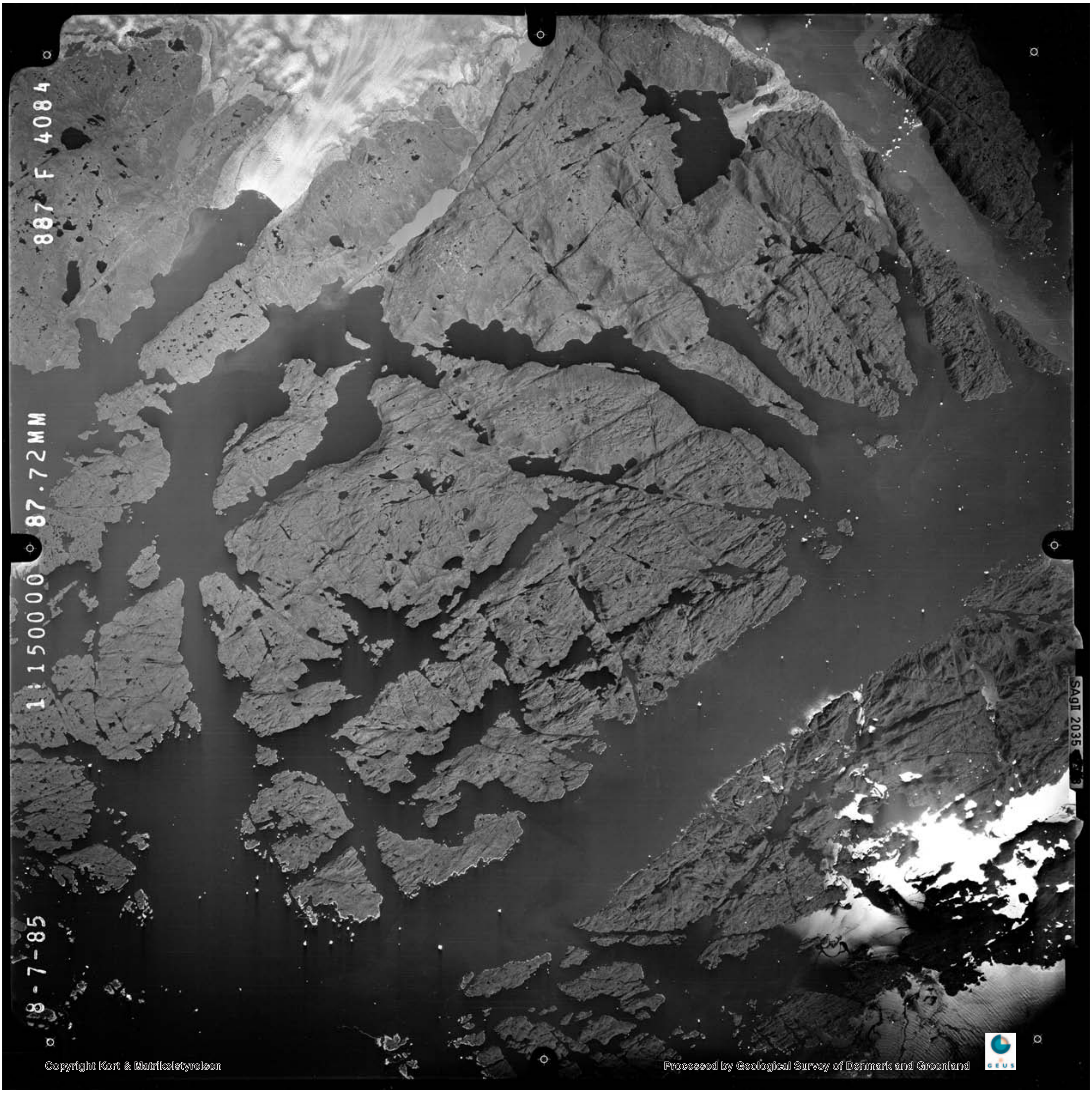
Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



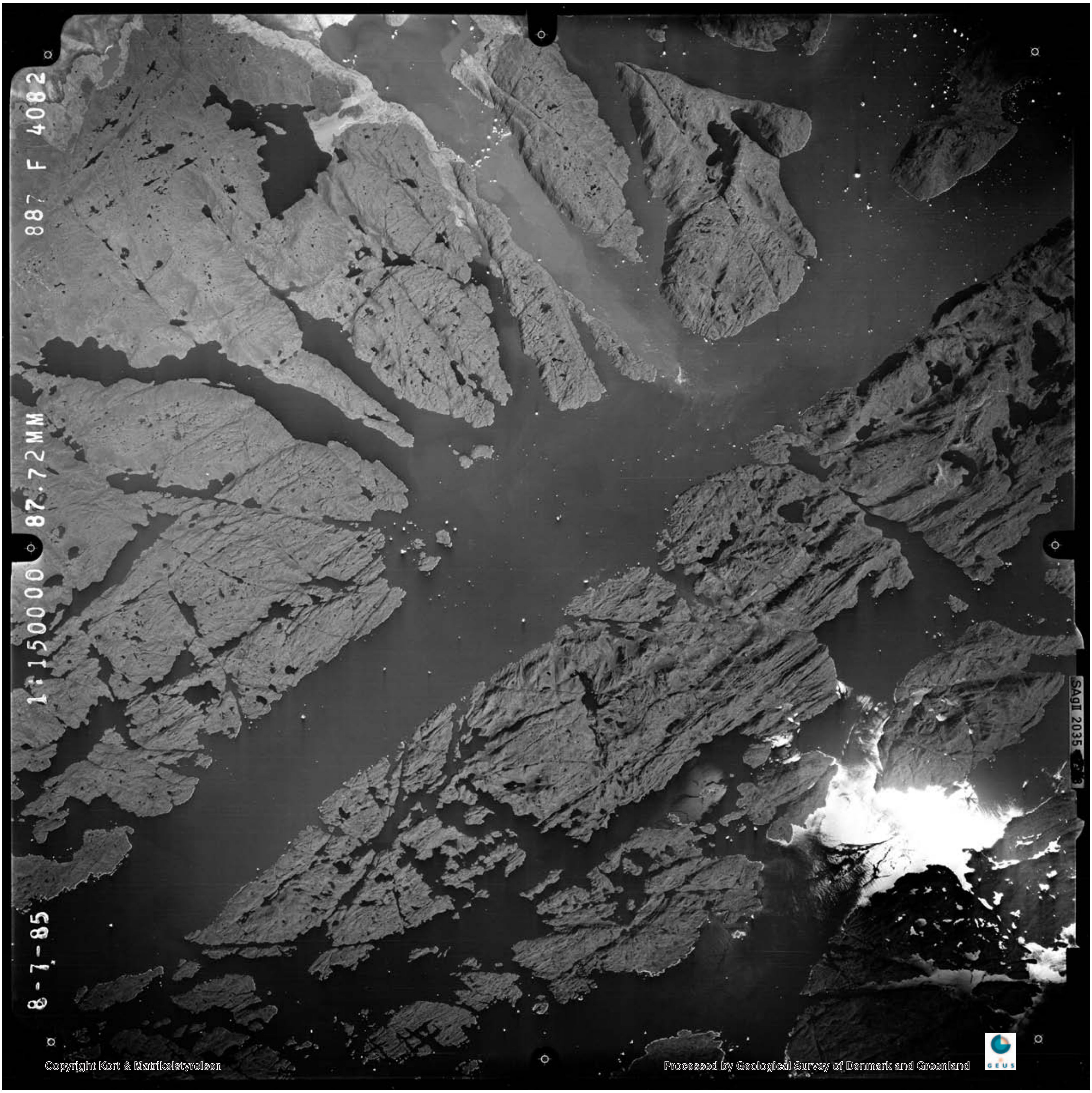
Approximate scale 0 2 4 6 8 10 km



Approximate scale 0 2 4 6 8 10 km

Contents

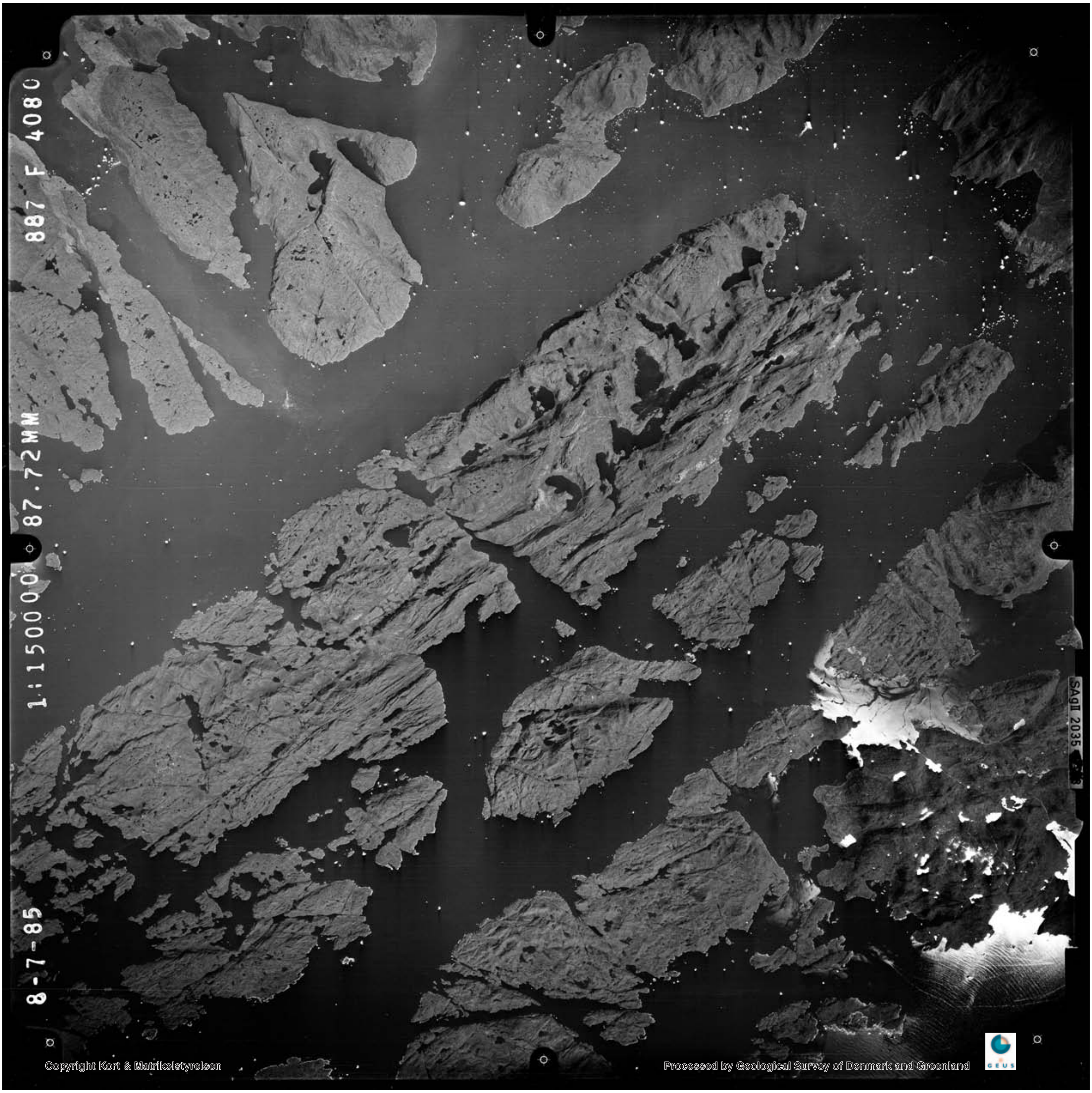
Airphoto Keymap



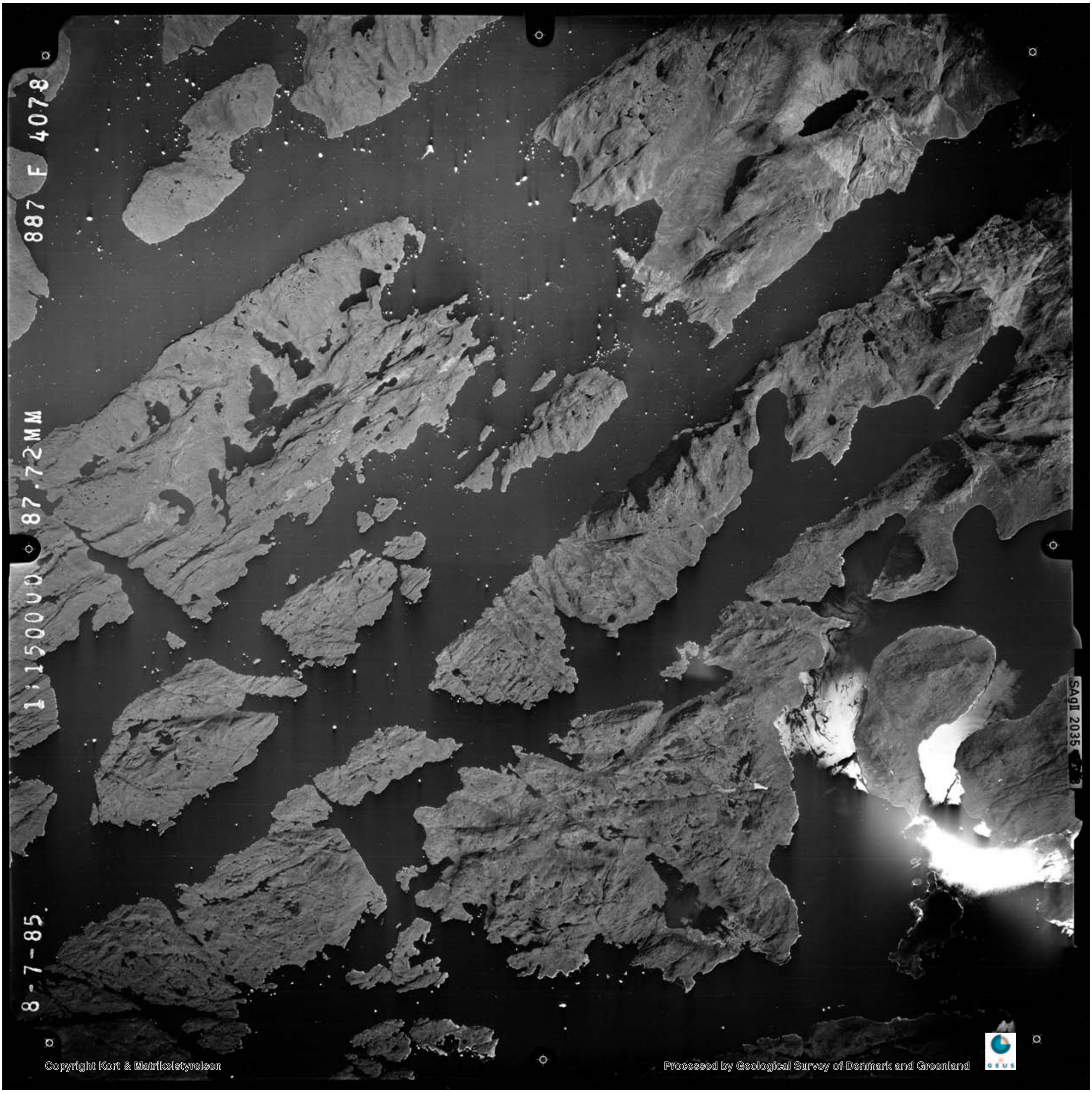
Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



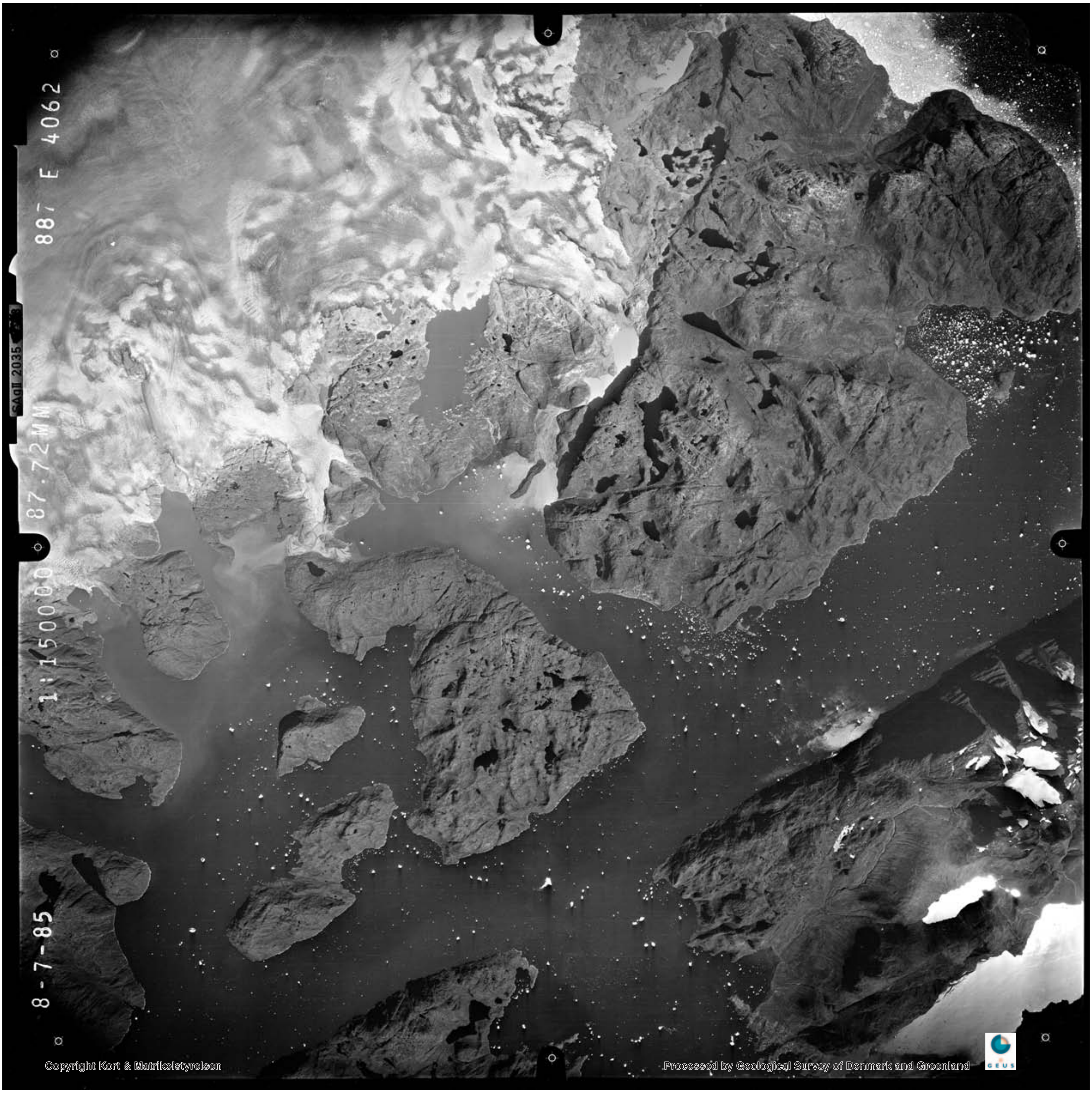
Approximate scale 0 2 4 6 8 10 km



Approximate scale 0 2 4 6 8 10 km

Contents

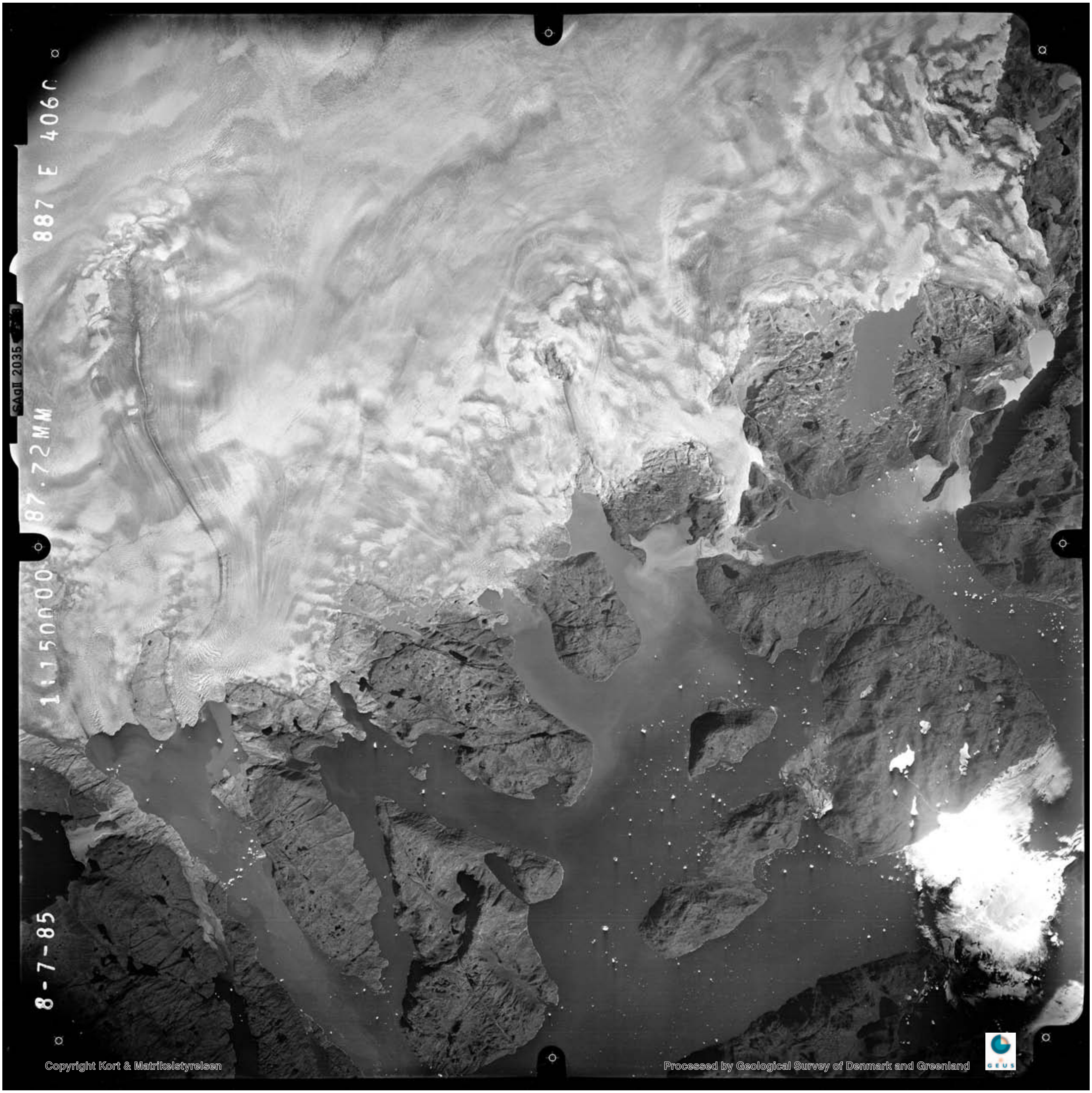
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

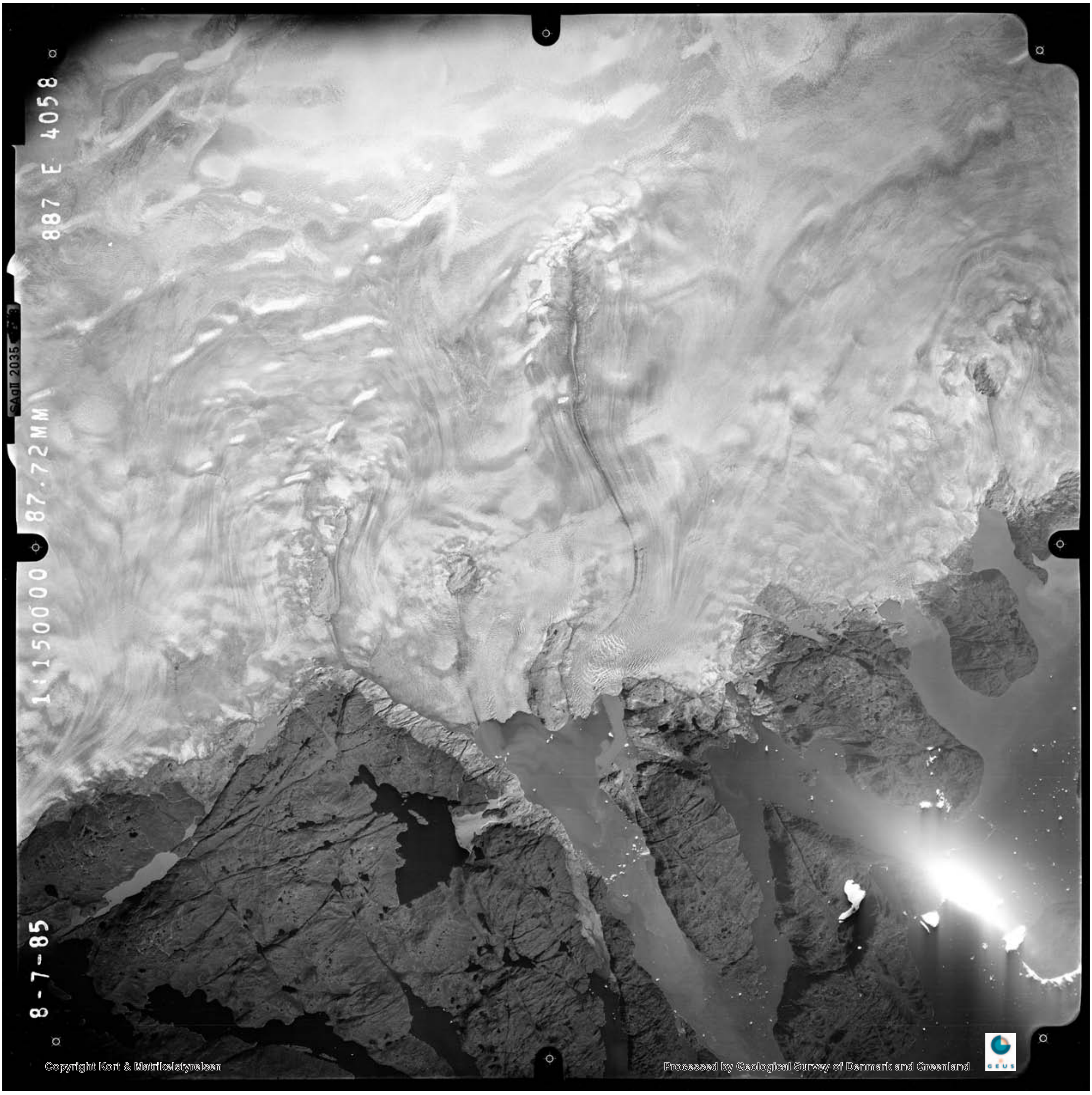
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

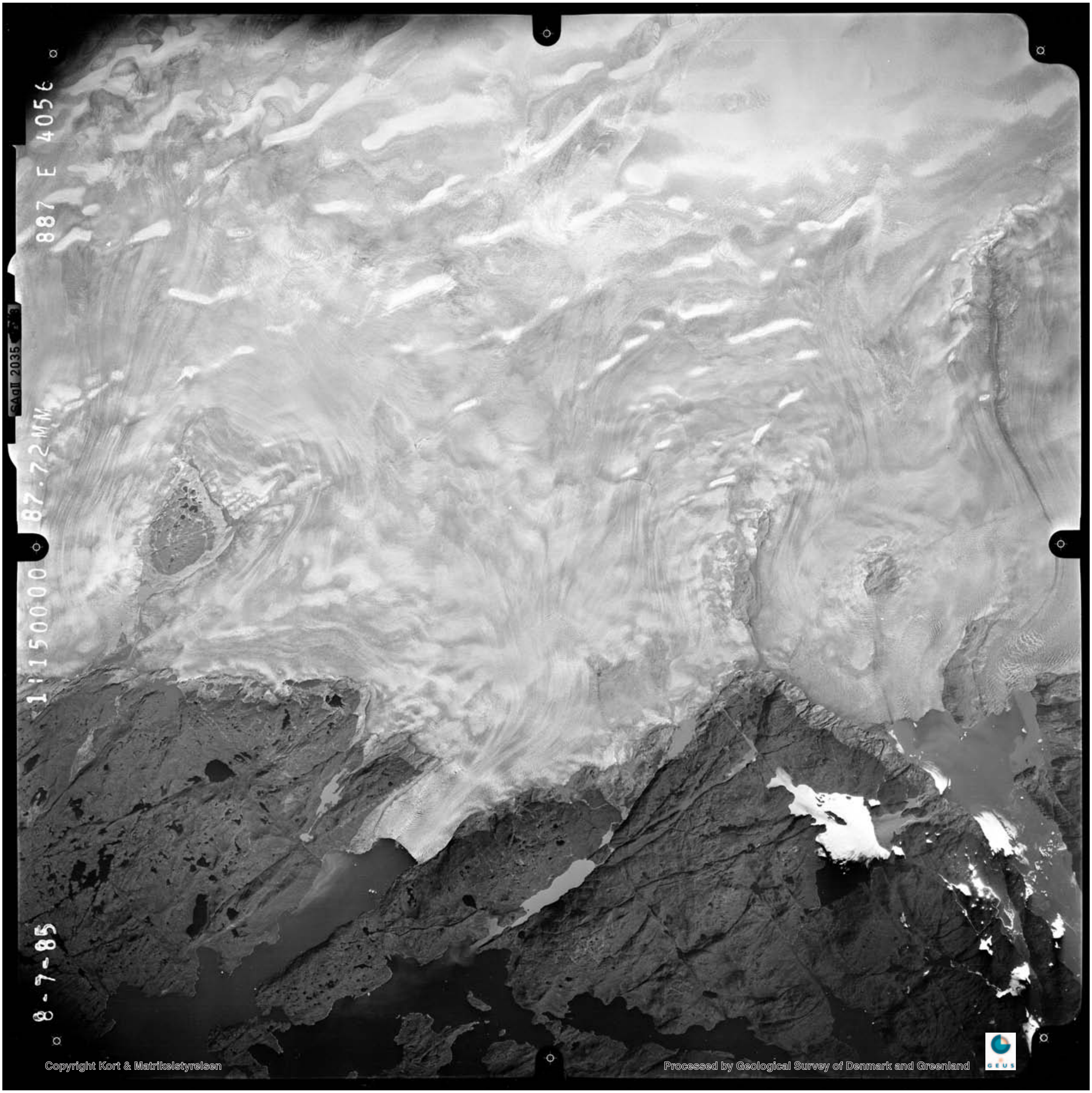
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

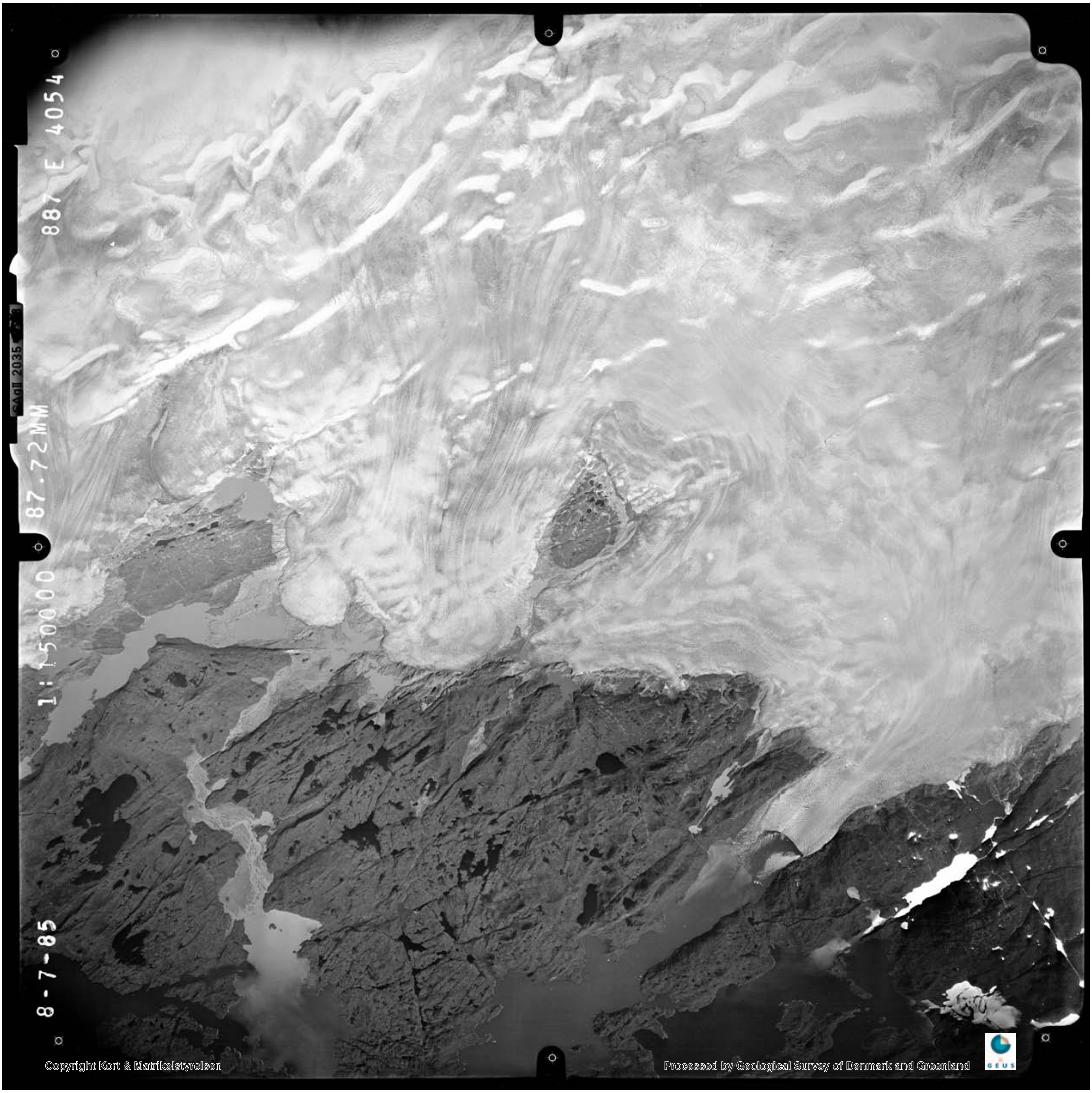
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

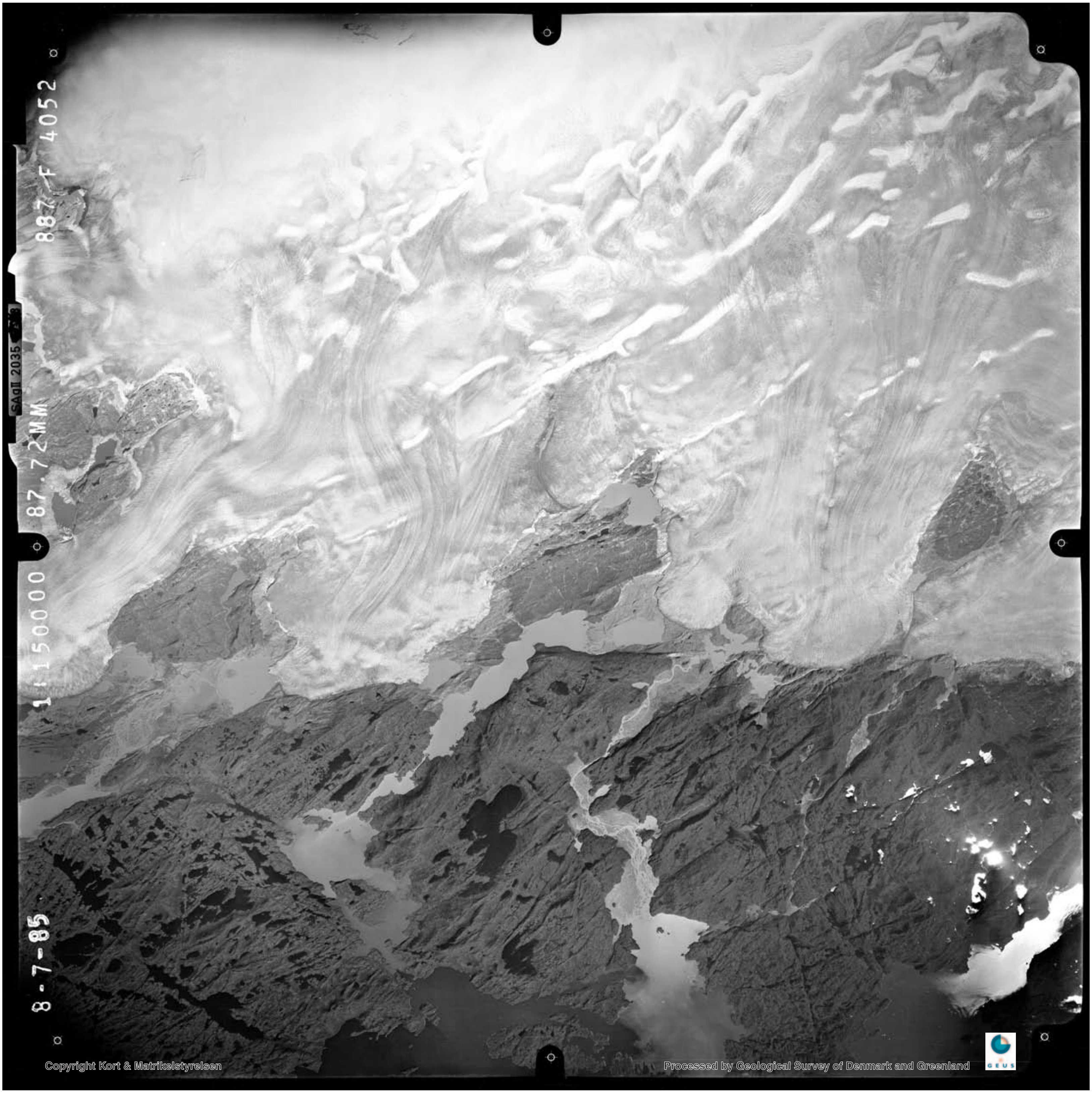
Airphoto Keymap



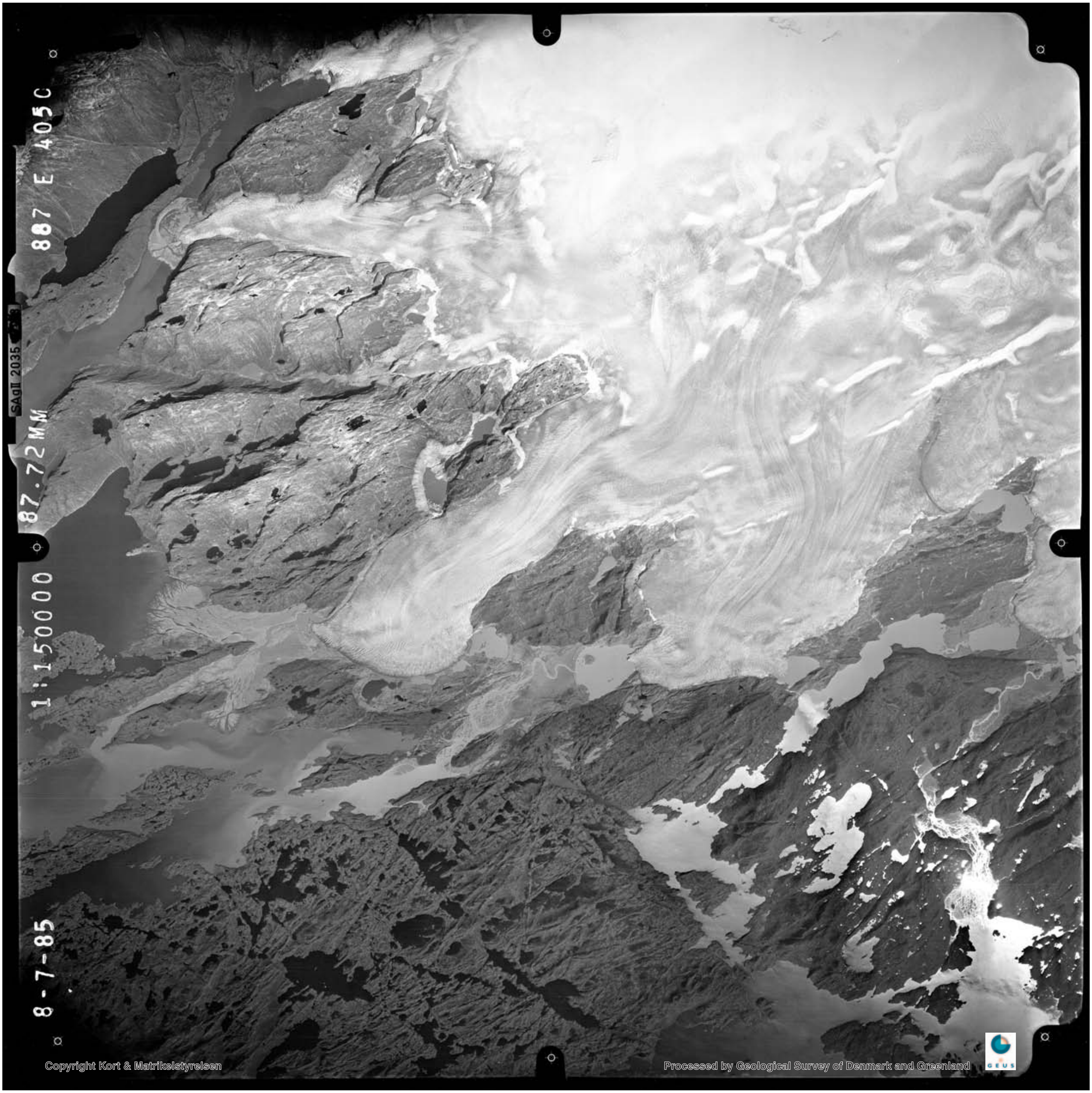
Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

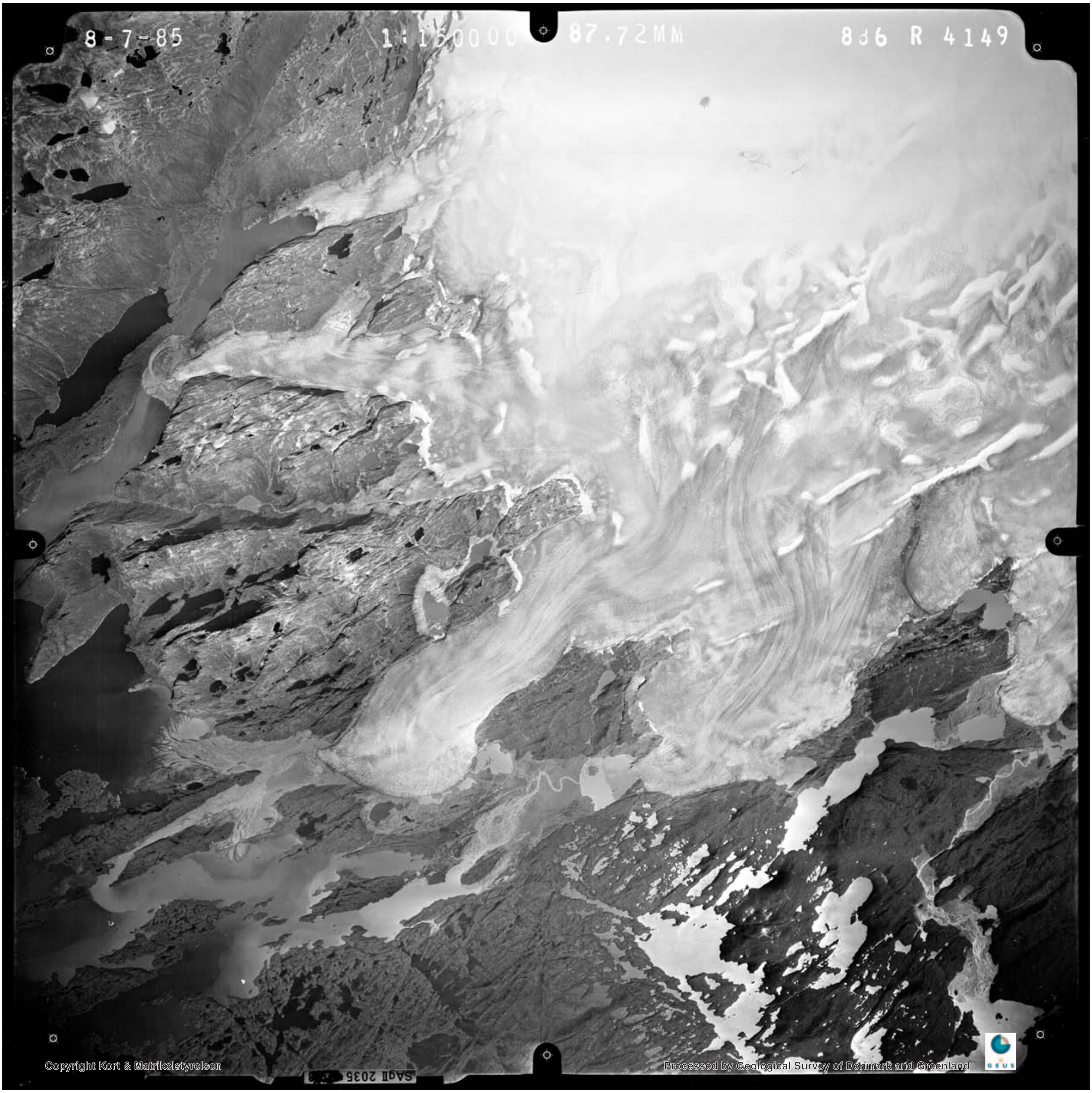


Approximate scale 0 2 4 6 8 10 km

Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

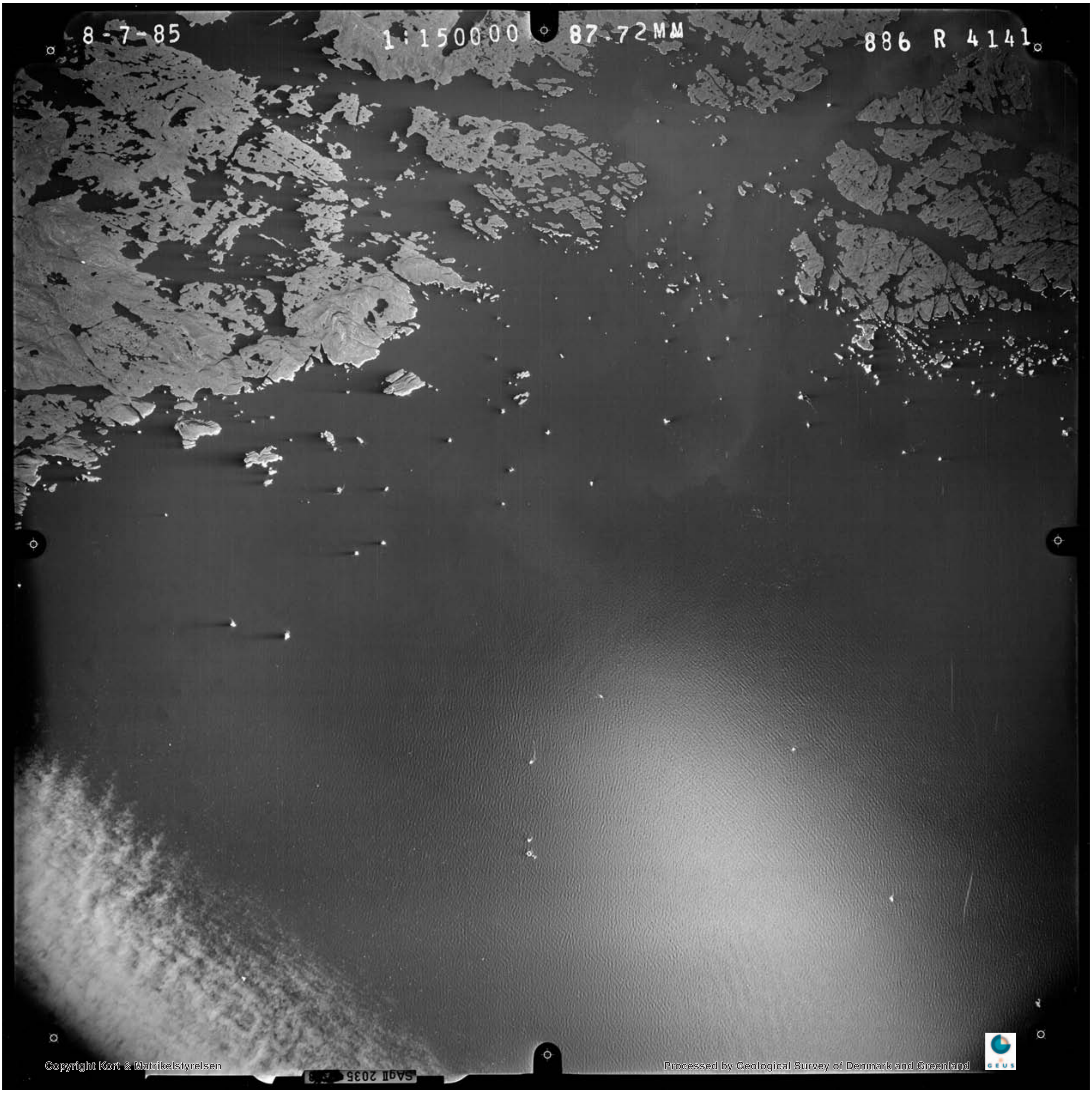
Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Contents

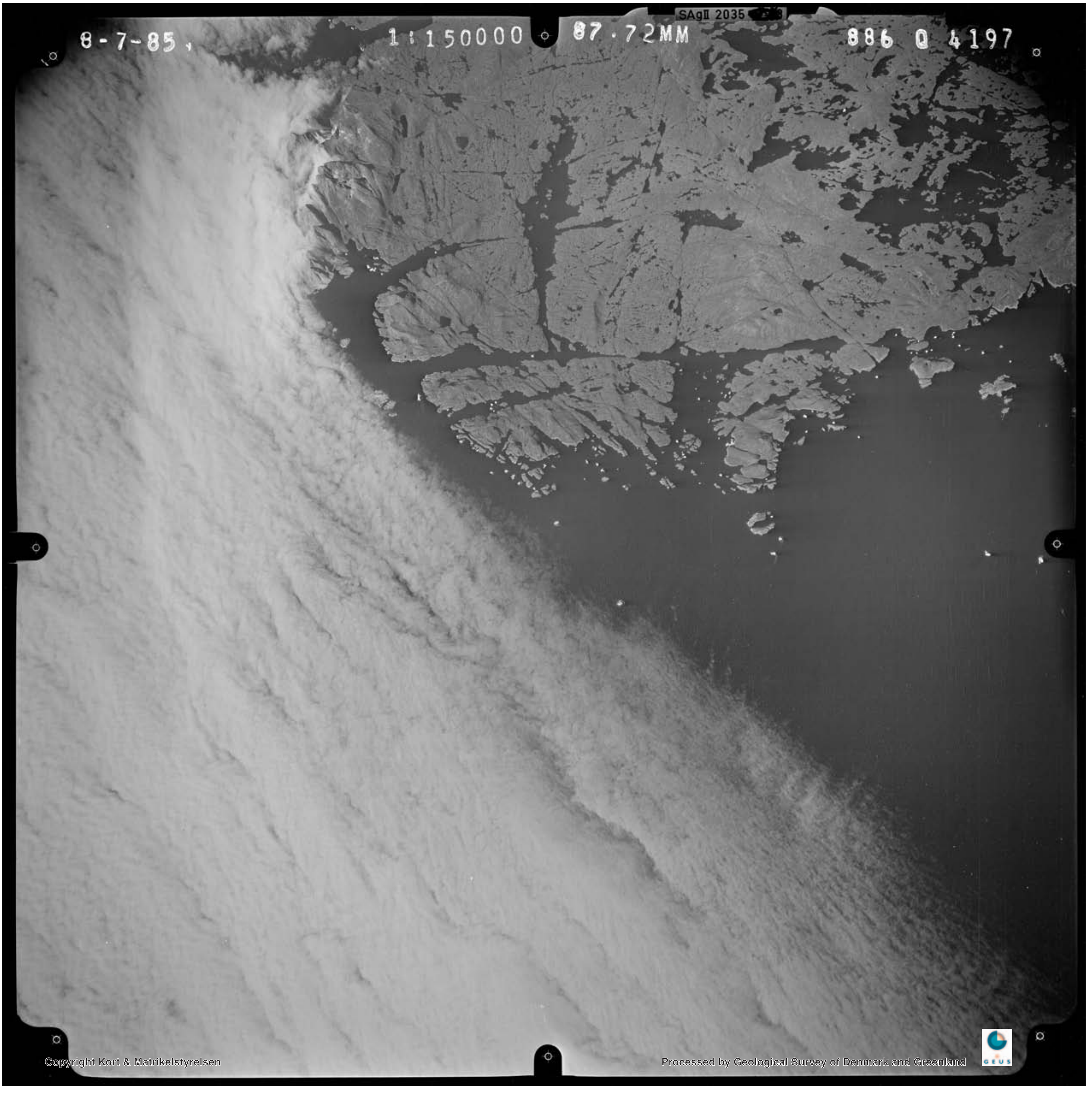
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

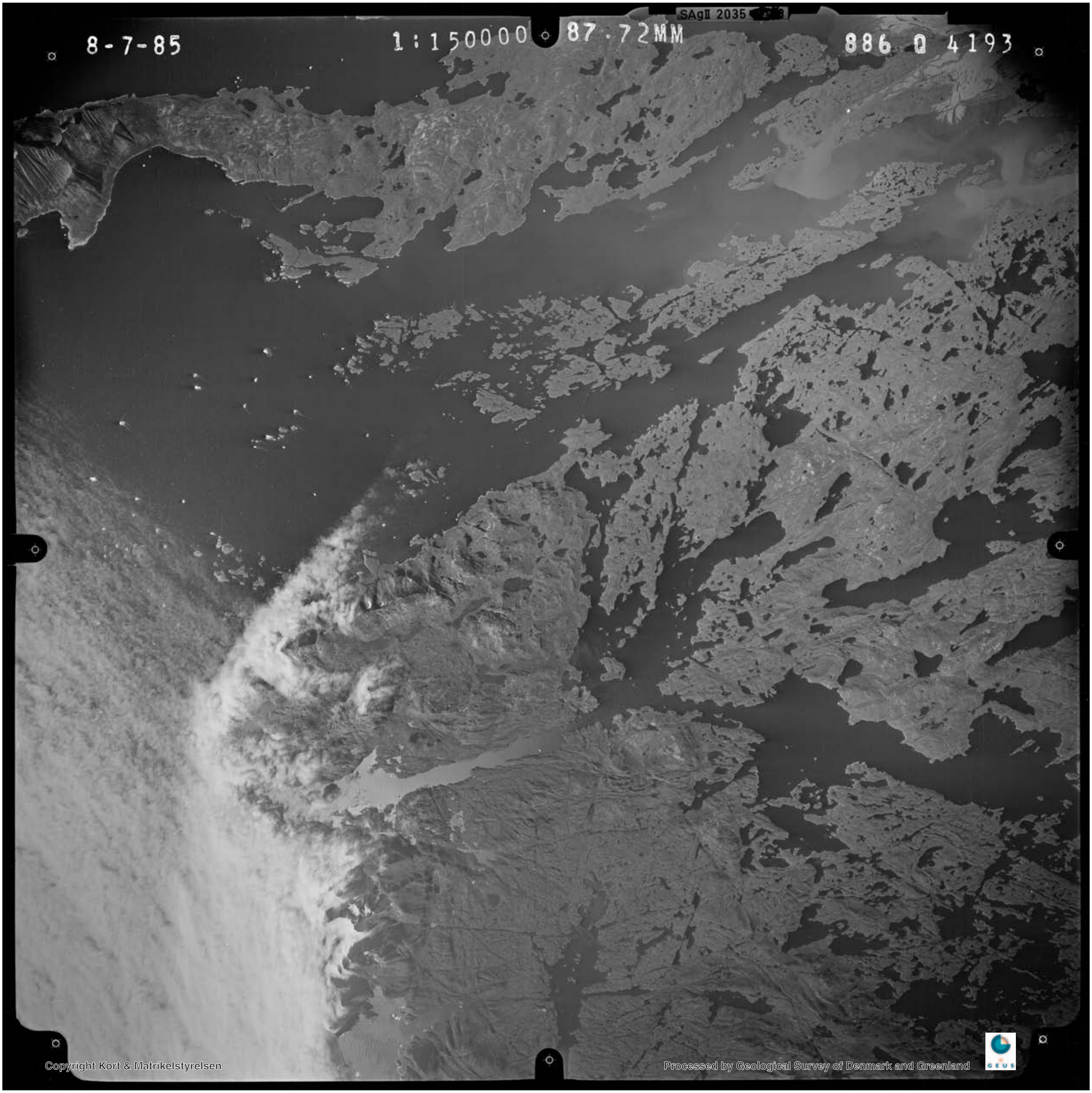
Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Contents

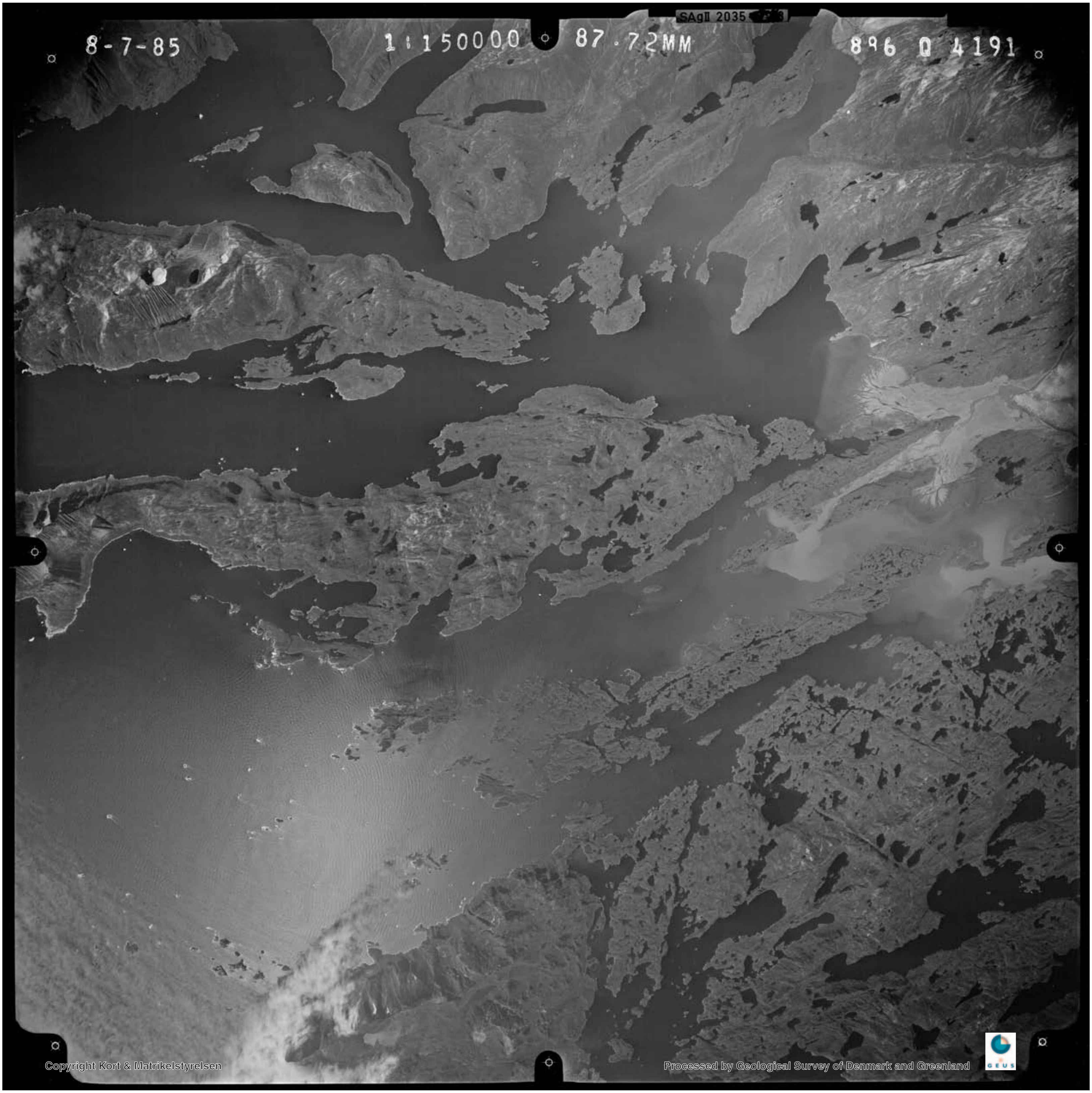
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

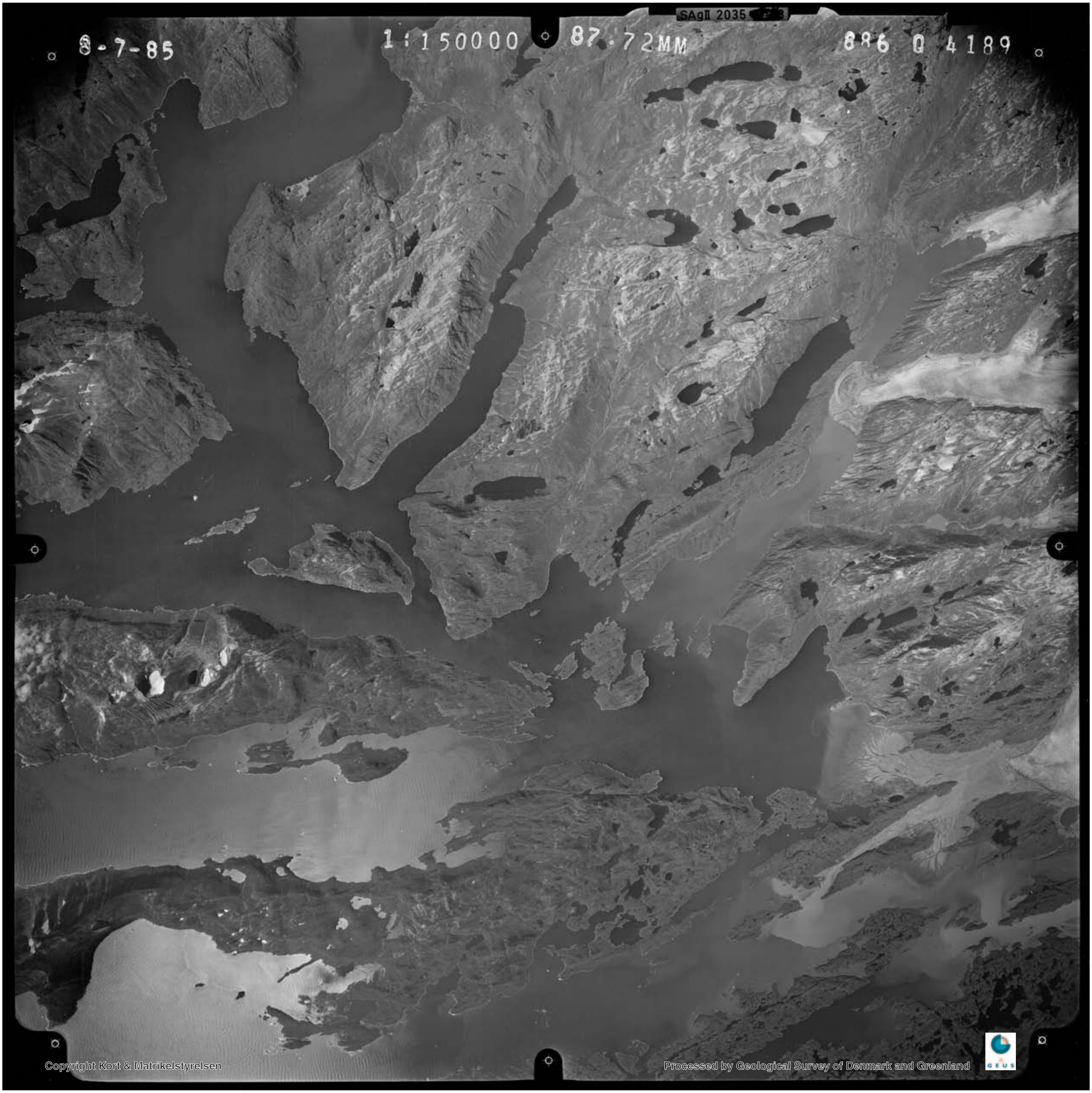
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

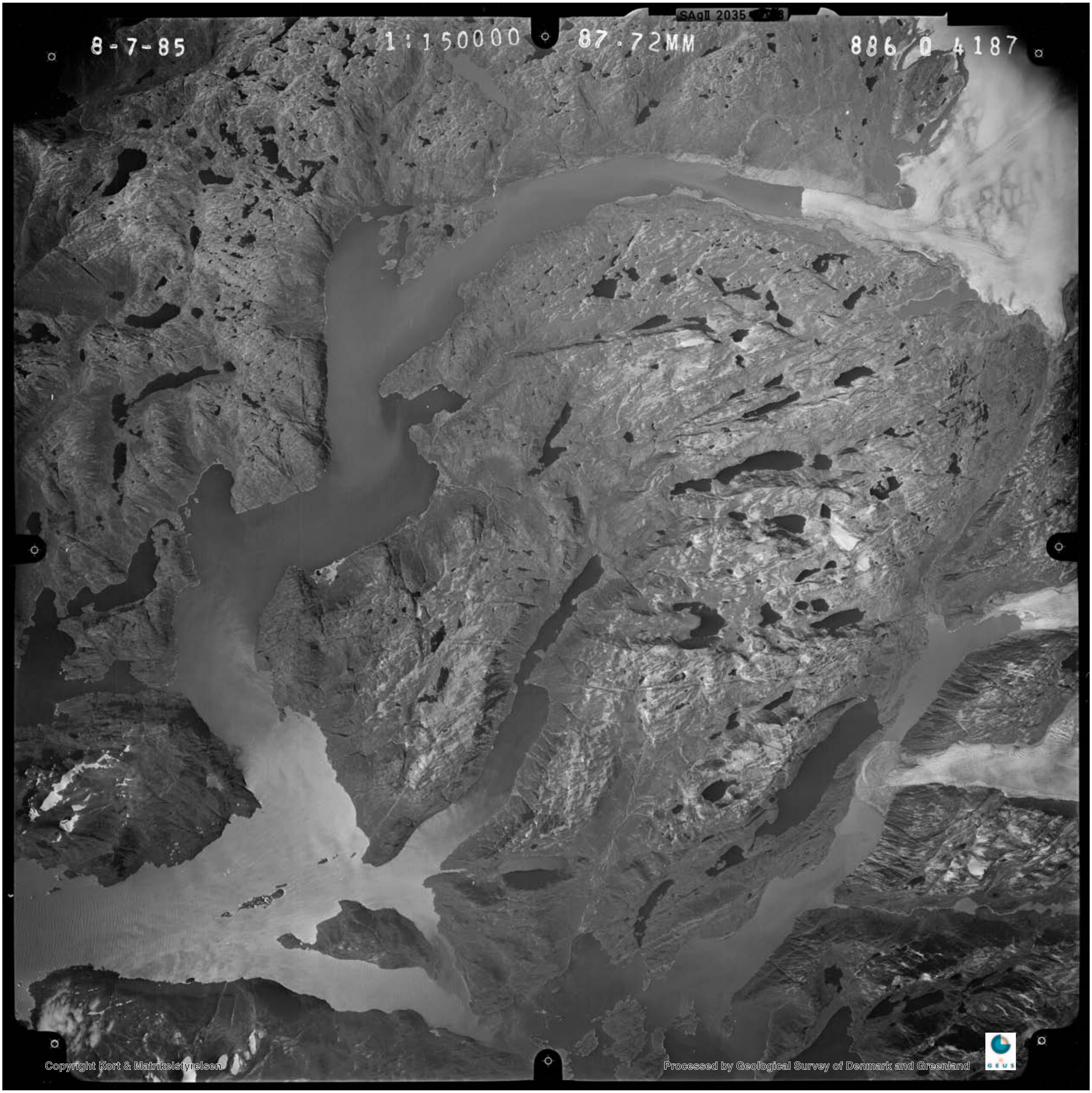
Airphoto Keymap



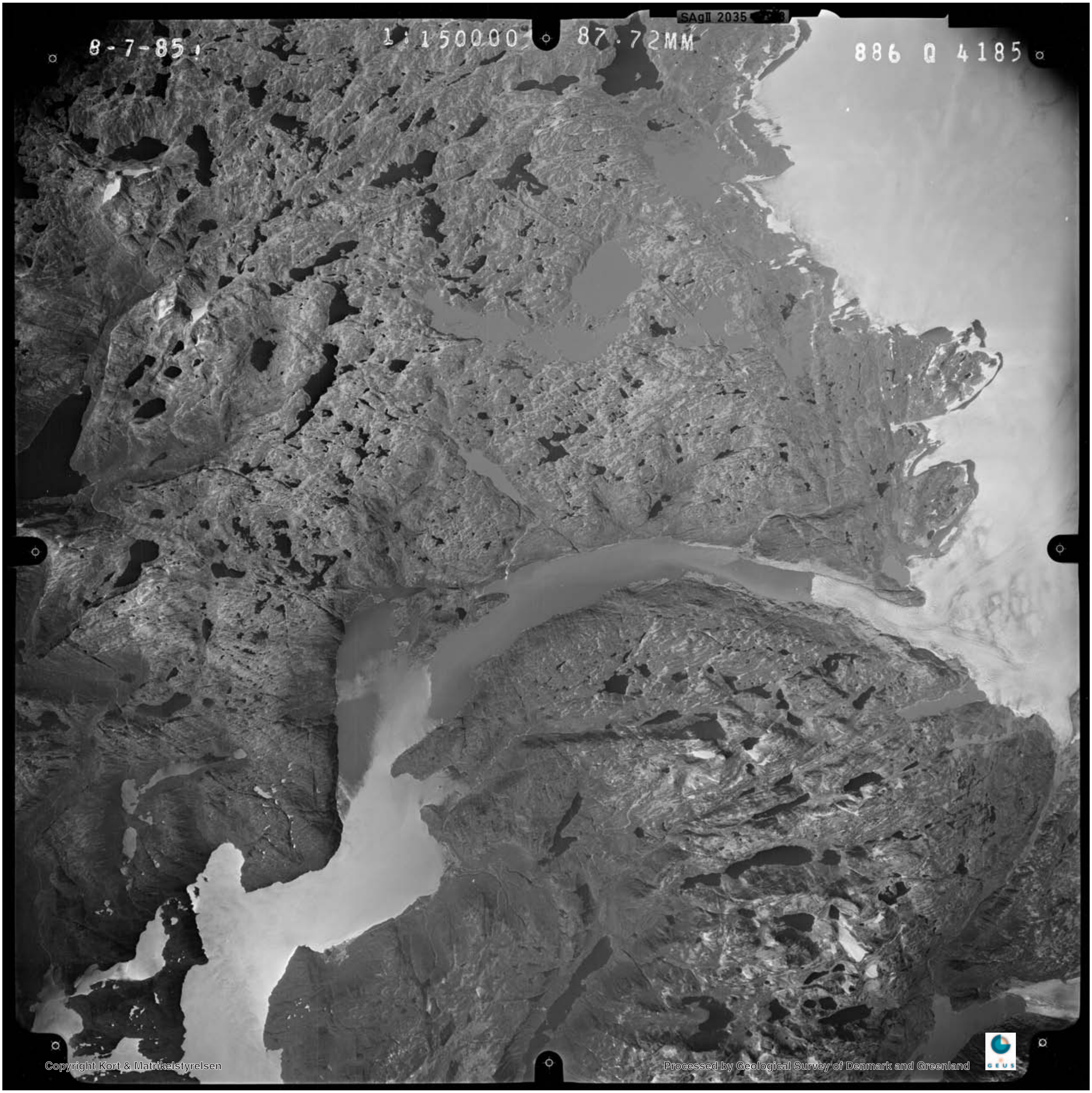
Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



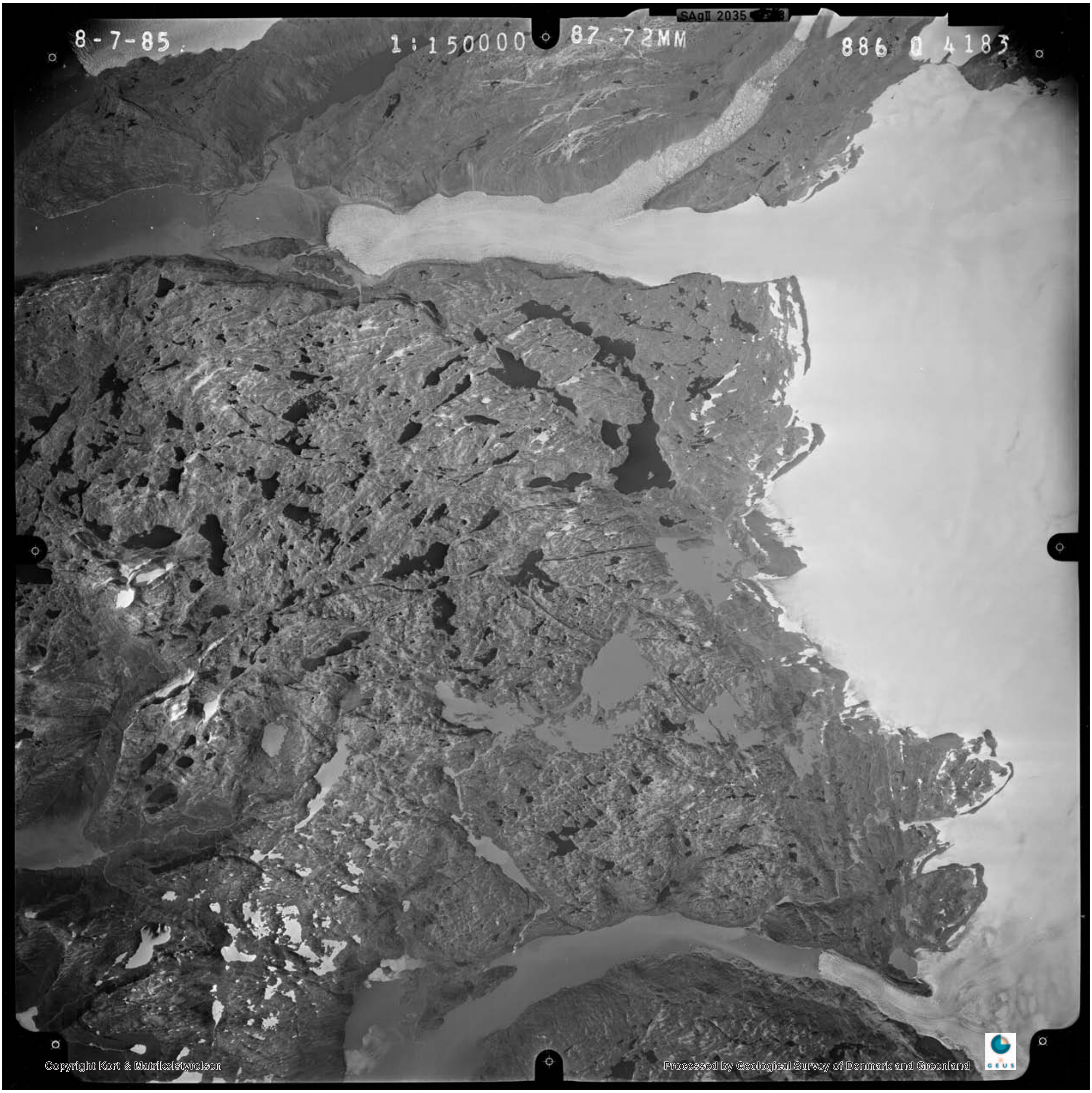
Approximate scale 0 2 4 6 8 10 km



Approximate scale 0 2 4 6 8 10 km

Contents

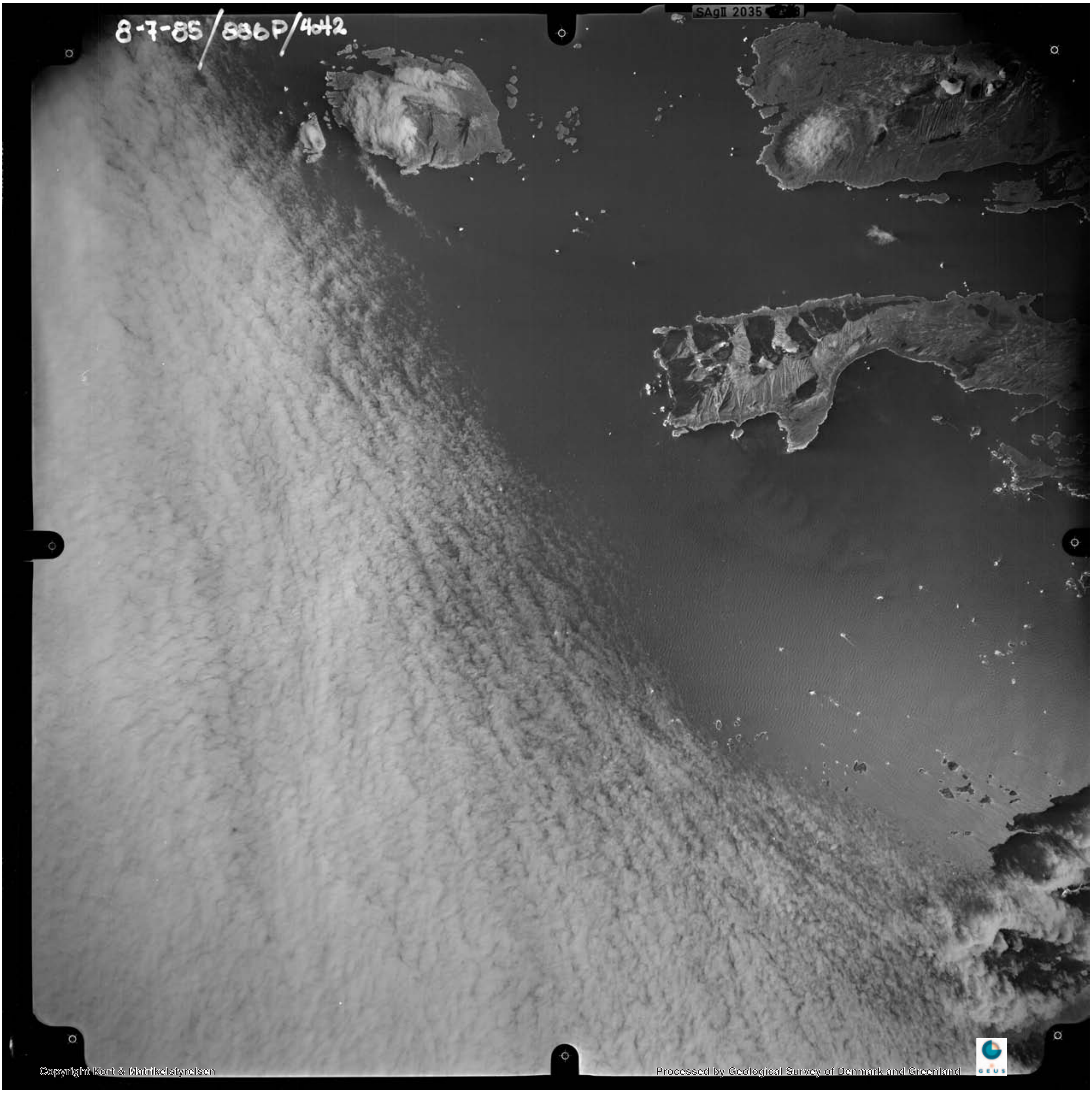
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

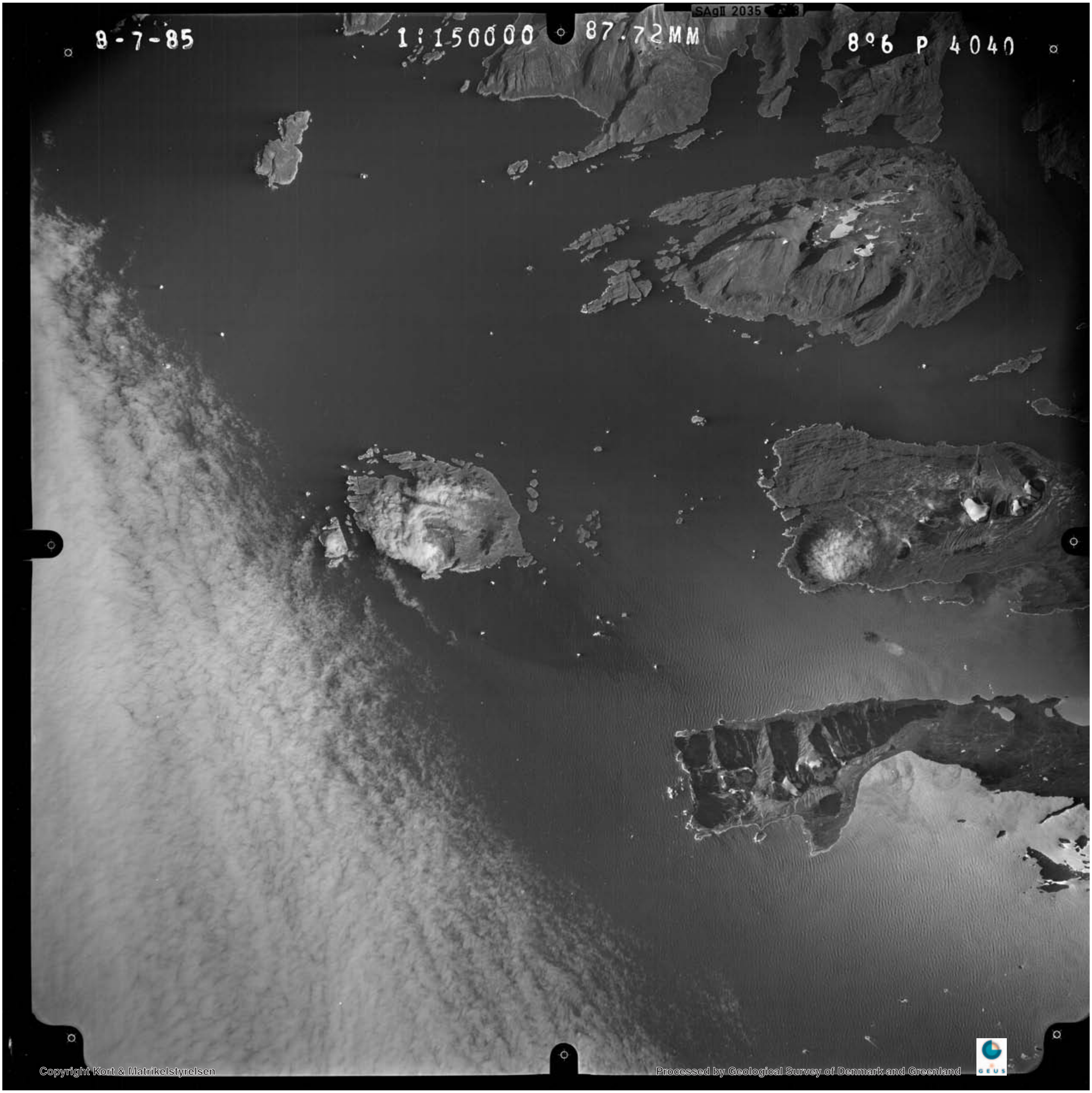
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

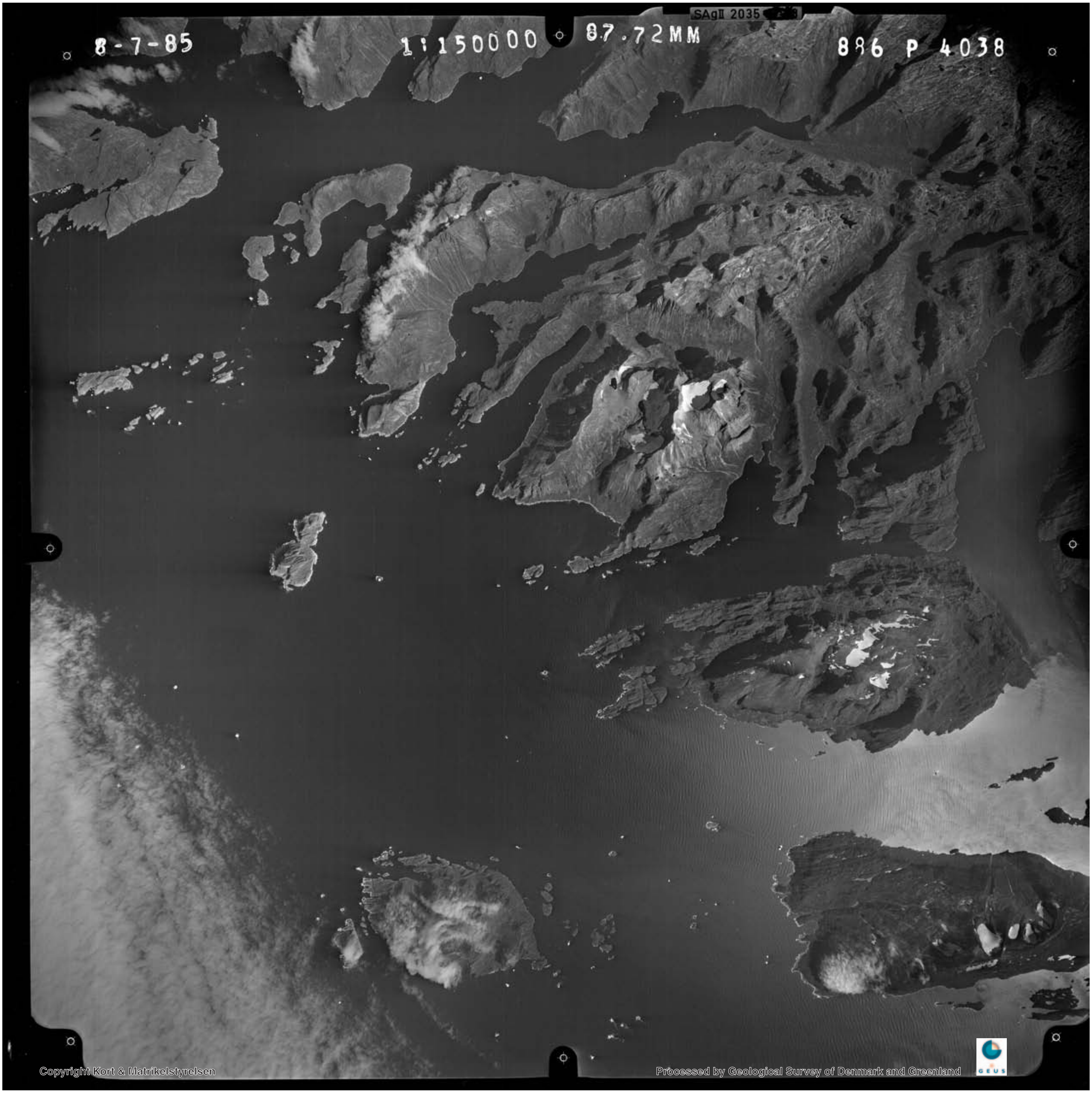
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

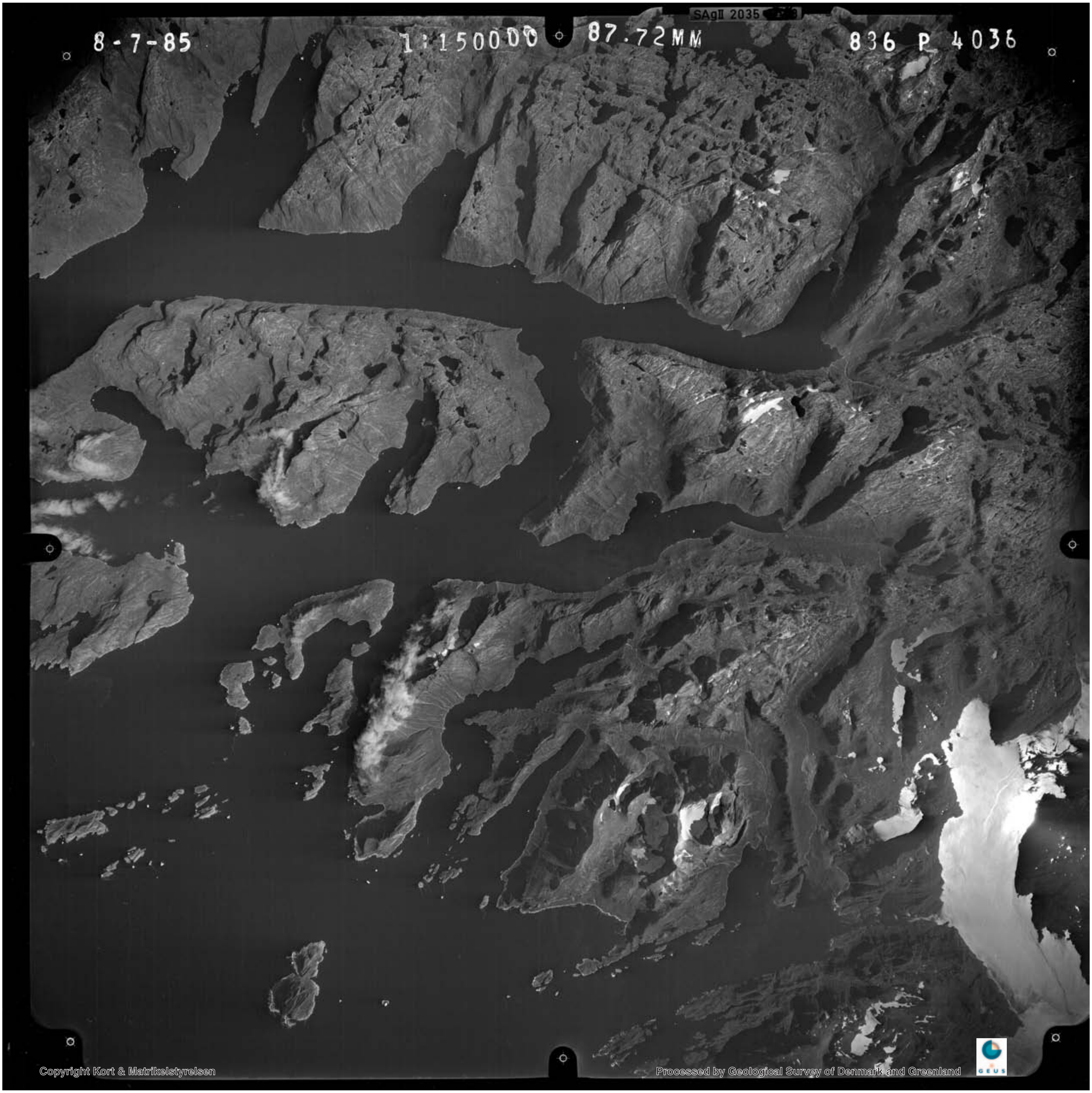
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



Processed by Geological Survey of Denmark and Greenland

Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Contents

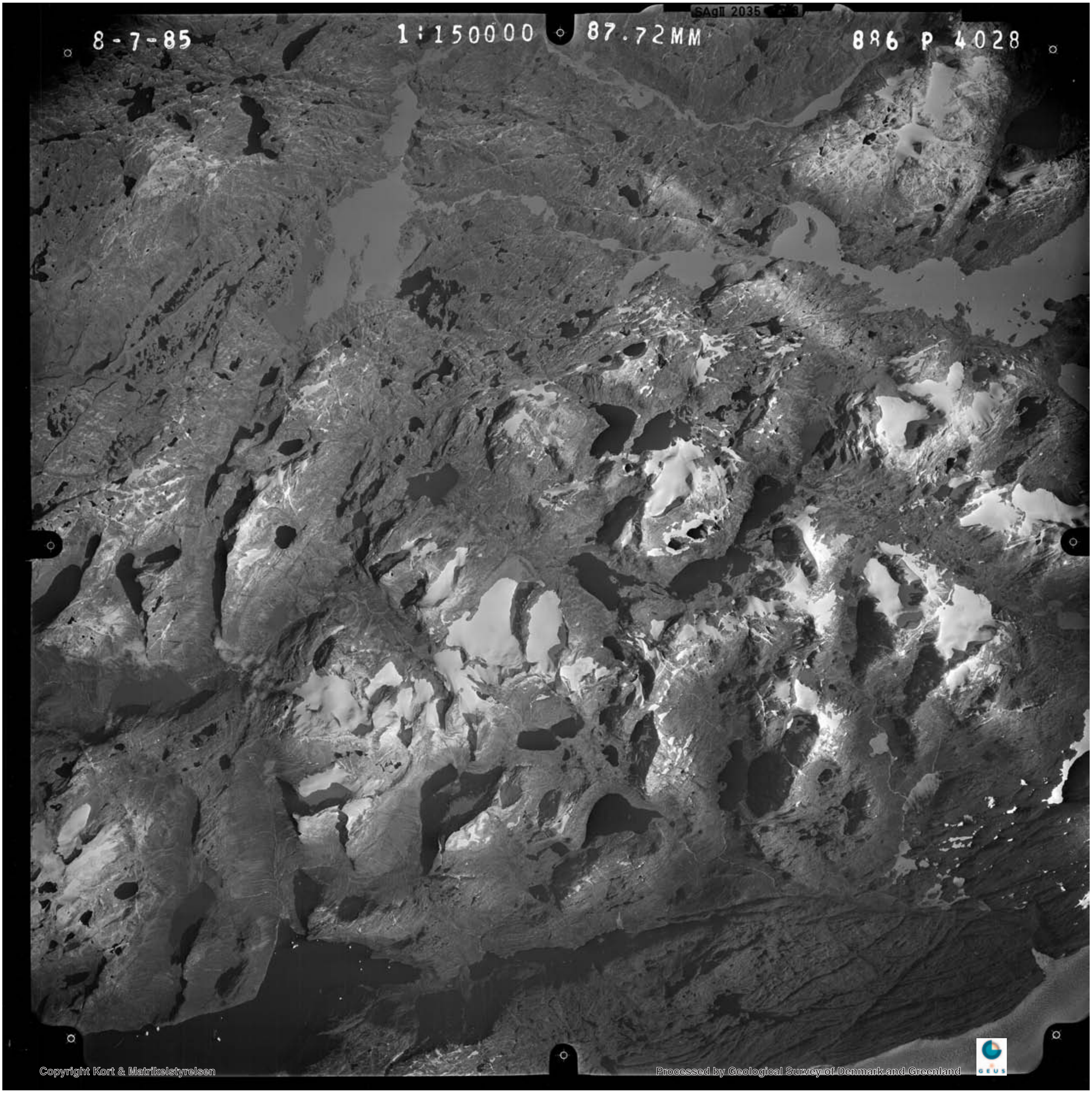
Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Approximate scale 0 2 4 6 8 10 km

Contents

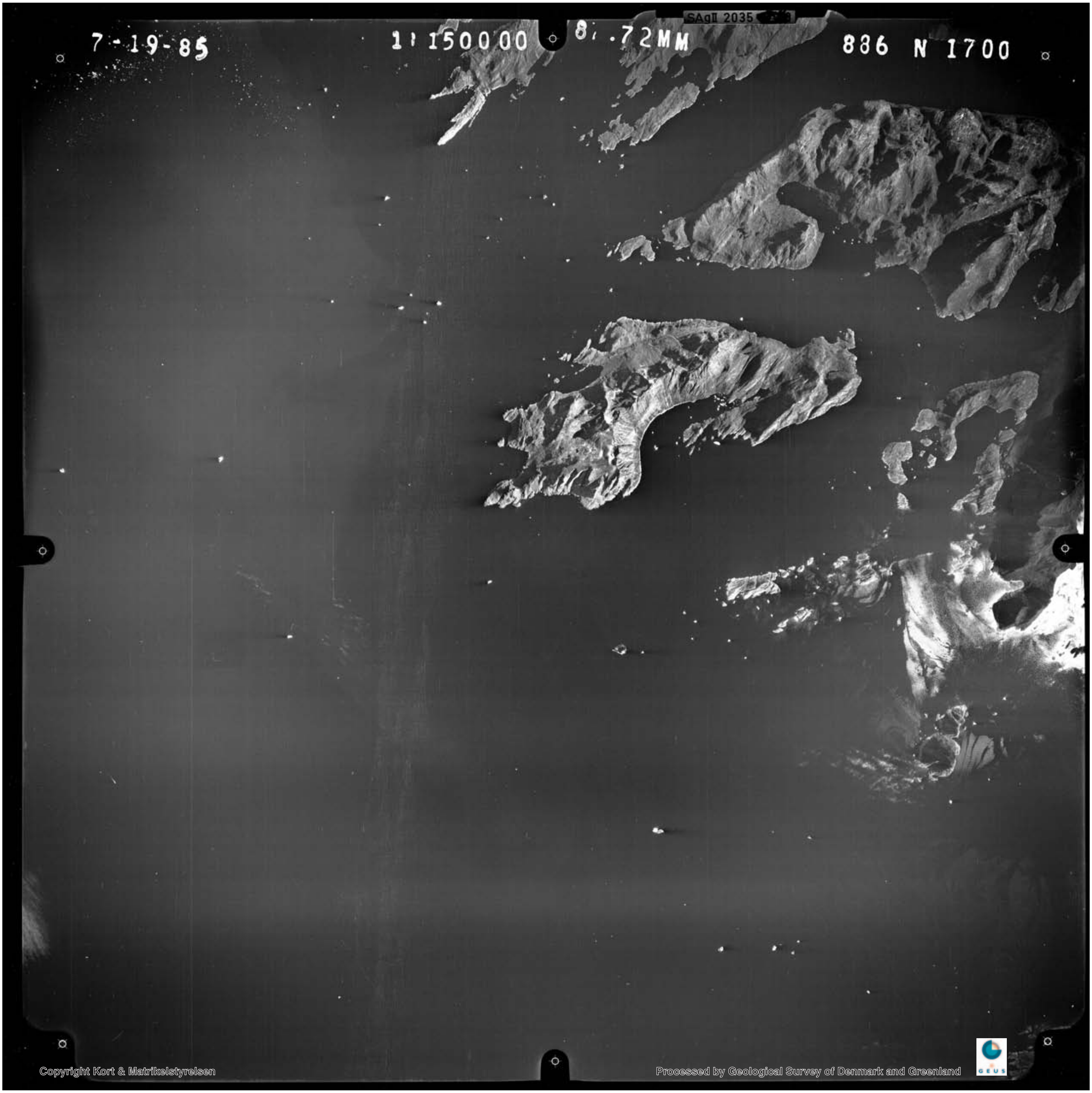
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

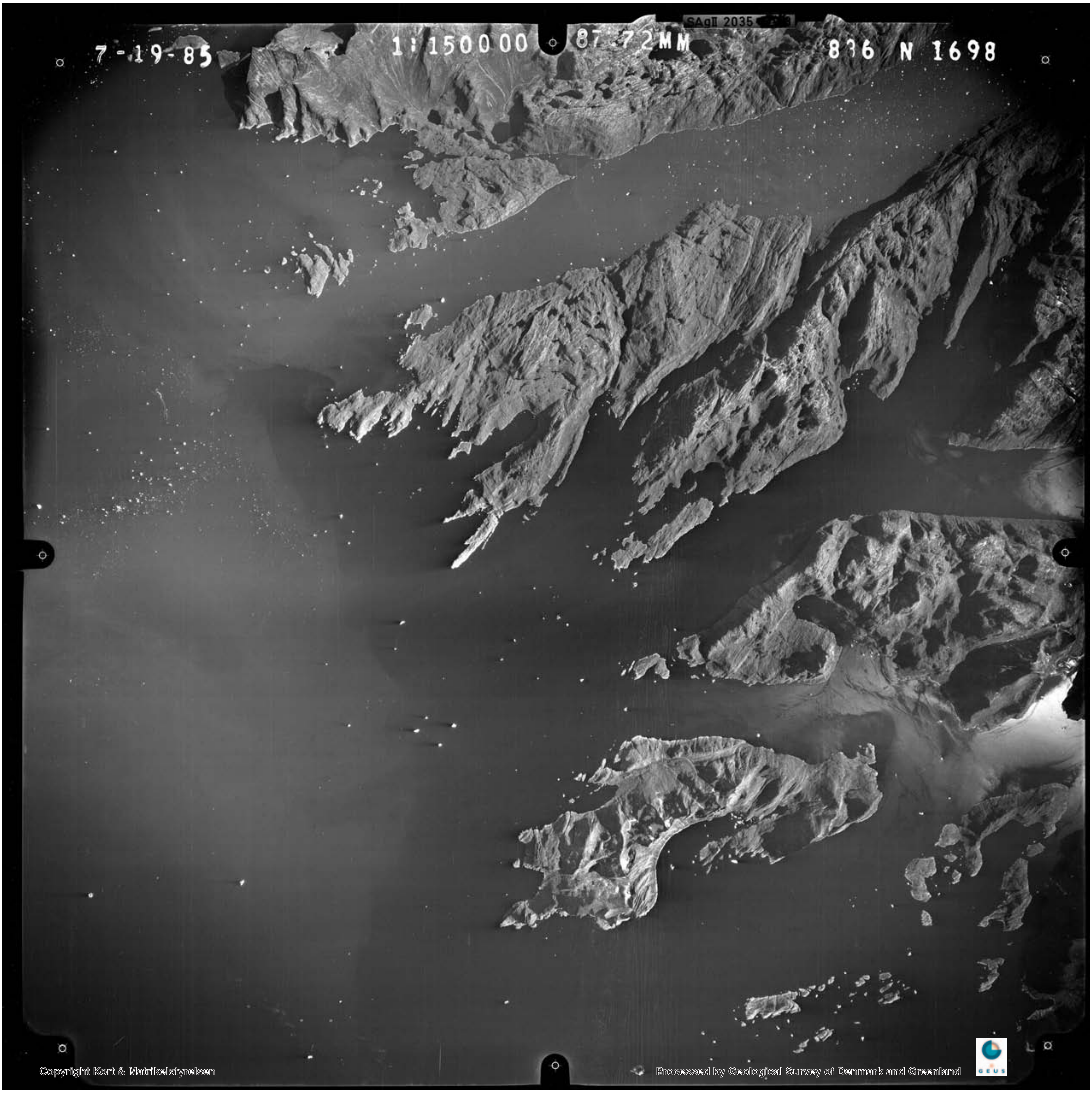
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

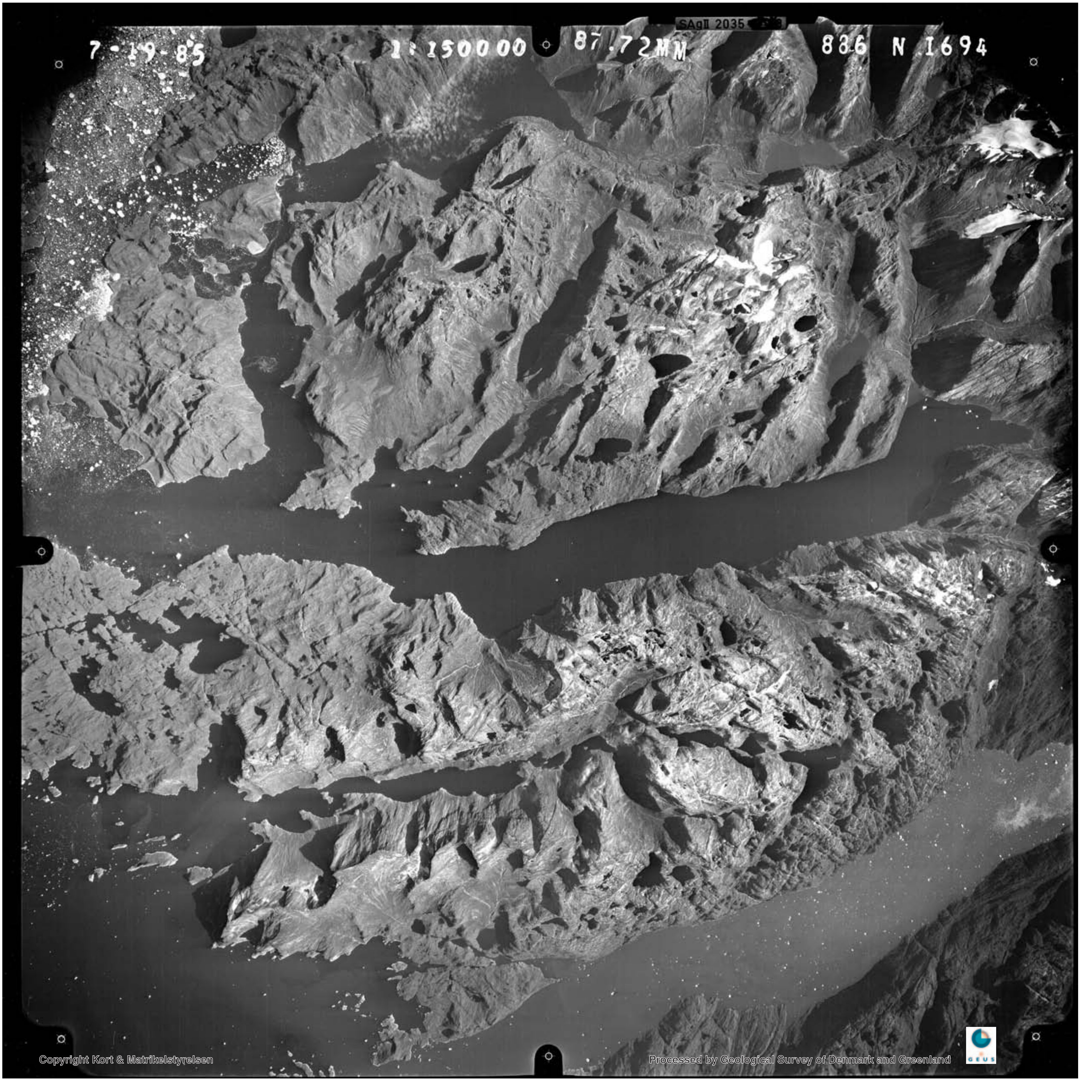
Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Contents

Airphoto Keymap

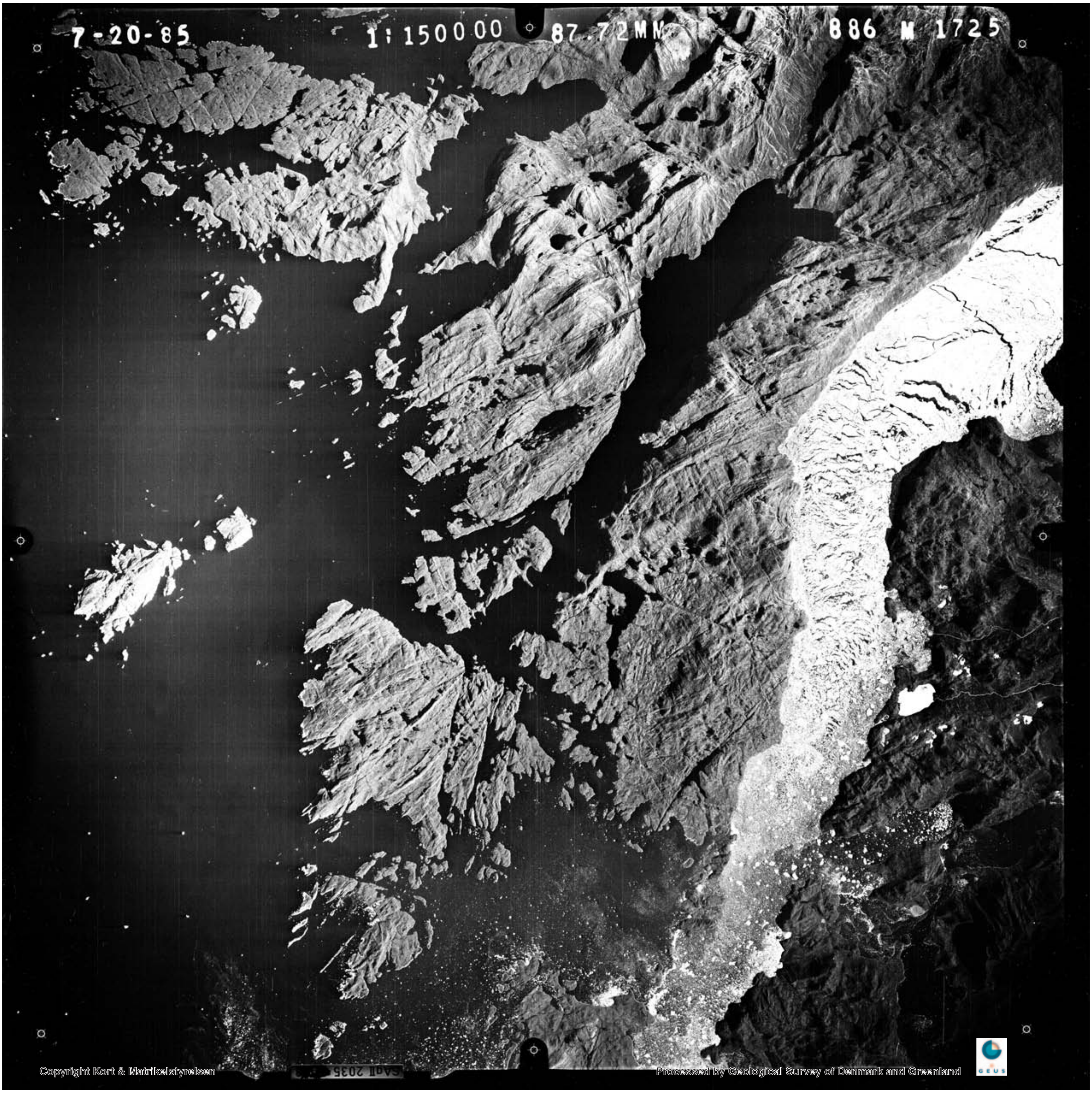
Approximate scale 0 2 4 6 8 10 km

Contents Airphoto Keymap

Approximate scale 0 2 4 6 8 10 km

Contents

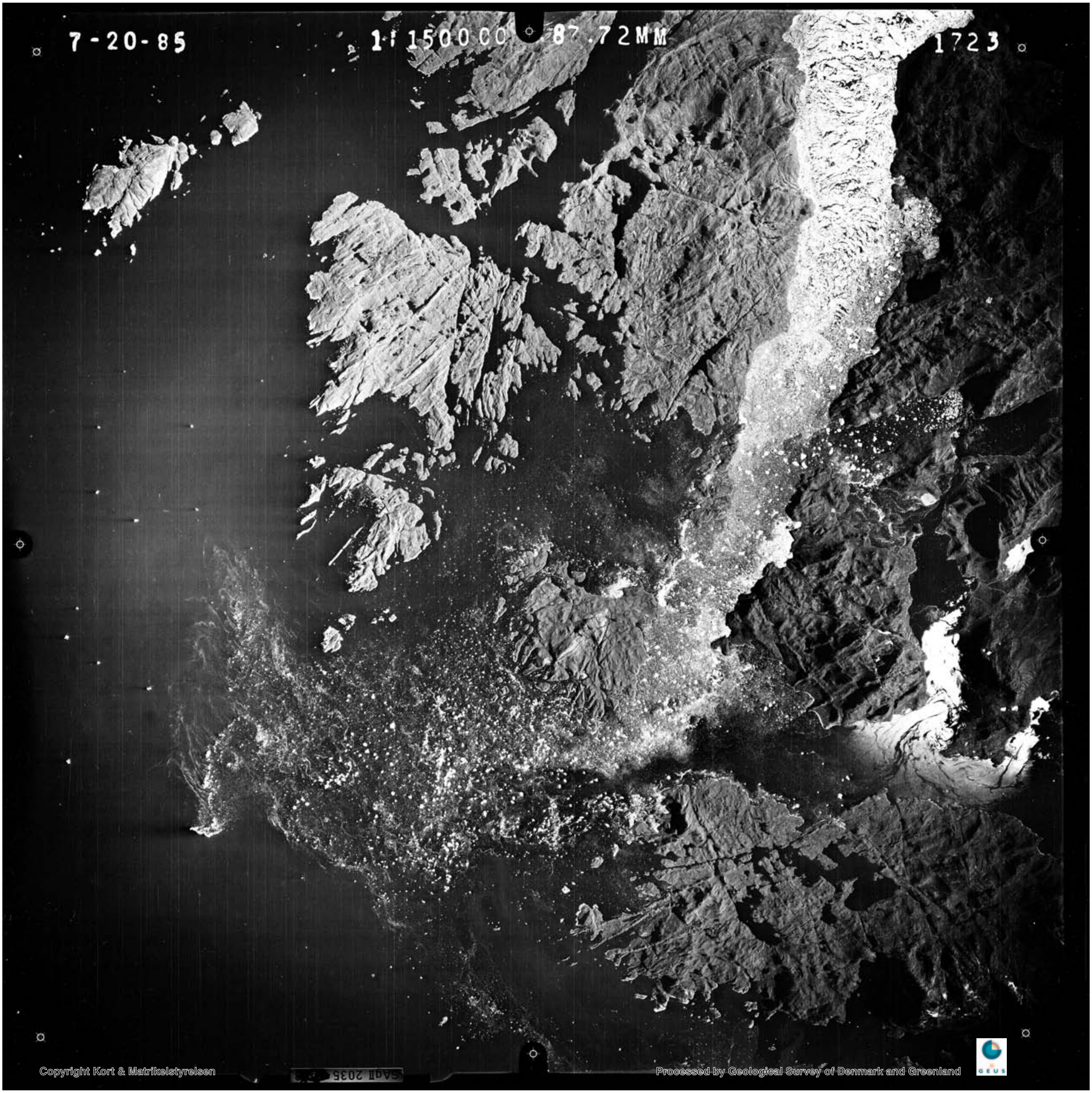
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

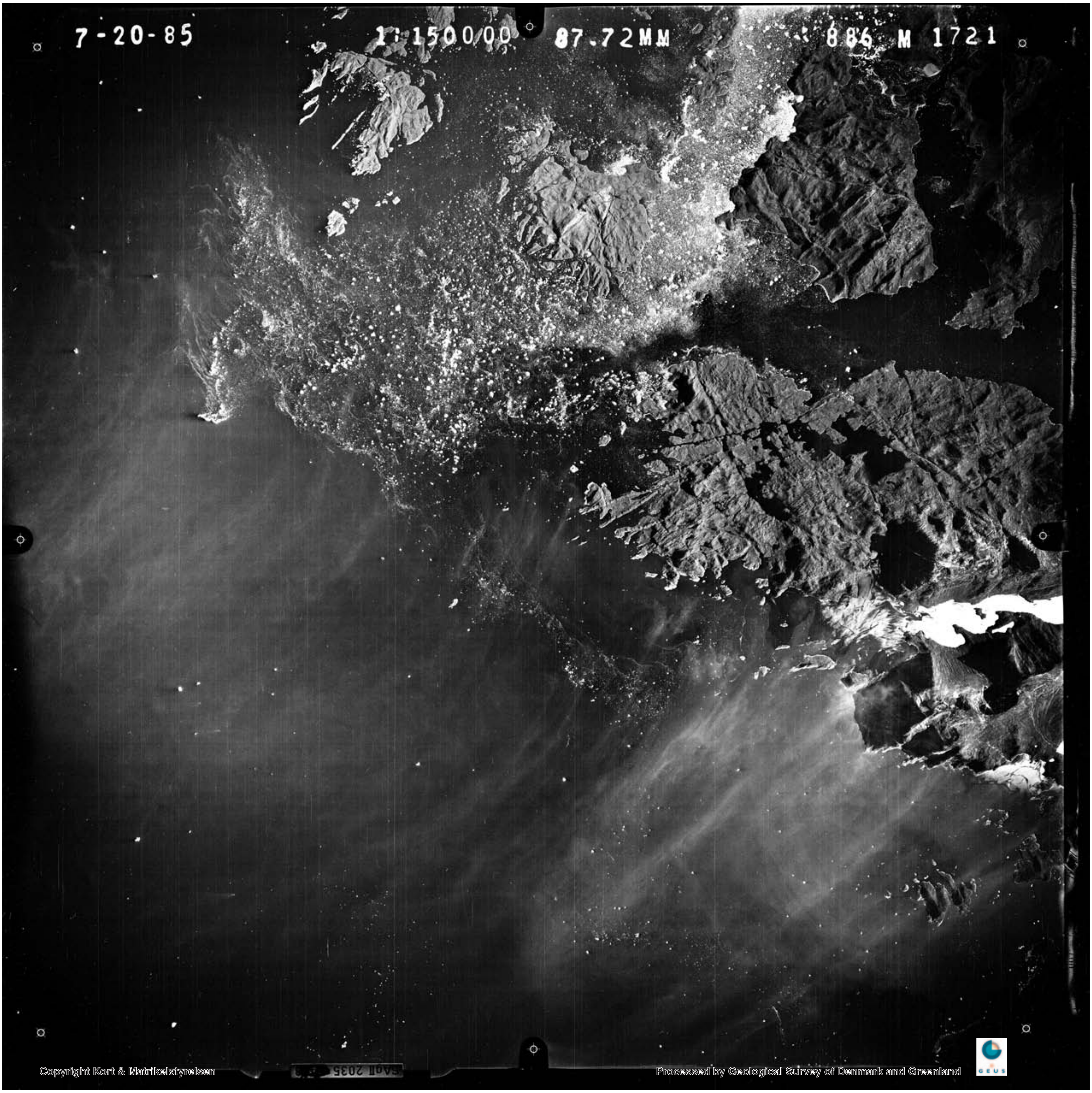
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

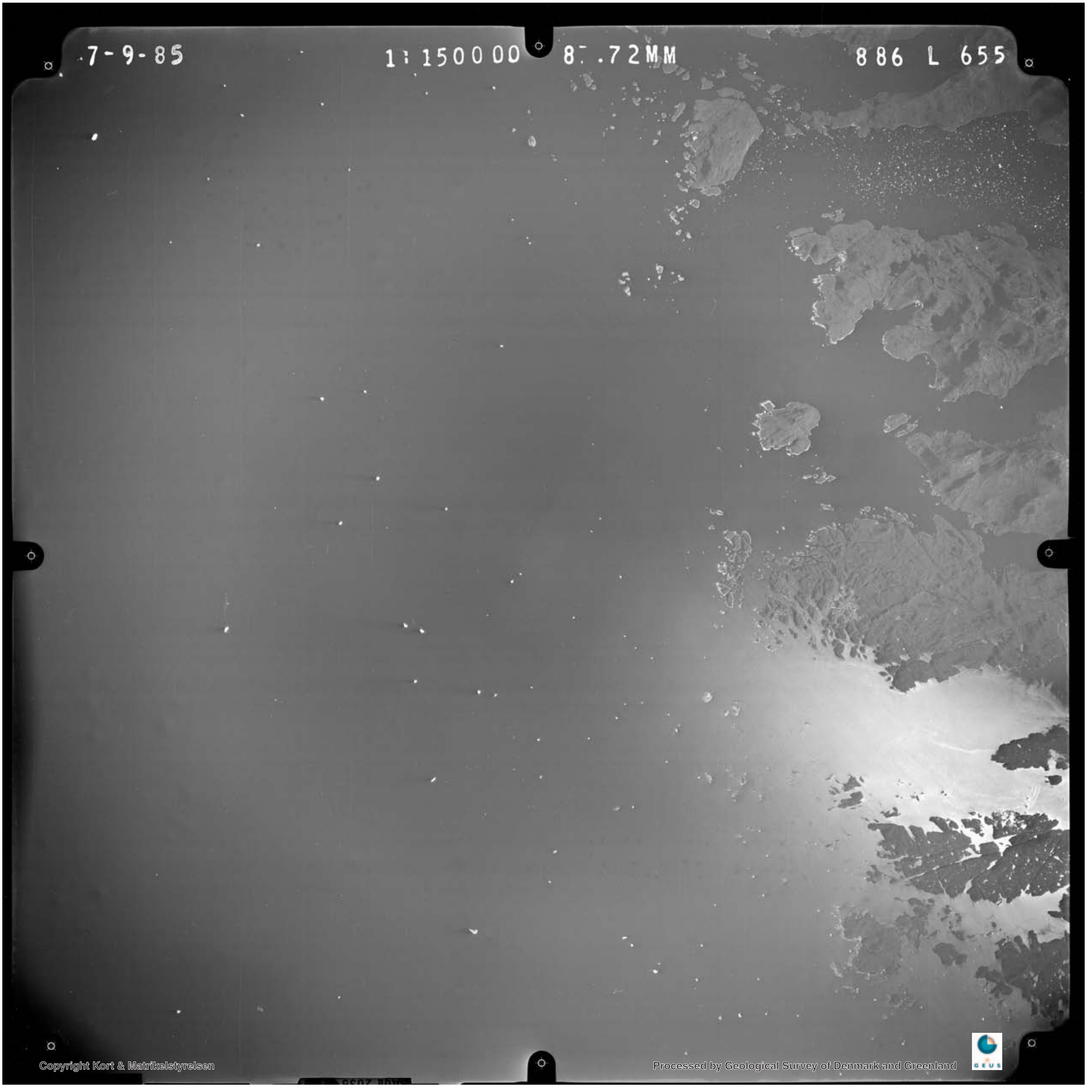
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents

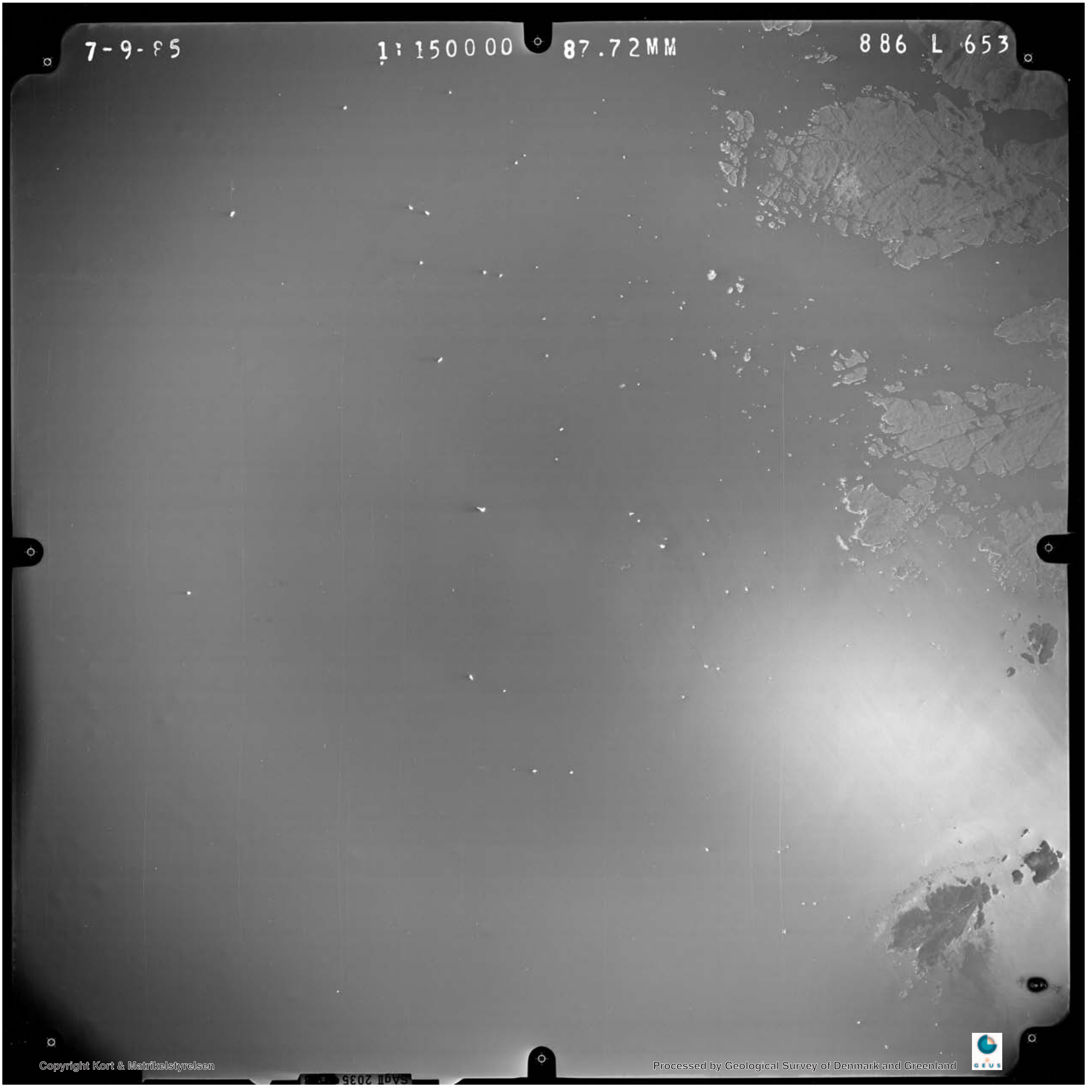
Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

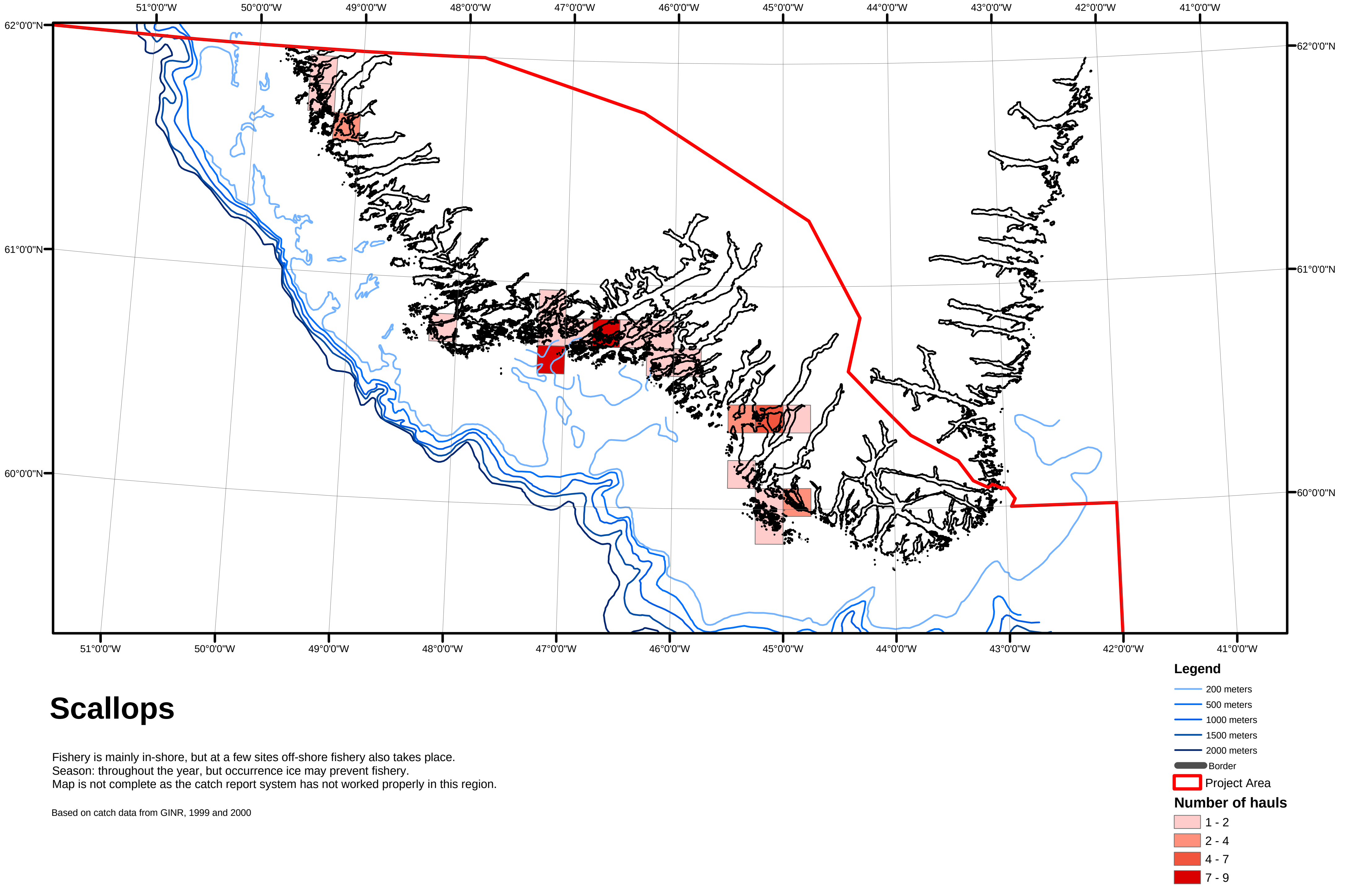
Contents

Airphoto Keymap



Approximate scale 0 2 4 6 8 10 km

Contents | Airphoto Keymap

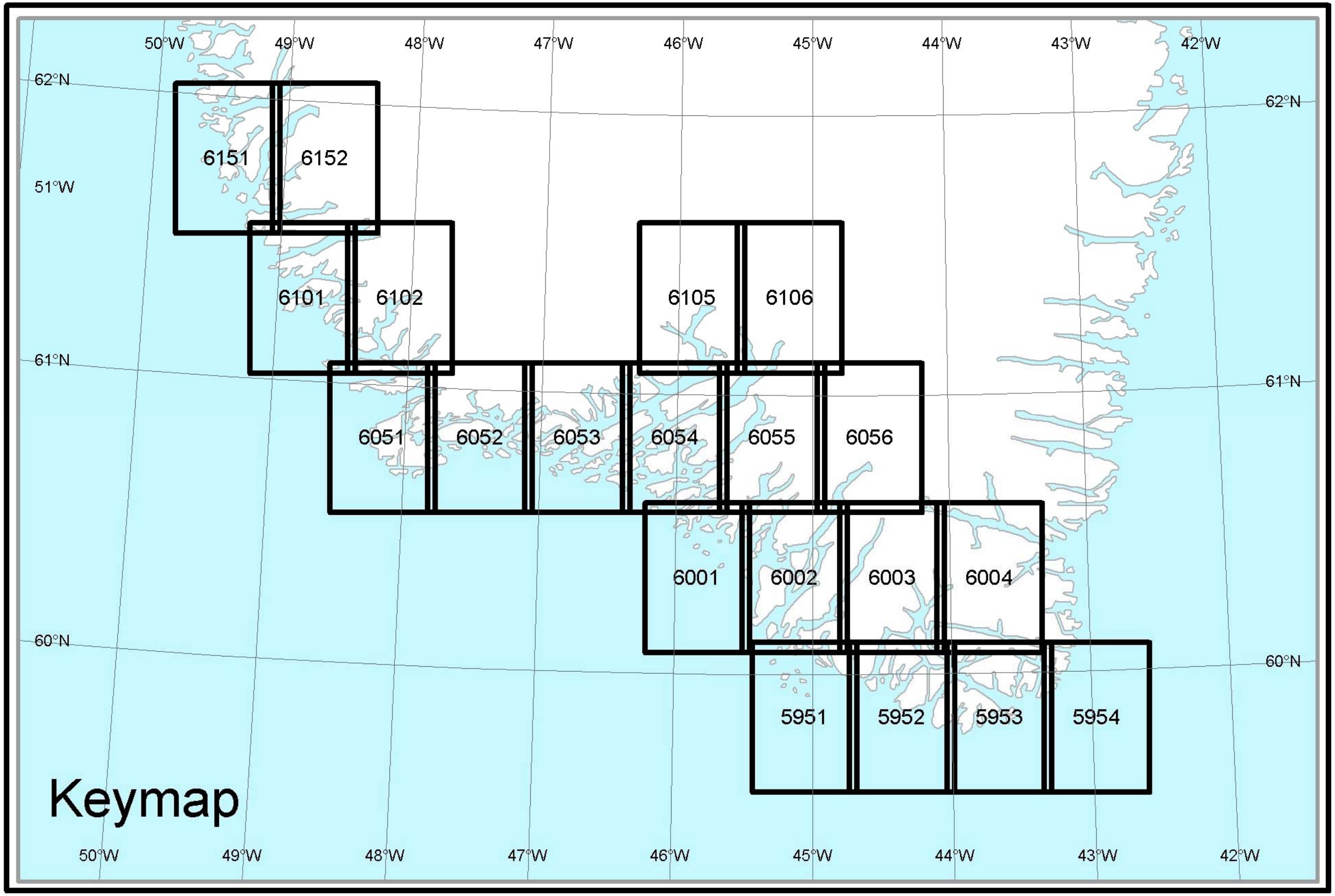


Scallops

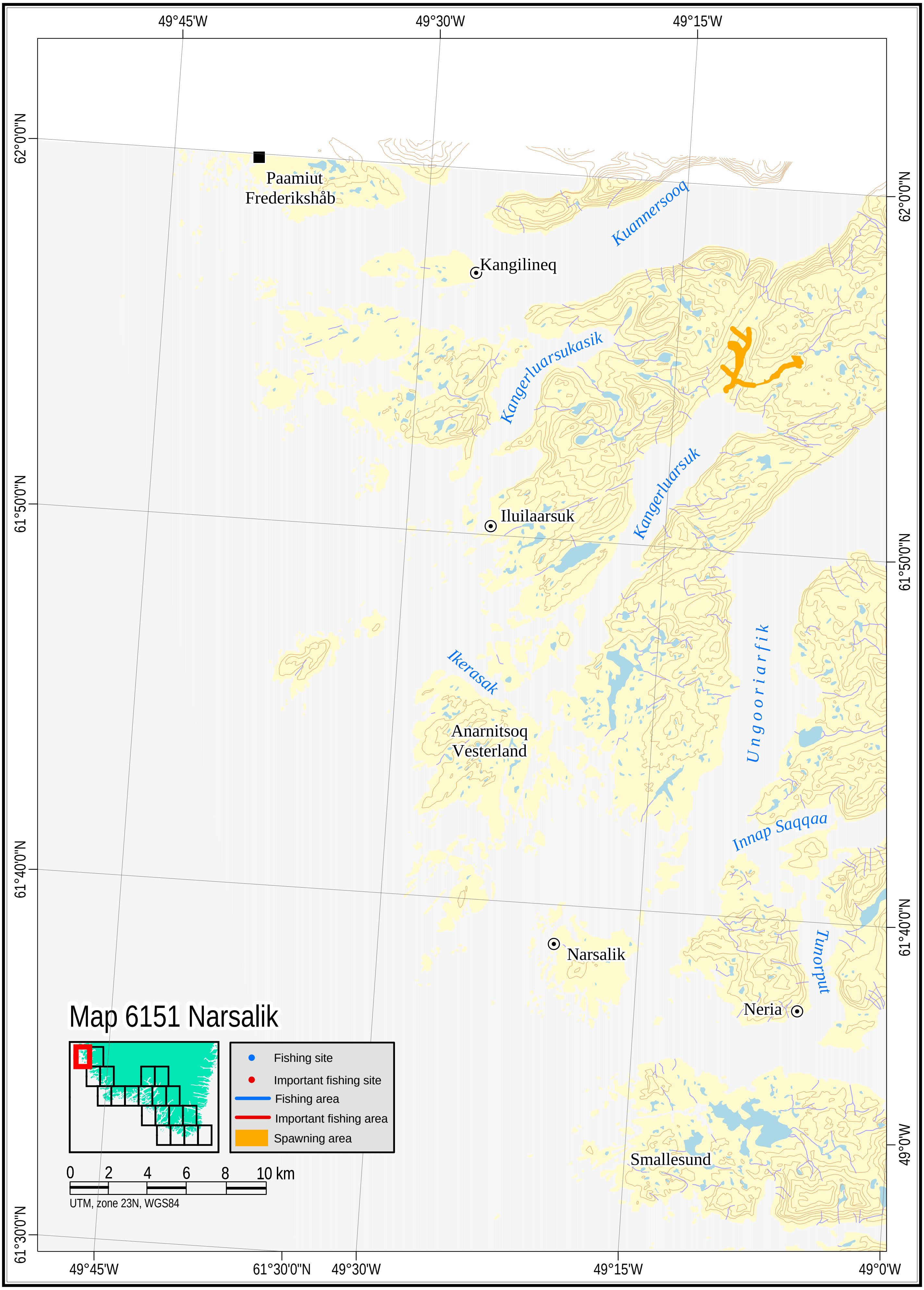
Fishery is mainly in-shore, but at a few sites off-shore fishery also takes place.
Season: throughout the year, but occurrence ice may prevent fishery.
Map is not complete as the catch report system has not worked properly in this region.

Based on catch data from GINR, 1999 and 2000

Distribution of arctic char rivers and fishing areas

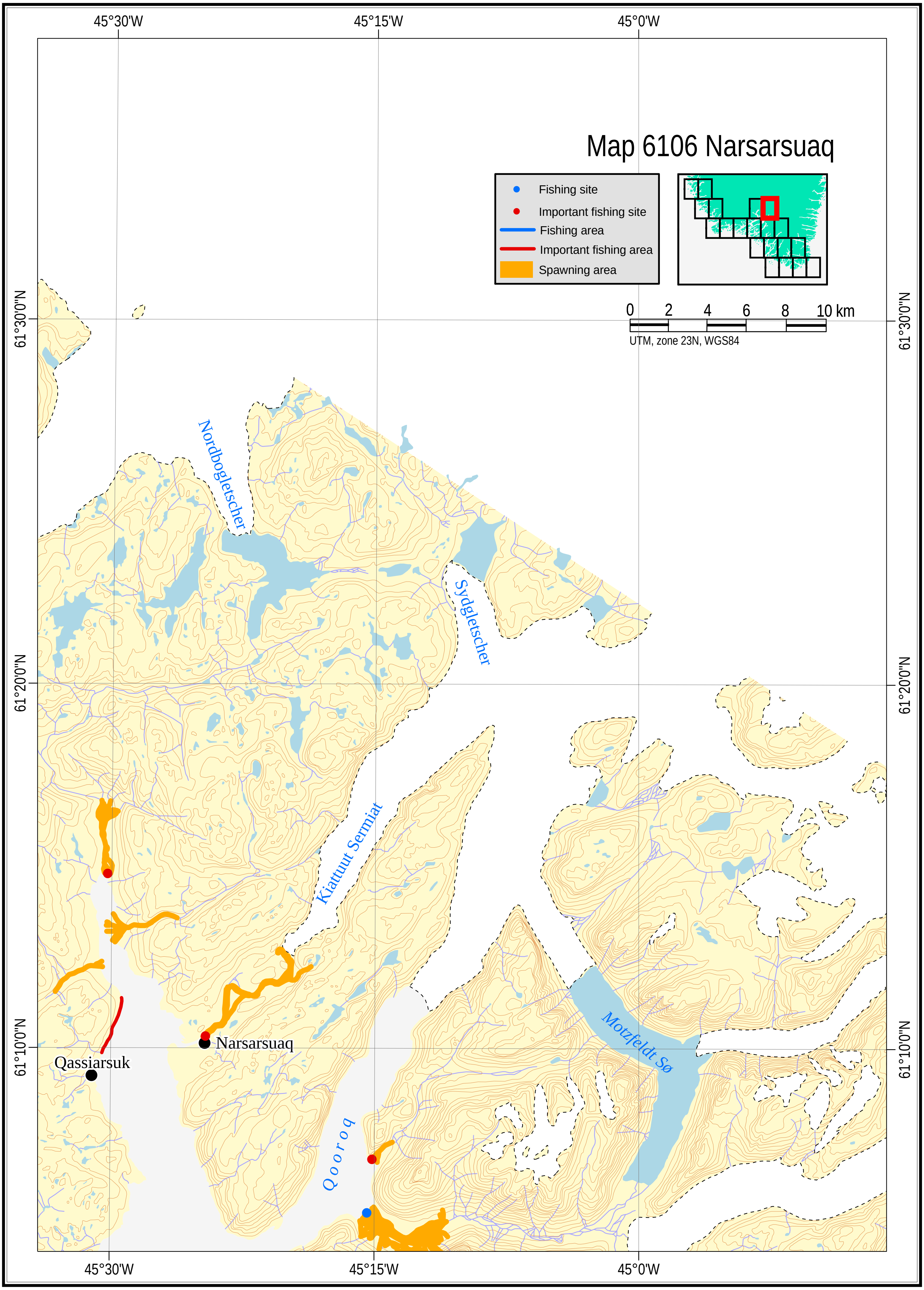


Arctic char - Distribution of spawning and fishing areas.

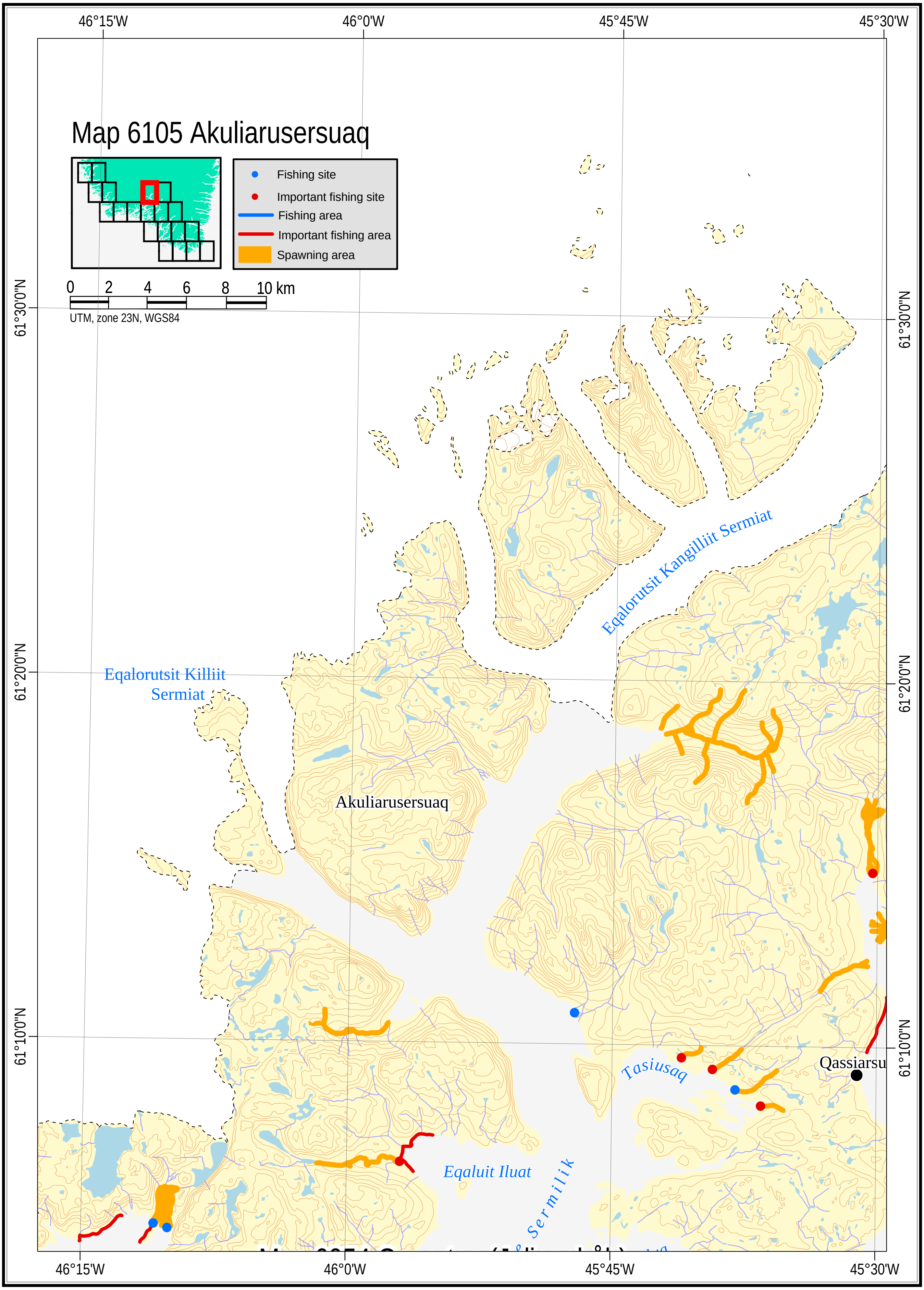


Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Arctic char - Distribution of spawning and fishing areas.

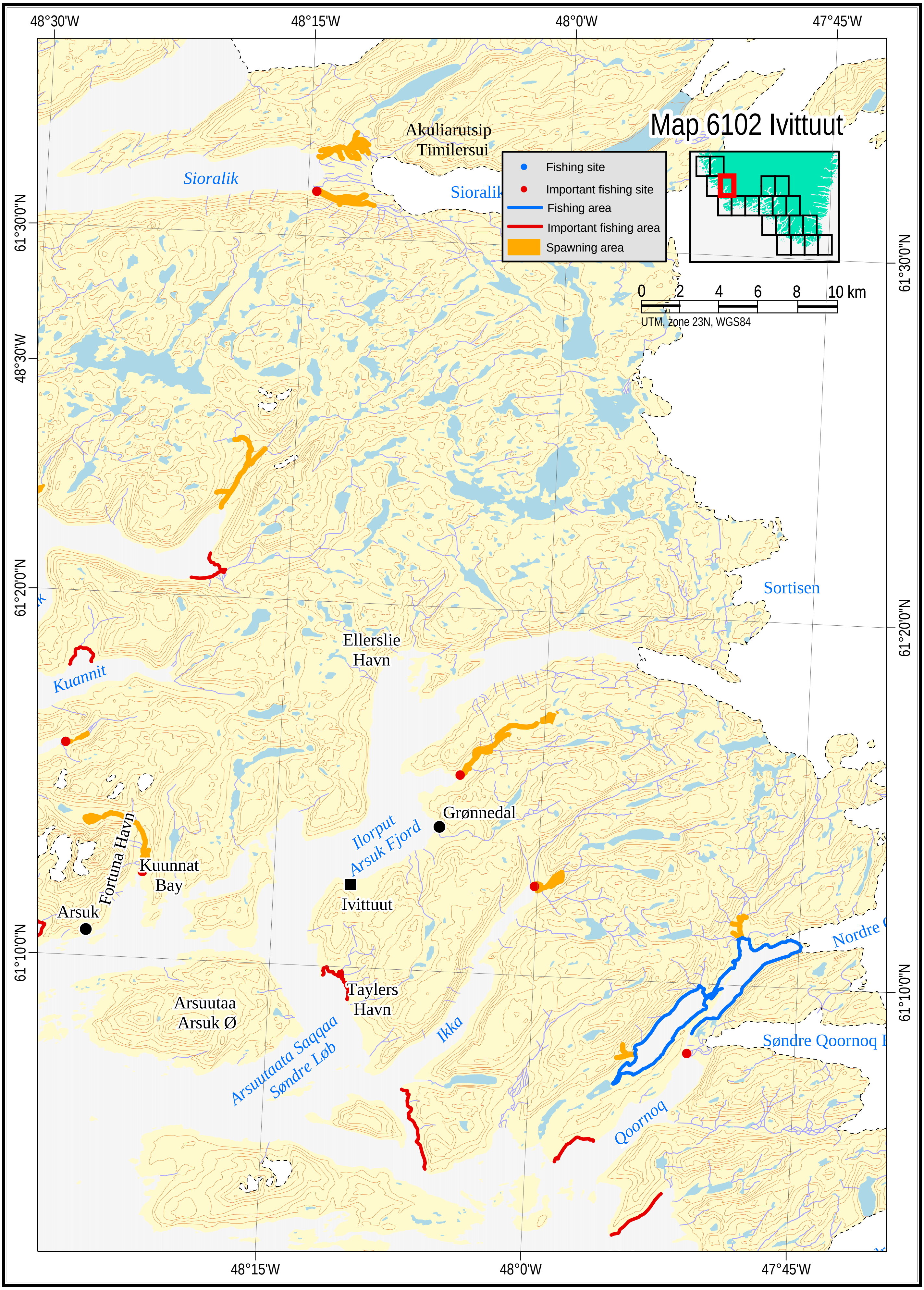


Arctic char - Distribution of spawning and fishing areas.

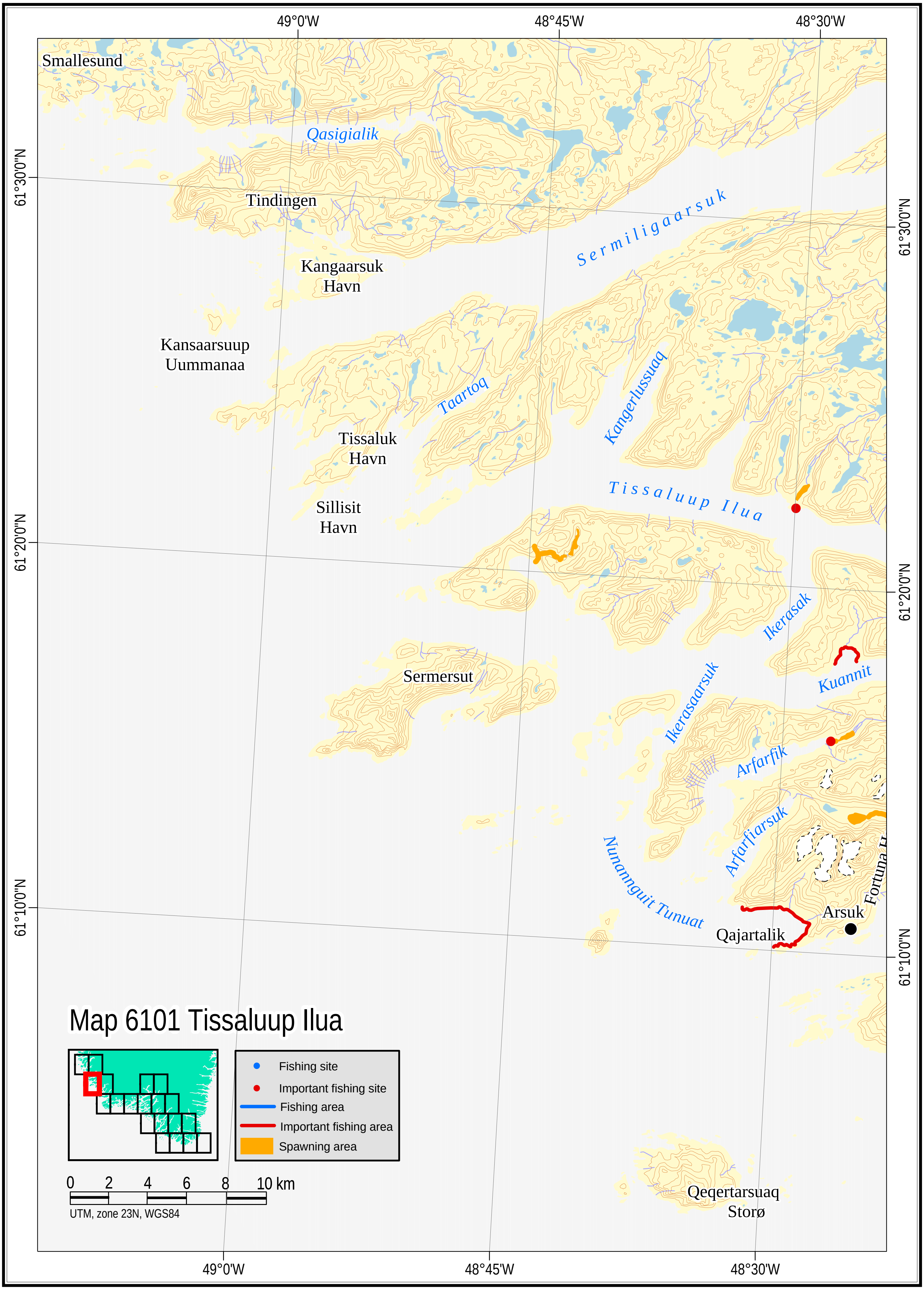


Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Arctic char - Distribution of spawning and fishing areas.

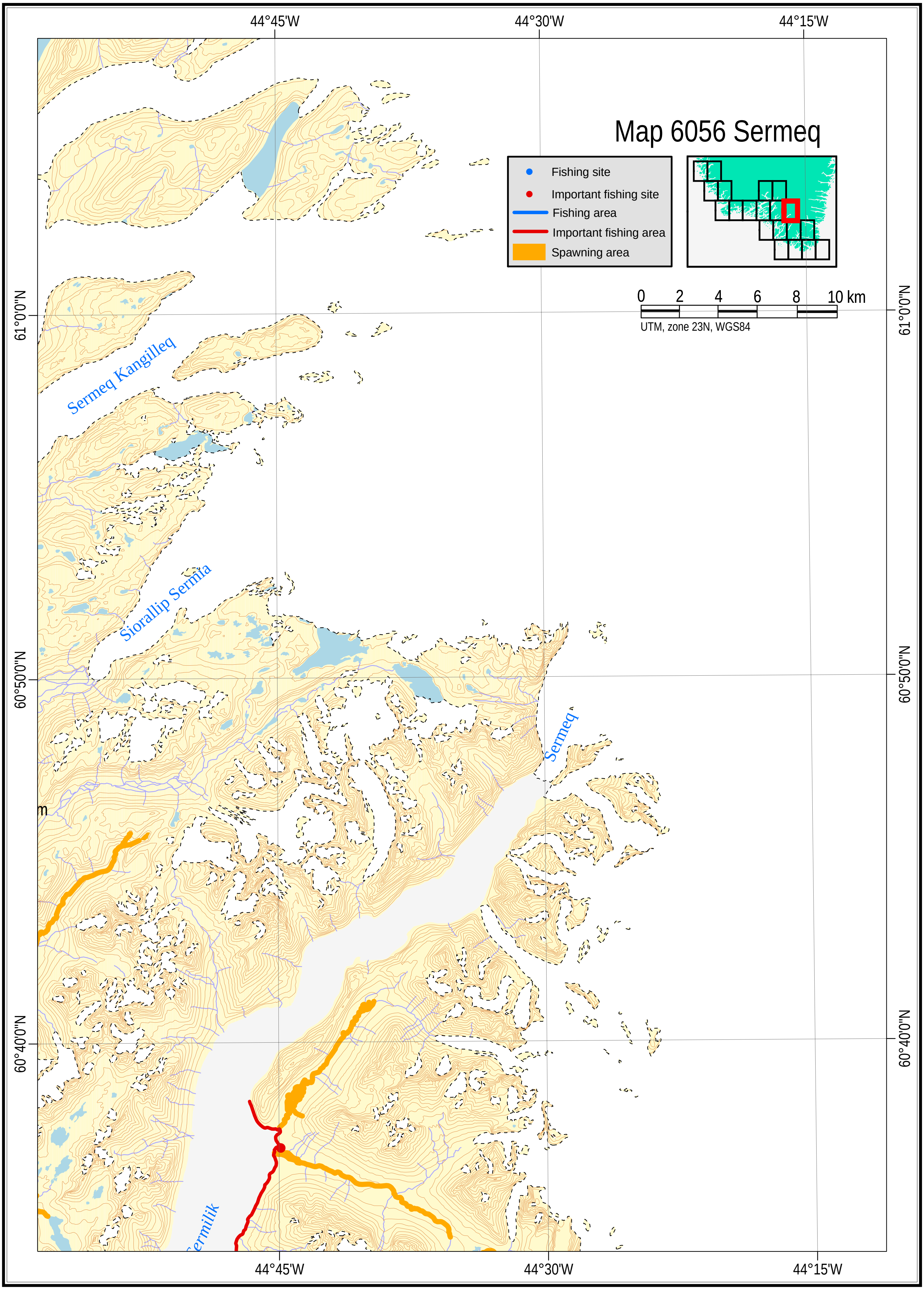


Arctic char - Distribution of spawning and fishing areas.

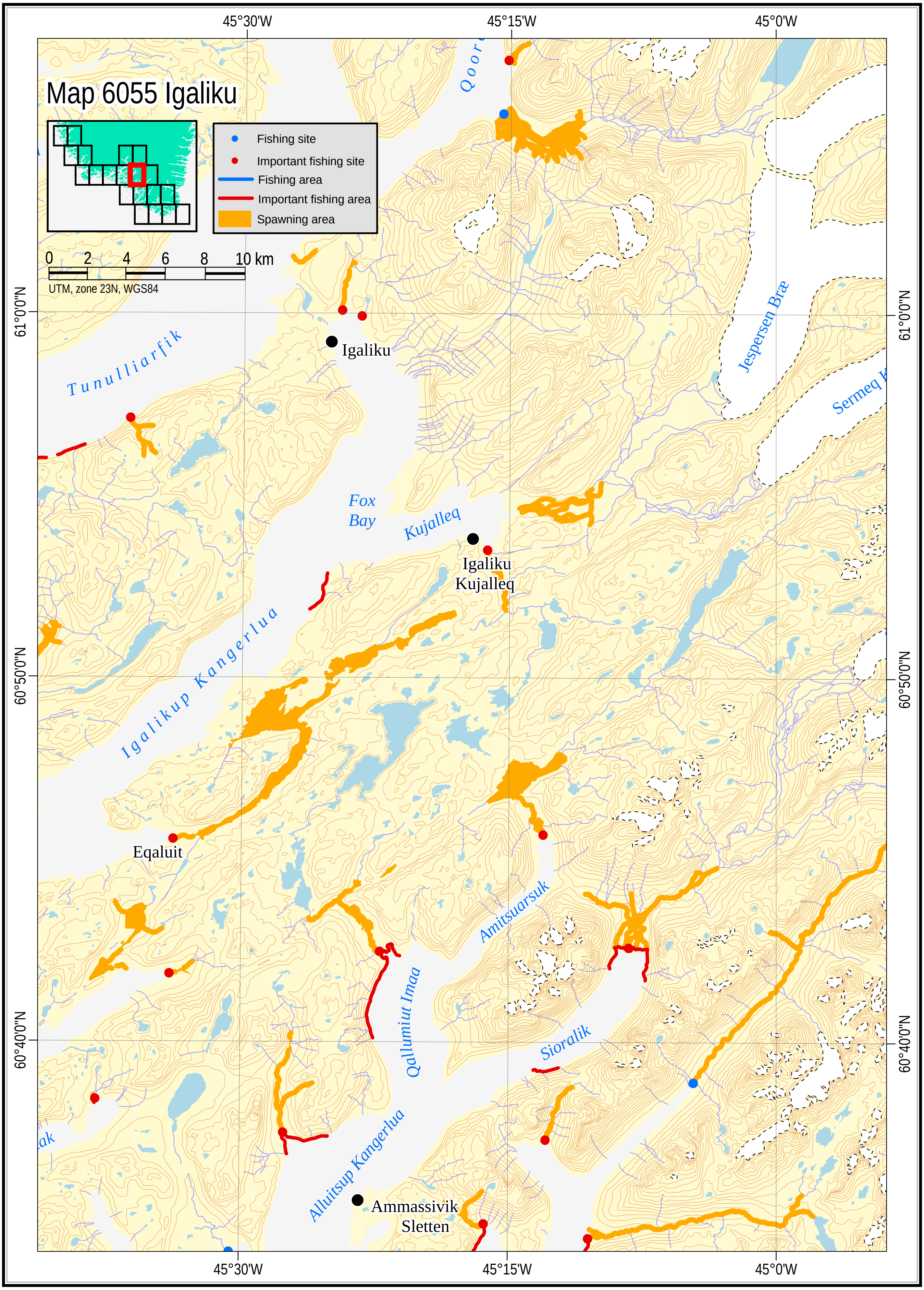


Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Arctic char - Distribution of spawning and fishing areas.

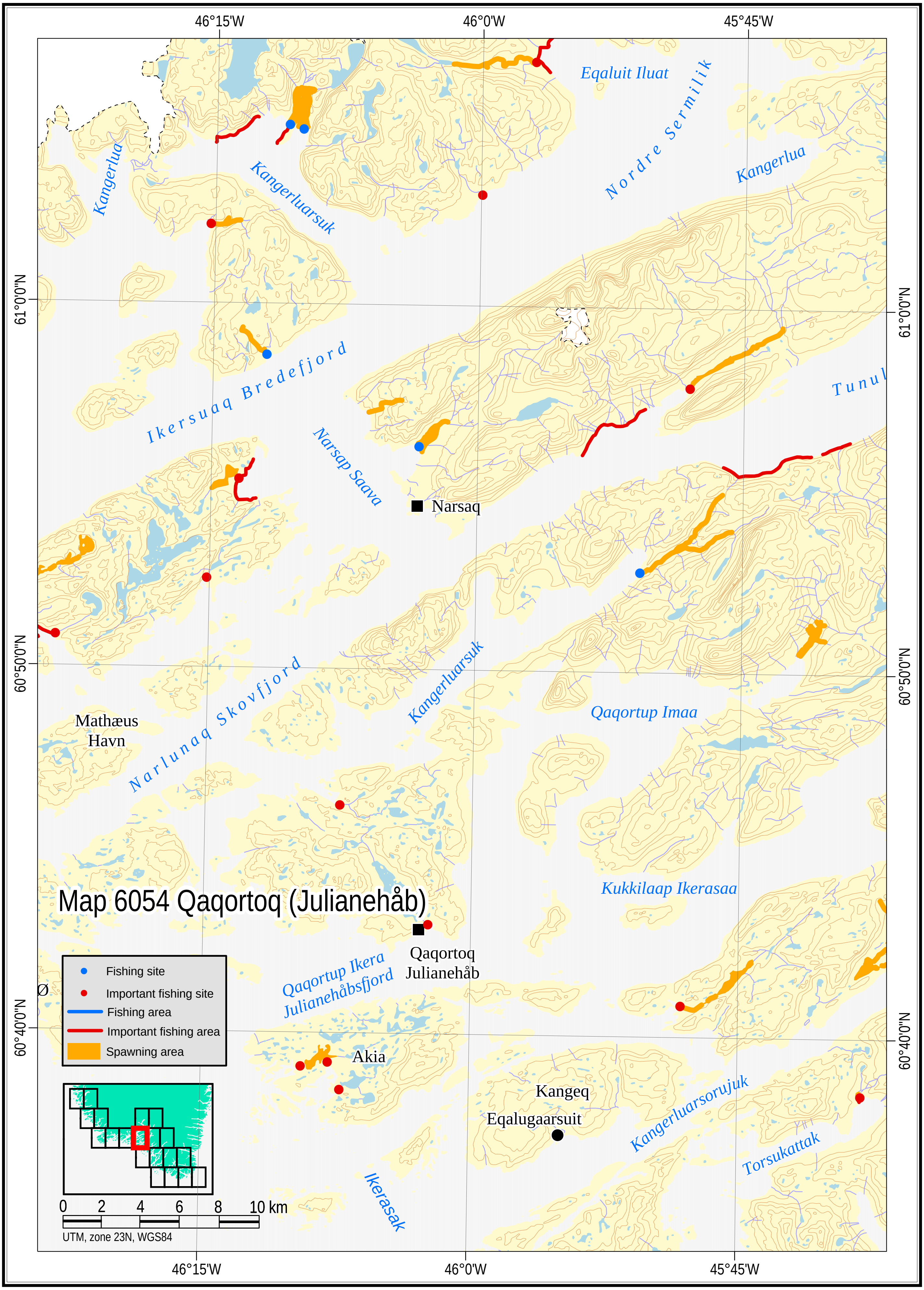


Arctic char - Distribution of spawning and fishing areas.

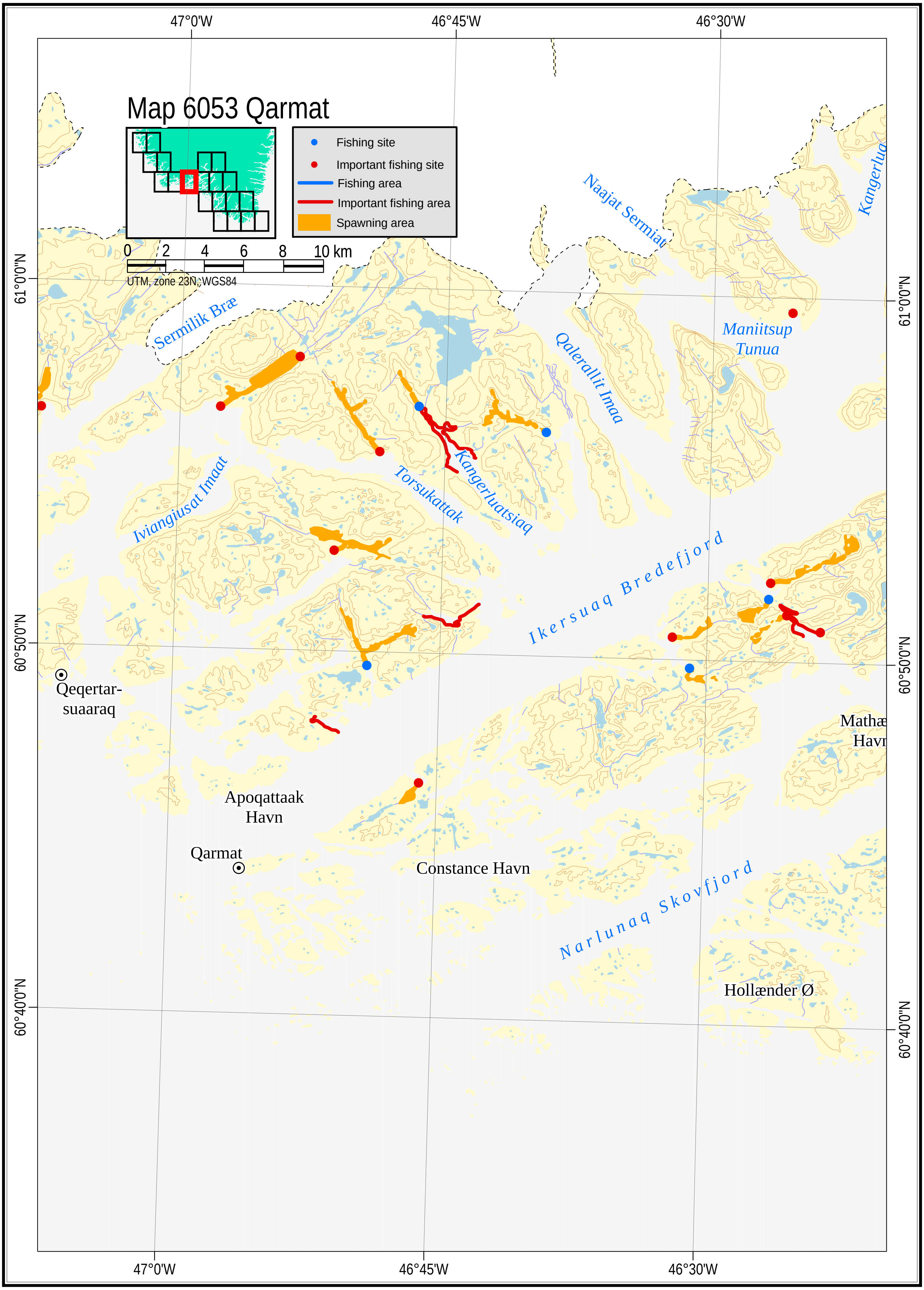


Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Arctic char - Distribution of spawning and fishing areas.

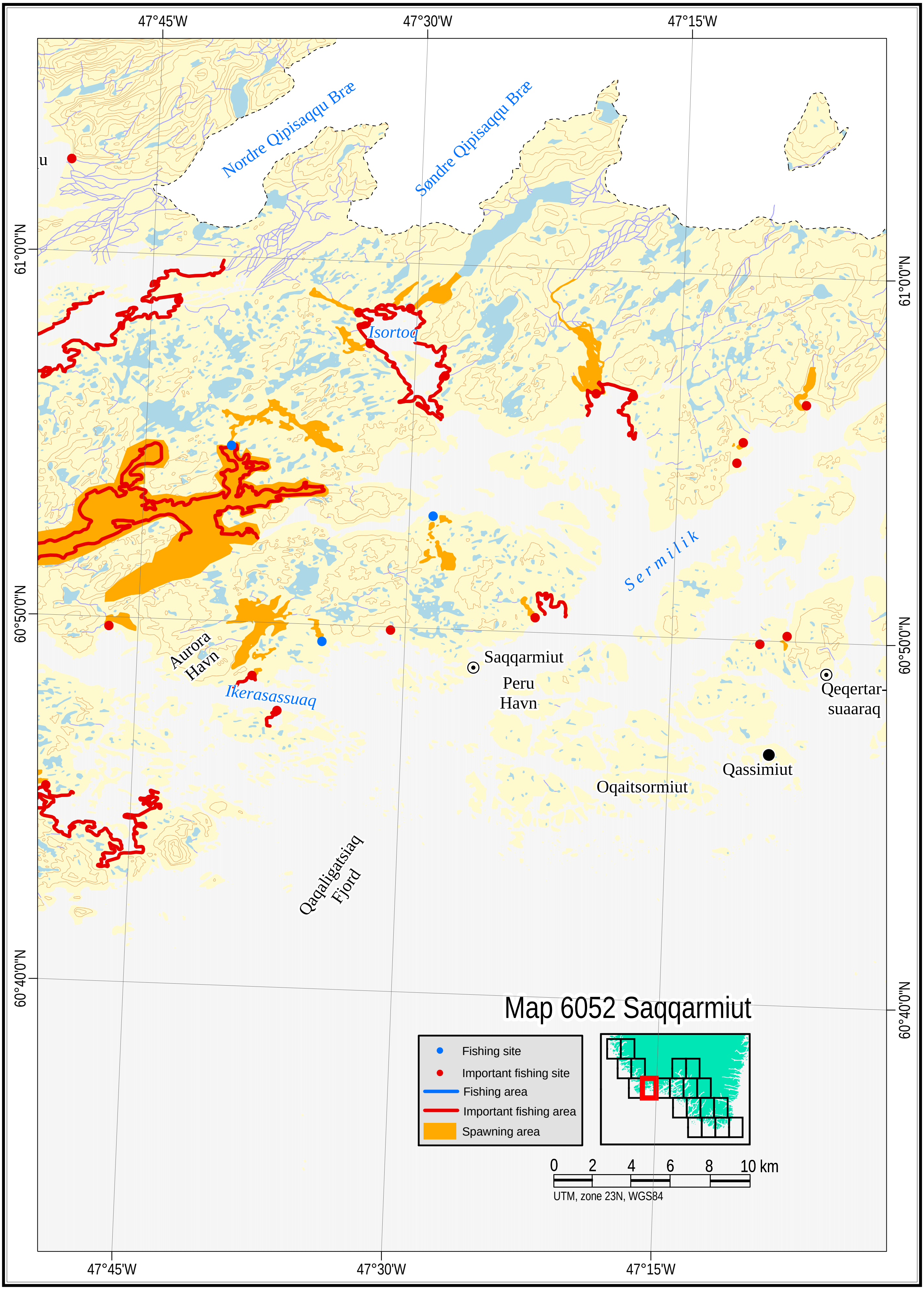


Arctic char - Distribution of spawning and fishing areas.

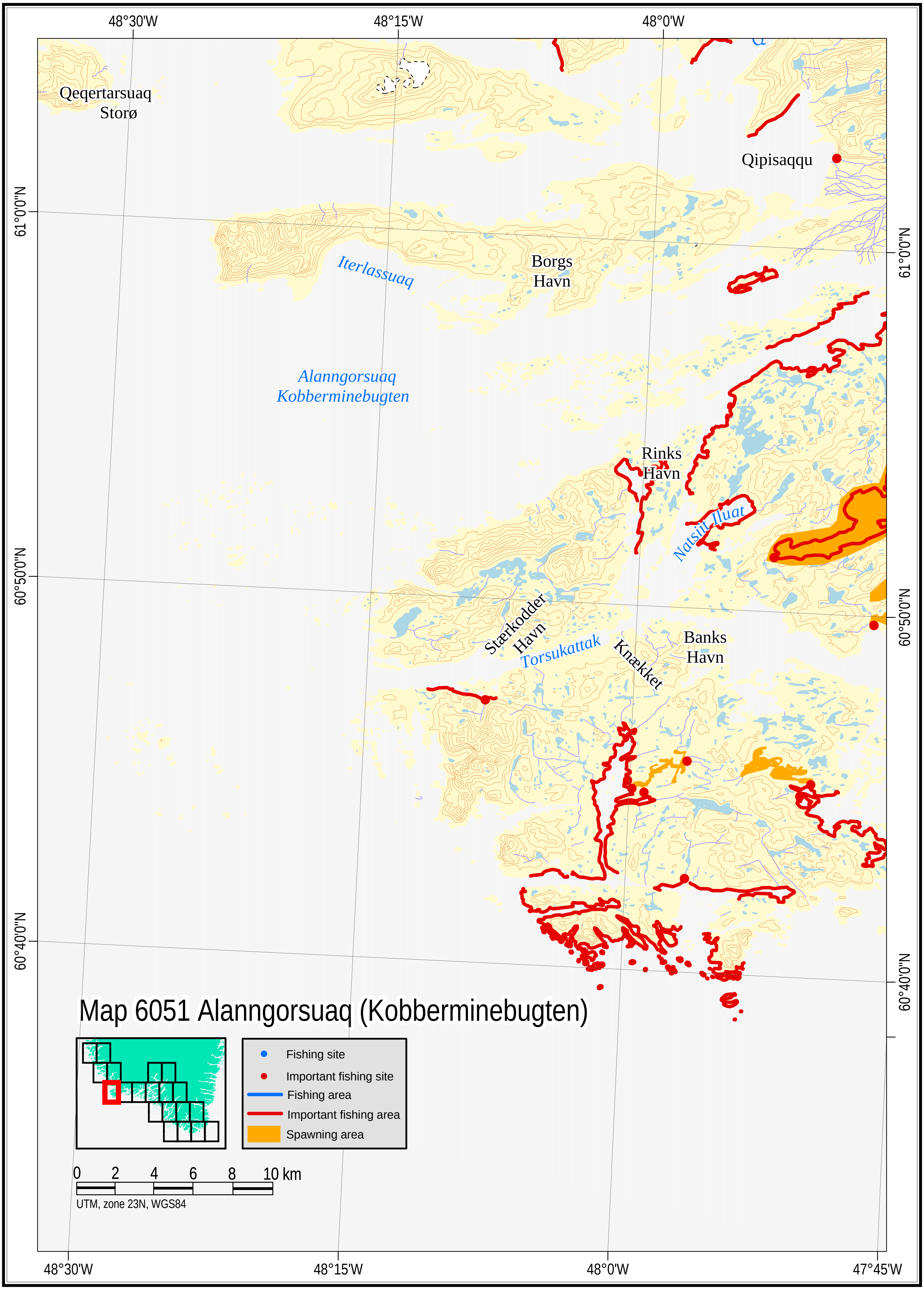


Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Arctic char - Distribution of spawning and fishing areas.

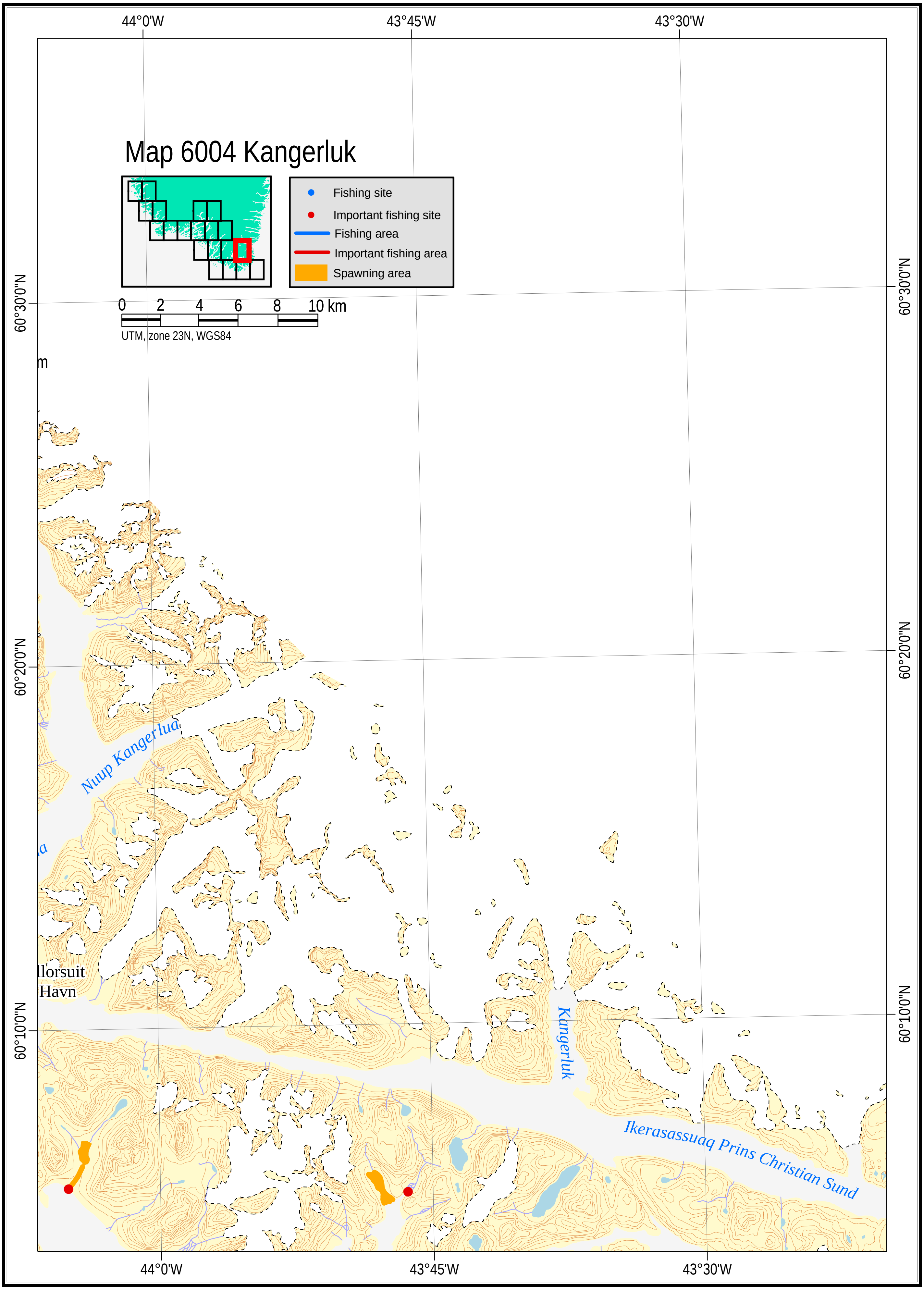


Arctic char - Distribution of spawning and fishing areas.

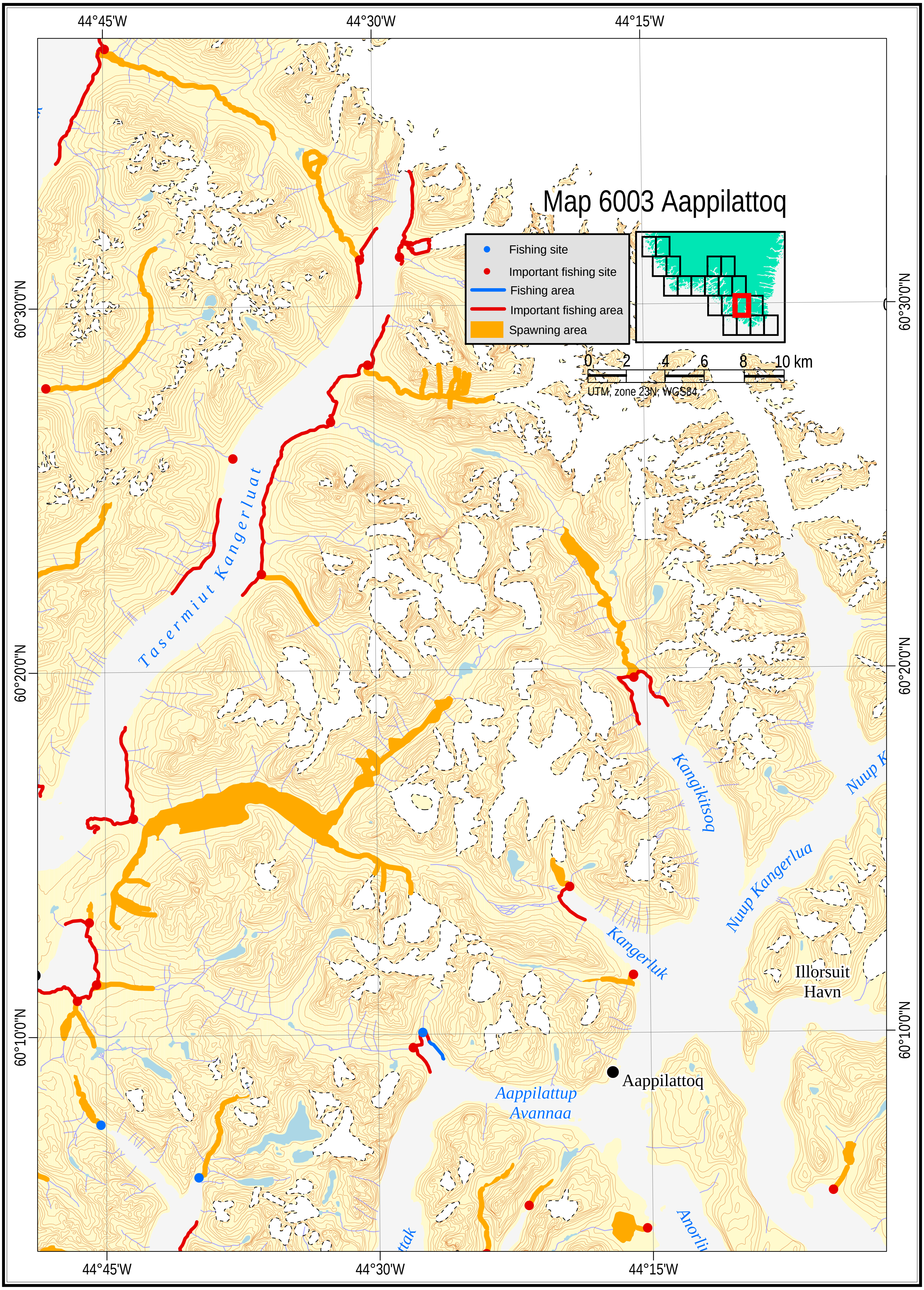


Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Arctic char - Distribution of spawning and fishing areas.

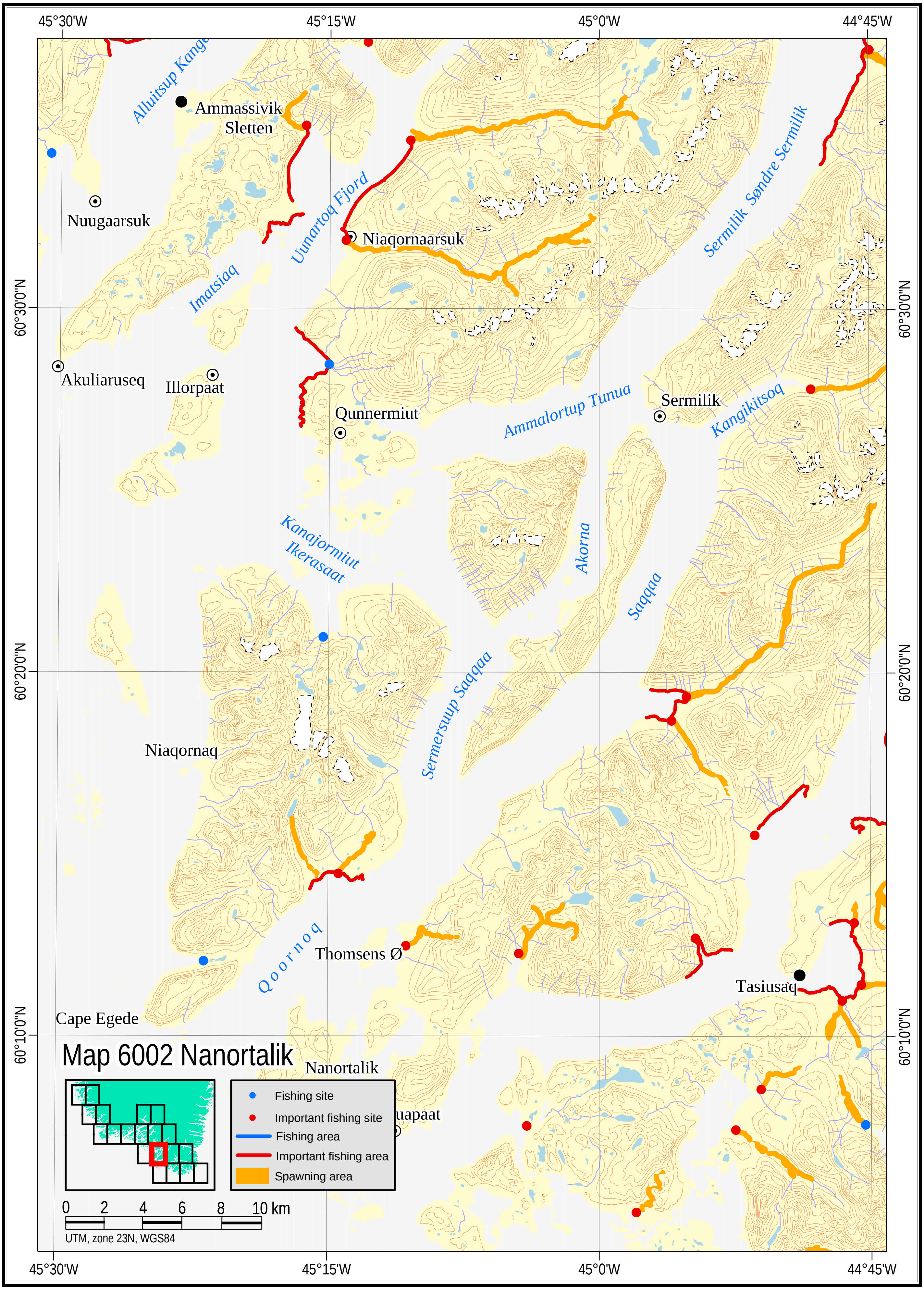


Arctic char - Distribution of spawning and fishing areas.



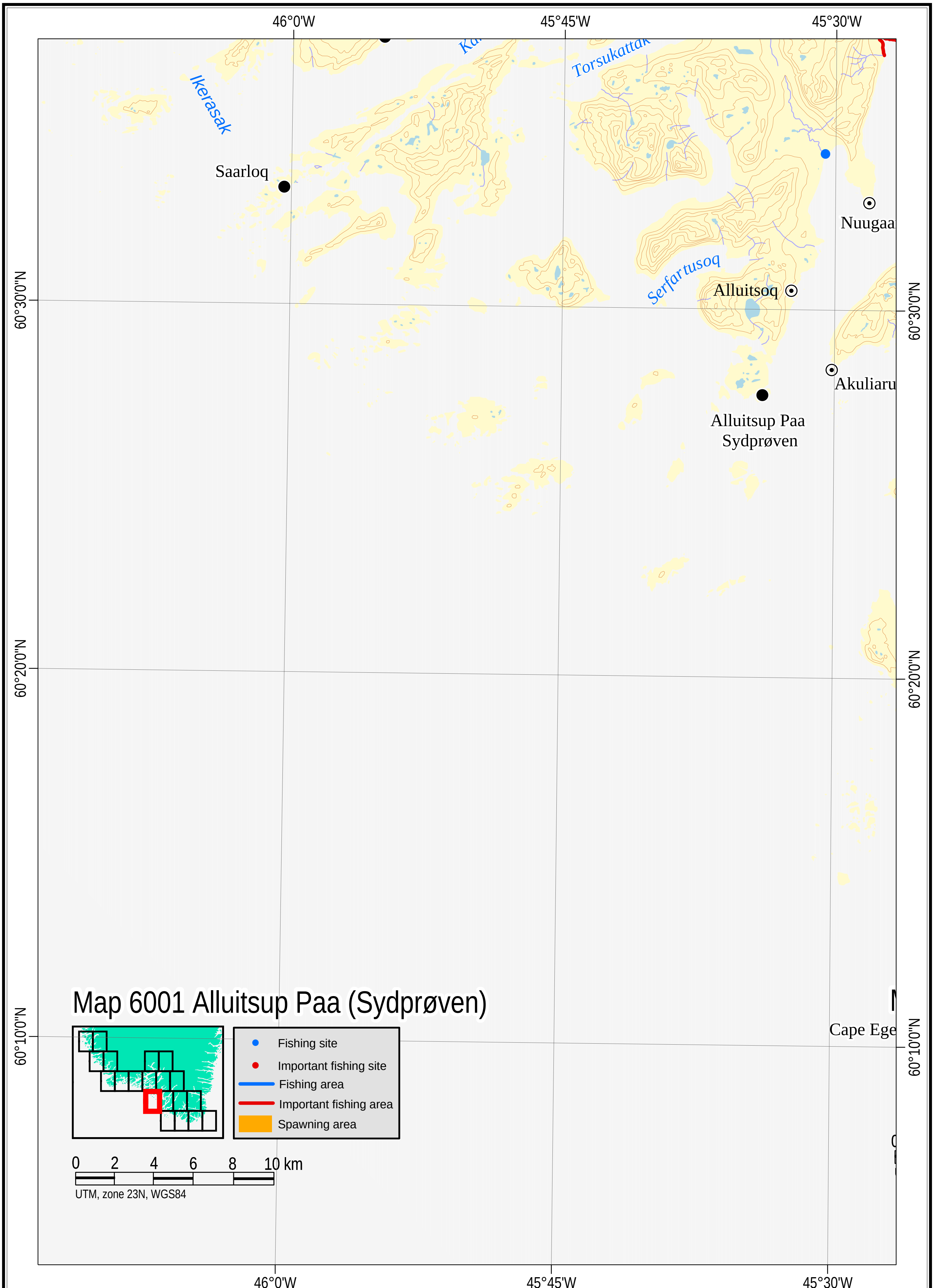
Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Arctic char - Distribution of spawning and fishing areas.



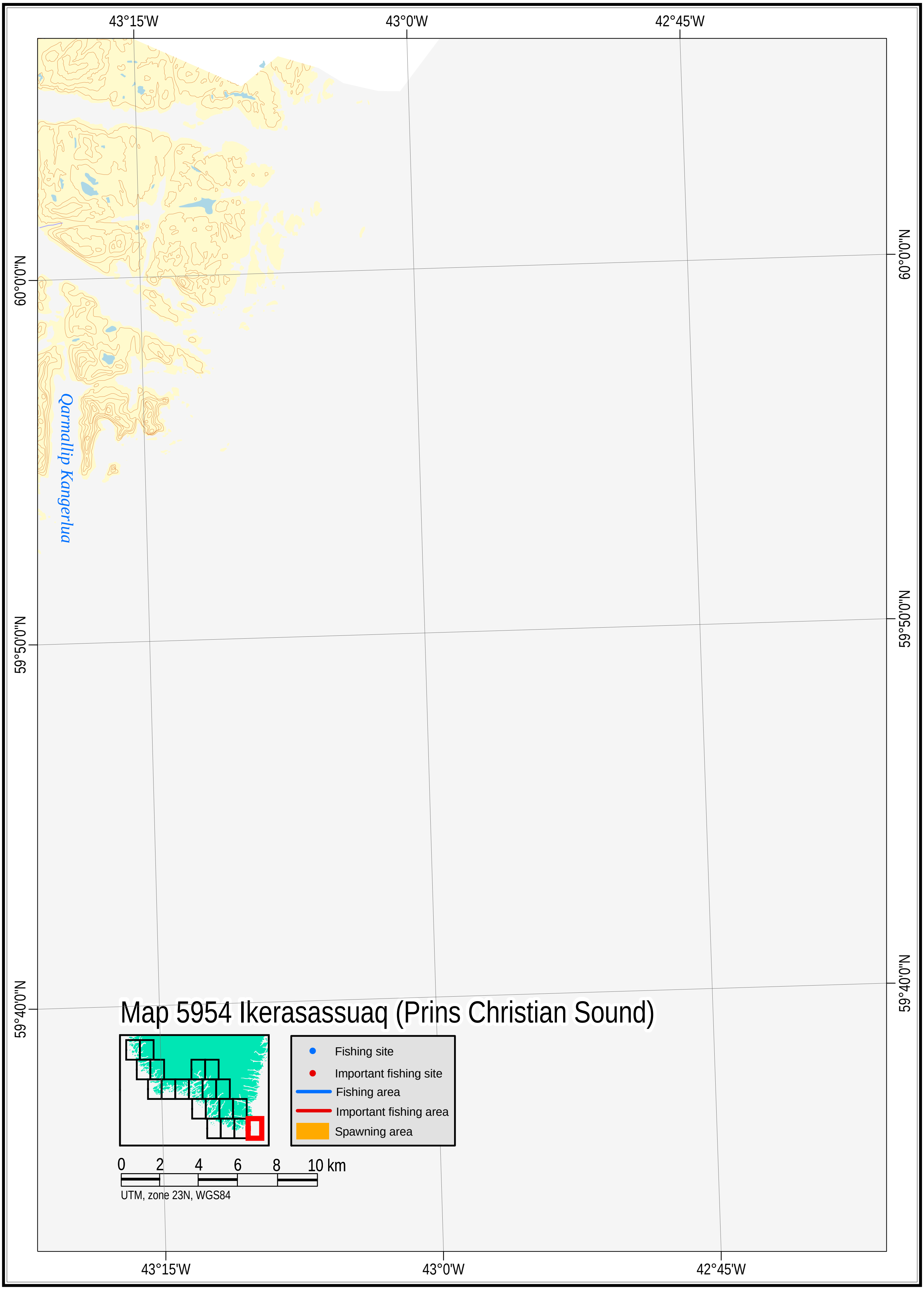
Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Arctic char - Distribution of spawning and fishing areas.

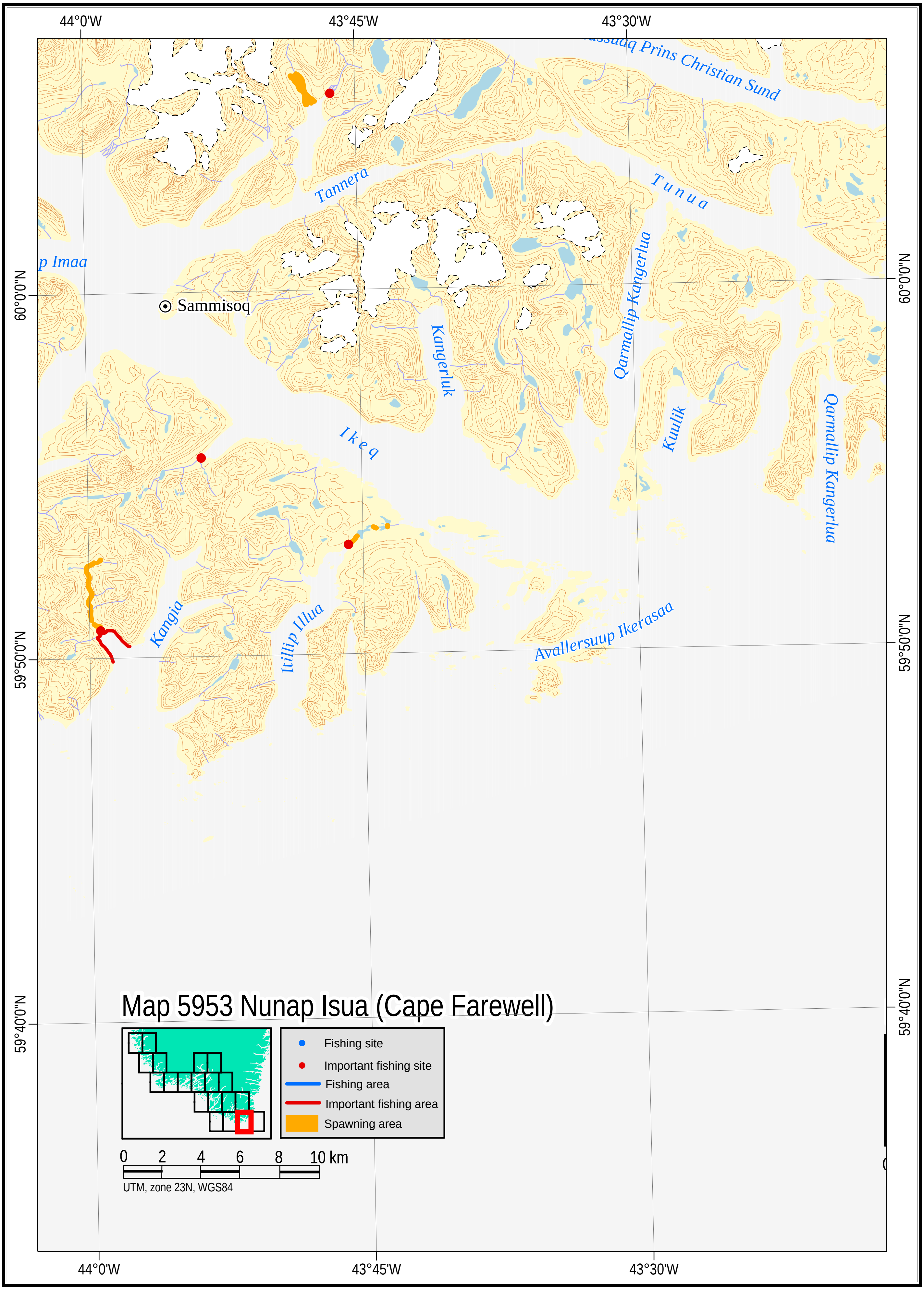


Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

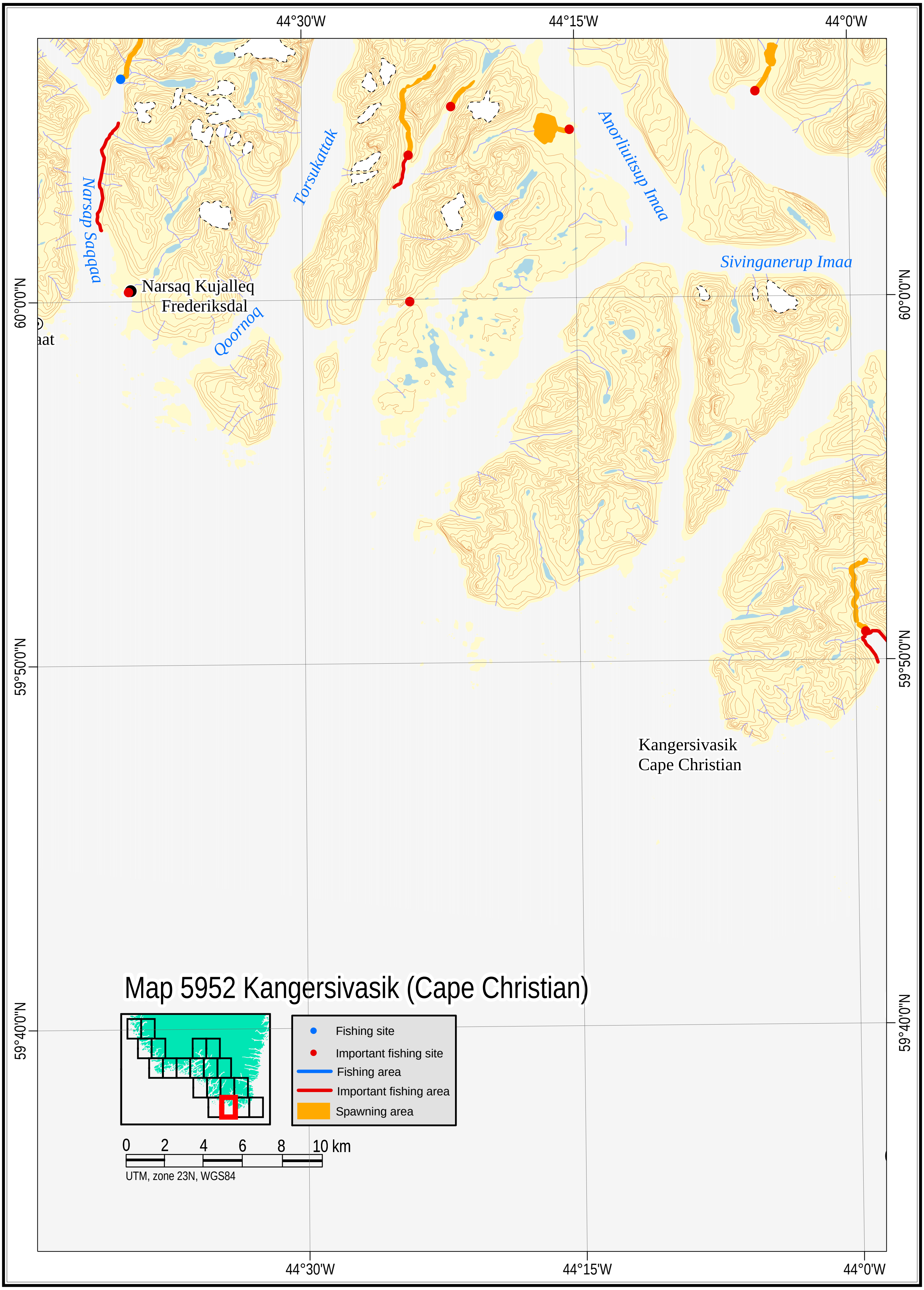
Arctic char - Distribution of spawning and fishing areas.



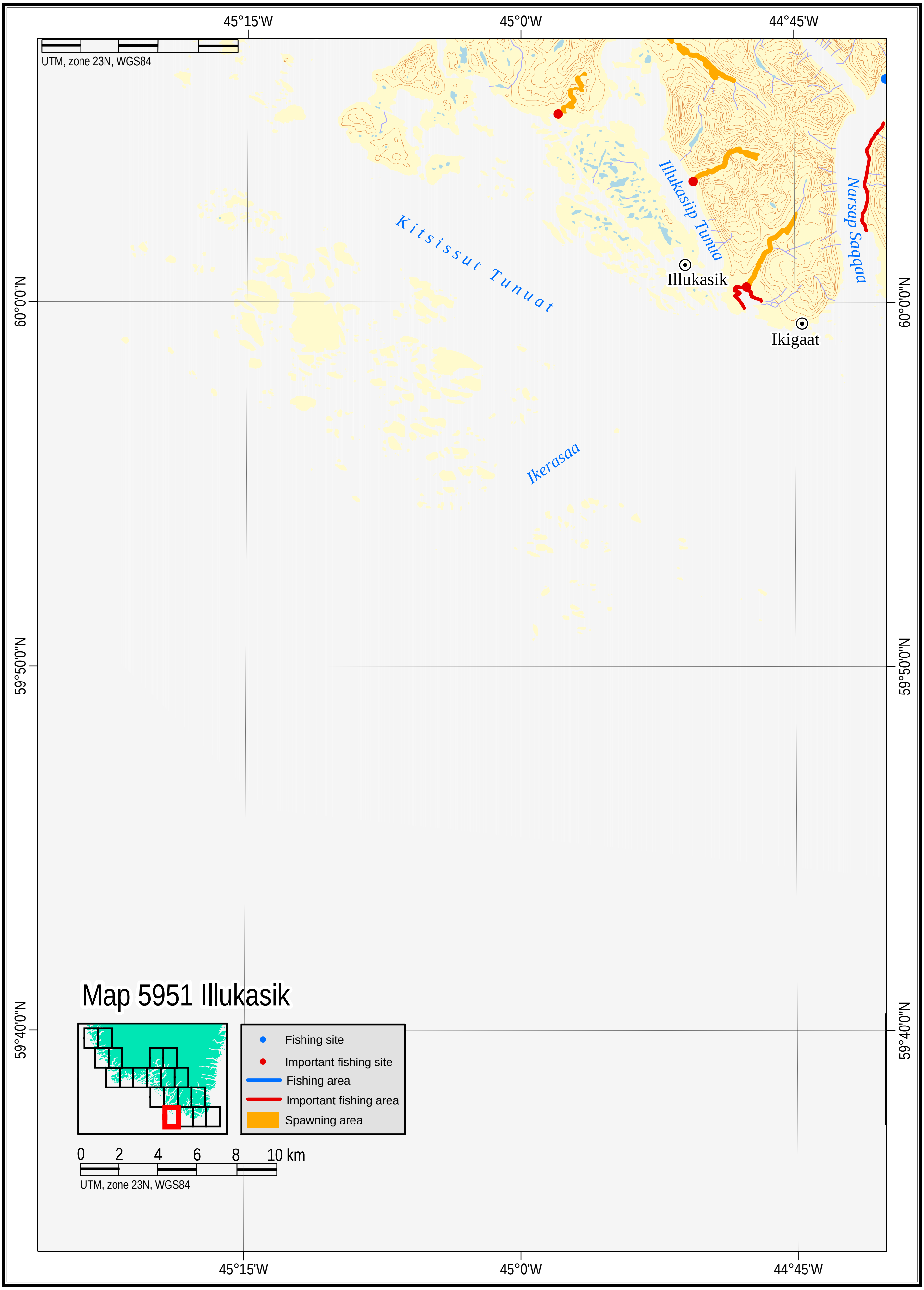
Arctic char - Distribution of spawning and fishing areas.



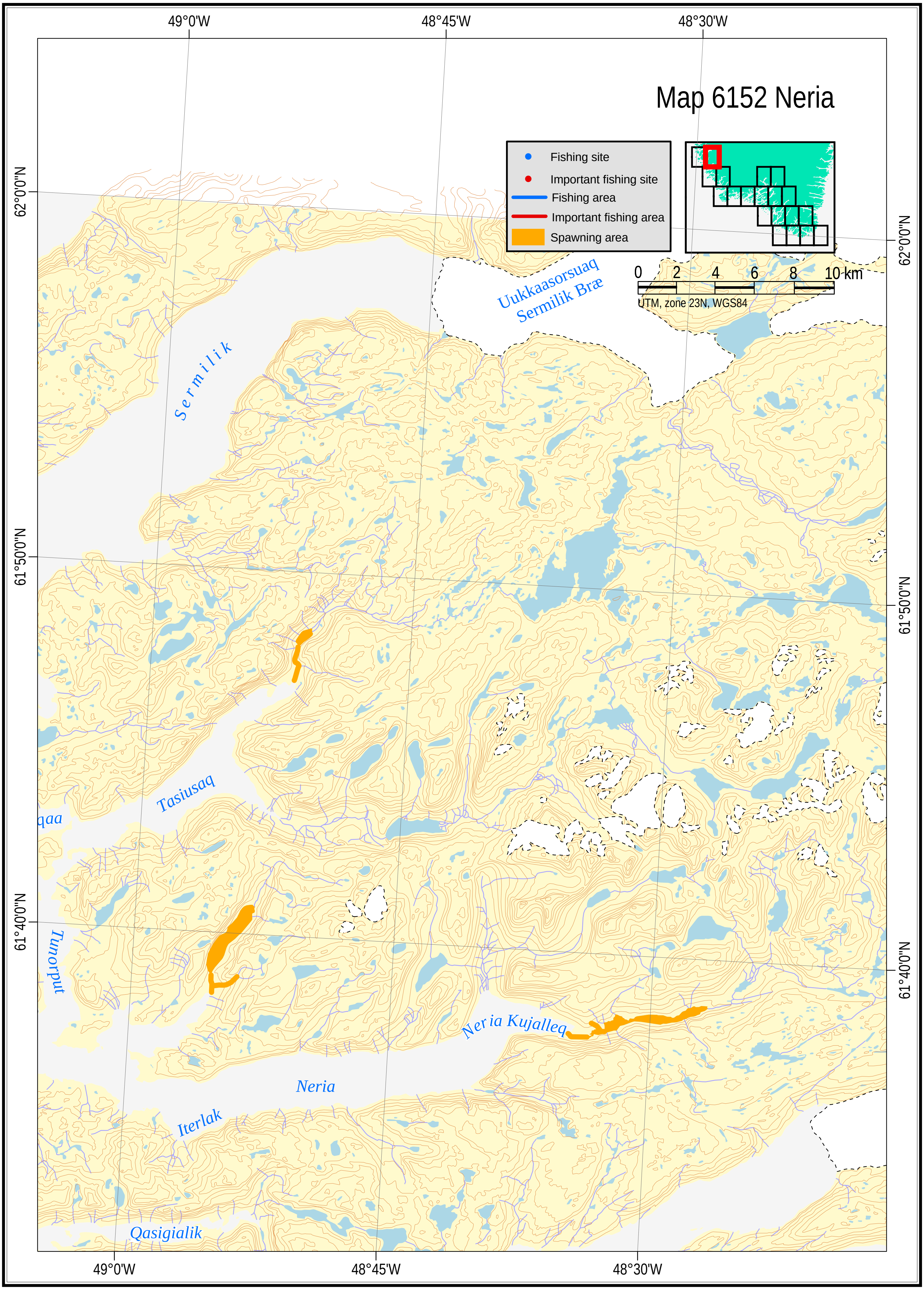
Arctic char - Distribution of spawning and fishing areas.



Arctic char - Distribution of spawning and fishing areas.

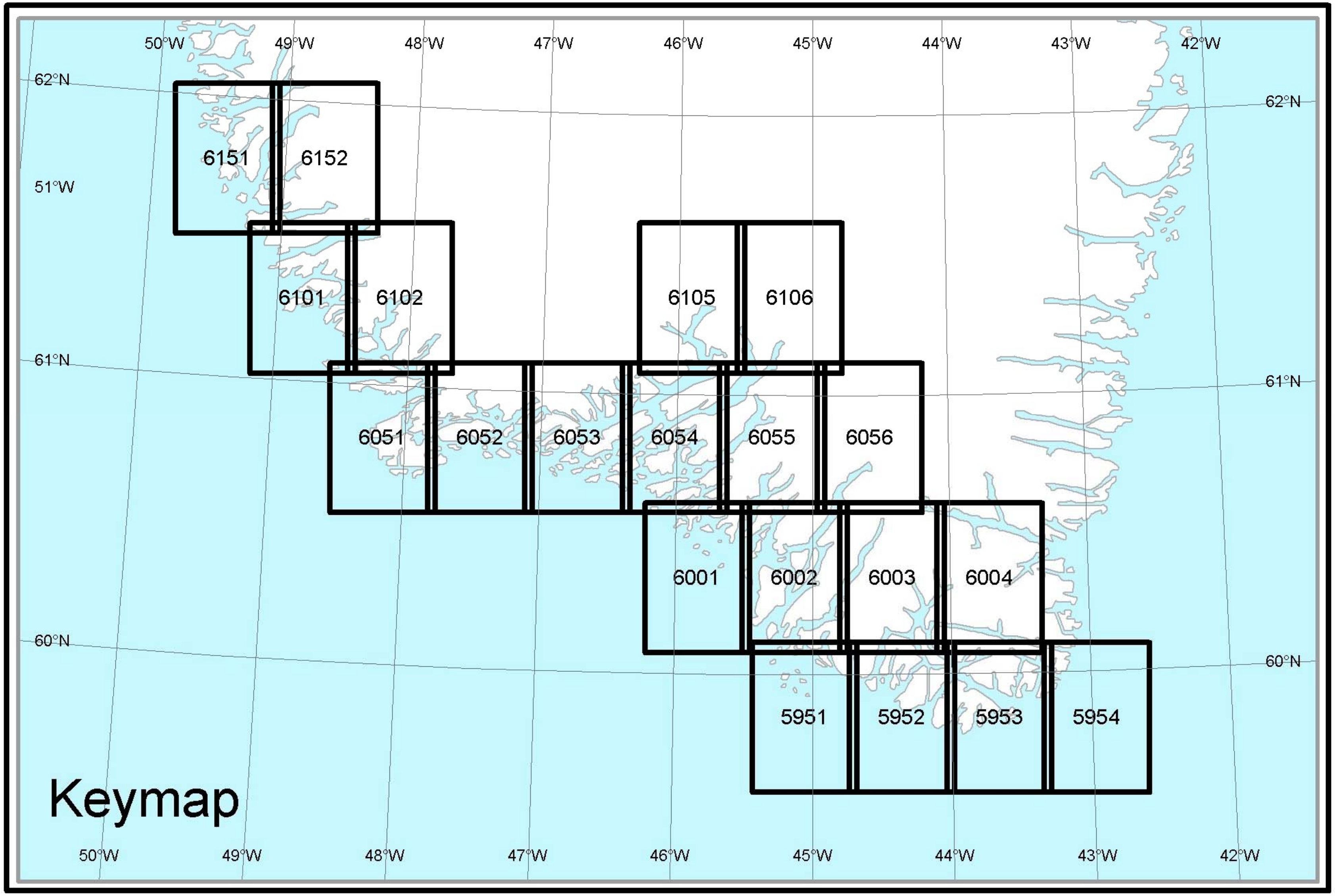


Arctic char - Distribution of spawning and fishing areas.

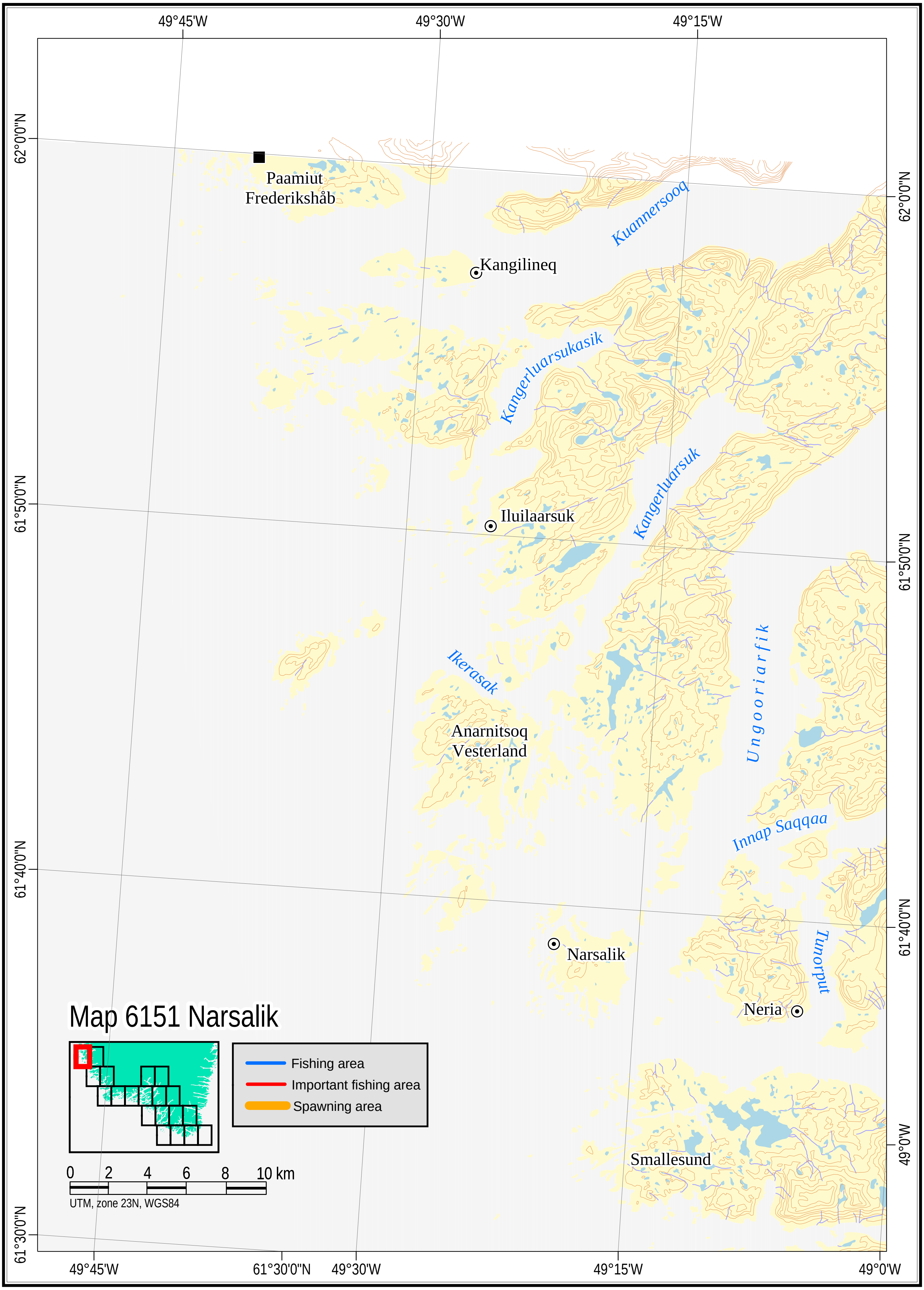


Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Distribution of capelin spawning and fishing areas

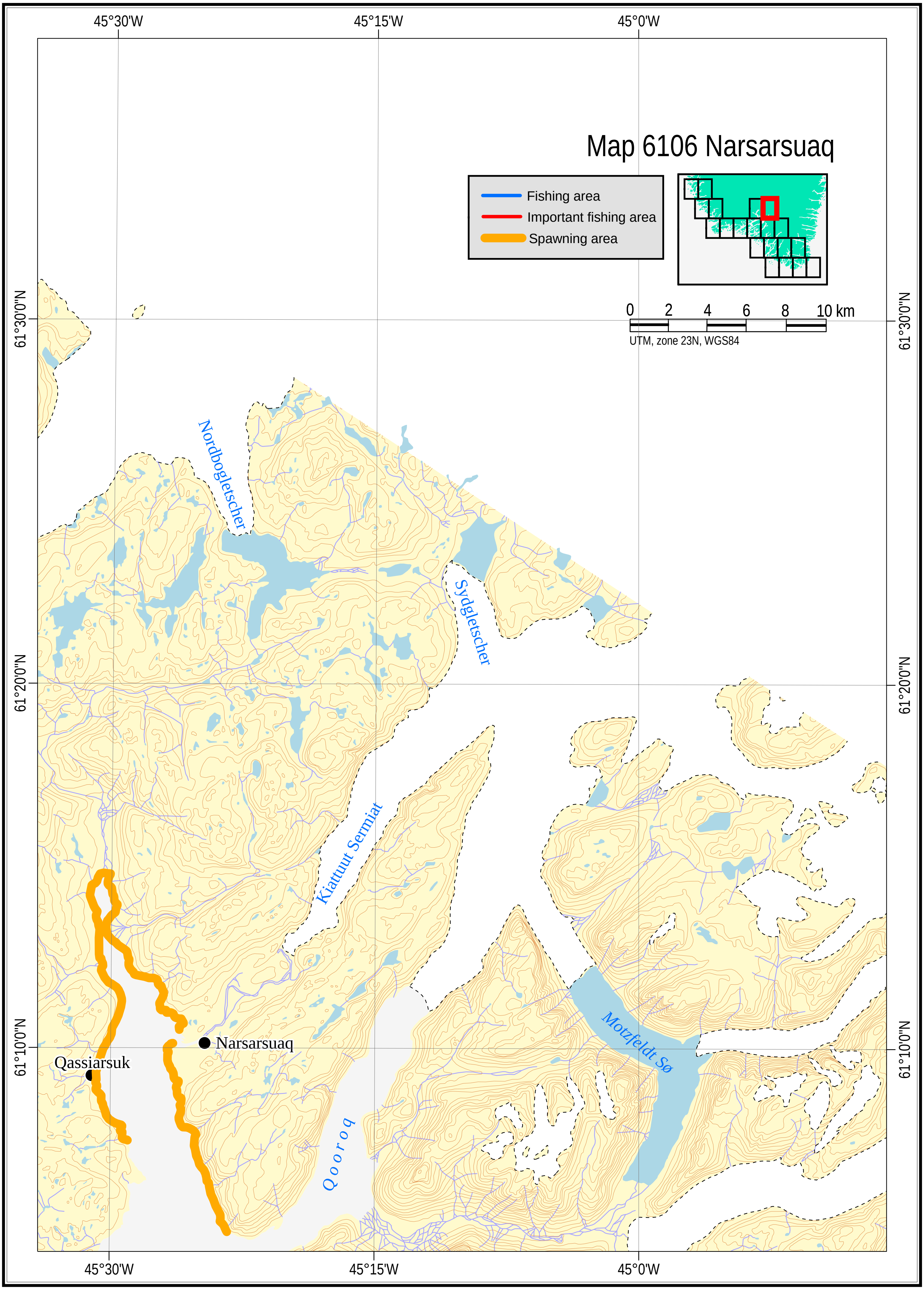


Capelin - Distribution of spawning and fishing areas.

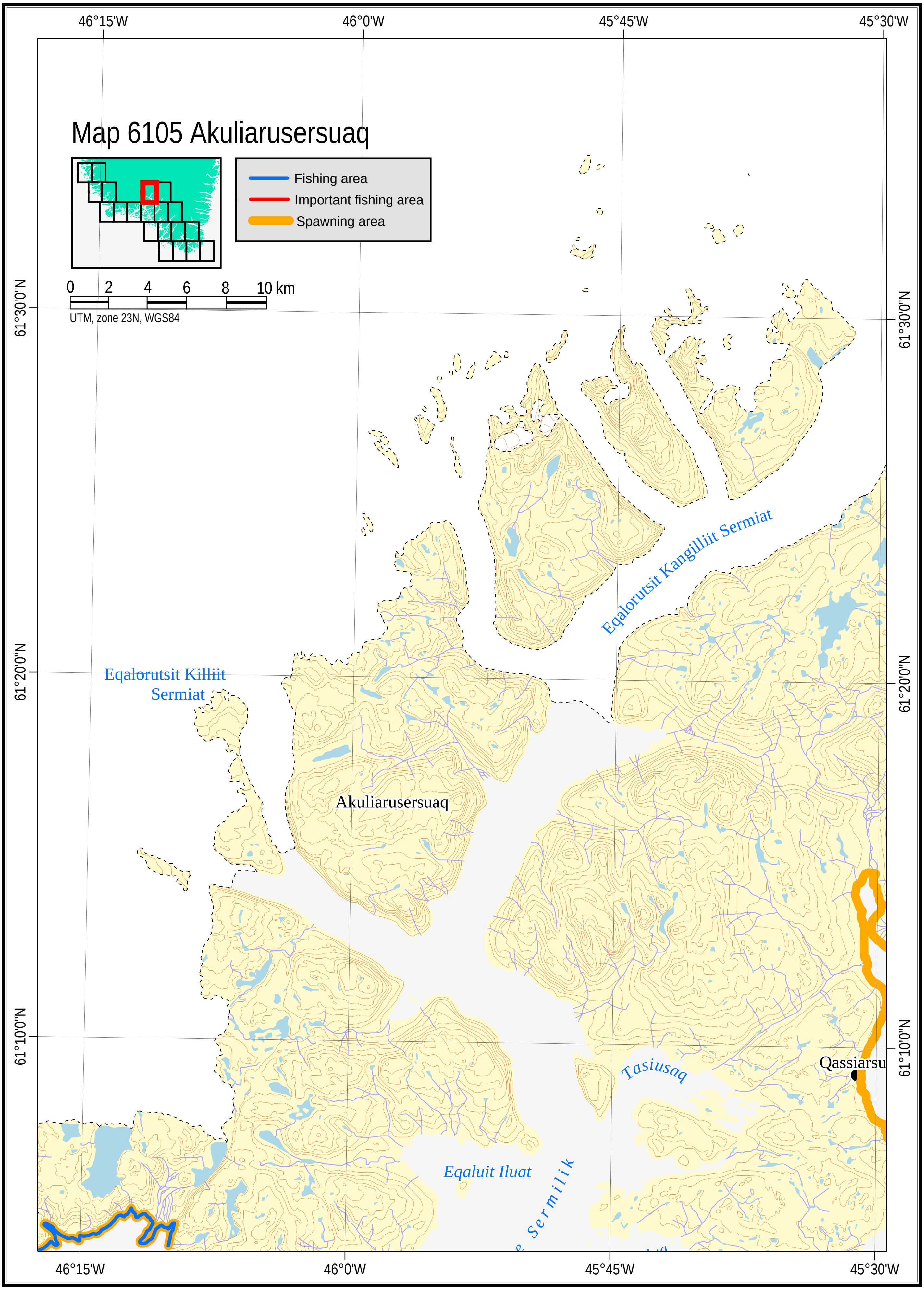


Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Capelin - Distribution of spawning and fishing areas.

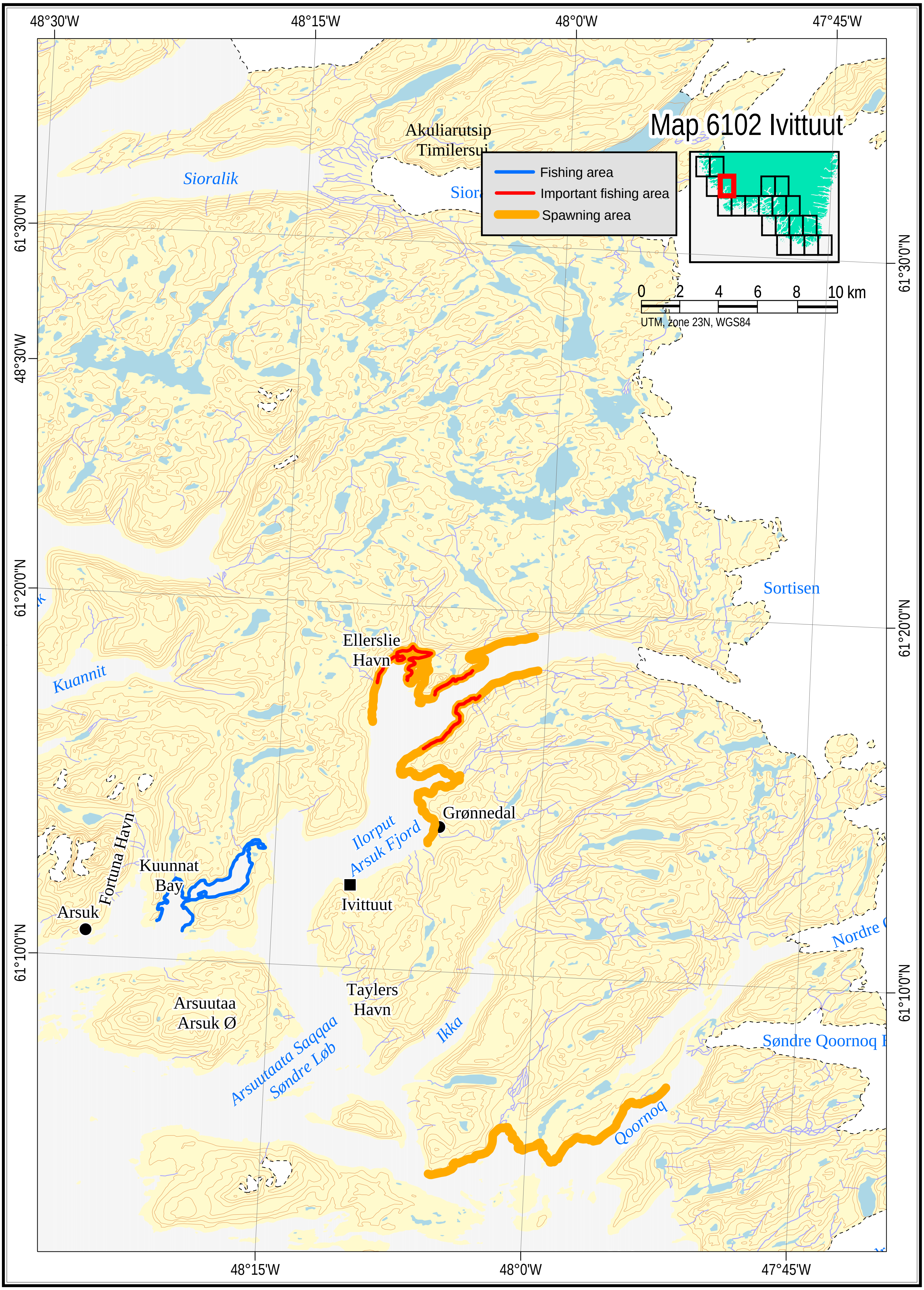


Capelin - Distribution of spawning and fishing areas.



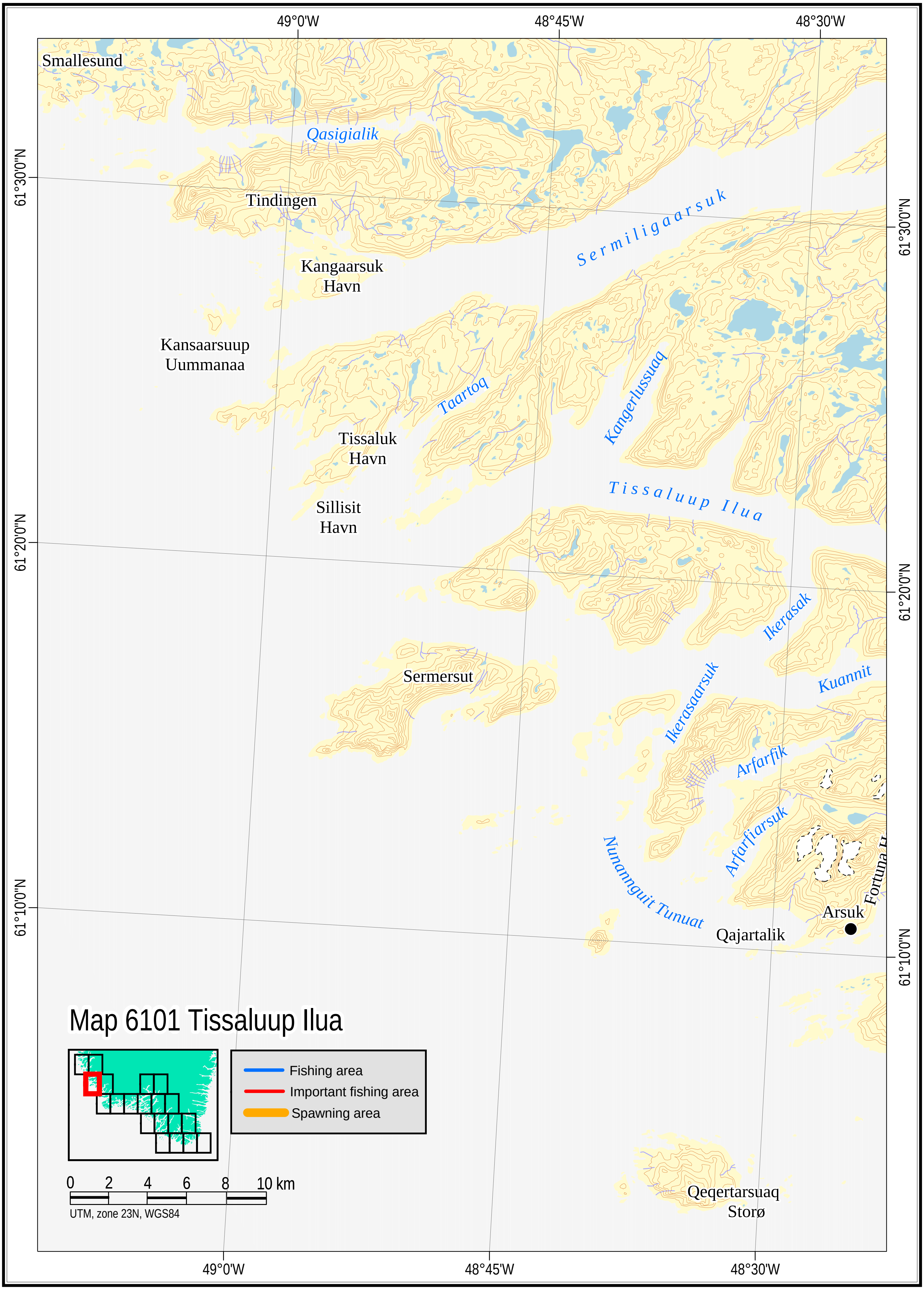
Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Capelin - Distribution of spawning and fishing areas.

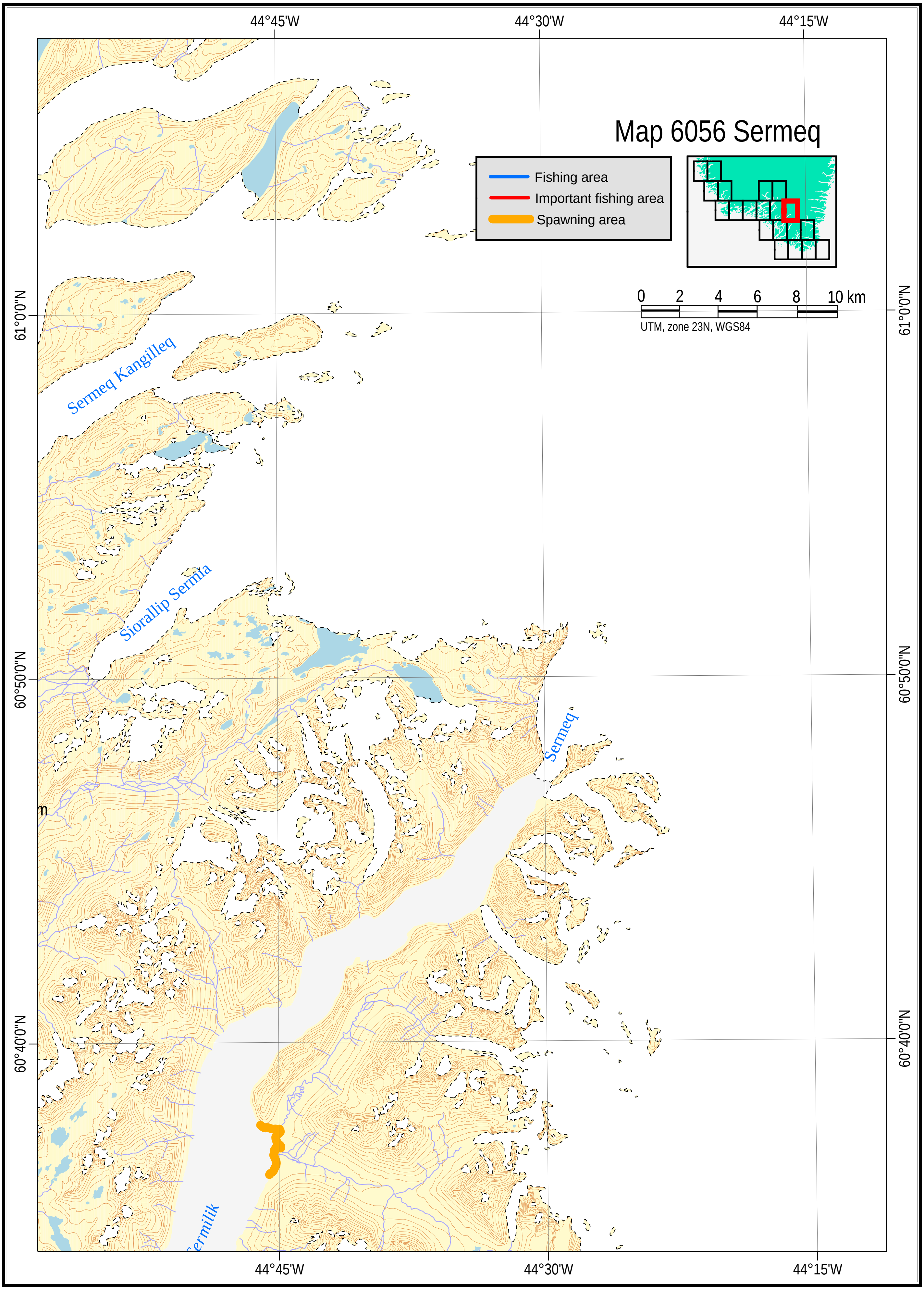


Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Capelin - Distribution of spawning and fishing areas.

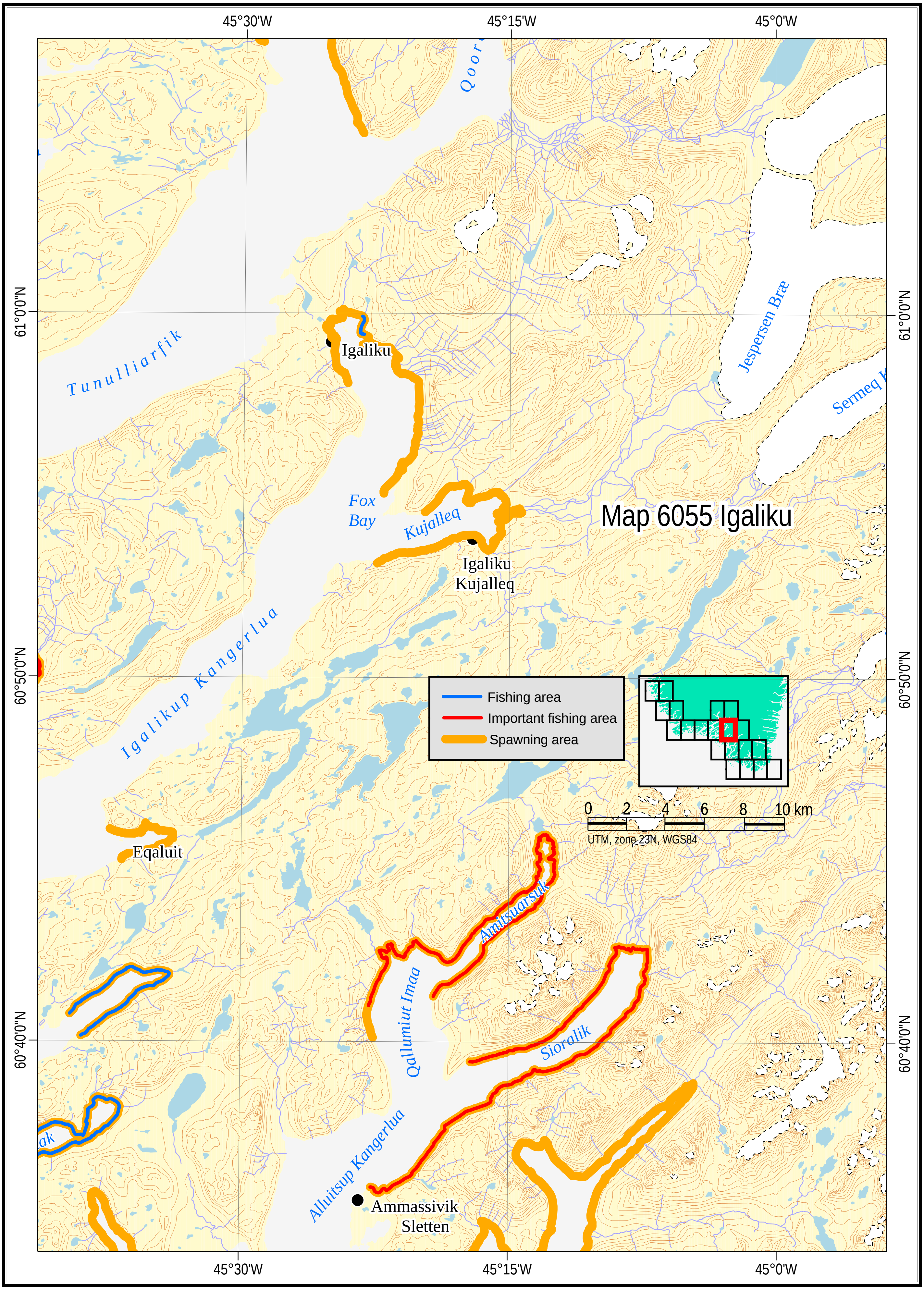


Capelin - Distribution of spawning and fishing areas.

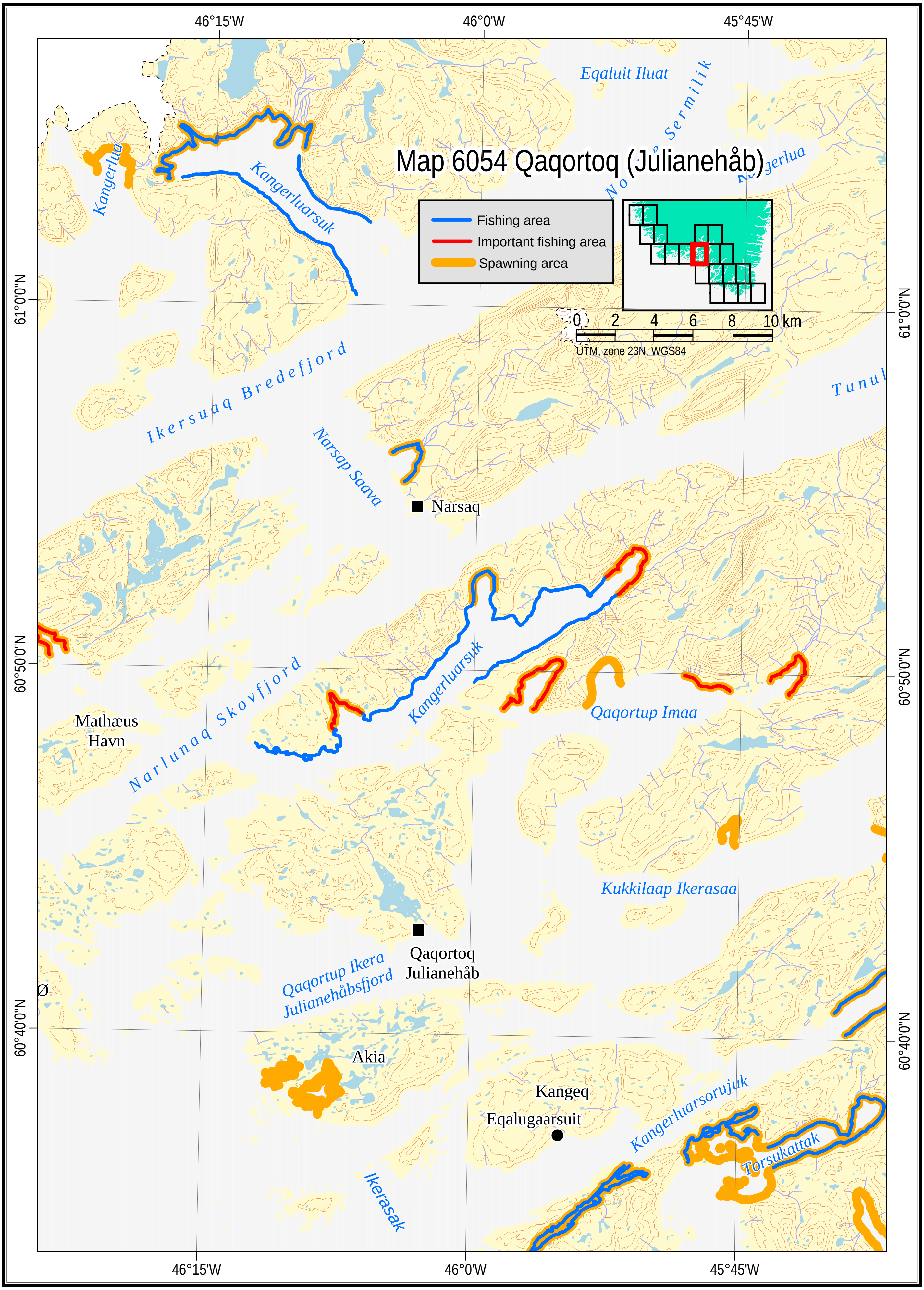


Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Capelin - Distribution of spawning and fishing areas.

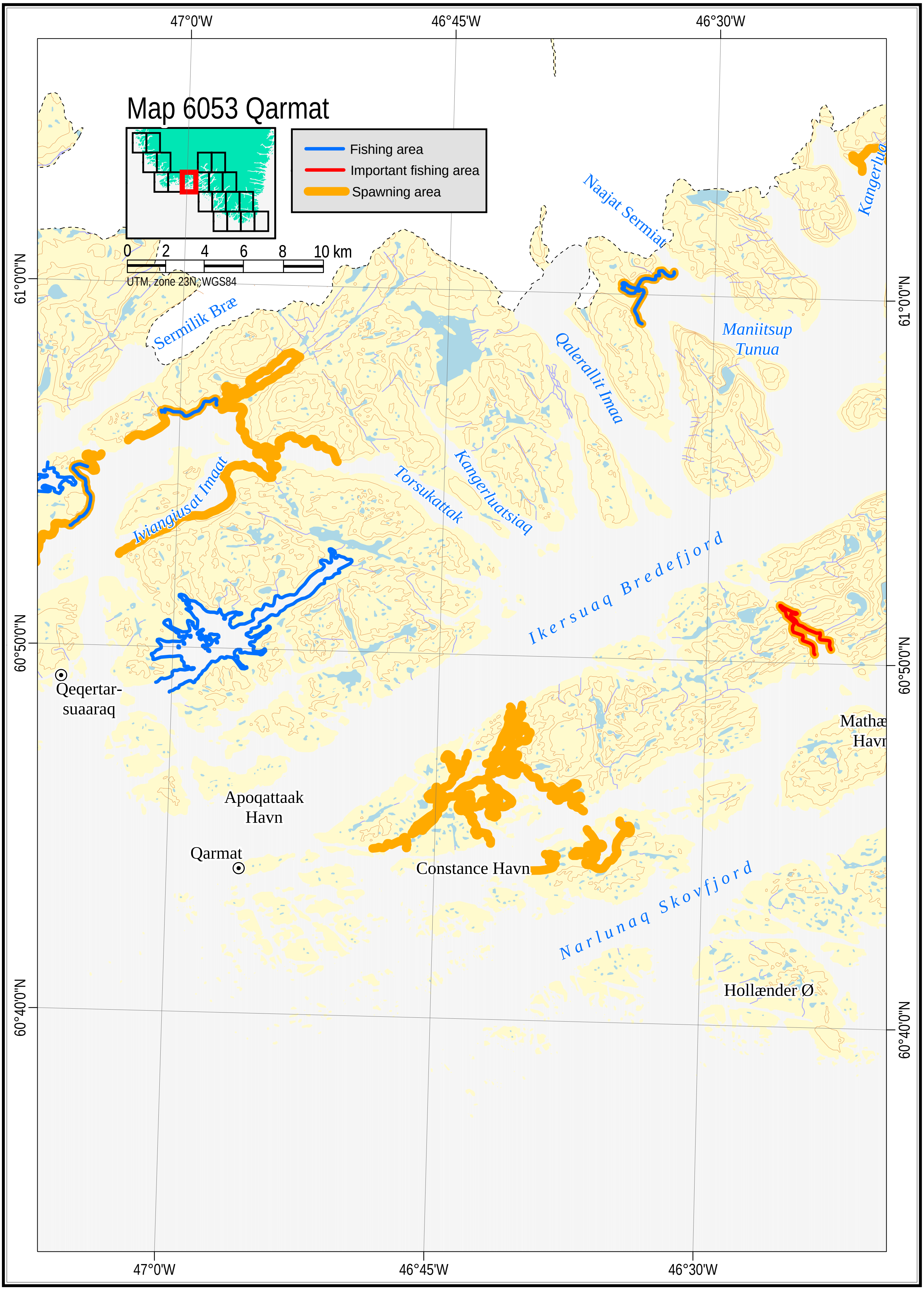


Capelin - Distribution of spawning and fishing areas.



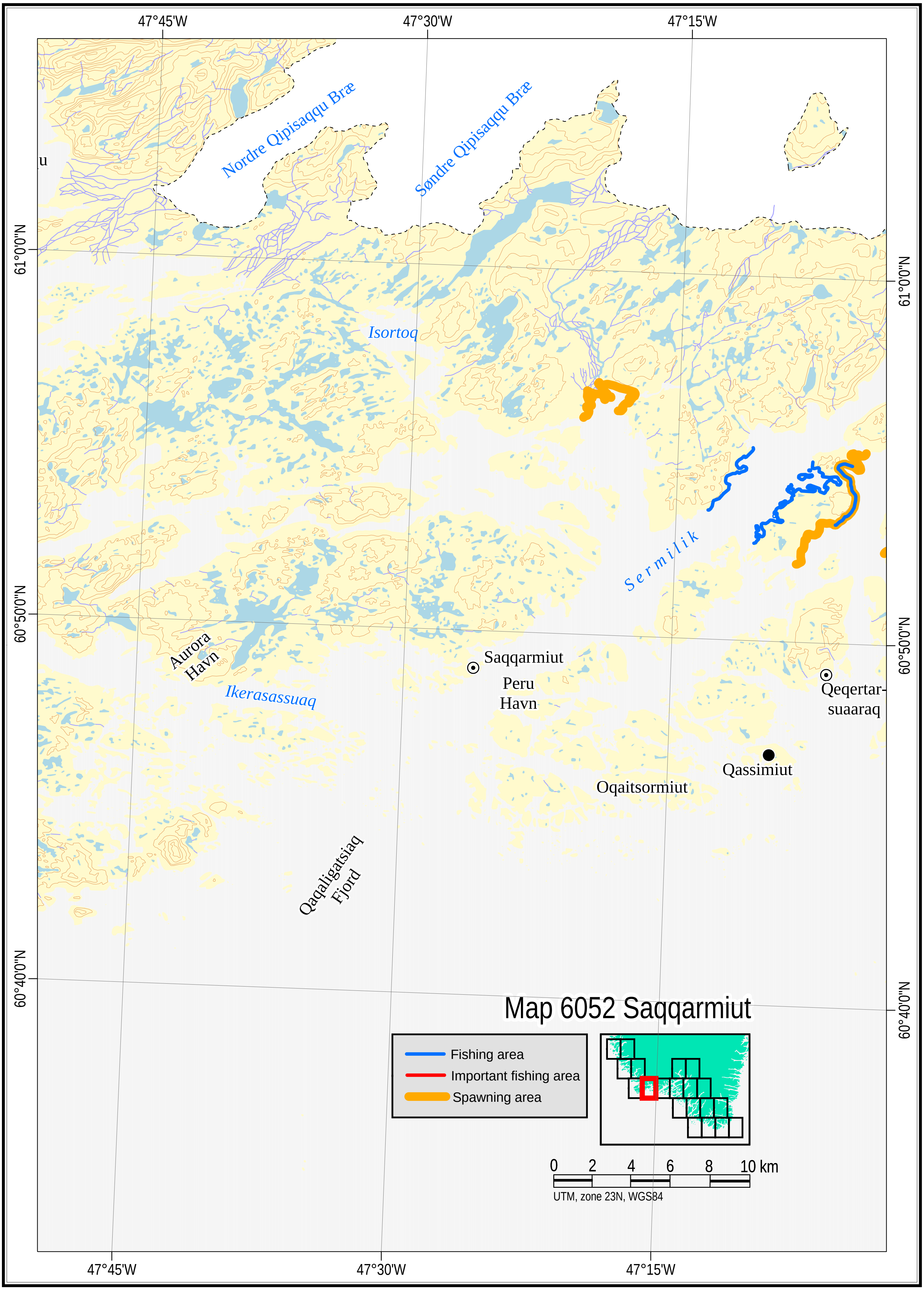
Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Capelin - Distribution of spawning and fishing areas.



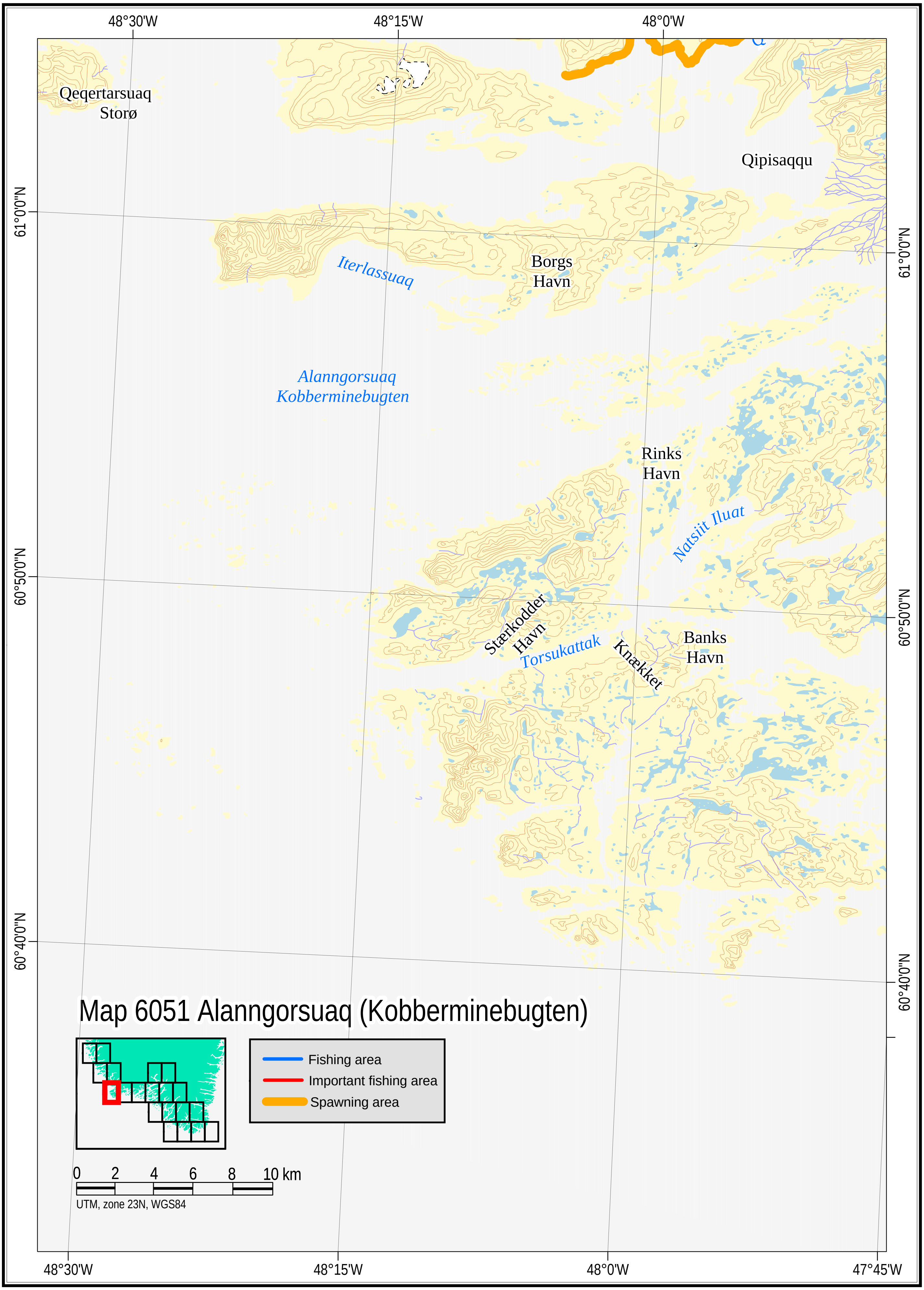
Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Capelin - Distribution of spawning and fishing areas.



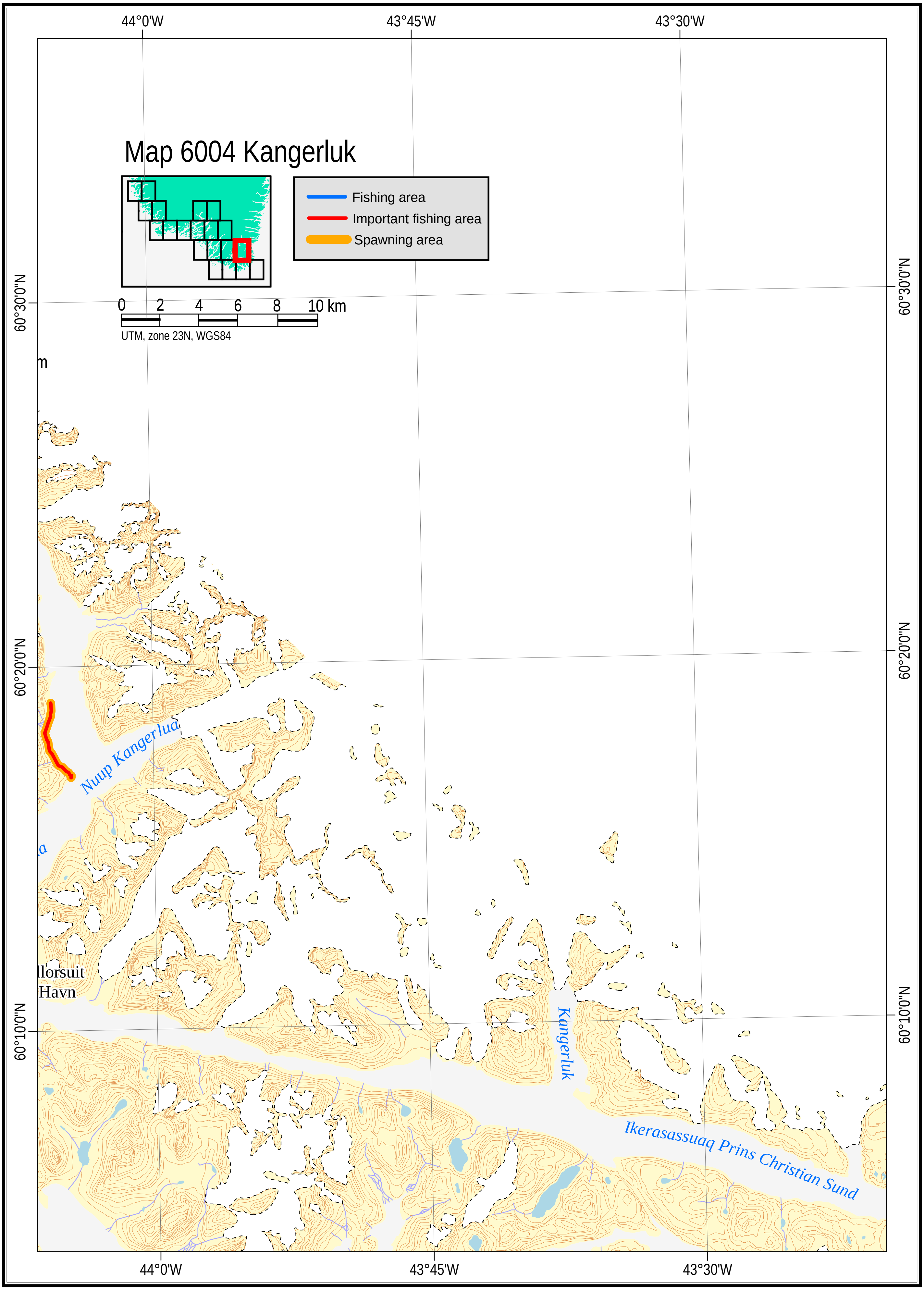
Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Capelin - Distribution of spawning and fishing areas.

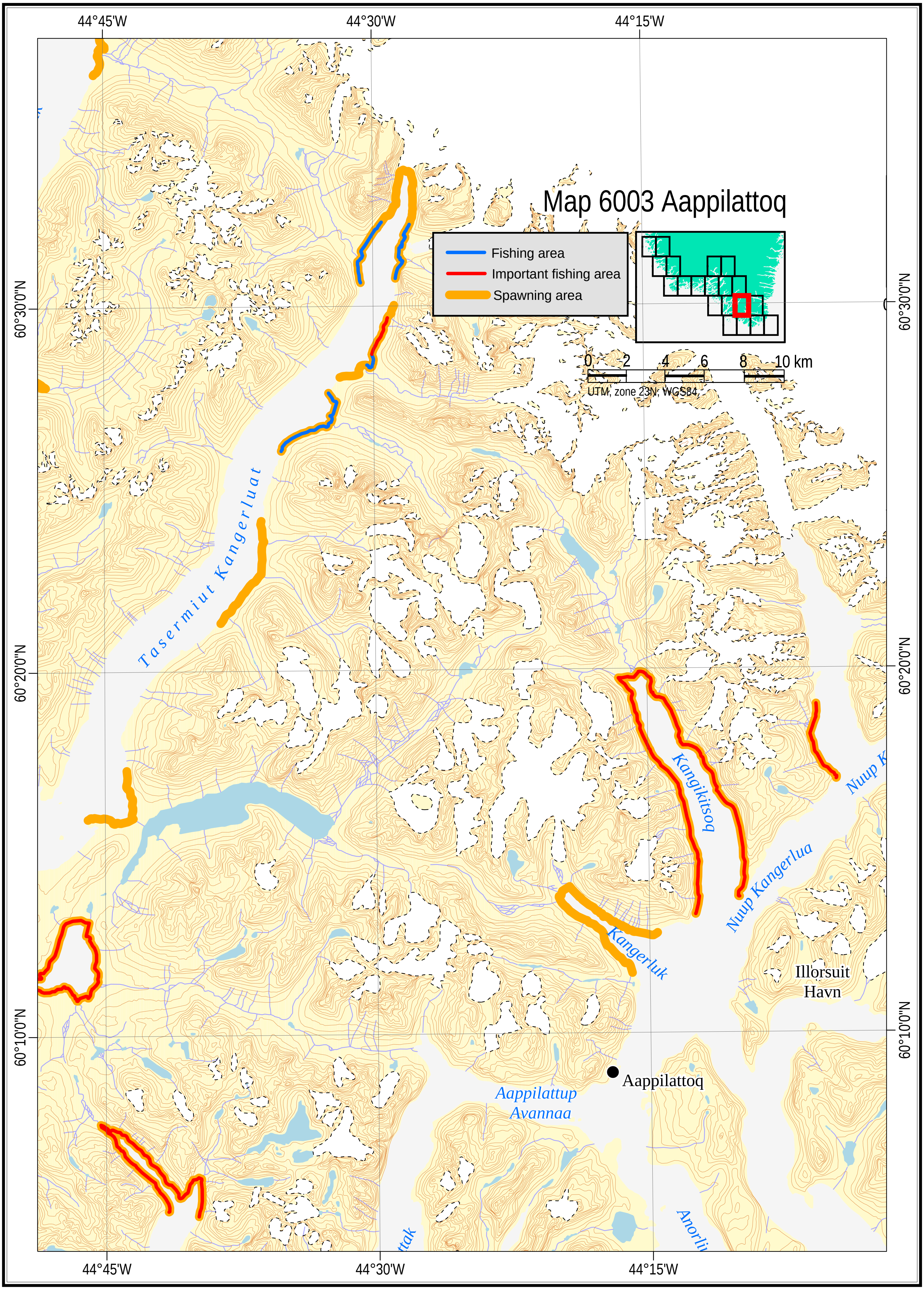


Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

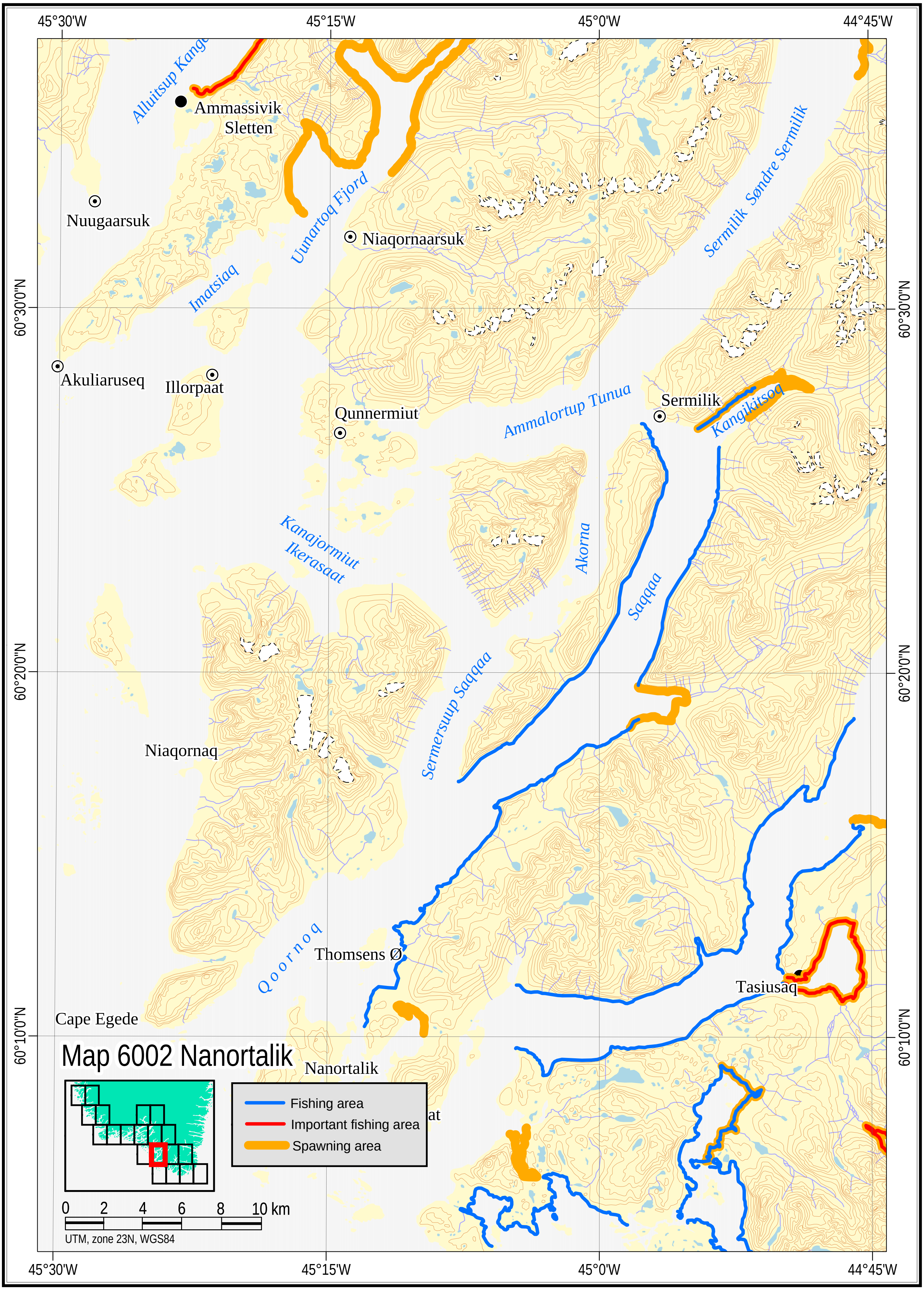
Capelin - Distribution of spawning and fishing areas.



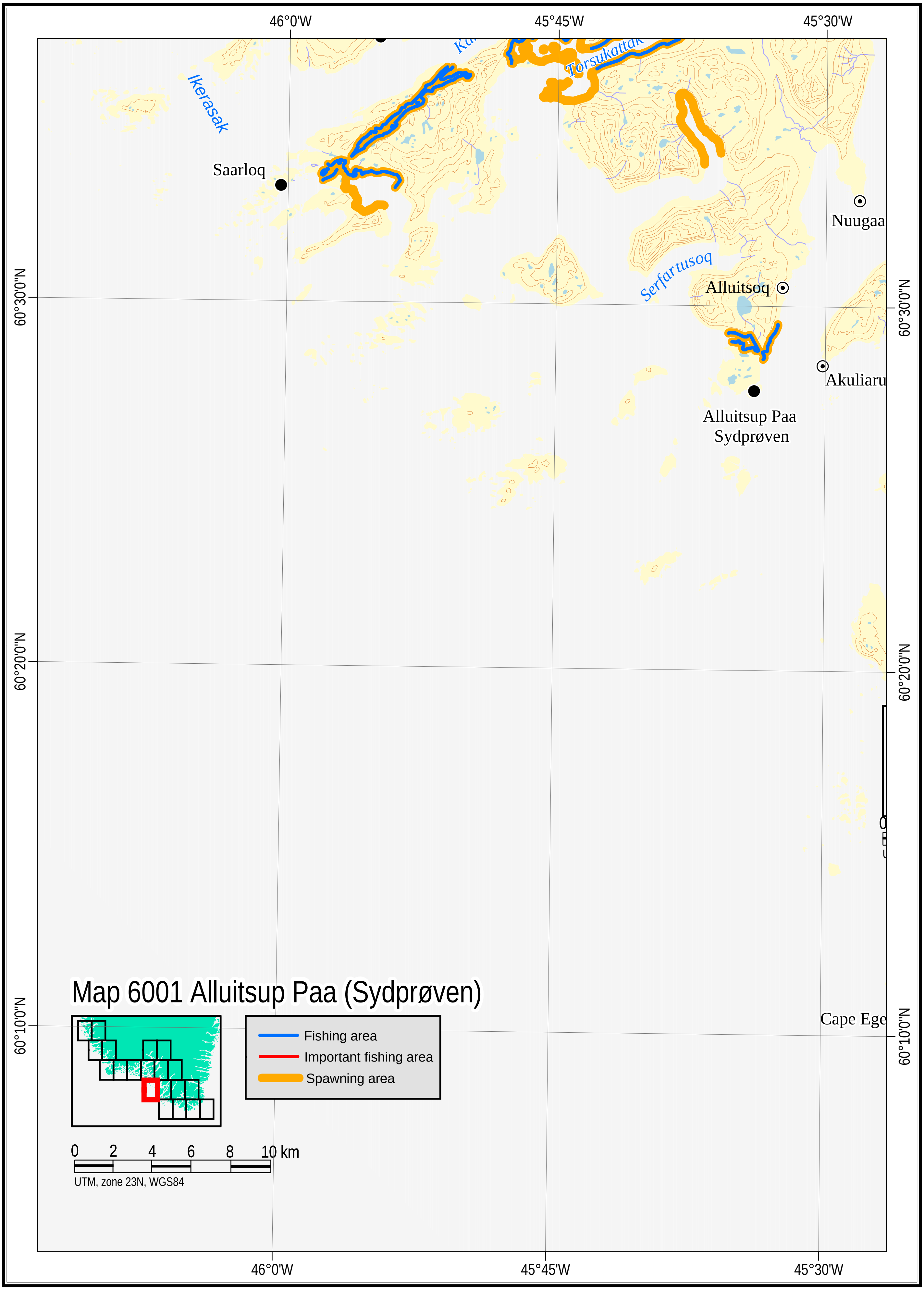
Capelin - Distribution of spawning and fishing areas.



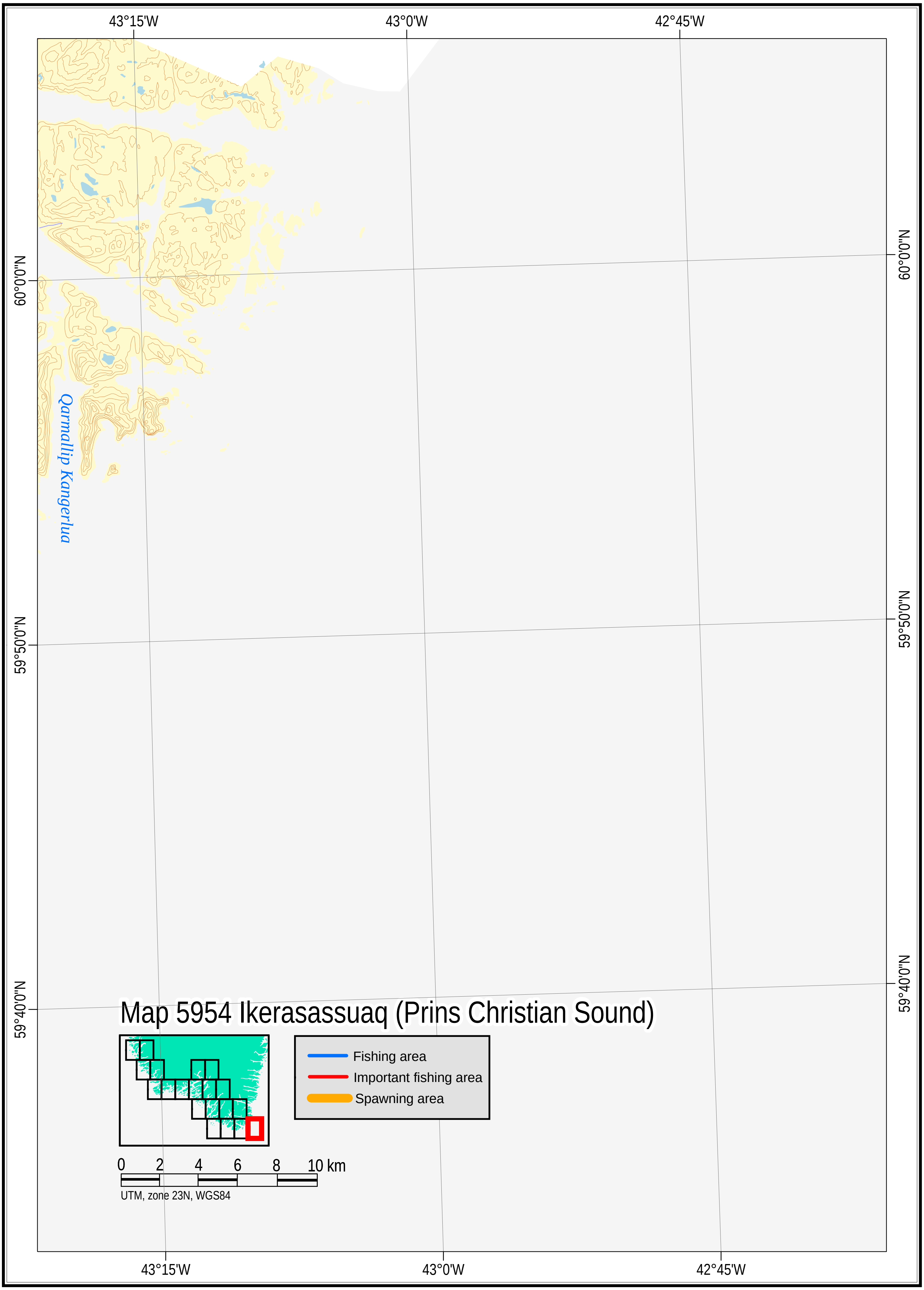
Capelin - Distribution of spawning and fishing areas.



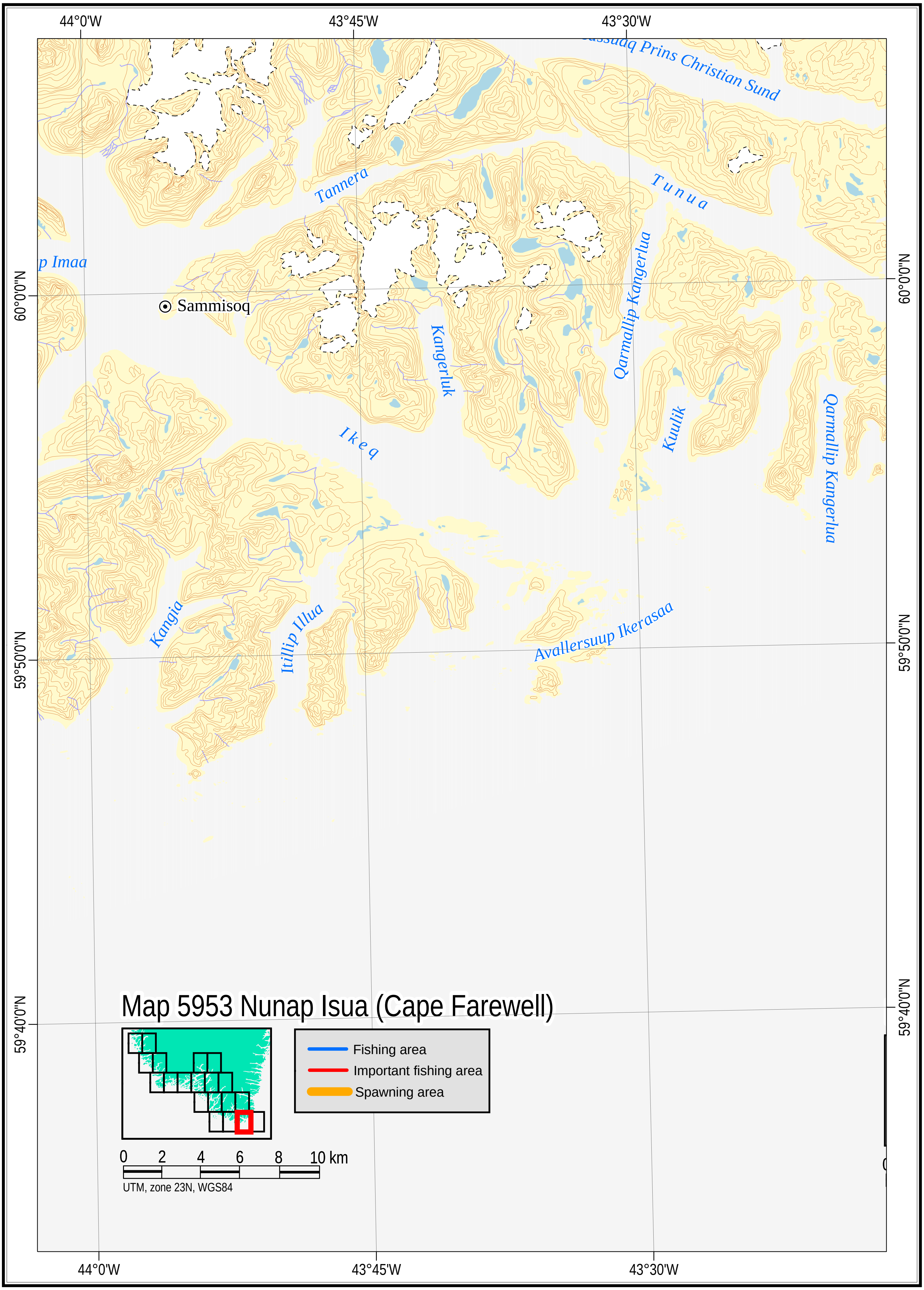
Capelin - Distribution of spawning and fishing areas.



Capelin - Distribution of spawning and fishing areas.

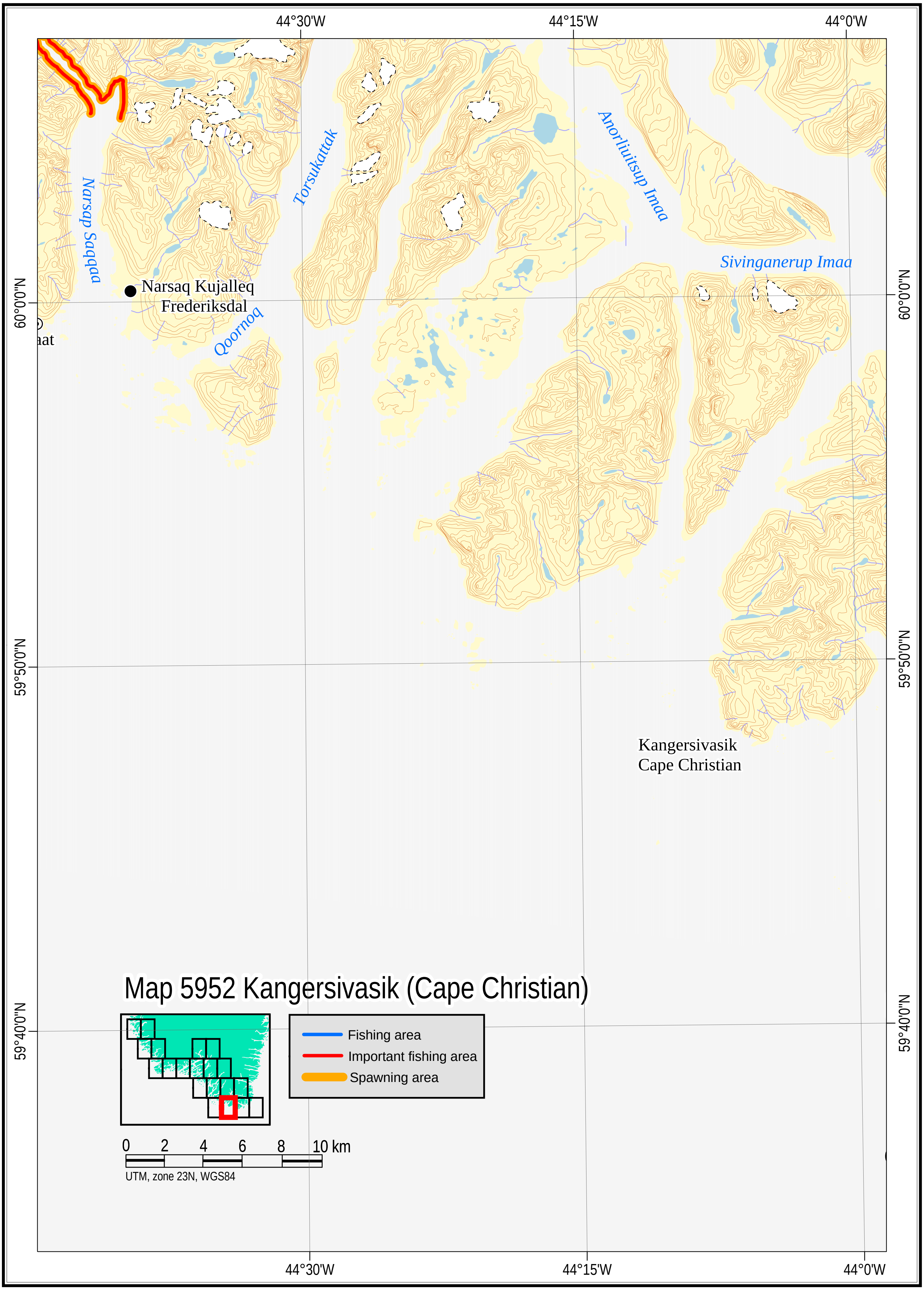


Capelin - Distribution of spawning and fishing areas.



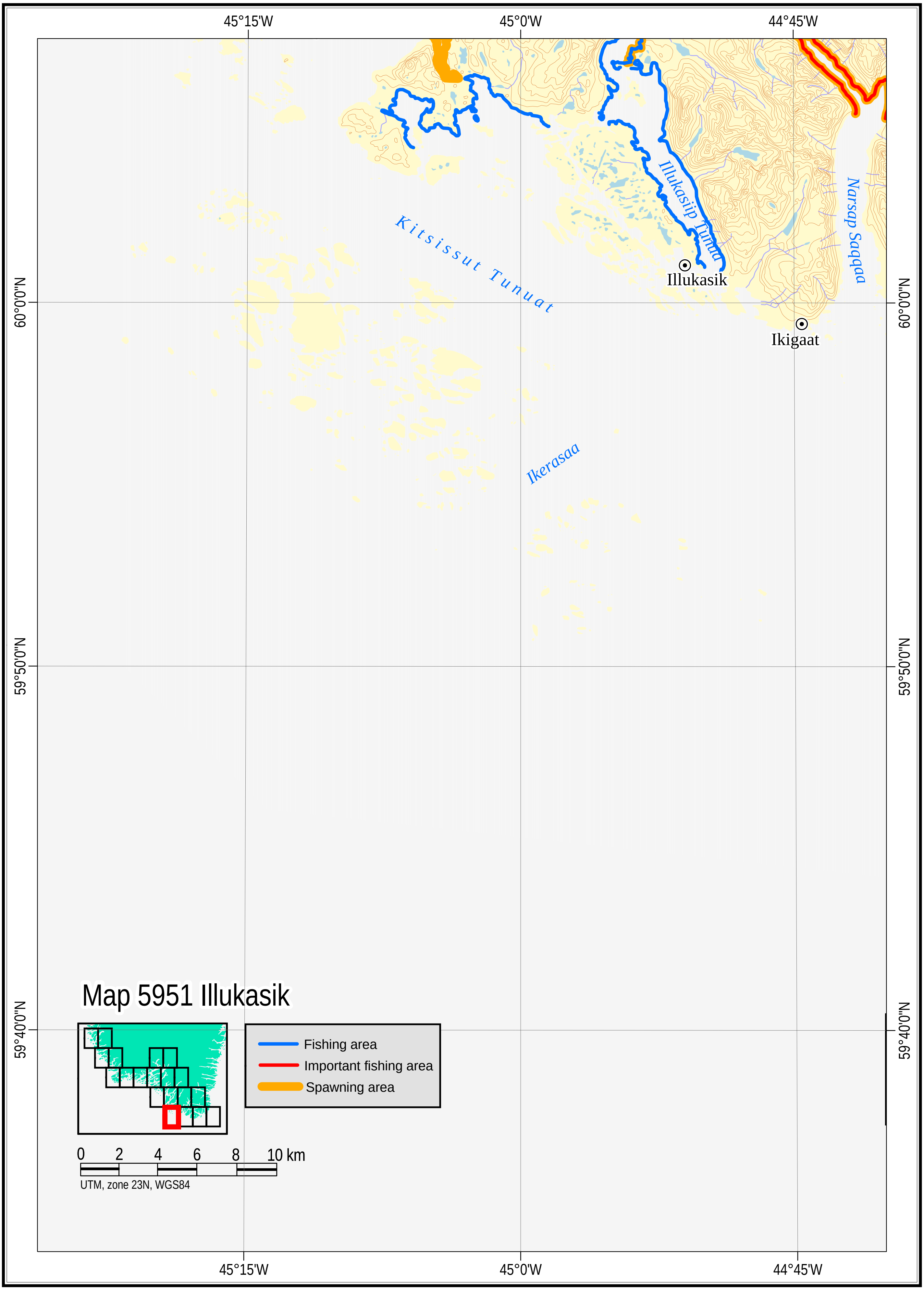
Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Capelin - Distribution of spawning and fishing areas.



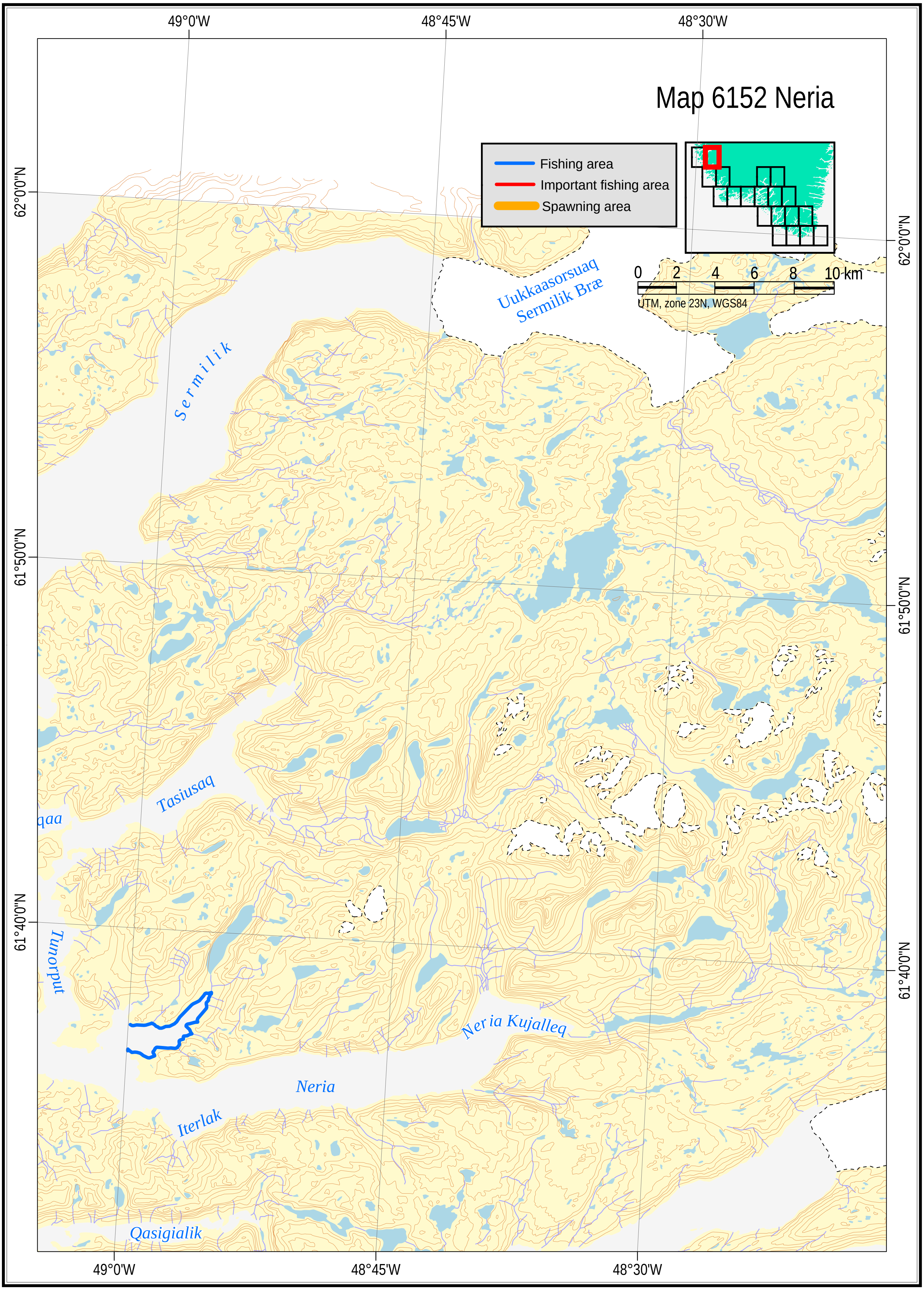
Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Capelin - Distribution of spawning and fishing areas.



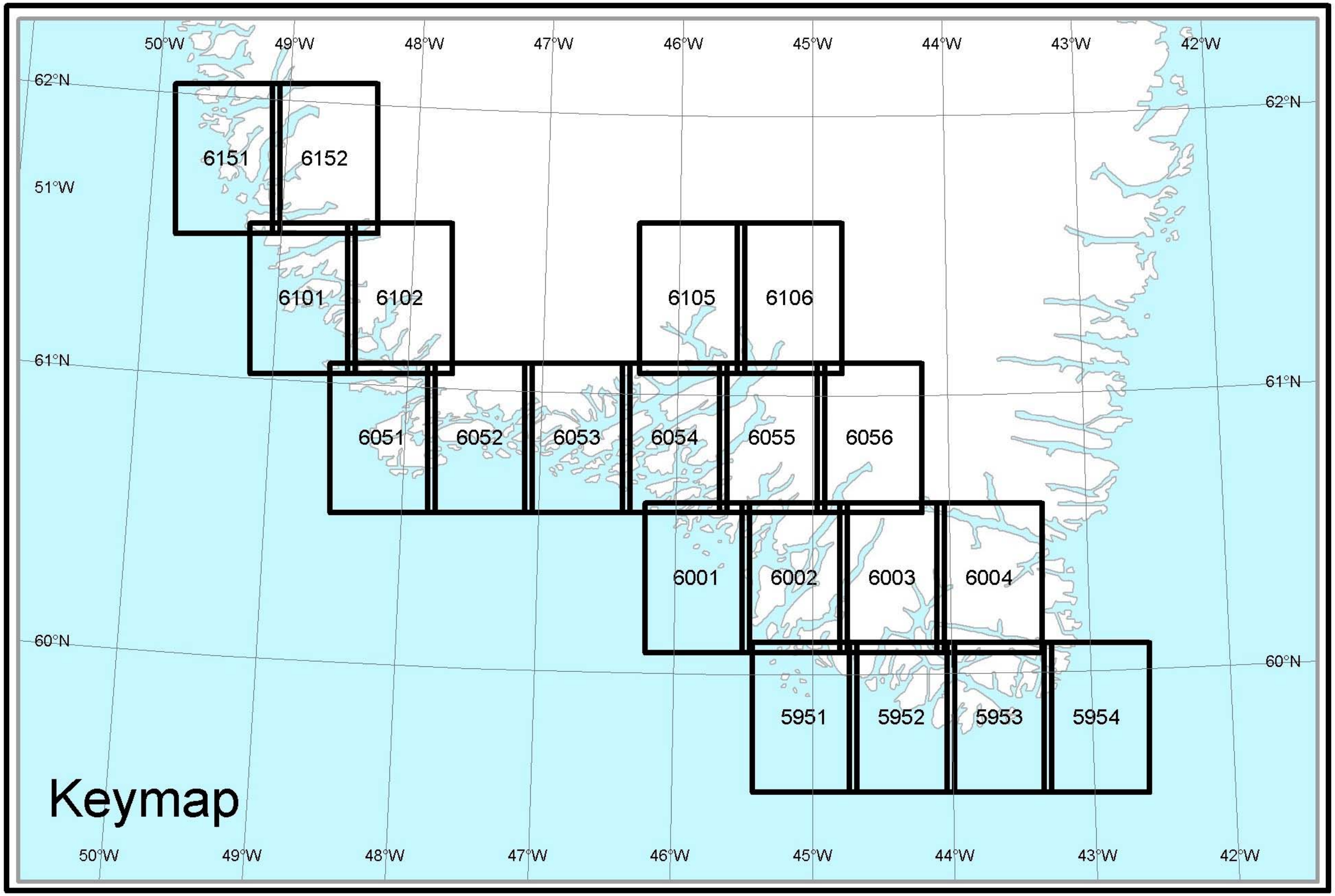
Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Capelin - Distribution of spawning and fishing areas.

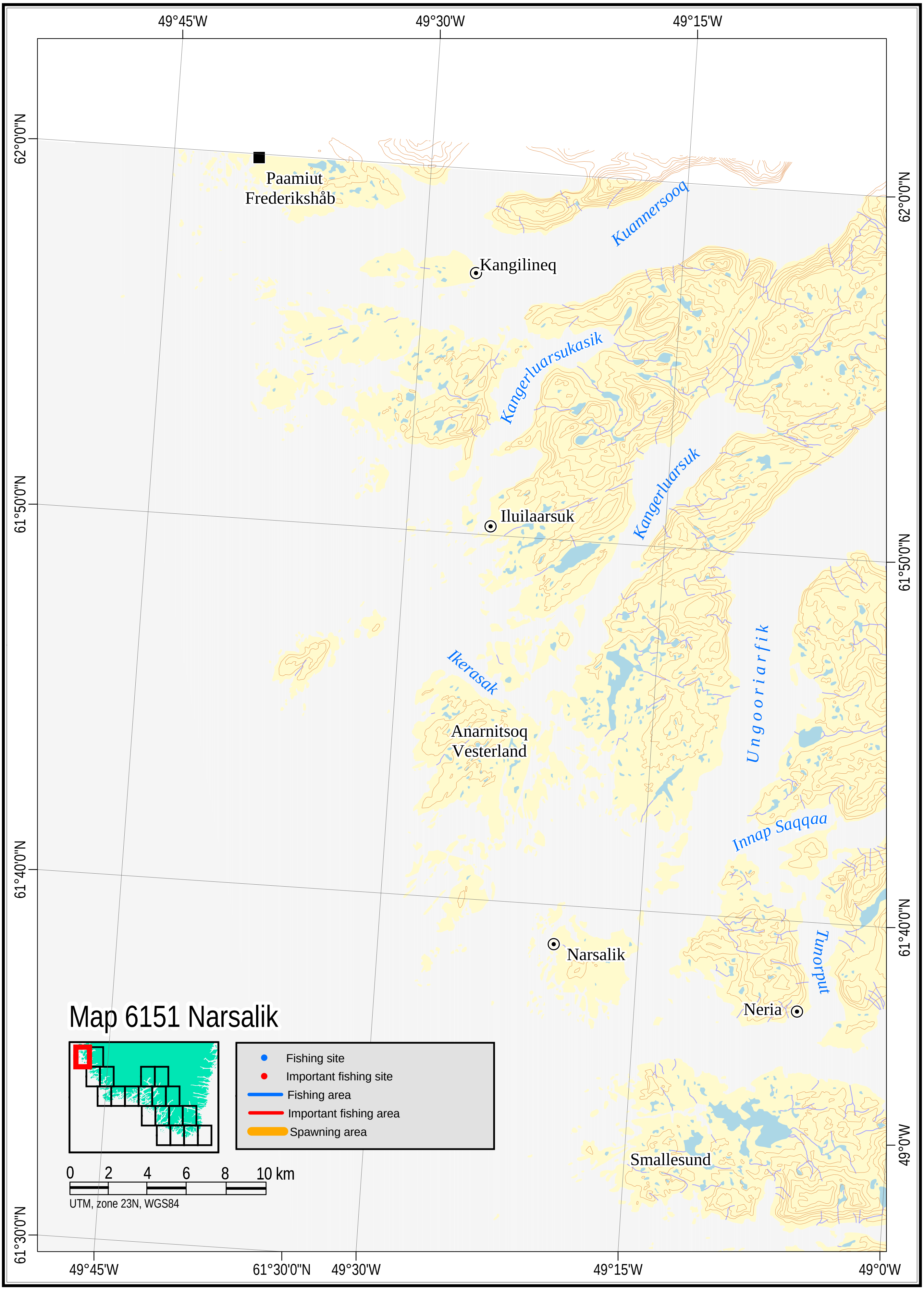


Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

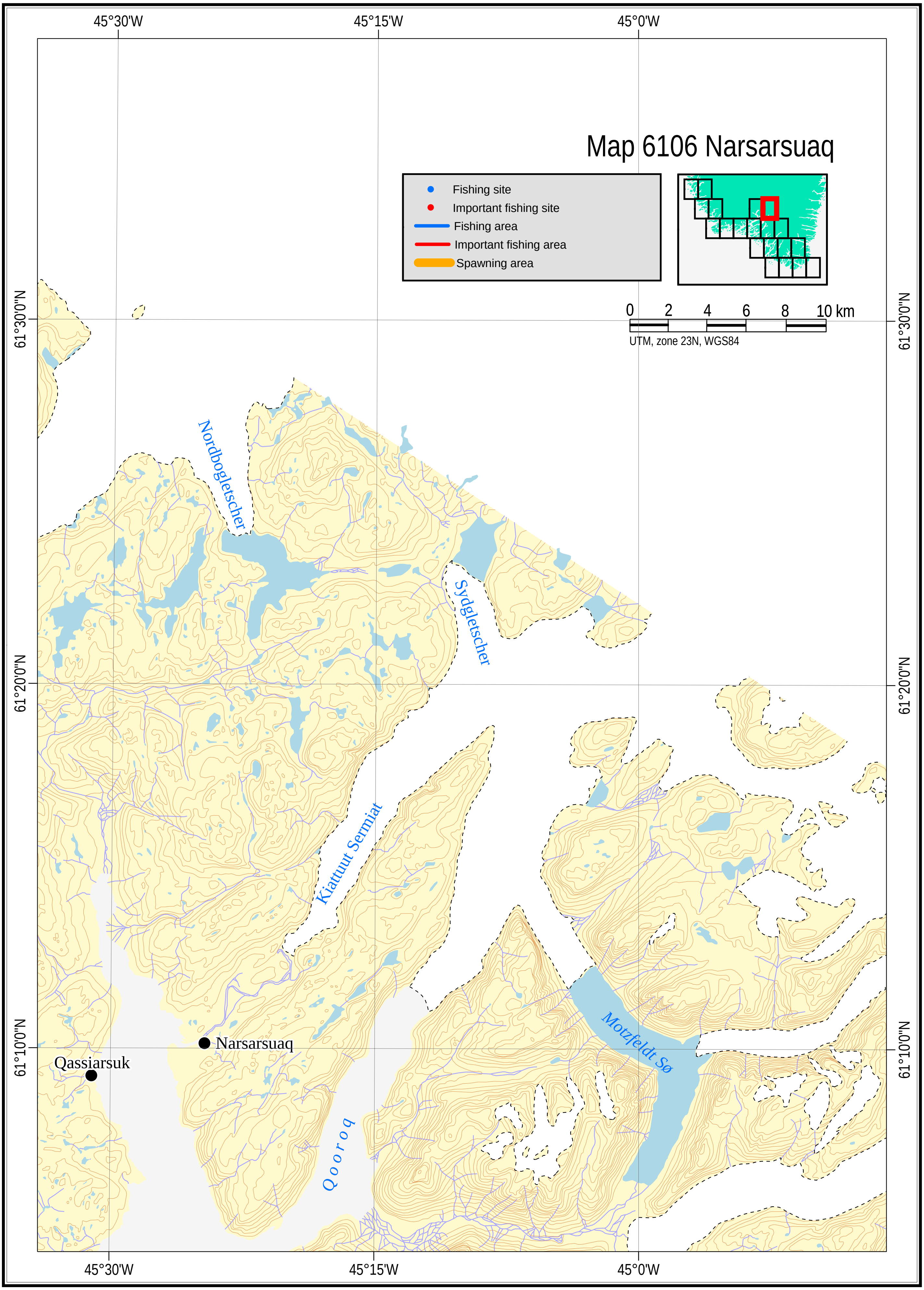
Distribution of lumpsucker spawning and fishing areas



Lumpsucker - Distribution of spawning and fishing areas.

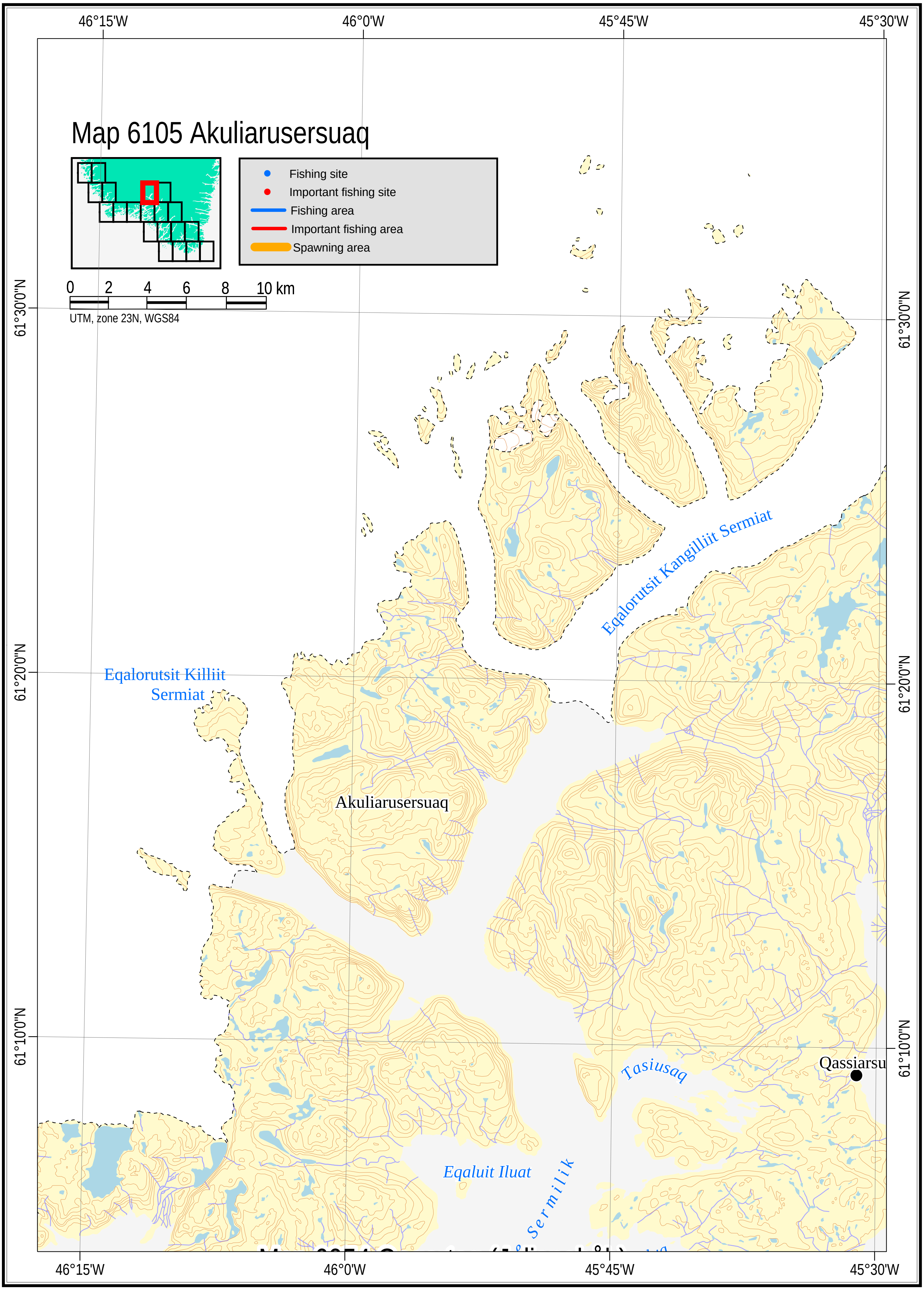


Lumpsucker - Distribution of spawning and fishing areas.



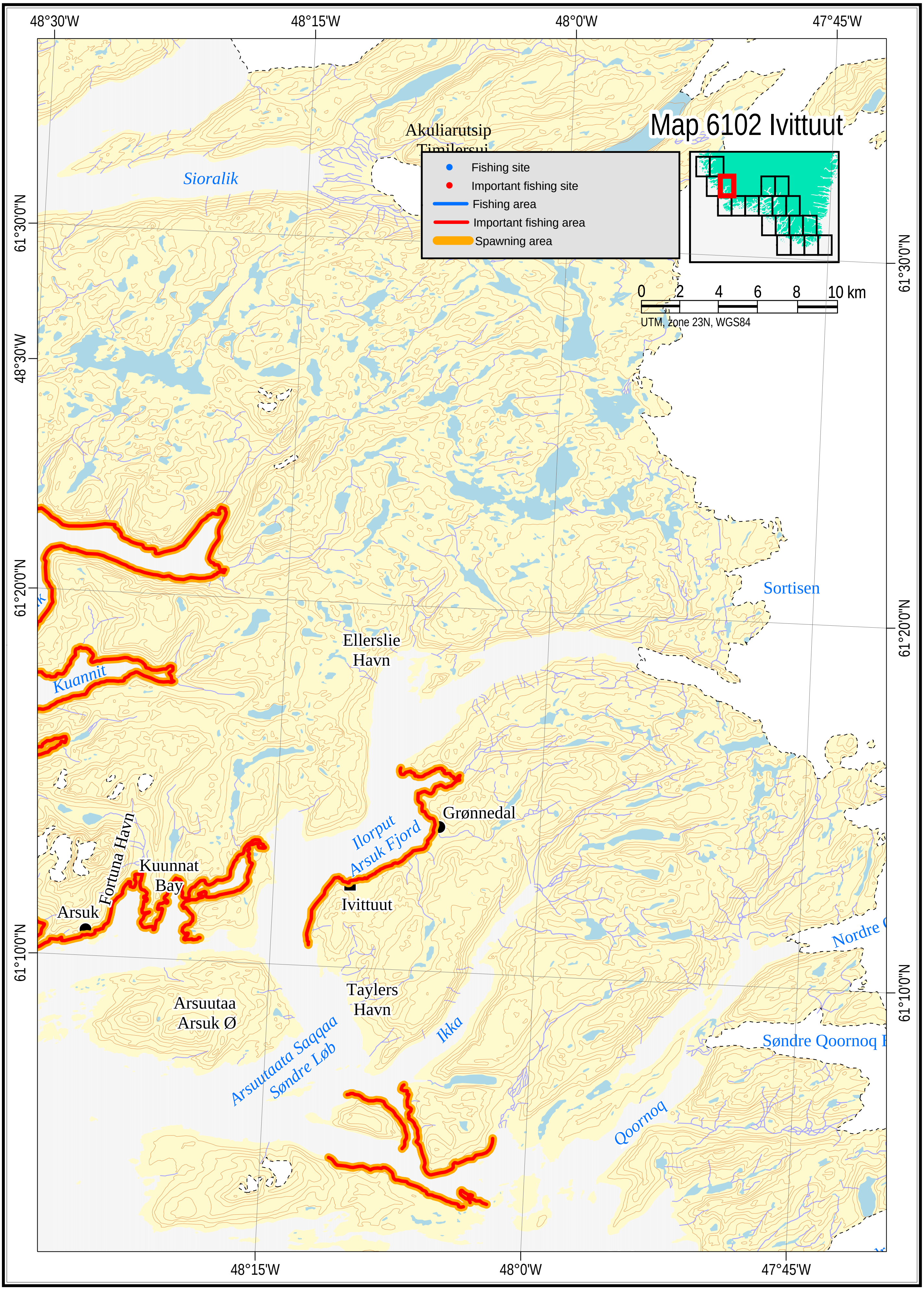
Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Lumpsucker - Distribution of spawning and fishing areas.



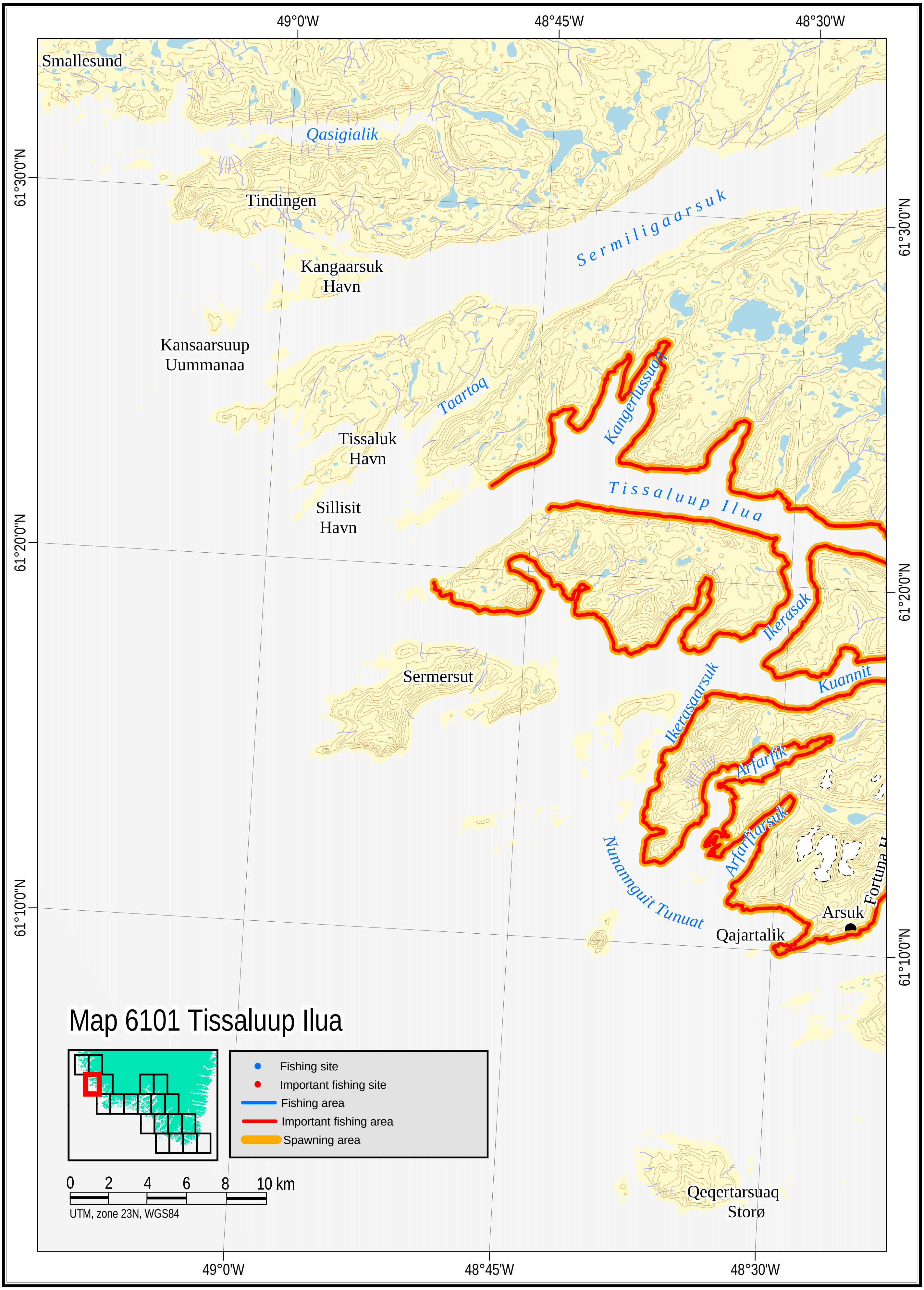
Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Lumpsucker - Distribution of spawning and fishing areas.

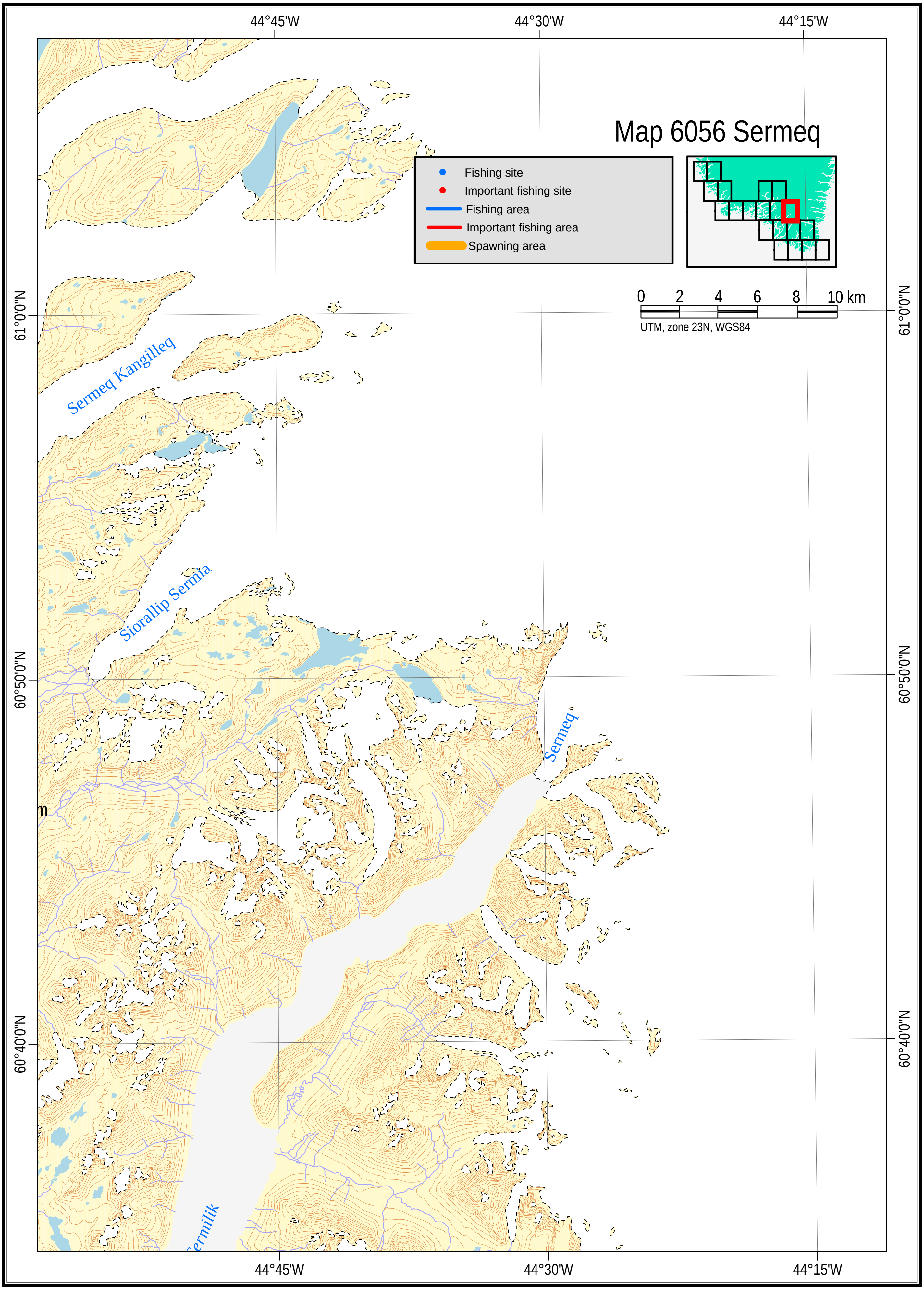


Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Lumpsucker - Distribution of spawning and fishing areas.

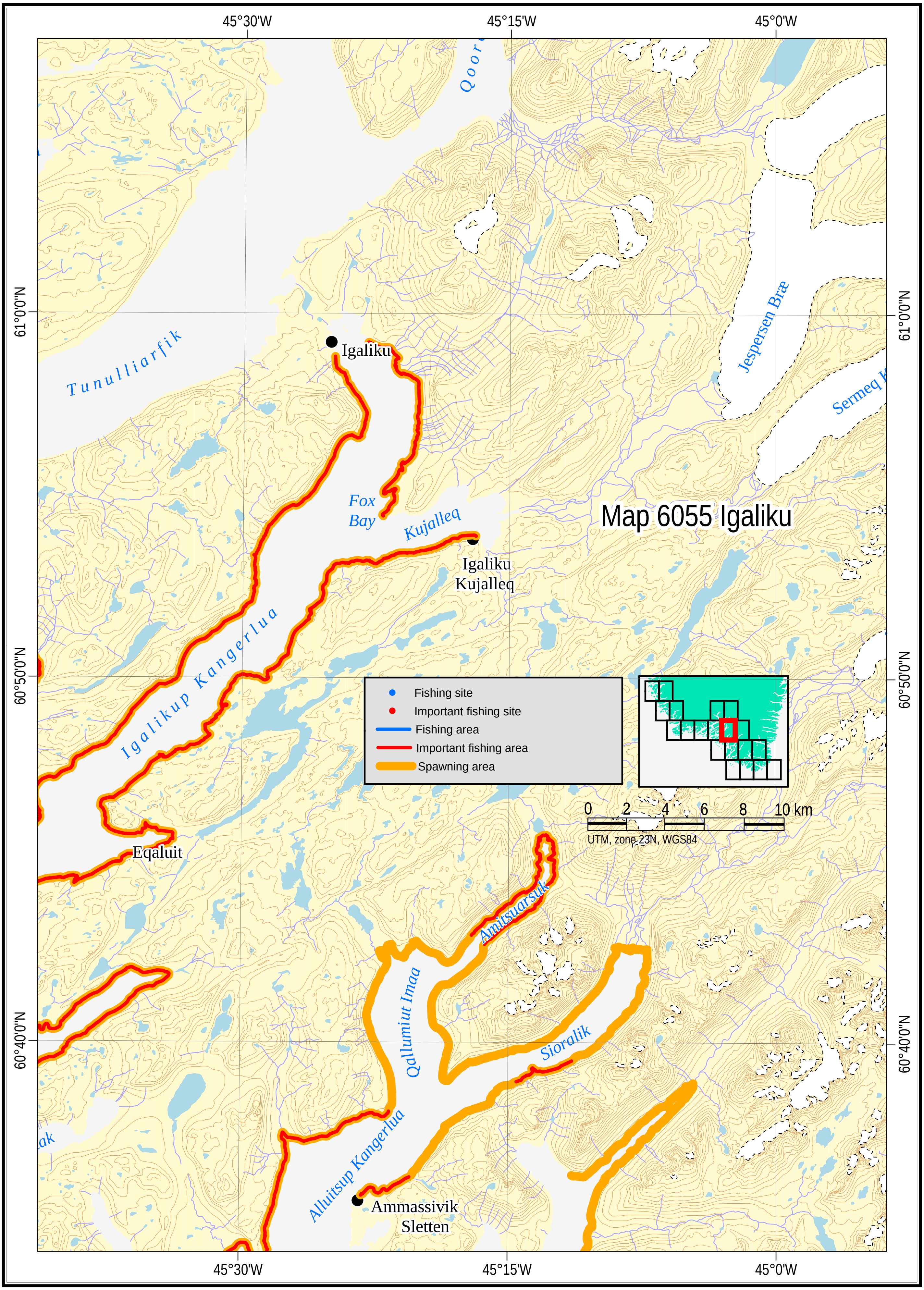


Lumpsucker - Distribution of spawning and fishing areas.

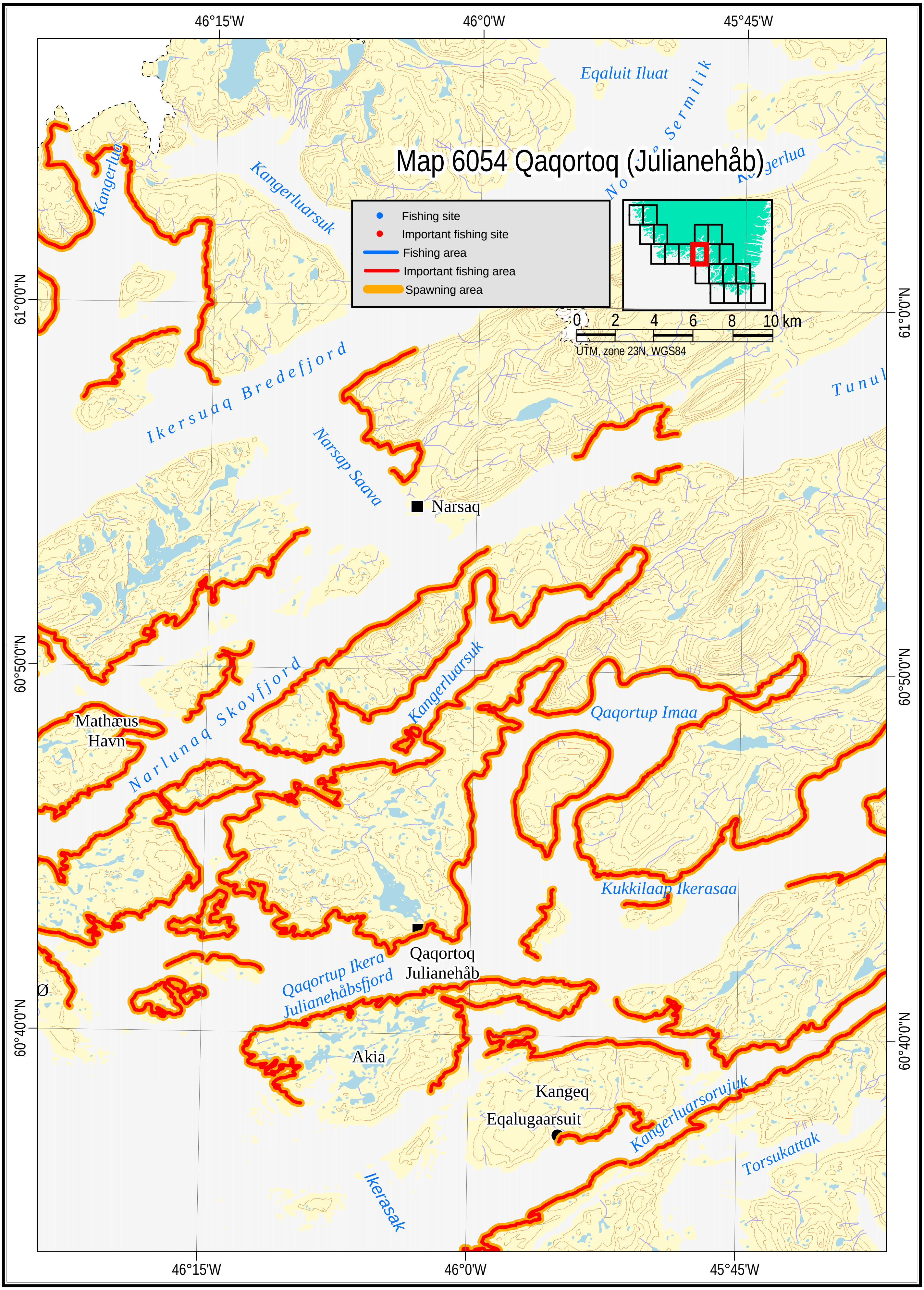


Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

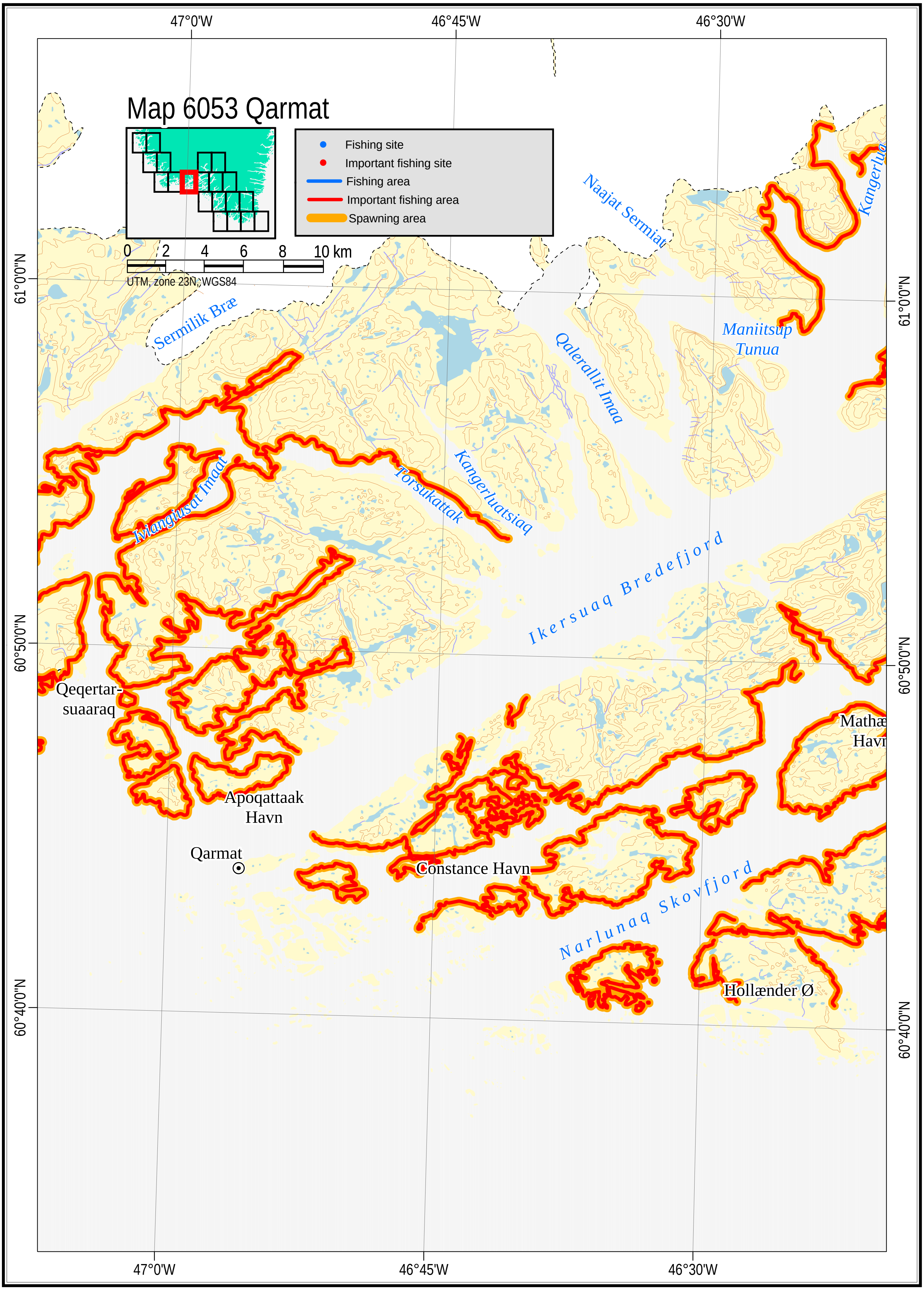
Lumpsucker - Distribution of spawning and fishing areas.



Lumpsucker - Distribution of spawning and fishing areas.

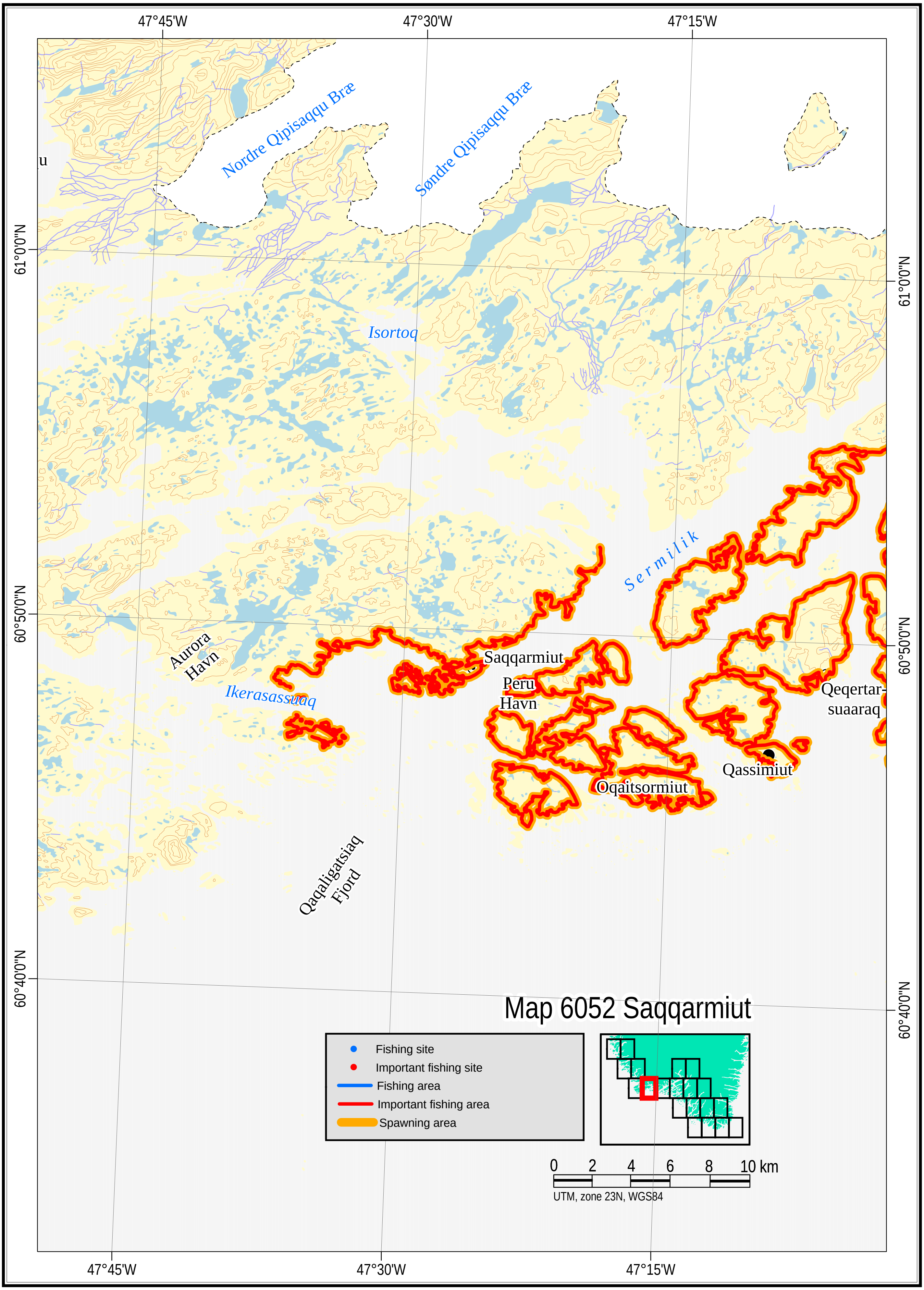


Lumpsucker - Distribution of spawning and fishing areas.



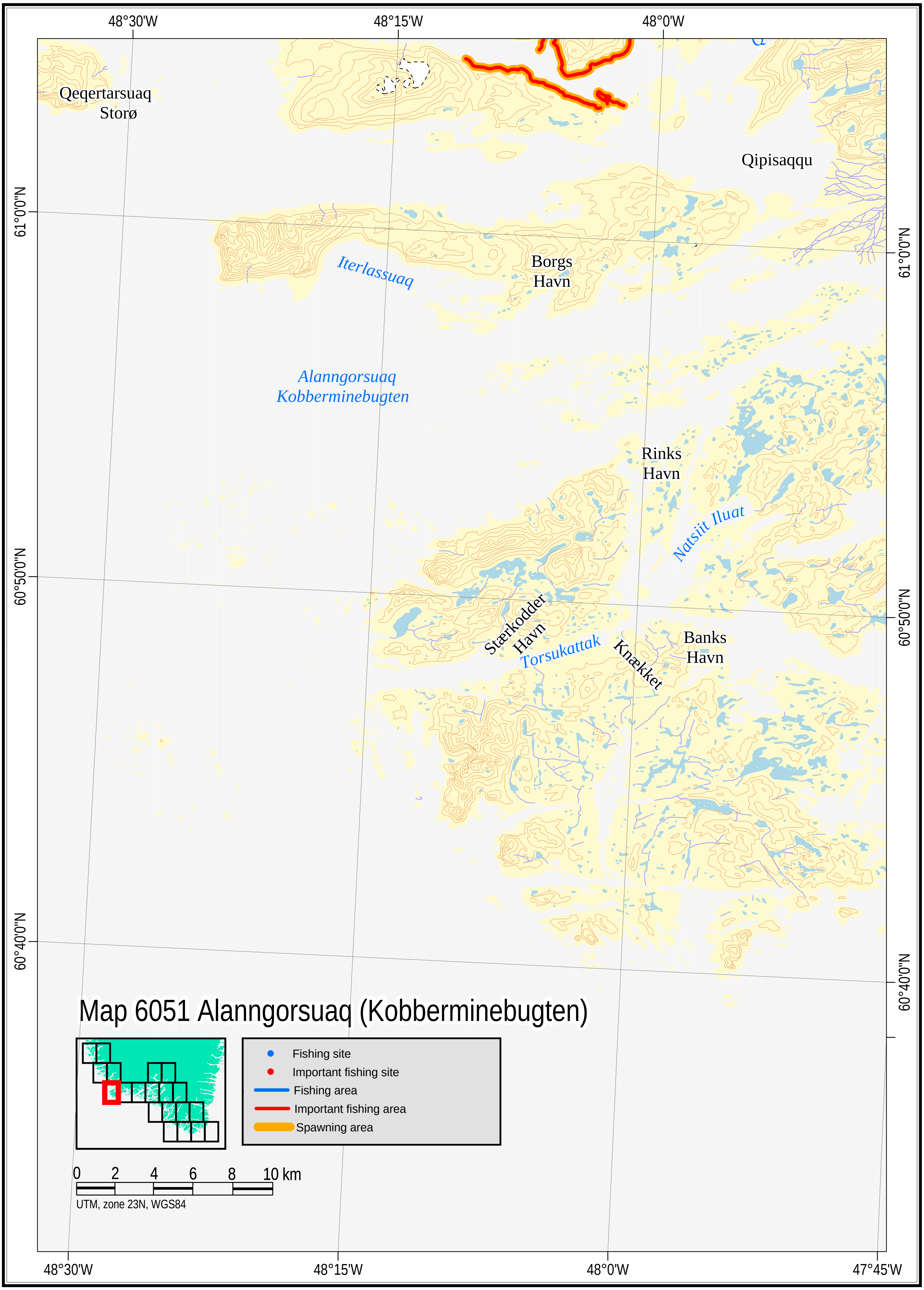
Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

Lumpsucker - Distribution of spawning and fishing areas.

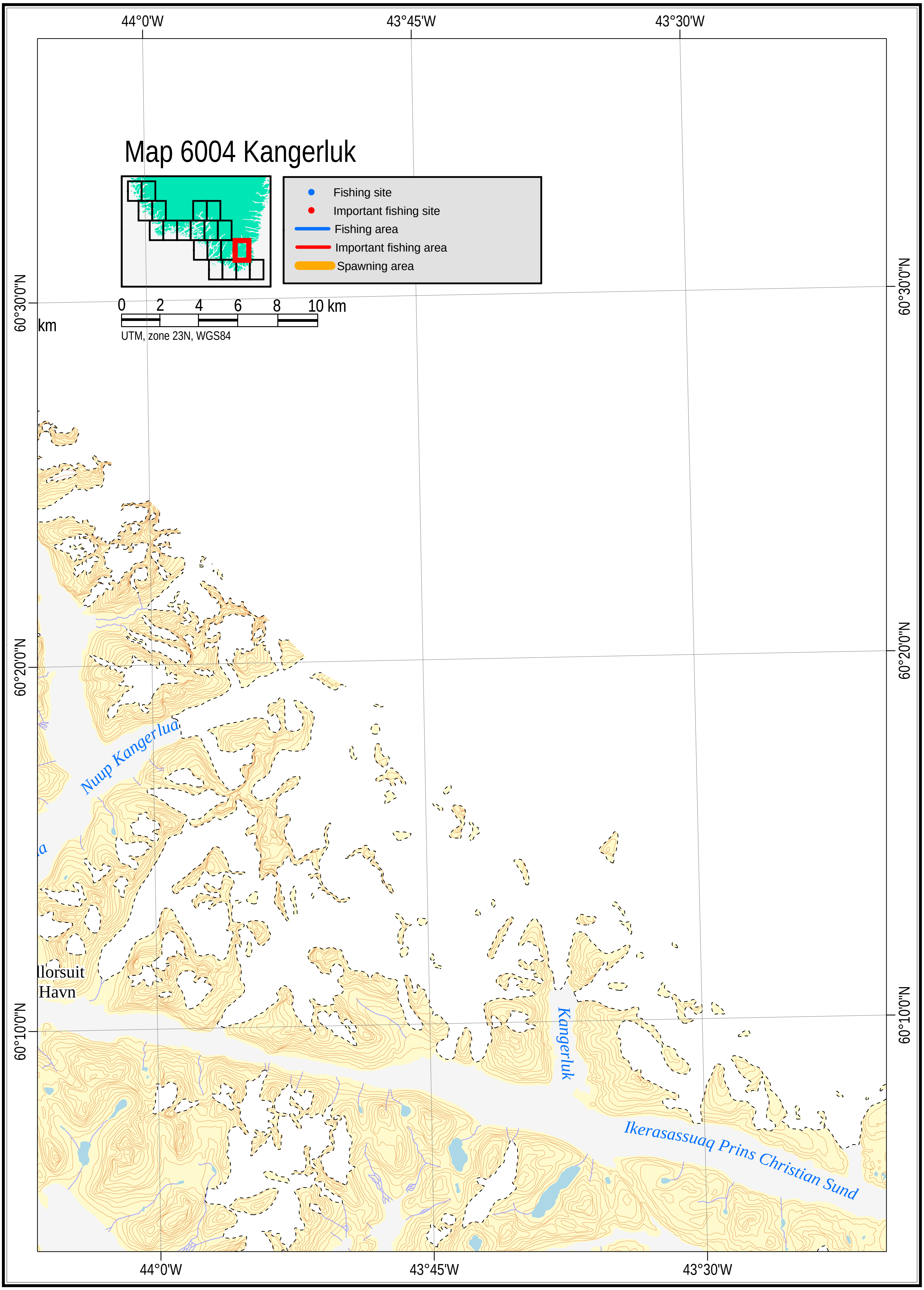


Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

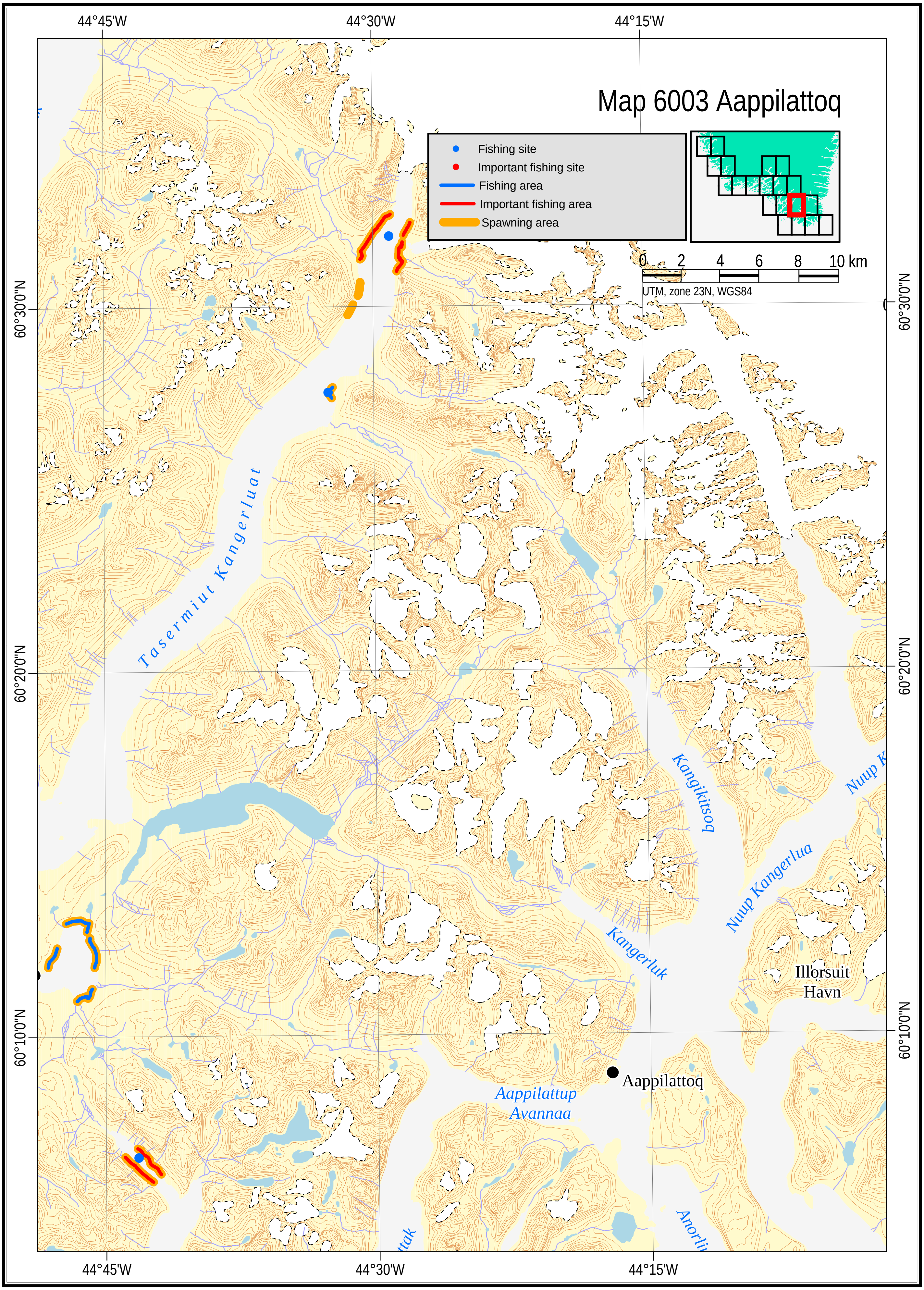
Lumpsucker - Distribution of spawning and fishing areas.



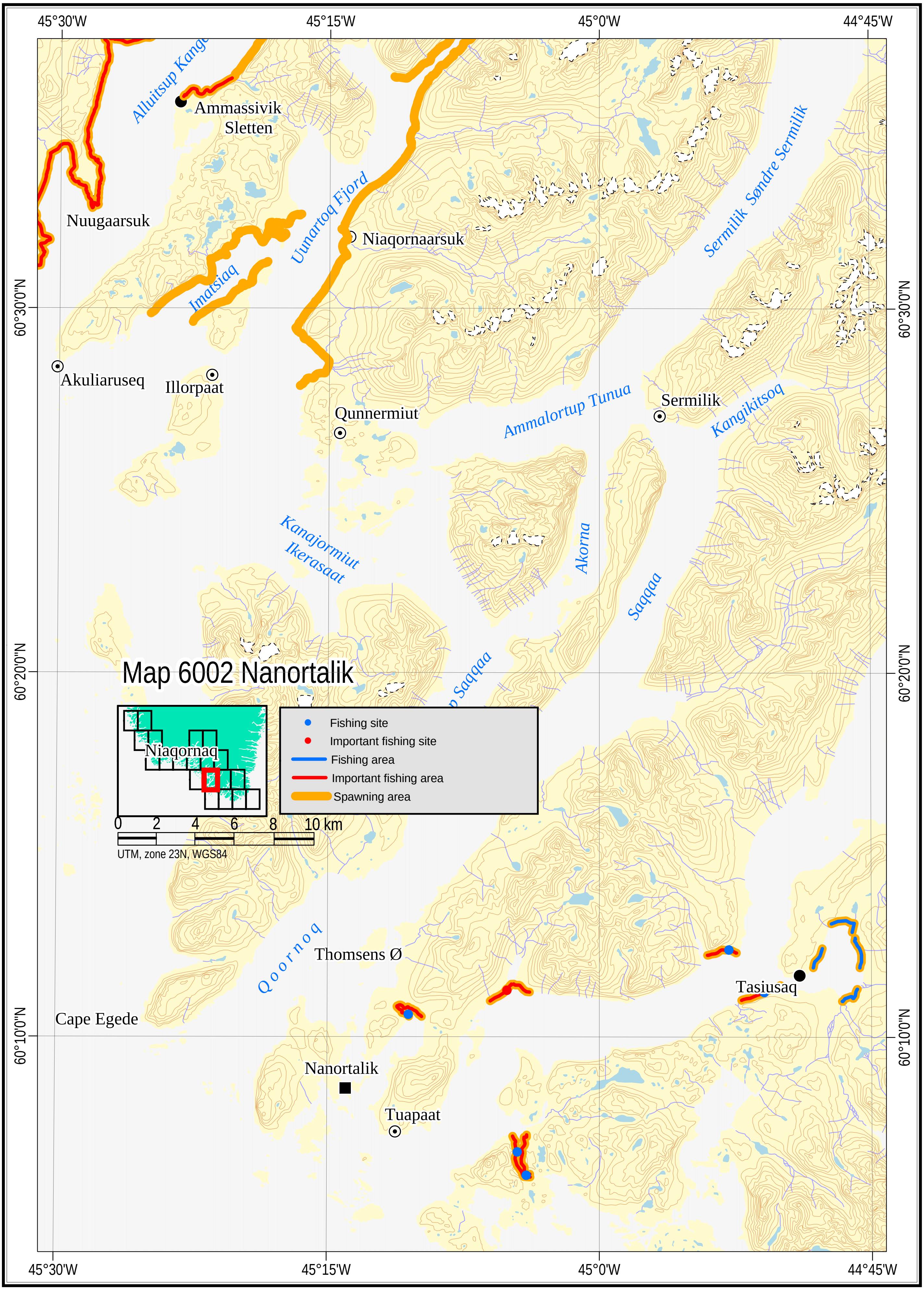
Lumpsucker - Distribution of spawning and fishing areas.



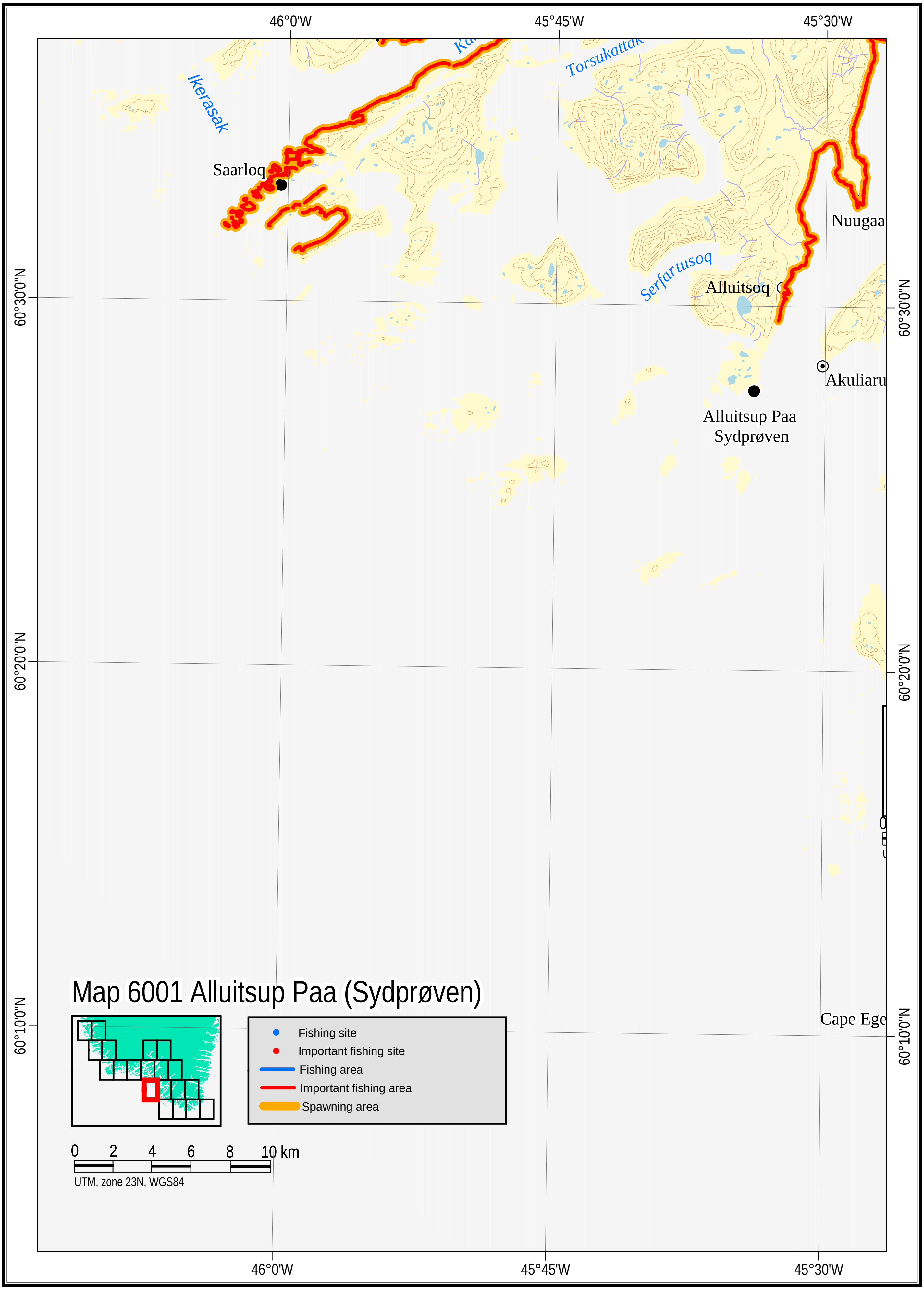
Lumpsucker - Distribution of spawning and fishing areas.



Lumpsucker - Distribution of spawning and fishing areas.

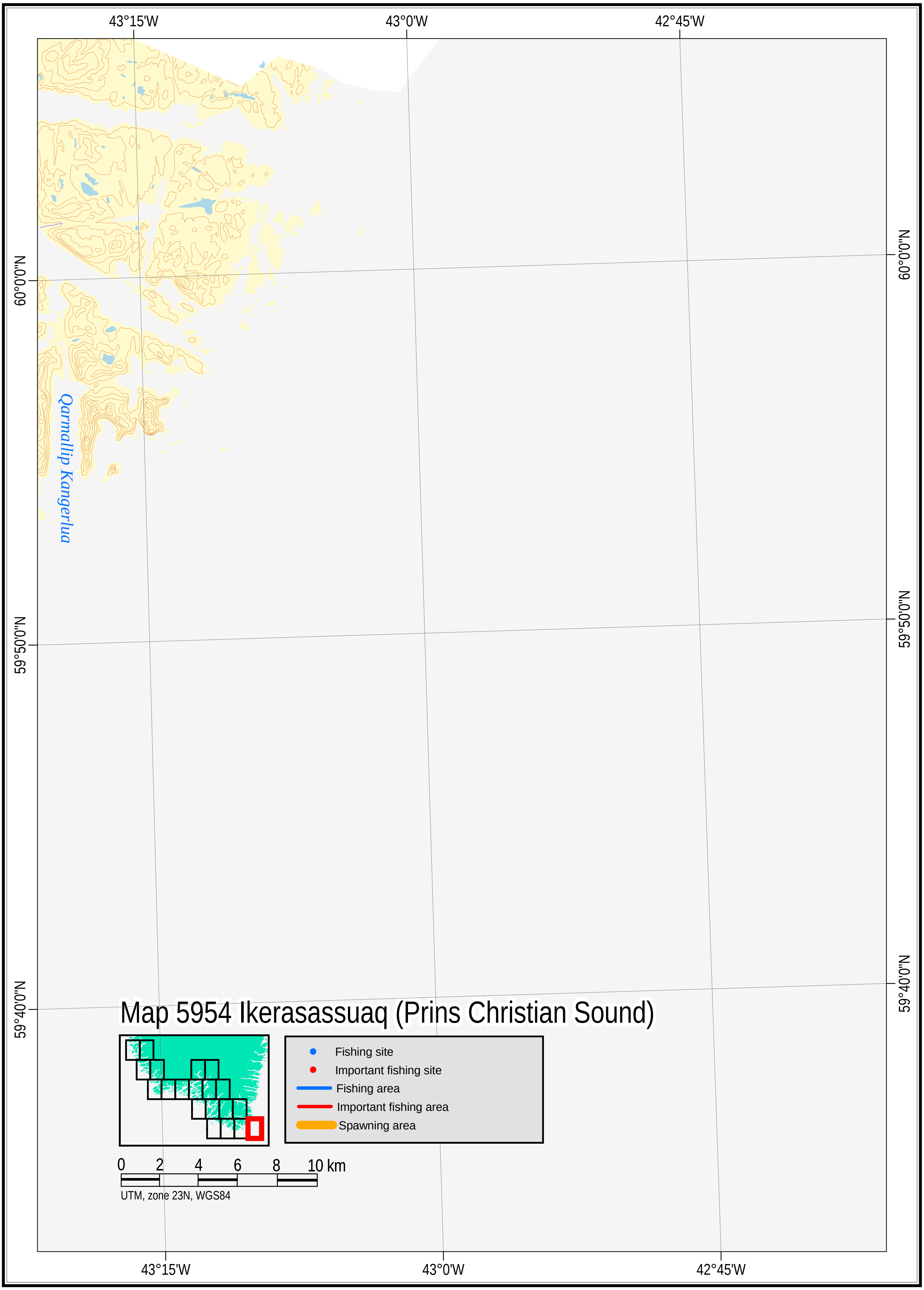


Lumpsucker - Distribution of spawning and fishing areas.

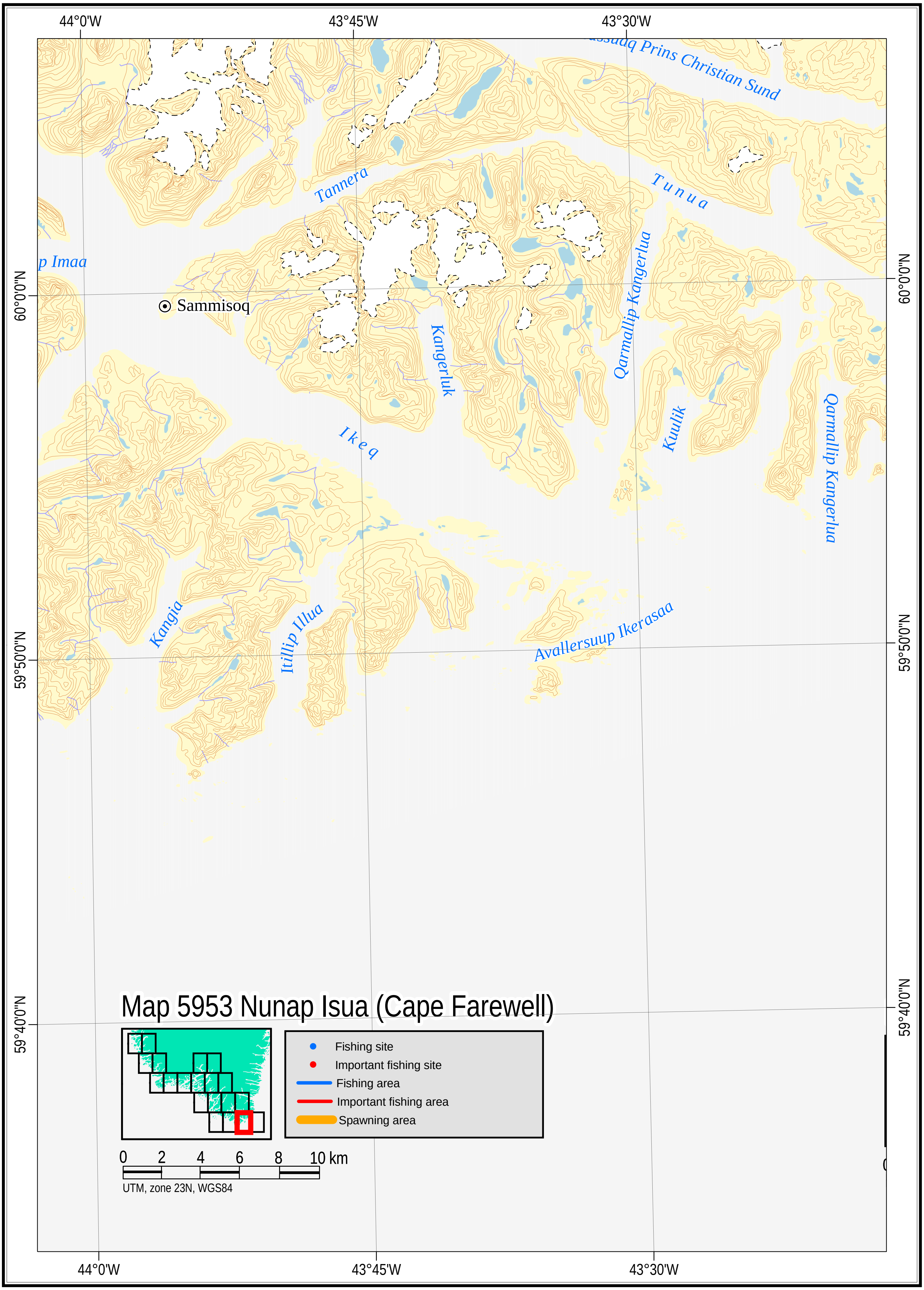


Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

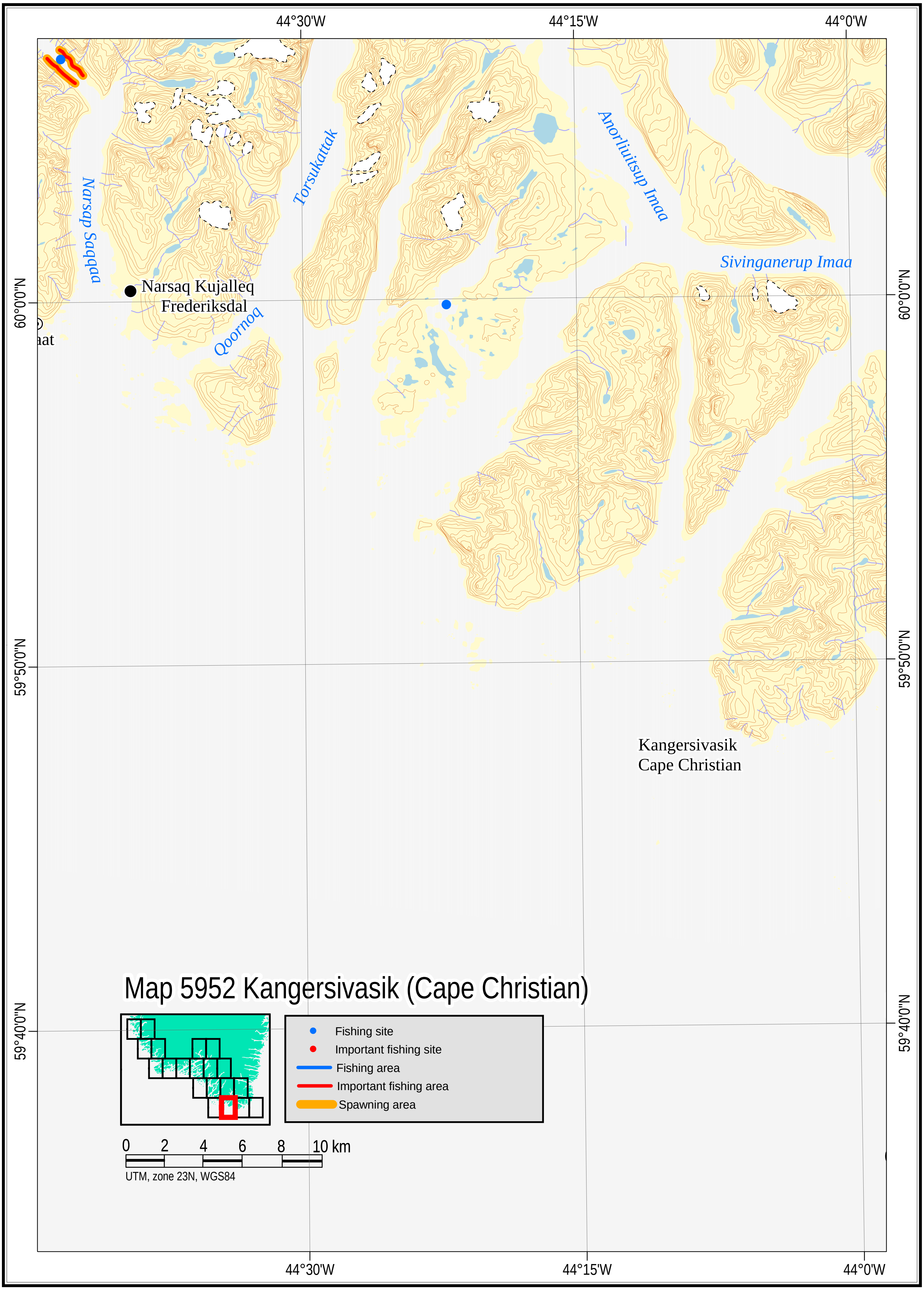
Lumpsucker - Distribution of spawning and fishing areas.



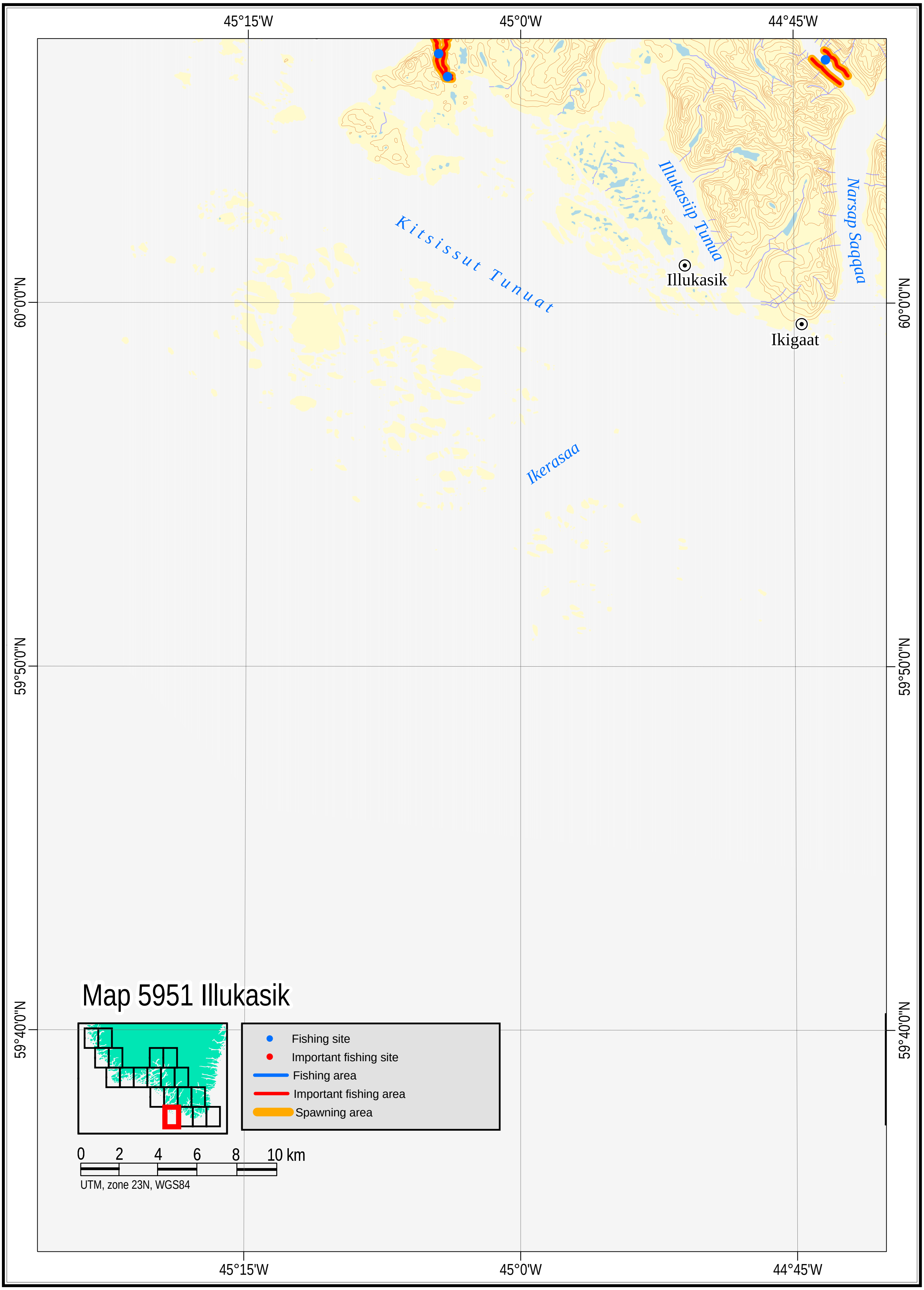
Lumpsucker - Distribution of spawning and fishing areas.



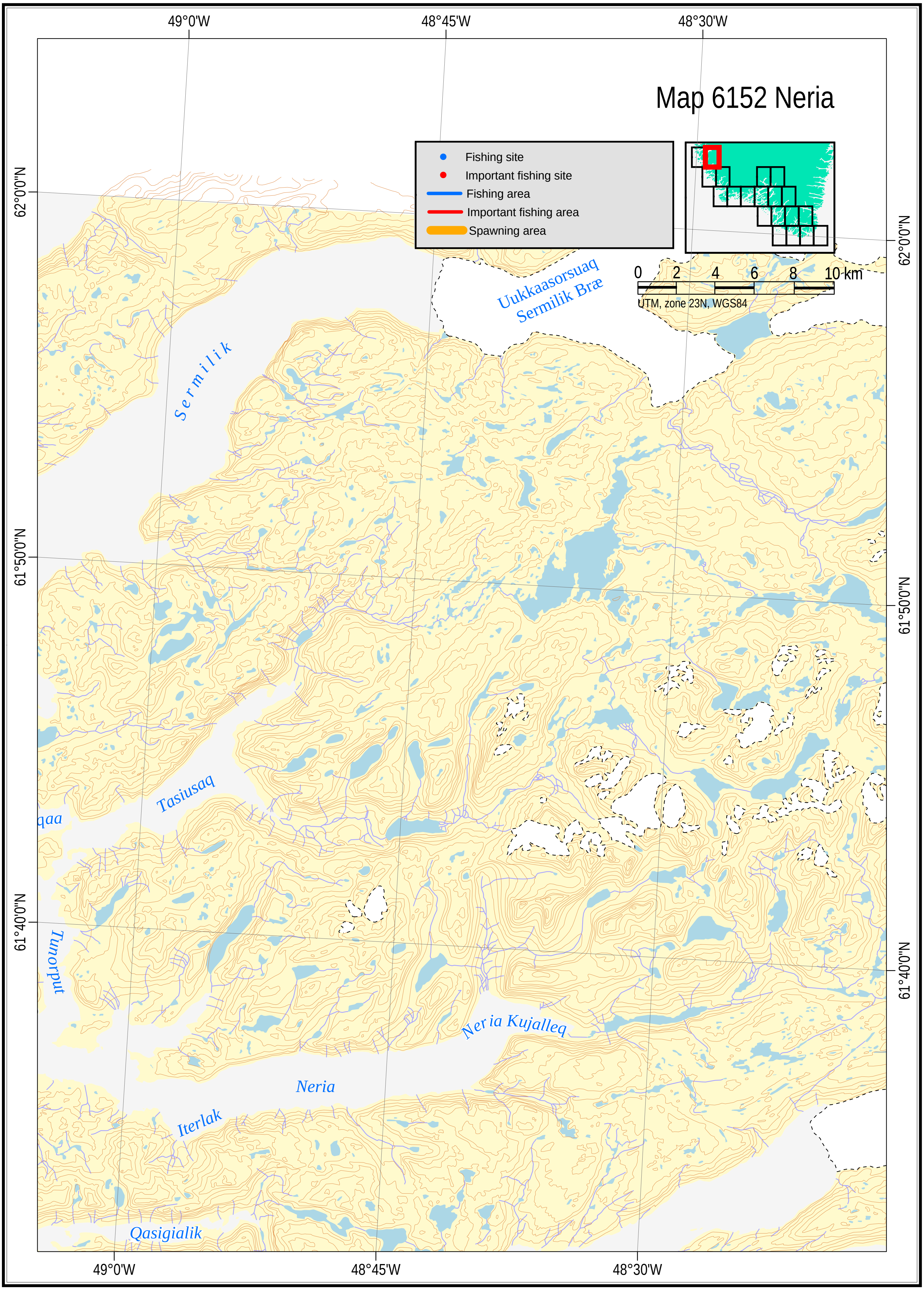
Lumpsucker - Distribution of spawning and fishing areas.



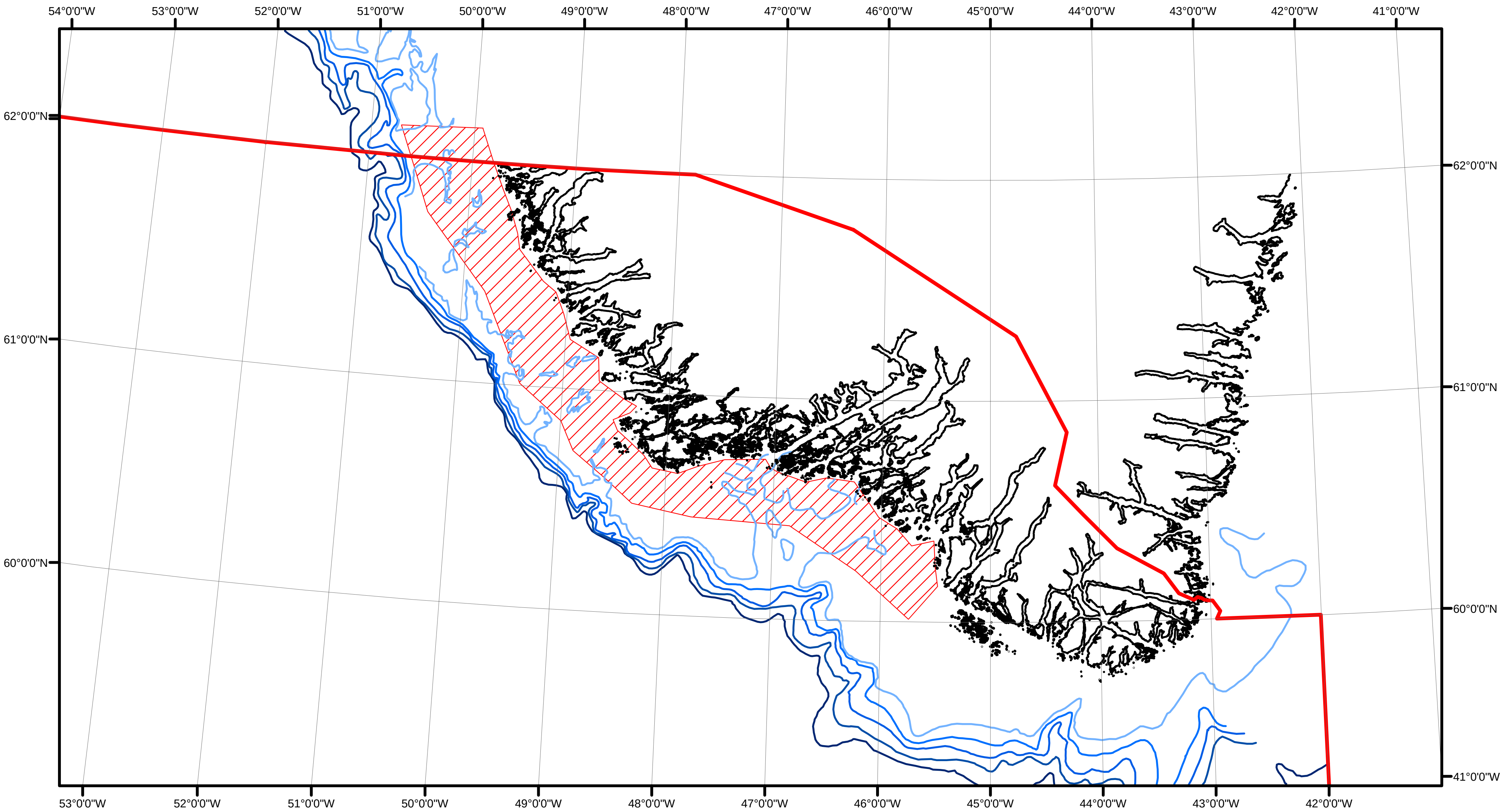
Lumpsucker - Distribution of spawning and fishing areas.



Lumpsucker - Distribution of spawning and fishing areas.



Topographic base: G/250 Vector, Copyright Kort & Matrikelstyrelsen, 1998

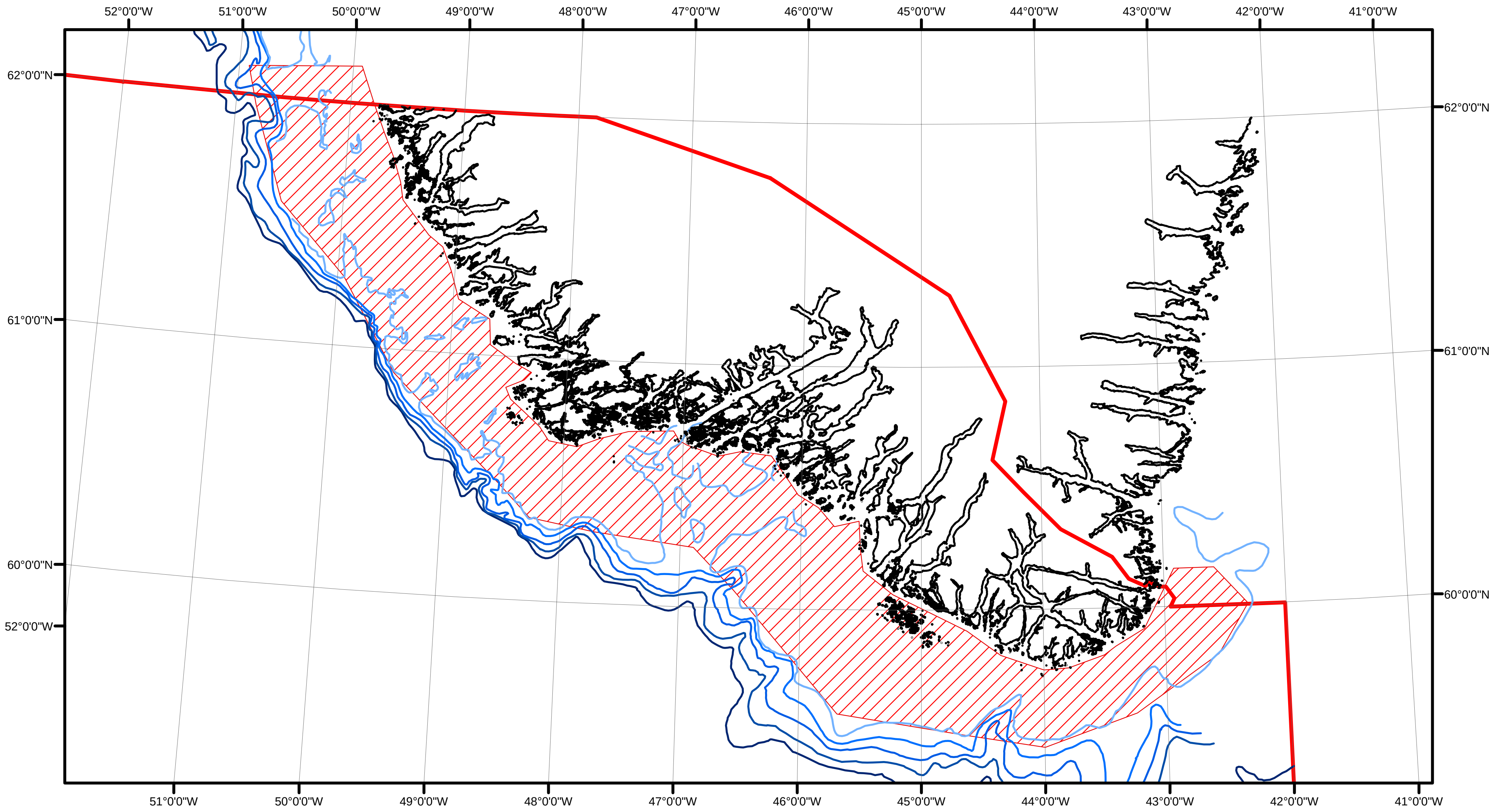


Seabirds Winter

In October to May seabirds (mainly Brünnich's guillemot, common eider and gulls), occur in internationally important numbers in the shown area.
The distribution governed by ice and food abundance (again governed by oceanic features), and it is generally difficult to predict occurrence of larger concentrations.
The occurrence of seabirds further out and beyond the shelf in winter is unknown.

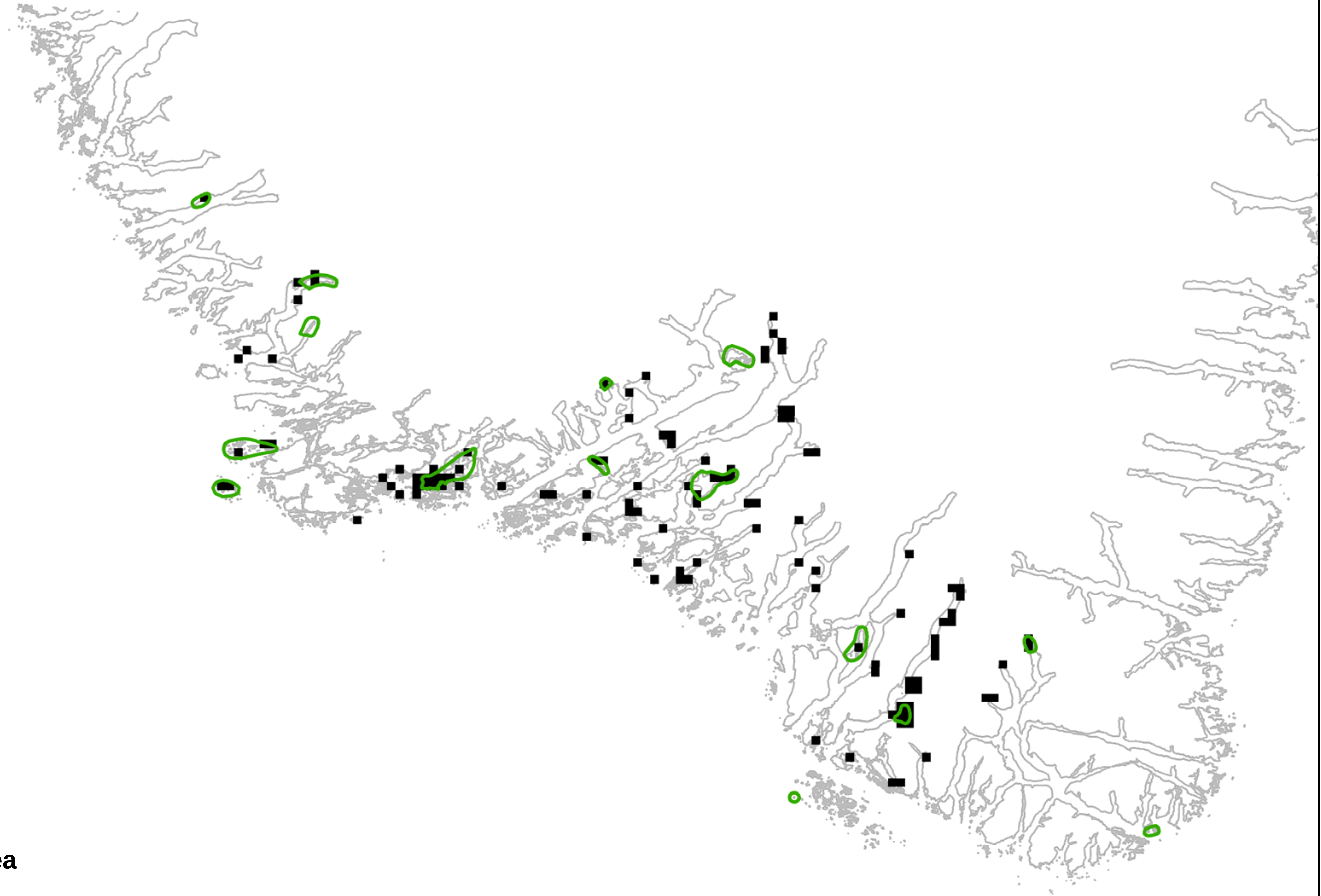
Legend

- Project Area
- 200 meters
- 500 meters
- 1000 meters
- 1500 meters
- 2000 meters
- Seabirds Winter



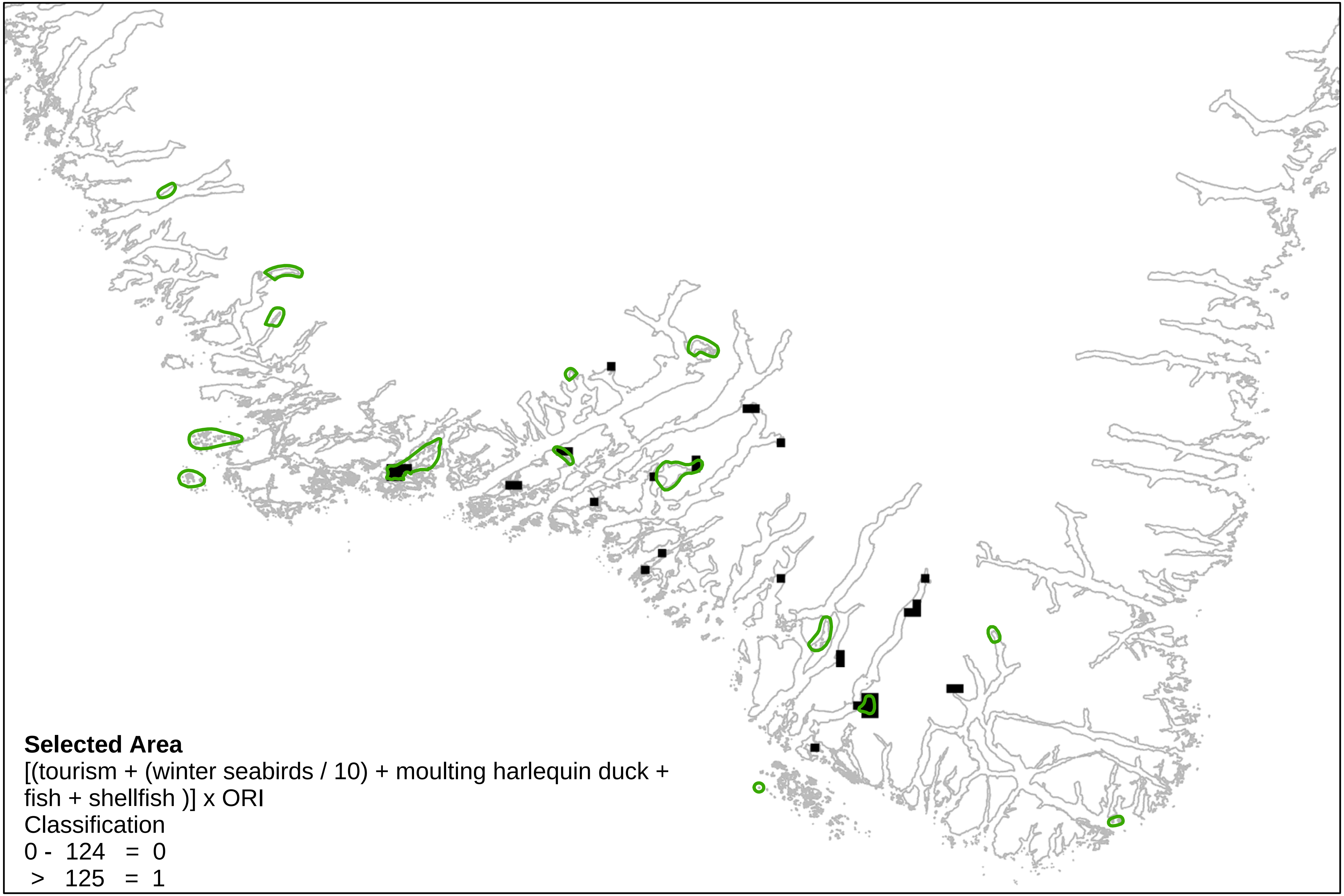
Large Baleen Whales

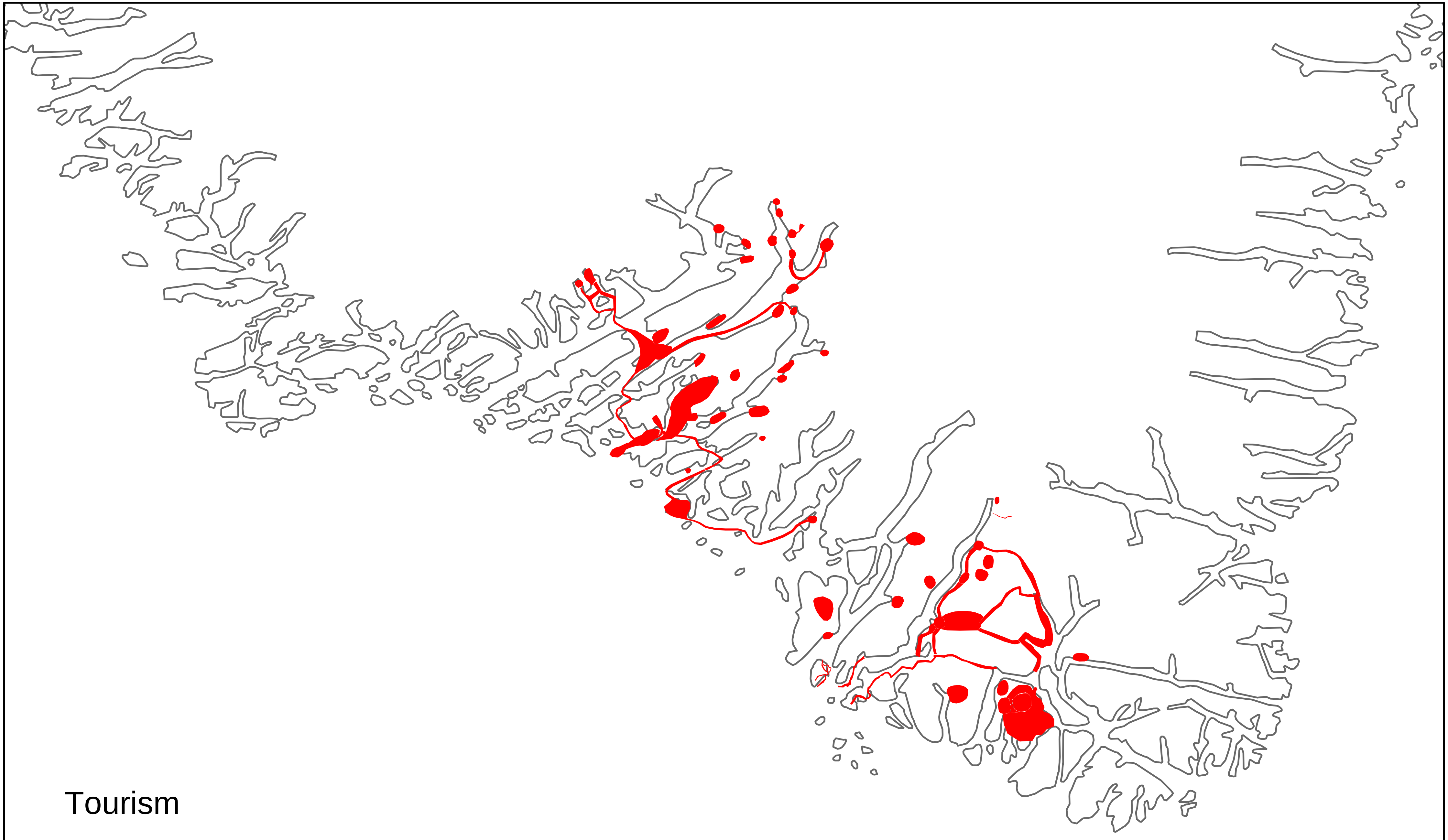
Fin, Minke, and Humpback whales occur mainly in the shelf waters.
Minke whales from May to November, fin whales from June to November
and humpbacks May to November.
The occurrence of these whales further off the shelf is not known.
It is not possible to give any information on specific concentrations areas
or number of the whales occurring in the area.
The distribution of the whales in the region is governed by the presence of the
drift ice arriving via the East Greenland Current.
This ice may in heavy ice years cover the waters until mid-July and occasionally
as far north as 62º N.
In other years the drift ice is almost absent from the coast of the region.



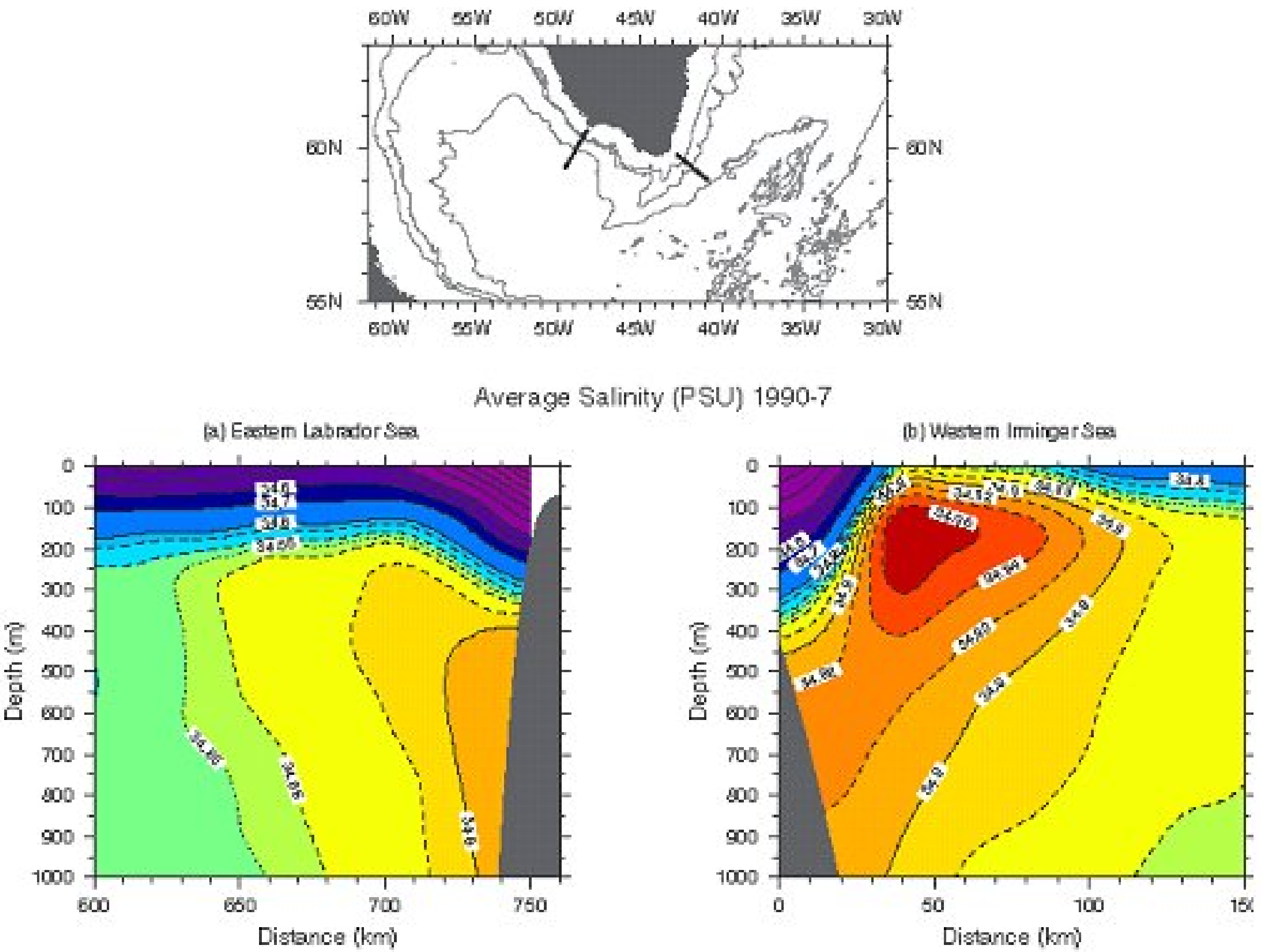
Selected Area
Classification
0 - 100 = 0
> 100 = 1

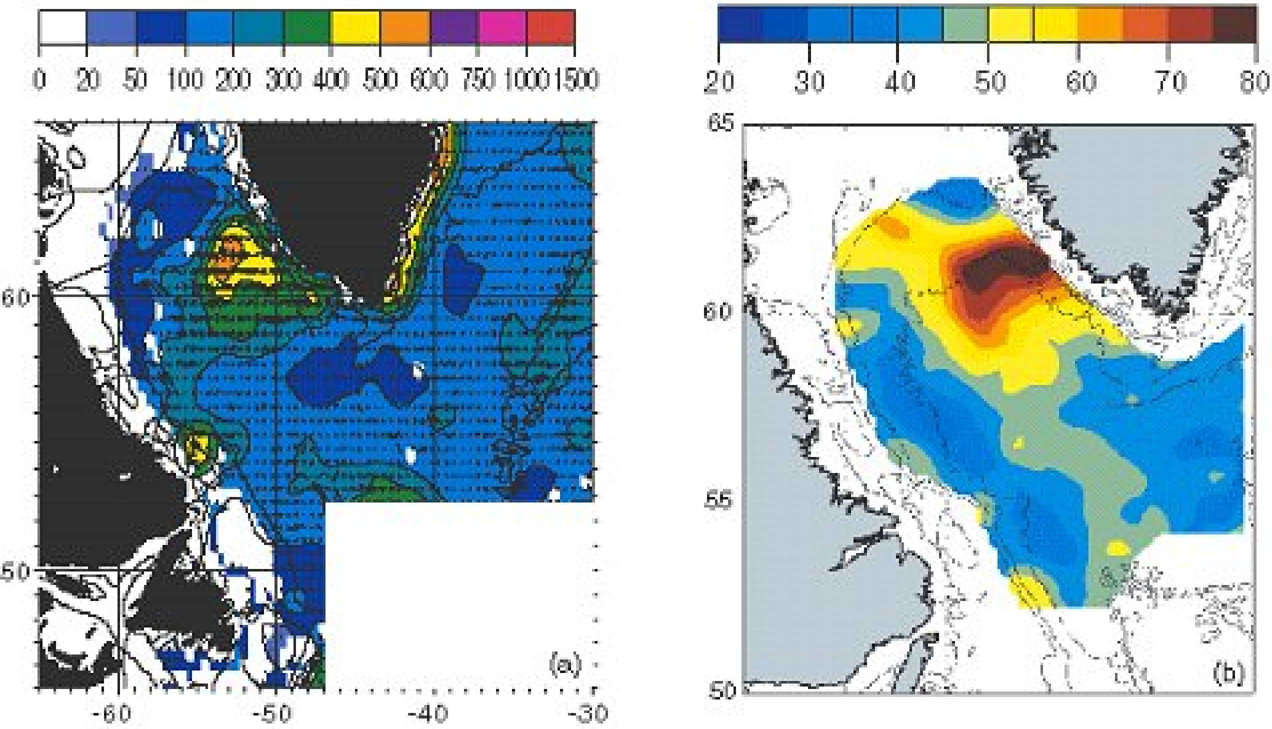
[Tourism + Bird colonies + Moulting Harlequin duck + (Winter seabirds / 10) +Fish + Shellfish + Archaeology] x ORI


Selected Area
[(tourism + (winter seabirds / 10) + moulting harlequin duck +
fish + shellfish)] x ORI
Classification
0 - 124 = 0
> 125 = 1

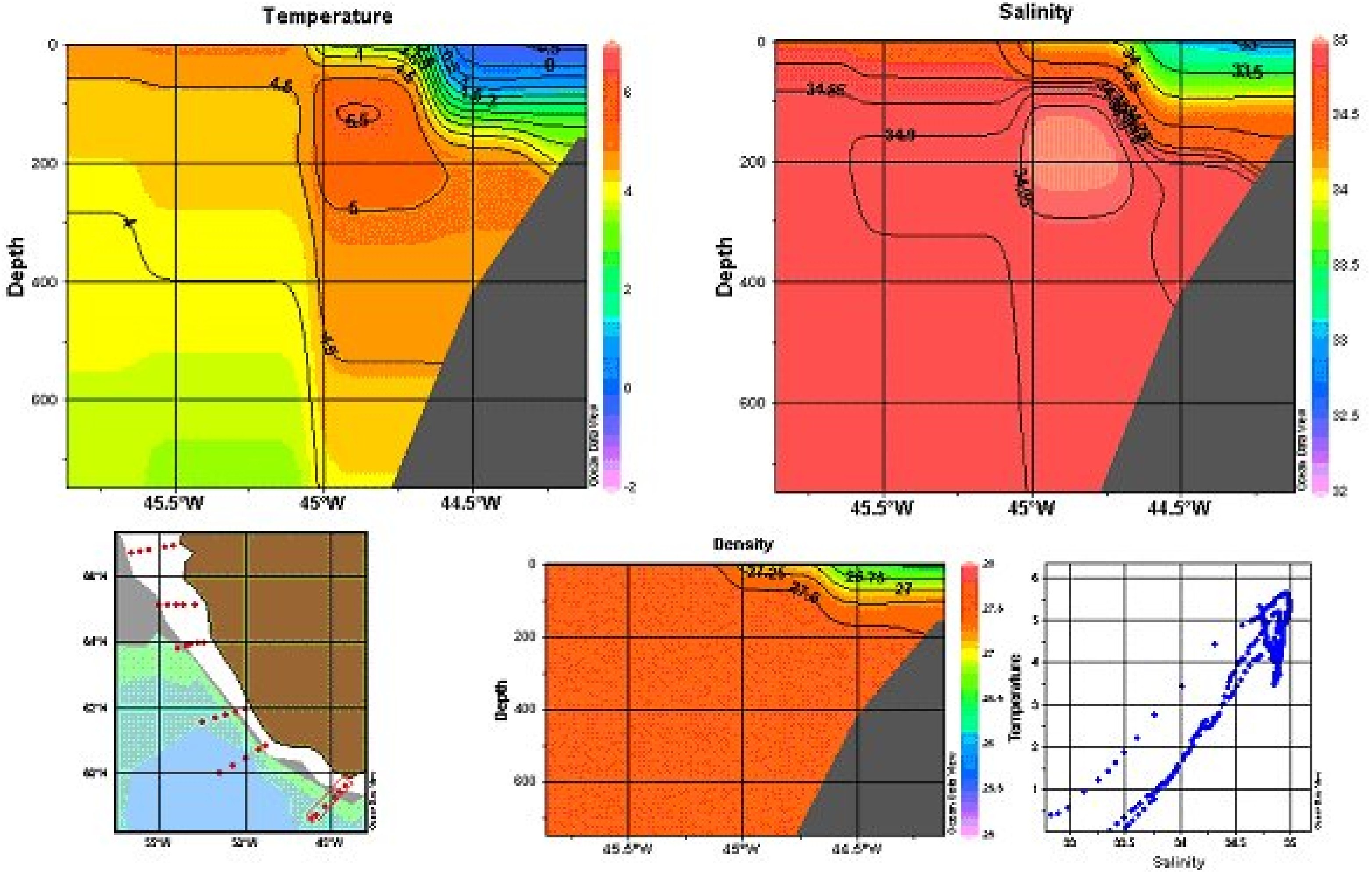


Tourism

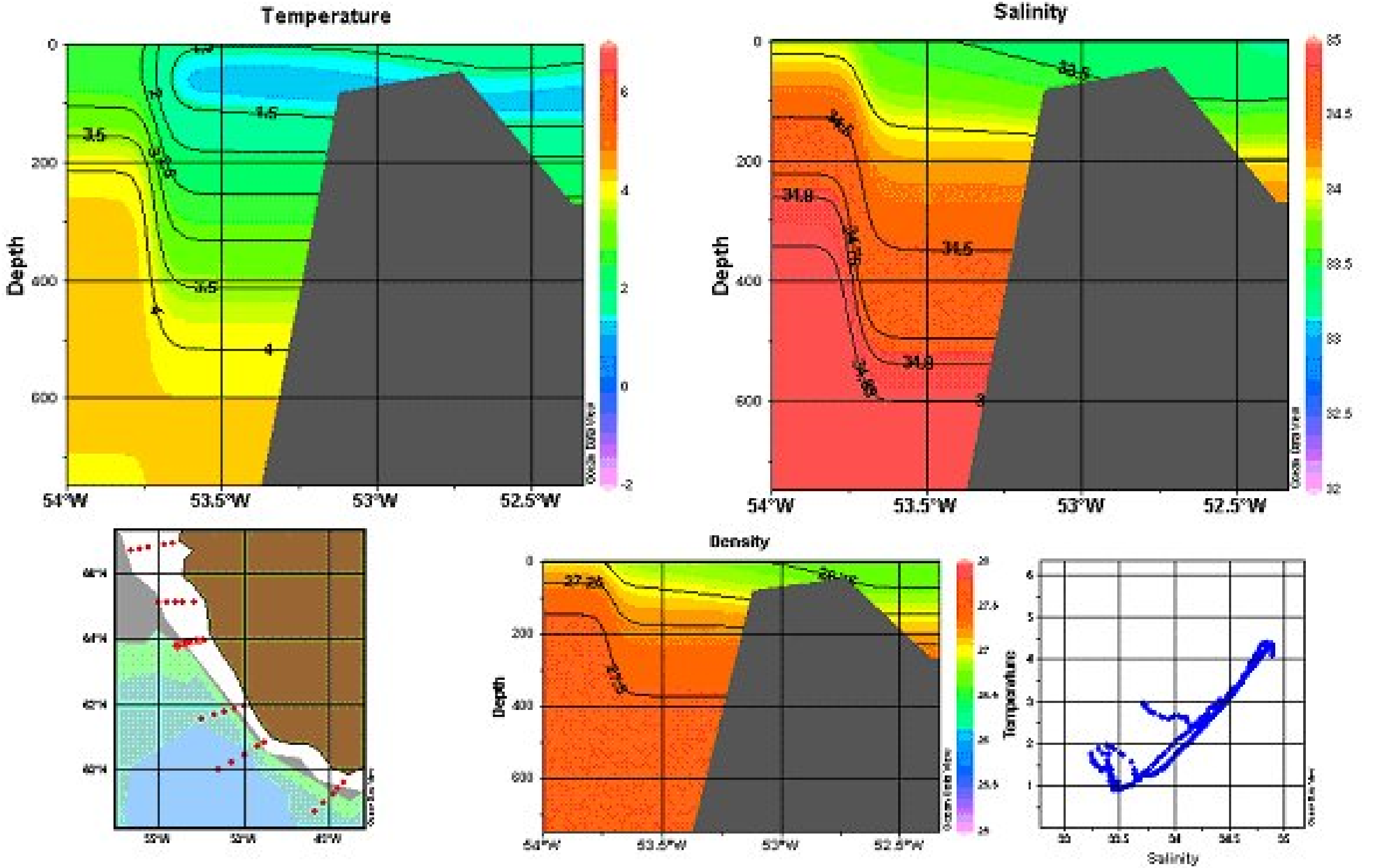

60W
55W
50W
45W
40W
35W
30W
60N
55N
Average Salinity (PSU) 1990-7
(a) Eastern Labrador Sea
(b) Western Irminger Sea
Depth (m)
Distance (km)
0
100
200
300
400
500
600
700
800
900
1000
600
650
700
750
50
100



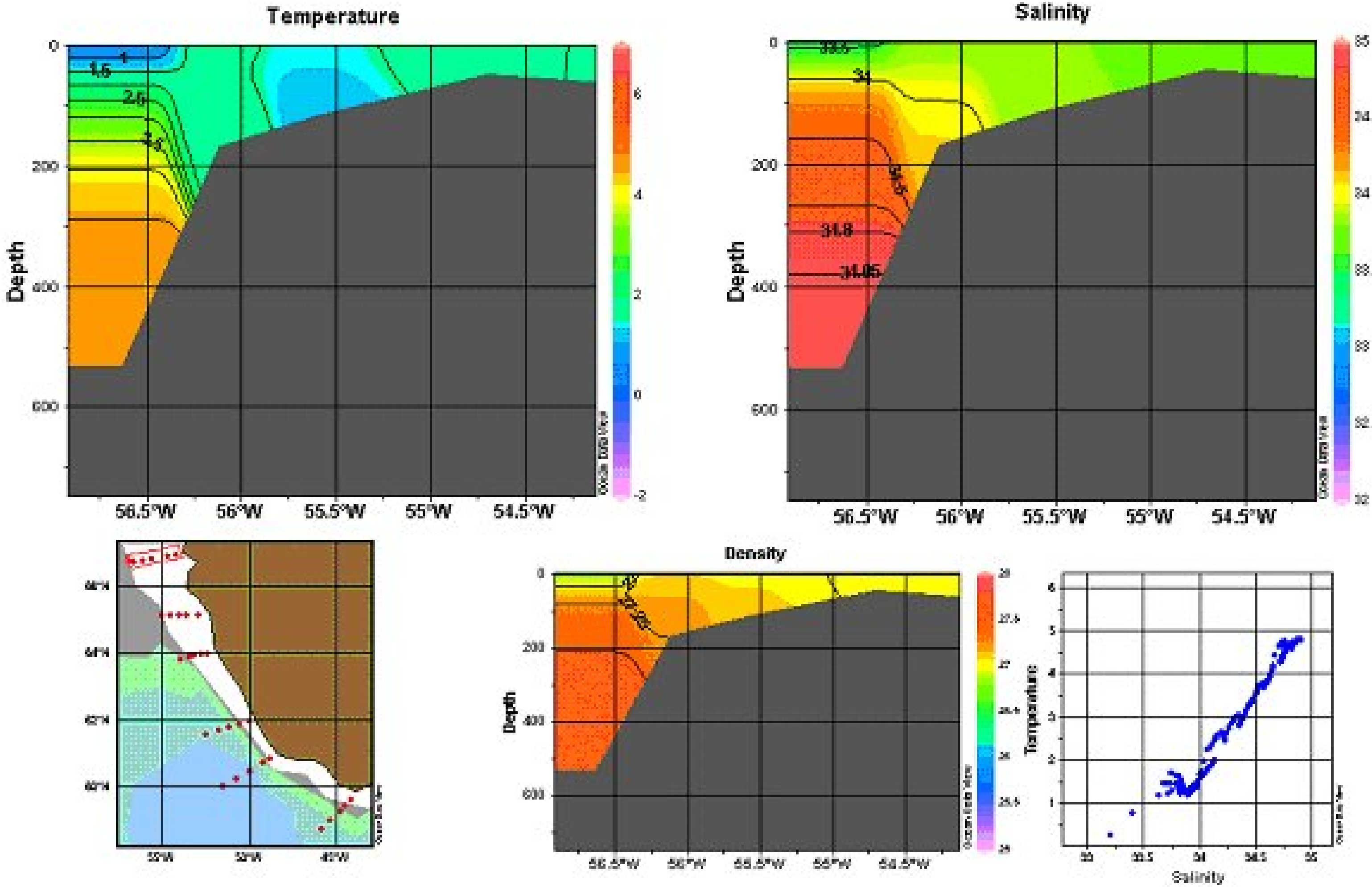
0 20 50 100 200 300 400 500 600 750 1000 1500
60
50
-60 -50 -40 -30
(a)
20 30 40 50 60 70 80
65
60
55
50
(b)



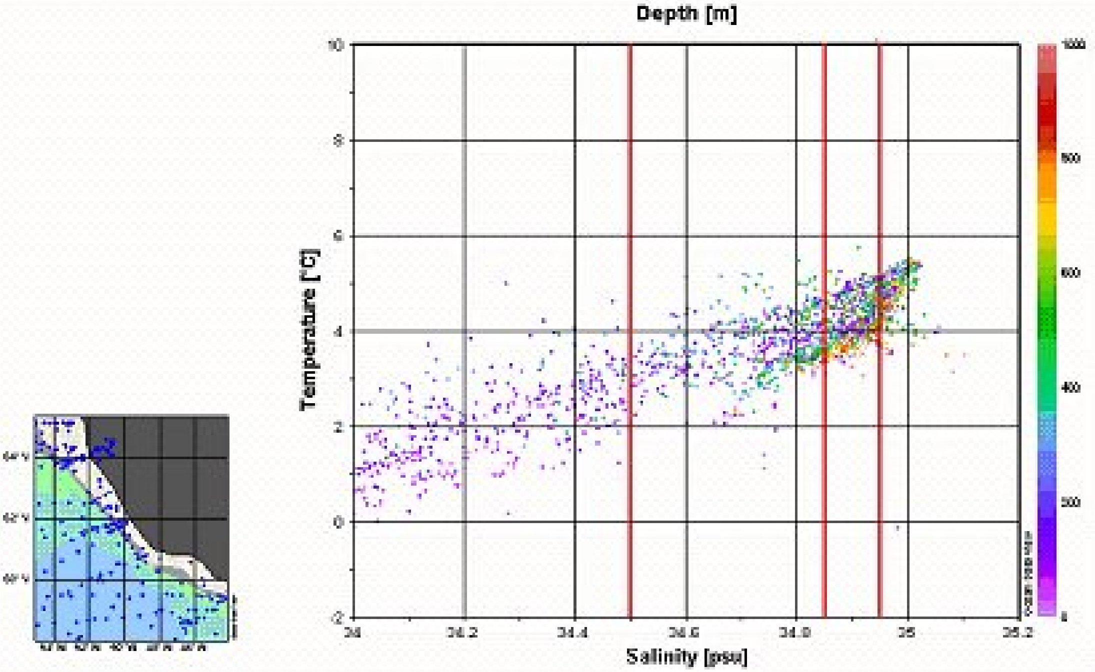
Temperature
Salinity
Density
Depth
45.5°W
45°W
44.5°W
Temperature
Salinity



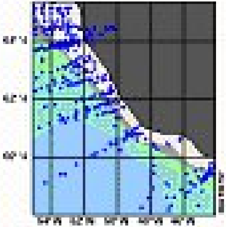
Temperature
Salinity
Density
Depth
Temperature
Salinity
54°W
53.5°W
53°W
52.5°W

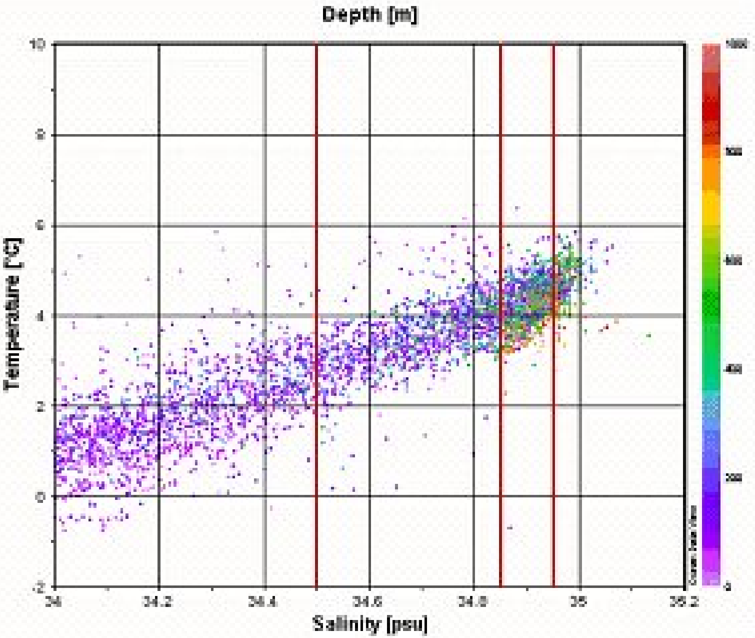


Temperature
Depth
56.5°W
56°W
55.5°W
55°W
54.5°W
Salinity
Density
Temperature
Salinity

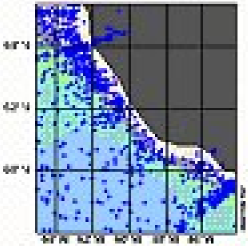


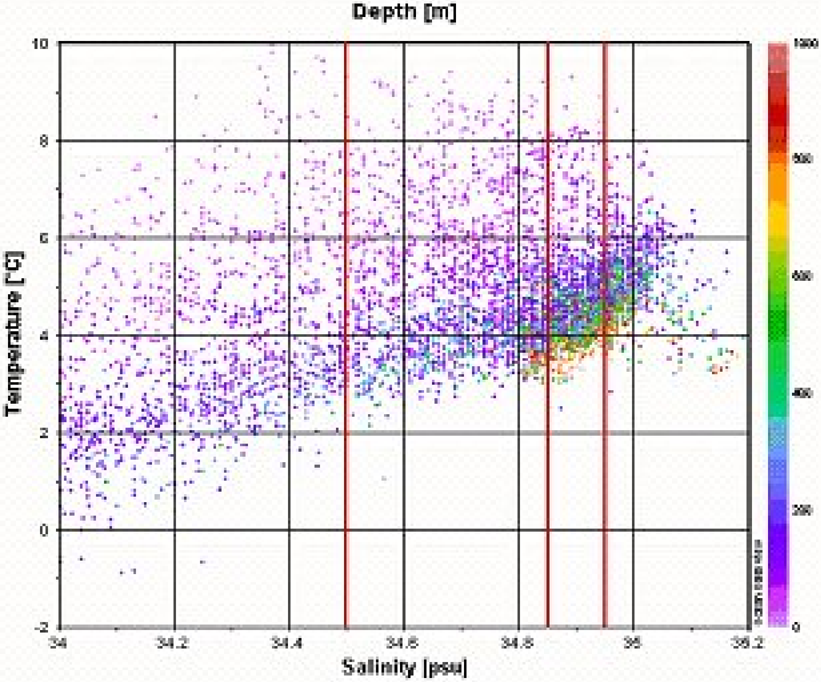
Depth [m]
Temperature [°C]
10
8
6
4
2
0
-2
34
34.2
34.4
34.6
34.8
35
35.2
Salinity [psu]

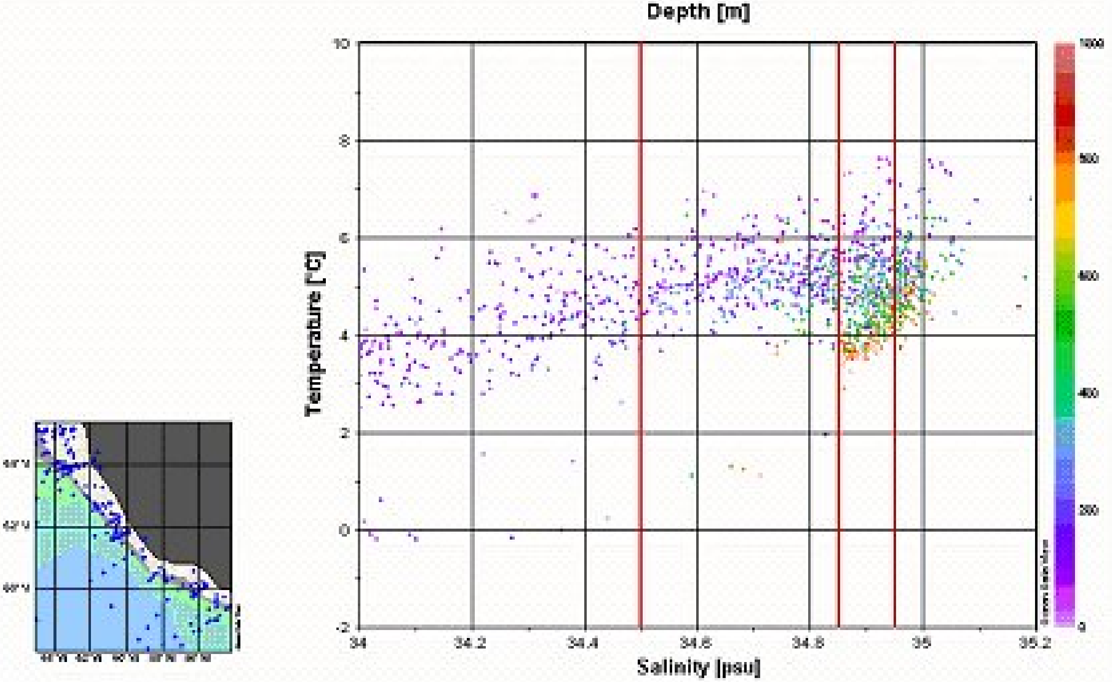


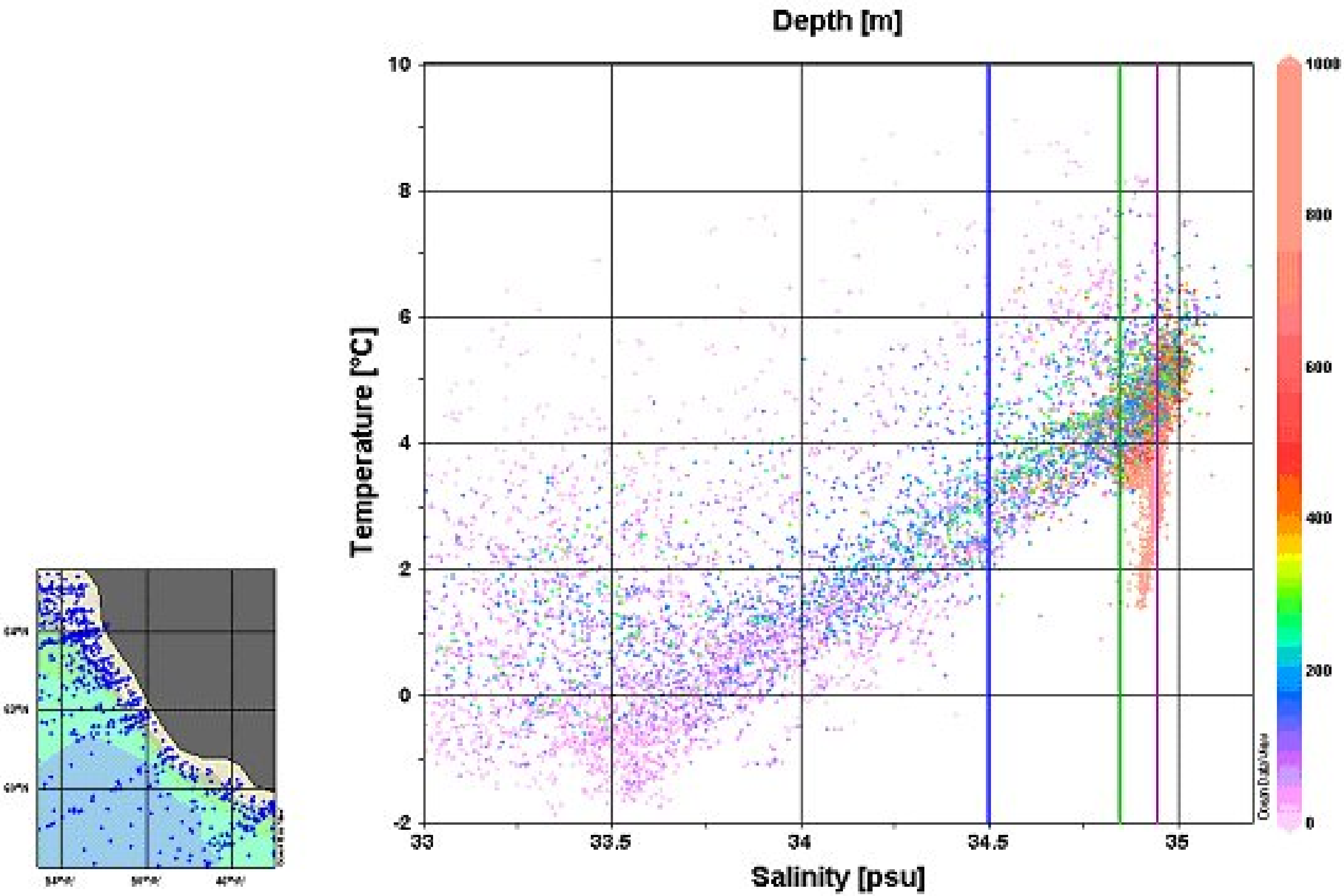


Depth [m]
Temperature [°C]
Salinity [psu]
10
8
6
4
2
0
-2
34
34.2
34.4
34.6
34.8
35
35.2

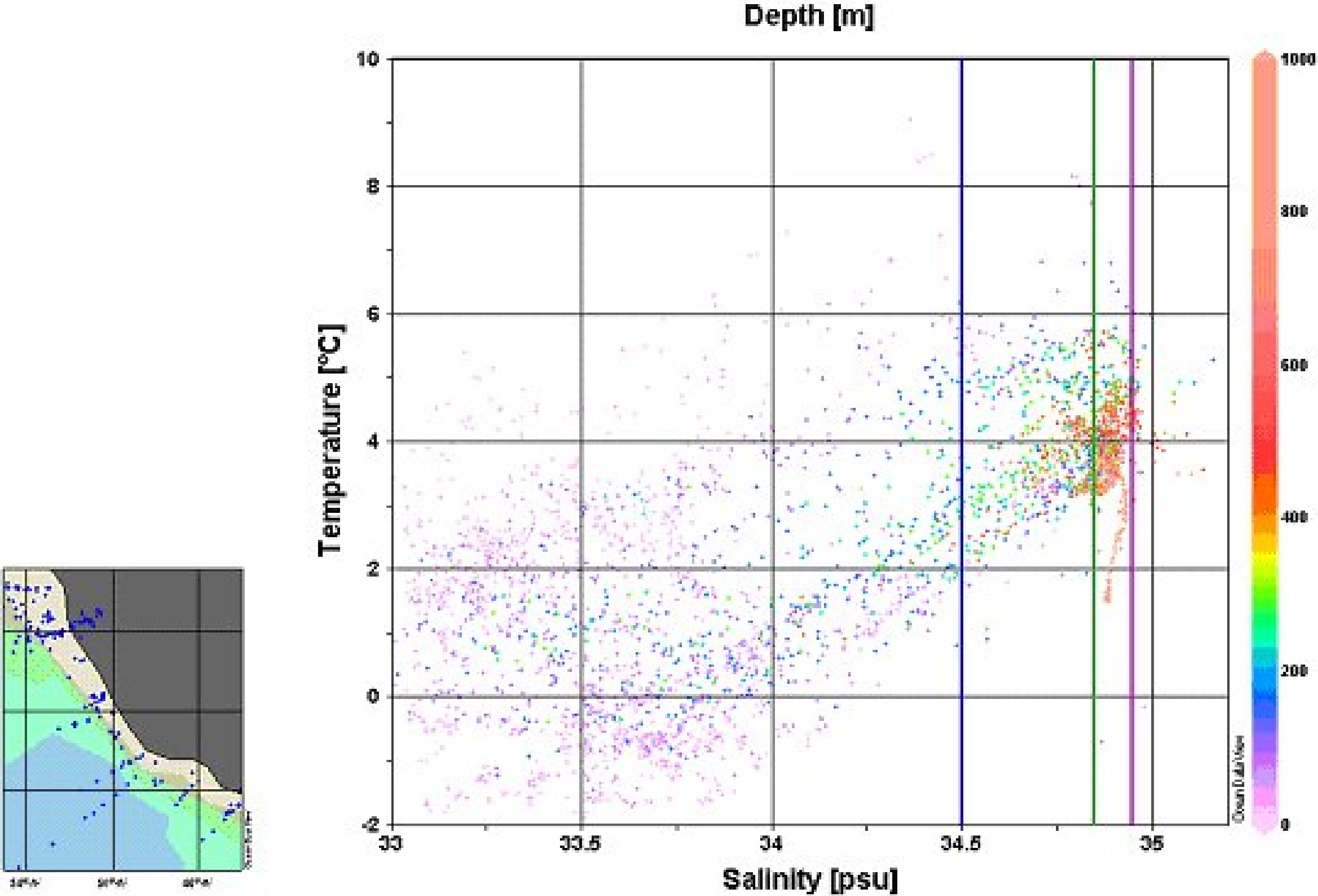


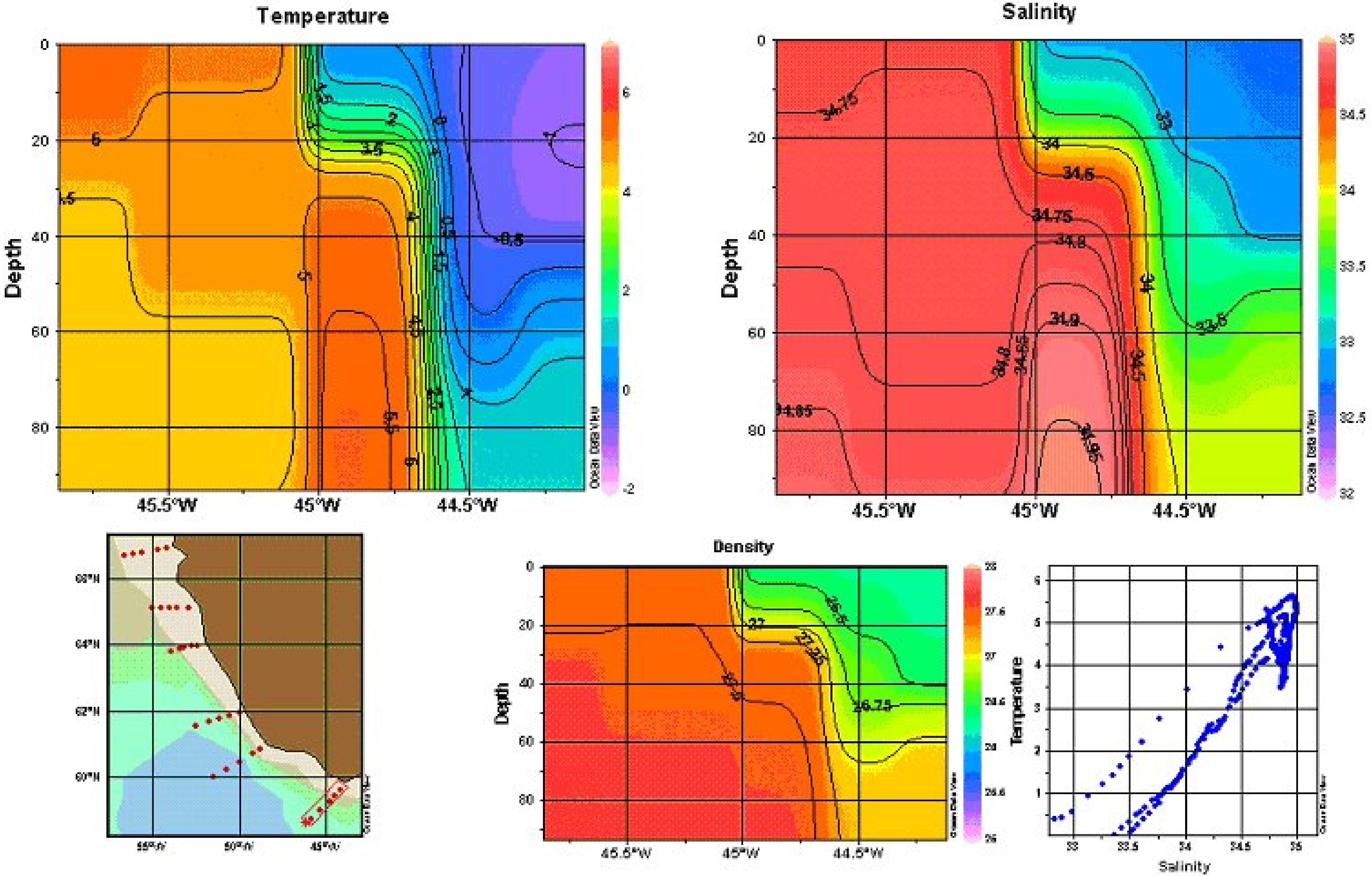

Depth [m]
Temperature [°C]
Salinity [psu]
10
8
6
4
2
0
-2
34
34.2
34.4
34.6
34.8
35
35.2
0
200
400
600
800
1000


Depth [m]
Temperature [°C]
Salinity [psu]
10
8
6
4
2
0
-2
34
34.2
34.4
34.6
34.8
35
35.2
1000
800
600
400
200
0

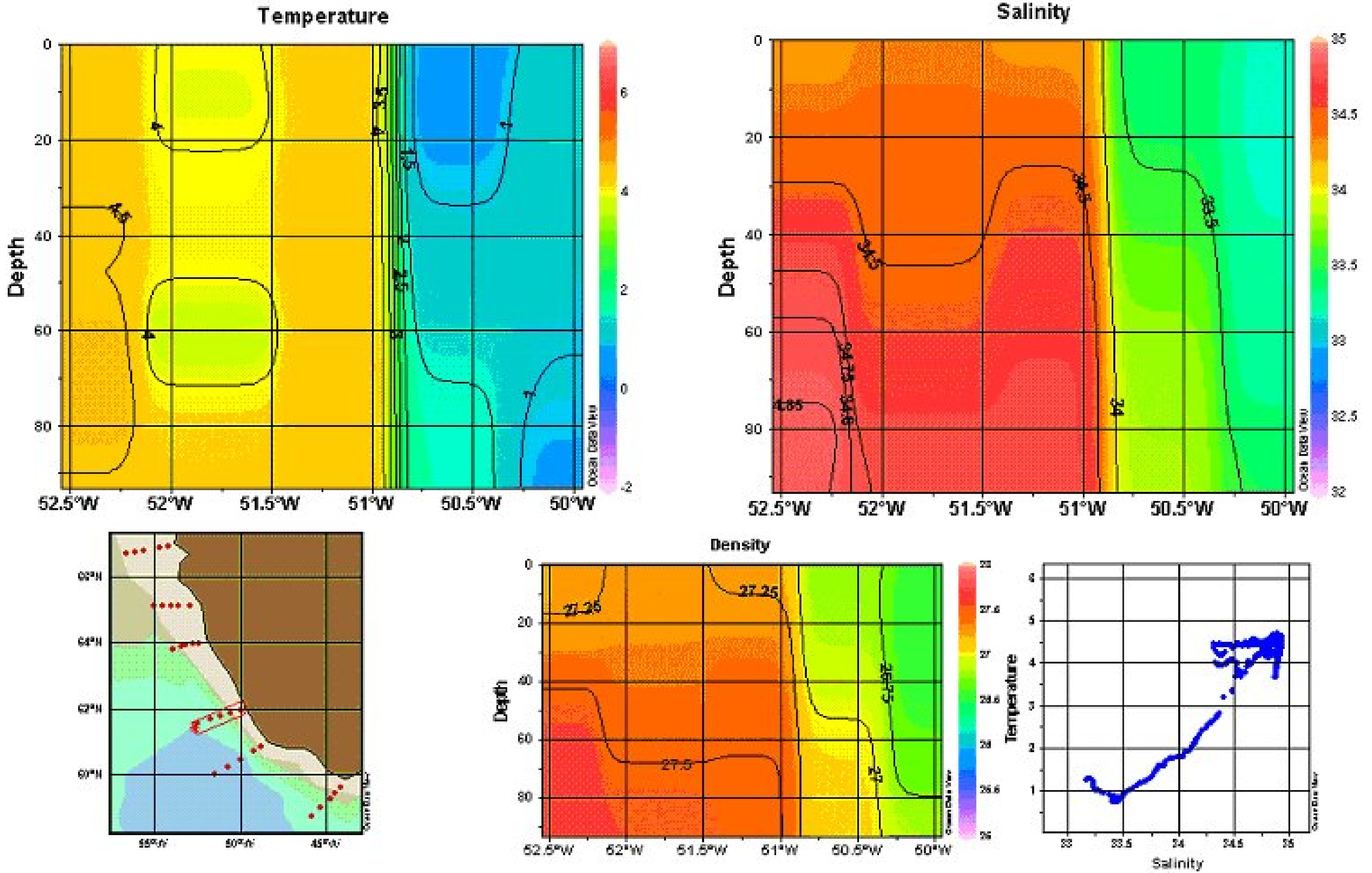


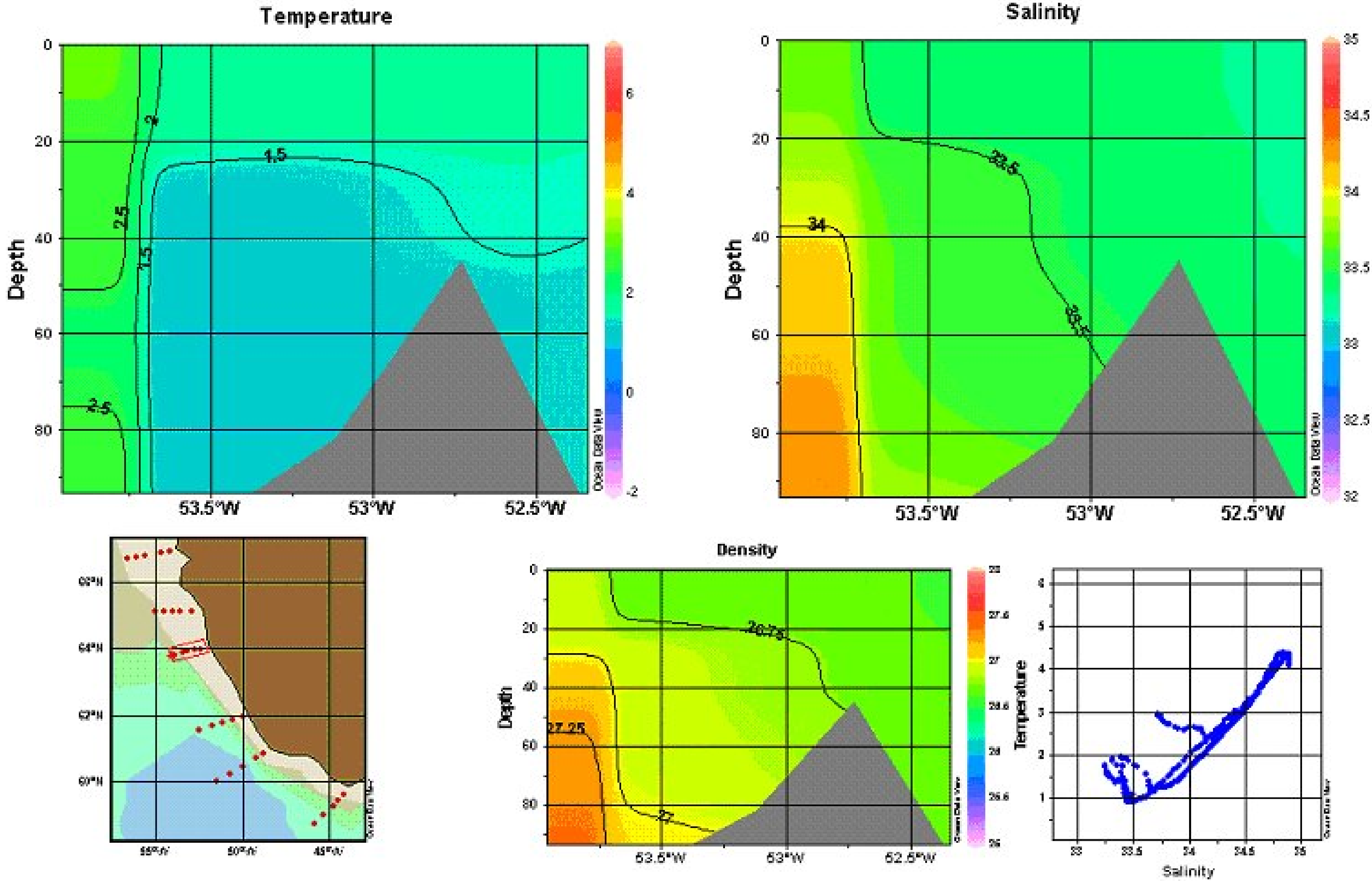
Depth [m]
10
8
6
4
2
0
-2
Temperature [°C]
33
33.5
34
34.5
35
Salinity [psu]
1000
800
600
400
200
0
Ocean Data View

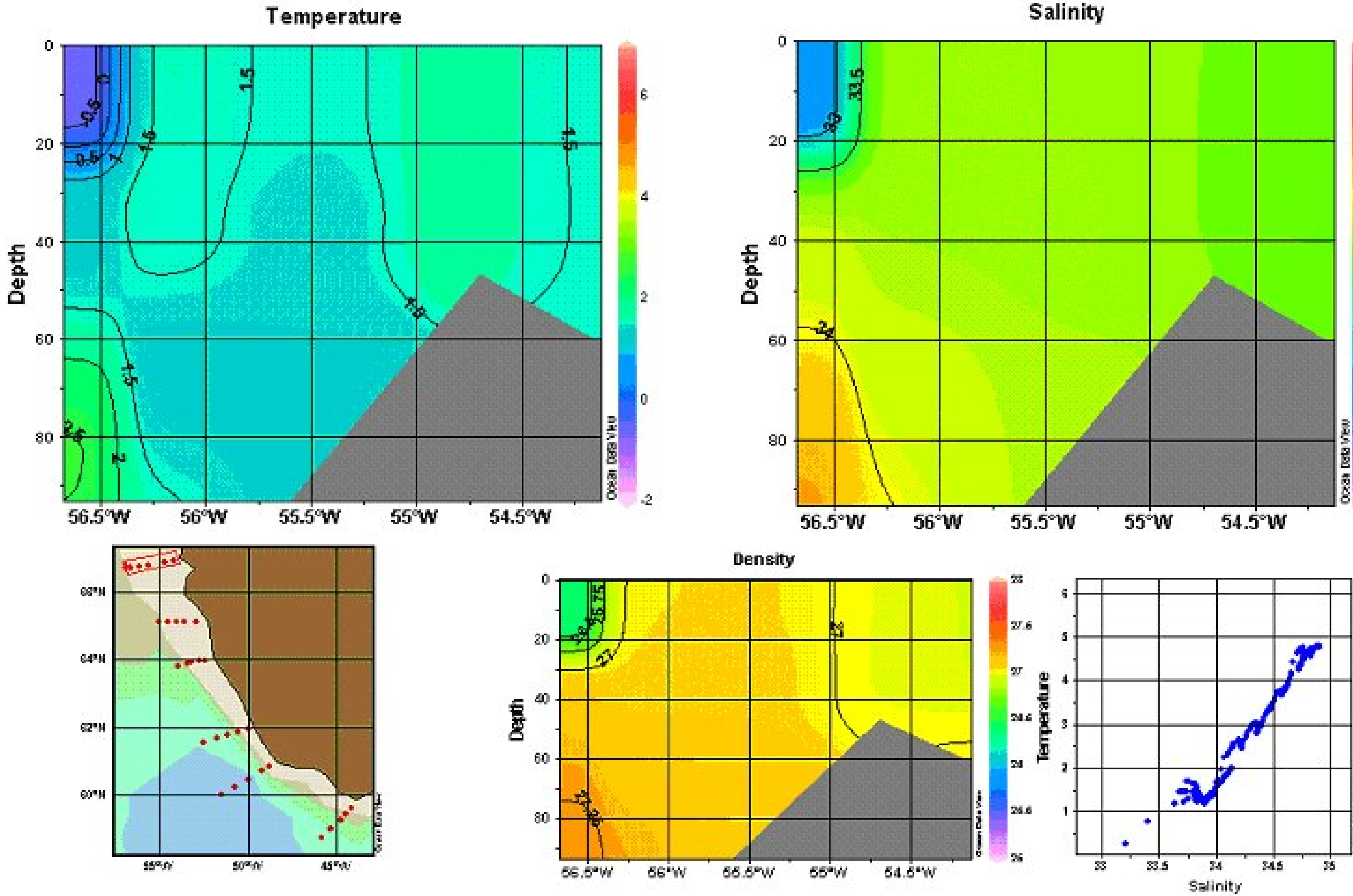

Depth [m]
Temperature [°C]
Salinity [psu]
10
8
6
4
2
0
-2
33
33.5
34
34.5
35
1000
800
600
400
200
0
Ocean Data View

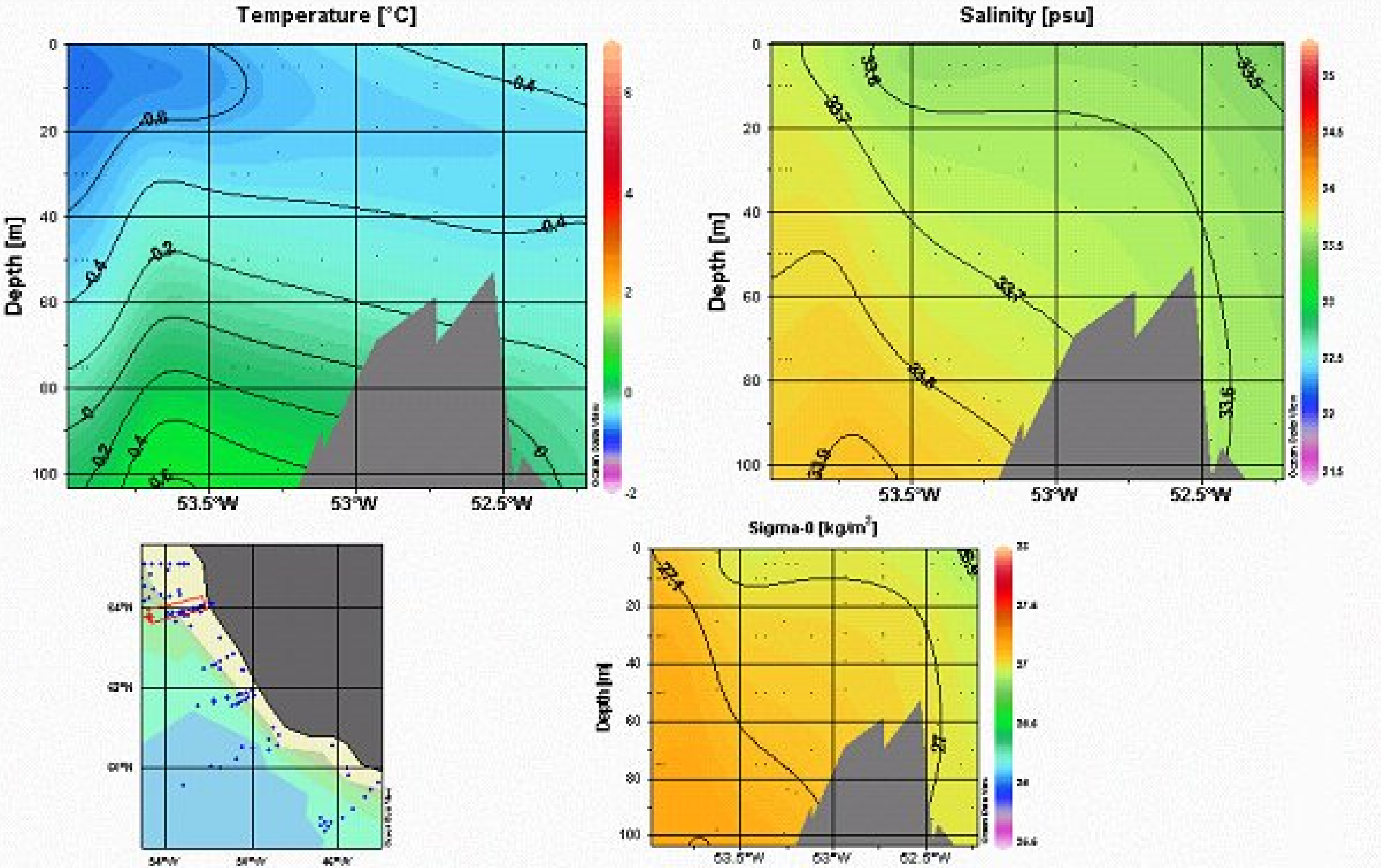


Temperature
Salinity
Density
Depth
45.5°W
45°W
44.5°W
Ocean Data View
60°N
62°N
64°N
66°N
55°W
50°W
45°W
Temperature
Salinity

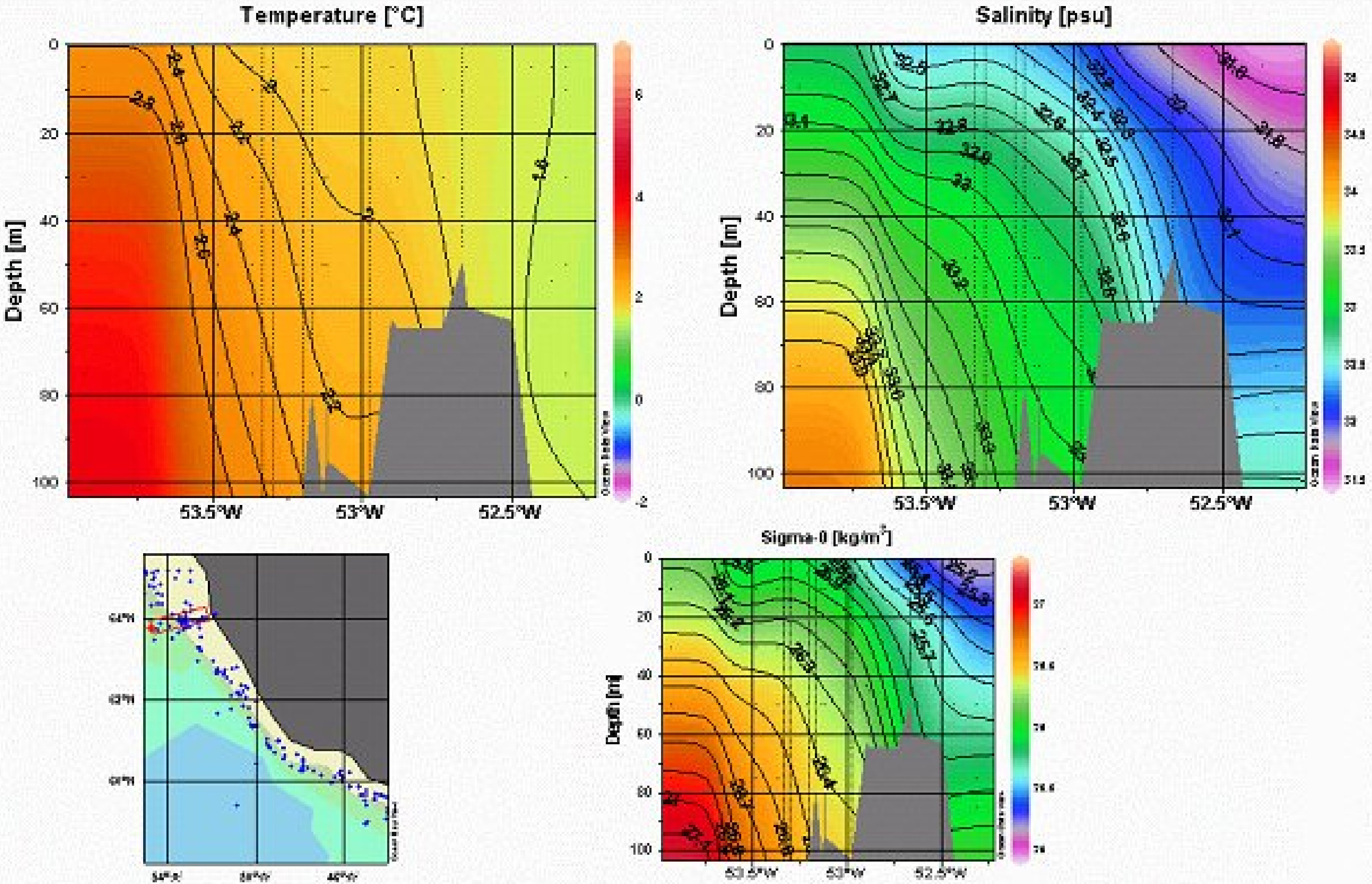

Temperature
Depth
0
20
40
60
80
52.5°W
52°W
51.5°W
51°W
50.5°W
50°W
6
4
2
0
-2
Ocean Data View
Salinity
35
34.5
34
33.5
33
32.5
32
Density
Temperature
Salinity


Temperature
Depth
0
20
40
60
80
53.5°W
53°W
52.5°W
2
2.5
1.5
6
4
2
0
-2
Ocean Data View
Salinity
33.5
34
35
34.5
34
33.5
33
32.5
32
Density
27.25
27
26.75
Temperature
Salinity
33
33.5
34
34.5
35
1
2
3
4
5
6


Temperature
Salinity
Density
Depth
Temperature
Salinity
56.5°W
56°W
55.5°W
55°W
54.5°W
66°N
64°N
62°N
60°N
55°W
50°W
45°W
Ocean Data View



Temperature [°C]
Salinity [psu]
Sigma-0 [kg/m³]
Depth [m]
53.5°W
53°W
52.5°W
-0.8
-0.4
-0.2
0
0.2
0.4
0.6
33.6
33.7
33.8
33.5
27
27.4


Temperature [°C]
Salinity [psu]
Sigma-0 [kg/m³]
Depth [m]
53.5°W
53°W
52.5°W

493 Environmental Oil Spill Sensitivity Atlas for the South Greenland Coastal Zone

National Environmental Research Institute
Ministry of the Environment

ISBN 87-7772-806-8