Årsbok Yearbook 2005

Polarforskningssekretariatet

Swedish Polar Research Secretariat

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Belly-to-belly Elephant seals, King George Island, Antarctica.

Förord

Britt-Marie Danestig
Styrelseordförande
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Chairwoman of the Board
Swedish Polar Research Secretariat

2005 blev ett lysande polarår. Den största expeditionen till Arktis i Polarforskningssekretariatets historia, Beringia 2005, genomfördes med över 130 forskare från sexton olika nationer. Forskarna studerade bland annat flyttfåglars navigering, fågelvirus, det minskande ozonlagrets hot mot det marina livet, klimatvariationer och miljögifter. Resultaten av forskningen kommer säkert att ge oss mycket värdefull kunskap. För mig, som hade privilegiet att få göra resan till Arktis i ett fullastat Herculesplan i samband med rotationen av forskare, var upplevelsen hisnande. Jag fick en inblick i hur komplicerat logistiskt arbete är, och vilken förmåga att tänka nytt och tänka om som fordras för att tillgodose forskarnas önskemål. Barrow, vårt mål för resan, var en både säregen och fascinerande bekantskap med knappt 5 000 invånare från en mängd olika nationer och kulturer. Först tyckte jag att Barrow var ogästvänligt, kalt och grått, men efter några dagar upplevde jag den säregna skönheten och såg värmen och stoltheten hos dem som lever där.

En annan upplevelse under året som gått var expeditionen Ymer-80:s 25-årsjubileum på Kungl. Vetenskapsakademien. Ymer-80 var inspirationen till Polarforskningssekretariatets tillblivelse. Frågorna som forskarna ställde 1980 är till en del desamma som idag, men den tekniska utvecklingen har gjort att villkoren för forskningen nu ser helt annorlunda ut.

Jag ser med stor tillförsikt fram mot ett nytt polarår, som bland annat kommer att innebära att Polarforskningssekretariatet blir värd för IASC-sekretariatet (International Arctic Science Committee) och dess verksamhet, och att planeringen av det Internationella polaråret 2007–2008 (IPY) går in i en mer intensiv fas.

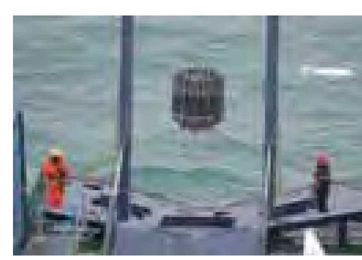
Foreword

It was a brilliant Polar Year in 2005. The biggest Arctic expedition in the Swedish Polar Research Secretariat's history, Beringia 2005, was carried out with more than 130 researchers from 16 countries. Research subjects included the navigation of migratory birds, avian viruses, the threat posed to marine life by the diminishing ozone layer, climate variations and environmental toxins. The scientists' findings are sure to give us a great deal of valuable knowledge.

As for me, I had the privilege of making the trip to the Arctic in a fully loaded Hercules plane in connection with the rotation of the researchers. The experience was dizzying. I gained insight into how complex the logistics are and what enormous capacity to think innovatively – and think anew – is required to meet the requests of researchers. Barrow, our destination, provided a unique and fascinating opportunity to get to know a community, whose 5,000 or so residents come from a wide variety of countries and cultures. At first I thought Barrow was inhospitable, barren and gray, but after a few days its singular beauty unfolded and I saw the warmth and pride of the people who live there.

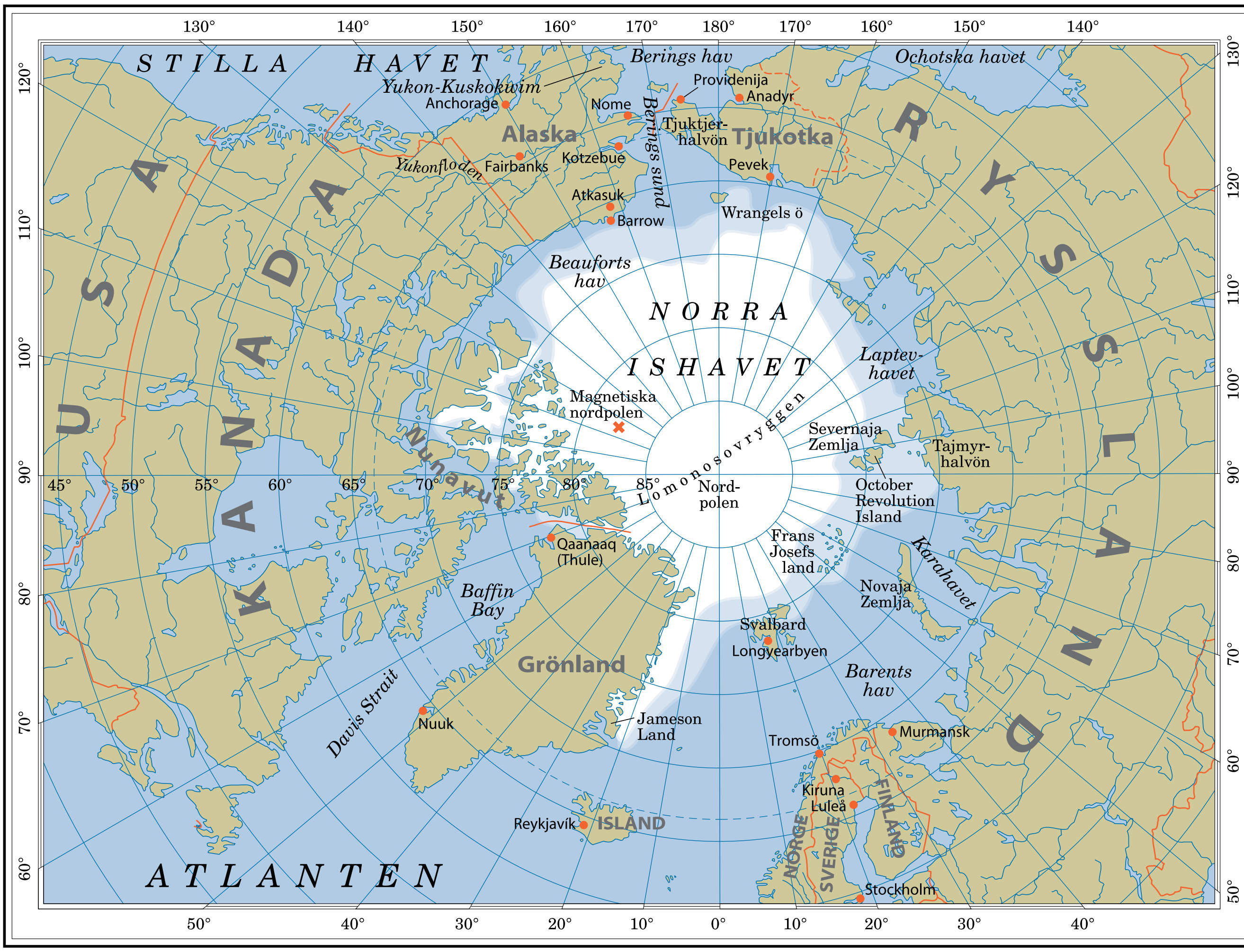
The 25th anniversary of the expedition Ymer-80 at the Royal Swedish Academy of Sciences was another memorable experience. Ymer-80 was the inspiration behind the creation of the Swedish Polar Research Secretariat. Researchers are still asking some of the same questions they asked in 1980, but technical progress since has made current research conditions utterly different.

I am looking forward with great confidence to a new Polar Year. Among else, the Swedish Polar Research Secretariat will be hosting the secretariat of IASC (International Arctic Science Committee) and the planning of the International Polar Year 2007–2008 will be moving into a more intensive phase.



CTD-rosetten i Odens akter är ett viktigt instrument för de marina forskarna.

The CTD rosette on Oden's stern deck is an important instrument for the marine scientists.



Anders Karlqvist
Chef
Polarforskningssekretariatet

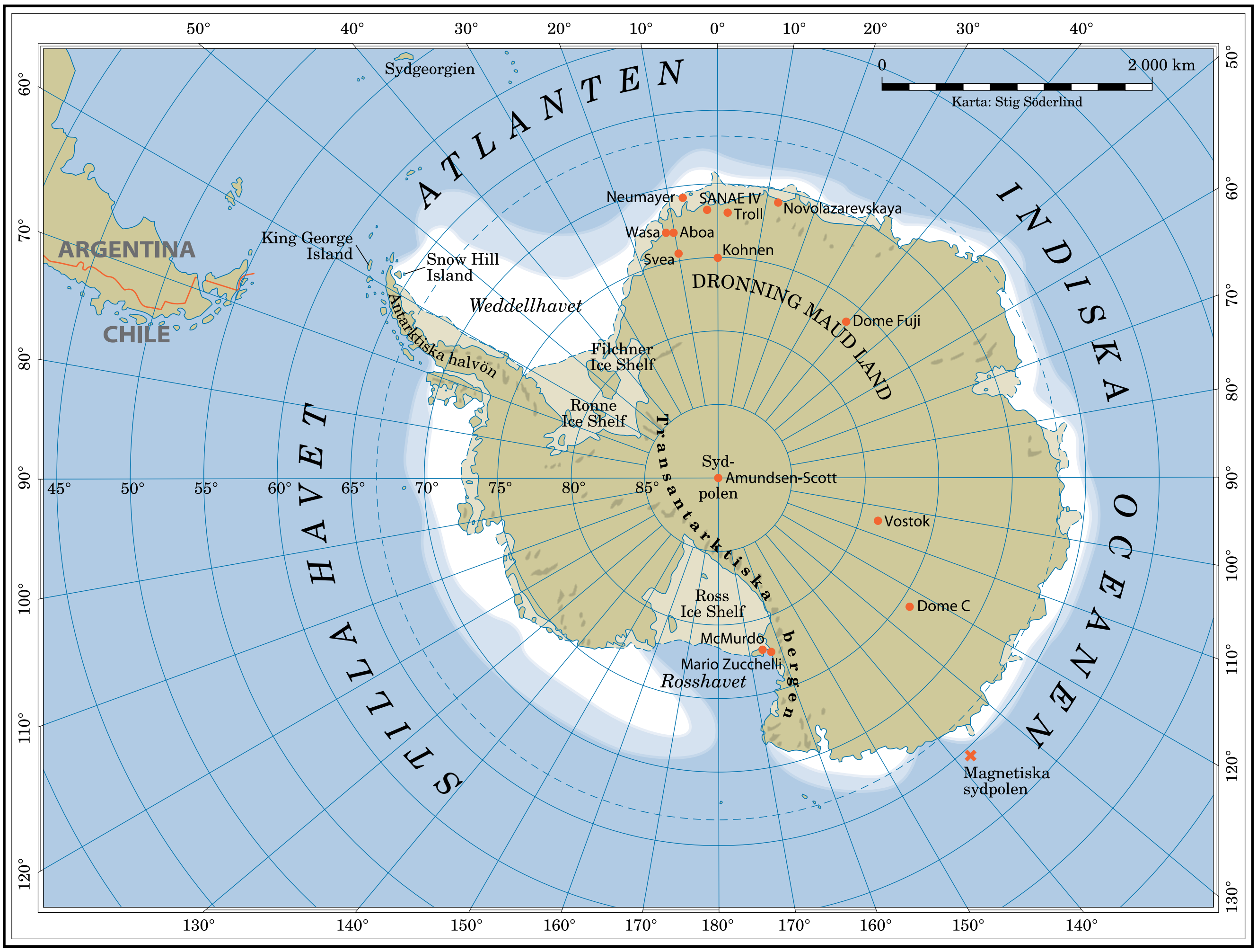
Polaråret som gått

Polaråret 2005 skulle kunna sammanfattas i ett begrepp – Beringia 2005. Expeditionen till området kring Berings sund sommaren 2005 var den största svenska polarforskningssatsningen någonsin. Det var ett stort vetenskapligt företag, eftersom det omfattade en mängd olika discipliner med intresseområden såväl på land som till havs. Expeditionen rörde sig inom kanadensiska, amerikanska och ryska territorier med ett svenskt forskningsfartyg, isbrytaren Oden, och svenska flygvapnets Hercules C-130. Tidsschemat för alla dessa aktiviteter var knapp och samordningen mellan olika forskargrupper ställde stora krav på den operativa ledningen och de logistiska resurserna. Det säger sig självt att det var en stor utmaning för vår lilla organisation att hantera denna kombination av vetenskap, politik, byråkrati och logistik. Planeringen under våren och försommaren samt genomförandet under juli–september blev den dominerande aktiviteten under det svenska polaråret 2005. Resultaten av denna satsning börjar successivt synas i rapporter och föreläsningar, men den vetenskapliga och konstnärliga efterbörden från Beringia 2005 kommer säkerligen att sätta spår långt in i framtiden. Det finns mycket mer att läsa om Beringia-expeditionen i denna årsbok.

År 2005 var på många sätt också ett år fyllt av andra internationella händelser där Polarforskningssekretariatet spelade en aktiv roll. Förutom de många resor och möten som föregick Beringia-expeditionen, som inte minst handlade om kontakter med våra ryska samarbetspartner, så hölls på sedvanligt sätt internationella konferenser med deltagande från vår organisation. En viktig händelse och ett stort arrangemang var Antarktisfördragets konsultativa möte (ATCM) som för första gången hölls i Sverige och Stockholm i juni månad. Utrikesdepartementet var värdar och höll i de praktiska arrangemangen men Polarforskningssekretariatet bidrog på många sätt med polarutställning, informationsmaterial och

Silvertärna på stranden.

Arctic tern on the beach.



Isbrytarna Oden och Healy följdes åt över Arktiska oceanen och nådde Nordpolen tillsammans den 12 september 2005.

Icebreakers Oden and Healy accompanied each other across the Arctic Ocean and reached the North Pole on 12 September 2005.

mediakontakter etc., förutom den rådgivande roll som sekretariatet spelar vid förhandlingsbordet. Ett uppskattat inslag i det sociala programmet under ATCM var visningen av isbrytaren Oden, som just under denna period låg i Stockholms hamn för att mobiliseras inför Beringia-expeditionen. För övrigt tjänstgjorde isbrytaren Oden också som plattform för ett Royal Colloquium (ett möte där Kung Carl XVI Gustaf samlar internationella forskare kring ett aktuellt ämne), som hölls under resan från Luleå till Stockholm med Kungen, Kronprinsessan Victoria och Kronprins Frederik av Danmark samt en grupp forskare och experter. Ämnet var klimatförändringarnas inverkan på den arktiska tundran, ett ämne som Kungen känner ett starkt engagemang för. ATCM i Stockholm blev en stor framgång såväl organisatoriskt som förhandlingsmässigt. Det viktigaste resultatet var utan tvekan annexet om ansvar (liability) i anknytning till miljöprotokollet, som efter många års arbete blev slutförhandlat och beslutat i Stockholm.

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Anne Dekinga letar efter evertebrater (föda för vadarfåglar) på en vidsträckt gyttjig tidvattenstrand i Alaska.

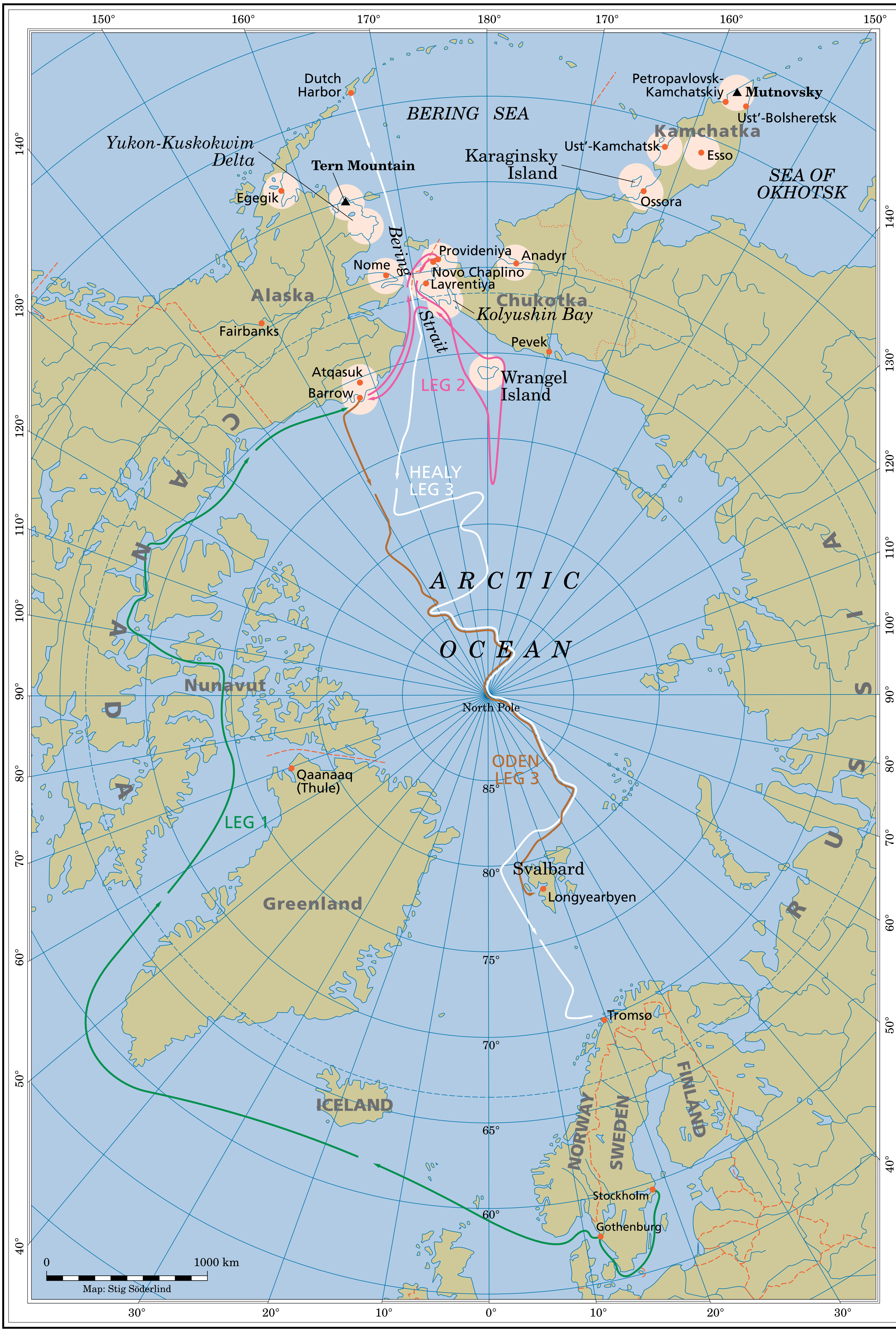
Anne Dekinga looks for evertebrates (shorebird food) on one of the vast Alaskan tidal mudflats.

I april hölls den årliga Arctic Science Summit Week i Kunming, Kina. Med mötet avslutades en epok i IASC:s (International Arctic Science Committee) historia, då sekreteraren sedan starten 1990, Odd Rogne, nu går i pension. Med detta aktualiserades sekretariatets placering och nyrekrytering av en efterföljare till Rogne. Resultatet blev att IASC-sekretariatet från och med januari 2006 har sin placering vid Kungl. Vetenskapsakademien i Stockholm med Polarforskningssekretariatet som värdorganisation och med finansiellt stöd av Vetenskapsrådet. Att vi på detta sätt blir en nod i ett internationellt forskningsnätverk kommer säkert att också bli stimulerande för svensk polarforskning.

Om Beringia 2005 dominerade den operativa verksamheten under året kan det Internationella polaråret (IPY) sägas ha varit det dominerande ämnet för planering och samarbetsdiskussioner. Polaråret, som ska pågå under tidsperioden mars 2007 till mars 2009, kommer att engagera många delar av det svenska forskarsamhället. Finansiering av de stora ambitiösa forskningsprogram med svensk medverkan som nu lanserats kommer med all säkerhet att vara en huvudfråga när vi nu går in i 2006 och genomförandet av polaråret rycker allt närmare. Vetenskapsrådet har det övergripande ansvaret för att koordinera de svenska IPY-insatserna och dess IPY-kommitté fungerar som en samlingspunkt för de svenska intressenterna och de internationella kontakterna.

En viktig resurs för Sveriges polarforskning är isbrytaren Oden, som allt mer fungerar som ett avancerat forskningsfartyg för operationer i Arktis. Knut och Alice Wallenbergs stiftelse har beviljat medel för att utrusta Oden med ett s.k. multibeam, en avancerad typ av ekolod. Detta gör det möjligt att än mer flytta fram positionerna för svensk forskningsverksamhet i Arktis.

Under hösten 2006 kommer Polarforskningssekretariatet att lämna sina logistiklokaler i Veddesta. Verksamheten där flyttas till Kräftriket i anslutning till Stockholms universitets campus, och inom gångavstånd från Sekretariatets lokaler på Kungl. Vetenskapsakademien. Den tyngre utrustningen, som kontainrar och bandvagnar, kommer fortsättningsvis att vara placerad "i fält" i anslutning till isbrytaren Oden i Luleå och stationen Wasa i Antarktis. Det ger anledning till delvis nya satsningar inom teknik och logistik. Vi ser fram emot verksamhetsåret 2006 med tid för förberedelser och planering inför nya stora uppgifter under IPY.



Forskningsexpeditionen Beringia 2005 sträckte sig över stora delar av Arktis. Isbrytaren Oden genomförde tre etapper, varav en över Arktiska oceanen tillsammans med den amerikanska isbrytaren Healy. De ljusa cirklarna markerar forskningsområden på land.

The research expedition Beringia 2005 spread out over large areas of the Arctic. The icebreaker Oden carried out three legs, one together with the US icebreaker Healy across the Arctic Ocean. The highlighted circles mark terrestrial research sites.

Anders Karlqvist
Director-General
Swedish Polar Research Secretariat

The past polar year

The Swedish polar year 2005 can be summed up in one expression – Beringia 2005. The expedition to the region surrounding the Bering Strait in summer 2005 was the biggest Swedish polar research initiative ever. It was a tremendous scientific undertaking as it comprised a wide variety of disciplines and areas of interest on both land and sea. The expedition traveled through Canadian, American and Russian territories on a Swedish research vessel, the icebreaker Oden, and a Swedish Air Force Hercules C-130. The schedule for all of these activities was tight and coordination among various research teams put tough demands on operational management and logistical resources. It goes without saying that it was a huge challenge for our small organization to manage this combination of science, politics, bureaucracy and logistics. The planning in spring and early summer and the expedition itself in July-September became the dominant activities of the Swedish polar year 2005. The results of the initiative are beginning to show up in reports and lectures now, but the scientific and artistic reverberations of Beringia 2005 will surely be heard long into the future. There is much more to read about the Beringia expedition in this yearbook.

In many ways, 2005 was also a year filled with other international events in which the Swedish Polar Research Secretariat played an active role. In addition to the numerous trips and meetings that preceded the Beringia expedition, which in no small measure involved contacts with our Russian partners, our organization participated in the customary international conferences. The Antarctic Treaty Consultative Meeting (ATCM) was a major event held in Sweden for the first time, in Stockholm in June. The Ministry for Foreign Affairs was the official host and managed the practical arrangements, but the Swedish Polar Research Secretariat contributed in many ways with a polar exhibition, information materials and media contacts, etc., in addition to the advisory role the Secretariat plays at the negotiating table.

Fältläger för de landbaserade forskarna under etapp 2, Tjukotka.

Field camp for the terrestrial scientists on leg 2, Chukotka.

Visitors especially enjoyed one of the events on the social program, a tour of the icebreaker Oden, which happened to be tied up in the Port of Stockholm during that particular period for her mobilization for the Beringia expedition. Oden also served as the platform for a Royal Colloquium (a meeting at which King Carl XVI Gustaf gathers international researchers around a topic of current interest) that was held during the journey from Luleå to Stockholm and attended by the King, Crown Princess Victoria of Sweden, Crown Prince Frederik of Denmark and a group of researchers and experts. The subject was the climate change and its influence on the Arctic tundra, an issue to which the king is strongly committed. The ATCM in Stockholm was a tremendous success organizationally and in terms of negotiations. Without a doubt, the most important result was the annex on liability in connection with the environmental protocol. After years of effort, the negotiations were finalized and the protocol adopted in Stockholm.

The annual Arctic Science Summit Week was held in April in Kunming, China. The meeting brought an epoch in the history of the International Arctic Science Committee to a close as the secretary since the beginning in 1990, Odd Rogne, is retiring. The event brought the location of the Committee and the recruiting of Rogne's successor to the fore. The outcome was that the IASC offices will be located at the Royal Swedish Academy of Sciences in Stockholm as of January 2006 with the Swedish Polar Research Secretariat acting as the host organization and with funding from the Swedish Research Council. Our becoming a node in an international research network in this way is certain to be stimulating for Swedish polar research.

If Beringia 2005 dominated operational activities during the year, the International Polar Year (IPY) can certainly be declared the dominant subject of planning and partnership discussions. The Polar Year, which actually extends from March 2007 to March 2009, will involve many components of the Swedish research community. Financing the large and ambitious research programmes recently launched in which Swedish scientists will be involved will most assuredly be one of the main issues now that we are moving into 2006 and implementation of the Polar Year is drawing ever closer. The Swedish Research Council has overall responsibility for coordinating Swedish IPY initiatives and its IPY committee acts as an assembly point for Swedish stakeholders and international contacts.

The icebreaker Oden, increasingly used as an advanced research vessel for operations in the Arctic, is a key resource for Swedish polar research. The Knut and Alice Wallenberg Foundation has provided a grant to equip Oden with multibeam, a sophisticated type of echo sounder. This will make it possible to further advance positions for Swedish research activities in the Arctic.

The Swedish Polar Research Secretariat will be leaving its logistical premises in Veddesta in autumn 2006 and moving operations there to the Kräftriket area surrounding the campus of Stockholm University, within walking distance of the Secretariat's offices at the Royal Swedish Academy of Sciences. The heavier equipment, such as containers and tracked vehicles, will be placed "in the field" near icebreaker Oden in Luleå and at the Wasa station in Antarctica. This will require partially new initiatives in the areas of technology and logistics. We are looking forward to the 2006 operational year and time for preparations and planning for new major tasks during the IPY.

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Överst Top

Den svenska helikoptern gick i skytteltrafik mellan isbrytarna Oden och Healy under etapp 3 av Beringia 2005.

The Swedish helicopter had shuttle service between icebreakers Oden and Healy during leg 3 of Beringia 2005.

Höger Right

Det fanns gott om björnspår på Tjukotka.

There was plenty of bear tracks in Chukotka.

Åsa Lövenvald
Journalist på USCGC Healy
under etapp 3 av Beringia 2005

Det var tråkigt att vara där men ännu tråkigare att komma hem

Nu i efterhand är det de branta trapporna jag kommer ihåg. Att det dunsade av fotstegen, samtidigt som det klingade metalliskt i trapphuset. Alltid på väg ner, till gymmet eller till mässen. Man kände sig lättare när man gick uppför trappan, det dunsar inte på väg upp.

Och att det var ensamt. Jag ser mig själv ensam på väg ner till en måltid. Utan att vara riktigt hungrig. Sloppy Joes, inoljad potatis, och i slutet, när de förstått att det fanns två personer ombord som inte åt kött, panerad torsk. Varje dag. Det skarpa ljuset i mässen för att kunna operera på ett av matborden, om någon skulle få blindtarmsinfektion. Resten av Healy hade en beige hinna över belysningen. I mässen syntes man. Extra mycket om man var sen och alla platser bland forskarna var upptagna. Självmedvetet irrade man med blicken efter en ledig plats innan man gick över till babord sida, där besättningen satt. I början var det ensamt att vara civil bland alla blåklädda i U.S. Coast Guard. I slutet hade de fått namn.

Gymmet var också beigt. Och kallt. I taket satt ett luftintag direkt utifrån Arktis. När man gjorde sit-ups fattade man var man var. Runt luftröret ovanför sit-up-brädan växte en isklump. Vi svenskar värmde upp, i skid- eller trappmaskinen eller på cykel, minst en kvart. Nordamerikaner värmer inte upp. De stretchar nacken i tre minuter, sedan hårdkör de. Tunga vikter för stora muskler. De rycker. Och hinner inte titta på TV-monitorn. Den visade ändå bara det som vi alltid såg från bryggan. Is. Man kunde se i förväg att "snart smäller det". När isblocken låg i travar framför oss. Det var ofelbart, båten tippade alltid åt sidan när man visste att den skulle göra det. Det var i skidmaskinen och på löpbandet man tappade balansen.

De branta trapporna på Healy.
The steep stairs of Healy.

I gymmet kunde man lyssna på musik. I och för sig satt en stor lapp på stereon: ”Keep loud and obnoxiuos music for yourself.” Ändå hördes allt för ofta nordamerikansk deathmetal med rapinslag. Men att få höra musik rakt ut i ett rum. Då rockade och sken Healy.

I hytten hörde man grannarna genom väggen när de drog ut tandtråden ur sin behållare. Därför hade jag alltid musik i hörlurar. Jag fick ny, obnoxious, amerikansk pop av en ung militär. Det var det enda nya jag skaffade under resan. Men jag saknade inget. Jag kunde kombinera mina tröjor och byxor så att jag kände mig fin varje dag. Jag älskar den där begränsningen. Det som finns är det som finns och det är bra. Det räcker. Jag var nöjd. Bara ett handfat att städa av då och då. Och dammsugaren som gav städlust, som man bar på ryggen. En säng och ett skrivbord. Det är allt man behöver när maten är serverad och läkaren finns en halv minut bort. Elektrikern och dataexperten två minuters promenad bort.

Utan tidsbeställning. Då behöver man inte en ny liten, glittrig topp. De fester vi hade var på isen, så frågan om vad man skulle ha på sig handlade om overall eller jacka och termobyxor.

Vi var som kalvar när vi hade våra två fester. Kroppen skrek efter att få röra sig på en stor yta. Jag har inte festat så bra sen jaga-runt-kalasen när jag var sex år. Hela jag visste vad jag ville. Röra mig, skratta och tumla. Inte någon gång har jag sett så många människor tumla runt som på Nordpolen. Det är det man vill när man varit instängd i sex veckor. Men den militära disciplinen satte stopp för excesser. När kaptenen tyckte att det räckte med yra ringde han in oss. På led lydde vi och släntrade upp för landgången. Det var konstigt det där, att man nästan skämdes för galenskapen när man väl kom in i det beiga igen. Sordin. Efter första steget ombord blev vi tysta, kontrollerade och seriösa igen. Som i ett trollslag. Men det var det som gjorde festerna så bra. Kontrasten.

Alltid olika utrop i högtalarna. U.S Coast Guard övade flera gånger om dagen. Kaosberedskap. Klockan tolv varje dag var det övning i att känna igen hur olika varningssignaler låter. Man överbord. Flygkrasch. Jag har aldrig känt mig så trygg. Det jobbigaste utropet var när avloppet var trasigt. Om man var kissnödig då, kunde kommande tre timmar bli ett helvete. En dag fick kaptenen nog och berättade i högtalarna vad de hade hittat i avloppet. Vi blev förvånade att det fanns sex på Healy. Hur var det möjligt att någon hade behövt använda kondom? Ingen hade sett minsta tillstymmelse till erotik ombord. Var det bland nattarbetarna det hände? Var det på natten Healy sprakade och var laddad? Det blev lite annorlunda när nattjobbarna fick jobba dag efter att vi ställt om till europeisk tid. De var nästan uppklädda. Och vissa hade smink. Nattjobbare dagtid och musik i gymmet. Då sken Healy.

Det var en mjuk övergång till civilisationen att mellanlanda på isbrytaren Oden. Oden skimrar i rosa och guld. Det luktar blomma på Oden. De som rest på expeditionen där gick omkring i raggsockor och kramades. Gjorde halsband. Och dansade.

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Vänster Left

Den amerikanska kustbevakningens isbrytare Healy, som gick parallellt med isbryt-aren Oden under Beringia-expeditionens etapp 3, även kallad HOTRAX (Healy-Oden Trans-Arctic Expedition).

US Coast Guard Cutter Healy, who worked in pair with the Swedish icebreaker Oden during leg 3 of the Beringia 2005 expedition, also called HOTRAX (Healy-Oden Trans-Arctic Expedition).

Höger Right

Provtagningsutrustning på Healys däck.

Coring equipment on Healy's deck.

På flygplatsen i Longyearbyen fanns barn. Små människor som hoppade upp och ned. Och skrek. Som inte hade tålamod. Ibland kändes den där Healyverkligheten så konstruerad. Inga barn, inget liv. Jag saknade en frodig märr som sprang omkring i korridorerna. För att få med det där vilda, frustande, levande som djur och barn har. Vårt tålamod och vår återhållsamhet var inte riktigt mänsklig. Vi var så förbannat kultiverade att vi förlorade naturen på vägen. När inte avloppet var trasigt.

Oslo–Stockholm. Ingen mat serverad gratis och regelbundet längre. Man skulle använda pengar. Men Aftonbladet fick man av SAS. ”Kicki Danielsson smygäter korv.” Det var där det började. Rädslan för civilisationen.

När man inte korsat en gata på två månader måste man vara tvärsäker på att gubben är grön när man börjar röra sig i stan igen. Och att man har någon att hålla i handen. De är snabba, oberäkneliga och hårda, bilar. Det finns så mycket som är farligt när man inte är på båt i ishavet. Det är inte konstigt att så många har panikångest.

I början kunde jag inte avsluta ett telefonsamtal. Jag visste inte när det var dags att säga hej då. Eller om man ens säger hej då när man pratat klart. De flesta civilisationsbeteenden, som jag trodde satt i ryggmärgen, hade försvunnit. Datum, klockslag, pengar, räkningar, tvättstugan. Jag kom inte ihåg hur man gör. Berättar man för Affe i närbutiken hur man mår, samtidigt som man får växeln tillbaka?

Det kommer tidningar varje dag. Flera olika. Där står det om vad som är dåligt och vad som är bra. Recensioner. Recept. Tips på fräna inredningar för hemmet. Inget är bra som det är. Man ska inte nöja sig med det man har. Valet står inte mellan overall och termobyxor längre. Det har kommit en ny Bill Murray-film som ska vara bra, det är 70 % rea på Hennes och Mauritz, tonfisken är fin på Konsum, en transvestit har gjort årets popskiva. De mejlar från TEMO och undrar om jag känner att det händer saker som jag missar. Jag vill svara att jag har en känsla av att jag är med om för mycket. Det räckte bra med en beige hytt där jag hade en säng och ett handfat och det enda som kunde recenseras var förra lördagens Bingo-omgång.

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Skribenten i sin hytt på Healy och en nyfiken förbipasserare.

The writer in her Healy cabin and a curious passer-by.

Åsa Lövenvald
Journalist
onboard the USCGC Healy
on leg 3 of Beringia 2005

Being there was a drag but coming home was even more so

In hindsight, what I remember is the steep stairs. The thud of footsteps and the metallic clanking in the stairwell. Always on the way down, to the gym or the mess. You felt lighter when going up the stairs; you don't thud when you're on the way up.

And that it was lonely. I see myself alone on the way down to eat. Without being really hungry. Sloppy Joes, greasy potatoes and toward the end when they had finally understood that there were two people on board who did not eat meat, fried cod. Every single day. The glaring light in the mess that made it possible to operate on one of the dining tables should someone get appendicitis. There was a beige film over the rest of the lighting on Healy. You stood out in the mess. Especially if you were late and all the seats for the researchers were taken. Self-consciously scoping out the room for an empty seat before going over to the port side, where the crew sat. It felt lonely at first being a civilian among all the blue-uniformed U.S. Coast Guard personnel. By the end of the voyage, they all had names.

Den beiga mässen på Healy.
The beige mess deck at Healy.

The gym was also beige. And cold. There was a ventilation duct in the ceiling taking in air direct from the Arctic. You realized where you were as you did your sit-ups, for there was a clump of ice growing around the air duct above the sit-up board. We Swedes warmed up on the ski or stair machine or on a bike for at least fifteen minutes. North Americans don't warm up. They stretch their necks for three minutes and then go for the burn. Heavy weights for big muscles. They jerk. And they don't have time to look at the TV monitor. The only thing it showed anyway was what we always saw from the bridge. Ice. You could see ahead of time that the bang was coming. When the blocks of ice stacked up in front of us. Infallibly, the ship always tipped to the side when you knew it would. If you were on the ski machine or the treadmill, you lost your balance.

You could listen to music in the gym – although there was a big note on the stereo: "Keep loud and obnoxious music to yourself." Regardless, you heard North American death metal punctuated by rap far too often. But to be able to hear music straight out in to a room. That is when Healy rocked and shone.

The cabin walls were so thin I could hear my neighbors when they pulled their dental floss out of the box, so I always had music going in my earphones. I got new, obnoxious American pop from a young soldier. That was the only new thing I acquired on the journey. But I lacked for nothing. I could combine my tops and trousers so that I felt well-dressed every day. I love that restriction. You have what you have and that's fine. It's enough. I was happy. Only a sink to clean now and then. And the vacuum cleaner you carried on your back that gave you the urge to clean. A bunk and a desk. That's all you need when your food is served to you and a doctor is thirty seconds away. The electrician and the computer expert are a two-minute walk away. And you don't have to make an appointment. In those circumstances, who needs an adorable new little spangled top? When we partied, it was on the ice, so the question of what to wear came down to snowsuit or jacket and thermal trousers.

We were like calves when we had our two parties. The body was screaming to move over a large area. I haven't partied so hearty since the run-around-like-crazy gatherings when I was six. My entire being knew what I wanted. To move, to laugh, to tumble. I've never

+
Rörelseglädje på isen – med fotboll!
Enjoying the movement on ice – and soccer!

seen so many people tumbling around as on the North Pole. That's all you want when you've been shut in for six weeks. But the military discipline kept the excesses in check. When the captain thought there had been enough frenzy, he rounded us up. We formed a column and obeyed, sauntering up the gangway. It was so odd, we were almost embarrassed about the craziness once we were back in the beige again. Mute. After the first step onboard, we were silent, controlled and serious again. As if under a spell. But that was what made the parties so good. The contrast.

Constant, ever-changing orders and announcements over the PA system. The U.S. Coast Guard did exercises several times a day. Chaos-readiness. At noon every day, we practiced recognizing warning signals. Man overboard. Plane crash. I have never felt so safe. The worst announcement was when the pipes were clogged. If you had to pee at that particular moment, the next three hours would be hell on ice. One day the captain had had enough and announced over the PA system what had been found in the pipes. We were surprised that sex was apparently happening on Healy. How could it be that someone had needed to use a condom? Nobody had seen the least vestige of eroticism onboard. Was it the night workers going at it? Was it at night that Healy was charged up and crackling? Things were a little different when the night workers started working days after we switched to European time. They were almost dressed up. And some of them had makeup on. Night workers in the daytime and music in the gym. That is when Healy shone.

The intermediate stop on Oden was a gentle transition to civilization. Oden shimmers in pink and gold. It smells like flowers on Oden. The people who were on that part of the expedition walked in their stocking feet and hugged. Made necklaces. And danced.

There were kids at the airport in Longyearbyen. Little people who jumped up and down. And shrieked. Who were not patient. Sometimes it felt like that Healy reality was so constructed. No children, no liveliness. I wanted to see a fat, glossy mare running around in the corridors. To bring in that wild, snorting, aliveness of animals and children. Our patience and restraint were not really human. We were so bloody cultivated that we had lost nature along the way. When the pipes weren't clogged, that is.

Oslo–Stockholm. No food served free and regularly any more. You had to use money – although SAS gave us copies of the evening scandal rag. "Kicki Danielsson [Swedish singer] secretly pigs out on hotdogs." That is when it started. The fear of civilization.

When you haven't crossed a street in two months, you really have to make sure the little man is green when you start navigating the city again. And that you have somebody to hold your hand. They are fast, unpredictable and hard, those cars. There is so much danger when you are not on a ship in the Arctic Ocean. It's no wonder so many people have panic attacks.

At first I couldn't bring a phone call to an end. I didn't know when it was time to say bye. Or if you even say bye when you're finished talking. Most of the civilized behaviors that I thought were bred in the bone had vanished. Date, time, money, bills, the laundry room. I couldn't remember what to do. Do I tell Alf in the convenience store how I am doing while he is giving me my change?

Newspapers come every day. Several. They tell us what is bad and what is good. Reviews. Recipes. Reports on the new and hip in home decor. Nothing is fine as it is. You should not be happy with what you have. The choice is no longer between snowsuit and thermal trousers. There is a new Bill Murray flick that is supposed to be good, there's a 70 percent-off sale at H&M, the tuna is good at the local market, a transvestite made the pop record of the year. A market survey company e-mails me, wanting to know if I feel like I'm missing out on events. I want to reply that I have a feeling I'm involved in too much. A beige cabin where I had a bunk and a sink and the only thing that could be reviewed was last Saturday's Bingo session was, in fact, enough.

Innehåll Årsredovisning 2005

Resultatredovisning

Verksamhetsåret 2005

Polarforskningssekretariatet har enligt instruktionen (SFS 1998:414) till uppgift att främja och samordna svensk polarforskning och utveckling som har anknytning till denna.

I regeringens regleringsbrev för 2005 anges Polarforskningssekretariatets politikområde som forskningspolitik. Målet är att Sverige skall vara en ledande forskningsnation, där forskning bedrivs med hög vetenskaplig kvalitet. Vidare anges verksamhetsområdet till forskningsfrämjande insatser och målet till att tillhandhålla goda logistiska och operativa förutsättningar för polarforskning.

I återrapporteringen skall Polarforskningssekretariatet redovisa en samlad bedömning av hur sekretariatets verksamhet bidragit till den del av målet som avser polarforskning.

Under verksamhetsåret 2005 har sekretariatets operativa insatser varit fokuserade på planering och genomförande av expeditionen Beringia 2005. Expeditionen, som omfattade såväl landbaserad forskning på den arktiska tundran i Tjukotka, Kamtjatka och Alaska som marin forskning över Arktiska oceanen från Alaska via Nordpolen till Svalbard med isbrytaren Oden som plattform, engagerade nära ett par hundra deltagare från 16 nationer. Expeditionen skedde i samarbete med ryska, kanadensiska och amerikanska partners.

Beringia 2005 har ställt stora krav på sekretariatets resurser. Det har varit nödvändigt att ta i anspråk såväl anslagssparande från föregående år som att utnyttja kommande års anslag för slutbetalningar under 2006 till Sjöfartsverket. Den ogynnsamma kostnadsutvecklingen av olja har varit en stor belastning på budgeten. Oljeprisets utveckling torde vara den mest kritiska faktorn för framtida verksamhet.

Det internationella samarbetet har engagerat Polarforskningssekretariatet på flera plan. Förutom de vetenskapliga och logistiska insatserna under Beringia 2005, där samarbetet med amerikanska National Science Foundation och forskningsfartyget Healy under färden över Arktiska oceanen var en pionjärinsats för svensk polarforskning, har sekretariatet varit aktivt i flera internationella samarbetsorganisationer. Sekretariatet för International Arctic Science Committee (IASC), som kommer att finansieras av Vetenskapsrådet, flyttar från Oslo till Stockholm i januari 2006 med Polarforskningssekretariatet som värd.

Polarforskningssekretariatet har ett nära samarbete med Vetenskapsrådet, som har ett övergripande ansvar för polarforskning, genom dess Polarforskningskommitté och Kommittén för infrastruktur, som har en strategiskt viktig uppgift för finansiering av infrastruktur för forskning. Polarforskningssekretariatet och Vetenskapsrådet har också ett gemensamt engagemang för den utåtriktade verksamheten.

En viktig händelse under 2005 var Antarktisfördragets konsultativa möte där Sverige för första gången var värd. För mötet som ägde rum i Stockholm i juni ansvarade Utrikesdepartementet och sekretariatet bidrog både i den praktiska planeringen och genomförandet, och i en rådgivande funktion under mötet.

Planeringen för framtida expeditioner domineras av förberedelserna inför Internationella polaråret 2007–2008 (International Polar Year, IPY). Av resursmässiga skäl kommer inga stora expeditioner att genomföras under 2006, endast förberedelser vid forskningsstationen Wasa i Antarktis kommer att göras under säsongen 2006/07.

Anspråken på resurser för svenska polarinsatser under Internationella polaråret kommer att vara mycket stora och vida överskrida de ramar som Polarforskningssekretariatet disponerar över. Därför vilar ett stort ansvar på Vetenskapsrådet och andra forskningsfinansiärer att tillsammans med sekretariatet finna vägar att uppnå en kraftfull och kostnadseffektiv medverkan av svenska polarforskare i den storskaliga internationella satsning på polarforskning som kommer att genomföras under IPY med början i mars 2007.

Årsredovisningen i sin helhet, kommer i likhet med tidigare år, att ingå i Polarforskningssekretariatets årsbok, som innehåller en fyllig redogörelse med bland annat forskarnas rapporter från det gångna årets arbete.

Organisationsstyrning

I regleringsbrevet anges målet för organisationsstyrning till att sekretariatet skall verka för en långsiktig och god personalförsörjning med för verksamheten ändamålsenlig kompetens.

I återrapporteringen skall Polarforskningssekretariatet redovisa mål och måluppfyllelse för kompetensförsörjningen i förhållande till verksamhetens mål och resultat. Av redovisningen skall framgå

- i vilken omfattning myndighetens mål för kompetensförsörjningen under 2005 har uppnåtts,
- vilka åtgärder som har vidtagits, och
- vilka mål som gäller för myndighetens kompetensförsörjning 2006 och 2007–2008.

Inom ramen för detta skall myndighetens insatser för att främja etnisk och kulturell mångfald och ökad hälsa samt för att åstadkomma en ändamålsenlig åldersstruktur, könsfördelning och rörlighet bland personalen framgå. Redovisningen skall göras för grupper av anställda inom de tre kompetenskategorierna lednings-, kärn- och stödkompetens, om så är lämpligt.

Organisation

Styrelsen består av sju ledamöter som är förordnade av regeringen för en treårsperiod. Den 1 juli 2005 inleddes en ny period. Chefen för sekretariatet ingår i styrelsen. Under 2005 hölls tre styrelsesammanträden.

Den interna organisationen är indelad i funktionerna ledning, administration, information och dokumentation, miljö, teknik och logistik medan planeringen av expeditioner sker i projektform.

Personal

De personella resurserna utgjordes vid årsskiftet av en fast kärna tillsvidareanställd personal (15 personer) som kompletteras med extern kompetens för att tillgodose särskilda bemanningsbehov, framför allt i samband med genomförandet av expeditioner. Vid årsskiftet var fyra personer tjänstlediga för studier eller annat arbete. Under 2005 hade åtta personer expeditionsanknutna tidsbegränsade anställningar. Ytterligare sex personer har haft vikariat eller andra tidsbegränsade anställningar. Genomsnittsåldern var under året 47 år för kvinnor och 45 år för män.

Kompetensförsörjning

Polarforskningssekretariatet bedömer att kompetensförsörjningen är fortsatt god avseende både att behålla och utveckla den egna personalen samt vid rekrytering av ny personal. Avgångar på grund av ålderspension planeras ske från år 2009. I samband med rekrytering görs ansträngningar att främja etnisk och kulturell mångfald, likaså att bryta den traditionella könsrollsindelningen som finns inom administrativa och tekniska yrken. Verksamheten kräver mångfald i kompetensen vilket speglas i medarbetarnas erfarenheter och bakgrund. Genom projektarbetsformen involveras olika yrkesgrupper i både planeringen och genomförandet av expeditioner. I likhet med föregående år har målen för större och/eller komplexa expeditioner uppfyllts, dvs.:

- att expeditionsledare och logistikansvarig tillhör den fasta personalen
- att flera bland personalen genom deltagande i expeditioner får kompetens att aktivt delta i fältverksamheten
- att personal med specialistkompetens projektanställs
- att servicefunktioner fullgörs av såväl projektanställd personal, som konsulter.

Policyn att ha en fast personalstyrka som förstärks med personal med specialistkompetens har även detta år fungerat väl. Sedan flera år tillbaka har sekretariatet ett omfattande kontaktnät för specialbemanning.

Under 2006 planeras rekrytering som förstärker IT-kompetensen. Erfarenheterna från Beringia 2005 kommer att skapa en bas för den fortsatta inriktningen på kompetensutvecklingen och den framtida bemanningen.

Examensarbeten

Polarforskningssekretariatets verksamhet spänner över flera områden där utvecklingen går snabbt framåt. Ett sätt att ta tillvara och utnyttja ny teknologi inom miljö, teknik och logistik är att stärka samarbetet med universitet och skolor och att involvera studenter i verksamheten. Studenterna erbjuds möjlighet att göra sina examensarbeten hos oss. Under 2005 har en student från Kungliga Tekniska Högskolan (KTH) i Stockholm skrivit en uppsats på D-nivå om rening av gråvatten från den svenska forskningsstationen Wasa i Antarktis. Samarbete har också skett med KTH Kista och Ericsson AB avseende kommunikation i polarområdena.

Att involvera studenter i verksamheten har visat sig vara ett bra sätt att få tillgång till nya idéer och aktuell forskning. Samtidigt bidrar det till att göra svensk polarforskning mer känt på universiteten, inom näringslivet och även internationellt. Samarbete inriktat på ny teknologi fortsätter med högskolor och universitet, liksom med företag inriktade på kommunikation och teknik.

Miljöledningssystem

Polarforskningssekretariatets miljöledningssystem utgår från resultaten av den miljöutredning som gjordes 2004. Miljöledningssystemet har strukturerats i enlighet med ISO 14 001 och regeringens riktlinjer. En generell miljöutbildning har getts under året till alla expeditionsdeltagare.

Lokaler och infrastruktur

Polarforskningssekretariatet har sina lokaler hos Kungl. Vetenskapsakademien i Stockholm. Förutom dessa kontorslokaler har logistikenheten ett utrustningsförråd med verkstad i Järfälla. Det nuvarande hyreskontraktet, som går ut hösten 2006, har sagts upp eftersom utrymmena inte längre är ändamålsenliga för nuvarande verksamhet. Under hösten 2006 kommer en ny logistik/teknikfunktion att skapas i lokaler inom Stockholms universitets område.

I Antarktis finns två forskningsstationer, Wasa och Svea, med infrastruktur i form av fordon, forskningsmoduler och annan fältutrustning. Den tunga utrustning, containrar och vinschar, som används ombord på isbrytaren Oden förvaras mellan expeditionerna i fartygets förråd i Luleå.

Verksamhetens kostnader och intäkter

Polarforskningssekretariatets verksamhet redovisas inom följande områden:

- Polarforskning – genomförda och planerade expeditioner
- Miljöverksamhet
- Internationellt samarbete
- Information och dokumentation

Kostnaderna varierar stort mellan åren beroende på expeditionernas storlek och inriktning. Forskningssatsningar med omfattande samordning och tung logistik dominerar, även om mindre krävande logistik och annat stöd är viktigt för enstaka projekt och återkommande program. Finansieringen av de stora expeditionerna har under flera år möjliggjorts genom att uppkommet anslagssparande från ett år har fått användas under ett senare år. Så var fallet även under 2005 då sekretariatet fick disponera hela sitt anslagssparande från 2004.

Ramanslag med anslagssparande (tkr)					
	2005	**2004**	**2003**	**2002**	**2001**
Ramanslag	25 203	25 080	24 169	25 526 7 000	23 605
Anslags-sparande från föregående år	5 357	3 610	757	1 797	6 680
Disponibelt belopp	**30 560**	**28 690**	**24 926**	**32 526**	**30 285**

Både år 2004 och år 2005 har sekretariatet haft stora kostnader i och med att verksamheten har varit omfattande. Under 2004 hade sekretariatet det logistiska ansvaret för genomförandet av Arctic Coring Expedition (ACEX), en internationell expedition med huvudsaklig finansiering av British Geological Survey. Under 2005 har Beringia 2005 dominerat.

Resurserna under den senaste femårsperioden har utnyttjats maximalt då sekretariatet har genomfört flera stora expeditioner, fyra isbrytarexpeditioner (2001, 2002, 2004 och 2005) samt en geologiexpedition till arktiska Ryssland 2002. Forskning har också bedrivits i Antarktis vid Wasa och Svea under säsongerna 2001/02–2004/05. Informationsfunktionen stärktes under 2003 från en till två tjänster.

Verksamhetens kostnader (tkr)					
	2005	**2004**	**2003**	**2002**	**2001**
Expeditioner	53 223	54 230	14 524	31 858	26 503
Miljö	366	316	408	445	439
Internationellt	1 677	1 168	2 389	1 097	854
Information	1 850	2 885	2 248	1 335	1 502
Totalt	**57 116**	**58 599**	**19 569**	**34 735**	**29 298**

Verksamhetens intäkter exklusive anslaget (tkr)					
	2005	**2004**	**2003**	**2002**	**2001**
Bidrag från Utrikes-departementet	160	160	165	160	160
Bidrag från British Geological Survey	448	33 847	150	0	0
Bidrag från Joint Oceanographic Institutions	0	618	573	884	29
Övriga bidrag	0	0	254	0	0
Intäkter av avgifter	4 598	387	54	123	121
Finansiella intäkter	88	28	212	418	347
Totalt	**5 294**	**35 873**	**1 408**	**1 585**	**657**

Sekretariatets bedömning inför framtida expeditioner är att ett utökat samarbete med andra länder och därmed gemensam finansiering kommer att bli allt vanligare. Samutnyttjande och samfinansiering ger svenska forskare ytterligare möjligheter att bedriva forskning i de arktiska farvattnen och även vid de svenska stationerna i Antarktis.

Polarforskningsexpeditioner

Polarforskningssekretariatets verksamhetsgren är polarforskningsexpeditioner.

Mål 1: Polarforskningssekretariatet skall tillhandahålla logistik och utrustning för planering och genomförande av polarforskningsexpeditioner och polarforskning av hög internationell klass.

Återrapportering: Polarforskningssekretariatet skall redovisa

- vilka polarexpeditioner som sekretariatet bidragit till, fördelade på expeditioner med svenskt respektive utländskt logistikansvar,
- vilka forskningsprojekt som utförts under expeditionerna och hur dessa prioriterats av den vetenskapliga kommitté som hanterar polarforskning och översiktligt vilka forskningsprojekt som inte har kommit i fråga inom ramen för de utförda expeditionerna,
- antalet expeditionsdeltagare fördelade på forskare och logistikpersonal, och uppdelade efter kön,
- kostnaderna under året för varje planerad och genomförd expedition, fördelad på personal och utrustning samt
- en förteckning över de publikationer som har producerats under året som resultat av svenska polarforskningsexpeditioner.

Återrapporteringen inom de olika verksamheterna skall där så är möjligt ske i form av tidsserier över de senaste två budgetåren.

Forskningsprogrammen SWEDARP (Swedish Antarctic Research Programme) och SWEDARCTIC (Swedish Arctic Research Programme) fastställs för varje säsong i samråd med Polarforskningskommittén. Fastställande av forskningsprogram och urval av deltagande i forskningsprojekt är en lång process som sker genom en fortlöpande dialog med forskarsamhället och berörda forskningsråd. Den vetenskapliga inriktningen bestäms av forskningens egen dynamik så som den kommer till uttryck i forskarnas idéer och val av forskningsområden. Förslagen behandlas i Polarforskningskommittén, vilka gör en övergripande vetenskaplig bedömning av förslagen varvid det internationella perspektivet, den svenska kompetensen och genomförbarheten vägs samman. Kommittén och sekretariatet tillsätter särskilda arbetsgrupper för att i samråd vidareutveckla idéerna och utarbeta expeditionsplaner.

Expeditionsplaneringen ställer stora krav på samarbete mellan forskare, forskningsfinansiärer och internationella aktörer inom polarforskningen. De vetenskapliga prioriteringarna är styrande för den forskning som utförs under expeditionerna. Planeringen av expeditionsverksamhet kräver lång tid och från idé till genomförande av en expedition är tidsrymden ofta två till fyra år. Beslut behöver tas tidigt, likaså försäkran om att det finns tillräcklig finansiering för verksamheten.

De vetenskapliga publikationer som rapporterats till sekretariatet under 2005 och har anknytning till expeditionsverksamheten redovisas i bilaga 1.

Polarforskning – genomförda expeditioner

En sammanfattning av genomförda expeditioner framgår av bilaga 2, Expeditionsverksamheten 2004–2005 .

SWEDARP 2004/05

SWEDARP 2004/05, liksom föregående säsong, bestod av en flygburen expedition till Dronning Maud Land samt stöd till AMANDA/IceCube. Dessutom förekom aktiviteter inom DROMLAN, det logistiska samarbetet mellan operatörer i Dronning Maud Land med inriktning på flygtransporter.

SWEDARP 2004/05 – logistikansvar

Expeditioner	Logistikansvar
Dronning Maud Land 2004/05	Sverige
AMANDA 2004/05	USA
EPICA 2004/05	Tyskland
SWEDARP 2004/05, övriga	Argentina, Tyskland

Dronning Maud Land 2004/05

Expeditionen till Dronning Maud Land genomfördes under perioden oktober–december 2004 och bestod av tio deltagare. Kostnaderna belastar både budgetåret 2004 och 2005. Syftet var att stödja de fyra forskningsprojekten och utföra tekniskt-logistiskt arbete på stationerna Wasa och Svea. Det geologiska projektet studerade permafrost i områdena runt stationerna. Geodesiprojektet installerade en permanent GPS-station för övervakning av rörelser i jordskorpan vid Svea. Projektet ingår i det permanenta GPS-nätverket i Antarktis som samordnas av SCAR (Scientific Committee on Antarctic Research). Den atmosfärsfysiska undersökningen har testat utrustning som upptäcker och analyserar troposfäriska och stratosfäriska spårgaser. Simultana mätningar sker på den tyska stationen Neumeyer. Med hjälp av optisk mätning kan man i detalj studera luftmassorna som passerar de båda stationerna. Det meteorologiska projektet är ett svensk-holländskt samarbete som undersöker klimatförändringar och vilken roll istäcket i östra Antarktis spelar i detta sammanhang.

AMANDA/IceCube 2004/05

AMANDA/IceCube 2004/05 var inriktat på den nya fasen, IceCube, där undersökningsområdet ska komma att utökas till en kubikkilometer. Arbetet med AMANDA påbörjades 1993/94 och byggandet av den nya detektorn beräknas pågå minst sex år.

SWEDARP 2004/05, övriga

Även denna säsong lämnades stöd till en svensk forskare som deltog i ett marinbotaniskt projekt på King George Island.

SWEDARP 2003/04 och 2004/05 – antal expeditionsdeltagare

Expedition	Forskare/lärare		Logistik	
	Kvinnor	Män	Kvinnor	Män
Dronning Maud Land 2003/04, etapp 1	1	1	0	6
Dronning Maud Land 2003/04, etapp 2	2	2	0	5
AMANDA 2003/04	2	4	0	0
EPICA 2003/04	0	0	1	0
SWEDARP 2003/04, övriga	1	0	0	0
Dronning Maud Land 2004/05	1	3	0	6
AMANDA/IceCube 2004/05	1	6	0	1
SWEDARP 2004/05, övriga	1	0	0	0

DROMLAN 2004/05

DROMLAN (Dronning Maud Land Air Network) bildades 2001 för att vidareutveckla arbetet kring flygoperationer mellan Sydafrika och Dronning Maud Land. Varje medlemsland har åtagit sig att bidra med ett startkapital om 100 000 US$ eller motsvarande i utrustning för att erbjuda internationell standard, service och säkerhetsnivå. DROMLAN består av representanter från Belgien, Finland, Indien, Japan, Nederländerna, Norge, Ryssland, Storbritannien, Sverige, Sydafrika och Tyskland.

Kostnader

Kostnaderna för expeditioner till Antarktis sträcker sig över minst två budgetår och avser planering, genomförande och efterarbete/återställande av utrustning. Kostnaderna för personal avser direkta och fördelade gemensamma lönekostnader. I utrustning ingår varor och tjänster samt avskrivningar av anläggningstillgångar liksom fördelade övriga gemensamma kostnader.

SWEDARP 2003/04 – kostnader (tkr)						
Expedition	**Kostnad 2004**		**Kostnad 2003**		**Total kostnad**	
	Personal	**Utrustning**	**Personal**	**Utrustning**	**Personal**	**Utrustning**
Dronning Maud Land 2003/04	770	1 747	1 634	3 198	2 404	4 945
EPICA 2003/04	0	129	2	0	2	129
AMANDA/IceCube 2003/04	7	3	5	60	12	63
DROMLAN 2003/04	10	6	54	0	64	6
Dronning Maud Land, besök	80	450	87	0	168	450
SWEDARP 2003/04, övriga	0	0	11	0	11	0
Totalt	**867**	**2 335**	**1 793**	**3 258**	**2 661**	**5 593**

SWEDARP 2004/05 – kostnader (tkr)						
Expedition	**Kostnad 2005**		**Kostnad 2003–2004**		**Total kostnad**	
	Personal	**Utrustning**	**Personal**	**Utrustning**	**Personal**	**Utrustning**
Dronning Maud Land 2004/05	53	402	1 248	2 651	1 301	3 053
AMANDA/IceCube 2004/05	76	15	76	149	152	164
DROMLAN 2004/05	8	3	24	770	32	773
SWEDARP 2004/05, övriga	0	0	69	17	69	17
Totalt	**137**	**420**	**1 417**	**3 587**	**1 554**	**4 006**

SWEDARCTIC 2005

SWEDARCTIC 2005 dominerades av Beringia 2005, den mest omfattande expedition som sekretariatet planerat och genomfört.

Beringia 2005

Planeringen av Beringia 2005 startade 2000 som en uppföljning av två tidigare tundraekologiska expeditioner, den svensk-ryska tundraekologi-expeditionen 1994 och Tundra nordväst 1999.

Beringia 2005 hade sitt huvudsakliga fokus på ekologiska frågor i Arktis och forskningsprojekten kan delas in i tre teman: geologisk och ekologisk historia, ekologi och evolution samt förändringar i klimat och ekosystem.

Konkurrensen bland forskningsprojekten var mycket hård med 59 projektansökningar som involverade totalt cirka 260 personer. Endast mycket högt vetenskapligt rankade projekt har kommit i fråga. Totalt deltog 26 forskningsprojekt, se bilaga 3, på en eller flera etapper.

Planeringsprocessen har varit komplex och omfattade urval av forskningsprojekt i samarbete med Polarforskningskommittén, samordning av forskningsprojekten, tillståndshantering i Ryssland, USA och Kanada, logistikplanering med Oden som bas, samordning med det amerikanska fartyget Healy, logistikplanering av landbaserade delar, förhandlingar med ryska samarbetspartners, planering tillsammans med lokala ryska, amerikanska och kanadensiska samarbetspartners, rekognosceringsresor till Kamtjatka, Tjukotka och Alaska. Förberedelserna har också inneburit omfattande kontakter med nästan 200 deltagare med bland annat hälsokontroller, individuella deltagaravtal och logistiskt-tekniska förberedelser liksom omfattande administration av tillstånds- och visumansökningar. Dessutom planerades och genomfördes två rotationer med från svenska flygvapnet chartrat transportflygplan (Hercules C-130) till Fairbanks och Barrow i Alaska, och Providenija i Tjukotka. Rotationerna innebar byte av forskargrupper mellan etapperna 1 och 2AB samt etapperna 2AB och 3 liksom komplettering av utrustning till både isbrytaren och forskargrupperna. Vid den andra rotationen ingick även transport av en svensk helikopter till isbrytaren Oden, en besöksgrupp som gjorde studiebesök ombord och i fält och hemtransport av besättning från Oden.

Den ursprungliga planen var att färdas med isbrytaren Oden längs Nordostpassagen till Berings sund och därifrån över Arktiska oceanen till Skandinavien. Under våren 2005 beslutades att ändra rutten så att den första delen i stället blev en transit med marin forskning genom Nordvästpassagen. Ändringen föranleddes av att avgiften för färd i Nordostpassagen hade höjts kraftigt, medan det var avgiftsfritt genom Nordvästpassagen. Det ursprungliga provtagningsprogrammet var anpassat till att kunna genomföras utan planerade stopp under färden. Forskningsmässigt innebar

Beringia 2005 – antal expeditionsdeltagare

Etapp	Forskare*		Logistik		Totalt
	Kvinnor	Män	Kvinnor	Män	
Etapp 1 Oden	10	15	2	4	31
Etapp 2A terrester+Oden	6	17	0	5	28
Etapp 2A post-Barrow	2	5	0	1	8
Etapp 2B Oden	4	6	2	5	17
Etapp 2C Kamtjatka	7	9	0	3	19
Etapp 2C Anadyr	2	3	0	1	6
Etapp 2D Alaska	5	10	0	0	15
Etapp 3 Oden	12	23	0	10	45
Etapp 3 Healy	3	4	1	0	8
Rotation 1/logistik	0	0	1	0	1
Rotation 2/logistik+besöksgrupp	2	3	2	0	7

*Gruppen inkluderar lärare, journalister, konstnärer och besöksgrupp.

ändringen att ett av projekten med fokus på vattenflödet från de sibiriska floderna avsevärt fick ändra sitt program och endast kunde utföra reducerad provtagning under den nya rutten. Övriga projekt kunde anpassa sin provtagning till de nya förutsättningar som ändringen medförde.

Beringia 2005 bestod av sex delar, se tidtabell bilaga 4, och genomfördes med isbrytaren Oden, det amerikanska forskningsfartyget Healy, i Tjukotka, i Kamtjatka och i Alaska. Beringia 2005 genomfördes i samarbete med ryska, kanadensiska och amerikanska partners. Rutt och forskningsområden framgår av karta på sidan 9.

Drygt 200 personer (forskare, personal, flyg- och fartygsbesättning) har varit involverade i Beringia 2005. Förutom Sverige fanns 15 nationer representerade bland deltagarna: Australien, Danmark, Finland, Frankrike, Island, Kanada, Nederländerna, Norge, Nya Zeeland, Ryssland, Storbritannien, Taiwan, Tyskland, Ungern och USA. Endast ett fåtal av deltagarna har varit med på fler än en etapp.

Etapp 1 – Marin forskning ombord på Oden

Etapp 1 bestod av en transit från Göteborg till Barrow i Alaska, via Nordvästpassagen. Forskningen var inriktad på miljökemi och marin biogeokemi samt fåglars flyttning. Provtagning skedde i huvudsak från fartygets havsvattenintag och genom insamling av luft. Trots det pressade tidsschemat kunde också viss isprovtagning ske i kanadensiska Arktis.

Etapp 2A – Terrester forskning i samverkan med Oden

Etappen bestod av terrester (landbaserad) forskning i samverkan med Oden. Sammanlagt besöktes 14 huvudsakliga forskningsplatser samt ett antal mindre, på Tjukotkahalvön och i Alaska. Gruppen började arbeta i Tjukotka i östra Sibirien ett par veckor innan Oden anlände, varefter man arbetade med fartyget som plattform i norra Tjukotka, på Wrangelön och i Barrow i nordligaste Alaska. En mindre grupp (post-Barrow) fortsatte sedan med fältarbete i Atqasuk och Nome i Alaska. De tolv medverkande forskningsprojekten täckte en rad skilda forskningsfält, exempelvis botanik, fågelmigration, trofiska interaktioner mellan växter och däggdjur, kvartärgeologi och evolution hos plankton. Flera av projekten har nära kopplingar till projekt på etapperna 2C Anadyr och Kamtjatka, liksom etapp 2D i Alaska. Fältarbetet utfördes huvudsakligen med lokala transportmedel, i nära samverkan med lokala ryska och amerikanska organisationer och med lokala fältassistenter.

Etapp 2B – Marin forskning ombord på Oden

Den andra etappen med Oden startade i Barrow och gick vidare till Providenija i östra Tjukotka för att hämta upp deltagarna i etapp 2A. En mindre grupp arbetade med marina och miljörelaterade projekt ombord på Oden under etappen. Under den kombinerade etappen 2AB hade den terrestra forskningen prioritet.

Etapp 2C – Anadyr och Kamtjatka

Etapp 2C hade ingen fast forskningsplattform – och skilde sig därmed mycket från de som hade ett fartyg som bas. Logistiken fick anpassas till de lokala förhållanden och genomfördes med lätt utrustning. Transporterna sköttes med helikopter, båtar, lastbilar och andra lokala fordon. De planerade områdena för fältarbetet kunde besökas trots det tidvis mycket besvärliga vädret. Forskningsprojekten hade huvudsakligen samma inriktning som på etapp 2A.

Etapp 2D – Yukondeltat

Under denna etapp upprättades, i samarbete med amerikanska myndigheter, fältläger för svenska, amerikanska och holländska fågelforskare i Yukon-Kuskokwimdeltat i sydvästra Alaska. Under två månader studerades migration, navigering och energibudget hos vadarfåglar, bl.a. för att kartlägga de mindre kända flyttningsvägarna från Alaska till Nya Zeeland och Australien.

Beringia 2005 – kostnader (tkr)				
	2005	**2004**	**2000–2003**	**Beräknat 2006**
Personal	6 281	2 526	1 492	25
Utrustning	45 661	2 157	122	500
Totalt	**51 942**	**4 683**	**1 614**	**525**

2004 års expedition, ACEX, finansierades huvudsakligen med medel från British Geological Survey.

ACEX, Arctic Coring Expedition – kostnader (tkr)				
	2005	**2004**	**2000–2003**	**Totalt**
Personal	34	1 324	1 593	2 951
Utrustning	512	39 848	1 851	42 211
Totalt	**546**	**41 172**	**3 444**	**45 162**

Etapp 3 – Oceanografisk forskning ombord på Oden
Den tredje etappen av expeditionen startade i Barrow för att under drygt fem veckor genomföra ett forskningsprogram med tyngdpunkt på oceanografi. Ombord fanns också projekt inriktade på studier av fåglars navigation och orientering samt forskningsprojekt inom marin biogeokemi. Rutten gick genom packisen i Kanadabassängen över Lomonosovryggen och vidare via Nordpolen till Svalbard. Större delen av färden företogs i nära samarbete med det amerikanska forskningsfartyget Healy. Samarbetet handlade dels om fördelning av forskningsprojekt, dels om operativt samarbete för att bryta is och ta sig fram i den tidvis mycket svårforcerade isen. Oden anlände till Longyearbyen den 25 september och därmed avslutades den marina delen av Beringia 2005.

Etapp 3 – Healy
Det svenska forskningsprogrammet ombord på Healy genomfördes som ett samarbete med National Science Foundation, NSF. Forskningsprogrammen inom HOTRAX, Healy-Oden Trans-Arctic Expedition, bestod främst av maringeologi och geofysik men även av en handfull mindre program. I forskargruppen på Healy ingick 47 personer som representerade nio nationer: Argentina, Japan, Kanada, Norge, Ryssland, Sverige, Tyskland, USA och Venezuela. Healy anlände till Tromsö i Norge den 30 september.

SWEDARCTIC 2005, övriga
Logistiskt stöd har lämnats till en forskare som deltog i ett kvartärgeologiskt projekt om glaciationsutbredning vid Scoresbysund på östra Grönland.

Kostnader
Kostnaderna för Beringia 2005 belastar tre budgetår, 2004–2006, avseende chartern av isbrytaren Oden, medan planeringskostnader startar redan 2000. Resterande betalningar, 18 550 tkr, till Sjöfartsverket kommer att belasta anslaget 2006.

Polarforskning – planerade expeditioner
En sammanfattning av planerade expeditioner och projekt de kommande åren framgår av bilaga 6.

SWEDARP 2005/06
Efter Beringia 2005 är resursutrymmet mycket begränsat och sekretariatet har därför inte planerat någon egen verksamhet vid Wasa och Svea för säsongen 2005/06. I samarbete med det finländska forskningsprogrammet FINNARP, som har sin forskningsstation bredvid Wasa, följs dock monitoringverksamheten upp genom översyn, dataöverföring och testkörning.

IceCube 2005/06
Den svenska gruppen inom AMANDA/IceCube-projektet får fortsatt stöd under säsongen 2005/06.

SWEDARP 2005/06, övriga
Sekretariatet stöder liksom tidigare år svenskt deltagande i djupborrningsprojektet EPICA (European Project for Ice Coring in Antarctica) vid Kohnenbasen i Antarktis, under projektets sista säsong.

Vidare ges stöd till ett klimathistoriskt projekt på Staten Island, Argentina, som avser att komplettera resultat från tidigare expeditioner till Antarktiska halvön och Nordatlanten.

DROMLAN 2005/06
Samarbetet inom DROMLAN fortsätter och sekretariatet har åtagit sig att planera och genomföra en flygning till Antarktis under januari 2006.

Kostnader

Kostnader för planering av kommande expeditioner som hänförs till 2005.

SWEDARP 2005/06–2006/07 – kostnader (tkr)

Expedition	Kostnad 2005	
	Personal	Utrustning
AMANDA/IceCube 2005/06	2	1
DROMLAN 2005/06	9	15
Dronning Maud Land 2006/07	97	53
Totalt	**108**	**69**

International Polar Year

Perioden 1 mars 2007–1 mars 2009 är utlyst till International Polar Year (IPY) av International Council for Science (ICSU) och World Meteorological Organization (WMO) för att sätta fokus på forskning i polarområdena. Det är 125 år sedan det första Internationella polaråret 1882–83 och 50 år sedan det Internationella geofysiska året 1957–58. Forskningsstationerna Wasa och Svea i Antarktis, isbrytaren Oden och forskningsstationerna Abisko och Tarfala har identifierats som viktiga svenska forskningsplattformar med hög internationell relevans. Under våren 2006 avslutas den internationella urvalsprocessen för gruppen av officiella IPY-projekt, där minst ett tiotal projekt med stark svensk medverkan förutspås ingå. En svensk IPY-strategi har under hösten utarbetats av den nationella IPY-kommittén vid Vetenskapsrådet. Denna strategi kommer att vägas ihop med vetenskapliga projektgranskningar, internationell samverkan och logistiska bedömningar, för att ligga till grund för sekretariatets verksamhet under polaråret.

SWEDARP 2006/07–2008/09

Planeringen inom SWEDARP sker nu för tre säsonger framåt, avseende såväl forskningssamordning som utrustning och logistik kring de svenska stationerna. Säsongen 2006/07 är framför allt en förberedelse inför de kommande fältsäsongerna. Den huvudsakliga planeringen är inriktad på en glaciologisk bandvagnstravers säsongen 2007/08, vilken förbereds tillsammans med Japan. Under säsongen 2006/07 sker främst en uppbyggnad av utrustning inför denna travers samt upprättande av en radar för studier av atmosfärfysik. Bränsle och andra förnödenheter kommer att transporteras till Wasa. Monitoringverksamheten kommer att fortsätta, delvis i anslutning till ett långsiktigt meteorologiprojekt som genomförs i samarbete med holländska forskare.

Verksamheten vid Wasa och Svea avses att i allt högre grad präglas av samarbete med FINNARP och den närbelägna finska stationen Aboa, i syfte att effektivisera resursutnyttjandet inom såväl forskning som logistik. Intresse finns även för studier av glaciologisk historia och permafrost. Sekretariatet avser även att fortsätta stödet till projektet IceCube.

SWEDARCTIC 2006–2008

Ett antal svenska projekt med fokus på Arktis kommer att antas inom IPY. För att effektivt utnyttja resurserna avser Polarforskningssekretariatet att under de närmaste åren fokusera logistikstödet på ett antal viktiga forskningsplattformar, snarare än att stödja individuella forskningsprojekt. 2006 kommer att vara ett uppbyggnadsår även inom SWEDARCTIC. Ett nytt tioårigt samarbetsavtal planeras tillsammans med Sjöfartsverket för användning av isbrytaren Oden, som under 2006 kommer att utrustas med ett avancerat ekolod som möjliggör detaljstudier av havsbottnen. Sekretariatet planerar att ställa Oden till förfogande sommaren 2007 för maringeologiska undersökningar samt en oceanografisk provtagningsserie nordost om Grönland. Finansieringen är delvis beroende av internationella samarbeten, bland annat med Danmark. Om ytterligare finansiering görs tillgänglig kan sekretariatet även genomföra en fartygsexpedition sommaren 2008, vilket skulle möjliggöra studier av molnbildning i det inre av Arktiska oceanen.

Svenska forskare har också ledande roller inom ett flertal IPY-projekt med landbaserad forskning. Ett stort antal projekt skulle kunna stödjas genom en övergripande kraftsamling kring de befintliga svenska forskningsplattformarna i fjällkedjan: Abisko naturvetenskapliga station, Tarfala forskningsstation och Vindelfjällens forskningsstation. Polarforskningssekretariatet planerar att bidra med logistik och ledning för en sammanhållen forskningsplattform i form av transporter och fältläger i norra Sverige.

Nordostlandet på Svalbard och återuppbyggnaden av Kinnvikastationen har tagits som utgångspunkt för en omfattande tvärvetenskaplig insats på nordisk basis. Kinnvika har också en historisk betydelse från Internationella geofysiska året 1957–58 då stationen etablerades under ett svensk-finsk-schweiziskt samarbete. Sekretariatet planerar att medverka i detta projekt genom stödaktiviteter.

Miljöverksamhet i polartrakterna

Ur regleringsbrevet:

Mål 2: Polarforskningssekretariatet skall minimera den miljöpåverkan i polartrakterna som sker i samband med svenska verksamheter.

Återrapportering:

Polarforskningssekretariatet skall redovisa sitt arbete för att skydda miljön i polartrakterna i samband med svenska verksamheter samt översiktligt beskriva den internationella miljöverksamheten.

Sekretariatet skall redovisa antalet ansökningar om tillstånd för vistelse i Antarktis samt antalet beviljade tillstånd fördelade på forskning respektive annan verksamhet. Kostnaderna för verksamhet relaterad till internationella åtaganden, för tillståndsprövning samt för tillsyn över svensk verksamhet i Antarktis skall redovisas.

Tillstånd att vistas i Antarktis

Under året har 12 tillståndsärenden inkommit för svenska medborgare att vistas i Antarktis. Sammanlagt beviljades 154 svenska forskare, turister och personal ombord på kryssningsfartyg tillstånd, fördelat över säsongerna 2004/05 och 2005/06.

Tillstånd och tillsyn – antal och kostnader (tkr)						
	2005		2004		2003	
	Forskning	Övriga	Forskning	Övriga	Forskning	Övriga
Antalet tillstånd	10	144	29	245	12	48
Kostnad för tillstånd	10	34	17	28	9	34
Kostnad för tillsyn		19		5		4

Miljöarbete inom svensk verksamhet i polartrakterna

Två miljökonsekvensbeskrivningar har gjorts för svenska aktiviteter i polarområdena, dels för Beringia 2005, dels för en flygning till den norska stationen Troll i Antarktis. Flygningen ska ske i början av 2006 inom samarbetet Dronning Maud Land Air Network (DROMLAN).

Den internationella miljöverksamheten har till stor del ägnats åt att delta i internationella arbetsgrupper som rör miljöfrågor inför Antarktisfördragets årliga konsultativa möte. 2005 var första gången som det två veckor långa mötet ordnades under svenskt ordförandeskap. Sekretariatet har aktivt varit involverat under Stockholmsmötet och bidrog med tre informationsdokument om vindkraft i Antarktis, hantering av gråvatten på antarktiska forskningsstationer samt kommunikation i polarområdena. Polarforskningssekretariatet har dessutom varit engagerat i olika arbetsgrupper inför fördragsmötet rörande frågor om miljöövervakning, miljökonsekvensbeskrivningar, miljötillståndet samt en eventuell framtida miljöstrategi för Antarktis.

Den praktiska internationella miljöverksamheten bestod till största delen av samarbete mellan Finland, Norge och Sverige i samband med expeditionsplanering. En handbok för miljöarbetet i Antarktis har gemensamt tagits fram och innehåller bland annat en avfallshanteringsplan, beredskapsplaner för eventuella miljöolyckor och riktlinjer för flygningar. Handboken, som är publicerad på sekretariatets webbplats, är ett dokument som hela tiden uppdateras. Under 2005 kompletterades handboken med ett kapitel om miljöanpassade inköp.

Miljöverksamhet – kostnader (tkr)			
	2005	2004	2003
Tillstånd/tillsyn	63	52	47
Internationellt miljöarbete	292	235	306
Miljöprojekt	11	29	55
Totalt	**366**	**316**	**408**

Internationellt samarbete

Ur regleringsbrevet:

Mål 3: Polarforskningssekretariatet skall bidra till att svensk polarforskning ges goda förutsättningar till internationellt samarbete.

Återrapportering:

Polarforskningssekretariatet skall översiktligt redovisa internationell verksamhet där sekretariatet medverkat samt internationella förhandlingar där sekretariatet deltar i en rådgivande funktion.

Det internationella arktiska samarbetet koordineras huvudsakligen genom International Arctic Science Committee (IASC) och Arctic Ocean Sciences Board (AOSB). I båda dessa organisationer deltar svenska forskare och i styrelserna är Sverige representerade via Vetenskapsrådet och i IASC Regional Board via Polarforskningssekretariatet. Forum of Arctic Research Operators (FARO) representerar de arktiska forskningsoperatörerna och där har Polarforskningssekretariatet en plats i styrelsen. FARO har nyligen fått ett eget sekretariat med placering i Köpenhamn.

I samband med att den nuvarande sekreteraren för IASC går i pension i början av 2006 har sekretariatets placering, som hittills varit Oslo, omprövats och från och med 1 januari 2006 är Polarforskningssekretariatet värd för IASC:s sekretariat, som flyttas till Stockholm och Vetenskapsakademins lokaler. Sekretariatets personal på två personer finansieras av Vetenskapsrådet.

På den europeiska scenen fungerar European Polar Board (EPB), med säte i Strasbourg, som samarbetsorganisation. EPB ingår i ESF och har ett mandat för europeiskt forskningssamarbete i såväl Arktis som Antarktis. Polarforskningssekretariatet är representerat i styrelsen. Såväl Vetenskapsrådet som Polarforskningssekretariatet är svenska medlemmar i EPB.

Arctic Science Summit Week, som samlar dessa arktiska organisationer för möten under en gemensam vecka, hade denna gång sin årliga sammankomst i Kunming, Kina, där representanter för sekretariatet deltog.

Det internationella forskningssamarbetet i Antarktis sker främst genom Scientific Committee on Antarctic Research (SCAR) för vetenskap och Council of Managers of National Antarctic Programs (COMNAP) för logistik och management. Årets SCAR- och COMNAP-möten ägde rum i juli i Sofia, Bulgarien och sekretariatets personal är engagerade på olika plan i dessa organisationer. Ett exempel är DROMLAN, det samarbete kring flygtransporter till och inom Antarktis som länderna med aktiviteter i Dronning Maud Land har gemensamt.

Antarktisfördraget (ATCM) höll sitt 28:e konsultativa möte i Stockholm i juni med Utrikesdepartementet och den svenska regeringen som värd. Polarforskningssekretariatet spelade en aktiv roll i förberedelser och i genomförande. Ett stort genombrott gjordes vid mötet då man, efter tretton års förhandlingar, enades om det s.k. liabilityannexet till miljöprotokollet, vilket innebär att ansvarsförhållanden vid miljöolyckor regleras.

Det Internationella polaråret (IPY) 2007–2008 spelar en allt mer dominerande roll i de internationella diskussionerna. En struktur för internationell koordinering finns nu på plats med ett programkontor i Cambridge i England. En s.k. Joint Committee med forskare från olika länder, däribland en svensk, har också etablerats.

Sekretariatets representation i olika internationella organisationer framgår av bilaga 7.

Information och dokumentation

Ur regleringsbrevet:

Mål 4: Polarforskningssekretariatet skall sprida information om expeditionsverksamheten och om den aktuella svenska polarforskningen.

Återrapportering:
Polarforskningssekretariatet skall redogöra för inriktning och omfattning av informationsverksamheten, dess kostnader samt sekretariatets egen insats.

Aktuell svensk polarforskning och expeditionsverksamhet presenteras i olika former och genom olika informationskanaler, t.ex. på webbplatsen www.polar.se, årsbok, broschyrer, nyhetsbrev och pressmeddelanden. Lärare, barn och ungdomar, konstnärer, museer och andra kulturorganisationer är målgrupper och samarbetspartners som prioriteras i arbetet med att sprida populärvetenskaplig information om polartrakterna.

I anslutning till Beringia 2005 genomfördes ett flertal aktiviteter för målgruppen lärare och elever: vid Abisko naturvetenskapliga station hölls en sommarskolekurs i arktisk ekologi för lärarstuderande och lärare i samarbete med Institutionen för utbildningsvetenskap vid Luleå tekniska universitet. Även Linnédagarna – exkursioner och föreläsningar för ett femtiotal gymnasieelever från hela Sverige – hölls i Abisko och eleverna hade direktkontakt med expeditionen. Inom Polarforskningssekretariatets lärarprogram hade tre lärare utsetts att delta i olika etapper under Beringia 2005 och genom samarbetet med den amerikanska organisationen ARMADA kunde en amerikansk lärare delta i sommarskolekursen i Abisko.

Inom konstnärsprogrammet deltog under Beringia 2005 sammanlagt 9 konstnärer med sju olika projekt i expeditionen. Även fem journalister deltog och bevakade forskningen såväl ombord på isbrytarna Oden och Healy som under fältarbete i Ryssland och Alaska. Expeditionen uppmärksammades stort i media, vilket visar sig i den digra samlingen av pressklipp och mängden inslag i både radio och TV.

På resan från hemmahamnen i Luleå till Stockholm, 30 maj–1 juni, arrangerades ett Royal Colloquium ombord på Oden. Temat var ”Arctic under Stress”. Mötet leddes av Kung Carl XVI Gustaf och deltog gjorde Kronprinsessan Victoria och Kronprins Frederik av Danmark tillsammans med en grupp internationella forskare. Isbrytaren Oden låg vid kaj i Stockholm under förberedelserna innan avresa och var då den naturliga samlingsplatsen för presentationer av Beringia 2005. Totalt besöktes isbrytaren av ca 600 inbjudna personer som representerande ambassader, myndigheter, forskarkollegor, politiker, leverantörer osv. Ett tiotal journalister deltog i en diskussion ombord, i samarbete med Vetenskapsrådet, om samspelet mellan forskare och vetenskapsjournalister, om forskningskommunikation och bevakning av vetenskaperna.

Beringia 2005 presenterades utförligt på svenska, engelska och ryska på en egen webbplats. Under expeditionens gång publicerades så gott som dagliga rapporter på svenska och engelska från alla expeditionens etapper.

Under Sveriges värdskap för Antarktisfördragets möte med ca 300 deltagare hade Polarforskningssekretariatet en aktiv roll i konferensen och kringaktiviteterna, bland annat med arbetet kring presskontakter och med en visning av isbrytaren Oden för delegaterna. Fördragsmötet hölls i Tekniska museets lokaler i Stockholm. I anslutning till mötet producerade museet en utställning om Antarktis som har använts till skolvisningar under hösten och kommer att stå kvar även under vårterminen 2006. Sjöhistoriska och Etnografiska museerna hade också särskilda utställningar i samband med fördragsmötet. Sekretariatet bidrog med material och trycksaker till utställningarna.

Polarforskningssekretariatet medverkade under året i flera populärvetenskapliga sammanhang: Forskartorget på Bok- och biblioteksmässan i Göteborg, Geologins Dag på Stockholms universitet, Vetenskapsfestivalen i Göteborg och Utbrott på ungdomsstället Lava på Kulturhuset i Stockholm (inom aktiviteten Forskarnas kväll, utlyst av EU). I anslutning till programpunkterna på Vetenskapsfestivalen producerades även trycksaken Resebrev från Sydpolen, med ursprung i korrespondensen mellan elever och forskare inom AMANDA/IceCube på Sydpolen.

Under hösten har arbetet inför det Internationella polaråret tag fart och i samarbete med Vetenskapsrådet har internationella och svenska kontakter tagits för att etablera samarbeten kring utåtriktade IPY-aktiviteter. En förstudie inför en eventuell produktion av ett dataspel om polarforskning har också inletts i samarbete med Vetenskapsrådet.

En ny formgivare till Polarforskningssekretariatets årsbok har upphandlats under året. Nyhetsbrevet Polaraktualiteter har utkommit med sju nummer. Supplementet till Swedish Polar Bibliography för 2004 färdigställdes under året och publicerades på webbplatsen.

Information – kostnader (tkr)

2005	2004	2003	2002	
Webbplats	282	198	231	221
Trycksaker	681	1 045	696	551
Kontaktverksamhet	406	1 205	842	212
Bibliotek och dokumentation	481	437	479	351
Totalt	**1 850**	**2 885**	**2 248**	**1 335**

Resultaträkning

(tkr)	Not	2005	2004
Verksamhetens intäkter			
Intäkter av anslag		30 140	23 333
Intäkter av avgifter och andra ersättningar	1	4 598	387
Intäkter av bidrag	2	608	34 625
Finansiella intäkter	3	88	208
Summa		**35 434**	**58 553**
Verksamhetens kostnader			
Kostnader för personal	4	-9 039	-8 327
Kostnader för lokaler		-1 119	-1 153
Övriga driftkostnader	5	-46 118	-48 492
Finansiella kostnader	6	-220	-56
Avskrivningar och nedskrivningar		-620	-571
Summa		**-57 116**	**-58 599**
Verksamhetsutfall		**-21 682**	**-46**
Årets kapitalförändring	**7**	**-21 682**	**-46**

Balansräkning

(tkr)	Not	2005-12-31	2004-12-31
TILLGÅNGAR			
Materiella anläggningstillgångar			
Byggnader, mark och annan fast egendom	8	110	170
Maskiner, inventarier, installationer m.m.	9	2 273	1 631
Summa		**2 383**	**1 801**
Fordringar			
Kundfordringar		140	6
Fordringar hos andra myndigheter		145	225
Övriga fordringar		16	0
Summa		**301**	**231**
Periodavgränsningsposter			
Förutbetalda kostnader	10	315	3 594
Övriga upplupna intäkter	11	201	37
Summa		**516**	**3 631**
Avräkning med statsverket			
Avräkning med statsverket	12	-420	-5 357
Summa		**-420**	**-5 357**
Kassa och bank			
Behållning räntekonto i Riksgäldskontoret	13	5 905	5 780
Kassa, postgiro och bank		2	2
Summa		**5 907**	**5 782**
SUMMA TILLGÅNGAR		**8 687**	**6 088**
KAPITAL OCH SKULDER			
Myndighetskapital			
Balanserad kapitalförändring	14	1 444	1 490
Kapitalförändring enligt resultaträkningen		-21 682	-46
Summa		**-20 238**	**1 444**
Skulder m.m.			
Lån i Riksgäldskontoret	15	2 383	1 801
Skulder till andra myndigheter	16	6 724	318
Leverantörsskulder		65	928
Övriga skulder		120	149
Summa		**9 292**	**3 196**
Periodavgränsningsposter			
Upplupna kostnader	17	19 589	957
Oförbrukade bidrag	18	33	480
Övriga förutbetalda intäkter		11	11
Summa		**19 633**	**1 448**
SUMMA KAPITAL OCH SKULDER		**8 687**	**6 088**

Anslagsredovisning

Redovisning mot anslag Anslag (tkr)	Not	Ingående överförings-ibelopp	Årets tilldelning enl. regl.brev	Omdisponerade anslagsbelopp	Totalt disponibelt belopp	Utgifter	Utgående överförings-belopp
Uo 16 26:6 (2004)		5 357		-5 357			0
Uo 16 26:6 ap. 1	19	0	25 203	5 357	30 560	30 140	420
Ramanslag Polar-forskningssekretariatet							
Summa		**5 357**	**25 203**	**0**	**30 560**	**30 140**	**420**

Finansieringsanalys

(tkr)	Not	2005		2004	
DRIFT					
Kostnader	20		-56 496		-58 028
Finansiering av drift					
Intäkter av anslag		30 141		23 333	
Intäkter av avgifter och andra ersättningar		4 598		387	
Intäkter av bidrag		608		34 625	
Övriga intäkter		88		208	
Summa medel som tillförts för finansiering av drift			**35 435**		**58 553**
Minskning(+) av kortfristiga fordringar			3 045		334
Ökning(+) av kortfristiga skulder			23 698		951
KASSAFLÖDE FRÅN DRIFT			**5 682**		**1 810**
INVESTERINGAR					
Investeringar i materiella tillgångar		-1 202		-805	
Summa investeringsutgifter			**-1 202**		**-805**
Finansiering av investeringar					
Lån från Riksgäldskontoret		1 202		815	
- amorteringar		-620		-581	
Summa medel som tillförts för finansiering av investeringar			**582**		**234**
KASSAFLÖDE TILL INVESTERINGAR			**-620**		**-571**
FÖRÄNDRING AV LIKVIDA MEDEL			**5 062**		**1 239**
SPECIFIKATION AV FÖRÄNDRING AV LIKVIDA MEDEL					
Likvida medel vid årets början			**425**		**-814**
Minskning(-) av kassa, postgiro			0		-106
Ökning(+) av tillgodohavande hos Riksgäldskontoret			125		3 092
Ökning(+) av avräkning med statsverket			4 937		-1 747
SUMMA FÖRÄNDRING AV LIKVIDA MEDEL			**5 062**		**1 239**
Likvida medel vid årets slut			**5 487**		**425**

Tilläggsupplysningar och noter

(Belopp i tusental kronor där ej annat anges)

TILLÄGGSUPPLYSNINGAR

Redovisningsprinciper

Tillämpade redovisningsprinciper

Myndighetens redovisning följer god redovisningssed och årsredovisningen är upprättad i enlighet med förordningen (2000:605) om årsredovisning och budgetunderlag samt ESV:s föreskrifter och allmänna råd till denna.

Bokföringen följer förordningen (2000:606) om myndigheters bokföring samt ESV:s föreskrifter och allmänna råd till denna.

Efter brytdagen har fakturor överstigande 5 tkr bokförts som periodavgränsningsposter.

Värderingsprinciper

Anläggningstillgångar

Som anläggningstillgångar redovisas byggnader samt maskiner och inventarier som har ett anskaffningsvärde om minst 10 tkr och en beräknad ekonomisk livslängd som uppgår till lägst tre år. Avskrivning under anskaffningsåret sker från den månad tillgången tas i bruk.

Tillämpade avskrivningstider:

3 år	Elektriska apparater
	Datorer och kringutrustning
	Övriga kontorsmaskiner
5 år	Maskiner, fordon och inredning
	Bostadsmodul
10 år	Byggnader (stationen Wasa i Antarktis)

Tillämpad avskrivningstid för datorer gäller inte bärbara datorer eller datorer som används under expeditioner. Dessa kostnadsförs vid anskaffningstillfället.

Omsättningstillgångar

Fordringarna har tagits upp till det belopp som de efter individuell prövning beräknas bli betalda.

Övriga omsättningstillgångar har tagits upp till anskaffningsvärdet enligt lägsta värdets princip.

Skulder

Skulderna har tagits upp till nominellt belopp.

Ersättningar och andra förmåner

Styrelseledamöter/andra styrelseuppdrag	Ersättning
Britt-Marie Danestig Linköpings universitet	6
Désirée Edmar Internationella meteorologiska institutet i Stockholm, Lärarhögskolan i Stockholm, Svenska Turistföreningen, STF AB	1
Håkan Jorikson -	1
Lars-Erik Liljelund Naturvårdsverket, Skogsstyrelsen, Miljövårdsberedningen, MISTRA, NEFCO, EEA	1
Annika Stensson (t.o.m. 2005-06-30) Svenska Fordonstekniska Föreningen Service AB	-
Per Tegnér Rymdstyrelsen	0,5
Eva Olsson (fr.o.m. 2005-07-01) Stiftelsen för Strategisk forskning, Svenska Keraminstitutet	0,5
Ledande befattningshavare/styrelseuppdrag	**Lön**
Anders Karlqvist, föreståndare -	648

Anställdas sjukfrånvaro

I tabellen redovisas anställdas totala sjukfrånvaro i förhållande till den sammanlagda ordinarie arbetstiden. Vidare redovisas andel av totala sjukfrånvaron under en sammanhängande tid av 60 dagar eller mer (andel i procent).

Sjukfrånvaro	2005	2004
Totalt	2,9	4,7
Andel 60 dagar eller mer	83,9	73,6

Sjukfrånvaro för en särskild grupp lämnas inte om antalet anställda i gruppen är högst tio eller om uppgiften kan hänföras till en enskild individ.

Noter
Resultaträkning

			2005	2004
Not	1	**Intäkter av avgifter och andra ersättningar**		
		Intäkter av avgifter enligt 4 § avgiftsförordningen	4 052	10
		Övriga intäkter av avgifter och andra ersättningar	546	377
		Summa	**4 598**	**387**

I beloppet Intäkter av avgifter enligt 4 § avgiftsförordningen för år 2005 ingår ersättning 3 832 tkr från Oljedirektoratet i Norge för hyra av isbrytaren Oden i samband med expeditionen Beringia 2005.

			2005	2004
Not	2	**Intäkter av bidrag**		
		Intäkter av bidrag från Utrikesdepartementet	160	160
		Intäkter av bidrag från internationella organisationer	448	34 465
		Summa	**608**	**34 625**

Intäkter av bidrag från internationella organisationer avser bidrag från British Geological Survey. I beloppet för år 2004 ingår 33 847 tkr för genomförande av Arctic Coring Expedition 2004.

			2005	2004
Not	3	**Finansiella intäkter**		
		Ränteintäkter räntekonto i Riksgäldskontoret	75	141
		Övriga finansiella intäkter	13	67
		Summa	**88**	**208**
Not	4	**Kostnader för personal**		
		Lönekostnader (exkl. arbetsgivaravgifter, pensionspremier och andra avgifter enligt lag och avtal)	5 811	5 179
		Övriga kostnader för personal	3 228	3 148
		Summa	**9 039**	**8 327**
Not	5	**Övriga driftkostnader**		
		Driftkostnaderna har varit höga både 2004 och 2005 med anledning av två stora internationella expeditioner, Arctic Coring Expedition 2004 och Beringia 2005.	46 118	48 492
		Summa	**46 118**	**48 492**
Not	6	**Finansiella kostnader**		
		Räntekostnader avseende räntekonto i Riksgäldskontoret	6	0
		Räntekostnader avseende lån i Riksgäldskontoret	31	33
		Övriga finansiella kostnader	183	23
		Summa	**220**	**56**
Not	7	**Årets kapitalförändring**		
		Periodiseringsdifferenser	-21 682	-46
		Summa	**-21 682**	**-46**

Balansräkning			2005-12-31	2004-12-31
Not	**8**	**Byggnader, mark och annan fast egendom**		
		Ingående anskaffningsvärde	5 300	5 300
		Ingående ackumulerade avskrivningar	-5 130	-5 070
		Årets avskrivningar	-60	-60
		Utgående bokfört värde	110	170
Not	**9**	**Maskiner, inventarier, installationer m.m.**		
		Ingående anskaffningsvärde	4 839	4 212
		Årets anskaffningar	1 202	805
		Årets försäljningar/utrangeringar, anskaffningsvärde	0	-178
		Ingående ackumulerade avskrivningar	-3 208	-2 875
		Årets avskrivningar	-560	-511
		Korrigering av tidigare års avskrivningar	0	178
		Utgående bokfört värde	**2 273**	**1 631**
Not	**10**	**Förutbetalda kostnader**		
		Beredskapshyra Sjöfartsverket avseende isbrytaren Oden	0	3 240
		Övriga förutbetalda kostnader	315	354
		Summa	**315**	**3 594**
Not	**11**	**Övriga upplupna intäkter**		
		Upplupna intäkter avseende försäljning av profilplagg	201	0
		Övriga upplupna intäkter	0	37
		Summa	**201**	**37**
Not	**12**	**Avräkning med statsverket**		
		Ingående balans	-5 357	-3 610
		Avräknat mot statsbudgeten:		
		Anslag	30 140	23 333
		Avräknat mot statsverkets checkräkning:		
		Anslagsmedel som tillförts räntekonto	-25 203	-25 080
		Utgående balans	**-420**	**-5 357**
Not	**13**	**Behållning räntekonto i Riksgäldskontoret**		
		Beviljad räntekontokredit hos Riksgäldskontoret enligt regleringsbrev	3 803	2 508
		Anslagsmedel	5 861	5 209
		Bidrag från annan statlig myndighet	33	33
		Övriga icke-statliga bidrag	11	538
		Summa behållning på räntekonto	**5 905**	**5 780**
		varav kortsiktigt likviditetsbehov	905	0
		Saldoutvecklingen på räntekontot påverkas av leverantörsskulder samt övriga skulder och fordringar.		
Not	**14**	**Balanserad kapitalförändring**		
		Periodiseringsdifferenser	1 444	1 490
		Summa	**1 444**	**1 490**

Not 15	**Lån i Riksgäldskontoret**	**2005-12-31**	**2004-12-31**
	Avser lån för investeringar i anläggningstillgångar.		
	Ingående balans	1 801	1 567
	Under året nyupptagna lån	1 202	815
	Årets amorteringar	-620	-581
	Utgående balans	**2 383**	**1 801**
	Beviljad låneram enligt regleringsbrev	4 000	4 000
Not 16	**Skulder till andra myndigheter**		
	Faktura Sjöfartsverket avseende hyra av Oden 2005	6 480	0
	Övriga skulder till andra myndigheter	244	318
	Summa	**6 724**	**318**
Not 17	**Upplupna kostnader**		
	Slutbetalning avseende hyra av Oden i samband med Beringia 2005.	18 551	0
	Övriga upplupna kostnader	1 038	957
	Summa	**19 589**	**957**
Not 18	**Oförbrukade bidrag**		
	Bidrag som erhållits från statlig myndighet, FRN	33	33
	Bidrag som erhållits från icke-statliga organisationer, BGS	0	447
	Summa	**33**	**480**

Anslagsredovisning

Not 19 **Polarforskningssekretariatet**

Uo 16 26:6 ap. 1

Enligt regeringsbeslut I:17 (Utbildnings- och kulturdepartementet, U2005/842) daterat 2005-12-08 disponerar Polarforskningssekretariatet hela anslagssparandet från 2004.

Finansieringsanalys

		2005	**2004**
Not 20	**Kostnader**		
	Kostnader enligt resultaträkningen	57 116	58 599
	Avskrivningar	-620	-571
	Kostnader	**56 496**	**58 028**

Sammanfattning väsentliga uppgifter

(tkr)	2005	2004	2003	2002	2001
Låneram Riksgäldskontoret					
Beviljad	4 000	4 000	3 000	4 000	4 000
Utnyttjad	2 383	1 801	1 567	2 305	1 237
Kontokrediter Riksgäldskontoret					
Beviljad	3 803	2 508	2 417	3 873	2 317
Maximalt utnyttjad	2 598	0	2 366	3 167	0
Räntekonto Riksgäldskontoret					
Ränteintäkter	75	141	68	154	347
Räntekostnader	6	0	20	0	0
Avgiftsintäkter					
Avgiftsintäkter som disponeras					
Beräknat belopp enligt regleringsbrev	0	0	0	0	0
Avgiftsintäkter	4 598	387	54	123	121
Anslagskredit					
Beviljad	0	752	363	712	695
Utnyttjad	0	0	0	0	0
Anslag					
Ramanslag					
Anslagssparande	420	5 357	3 610	757	1 797
varav intecknat	420	5 357	3 610	757	1 797
Bemyndiganden / ej tillämpligt					
Personal					
Antalet årsarbetskrafter (st)	13,7	14,3	13,5	13,8	15,0
Medelantalet anställda (st)	15,0	15,0	14,0	14,5	15,5
Driftkostnad per årsarbetskraft *	4 108	4 054	1 376	1 851	1 886
Kapitalförändring					
Årets	-21 682	-46	3 154	-1 381	-153
Balanserad	1 444	1 490	-1 664	-282	-129

* Driftkostnad per årsarbetskraft har varit betydligt högre år 2004 och 2005 p.g.a. genomförandet av två stora internationella expeditioner, ACEX 2004 och Beringia 2005.

Undertecknande

Styrelsen fastställde årsredovisningen för 2005 vid sammanträde den 13 februari 2006.

Britt-Marie Danestig
Ordförande

Désirée Edmar	*Håkan Jorikson*
Anders Karlqvist	*Lars-Erik Liljelund*
Eva Olsson	*Per Tegnér*

Publikationer med anknytning till expeditionsverksamheten som rapporterats till Polarforskningssekretariatet 2005

SWEDARCTIC
Publikationer baserade på data från flera expeditioner

Johansson, Åke & Gee, David G. & Larionov, Alexander N. & Ochta, Yoshihide & Tebenkov, Alexander M.
Grenvillian and Caledonian evolution of eastern Svalbard – a tale of two orogenies
Terra Nova
Vol. 17, No. 4, pp. 317–325
SWEDARCTIC

Johansson, Åke & Larionov, Alexander N. & Gee, David G. & Tebenkov, Alexander M. & Sandelin, Stefan
Grenvillian and Caledonian tectono-magmatic activity in northeasternmost Svalbard
Memoirs
Geological Society, London.
Vol. 30, 2004, pp. 207–232
SWEDARCTIC

SWEDARCTIC 1994
Dalén, Love & Elmhagen, Bodil & Angerbjörn, Anders
DNA analysis on fox faeces and competition induced niche shifts
Molecular Ecology
Vol. 13, 2004, pp. 2389–2392
Paper 6 in: *Distribution and abundance of genetic variation in the arctic fox* / **Love Dalén**, Stockholm, Stockholms universitet, Zoologiska institutionen, Stockholm 2005
SWEDARCTIC 1994

Dalén, Love & Fuglei, Eva & Hersteinsson, Páll & Kaple, Christian M.O. & Roth, James D. & Samelius, Gustaf & Tannerfeldt, Magnus & Angerbjörn, Anders
Population history and genetic structure of a circumpolar species: the arctic fox
Biological Journal of the Linnean Society
Vol. 84, 2005, pp. 79–89
Paper 1 in: *Distribution and abundance of genetic variation in the arctic fox* / **Love Dalén**, Stockholm, Stockholms universitet, Zoologiska institutionen, Stockholm 2005
SWEDARCTIC 1994, SWEDARCTIC 1999

Dalén, Love & Götherström, Anders & Angerbjörn, Anders
Identifying species from pieces of faeces
Conservation Genetics
Vol. 5, 2004, pp. 109–111
Paper 5 in: *Distribution and abundance of genetic variation in the arctic fox / Love Dalén*, Stockholm, Stockholms universitet, Zoologiska institutionen, Stockholm 2005
SWEDARCTIC 1994

Nyström, Veronica & Angerbjörn, Anders & Dalén, Love
Genetic consequences of a demographic bottleneck in the Scandinavian arctic fox
Oikos, provisionally accepted
Paper 2 in: *Distribution and abundance of genetic variation in the arctic fox* / **Love Dalén**, Stockholm, Stockholms universitet, Zoologiska institutionen, Stockholm 2005
SWEDARCTIC 1994

SWEDARCTIC 1996
Kylin, Henrik
Juvenile black-legged Kittiwakes *Rissa tridactyla* with deformed bills and clubfeet in the Barents Sea
Ornis Svecia
Vol. 15, 2005, pp. 149–152
SWEDARCTIC 1996

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Expeditionsverksamheten 2004–2005

SWEDARP 2003/2004

Nr	Expedition/projekt	Syfte	Tidpunkt	Plats	Logistikansvar
1 8 deltagare	**Dronning Maud Land**	Glaciologi, biologi och monitoring	Nov-dec	Dronning Maud Land	Sverige
a	Geomorfologi	Permafroststudier			
b	Atmosfärsfysik globala elektriska förhållanden	Solvindeffekter på atmosfärens			
2 9 deltagare	**Dronning Maud Land** meteorologi och atmosfärsfysik)	Monitoring (glaciologi,	Jan-feb	Dronning Maud Land	Sverige
a	Geomorfologi moränformation	Nischglaciärers			
b	Paleoklimatologi kopplingen klimat-iskärnor	Deposition av aerosoler,			
c	Biologi biologi	Björndjurs (tardigrada)			
d	Lärarprogram	Inom biologi ovan	Nov-jan	Amundsen-Scottbasen	USA
3 6 deltagare	**AMANDA**	Neutrinodetektion (internationellt program)			
4 1 deltagare	**EPICA** med djupisborrningar)	Klimathistoria (internationellt program	Dec-jan	Kohnen Base	Tyskland
5 1 deltagare	**King George Island**	Marin botanik (internationellt program rörande algers ekofysiologi)	Okt-dec	King George Island	Tyskland/ Argentina

SWEDARCTIC 2004

Nr	Expedition/projekt	Syfte	Tidpunkt	Plats	Logistikansvar
1 66 deltagare	**ACEX** isbrytarexpedition)	Maringeologi (internationell	Aug-sep	Lomonosovryggen	Sverige
2 24 deltagare	**Ryssland** Bedrock Expedition)	Berggrundsgeologi (Novaya Zemlya	Jul-aug	Novaja Zemlja	Ryssland
3 3 deltagare	**Grönland**	Kvartärgeologi	Jul-aug	Grönland	Danmark
4 22 deltagare	**Internationell forskarskola**	Gruvhistoria	Jul-aug	Svalbard	
5 5 deltagare	**Spetsbergen** of NW Spitsbergen	The timing and origin of granitoid migmatites	Jul-aug	Svalbard	
6 2 deltagare	**Grönland**	Drilling to the bedrock (NordGRIP)		Grönland	Danmark
7 3 deltagare	**Alaska rekognoscering**	Alaska – inför Beringia 2005	Juli	Alaska	Sverige

SWEDARP 2004/05

Nr	Expedition/projekt	Syfte	Tidpunkt	Plats	Logistikansvar
1	**Dronning Maud Land** 10 deltagare	Monitoring (glaciologi, meteorologi och atmosfärsfysik)	Nov-dec	Dronning Maud Land	Sverige
a	Atmosfärsfysik	DOAS-mätning av luft-partiklar på Wasa			
b	Geodesi	GPS-mätningar på Svea			
c	Geologi	Permafrostmätningar på Svea och Wasa			
d	Meteorologi	Rekognoscering inför 2006/07 och service			
2	**AMANDA/IceCube** 8 deltagare	Neutrinodetektion (internationellt program)	Nov-jan	Amundsen-Scottbasen	USA
3	**EPICA** 1 deltagare	Klimathistoria (internationellt program med djupisborrningar)	Nov-jan	Dome Concordia/ Kohnen Base	Frankrike/ Italien/ Tyskland
4	**King George Island** 1 deltagare	Marin botanik (internationellt program rörande algers ekofysiologi)	Okt-dec	King George Island	Tyskland/ Argentina

SWEDARCTIC 2005

1	**Beringia 2005** 185 deltagare	Terrester och marin forskning i Beringiaområdet	Jun-okt	Nordvästpassagen, Tjuktjerhavet, Arktiska oceanen, Kamtjatka, Tjukotka, Alaska	Sverige
a	Marin forskning, etapp 1	Oceanografi, biogeokemi, miljökemi	Juli	Nordvästpassagen	
b	Fartygsbaserad terrester forskning, etapp 2A	Tundrans ekologi, geologi norra Beringia	Jul-sep		
c	Marin forskning, etapp 2B	Oceanografi, miljökemi	Aug	Tjuktjerhavet	
d	Terrester forskning, etapp 2C	Tundrans ekologi, geologi Kamtjatka, Tjukotka	Jul-aug		
e	Terrester forskning, etapp 2D	Flyttningsbiologi	Jun-okt	Alaska	USA
f	Marin forskning, etapp 3 Oden	Oceanografi, biogeokemi, miljökemi	Aug-sep	Arktiska oceanen	
g	Marin forskning, etapp 3 Healy	Maringeologi	Aug-sep	Arktiska oceanen	USA
h	Konstnärsprogram		Jul-sep		
i	Lärarprogram		Jul-sep		
j	Media		Jul-sep		
2	**Grönland**	Kvartärgeologi		Östra Grönland	Danmark

Beringia 2005 – deltagande forskningsprojekt

Projektledare	Projekttitel
Abrahamsson, Katarina Chalmers tekniska högskola	The biogeochemical cycle of organo-halogens in the Arctic
Alerstam, Thomas Lunds universitet	Bird migration, orientation and species diversity under polar conditions
Anderson, Leif Göteborgs universitet	Leg 1: Arctic Ocean carbon cycle – impact of river run-off Leg 3: The role of the Arctic Ocean in the climate system
Andersson, Per Naturhistoriska riksmuseet	Biogeochemically important constituents in arctic estuary-shelf slope systems
Angerbjörn, Anders Stockholms universitet	Evolutionary consequences of the Pleistocene glacial cycles on arctic species
Bennett, Keith Uppsala universitet	Beringian terrestrial palaeoecology
Danell, Kjell Sveriges lantbruksuniversitet	Mammalian herbivore communities and their food plants
Elmhagen, Bodil Stockholms universitet	The role of medium sized predators in the arctic ecosystem
Eriksen, Bente Göteborgs universitet	Migration and evolution of arctic plants in response to past climate change
Fernholm, Bo Naturhistoriska riksmuseet	Collections of museum specimens
Fransson, Agneta Göteborgs universitet	Surface-water biogeochemistry and air-sea exchange of CO_2
Hansson, Lars-Anders Lunds universitet	Food, predation and UV as drivers for benthic-pelagic coupling in arctic freshwater systems
Hjältén, Joakim Sveriges lantbruksuniversitet	Biogeographical patterns regarding the diversity, distribution and regulation of arctic willows and insects
Huss-Danell, Kerstin Sveriges lantbruksuniversitet	Nitrogen fixation in different successional stages of vegetation
Jakobsson, Martin Stockholms universitet	The palaeoenvironmental and tectonic evolution of the Arctic Ocean
Kylin, Henrik Sveriges lantbruksuniversitet NILU	Air-sea exchange and degradation of organic contaminants in Arctic lakes and the Arctic Ocean
Lindgren, Åsa Stockholms universitet	Herbivory and plant biodiversity in an arctic environment
Lindström, Åke Lunds universitet	Migration routes, fuelling and trans-oceanic flights of arctic shorebirds
Olsen, Björn Länssjukhuset, Kalmar Umeå Universitet	Avian flu, enterobacteria and tick borne diseases in the Arctic
Pease, Victoria Stockholms universitet	Alaska-Chukotka microplate tectonics
Skoog, Anneli University of Connecticut, USA	The biogeochemistry of organic matter in the Arctic Ocean
Sommar, Jonas Göteborgs universitet	Circumpolar transport and air-surface exchange of mercury
Tranvik, Lars Uppsala universitet	Dissolved organic matter (DOM) in the Arctic Ocean
Tweedie, Craig University of Texas, USA	Rapid assessment of recent changes in land cover and carbon balance in Beringia
Wassmann, Paul Tromsö universitet, Norge	Nutrients, suspended biomass and plankton in the upper waters of the Arctic Ocean
Åkesson, Susanne Lunds universitet	Bird orientation at high geographic and geomagnetic latitudes

Beringia 2005 – tidtabell

Översikt Oden alla etapper (1, 2AB, 3)

13 juni–17 juni	Mobilisering av vetenskaplig utrustning, Stockholm	
5 juli	Oden avgår från Göteborg, etapp 1 startar	
31 juli	Rotation i Barrow, etapp 1 avslutas	
3 augusti–5 augusti	Oden klarerar in i Providenija, etapp 2A går ombord	
17 augusti	Oden klarerar ut ur Ryssland till havs utanför Lavrentia	
19 augusti–20 augusti	Rotation i Barrow, etapp 3 startar	
25 september	Avslut i Longyearbyen, Svalbard, etapp 3 avslutas	
10 oktober	Demobilisering av vetenskaplig utrustning, Göteborg	

Etapp 1 Oden

5 juli	Avgång från Göteborg	
15 juli–27 juli	Nordvästpassagen genom kanadensiska Arktis	
21 juli	Hercules C-130 flyg från Stockholm till Barrow	
31 juli	Barrow, etapp 1 avslutas	
31 juli–2 augusti	Hercules C-130 flyg från Barrow till Stockholm via Svalbard	

Etapp 2AB Oden

21 juli–25 juli	Hercules C-130 flyg från Stockholm till Providenija, via Grönland och Alaska	
26 juli	Det terrestra arbetet startar i Ryssland	
3 augusti–5 augusti	Oden klarerar in i Providenija, etapp 2A går ombord	
17 augusti	Oden klarerar ut ur Ryssland till havs utanför Lavrentia	
19 augusti–21 augusti	Terrestra fältläger i Barrow	
21 augusti–23 augusti	Hercules C-130 flyg från Barrow till Stockholm via Grönland	Alla utom post-Barrow
23 augusti–24 augusti	Terrestra fältläger i Atqasuk	post-Barrow
25 augusti	Reguljärt flyg till Nome via Fairbanks	post-Barrow
26 augusti–1 september	Terrestra fältläger längs tre vägar vid Nome	post-Barrow
1 september–4 september	Reguljärflyg till Skandinavien via Seattle och Köpenhamn	post-Barrow

Etapp 2C Anadyr

17 juli–9 juli	Reguljärflyg till Anadyr, via Moskva	
22 juli–4 augusti	Terrestra fältläger vid tre områden runt Anadyr	
16 augusti–17 augusti	Reguljärflyg till Stockholm via Moskva	

Etapp 2C Kamtjatka

11 juli–12 juli	Reguljärflyg till Petropavlovsk via Moskva	
15 juli–1 augusti	Fältarbete vid sju läger från Ust'-Bolsheretsk till Karaginskiy Island	
13 augusti–14 augusti	Reguljärflyg till Skandinavien via Moskva	

Etapp 2D Alaska

1 augusti	Fältarbetet startar	
20 augusti–26 september	Huvudsäsong med tre fältläger vid tre områden i Yukon-Kuskokwimdeltat och ett läger vid Egegik. Reguljärflyg till Europa	
15 oktober	Fältarbetet slutar	

Etapp 3 Oden

15 augusti–17 augusti	Hercules C-130 flyg från Stockholm till Barrow via Svalbard	
20 augusti	Oden avgår från Barrow	
1 september	Rendez-vous med Healy	
12 september	Nordpolen	
25 september	Etapp 3 avslutas i Longyearbyen, Svalbard. Till Skandinavien med reguljärflyg	

Etapp 3 Healy

5 augusti	Healy avgår från Dutch Harbor, Alaska	
1 september	Rendez-vous med Oden	
12 september	Nordpolen	
30 september	Healy anländer Tromsö, Norge	

Planerade expeditioner 2006–2009

SWEDARP 2005/06

Nr	Expedition/projekt	Syfte	Tidpunkt	Plats	Logistikansvar
1	AMANDA/ IceCube	Neutrinodetektion	Nov-jan	Amundsen-Scottbasen	USA
2	EPICA (internationellt program med djupisborrningar)	Klimathistoria	Nov-feb	Kohnen Base	Frankrike/ Italien/ Tyskland
3	Staten Island	Klimathistoria	Nov-dec	Staten Island	Argentina
4	DROMLAN	Logistiksamarbete	Jan	Dronning Maud Land	Sverige

SWEDARCTIC 2006 Inga planerade expeditioner

SWEDARP 2006/07

Nr	Expedition/projekt	Syfte	Tidpunkt	Plats	Logistikansvar
1	Dronning Maud Land	Monitoring, permafrost, atmosfärsfysik, geodesi	Nov-jan	Dronning Maud Land	Sverige
2	AMANDA/ IceCube	Neutrinodetektion	Nov-jan	Amundsen-Scottbasen	USA

SWEDARCTIC 2007

Nr	Expedition/projekt	Syfte	Tidpunkt	Plats	Logistikansvar
1	NO Grönland	Maringeologi	Aug-sep	Norra ishavet nordost Grönland	Sverige
2	Abisko	Terrester ekologi	Jul-aug	Forskningsstationer i svenska fjällen	Sverige
3	Kinnvika	Tvärvetenskapligt projekt	Jul-aug	Svalbard	Finland

SWEDARP 2007/08

Nr	Expedition/projekt	Syfte	Tidpunkt	Plats	Logistikansvar
1	Dronning Maud Land	Monitoring, permafrost, atmosfärsfysik	Nov-feb	Dronning Maud Land	Sverige
2	ITASE-travers	Glaciologisk travers	Nov-feb	Dronning Maud Land	Sverige
3	AMANDA/ IceCube	Neutrinodetektion	Nov-jan	Amundsen-Scottbasen	USA

SWEDARCTIC 2008

Nr	Expedition/projekt	Syfte	Tidpunkt	Plats	Logistikansvar
1	Högarktis	Atmosfärskemi, meteorologi	Aug-sep	Arktiska oceanen	Sverige
2	Laptevhavet	Oceanografi, marin kemi	Aug	Laptevhavet	Ryssland
3	Abisko	Terrester ekologi	Jul-aug	Forskningsstationer i svenska fjällen	Sverige
3	Kinnvika	Tvärvetenskapligt projekt	Jul-aug	Svalbard	Finland

SWEDARP 2008/09

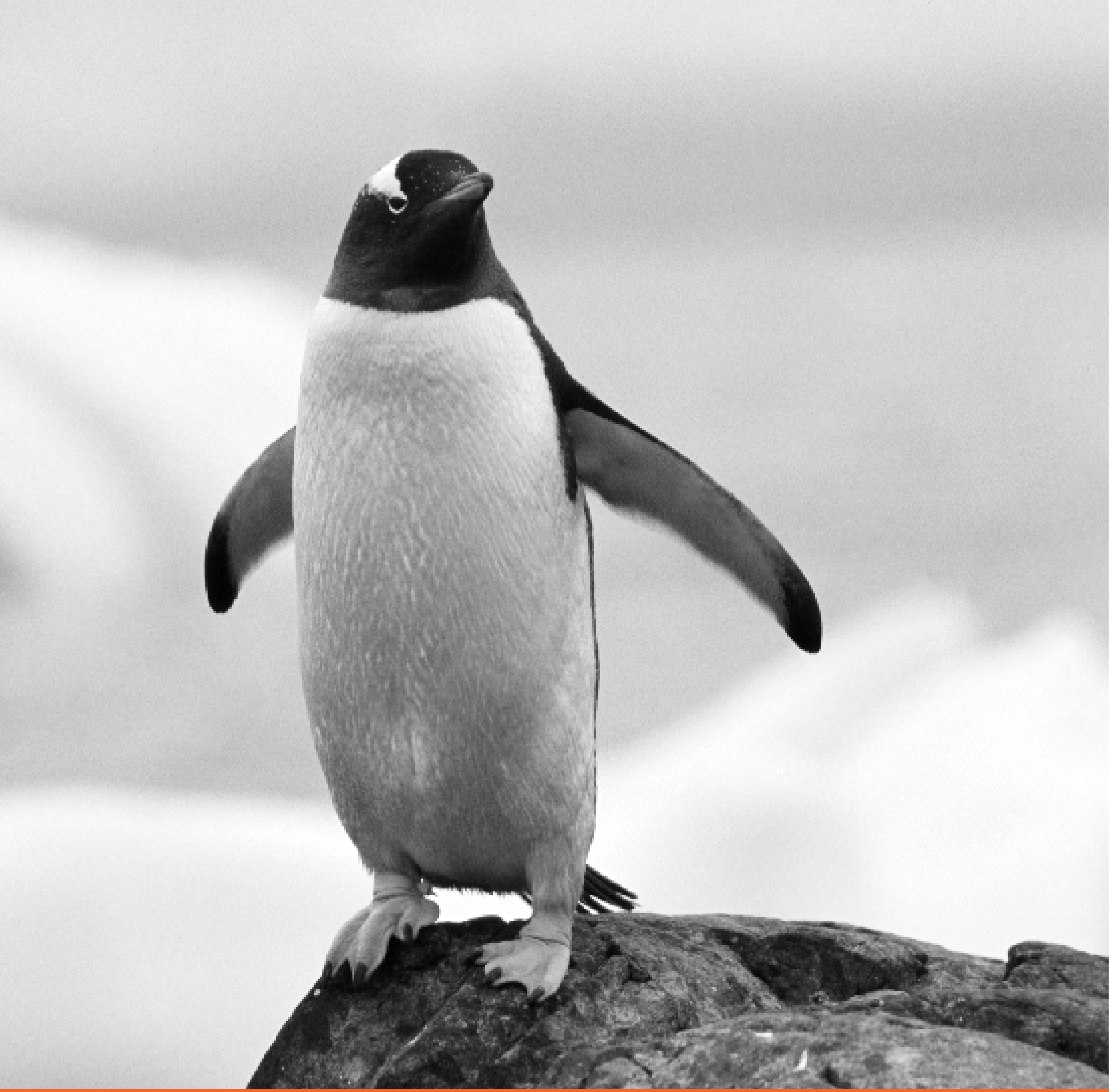
Nr	Expedition/projekt	Syfte	Tidpunkt	Plats	Logistikansvar
1	Dronning Maud Land	Monitoring, atmosfärsfysik, permafrost	Nov-feb	Dronning Maud Land	Sverige
3	AMANDA/ IceCube	Neutrinodetektion	Nov-jan	Amundsen-Scottbasen	USA

Representation i internationella organisationer 2005

Organisation/nätverk	**Uppgift**
COMNAP – Council of Managers of National Antarctic Programs	Ledamot
COMNAP – Executive Committee	Ledamot
COMNAP Working groups	Ledamot
ENMANET – Energy Management Network	Ledamot
INFONET – Antarctic Information Officers Network	Ledamot
IPYCG – International Polar Year Coordinating Group	Ledamot
NAEON/AEON – (Nordic) Antarctic Environmental Officers Network	Ledamot
SCALOP – Standing Committee on Antarctic Logistics and Operations	Ledamot
STADM – Joint SCAR/COMNAP Steering Committee for Data Management	Ledamot
TANGO – Working Group on Tourism and NGOs	Ledamot
DROMLAN – Dronning Maud Land Air Network	Ledamot
IASC Regional Board – International Arctic Science Committee	Ledamot
NSP – Nordiska samarbetskommittén för polarforskning	Ledamot
FARO – Forum of Arctic Research Operators	Styrelseledamot
CEP – Open Ended ICG – Antarctic Treaty Committee for Environmental Protection Open Ended Intersessional Contact Group	Ledamot
EPB – European Polar Board	Styrelseledamot

Forskarrapporter Cruise Reports

Innehåll Content Forskarrapporter Cruise Reports



SWEDARP 2004/05

Forskarrapporter **Cruise Reports**

Project leader

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Project participant

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Landforms, processes and climate in the active layer, Dronning Maud Land, Antarctica

Background

About 5% of the total area of the Antarctic continent is ice-free permafrost terrain. The special climatic conditions, with very low temperatures and little precipitation, lead to permafrost with a very low moisture content and a thin active layer. The Antarctic environment therefore offers unique opportunities to study geomorphological processes in a setting very different from the northern polar region. Permafrost research has so far been concentrated to the northern hemisphere and therefore the understanding of how climate and permafrost interact on Antarctica is very limited. Since permafrost is now recognized as an important part of the global cryosphere there are also new demands for more knowledge on permafrost conditions in the southern hemisphere.

The research undertaken during the SWEDARP expedition to Dronning Maud Land (DML) in 2004/05 is part of an ongoing project initiated during the DML-expedition 2003/04. During the expedition 2003/04, which was concentrated to Wasa and Fossilryggen, ground temperatures and soil moisture conditions were found to enable active layer processes and generate a rich variety of patterned ground landforms. The same process was also confirmed at Svea, during the expedition 2004/05, where patterned ground phenomena were observed (Fig. 1). A climate station for measurements of ground temperatures and other climate parameters was also installed at the Finnish base Aboa close to Wasa in 2003/04.

Figure 1
Patterned ground in proximity to the field station Svea. Photo: Hanna Ridefelt.

Objectives

The principal aim during the expedition 2004/05 was to install data loggers for long-term measurements of ground temperatures at Fossilryggen and Svea, forming a temperature monitoring transect from the coast to the inland escarpment (Fig. 2). Furthermore different climatic parameters, such as soil moisture, ground and air temperatures, incoming radiation and wind speed, were also measured in relation to frost heave landforms. The objective of these measurements is to see how ground micro-climate drives and inhibits soil movement in the active layer and landform generation.

Long-term monitoring of ground temperatures

Two loggers were installed at Fossilryggen and Svea respectively. These loggers measure ground temperatures at depths of 2, 10, 30 and 60 cm and contribute data to the Circumpolar Active Layer Monitoring (CALM) programme. The loggers remain at the mentioned sites for year-round monitoring and data from them should be downloaded annually. The data set will be integrated in the snapshot documentation of the global state of permafrost during the International Polar Year 2007–2008.

Short-term micro-climate observations at sorted patterned ground

Short-term measurements were made for 12 days in proximity to a frost heave-generated landform during a period of initial thaw after the winter freeze-up of the ground. The measured parameters were soil moisture and ground temperatures at depths of 5 and 10 cm, incoming short-wave radiation on the ground surface, wind speed close to the ground surface and air temperatures at heights of up to 1 m (Fig. 3). The latter were measured to test wind cooling effects on ground surface temperatures under different vertical temperature gradients. Soil moisture was measured with delta-T TDR-probes.

Results

Data from the loggers located at Fossilryggen and Svea will not be available until after the SWEDARP 2006/07 expedition. However the data from the short-term measurements is of great interest, especially with respect to soil moisture and ground temperatures (Fig. 4). There is a clear relationship between temperature and soil moisture. The near-surface soil moisture (at a depth of 5 cm) shows a decrease during the measurement period, while the soil moisture further down (at a depth of 10 cm) increases during the period. The high salt content causes a distinct freezing point depression of the soil water.

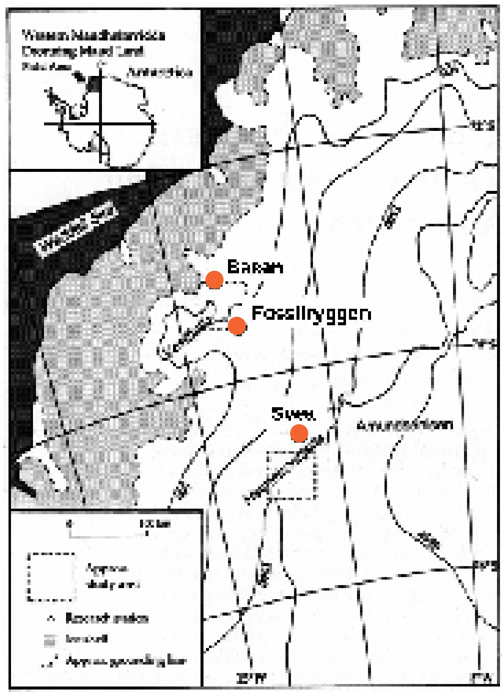

Figure 2
Locations of loggers for long-term monitoring.

Installed climate stations for ground temperatures.

This results in diurnal water melt and refreezing, even though the temperature is not above zero. These preliminary results suggest that surface release of soil moisture commences as soon as ice melts, even at sub-zero temperatures. Antarctic soils are known to be highly saline and this appears to play an important role in the freeze-thaw dynamics of the active layer. The origin of ice in the soils needs further study but field observations suggest crystalline pore ice development by direct atmospheric precipitation in the pores.

Data from the air and ground temperature profiles are still under analysis. Analysis of similar measurements made during SWEDARP 2003/04 at a rock surface illustrates some principles (Fig. 5). Diurnal radiational heating commonly results in rock surface temperatures far exceeding those in the air and at deeper levels in the rock material. However low air temperatures, especially in association with strong winds, result in effective surface heat loss and rock surface temperature depression. Porous media such as soils, with lower heat conductivity, are expected to show even stronger surface cooling. This mechanism is expected to be an important driving factor for the very high frequency of diurnal frost cycles in the maritime Antarctic (Boelhouwers et al. 2003). The temperature profiles measured during the cruise and reported here are expected to provide further insights into the importance of convective heat loss in freeze-thaw processes.

Figure 3
Installed dataloggers for short term monitoring of climate parameters in relation to frost heave landforms at Wasa.
Photo: Hanna Ridefelt.

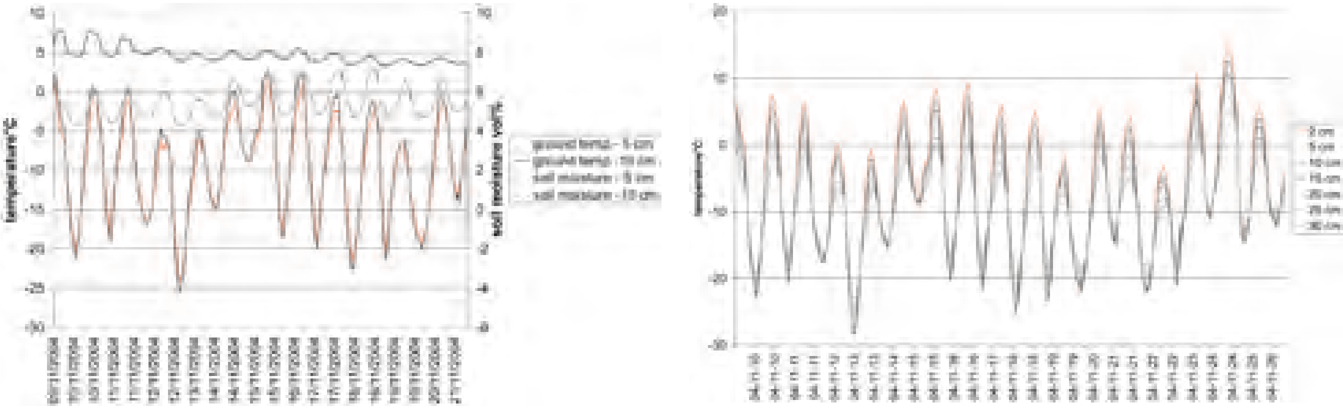

Figure 4
Ground temperatures and soil moisture from 9 to 20 November 2004. Note that soil moisture values must be considered relative as the instrument was not calibrated for the high salt content of the sediment. The high salt content also explains the high freezing point depression of soil water suggested by the results.

Preliminary conclusions

- An active layer monitoring network has been installed along the Wasa, Fossilryggen and Svea transect. Data will be used during the International Polar Year 2007/08 and submitted on an ongoing basis to the CALM/GTN-P programme.
- Ground temperature and soil moisture measurements show that ground water is present in the form of both pore and segregation ice, but is rapidly released during the short thawing period during summer.
- The high salinity of Antarctic soils plays an important role in freeze-thaw dynamics and needs further understanding. As a first result, diurnal freeze-thaw cycles occur even where temperatures remain sub-zero.
- Clearly soil moisture and temperature fluxes need to be followed throughout the whole thaw season for a better understanding of active-layer dynamics.
- The low absolute soil moisture content limits the potential frost activity and the landforms are therefore believed to result from a very slow process activity during the Holocene.

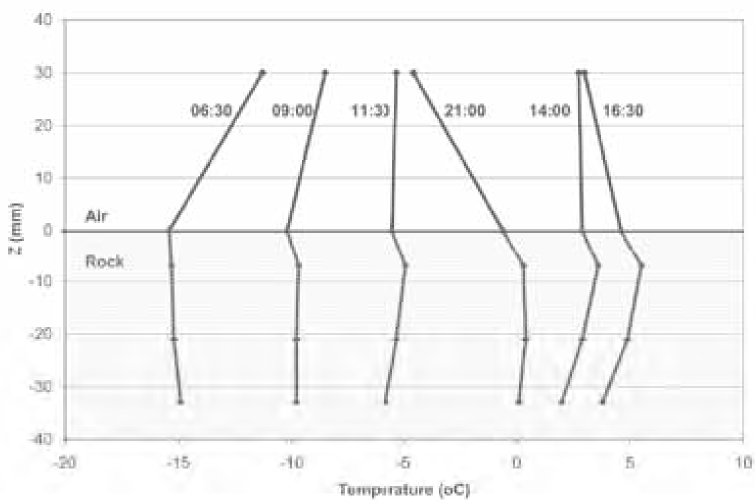

Figure 5
Near rock surface temperatures on the 18 November 2003, Wasa, Dronning Maud Land, Antarctica.

Alla isfria områden på Antarktis, ca 5 % av den totala arealen, har permafrost. Det kalla och torra klimatet skapar en torr permafrost med ett mycket begränsat aktivt lager. Den antarktiska miljön ger unika möjligheter att studera geomorfologiska processer i en miljö som skiljer sig markant från de norra polarregionerna, som har ett betydligt fuktigare klimat. Permafrost har hittills främst studerats på det norra halvklotet. Förståelsen av hur klimat och permafrost på Antarktis påverkar varandra är därför inte så stor. I dagsläget utgör kunskapen en mycket begränsad utgångspunkt för att kunna identifiera tecken på klimatförändringar och dess konsekvenser inom det antarktiska området. Inom detta projekt studerar vi därför landformer och dess förhållande till olika klimatologiska faktorer. Dataloggar har installerats på Svea och på nunataken Fossilryggen för automatisk mätning året runt av markfuktighet och marktemperatur i anslutning till landformer som bildats genom frostprocesser. Denna information ska komplettera den klimatstation som installerades på Wasa under expeditionen 2003/04. Preliminära slutsatser är att markvatten finns i form av segregationsis som frigörs under den korta töperioden på sommaren. Dygnsbundna frostcykler resulterar i smältning och delvis återfrysning av is, som leder till bildandet av sorterad strukturmark. Den låga halten av markfuktighet begränsar den potentiella frostaktiviteten vilket antyder att de landformer som observerats har bildats genom mycket långsamma processer under holocen.

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UU/IMAU AWS in Dronning Maud Land, 2004/05 activities

Aim of the work

Since 1997/98 IMAU has been operating Automatic Weather Stations (AWS) in western Dronning Maud Land, of which one is situated close to Wasa (AWS 5) and one near Svea (AWS 6). The data from these stations have a very wide range of applications, from model validation, energy balance and mass balance calculations to supporting logistic operations. Funding for the operation of the AWS is secured until 2012. There are advanced plans for detailed meteorological measurements at the site of AWS 5 in 2006/07, in close collaboration with SWEDARP/Swedish Polar Research Secretariat and Stockholm University. As part of that experiment the AWS will be equipped with sensors for year-round eddy-correlation measurements. It is expected that data from AWS 5 and 6 will be available on GTS (Global Telecommunication System, used by weather forecasters to collect meteorological data from around the world) for weather forecasting and logistical purposes from November 2005 onwards. For several years already, the ARGOS receiver at McMurdo station has enabled online publication of the AWS data on the Antarctic AWS website of the University of Wisconsin, see http://amrc.ssec.wisc.edu/realaws.html.

Fieldwork in 2004/05

In the field season of 2004/05, AWS 5 near Wasa and AWS 6 near Svea were visited by IMAU technician Marcel Portanger, supported by personnel and vehicles from the Swedish Polar Research Secretariat (Fig. 1).

Figure 1
AWS 5 and AWS 6 were given a new mast extension system, which should considerably simplify AWS maintenance in the future. Photo: Uwe Raffalski.

Memory modules were exchanged, battery packs replaced and the mast system was replaced, allowing for easier mast extension in the future. Where necessary, sensors were replaced and snow temperature sensors were brought to the surface.

Some results

AWS 5 and AWS 6 are the most reliable IMAU AWS, because they experience persistent katabatic wind, which prevents ice accretion. As a result, nearly continuous measurements are now available since the beginning of 1998, i.e. covering more than 7 years. Figure 2 shows the newest logger data of wind speed and temperature (hourly means are stored). A very long-lasting strong wind event occurred in May 2004, associated with high temperatures. Both at AWS 5 and 6, -40°C is occasionally reached, but only for short periods of time. The spring of 2004 was colder than the year before.

Data availability

The AWS data are available for research purposes free of charge (certain conditions apply when data are used in publications, contact Michiel van den Broeke).
Those interested to work with the data should contact Michiel van den Broeke broeke@phys.uu.nl or Carleen Reijmer c.h.reijmer@phys.uu.nl.

Acknowledgments

We thank all those involved in the 2004/05 maintenance of AWS 5 and 6, especially those that supported the fieldwork.

More information

For more information about IMAU AWS, go to: http://www.phys.uu.nl/~wwwimau/research/ice_climate/aws/

Figure 2
Wind speed (above) and temperature (below) at AWS 5 and 6 during the year preceding the 2004/05 fieldwork.

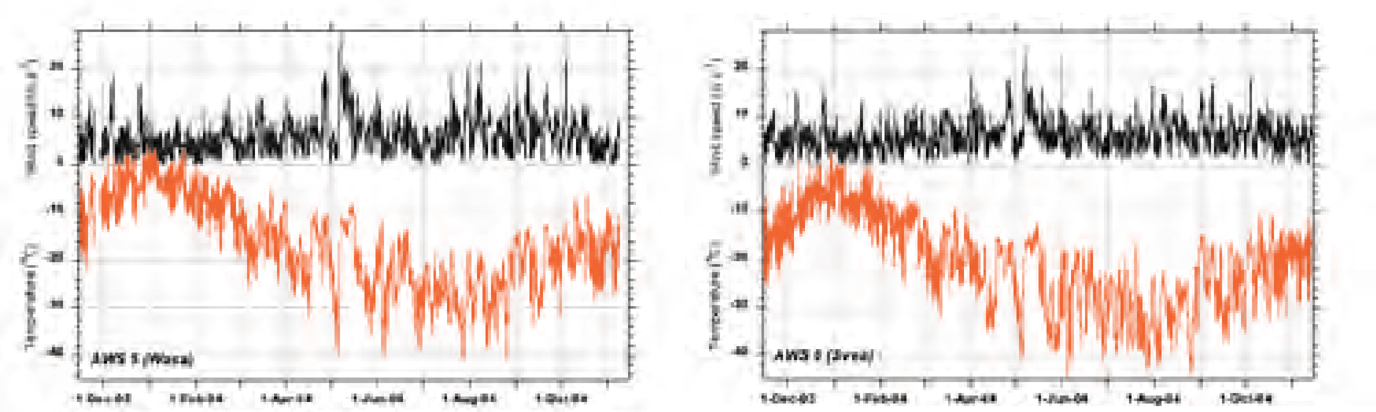

Table 1
IMAU-AWS locations in western Dronning Maud Land, Antarctica

AWS name	Location	Coordinates and elevation
AWS 5	Camp Maudheimvidda	73˚06'19"S, 13˚09'53"W, 363 m a.s.l.
AWS 6	Svea Cross	74˚28'89"S, 11˚31'06"W, 1100 m a.s.l.

För sjunde året i rad har de automatiska väderstationerna AWS 5 (vid den svenska Antarktisstationen Wasa) och AWS 6 (vid den svenska Antarktisstationen Svea) levererat meteorologiska observationer utan avbrott. Väderstationerna drivs av Utrecht University i nära samarbete med Polarforskningssekretariatet. Under säsongen 2004/05 byttes masterna ut mot teleskopmaster utan stagvajrar. Under säsongen 2006/07 kommer AWS 5 att utrustas med en turbulenssensor och utförliga meteorologi- och strålningsstudier ska utföras i väderstationens närhet i samarbete med Stockholms universitet.

The neutrino telescopes AMANDA and IceCube at the South Pole

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The aim of AMANDA and IceCube

The AMANDA telescope for high-energy cosmic neutrinos was constructed between 1995 and 2000 deep down in the ice sheet at the Amundsen-Scott base at the South Pole, Antarctica. The scientific goals are, among others, to use the neutrino particles to investigate the question of the "dark matter" of the Universe and to search for the sources of the highest energy cosmic rays. The neutrino particles are extremely penetrating and interact only very rarely with matter. They are expected to be produced through different violent processes in the Universe, and the possibility to detect high-energy neutrino sources will open a new window in the study of the Cosmos. In order to compensate for the extremely low probability for the neutrino to interact with matter one needs very large detectors. The AMANDA detector is sensitive to the emitted Cherenkov light from muons created by neutrino interactions deep in the ice.

In detectors of this type it is necessary to have a very transparent material, such as clear ice, in order to obtain efficient light propagation. The ice sheet at the South Pole is 2 900 m deep and extremely transparent at large depths (Askebjer et al. 1997, Askebjer et al. 1998). The detector consists of 677 optical modules deployed in 19 holes in the ice. The holes were made using a hot water drilling technique and the modules were frozen in during a period of about one week. The optical modules are photomultipliers contained in pressure vessels (glass spheres) deployed at depths between 1 200 m and 2 300 m. The central part of the detector, with the highest density of optical modules, is between 1 500 m and 2 000 m below the surface. The diameter of the detector is 200 m. The photomultipliers are sensitive to single photons in the wavelength range from 330 nanometres (nm) to 600 nm and have a diameter of 20 cm. The signal from each photomultiplier is transmitted via cables up to the surface and read by on-line computers. The American Polar Ice Core Office (PICO) has performed the hot water drilling with help of Swedish drillers from the Swedish Polar Research Secretariat.

The AMANDA detector has been fully operational and taking data since February 2000. The completed detector is named AMANDA-II in order to distinguish it from the partially equipped stages AMANDA-B4 and AMANDA-B10. The detector is modular and it was possible to start data taking with only a fraction of the total number of strings. In this way data from the 4-string (B4) and 10-string (B10) detectors have been analyzed and published.

The AMANDA neutrino telescope is the largest in the world, but due to the extremely low expected rate of neutrinos it is probably still too small. The construction of a much larger telescope, the new IceCube Neutrino Observatory, started at the South Pole in January 2005. The complete observatory will consist of 4 800 optical modules deployed between 1 450 and 2 450 m depth in 80 holes covering an instrumented volume of about 1 km^3. On top of the neutrino telescope an air shower array, IceTop, will detect air showers from cosmic rays interacting in the atmosphere (see Figure 2). The combination of IceTop and the detectors in the ice will allow calibration of IceCube with the help of the atmospheric muons, as well as the study of the chemical composition of the incoming cosmic rays. The AMANDA telescope will be an integral part of the IceCube observatory; the AMANDA collaboration joined the new IceCube collaboration in 2005.

The IceCube project is a collaboration between Chiba University, Japan; IAS Princeton, USA; Clark Atlanta University, USA; University of Maryland, USA; University of Alabama, USA; Université Libre de Bruxelles, Belgium; Vrije Universiteit Brussel, Belgium; University of Mons-Hainaut, Belgium; University of California, Berkeley, USA; Lawrence Berkeley National Laboratory, Berkeley, USA; Bartol Research Institute, University of Delaware, USA; University of Kansas, USA; Southern University and A&M College, Baton Rouge, USA; Universität Berlin, Germany; University of California, Irvine, USA; Pennsylvania State University, USA; University of Mainz, Germany; University of Dortmund, Germany; University of Gent, Belgium; Stockholm University, Sweden; Uppsala University, Sweden; DESY-Zeuthen, Germany; University of Wisconsin, Madison, USA; University of Wisconsin-River Falls, USA; University of Wuppertal, Germany; Imperial College, London, UK; University of Oxford, UK; Utrecht University, the Netherlands; University of Canterbury, New Zealand.

The fieldwork

Researchers and scientific equipment are transported by air from Christchurch, New Zealand to the American base McMurdo on Ross Island, and from there to the Amundsen-Scott station at the geographical South Pole. Heavy equipment can also be transported by vessel once a year arriving at McMurdo in January-February. This year the Swedish researchers were involved in general service of the AMANDA telescope. A Very Low Frequency (VLF) antenna started to transmit in January 2003 a few km from the AMANDA site at the South Pole. It transmitted 1 min every 15 minutes and completely prevented AMANDA from collecting data during that time due to a general increase in the noise level. A new filter was constructed in Stockholm and tested at the South Pole by people from Stockholm University in November 2003. During this season (2004/05) all channels in AMANDA were equipped with VLF filter allowing AMANDA to collect data continuously. In addition the electronics in AMANDA were tuned for a higher dynamic range using the new transient waveforms recorder system (TWR) in AMANDA.

The most important activity this season was the start of the construction of the IceCube Neutrino Observatory. The new hot water drill for IceCube has a heating power of 5 MW compared with 2 MW for the AMANDA drill. It is more advanced and is designed to drill a 60 cm diameter hole down to 2 500 m within less than 40 hours. The optical modules for IceCube digitize the signals and transmit all information in digital form. The timing calibration – which took several weeks for AMANDA – is done automatically every 2 seconds for the whole IceCube array. The hot water drill was assembled during November–December 2004 and was ready in January 2005. Some problems were found during the preparation of the drill and only one hole was successfully made at the end of January 2005. The first IceCube string with 60 optical modules was deployed. All optical modules survived the freezing of the hole and fulfil the design performance. This season Sweden contributed with 3 technicians for the drilling operation. The last string of IceCube is planned to be deployed in January 2010. The telescope is modular and any newly deployed string will be commissioned as soon as it is in. In this way the sensitivity of the observatory to detect neutrinos will continuously increase.

There was a serious accident during drilling, in which one Swedish driller was critically injured. Thanks to the professional intervention of the station trauma team his

Figure 1
Walking towards the new South Pole station from the IceCube area.
Photo: Per Olof Hulth.

condition could be stabilised prior to evacuation by a specially summoned Hercules C-130 aircraft. The transfer to a Christchurch hospital was completed 22 hours after the accident, and resulted in almost complete recovery for the injured person.

Preliminary results

The AMANDA telescope is working very well and detects about 10 atmospheric neutrinos per day. The atmospheric neutrinos are produced in the collisions between cosmic rays and atoms in the atmosphere of the Earth. So far no evidence for extraterrestrial neutrinos has been found. About 20 scientific papers have been published in refereed journals since the year 2000 and many results have been presented at conferences. One example is a general paper on principles and first results which was published in Nature (Andrés et al. 2001). Papers on the search for supernova neutrinos and dark matter particle-annihilations in the centres of the Earth and Sun have also been published (Ahrens et al. 2002a, Ahrens et al. 2002b, Ackermann et al. 2005a), as have searches for point sources of neutrinos (Ahrens et al. 2004a, Ackermann et al. 2005b) and neutrino-induced cascades (Ahrens et al. 2003). The composition of the cosmic rays has been studied using AMANDA data in coincidence with the air shower detector SPACE situated on the ice surface above AMANDA (Ahrens et al. 2004b).

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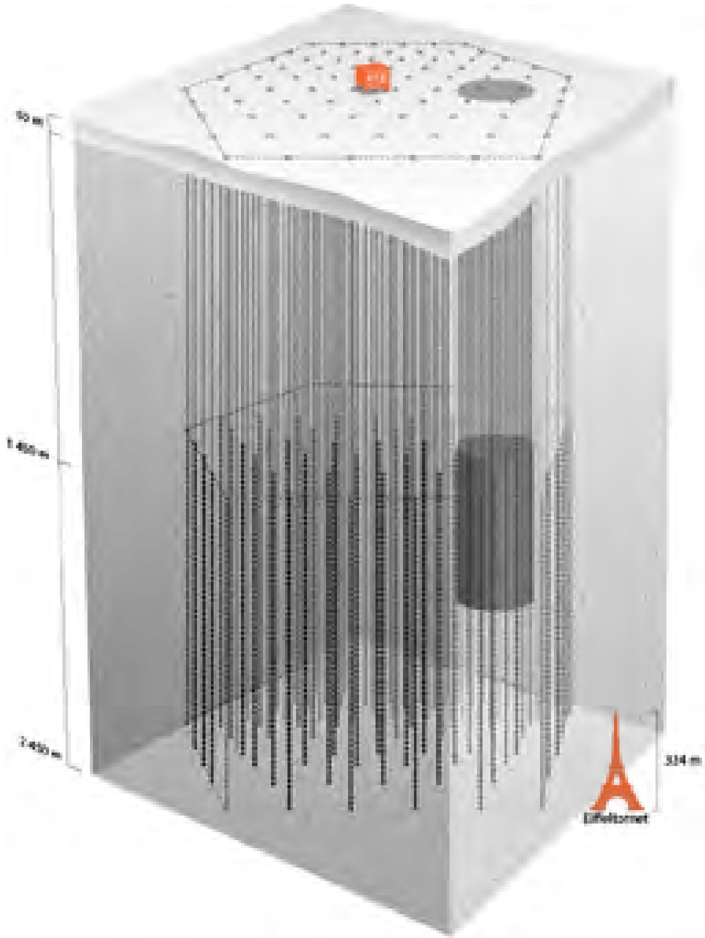

Figure 2
The IceCube neutrino observatory with the air shower telescope IceTop at the surface and the IceCube neutrino telescope deep in the ice. Each dot corresponds to one Digital Optical Module (DOM).The darker cylinder inside IceCube is the AMANDA telescope. In total there are 4 800 DOMs deployed in the 80 strings. As a comparison the size of the Eiffel tower is shown.

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Neutrinoteleskopet AMANDA är placerat på 1 500–2 000 meters djup i isen vid Amundsen-Scott-basen på Sydpolen. Totalt har 670 ljusdetektorer placerats där. Dessa detekterar den mycket svaga ljusblixt som bildas då neutrinopartiklar kolliderar med en atom nere i isen. Teleskopet kan bestämma riktningen på den inkommande neutrinon till några graders noggrannhet. Man har observerat sedan februari 2000 med vissa avbrott för service under november-januari varje år. Svenska forskare deltog i november–december 2004 i servicen på Sydpolen med att bl.a. testa och uppgradera den svenskbyggda elektroniken. AMANDA-teleskopet är nu världens främsta instrument för att detektera högenergetiska neutriner från rymden. Hittills har man enbart detekterat neutriner producerade i atmosfären av kosmisk strålning (ca 10 per dag). En mängd intressanta resultat har publiceras. Den viktigaste aktiviteten under säsongen 2004/05 var dock starten av byggandet av det nya teleskopet IceCube som kommer att bestå av 4 800 ljusdetektorer utplacerade i en volym av 1 kubikkilometer. Den första detektorssträngen med 60 ljusdetektorer placerades på 1 450–2 450 meters djup. Svenska borrare och forskare deltog i arbetet.

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Atmospheric measurements at the Swedish antarctic station Wasa

Scientific background

Everybody knows that the Antarctic meteorological conditions on the ground are rather unique, with low temperature, strong winds and very low precipitation. In addition the troposphere (up to 10 km) and the stratosphere (up to 60 km) are very different from the Arctic troposphere and stratosphere. The very low temperature in the stratosphere during the Antarctic winter has lead to the development of the ozone hole since human activities have substantially changed the atmosphere's chemical composition. The chlorine loading in the stratosphere is four times the natural abundance (WMO, 2002) causing, since the beginning of the 1980s, severe ozone depletion between 13 and 23 km in the late winter period, commonly called the ozone hole.

Ground-based instruments all over the world are now monitoring the atmosphere for variation and trends in ozone and other atmospheric constituents. Satellites are also used for this task, but despite the valuable global coverage under their lifetime they still need groundtruth data for validation purposes.

Ground-based monitoring at the Swedish Antarctic station Wasa (see Figure 1) would provide one more data point in the sparse distribution of measurements on the Antarctic continent.

Observations at additional Antarctic stations are also of great value in order to investigate the chemical evolution as well as transport processes of stratospheric and tropospheric trace gases. In particular simultaneous measurements with the nearby German Georg von Neumayer-Station offers a great potential for related studies. The fate of air masses passing both stations can be studied in detail. Such studies are of great importance and have never before been performed in Antarctica.

The aim of this part of the project was to investigate the environmental and logistical prerequisites for continuous observation of stratospheric and tropospheric trace gases with a MAX DOAS instrument (Multi-Axis Differential Optical Absorption Spectrograph), which would allow us to address the above mentioned scientific questions (Hönninger 2004 and Friess 2004).

The second part of this project was to identify a suitable location for the 'Moveable Atmospheric Radar for Antarctica' (MARA) with respect to prevailing wind conditions at Wasa. MARA will be installed at Wasa station during the Antarctic summer 2006/07 for the observation of atmospheric waves. The MARA experiment will be operated during the summer months and we will investigate the suggested connection between planetary wave activity and the observed

Figure 1
The Swedish antarctic station Wasa.
Photo: Uwe Raffalski.

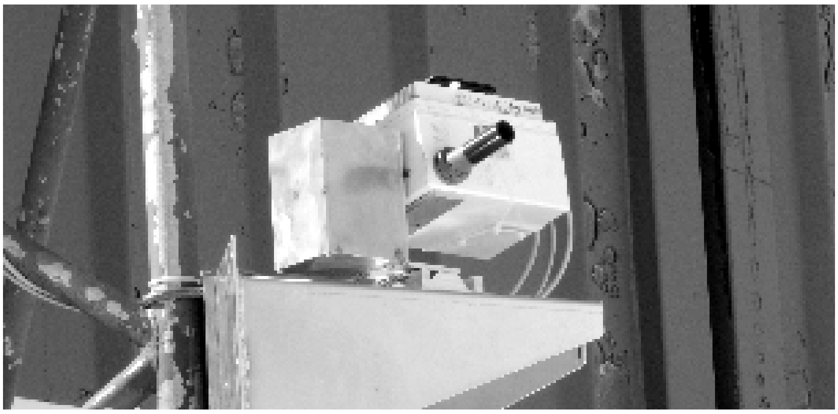

Figure 2
The Multi-Axis DOAS installed behind the generator container.
Photo: Uwe Raffalski.

decadal variability of noctilucent clouds (NLC or PMC) and polar mesospheric summer echoes (PMSE), which could not yet be explained sufficiently.

The polar upper mesosphere (between 50 and 90 km altitude) in summer is the site of the lowest temperatures in Earth's atmosphere, as low as -150°C. These cold conditions lead to the formation of ice clouds called NLC (noctilucent clouds, or polar mesospheric clouds, PMC) at around 85 km and of charged aerosol-particle layers (PMSE).

PMC and PMSE are expected to be affected by solar radiation and meteor input from above, by temperature oscillations and winds due to atmospheric waves propagating up from below and by changes in greenhouse gases in the atmosphere.

The location of MARA with its long dipole antennas needs to be chosen carefully in order to protect the antenna field from gusts and extraordinarily high wind speeds. Measurements of wind speed and direction have been obtained at a place on the glacier on the wind protected region behind the nunatak with Wasa and Aboa stations on its top. Figure 3 shows the meteorological station on the glacier.

The third part of this project was to revive the Air–Earth-current instrument installed at Wasa station in 2003 which was supposed to study the 'fair weather current' between the ground and the ionosphere above around 90 km altitude. This instrument stopped operating during 2004 and unfortunately could not be revived during the SWEDARP 2004/05 expedition.

The measurements and results

The MAX-DOAS feasibility study

MAX-DOAS measurements were performed continuously after the instrument was installed at a mast close to the generator container. The instrument collected sunlight that was scattered into the direction of observation of the DOAS. By variation of the elevation angle it is possible to distinguish between gases scattering in the troposphere (up to 10 km) and stratosphere (between 10 and 60 km).

The measurements turned out to be very stable as long as the direct sunlight did not reach the instrument. The heating due to direct sunlight could not be counteracted by the internal cooling system and the measurements could not be analysed. Proper shading of the MAX-DOAS instrument is obviously an important issue for a future long-term operation at Wasa station.

Extensive cooling might lead to increased power consumption, which might be a problem when the instrument is operated on Wasa station batteries after the dark winter season during which it has been idle. Meteorological conditions such as wind and low temperature (up to 25 m/s and down to -15°C, respectively) did not affect the MAX-DOAS instrument, except for strong snowdrift, which led to moderate snow accumulation in the open part of the instrument. A suitable construction to keep the snowdrifts away has to be developed for a DOAS instrument permanently installed at Wasa station.

However the main issue for a long-term operation of a future MAX-DOAS at Wasa station is still the telecommunication, that is the data transfer and the remote control of the instrument. These questions have to be solved by the Swedish Polar Research Secretariat in order to ensure a continuous operation at Wasa.

Meteorological measurements

Figure 3
The meteorological station at the 'glacier site' with the nunatak Basen in the background.
Photo: Uwe Raffalski.

A meteorological station was installed at the glacier adjacent to the foot of the nunatak Basen (see Figure 3). An area with a small rocky ridge sticking out of the glacier was chosen as the location for the measurements. Once the meteorological station was put up it measured continuously until the last day of the expedition. The results are presented in Figure 4. The conclusions drawn from the measurements are:

The average wind speed down at the glacier was lower than on top of the nunatak close to Wasa station. However the gusts were stronger than on top of the nunatak. Since the extreme wind speed is a problem for the MARA rather than

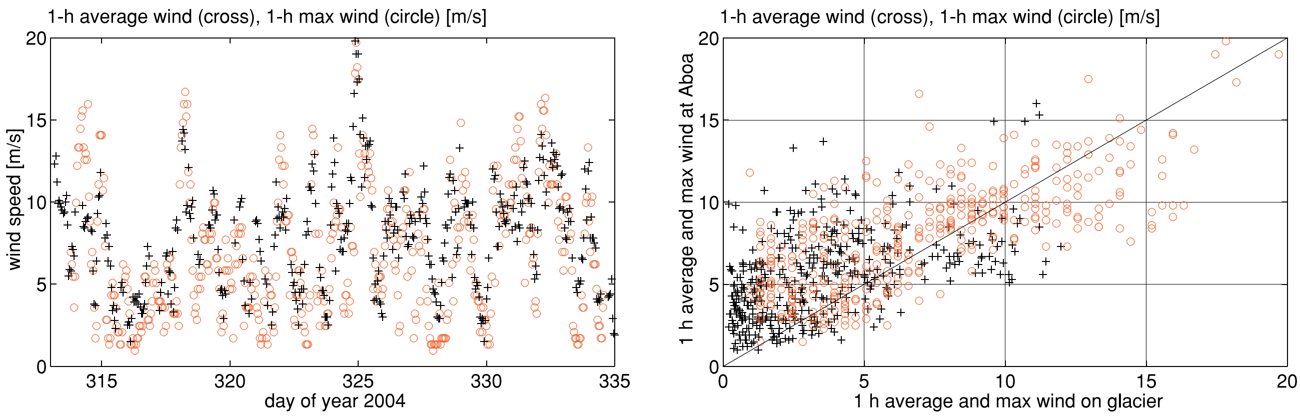

Figure 4
Comparison of winds between Wasa and the 'glacier site' (at the base of the nunatak Basen) for November 2004. The left panel with the wind speed averaged over one hour shows that Wasa has the higher wind speeds in average. However, the right panel shows that the stronger gusts have been observed at the 'glacier site' making this site less suitable for the MARA experiment.

continuous strong winds the site close to Wasa station will be the favorable site for the future MARA experiment. This will also easily solve the problem with the power supply for the experiment.

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Atmosfären och dess sammansättning ovanför den antarktiska kontinenten är unik i många avseenden. Det är inte bara kallt och blåsigt på ytan, utan temperaturen i den högre atmosfären, på ca 20–30 kilometers höjd, är också mycket lägre än temperaturerna över det norra halvklotet. Vid temperaturer lägre än -85°C under flera månader inträffar kemiska processer som är sällsynta över norra halvklotet, och som leder till kraftig ozonnedbrytning, och skapar det så kallade ozonhålet. Kontinuerliga markbaserade observationer på Wasa av den kemiska sammansättningen och transportprocesserna kan bidra med en mätpunkt till de annars så glesa mätningarna av detta fenomen på Antarktis.

Under SWEDARP 2004/05 genomfördes en studie för att se om ett Multi-Axis DOAS-mätinstrument kan installeras permanent på Wasa. Ett resultat av studien var att vi insåg att uppvärmningen från solen skapade stora problem för instrumentets interna kylningssystem. En lämplig avskärmning måste utvecklas, som dessutom förhindrar snödrivor kring eller på instrumentet om det ska övervintra och kunna starta mätningar på våren efter den mörka vintern. Strömförsörjning och fjärrstyrning är några av de problem som måste lösas av Polarforskningssekretariatets logistikavdelning om instrumentet ska kunna mäta på Wasa året runt.

Högre upp i mesosfären, på ca 50–90 kilometers höjd, faller temperaturerna till -150°C under den antarktiska sommaren, vilket ger upphov till ismoln och ett skikt av laddade aerosolpartiklar på 85 kilometers höjd. Detta fenomen ska undersökas på Wasa under flera antarktiska sommarperioder med början 2006/07 med hjälp av MARA-radarn (Moveable Atmospheric Radar for Antarctica). Vindmätningar som genomfördes under november 2004 vid foten av nunatakken Basen visade att den genomsnittliga vindhastigheten i lä av Basen var lägre, medan den maximala vindhastigheten (som vindkast) låg högre där. Därför kommer MARA:s antennfält med 48 dipolantenner att installeras på toppen av Basen.

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Continuous GPS-monitoring at Station Svea

Introduction

The participation of the Division of Geodesy of the Royal Institute of Technology, Stockholm, Sweden, in the SWEDARP Antarctic expedition in 2004/05 is a contribution to the SCAR permanent GPS tracking network. During the period 1991–2005 our division has taken part in five different expeditions to the Antarctic continent (1991/92, 1993/94, 1997/98, 1999/2000 and now 2004/05). The geodetic task was to continue the Swedish participation in the SCAR Epoch Crustal Movement GPS Campaigns at the Wasa Station (a short GPS observation time, 20 days measurement in the Antarctic summer observed from different sites) and to establish a continuous GPS monitoring site at Svea, the Swedish research station located in Heimefrontfjella in Dronning Maud Land about 100 km south of Wasa.

Figure 1
GPS measurement at Wasa station.
Photo: Erick Asenjo.

The SCAR GPS Crustal Movement Campaigns

The goal of the SCAR GPS campaigns, a part of the program Geodetic Infrastructure in Antarctica (GIANT, see www.geoscience.scar.org/geodesy/giant.htm) is to establish and to maintain a precise geodetic reference network linked to the international reference frame ITRF, to use the Antarctic network for geodynamic research and as a reference network with sites for other GPS applications. The GPS observation campaigns have become an important component of research in the frame of the SCAR group on specialists of Antarctic neotectonics, ANTEC (www.antec.scar.org).

SCAR GPS campaigns have been carried out annually with various participations since 1990/91. The list of participation this time was Base Artigas (supervised by Uruguay), Fossil Bluff (UK) Maitri (India), Vernadsky (Ukraine), and Svea and Wasa (supervised by Sweden). Since a few years ago some stations operate with permanent GPS stations all year round. The data from the permanent tracking sites have to be included in the list of participation and in the data analysis.

The observation parameters for this type of measurements are: 15-second recordings of the L1 and L2 GPS phase and code signals of all GPS satellites down to an elevation angle of 10 degrees above the horizon. A new instrument was used this time at site Wasa (Fig. 1): a Trimble R7 receiver with a Trimble Zephir Geodetic antenna with ground plane. More information about the observations, the instrument used and antenna and site definition is found at www.tu-dresden.de/ipg/service/scargps/scar2006.html.

Continuous GPS-monitoring at Svea station

Since January 2003 the Finnish Geodetic Institute (FGI) has been performing continuous GPS observations at Aboa station, only a few hundred metres from Wasa station, which has participated in several SCAR Epoch GPS campaigns. The set of observations at Aboa, connected to Wasa, is a natural continuation of the five previous GPS campaigns undertaken at Wasa. In a similar way it was decided to set up a new reference point at the Swedish research station Svea located in the Heimefrontfjella area. Our future efforts will mainly be focused on the maintenance of the continuously operating GPS station at Svea.

The GPS point at Svea is fixed to the solid bedrock, a few metres away from the main container of Svea, in such a way that we could accommodate there the battery pack for the power supply to the receiver. The instrument selected is a low-power GPS receiver R7 from Trimble with a consumption of 1.8–2.3 W. The R7 GPS receiver is a dual frequency system with L2C capability. The accuracy specified for the 24 channel instrument is ± 5 mm +0.5 ppm RMS in the horizontal and ± 5 mm + 1 ppm RMS in the vertical component. We disconnected the integrated UHF radio modem of the instrument to maintain a low energy consumption. The instrument collects 24-hour daily L1/L2 carrier phase data of high quality acquired with the 15-second sampling rate. Data are logged in a 1GB Compact Flash memory. We can log in the CF memory up to 512 days of raw observations collected at the specified sampling rate. The CF memory is for industrial use and can work down to -40°C. The operating temperature of the receiver also goes down to -40°C. The data are collected annually by manually changing the memory card during summer expeditions. The automatic transfer of data via satellite communication is not possible at this time.

Six 12 V batteries with total 600 Ah are charged through solar panels until the sun is below the horizon. This and a wind generator for the period of winter darkness are the options for power supply. The Swedish Polar Research Secretariat's logistic group is already planning a better future solution for power supply.

The Ashtech choke ring antenna is used with conical Ashtech snow radome and with a Dorne & Margolin vertical dipole element, a high precision antenna used in a number of reference stations all around the world.

As an antenna mount we decided to follow more or less the recommendation – referring mainly to the Wasa station – by the geodesist team participating in the expedition in 1999/2000 (see Andersson 2001). The solution consists of a 1.5 m high steel grid with a hot galvanized mast. As the point is marked in the solid bedrock we used a tribrach with optical plummet for centring the antenna exactly over the point.

A Real Time Kinematic (RTK) service is included in the project when the Svea station is open. RTK corrections are sent with 439.800 MHz using a 35 W Pacific Crest radio modem, model PDL HP Base. The RTK will be available for an area up to 30 km in order to obtain accurate coordinates in real time to within ± 2 cm.

In November 14, 2004, at 2.21 pm the station became operational, and we immediately started the GPS measurements at the permanent reference Station Svea (Fig. 2).

A complete description of the antenna and the antenna mount can be found in www.tu-dresden.de/ipg/service/scargps/SVEA_05

Acknowledgements

The GPS equipment used during the expedition and the GPS receiver and antenna for the permanent Svea GPS station are financially supported by a donation in 2003 from Knut and Alice Wallenberg

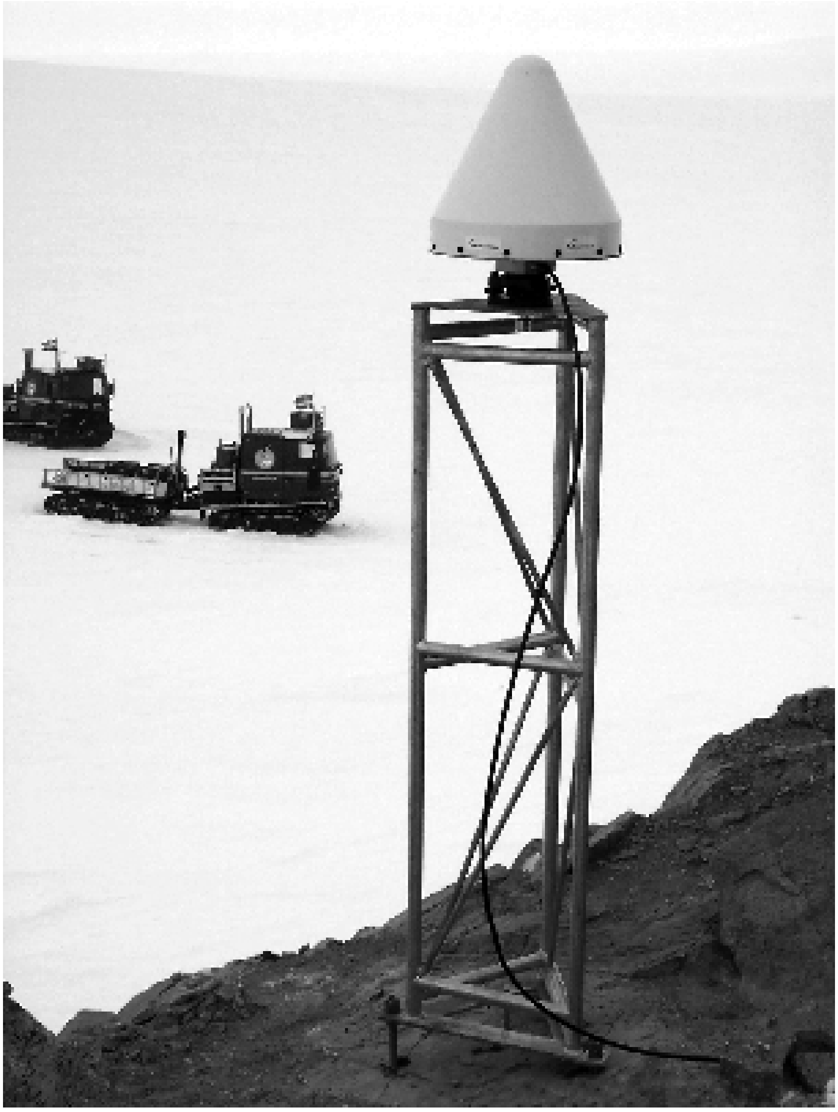

Figure 2
Permanent GPS Station Svea in Heimefrontfjella.
Photo: Erick Asenjo.

Foundation. The logistic support was fully covered by the Swedish Polar Research Secretariat. We want to thank the logistics people that participated in the installation of permanent Svea reference station. We are also grateful to Dr. Jaakko Mäkinen from the Finnish Geodetic Institute for sharing his experiences and for collecting data from the station in the Antarctic summer 2005/06.

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Kontinuerlig GPS-mätning vid Station Svea

Geodesi-avdelningen vid KTH har deltagit i SCAR Epoch Crustal Movement GPS Campaigns fem gånger sedan 1991/92 genom mätningar vid den svenska antarktiska stationen Wasa. Mätresultaten har rapporterats till det internationella beräkningscentrat vid TU Dresden i Tyskland. Det främsta syftet med projektet är att bestämma tredimensionella rörelser i jordskorpan mellan deltagande GPS-stationer. År 2003 etablerade Finska Geodetiska Institutet en kontinuerligt mätande GPS-station vid Aboa, några hundra meter från Wasa. I detta projekt etablerar vi en motsvarande permanent och kontinuerligt observerande GPS-station vid den svenska stationen Svea i Heimefrontfjella, Dronning Maud Land, Antarktis. Mätningarnas syfte är primärt att ingå i SCAR:s GPS-nät och sekundärt att erbjuda en referensstation för GPS runt Svea, till nytta för allehanda vetenskapliga projekt i området.

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Impact of ultraviolet radiation and grazers on benthic primary producers in Antarctica

Aim

The overall objective of this study is the estimation of the early, mid- and long-term effects of ultraviolet radiation (UVR: 280–400 nm, further divided into UVBR: 280–320 nm and UVAR: 320–400 nm) on the succession of benthic primary producers in the presence or absence of grazers. In particular the impact of ambient (and enhanced) UVR on the succession of micro- and macroalgae will be determined in the rocky intertidal in Potter Cove on King George Island, Antarctica (Fig. 1).

Figure 1
Dallmann Laboratory and Jubany base, 62°14'S, 58°40'W, Potter Cove, King George Island, South Shetland Islands, Antarctica.

Background

Marine macroalgae are the most important primary producers in coastal hard bottom ecosystems. Furthermore they contribute essentially to the structural heterogeneity of their habitat, thereby increasing the number of ecological niches available to other organisms. Macroalgal stocks serve as nursery areas and shelter for numerous animals, as well as providing a substrate for epiphytic communities. In this way they are crucial prerequisites for the diversity and stability of coastal ecosystems. Marine microalgae are generally dominated by diatoms. Marine diatoms constitute the basis of the marine food web and are responsible for 50% of the global marine primary productivity. In Potter Cove, benthic diatoms are of particular interest because the phytoplankton biomass is not sufficient to explain the benthic consumer abundance and it has been hypothesized that microbenthic algae (diatoms) account for the nutrition of the local fauna.

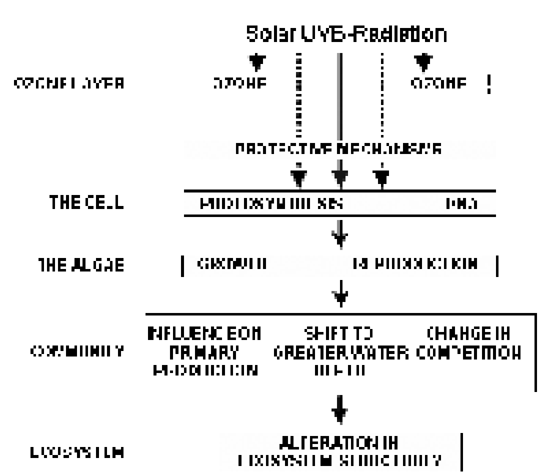

Figure 2
Possible damaging effects of UV-B radiation on different levels, from the algal cell to the ecosystem.

The seasonal depletion of the stratospheric ozone layer and the resulting increase in UVBR reaching Earth's surface, particularly over the Antarctic region, is a potential threat to all organisms, including marine macro- and microalgae. In the study area, UVR penetrated down to

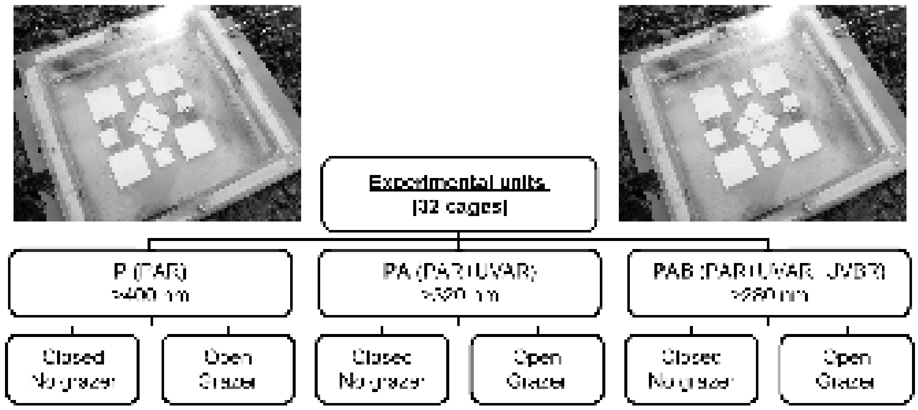

Figure 3
The experimental design is shown, together with the experimental units (cages) with ceramic tiles and different filters for excluding parts of the solar spectrum. Control units for filter and cage artefacts were also included.

10 to 30 m depth and 1% of the surface UVBR intensity was reached at around 9 m depth. Thus, the UVR penetration depth is large enough to cause damaging effects on both tidal and subtidal organisms.

UVR has several damaging effects on biological molecules and metabolic pathways (Fig. 2). On the other hand there are also protective and repair mechanisms. If the damaging effect predominates then growth and reproduction are inhibited. The role of UVBR at the community and ecosystem level is still poorly understood and few long-term experiments using natural communities or model ecosystems have been carried out. On several taxonomic levels organisms appear to differ widely in their tolerance and in their capacity to adapt to UVR, which may result in changed species compositions. The few existing studies that have considered effects on more than one functional level, within natural or semi-natural systems, have all demonstrated complex responses to UVBR and the need for integrative studies. The results of our field and laboratory experiments will allow us to predict the consequences of UVR, including enhanced UVBR, for the diversity and stability of the algal community.

Fieldwork

Our studies have continued over two growth seasons, December 2003 to March 2004 and November 2004 to March 2005. Thus the experiments started during the main growth season of Antarctic algae concomitant to the time of sea ice break-up in October and the time of highest UVBR due to the seasonal depletion of the ozone layer in the Antarctic region. In addition to the main field experiments, several laboratory experiments on both micro- and macroalgae have been completed.

Experimental design

32 experimental units with ceramic tiles (Fig. 3) were installed on an intertidal platform. The number of replicates was 4, plus control cages for filter and cage effects. Different filters were used to exclude parts of the solar spectrum. The experimental chambers were further designed to allow or prevent grazing on the algae (open vs. closed cages).

Four samplings took place, the first after 4–6 weeks, then approximately every 16 to 17 days (depending on weather conditions). One large and one small tile were removed at each sampling occasion. The algae were collected, identified and treated for further chemical analyses. Biomass and composition of micro- and macroalgae were analysed by light microscopy. The biomass data was used to calculate the biodiversity of the communities, employing the Shannon-Weaver index H', together with the species richness S and the evenness index J'. Photosynthetic activity of microalgae, macroalgal spores or early life stages of macroalgae were investigated at the times of collection by

The divers are getting ready for sampling. Photo: Angela Wulff.

using different models of pulse-amplitude modulated PAM fluorometers (PAM 2000, Xenon PAM, Walz, Germany). Photosynthetic characteristics can be described by measuring the optimum quantum yield (Fv/Fm), i.e. the ratio of variable to maximum chlorophyll fluorescence after dark adaptation. A few species were also fixed for electron microscopic examination.

Statistical analysis

Data were analysed by factorial ANOVA (analysis of variance) including "grazers" (GRAZERS vs. NO GRAZER) and "radiation" (PAR, PAR+UVAR, PAR+UVAR+UVBR, Control) as the main effects.

Light measurements

Because light is crucial in our study we used several different light meters. PAR (atmosphere) was measured continuously with a Li-Cor data-logger (LI-1000, Li-Cor, USA), equipped with a flat-head sensor (LI-190). UVBR was measured using a 32-channel single-photon counting spectroradiometer developed at the AWI and installed on the roof of the Dallmann Laboratory. Underwater spectra of ambient radiation of the wavelength 280–700 nm were recorded at various depths using a spectroradiometer (Isitec, Germany).

Microalgal experiments

The objective of this mechanistic part of the study was to estimate the long-term (weeks) and short-term (hours) impact of UVBR and UVAR respectively on the photosynthetic capacity of a shade adapted benthic diatom community.

Fine-grained sandy sediment was collected from 5 m water depth and divided into experimental chambers in the laboratory. In total 22 experiments were carried out. Treatments were PAR, PAR+UVAR and PAR+UVAR+UVBR, respectively. The experiments were performed with intact diatom mats or diatom suspensions. The different treatments are shown in Table 1.

The effects of UVR on photosynthetic activity were determined by measuring the emission of variable chlorophyll fluorescence by use of PAM 2100 and the water-PAM (see above). Maximum quantum yield of photosynthesis was measured in light exposed diatom mats

Treatment	Exposure time	Recovery time
PAB+PA	4 h	1, 4, 24, 48 h
PAB+PA	8 h	1, 4, 24, 48 h
PAB+PA	16 h	1, 4, 24, 48 h
PAB+P	4 h	1, 4, 24 h
PAB+P	8 h	1, 4, 24 h
PAB+P	16 h	1, 4, 24 h
PAB+PA+P	4 h	6, 12, 26, 36, 50 h
PAB+PA+P	8 h	6, 12, 26, 36, 50
PAB+PA+P	8 h	10, 20, 40 min, 1, 24 h
PAB+PA+P	10, 20, 40 min, 1 h	-
PAB+PA+P	10, 20, 40 min, 1, 2 h	10, 20 min, 6.5 h
PAB+PA	4 h	1, 4, 24 h

Table 1
Showing different treatments for the different microalgal experiments. PAB equals exposure for PAR+UVAR+UVBR, PA equals PAR+UVAR and P equals PAR. Exposure and recovery time is the duration of the treatments and recovery, respectively. During recovery the microalgae were exposed for a PAR intensity of 25 μmol photons m^{-2} s^{-1}.

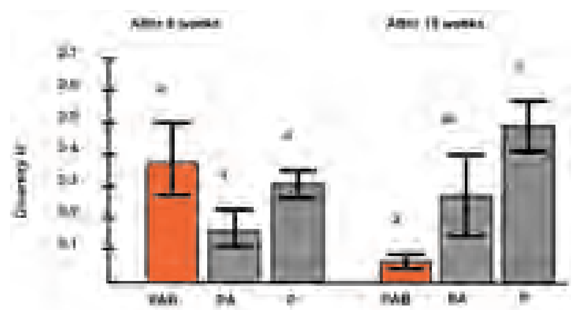

Figure 4
The macroalgal diversity after 6 and 15 weeks in relation to the different UV treatments is shown. PAB means exposure to PAR+UVA+UVB, PA exposure to PAR+UVA and P means exposure to PAR only. The letters a, ab, and b denote significant differences between treatments ($p<0.05$). After 6 weeks no significant differences between the treatments were found. After 15 weeks the diversity for the PAB treatment decreased, whereas it increased for the P treatment.

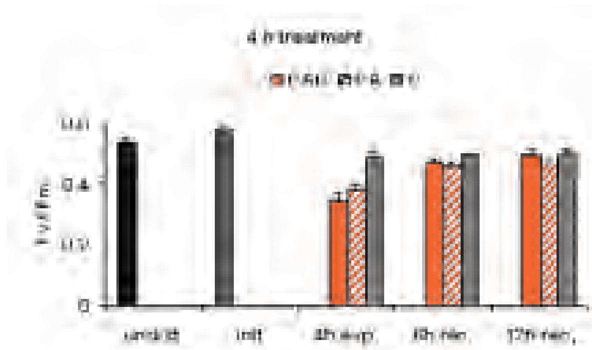

Figure 5
The light effect on the maximum quantum yield of photosynthesis (Fv / Fm) for benthic diatoms after 4 h of light exposure and different recovery times (rec) where they have been exposed to PAR only. PAB means exposure to PAR+UVA+UVB, PA exposure to PAR+UVA and P means exposure to PAR only. "Undist" is the untreated diatoms and "init" means initial values before the treatment started.

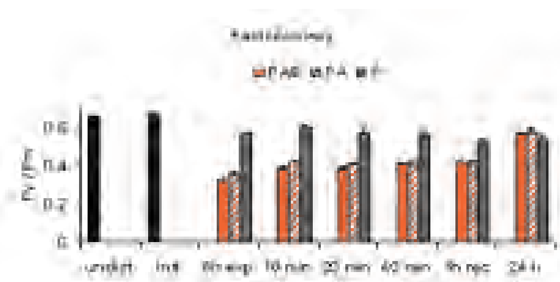

Figure 6
The light effect on the maximum quantum yield of photosynthesis (Fv / Fm) for benthic diatoms after 8 h of light exposure and different recovery times (rec) where they have been exposed to PAR only. PAB means exposure to PAR+UVA+UVB, PA exposure to PAR+UVA and P means exposure to PAR only. "Undist" is the untreated diatoms and "init" means initial values before the treatment started.

A high risk project! In a week all cages were destroyed by ice but after an intense repair campaign they were back in the water and stayed intact for over 100 days!
Photo: Angela Wulff.

and in diatom suspensions after dark adaptation by determination of the ratio of Fv/Fm. Any decrease in Fv/Fm reflects photoinhibition or even photodamage of the photosynthetic apparatus.

Some results

Field experiment

- UVR had a negative impact on a number of macroalgal species, individuals and diversity (Fig. 4).
- Green algal germlings were more affected by UVR during early stages of succession.
- Red algal germlings were more sensitive to UVAR than to UVBR, showing that
- UVAR had a large impact on community structure.
- Effects can change during succession but are different for different species. Thus UVR could lead to shifts in the distribution and abundance of macro-algal species in the intertidal.

Microalgal experiments

The results show that UVR clearly had a damaging effect in both our long-term and short-term experiments, but this effect was reversed after a period in low light (Fig. 5). Benthic diatoms can cope with UVB intensities up to at least 32 times higher than what can be expected at 5 m depth in Potter Cove. Furthermore, in terms of Fv/Fm, response to the light intensity and recovery were both measurable within 10 minutes (Fig. 6). Future studies have to show how the microalgae react in long-term experiments with ambient radiation.

Where are we going from here?

The project has generated a large number of data that still need to be analysed and interpreted. The species analyses will take 1–2 years to complete. Results from both field and laboratory experiments have been presented on the SCAR Open Science Meeting, Bremerhaven, Germany in July 2004, and at the International Phycological Congress, Durban, South Africa in August 2005.

På grund av hål i det skyddande ozonlagret, och den därmed ökade UVB-strålningen är den antarktiska kontinenten ytterst lämpad för att studera UV-strålningens effekter på naturliga marina samhällen. Successionen av mikro- och makroalgssamhällen på Potter Cove, Kung Georgs Ö, Antarktis, studerades i fältexperiment under olika UV-ljusförhållanden (manipuleras med filter) med och utan närvaro av betare. Studien pågick under 4 månader under den antarktiska sommaren (november–mars, säsongerna 2003/04 och 2004/05). En granskning och komplettering av tidigare resultat, genom undersökningar av algerna i deras naturliga miljö, är nödvändig för att verifiera de UV-skador man funnit i laboratoriemiljö, och för att kunna förutsäga eventuella negativa konsekvenser för algsamhällets stabilitet och biodiversitet.

Preliminära resultat tyder på att både UVA och UVB påverkar biodiversiteten hos makroalger negativt, men att effekten av UVB generellt är starkare. Vidare är algernas sporer och ”grodd-plantor” särskilt UV-känsliga. Känsligheten för UV-strålning visade sig vara artspecifik vilket kan leda till en förändrad artsammansättning vid en kontinuerlig UV-exponering. Mikroalgs-resultaten från fältstudien är ännu inte bearbetade, men resultat från kompletterande labora-torieexperiment visar att dessa algers fotosynteskapacitet visserligen påverkas negativt av både UVA och UVB, men att fotosynteskapaciteten återställs (repareras) efter en tid i svagt ljus.

Projektet är i huvudsak ett samarbete mellan Tyskland och Argentina till vilket Angela Wulff är inbjuden att delta.

SWEDARCTIC 2005

Forskarrapporter **Cruise Reports**

Project leaders

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Did ice-free areas exist on East Greenland during the peak of the last ice age?

Lena is sampling a quartzite boulder for analyses of cosmogenic isotopes. Quartzites are excellent for this purpose due to their mineralogy, but are 'hard as #@&&' and difficult to sample.
Photo: Helena Alexanderson.

Scientific background and aims

The Jameson Land peninsula (70-71°N) is situated at the Scoresby Sund fjord, which is the largest drainage route for the eastern part of the Greenland ice sheet (Fig. 1). The area is ice free today, but is partly covered by glacial deposits, that indicates that glaciers have on one or several occasions advanced across the peninsula.

During the past decade considerable effort has been put into both onshore and offshore investigations of the Late Quaternary glacial history in Greenland. These investigations have led to reconstructions having outlet glaciers in the fjords during the Last Glacial Maximum (LGM; ~20,000 years ago), while leaving inter-fjord areas such as the inner parts of Jameson Land ice-free through the whole last glacial cycle (e.g. Möller et al. 1994; Funder et al. 1998, Hansen et al. 1999, Adrielsson and Alexanderson 2005). This concept has, however, recently been challenged by marine geological studies (Evans et al. 2002, Ó Cofaigh et al. 2004) and land-based field observations (Bennike and Weidick 2001), which indicate that the Greenland ice sheet reached the shelf break during an extensive LGM advance. The two contrasting hypotheses show that there are still many questions to be answered about the ice extent and the existence of extensive ice-free areas in the East Greenland fjord zone during the last glaciation.

Investigations in the Ugleelv Valley on central Jameson Land (Adrielsson and Alexanderson 2005) have highlighted the effects of local glaciation in the area. The coastal Liverpool Land ice cap has on at least two occasions expanded westward onto Jameson Land, but the timing of these events is so far poorly constrained.

An increased knowledge of the nature and dynamics of ice sheets and glaciers at high latitudes is important, since changes in their extent may have large consequences for the global environment and climate. Learning more about past changes helps us to understand what is happening with the polar ice sheets and glaciers today and in the future. The aim of this project is to test the two conflicting hypotheses of ice-sheet extent and to find out more about the dynamic glacial advances from Liverpool Land by answering the following questions:

1. Did ice-free areas exist in East Greenland during glacial maxima?
2. When was the last time the Greenland ice sheet covered Jameson Land?
3. If this took place before the Last Glacial Maximum (~20,000 years ago), what was then the extent and dynamic character of the Late Weichselian ice sheet?
4. At what time(s) did the local Liverpool Land ice cap expand towards the west?

Our approach is to combine two dating methods, analyses of cosmogenic isotopes and optically stimulated luminescence dating, in an extensive effort at several sites on Jameson Land. A similar study, although mainly focused on sampling for analyses of cosmogenic isotopes, was carried out in several areas along the Northeast Greenland coast last year (Hjort et al. 2005).

Dating methods

Analyses of cosmogenic isotopes like ^{10}Be and ^{26}Al provide a measure of the time a rock surface has been exposed to cosmic radiation. When cosmic rays interact with the nucleus of an atom, cosmogenic isotopes are produced (Gosse and Phillips 2001). Most of this production takes place in the atmosphere, but it also occurs in the uppermost few meters of the lithosphere. When first accumulated within a rock, two processes act to reduce the amount of these nuclides, namely radioactive decay and erosion.

The accumulated amounts of the above nuclides indicate the timing of deglaciation, assuming that the ice once covering the sampled rock surface eroded enough material to erase the accumulation from earlier exposures. This is, however, not always the case. If the erosion was not sufficient to achieve this 'zeroing', the rock will be left with a nuclide inheritance from earlier exposures, which will make the sample look older than it is.

By using the different decay rates of ^{10}Be and ^{26}Al it is possible to find out if the sampled surface has experienced multiple episodes of burial and exposure. A complex exposure history implies that the surface has been covered several times, but without suffering very much erosion – e.g. if the cover has been cold-based ice. The analyses of cosmogenic isotopes can thus both give direct age estimates of the deglaciation and information about the thermal regimes of former ice sheets by indicating whether they were actively eroding their substratum or not (Miller et al. 2002).

With optically stimulated luminescence (OSL) it is possible to determine when a grain of sand last was exposed to sunshine, which is assumed to be at the time of its deposition (Huntley and Lian 1999). The luminescence ('brightness') of a quartz or feldspar grain comes from electrons that are trapped within the crystal lattice and the amount of electrons (the luminescence strength) is proportional to time (age). The method is best suited for wind-transported (aeolian) sediments, which are exposed to sunlight when moving through the air, but it also gives reliable results for other deposits, for example meltwater and glacial lake sediments.

Samples for OSL dating were taken from two depositional environments on Jameson Land: aeolian and meltwater/glacial lake sediments. The aeolian sediments were deposited under cold, dry and windy conditions (polar desert) and their ages provide the timing of ice-free periods during the last glacial cycle(s). On the other hand the meltwater sediments were deposited by, or in close association with, glaciers and date advances of the Greenland ice sheet from the west and of the Liver-pool Land ice cap from the east.

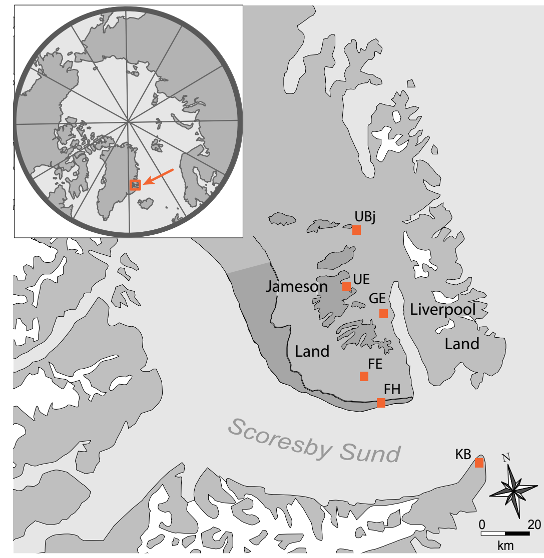

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Figure 1
Map of Jameson Land, East Greenland. The squares show our study sites at (from N to S): Umingmakbjerg/Lejrelv Valley, Ugleelv Valley, Gåseelv Valley, Fynselv River, Flakkerhuk, Kap Brewster.

Fieldwork and technology

The fieldwork was carried out during three weeks in August and our investigations focused on the six areas shown in Figure 1. These sites were selected based on previous knowledge of their suitability and their strategic location for this type of study (Möller et al. 1994, Adrielsson and Alexanderson 2005). The transport between sites took place by helicopter or by foot. From small base camps we made daily excursions and visited valleys and mountain tops, studied landforms and dug into sediment exposures.

We used a rollable, lightweight solar panel to supply our electronic equipment (computer, satellite phone, cameras) with power (Fig. 2). This worked fine the first week, when we had nice weather, but later the sky was almost always overcast and light conditions were just enough to power camera batteries but nothing bigger. Subsequently our satellite phone also broke down due to a flaw in manufacture. Luckily nothing disastrous happened and we could also keep to our scheduled helicopter flights. The low-tech equipment, such as shovels and sledge hammers, did not cause any problems except for hand ache after too much use.

Figure 2
The solar panel worked fine during nice weather, but for most of the time the sun was hidden behind clouds and provided only enough light to power camera batteries. Photo: Helena Alexanderson.

Sampling strategy

Greenland ice sheet advance(s)

Quartzite boulders of a western provenance occur both on the upland plateaux and on strongly weathered lower ground. To determine when the Greenland ice sheet last covered Jameson Land, these erratics were sampled for analyses of cosmogenic isotopes. OSL samples from glacilacustrine sediments at the water divide in the Ugleelv Valley will hopefully provide the timing of an event with contemporaneous Greenland ice sheet and Liverpool Land ice cap advances.

Liverpool Land coastal ice-cap advance(s)

Sequences of deltas deposited in glacial lakes dammed between advancing glaciers from Liverpool Land in the east and the water divide in the west were found in the Lejrelv and Nathorst valleys (cf. Lillieskröld and Salvigsen 1991). The altitudes of the deltas record different lake levels and thus different lake stages belonging to more than one glacial event or to different phases of lake level lowering during deglaciation. In valleys on eastern Jameson Land there are also series of moraine ridges that formed during advances of the Liverpool Land ice-cap and in association with the damming of the lakes. Several samples for OSL dating were collected from the deltas and boulders from the moraine ridges were sampled for analyses of cosmogenic isotopes.

Dating ice-free periods on Jameson Land

Aeolian deposits from the Ugleelv Valley have previously been OSL-dated to 27,000 and 10,300 years ago (Adrielsson and Alexanderson 2005). We took more samples from this site and if we can show that aeolian deposition occurred ~20,000 years ago (the LGM), this would prove that there was no ice sheet there at that time.

Acknowledgements

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Helena digs into a delta in the Gåseelv Valley on a cold and windy day.
Photo: Lena Håkansson.

I den östgrönländska fjordzonen är dalar och fjordar kraftigt eroderade av is medan de flacka höjdområdena där emellan utgörs av gamla, vittrade landskap. Under de senaste decennierna har forskare ingående undersökt områdets nedisningshistoria, men det råder fortfarande vitt skilda meningar om den grönländska inlandsisens utbredning under det senaste nedisningsmaximat för ca 20 000 år sedan. Var inlandsisen i kustområdet huvudsakligen begränsad till utlöparglaciärer i fjordar och större dalar eller täcktes även de idag isfria platåområdena av en stor och tjock inlandsis?

Vi testar de existerande hypoteserna genom en omfattande satsning på åldersbestämning av främst glaciala avsättningar, med hjälp av kosmogen exponeringsdatering och optiskt stimulerad luminiscens, i Scoresby Sundområdet på Östgrönland. Med detta tillvägagångssätt vill vi även belysa framstötarna från de lokala glaciärerna på Liverpool Land, ta reda på när framstötarna ägde rum och vilket inflytande de haft på landskapets utveckling. Fältarbetet utfördes under drygt tre veckor i augusti 2005.

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The bedrock geology expedition to Novaya Zemlya 2005

Over eighty percent of the world's energy is supplied by fossil fuels and most of the transport sector is driven by oil. Expanding world economies, especially in Asia, are pressing up the price of most geological resources, particularly oil. With an estimated 20–25% of the world's yet-to-be-found oil hidden beneath the Arctic continental shelves and ridges (about the same amount as is thought to exist in Saudi Arabia), there is a widening interest today to better understand Arctic geology; to investigate the origin and evolution of the Arctic Basin and better define the sedimentary basins and their hydrocarbon potential. The five High Arctic nations, Canada, Denmark (Greenland), Norway, Russia and USA are preparing claims to the outer parts (further than 200 nautical miles) of the Arctic shelves and into the ridges, in accordance with the United Nations Convention on the Law of the Sea.

Defining the character of the younger sedimentary basins, mostly of Mesozoic–Tertiary age, but some reaching back into the Palaeozoic, is essential for the hydrocarbon exploration. The older complexes forming the "basement" to these basins are also important: they influence the geometry of the basins, their subsequent deformation history and the thermal gradients that drive hydrocarbon production and dispersion in the overlying sedimentary successions.

For the last couple of decades, SWEDARCTIC bedrock expeditions have been analyzing the Palaeozoic and Precambrian evolution of High Arctic Eurasia, from Svalbard to Severnaya Zemlya (Gee and Pease 2004), to better understand the Uralian, Caledonian, Timanian and older history of the "basement" (Fig. 1). Recently it has proved possible to include Novaya Zemlya in our fieldwork, by working with the Russian Naval authorities in Murmansk. The fieldwork started in 2004 and is expected to continue in the years to come.

Experience gained in 2004 on the international expedition to southernmost Novaya Zemlya (Gee 2005) provided the foundation for a more ambitious investigation of the bedrock of northern parts of the archipelago (Fig. 1). Collaboration with VNIIOkeangeologia (St. Petersburg) concerning the organization established the necessary permissions for the fieldwork in the "open" areas of Novaya Zemlya. VNIIOk also looked after most of the communal logistics and took responsibility for the integration of the land-based work with marine programmes. Transport from Murmansk to and from Novaya Zemlya was on the Russian Navy's Hydrographic Survey ship *Gidrolog* and these arrangements were also organized by VNIIOk.

The budget for the expedition was defined in two parts – costs for the ship transport to and from Novaya Zemlya (including move of camps), and other expenses

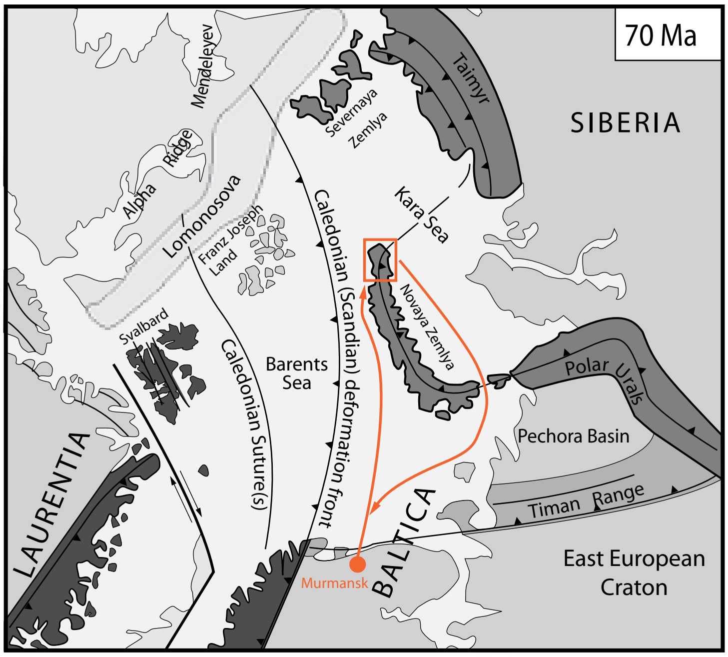

Figure 1
Eurasian margin in the latest Mesozoic.

(a miscellaneous group of items, including costs for everything from Russian visa invitations to food, guns, boats, iridiums, etc.). The total budget for the ship time was shared by those concerned with the land and marine science (particularly the foreign geologists and a group of six scientists from KOPRI, the Korean Polar Research Institute) and supplemented by contributions from the St. Petersburg organizations SevMorGeo and VNIIOkeangeologia.

The initial plan for the expedition involved departure from Murmansk on 6th (latest 7th) August and return to Murmansk on 26th (latest 27th) August. A minimum period in the field was agreed – six full days on the northwestern (Barents Sea) side of Novaya Zemlya and six days on the northeastern side (Kara Sea). One day was reserved for moving camps and an extra day on land was anticipated, assuming the agreed timetable could be maintained.

Departure of the expedition from Murmansk was delayed by bureaucratic problems until 11th August and accounted for the loss of four full days fieldwork. Despite this delay two camps were established on both sides of northern Novaya Zemlya (Fig. 2) and the fieldwork was rewarding. We obtained an overview of the stratigraphy, structure and tectonics, collected a wide range of suitable material for laboratory analyses, and we can now read the Novaya Zemlya literature (e.g. Lopatin et al. 2001, Korago et al. 2004 and references) with "opened eyes". Our Russian colleagues provided outstanding support and made the expedition a greater success than the initial delay of the fieldwork promised. Relationships with the marine scientists were most cordial.

The short time for the fieldwork required that the Bedrock Geology group split into two parts – a larger Younger unit, mainly concerned with the mid–late Palaeozoic successions and an Older unit examining the early Palaeozoic and Neoproterozoic rocks.

Barents Sea camps

After just over three days (ca. 1 300 km) at sea, *Gidrolog* anchored in Russian Harbour (Fig. 3) in northern Novaya Zemlya in the early morning of 14th August and established the larger of the two camps in abandoned military and meteorological houses. An unfortunate incident with reindeer delayed the start of fieldwork by a few hours. This Younger group was composed of all those expedition scientists whose interests were focused on the Late Palaeozoic successions (Devonian to Permian; also Quaternary).

The work of the Russian Harbour (Younger) group mainly involved studies of stratigraphy and sedimentology, with analysis of depositional environments. The Devonian to Permian sections were

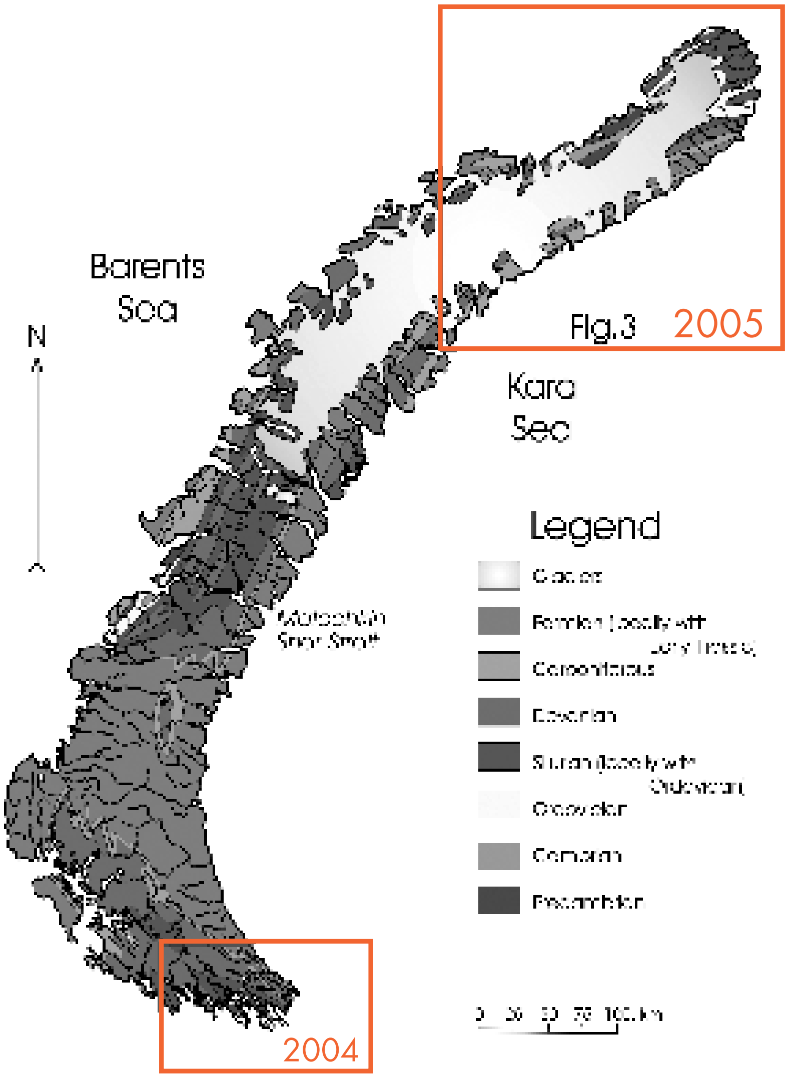

Figure 2
The bedrock geology of Novaya Zemlya, based on SEVMORGEO's unpublished 1:500 000 geological map.

examined and measured, with varying levels of detail, depending upon the priorities of the different participants. Samples were collected throughout the succession for petrographic study, clastic sediment provenance, detrital zircon investigations, TOC, apatite fission track analysis, and fluid inclusion analysis. A reconnaissance study of folds, thrusts and other structures was also possible in the short time available.

During the morning of 14th August, *Gidrolog* transported the remaining part of the bedrock geologists north-westwards to Sakharova Bay, where a camp was established that allowed work on the Early Palaeozoic and late Precambrian successions. This Older group concentrated its work to the southern side of Sakharova Bay and also visited Maka Bay for the Precambrian section. It obtained a good general overview of the structural geology and the stratigraphy and sedimentary characteristics of the successions, which are dominated by turbidites and related deep water deposits. A wide range of samples were collected for general petrography and about ten sandstones for provenance studies, particularly the isotope dating of detrital zircons. Dolerite dykes cutting the Early Palaeozoic succession were also collected for petrology and isotope dating.

Move to the Kara Sea coast

On the morning of August 19th, *Gidrolog* collected the Younger group from Russian Harbour and thereafter the Older group from Sakharova Bay. Waves on the beach and a substantial swell off-shore made the second withdrawal more strenuous. An intended pause of half a day at Inostrantseva Bay to examine sections from the Early Devonian (with bitumen seeps) down into the late Precambrian was abandoned due to the adverse weather conditions, and the

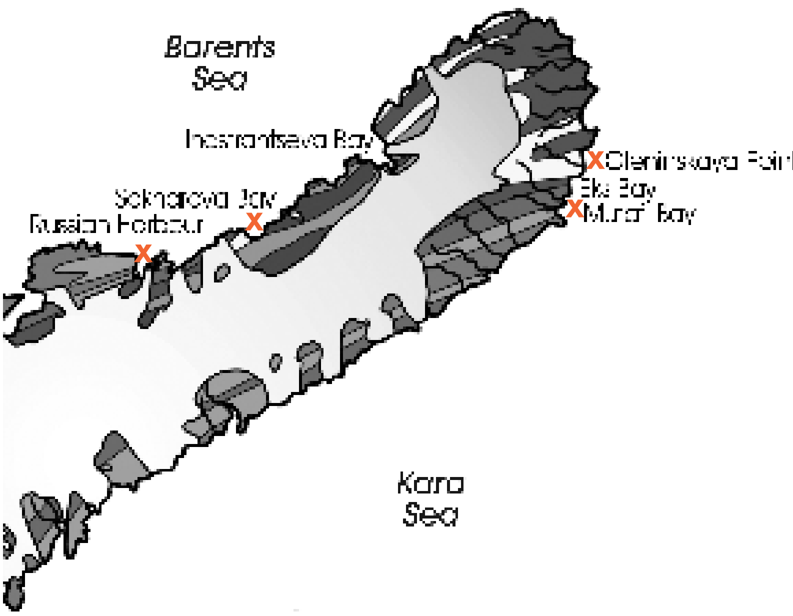

Figure 3
Bedrock Geology of northernmost Novaya Zemlya (X – camps), (for legend see Fig. 2).

ship continued eastwards to round the eastern end of Novaya Zemlya and then turn south and south-westwards for the two camps on the Kara Sea coast. Disembarkation there started at 17.00 on 19th August.

Kara Sea camps

Two camps were established on the northern Kara coast, at Oleninskaya Point and Mutafi Bay. The former allowed the Older group to study sections from the Late Cambrian to the Devonian, and the latter placed the Younger group in the Devonian to Permian sections.

The Older group examined the Late Cambrian to Early-Mid Ordovician section along the Neblyuinaya River and the coast section southwards from Oleninskaya Point to Eks Bay, which also included the Late Ordovician to Devonian. The entire section up into the Early Silurian appears to be turbidite dominated with associated deep marine conglomerates and an olistolith. In addition to many samples for petrography, twelve samples of sandstones were collected for provenance (zircon) studies, complementary to the sample collections at the first camp and representative of the entire stratigraphic section from the Late Cambrian to the Devonian.

The Younger group in Mutafi Bay studied the Devonian to Permian sections in the area north of the camp and also to the south on Cape Spory Navolok. A range of samples were collected for purposes similar to those in the Russian Harbour area.

The two groups in the Kara coast camps were collected on the afternoon-evening of 23rd August, after 3–4 days fieldwork. The ca. 1 700 km journey to Murmansk took four full days and we reached harbour at midnight on 27th August.

Geology

Despite the short field-season we obtained invaluable insight into Novaya Zemlya geology (Fig. 2). This 1 500 km long, 100 km wide archipelago, dominated by two islands (North and South), separates the Kara and Barents seas and two vast and very different hydrocarbon provinces. In the eastern Barents Shelf the gas fields are reported to be comparable in size to those in the North Sea; in the Kara Shelf the oil fields are apparently a direct northerly

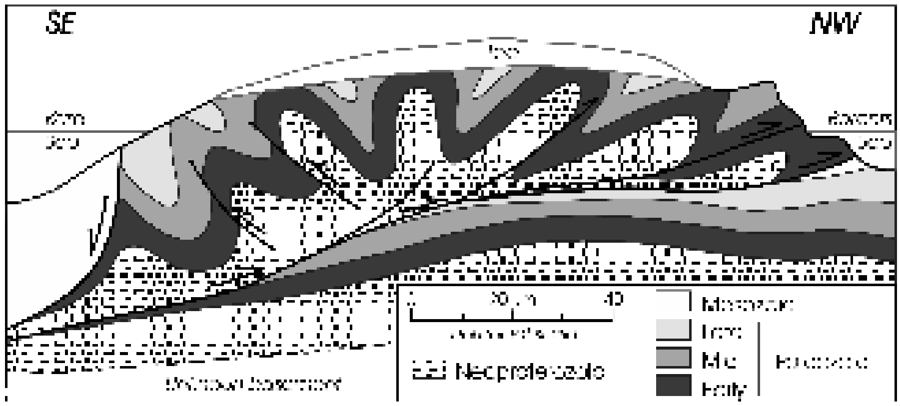

Figure 4
Diagrammatic section illustrating the allochthonous hypothesis for the structure of northeastern Novaya Zemlya.

extension of the West Siberian oil province. Thus Novaya Zemlya defines an enigmatic “barrier” between two geological provinces of global economic significance.

Our field-seasons on southern (2004) and northern (2005) Novaya Zemlya provided sedimentological and stratigraphic evidence of a remarkable contrast in the Early–Mid-Palaeozoic successions, from shallow water shelf in the south to deep marine environments in the north. In the north the turbidite-dominated successions start in the oldest exposed rocks (late Neoproterozoic) and reach into the early Devonian on the eastern side of North Island. Interestingly, the northwestern side of this island (Russian Harbour) provides evidence of some shallow marine and fluvial environments in the Devonian, a possible response to Caledonian orogeny further west.

The structure of Novaya Zemlya is enigmatic and open to very different interpretations. The major anticlinorium that dominates the entire structure (Fig. 2) is upright to southwest-vergent through much of South Island, apparently in response to sinistral transpression. However, further north and in western North Island, the northwestern limb of the Novaya Zemlya Anticlinorium is broken by several northwest-vergent thrusts. The amount of movement on these thrusts is unknown and the subject of much speculation (e.g. Otto and Bailey 1995). Relatively short transport is often inferred (e.g. Pogrebitsky 2004), but long transport (over 100 km) is possible, implying that the entire Palaeozoic complex of North Island could be allochthonous (i.e. that has been moved from its original place). This alternative is illustrated in Figure 4 in a northwest-southeast profile through the eastern end of North Island.

There is a clear need for better control of the deeper structure of Novaya Zemlya and its relationship to the surface features. If the thrusts that are mapped on the surface are listric in geometry and related to a major flat-lying thrust zone at depth, this should be identifiable by reflection seismic profiling. The differences between the alternative interpretations of the structure are great and could have profound implications for understanding the distribution of the hydrocarbons.

Comments on other aspects of the fieldwork

The weather was generally unstable, but allowed fieldwork on both sides of the Archipelago. Polar bears were seen on most days; they visited camps occasionally and had to be “moved” off outcrops a few times. This created no major problems, but guns were essential. Walrus were frequently seen along the Kara coast. The expedition participants were looked after well by the *Gidrolog*’s Captain and his crew, and Dr. Boris Vanshtein did a great job, wedding the land and marine operations and dealing with the Russian bureaucratic structure.

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Under 2004 och 2005 besökte geologiska expeditioner med ca 20 geologer från Sverige, Norge, Storbritannien, USA och Ryssland den sällan utforskade ögruppen Novaja Zemlja. Expeditionerna var de första större internationella samarbetsprojekten i Novaja Zemlja-skärgården sedan slutet av 1930-talet. Stora delar av Novaja Zemlja är av militära skäl stängt för utlänningar, andra delar av ögruppen är inte tillgängliga för någon pga. föroreningar från de kärnvapenprovsprängningar som ägde rum här under 1950- och 1960-talen.

Under sommaren 2004 besökte expeditionen södra delen av Novaya Zemlya, under augusti 2005 de nordligaste områdena. För transporten 2005 svarade den ryska marinens hydrologiska kontor i Murmansk och dess fartyg Gidrolog.

Novaja Zemlja är en viktig pusselbit för att kartlägga den geologiska utvecklingen i Högarktis. Ögruppen ligger mellan två enorma gas- och oljekällor under Barents- respektive Karahavet. Under de närmaste decennierna kommer sannolikt dessa fyndigheter att svara för en väsentlig del av Europas energibehov. Novaja Zemlja är ett nyckelområde för vår förståelse av geologin i Barents-Kara-sockeln. Områdets varierande geologi kräver olika undersökningar. Expeditionerna bestod därför av specialister inom olika discipliner såsom strukturgeologi, stratigrafi, palaeontologi, sedimentologi, petrologi och isotopgeokronologi.

Expeditionen sommaren 2005 fick bästa möjliga stöd av den ryska marinens personal och trots förseningar i Murmansk lyckades man utföra merparten av de planerade undersökningarna.

Changes in climate and ecosystems

Beringia has unique terrestrial and marine environments, and there is a growing concern for how this region is affected by climate change. The icebreaker *Oden*'s travel from Scandinavia and back during the Beringia 2005 expedition gave opportunities for marine and atmospheric science projects focused on the role of this region, and the entire Arctic Ocean, in the climate system. This addressed such diverse topics as water circulation patterns, geophysics, atmosphere–ocean interactions and land-shelf–basin interactions. The theme covered three legs with Oden; the Canadian Arctic, the Bering Strait region and the central Arctic Ocean. The third leg was performed in close co-operation with ocean floor mappings performed by Swedish and American geologists onboard the icebreaker USCGC *Healy*.

The oceanography around the Bering Strait is of great importance, being an apex of interactions between the Bering Sea and the Arctic Ocean which may affect climate change. This was investigated by a combination of physical and chemical oceanography, and atmosphere analysis. The direction and magnitude of water currents at different depths largely determine the movements of material, gases and temperature gradients through the ecosystem. One study focused on the formation of the halocline, the important layer separating saline seawater from fresher surface water. Major rivers flood the Arctic Ocean with fresh water and terrestrial material. Outside the immense Mackenzie River delta, for example, river water was present in large amounts even 100 km from the coast. The sea ice also acts as a vehicle for long-distance transportation of sediments. The extent and nature of this flux of elements from land to the shelf seas and further on into the ocean basin can have profound implications. For example coastal erosion in the Beringia region can wash away the coast by up to 3 metres per year! Such a huge input of terrestrial organic carbon to the Arctic Ocean could dramatically alter biogeochemical cycles, causing a positive or negative feedback to global change. Some of this carbon is also consumed by microbial activity, which was another aspect investigated during the expedition. Intensive biological production was found in the Arctic surface waters. Furthermore, water conditions affect gas exchange between sea and air, which in turn determines the level of greenhouse gases, such as carbon dioxide, in the atmosphere.

There is also a growing awareness of the importance of the exchange and transport between land, ocean and atmosphere of toxic elements such as mercury, PCB and brominated flame retardants. Most of these substances originate from human societies at more southerly latitudes and accumulate to dangerous levels in Arctic top predators: seals, polar bears and humans. Mercury levels were found to be very high in and above the ice-covered waters of the Canadian archipelago and the Arctic Ocean. Other chemical compounds destroy crucial atmospheric features such as cloud formation capabilities and the ozone layer, exposing the Earth's surface to higher levels of UV radiation. Man-made organic halogens are for very good reasons an important focus of environmental protection programmes, yet large quantities are also released into the atmosphere by natural processes in algae. This was examined in sea water, ice and melting ponds across the Arctic Ocean.

Studies of paleoecology, or ecological history, here presented under other scientific themes, also give important keys to the relationship between climate and ecosystems. By understanding how the composition of plants and animals have changed with previous glaciations and warm periods we are in a better position to predict future effects of climate change. Advanced measurements of gas flux and solar radiation were made in the field to assess how greenhouse gases interact with the tundra. These analyses, together with plant surveys and other ground measurements, will be compared with satellite photos and historical records to investigate the extent and effects of recent changes in the tundra landscape.

Beringia 2005

Forskarrapporter Cruise Reports

A

Förändringar i klimat och ekosystem
Changes in climate and ecosystems

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The biogeochemical cycle of organo-halogens in the High Arctic and along the Northwest Passage

Objective

The main objective was to investigate the distribution and production of volatile halogenated organic compounds (halocarbons) in different habitats in the Arctic Ocean. Special emphasis was put on the contribution of halocarbons to the atmosphere produced by organisms in snow and ice compared with the contribution from pelagic organisms. Also, efforts were made to establish the importance of bacteria and cyanobacteria as producers of halocarbons.

Halocarbons are ubiquitous trace constituents of the oceans and the atmosphere. Their role in the global circulation of halogens and in atmospheric chemical reactions has been discussed extensively within the last few years in connection with their ability to affect the atmospheric ozone budget. Unlike the chlorofluorohydrocarbons (CFC's), which are ozone depleting compounds of anthropogenic origin, other chlorinated, brominated and iodinated compounds are involved in a number of chemical and biological processes. It is known that a number of brominated and chlorinated compounds deliver chlorine and bromine to the stratosphere, and it has been shown that in the stratosphere, bromine is about 50 times more efficient in depleting ozone than is chlorine. It has also been shown that the synergistic effect of chlorine and bromine species accounts for approximately 20 % of the polar stratospheric ozone depletion. The iodinated substances have relatively short lifetimes in the atmosphere, and are therefore involved in reactions only in the lower troposphere.

The formation of halocarbons is presumed to be closely connected to the formation of hydrogen peroxide. We have suggested that during the reduction of hydrogen peroxide by haloperoxidases, halide ions are oxidised, thus forming hypochlorite and hypobromite, which will react with the dissolved organic matter, thus forming a number of halogen containing organic compounds.

In accordance with the objective the following studies have been performed:

- Studies of the production of halocarbons by pelagic, ice-living and snow microorganisms
- Studies of the surface water and air concentrations of halocarbons during transects
- Estimations of the flux of halocarbons from the sea surface to the atmosphere

Sampling strategy and analytical procedures

The project was part of leg 1 (Northwest Passage) and leg 3 (trans-Arctic). During leg 1, halocarbons were determined in surface sea water collected through the ship's surface water inlet every hour from 59°30'N, 44°33'W (Cape Farewel) to 71°34'N, 156°17'W (Barrow). Air samples were collected continuously during this transect.

Sea water samples were collected from the rosette sampler along the transects during leg 3 (45 stations) for the determinations of halocarbons.

Fifteen ice stations were occupied during the cruise. During the stations brine was collected from several holes drilled in the ice, as well as water from underneath the ice, melt pond water and snow. The samples collected were used for incubation experiments onboard the ship. The experiments were performed in 60 ml glass bottles and incubated at +1°C and 150 ◄E. The production rates of halocarbons were determined and filters were stored in –80°C in order to determine pigment composition to relate the production rates of halocarbons to classes of organisms. The measurements of pigments will be performed in Uppsala with high performance liquid chromatography.

During the entire cruise air was sampled through a teflon tube. The air was drawn from the front of the ship at approximately a height of 12 m.

The halocarbons were pre-concentrated with a purge-and-trap technique, and then determined by capillary gas chromatography with either electron capture detection or mass spectrometric detection. The compounds measured were:

iodomethane, iodoethane, 1-iodopropane, 2-iodopropane, 1-iodobuthane, 2-iodobuthane, diiodomethane, dibromomethane, tribromomethane, dibromochloromethane, bromodichloromethane, bromochloromethane, chloroiodomethane, dichloromethane, trichloromethane, trichloroethene and tetrachloroethene.

The photosynthetic rate and identification of classes of microorganisms were performed in all samples collected during ice stations with a Pulse Amplified Modulator (PAM).

Preliminary Results

Several factors are uncertain in the estimate of the emissions of halocarbons from the oceans to the atmosphere. It has been shown earlier that there are seasonal as well as geographical and diurnal differences in the production of halocarbons by marine algae. In addition, earlier studies have shown that there is a large release of halocarbons during spring in the Arctic, and it has been discussed if this "burst" is due to abiotic or biotic factors. During the Arctic Ocean 2002 expedition to the East Greenland Sea our investigations clearly demonstrated that the formation of halocarbons were predominantly taking place in sea ice and in snow, and that organisms occupying brine of high salinity were the most efficient producers.

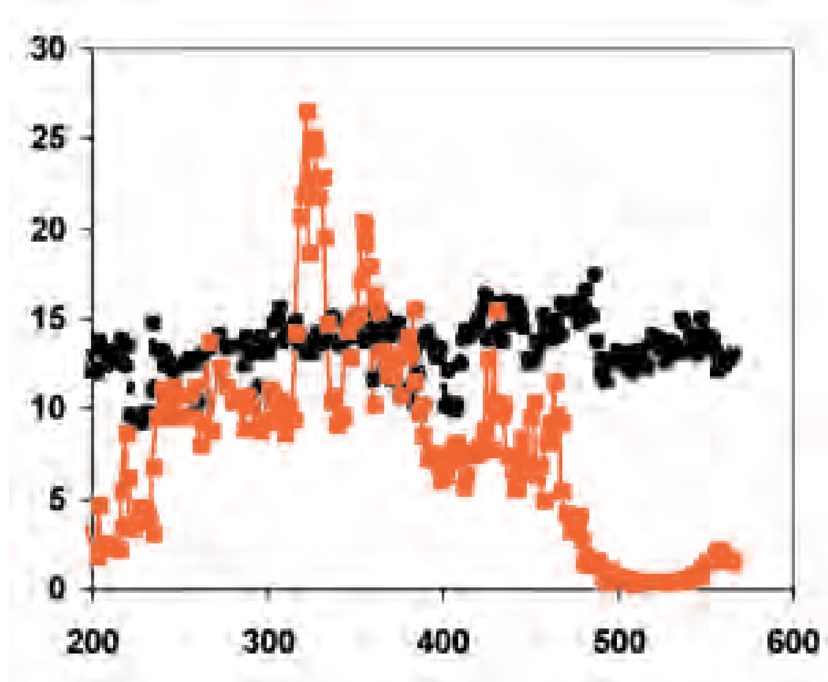

Figure 1
Surface waters concentrations of tribromomethane (red) and tertrachloromethane (black) from Resolute to Barrow. Concentrations given in pmol l^{-1} (y-axis) and sample number on the x-axis.

Air–Sea flux measurements

Sea surface samples were collected every hour during the transit from Göteborg to Barrow, and air samples were measured continuously and these data are presently being evaluated. In Figure 1 the surface water concentrations of tribromomethane (biogenic origin) and tetrachloromethane (anthropogenic origin) is compared. The observed increase of tribromomethane correlated well with the passages through heavy ice with the highest concentrations found in Peel Sound. Amazingly low concentrations of tribromomethane were found along the Canadian and Alaska coastline. The measured values corresponded to levels measured in waters of a depth larger than 2 000 m in the Canadian basin. The surface water concentrations of tetrachloromethane varied only slightly, which was expected.

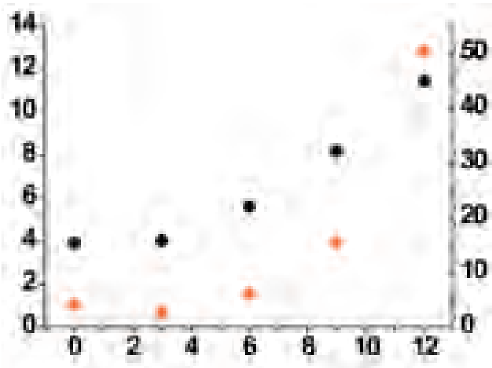

Figure 2
The increase of the concentration of trichloroethylene (black, left axis) and diiodomethane (red, right axis) in experiments conducted with water from melt ponds. Concentrations given in pmol l^{-1} (y-axis) and sample number on the x-axis.

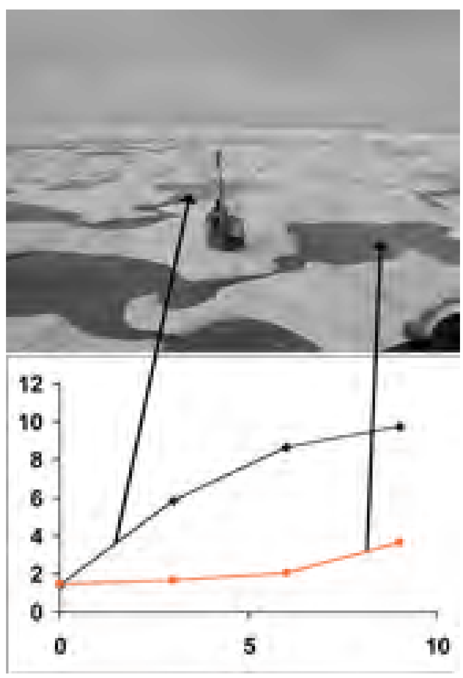

Figure 3
The spatial variability of the production of iodomethane in melt ponds. Concentrations given in pmol l^{-1} (y-axis) and hours on the x-axis.

Production of halocarbons in brine, snow and melt ponds

During leg 3 a number of experiments were performed in order to calculate the production rates of halocarbons formed in different environments. A production of halocarbons were measured in all experiments, and most surprisingly, halocarbons were formed in both melt ponds and snow (Fig. 2).

The preliminary results of measurements of photosynthesis with a Phyto/PAM in combination with light-microscopic observations showed that several species of green macroalgae, sometimes accompanied by cyanobacteria, dominated in the upper part of the sea ice layer (melt ponds, snow). When penetrating deeper into the ice the relative abundances of diatoms and dinoflagellates increased in the microalgal communities and these two groups fully dominated in the seawater just beneath the ice.

Another, more complicating, result was the observed spatial variability in the production rates. As can be seen in Figure 3, the production rate of iodomethane varied significantly between two melt ponds situated not far from each other.

To summarise, our results indicate that snow and melt ponds are active in the production of halocarbons. Since these habitats have a direct contact with the atmosphere, the amount of halocarbons produced will contribute to a large extent to the atmospheric content of halogenated compounds.

De senaste årtionden har det blivit uppenbart att interaktion mellan luft–snö, luft–is, biosfär–is–atmosfär och luft–hav i Arktis påverkar den överliggande atmosfären. Utbredningen och sammansättningen av snö- och istäcke förändras snabbt i Arktis, och därför behöver vi förstå dessa interaktioner för att kunna modelera den framtida atmosfären och se hur den relaterar till globala klimatförändringar. Vår förståelse för hur enstaka processer påverkar utbytet mellan snö, is, hav och luft, vilket bestäms till stor grad av kemi, fysik och biologi, är för närvarande ganska svag.

Varje vår då solen går upp i Arktis minskar halterna av ozon dramatiskt. Detta beror på processer som luft–yt-utbyten av gaser – främst halogeninnehållande organiska föreningar. Dessa halogenspecier kan också påskynda den fotokemiska bildningen av aerosoler. Aerosoler är en viktig del i bildandet av små droppar vilka är grunden till bildandet av moln, och påverkar på så sätt molntäcket och därmed strålningen vid ytan.

Alger producerar flyktiga halogenererade föreningar såsom kloroform, trikloretylen, perkloretylen, metyljodid, metylbromid och bromoform. Det är ämnen som deltar i nedbrytningen av ozon både i troposfär och stratosfär. Algproduktionen av ämnena är lika stor som världens sammantagna industriella produktion, och för vissa av de klorerade ämnena överstiger den naturliga produktionen till och med den industriella.

Under Beringia 2005 hade vi möjlighet att mäta både produktion och nedbrytning av dessa ämnen i snö, is och hav, och tog dessutom prover som kan hjälpa oss att förstå vilka organismer som är ansvariga för produktionen. Mätningar utfördes på naturliga prover i hela vattenmassan, luft samt snö och is. Dessutom genomfördes en rad laboratorieförsök ombord på isbrytaren Oden, vår forskningsplattform.

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A river runs through it: Dissolved organic matter in the Arctic Ocean

Scientific Background

Findings of the last 15 years have indicated significant environmental changes in the Arctic Ocean (Search SSC 2001) including a general warming trend, changing surface water distribution and decreasing sea ice cover. More recently major changes in the global hydrological cycle have been suggested, leading to increased precipitation and decreased surface water salinities in high latitude oceans (Curry et al. 2003), potentially contributing to increased freshwater discharge in Eurasian rivers (Peterson et al. 2002). Concern has risen as to how these changes might affect the heat budget of the Arctic Ocean, the fate of soil organic carbon stored in tundra and taiga soils, the global thermohaline circulation and the general climate in the northern hemisphere. In order to predict effects of environmental changes in the Arctic Ocean we need to develop a better understanding of how physical and biogeochemical processes in the Arctic Ocean are linked to continental run-off and atmospheric forcing. The large freshwater discharge and the extended shelf areas play an important role by influencing water mass modification on the shelf and stratification in the open Arctic Ocean. A halocline layer effectively separates the cold and fresh surface layer from the warm and salty Atlantic layer in wide areas of the Arctic Ocean. Although the role of this halocline is critical to the Arctic system we do not understand how the halocline is formed and sustained, much less how it responds to changes of freshwater discharge and sea ice formation. In a recent NSF funded investigation of the formation of the arctic halocline by using organic tracers and *in situ* fluorescence, we found elevated levels of terrestrial dissolved organic matter (DOM) and associated fluorescence in halocline waters. This is very intriguing and suggests the involvement of river water in halocline formation. Unfortunately we also found that the fluorescence signal can not be attributed to the terrestrial source alone, rather there seem to be several sources involved. The *in situ* probe is very general and does not allow any further distinction of the fluorescence signal. With the samples collected during the Beringia 2005 cruises leg 1 and 3 we hope to unravel some of these different sources by using a new method combining high resolution spectrofluorometry and parallel factor analysis. With this new method we will be in a much better position to determine the source waters involved in halocline formation, which is critical for our understanding of climate change in the Arctic Ocean system.

The fieldwork

During the two cruises on the icebreaker Oden we basically did two things. First, we monitored *in situ* fluorescence at every station and depth. For that purpose we either connected the probe to the seawater intake or mounted the sensor on the CTD unit to be lowered to the bottom of the ocean

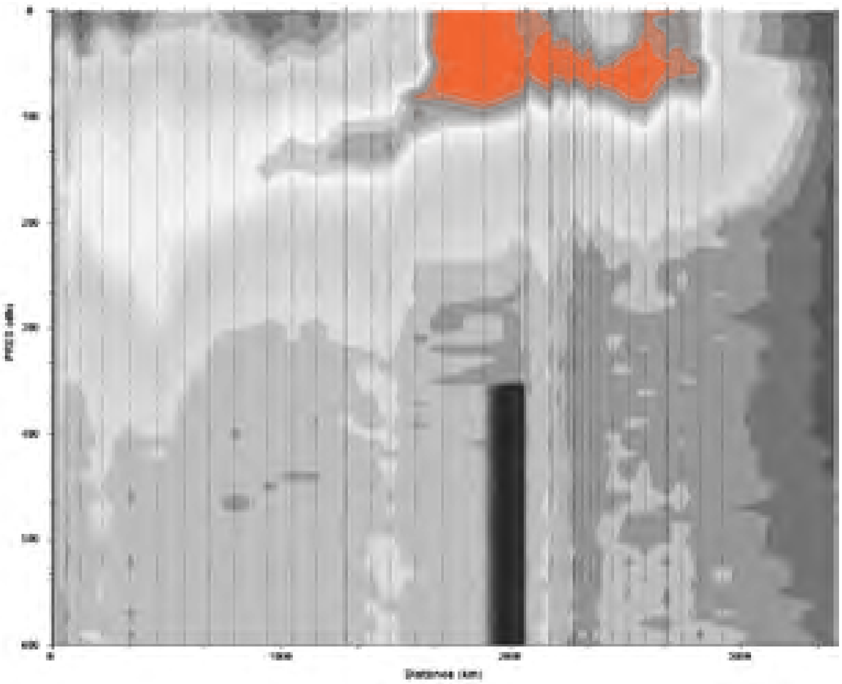

Figure 1
Distribution of in situ fluorescence across the Arctic Ocean from the Alaska coast (left) to the Svalbard shelf. Red colors indicate high fluorescence, dark colors indicate low fluorescence.

at every station. This gave us real time information on the horizontal and vertical distribution of fluorescence, which is caused by certain organic compounds dissolved in seawater. Second, based on the fluorescence signal we chose our sampling location and depth and collected between 1 and 20 l of seawater at several depths. We collected about 100 samples during leg 1 and 300 samples during leg 3. Each sample was split into sub-samples to determine the following parameters: dissolved organic carbon (DOC), dissolved organic nitrogen (DON), optical properties (absorbance and fluorescence), carbohydrates, lignin phenols, stable carbon, nitrogen (nitrate) and oxygen (DO) isotopes and radiocarbon for selected samples. Water samples were frozen and transported to the home laboratory for further analyses, which will take about one year to complete. Some of the analyses planned for these samples are novel to arctic oceanography and will allow significant new insight. We are especially excited about the combination of three-dimensional fluorescence and parallel factor analysis, especially in combination with new tracers such as nitrogen isotopes in nitrate.

Preliminary results

Since we already collected in situ fluorescence data we know the general distribution of fluorescence across the Arctic Ocean and we are able to find traces of fluorescence everywhere (Fig. 1). This shows that the samples we collected are extremely valuable for answering the questions of halocline formation and distribution. The figure shows the general distribution of DOM fluorescence in the upper 600 m across the entire Arctic Ocean.

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Senare års forskning visar förändringar i Norra Ishavet, såsom minskat istäcke och förändrade temperaturmönster. Den pågående globala klimatförändringen kan leda till ett ökat inflöde av vatten till Norra Ishavet från floderna, och därmed minskad salthalt. Skiktningen av havet till följd av olika salthalt i ytligt och djupt vatten kan i sin tur förändras. Vi studerar dessa fenomen genom att spåra flodburna organiska ämnen med ursprung i landmiljön i Norra Ishavet. Genom att mäta fluorescensen hos organiska ämnen lösta i havsvattnet kan vi dra slutsatser om deras ursprung. Under expeditionen Beringia 2005 genomfördes sådana mätningar, och prover togs för senare analys i laboratoriet. Resultaten förväntas ge nya möjligheter att hitta källorna till de vattenmassor som bidrar till salthaltsskiktningen i Norra Ishavet. Detta bidrar i sin tur till förståelsen av hur klimatförändringar påverkar Norra Ishavet och dess ekosystem.

Oceanographic investigations during leg 3 of the Beringia 2005 expedition

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Objective

The overarching objective of the oceanography project during Beringia 2005 was to increase our knowledge of the role of the Arctic Ocean in the global climate system. An important part of the project was to study water masses with the aim of elucidating their circulation patterns, their formation areas and their role in transportation of heat and climate relevant chemical constituents. Added to this is the oceanic exchange with surrounding oceans, with a special focus on the Arctic Ocean's role in the global thermohaline circulation.

Another aspect of the oceanic circulation, especially the transport of heat and salt, is its impact on ice formation and melting. During the last decades the sea ice summer coverage has decreased significantly, as has the mean thickness. An open question is if the cause is mainly atmospheric or oceanic forcing. The oceanography project aimed to add knowledge on the role of the ocean in affecting sea ice dynamics.

Much of the tracer work adds to the water mass investigation, but it also provides valuable information on ventilation of the subsurface waters. Hence the goal is to assess the magnitude of intermediate and deep water formation by utilizing the collected data in model computations of different levels of sophistication. Such studies will furthermore give estimates of the amount of anthropogenic carbon dioxide that the Arctic Ocean can sequester.

Finally it is expected that the oceanographic data collected during leg 3 of the Beringia 2005 expedition will make up an unprecedented data set for the evaluation of the functioning of the Arctic Ocean in climate change, including the assessment of feedback mechanisms.

The fieldwork

Samples from 53 stations were collected for the oceanography project (Fig. 1), at up to 36 depths per station. During each cast the temperature and salinity were recorded by the CTD rosette. After the cast the rosette sampler was brought into a heated double container and samples where taken for a number of constituents. In the laboratories on board the following constitutions were determined; oxygen, nutrients (phosphate, silicate, nitrate and nitrite), total dissolved

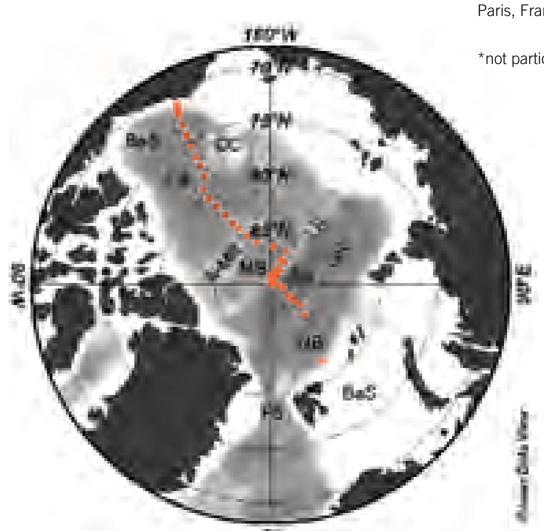

Figure 1
Map of the Arctic Ocean with the oceanographic station locations noted.

inorganic carbon (DIC), total alkalinity (TA), pH, halocarbon transient tracers (CFC-11, -12 and -113) as well as sulphur hexafluoride (SF_6). Furthermore samples were collected for later determination of ^{129}I as well as for the ratios of helium isotopes, tritium, oxygen isotopes and ^{14}C.

Oxygen was determined using automatic Winkler titration; nutrients by standard colorimetric methods using an auto-analyser; the DIC by gas extraction and colorimetric detection; TA by potentiometric titration; pH by a spectroscopic multi-wavelength method; and CFCs as well as SF_6 by gas-chromatography and electron capture detection. About 900 samples were collected to measure CFC-11, CFC-12, and CFC-113. This marked the first time that CFC concentrations were determined from the ocean surface to the ocean bottom across the central Canadian Basin, while full-depth measurements across the Amundsen Basin were able to provide repeat data to assess changes that have occurred there since 1991.

About 300 samples for the determination of ^{129}I were collected and will be analyzed in France using an AMS mass spectrometry technique. For measurement of the ratios of helium isotopes, tritium, and oxygen isotopes 820 samples were taken, covering all hydrographic stations. Approximately 22 bottles were sampled at each station, with resolution focused in the stratified waters above about 1 500 meters, extending more sparsely to the bottom of each cast. The samples have been shipped to the Lamont-Doherty Earth Observatory for mass spectrometric analysis. 112 water samples were also drawn for measurement of ^{14}C, which will be analysed at the NSFs NOSAMS mass spectrometry laboratory at Woods Hole. Samples were taken throughout the water column at 5 stations: two in the Canada Basin and one each in the Makarov, Amundsen and Nansen Basins. The ^{14}C results will yield estimates of the time since deep waters in these basins were last exposed to the surface. Tritium concentrations combined with helium isotope ratios and concentrations will yield similar estimates for shallower waters. Oxygen isotope ratios and tritium are both tracers for sources of the freshening of arctic surface and halocline waters.

Preliminary results

As illustrated in Figure 2, the upper waters of the Alaskan shelf and slope were very warm, suggesting local summer heating, the advection of warm Alaskan Coastal Current water and a convergence of warm surface water onto the slope. Pacific water was confined to the Canada Basin. It occupied a more than 200 m thick layer close to the slope, while further to the north, in the Beaufort Sea and beyond the Chukchi Cap, its thickness was close to, but less than, 200 m. At the Alpha-Mendeleyev Ridge its thickness was reduced to 150 m and Pacific water was practically absent in the Makarov Basin. The sub-surface temperature maximum of the Bering Strait summer water was located at 60–70 m and the temperature minimum of the upper, Pacific-derived halocline with a salinity close to 33.1, was identified around 150 m, except at the continental slope where it was located below 200 m. This upper Pacific-derived halocline water had nutrient maxima and oxygen minima as previously observed, which are believed to be formed by sediment interaction in the Chukchi-Bering Seas. Typically such conditions suggest low ventilation rates. However we note relatively high CFC values (as illustrated by CFC-12 in Figure 2), indicating that ventilation is reasonably robust. The explanation may lie in the Chukchi shelf being a high productivity, moderately ventilated region in which oxygen is quickly consumed, but CFCs, which are biologically inert, are not.

The underlying Atlantic water revealed the warmer Barents Sea branch lower halocline at the continental slope and in the Beaufort Sea, while the colder Fram Strait branch halocline dominated between the Chukchi Cap and the Alpha-Mendeleyev Ridge (Rudels et al. 2004). In the Makarov and Amundsen basins only the Fram Strait branch halocline was encountered. The salinity of the Fram Strait branch halocline and the winter mixed layer over the Gakkel Ridge was around 34.0, less than the 34.3 encountered on the Arctic Ocean expeditions in 1991 on Oden, and in 1996 on the Polarstern (Rudels et al. 2004).

The temperature maximum of the Atlantic layer was slightly warmer at the continental slope than in the interior of the Beaufort Sea: 0.65°C as compared to

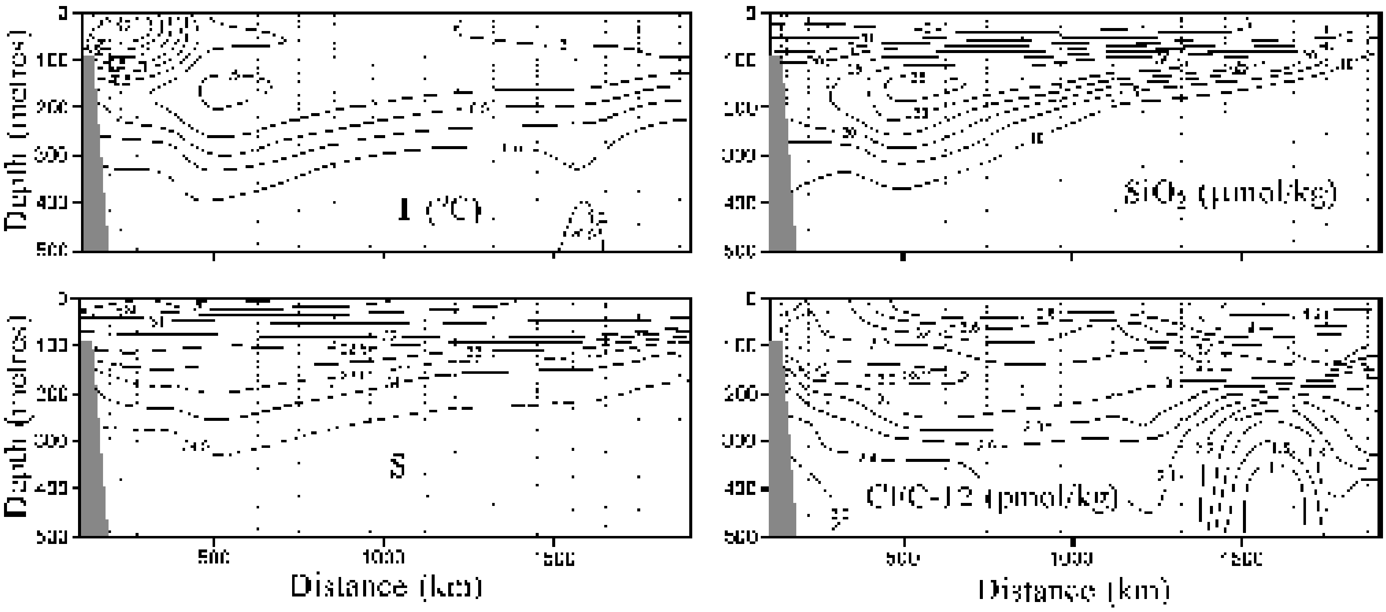

Figure 2
Sections of temperature, salinity, silicate and CFC-12 from the Alaskan Shelf to the Makarov Basin.

0.55°C. At the Chukchi Cap the Atlantic layer became warmer still, close to 1°C, and stayed that warm up to the Alpha-Mendeleyev Ridge where the coldest Atlantic layers, around and below 0.5°C, were encountered. The most obvious explanation for the observed temperature distribution in this layer is that the inflow of warmer Atlantic water first observed in 1990 (Quadfasel et al. 1991) now has reached the Beaufort Sea and replaced older and colder Atlantic water. The observations suggest that the boundary current partly separates from the slope at the Chukchi Cap and enters the deeper basin, while the rest follows the continental slope into the Beaufort Sea. There it enters the deep basin, perhaps as a broader front than at the Chukchi Cap. The colder Atlantic layer observed at the Alpha-Mendeleyev Ridge then implies that the displaced Atlantic water from the Beaufort Sea moves along the North American continental slope until it encounters the Alpha-Mendeleyev Ridge, where it re-enters the Canada Basin. This is one of the first observations of the closing of the gyre in the Canada Basin suggested by Rudels et al. (1994). Similar conclusions, based on oxygen observations, have been reached by Falkner et al. (2005). No similar indication of a closed gyre encompassing the Beaufort, corresponding to the outflow at the Chukchi Cap, could be seen.

The temperature of the Atlantic core was almost the same in the northern Canada Basin, in the Makarov Basin and in much of the Amundsen Basin. In particular at the Lomonosov Ridge almost no temperature contrasts could be detected. This is different from the observations in 1991 from Oden (Anderson et al. 1994, Rudels et al. 1994) and in 1994 from Louis S. St. Laurent (Swift et al. 1997), when a clear temperature gradient was present across the ridge. This implies that the warm pulse that was observed in the Nansen Basin in 1991 and at the Lomonosov Ridge in 1994 now has passed along the Lomonosov Ridge, returning towards Fram Strait, while the warm pulse that was observed at the Siberian side of the Mendeleyev Ridge in 1993 (Carmack et al. 1995) has circulated around the Makarov Basin and now is partly returning from the North American side along the Lomonosov Ridge, completing a loop around the Makarov Basin. This recent warming of the Atlantic water in the Makarov Basin and cooling of the Atlantic water in the Amundsen Basin at the Lomonosov Ridge have also been reported by Kikuchi et al. (2005), based on observations from drifting ice-tethered buoys.

That a two-directional flow still is present at the ridge is supported by the less saline upper Polar Deep Water seen below the Atlantic layer on the Amundsen Basin side of the ridge, suggesting a recent input

The 36-bottle rosette sampler is taken out of its container in preparation for the next cast. From the left: Jim Swift, Peter Winsor, Bert Rudels and Frank Zemlyak.
Photo: Göran Björk.

of less saline Barents Sea branch water (upper Polar Deep Water) entering at the St. Anna Trough and partly circulating along the Lomonosov Ridge. Low salinity upper Polar Deep Water was observed at the Siberian end of the Lomonosov Ridge in 1995 (Rudels et al. 2000).

The only sharp front in the Atlantic layer was observed in the central Amundsen Basin. As the Gakkel ridge was approached, the temperature and salinity of the Atlantic layer increased significantly. This indicates that a close recirculating loop brings recently entered Atlantic water back towards Fram Strait roughly along the Gakkel Ridge. Due to the ice conditions no stations could be occupied in the central Nansen Basin, but the final station taken at the continental slope north of Svalbard showed even higher temperatures and salinities. This agrees with the observations of warmer and stronger Atlantic inflow through Fram Strait in 2004 (Beszczynska-Möller, per. comm.), and with the warmer Atlantic water observed at the NABOS moorings north of the Laptev Sea in 2004 (Dmitrenko et al. 2005). This warm pulse has evidently not yet reached the central Lomonosov Ridge but a part of the warm inflow, which perhaps never reached as far into the Eurasian Basin as the NABOS moorings, has begun to return to Fram Strait along the Gakkel Ridge.

Compared with the 1994 Trans-Arctic Ocean section taken from the Canadian icebreaker Louis S. St. Laurent (Swift et al. 1997) the Canadian Basin has become warmer, while the Amundsen Basin and the Amundsen Basin side of the Lomonosov Ridge have become colder and the Gakkel Ridge again warmer. The high temperatures observed in the boundary current north of Svalbard suggest that further increase in the temperature of the return flows in the Nansen and Amundsen basins is to be expected in the near future. The effect of the warm pulses will later be seen in the Canadian Basin.

The CFC data strongly suggest that there is a significant flow of water entering the central basis north of the Mendeleyev Ridge from the better ventilated waters near the Eurasian coast. A similar less strong feature is seen west of the Chukchi Cap. The CFC concentrations were very low at the ocean bottom but were significantly above the detection level. This is consistent with an exchange time of the deepest water of a few hundred years.

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Målsättningen för det oceanografiska projektet under Beringia 2005 är att öka vår förståelse för den Arktiska oceanens betydelse för det globala klimatet, inkluderande studier av betydelsen av ett minskande sommaristäcke. Oceanografiska data samlades in från upp till 36 djup på 53 olika platser i den Arktiska oceanen från Alaska över Nordpolen till Svalbard. Ombord bestämdes 12 olika kemiska parametrar och prover togs för senare analys i Frankrike och USA av ytterligare 6 parametrar. Preliminära resultat visar hur vatten från Stilla havet ger en tydlig signatur, såväl i temperatur, salthalt och kemiska parametrar, på de översta ca 200 m i havet norr om Alaskas kust. Det framgår tydligt hur biokemiska processer i Berings- och Tjuktjerhaven ger upphov till ett flöde av koldioxid och närsalter från ytan ner till ca 150 m i den djupa arktiska centralbassängen. När data från etapp 3 av Beringia 2005-expeditionen jämförs med data som samlats in från tidigare expeditioner med bl.a. isbrytaren Oden, framgår att gränser mellan olika vattenmassor ändrat läge, liksom dess temperatur. Detta visar dels hur olika vattenmassor förändrar sitt cirkulationsmönster, dels på en varierande temperatur i det inströmmande vattnet från Atlanten. Om detta är en del av en naturlig variation eller en signal på klimatförändringar får den framtida utvärderingen avgöra.

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Biogeochemistry, trace elements and isotopes in Arctic Ocean margins

Figure 1
Water sampling in the North Atlantic using a rosette equipped with twenty-four 20 l Niskin bottles and a Sea Bird CTD.
Photo: Ralph Dahlqvist.

Background and aim of the project

About one third of the world's soil carbon is accumulated within the Arctic region. Arctic rivers make up about 10% of the global river water runoff and contain high concentrations of dissolved and particulate organic carbon. A climate change-driven increase in the terrestrial organic carbon input to the Arctic Ocean – through permafrost thawing, increased river runoff and/or accelerated coastal erosion – could dramatically alter the carbon budget and biogeochemical cycles, causing positive/negative feedback to global change. We proposed to study the transport and fate of biogeochemically important constituents transported from the Eurasian continent into the Arctic Ocean, on the original planned route of leg 1 along the Northeast Passage, passing the major Siberian Rivers. This project included six cruise participants and aimed at using multiple techniques, including mineralogy, major and minor elements, carbon forms, molecular biomarkers of vascular plants, stable and radiogenic isotopes (of C, N, O, Fe, Nd, and Sr) and compound-specific isotope analysis (^{14}C) of plant biomarkers. This multiproxy approach aimed at obtaining a detailed picture of both degradation and transport processes of organic and inorganic material released from the tundra and taiga to the Russian-Siberian continental shelf. Given the last minute changes in the expedition, altering the leg 1 route to go through the Northwest Passage and the Canadian Archipelago on the way to the Beringia region, our original project could not be undertaken and a substantially scaled down project during legs 1 and 2 was quickly launched.

The unusually large fresh water input to the Arctic Ocean, in relation to its size, makes it an ideal area for examining the fate of terrestrial weathering products transported via rivers to the ocean in the dissolved phase or associated to particles. Particles in rivers can have a size range from a few nanometres (colloids) up to several micrometres. Large particles mostly undergo sedimentation in the shelf areas, whereas small colloids and dissolved ions may be transported long distances in the ocean. Thus speciation (dissolved ions or incorporated in particles) directly affects the bioavailability of major and trace elements in the ocean. The study of speciation involves determination of the size distribution and chemical composition of material suspended or transported in water.

Long-lived radioisotopes (e.g. Nd and Sr) can be used to determine the terrestrial sources of both dissolved and particulate material in water as well as sources for sediments found on the Arctic Sea ice. Short lived radionuclides (e.g. ^{210}Po, ^{210}Pb, and ^{7}Be, and ^{234}Th) are also used to examine transport and fate of water transported particles and sediments. Dr. Mark Baskaran, who has extensive experience in short lived radionuclide analysis, participated in leg 2 and sampled both water and ice rafted sediments in order to investigate the behavior of these nuclides in the Arctic.

The primary objectives of the project during leg 1 and leg 2 include:

- Source apportionment using trace elements, stable isotopes and long-lived radioisotopes in particles and water from along the Northwest Passage and shelf region around Bering Strait
- Investigating the biogeochemical cycling of carbon and particle-reactive nuclides in the Arctic shelf
- Examining the bioavailability (dissolved fraction) of trace elements on the Arctic shelf
- Investigating the role of sea ice sediments in the removal of particle-reactive radionuclides from the surface waters of the Arctic Ocean.

Fieldwork

During the cruise water was sampled using the seawater intake on the icebreaker Oden, which continuously can sample seawater from 8 m depth below the ships hull. Collection of water from depth profiles was done using the CTD rosette equipped with water sampling bottles (Fig. 1). After sampling the water was transferred to the ship's laboratory for different types of filtration processes and experiments. The methods for speciation during this expedition included:

- *Membrane filtration* – Large particles (> 0.22 ◄m) are separated from the water. The filters can be analyzed for the particulate concentration, whereas the filter passing is analyzed for dissolved phase and colloidal nanoparticles.
- *Ultrafiltration* – This method enables a fine pore-sized membrane of 3 000 Dalton (molecular weight) nominal cut-off to enrich colloidal particles in a solution.
- *Diffusive gradients in thin films* (DGT) – This method is a passive in situ sampling device for dissolved metals. The concentration measured by the DGT represent dissolved ions and very small complexes. Large particles and colloids are excluded.

These three methods are used to separate out different size fractions. The separated fractions are preserved and brought back to onshore laboratories for determination of organic carbon, isotopes and trace elements.

Alaska through the Northwest Passage, a unique opportunity was offered to examine a rarely studied, and to a large extent unknown, part of the Arctic: the Canadian Archipelago. It is known that water from the Central Arctic Ocean and the Beaufort Sea is transported through the archipelago (e.g. via Lancaster Sound) to Baffin Bay. In these narrow and shallow straits, water flow may cause re-suspension and transport of deposited sediments to other locations. However, no detailed quantification for particle transport and metal speciation is currently available. Depth profiles were collected both in the north part of the Baffin Bay and in the central Lancaster Sound. The Northwest Passage also presented a much appreciated chance to sample the Mackenzie River fresh water plume. The Mackenzie is one of the largest rivers in the Arctic in terms of discharge. This could be clearly observed during the passage of the Mackenzie as the salinity at 8 m depth decreased from around 30‰ to a minimum of about 12‰ at a distance of more than 100 km from the river mouth (Fig. 2).

Although only about 50 m deep, Bering Strait is important for water exchange between the Arctic and the Pacific Ocean. Water exchange through the strait is complicated and believed to be controlled mainly by passing weather systems. Currents can alter their direction and can also be in different directions on the two sides of the strait. In general the currents are northerly in the eastern strait and southerly in the western. In addition a low salinity coastal current in the eastern strait supplies the Arctic with a large input of fresh water. During leg 2 sampling of water from vertical profiles on the shelf on both sides of Bering Strait was conducted. A vertical profile with samples down to 1 450 m was collected in the more central part of the Arctic Ocean (˜77°N, north of Wrangel Island). The water samples from the Bering Strait area will be analyzed for Nd-isotopes and the influence of Pacific Water in the Arctic Ocean will be estimated.

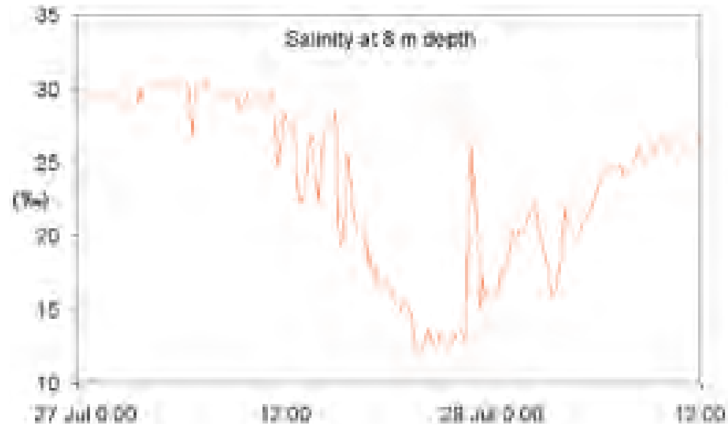

Figure 2
A dramatic drop in salinity at 8 m depth is measured as Oden passes by the mouth of the Mackenzie River in Canada.

Figure 3
Filtration in the clean room enables sampling of easily contaminated compounds and elements.
Photo: Ralph Dahlqvist.

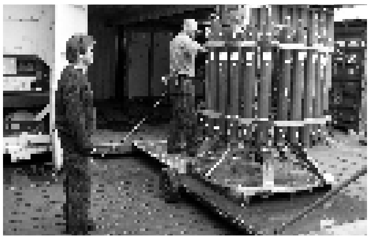

Figure 4
Agneta Fransson and Pär Ljusberg preparing the CTD rosette for a cast in the North Atlantic.
Photo: Ralph Dahlqvist.

During leg 2 large volume water samples were filtered for studies of the partitioning of ^{210}Po, ^{210}Pb, and ^{7}Be and ^{234}Th between the particulate and dissolved phases. Pre-concentration of the water samples was conducted onboard using one of the three methods:

a Passing water samples through a pre-filter and MnO_2-coated polypropylene cartridge filters (for particulate and dissolved Th isotopes, particulate ^{7}Be and ^{210}Pb and activity ratios of $^{228}Ra/^{226}Ra$ in the dissolved phase).
b The $Fe(OH)_3$ precipitation method (for ^{210}Po, ^{210}Pb, and ^{7}Be).
c Filtering through "fluffy fiber" (acrilon coated with MnO_2 for specific activity of ^{226}Ra).

In addition, sea ice samples from two stations were collected. At the second station we collected from seven sites for the measurements of ^{7}Be, ^{210}Po, ^{210}Pb, and ^{234}Th.

Preliminary results

The samples collected during the Beringia 2005 will be analyzed and the result interpreted by Dr. Ralf Dahlqvist during a two-year Marie Curie Fellowship at the Department of Earth Sciences, University of Oxford.

Preliminary results for the short lived radionuclides that must be analyzed soon after collection indicate the following:

1 The activities of excess ^{210}Pb are about 1–3 orders of magnitude higher than what we find in the bottom sediments, similar to an observation reported recently (Baskaran 2005).
2 The activities of ^{7}Be in the sea ice sediments are about 2–4 orders of magnitude higher than those found in bottom sediments, again indicating a large portion of ^{7}Be are derived from surface water and direct atmospheric deposition.
3 There is considerable inhomogeneity on the activities of ^{7}Be and ^{210}Pb in ice-rafted sediments collected from a given station.
4 A comparison of the concentrations of these nuclides in the water column to that in the ice-rafted sediments and suspended particulate matter provides insight into the mechanisms of transport of sea ice sediments.

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Syftet med projektet är att, med hjälp av de spårelement och radioaktiva isotoper som finns i partiklar och löst i vattnet, undersöka det biogeokemiska kretsloppet i Arktis. Den Arktiska oceanen är det minsta av världshaven men tar emot cirka 10 % av allt flodvatten som strömmar in i haven. Dräneringsområdena för de stora floderna är tundran och taigan, och dessa enorma områden magasinerar ungefär en tredjedel av det organiska kol som finns bundet i jordens markskikt. Klimatförändringar i Arktis – som innebär temperaturhöjningar – kan därför få stora konsekvenser för kolets och även andra biologiskt viktiga grundämnens geokemiska kretslopp. En ökande mängd partiklar och partikulärt bundet kol som transporteras ut i världshaven kan på sikt förstärka den ökning av koldioxid vi nu ser i atmosfären.

I den kanadensiska skärgården och i Berings sund togs vattenprover mer eller mindre kontinuerligt från Odens havsvattenintag, samt i djupprofiler med en vattenprovtagare som sänktes ner i havet. Omedelbart efter provtagning filtrerades vattnet i laboratoriet på Oden genom olika filtersystem för att ta fram de olika partiklar som finns i vattnet. Partiklar och vatten analyseras sedan på sitt innehåll av element och isotoper. Vissa isotoper, som har lång halveringstid, kan användas för att ta reda på varifrån materialet kommer och andra mer kortlivade isotoper kan utnyttjas för att beräkna hur mycket som sedimenterar på kontinentalsockeln respektive exporteras vidare ut i Arktiska oceanen och till världshaven.

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Surface water biogeochemistry and air–sea CO_2 exchange in the Canadian-Arctic shelf seas, the Bering Sea and the Chukchi Sea

Aim

The shallow shelves in the Arctic Ocean, in particular the Bering and Chukchi Seas, are considered to be important productive areas in the Arctic (see e.g. Cota et al. 1996). Biological production is important for the drawdown of atmospheric carbon dioxide (CO_2) in the ocean, where CO_2 is consumed during photosynthetic production of organic matter (soft tissue) by phytoplankton. Water from the North Pacific Ocean passes through the Bering Sea and enters the Arctic Ocean through the Bering Strait (Coachman and Aagaard 1988), contributing to the supply of nutrients to the shelf seas. In combination with nutrient availability, strong surface water stratification caused by the melting of sea ice in spring and river runoff contributes to the enhanced biological drawdown of atmospheric CO_2. In parts the Arctic Ocean is covered with sea ice, producing a protecting cap for CO_2 gas exchange between water and atmosphere.

The main goal of this project was to study the effect of sea ice, river runoff, biological production and inflow of Pacific water through the Bering Strait on the CO_2 content in the surface water of the Canadian shelf seas and the Chukchi Sea, and to estimate air–sea CO_2 fluxes regarding both open water and ice covered areas. The following issues were addressed in this project during the expedition Beringia 2005:

- Study of the inorganic carbon cycle in the surface water and its relation to physical conditions (e.g. inflow of Pacific water, seawater temperature, fronts and sea ice) along the shelves of the Canadian archipelago, in the Bering Strait and the Chukchi Sea.
- Estimation of the air–sea exchange of CO_2 in the upper water column during the productive season, with regard to utilization of CO_2 by phytoplankton in the areas above.
- Study of the biogeochemistry within and beneath the sea ice and evaluation of the role of sea ice in the air–sea CO_2 flux estimates.
- Diurnal study of the variability in the biogeochemical cycle in the upper water layer.

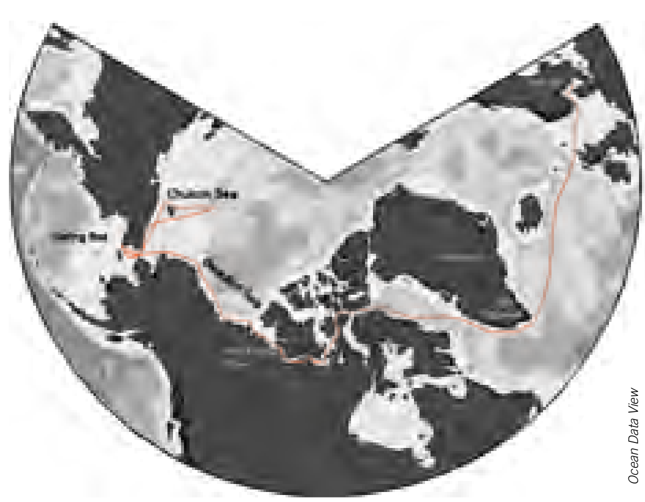


Figure 1
Map of the cruise track, leg 1 and 2.

Ocean Data View

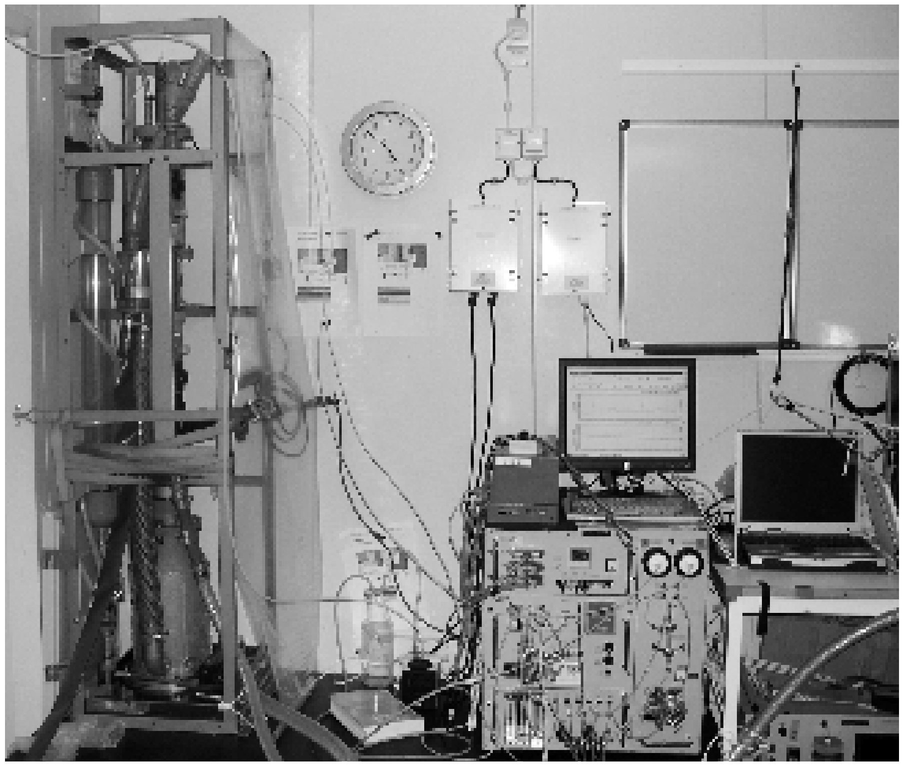


Figure 2
Instrumental setup for the automated *p*CO_2 measurements (Kimoto Electric Co., LTD) used onboard IB Oden. Photo: Agneta Fransson.

Fieldwork

In the summer of 2005 (4th July to 19th August), continuous measurements of *p*CO_2 and dissolved oxygen in the surface water were successfully carried out onboard the Swedish icebreaker Oden, leg 1 and 2. Additional parameters in the oceanic CO_2 system, obtained from discrete hourly sampling from the seawater intake, were measured: total dissolved inorganic carbon (C_T), total alkalinity (A_T) and pH. The cruise track followed the Northwest Passage from Sweden, passing Cape Farwell (S. Greenland), to the Bering Strait (Fig. 1). Continuous measurements were also performed in the Chukchi Sea passing the Wrangel Island and back to Barrow. Along the cruise track we encountered both open water and heavy sea-ice conditions. At 10 locations discrete sampling from the whole water column (from sea bottom to surface) was performed using a rosette with Niskin bottles and a CTD. Water samples for C_T, A_T, pH and dissolved oxygen were collected for analysis onboard.

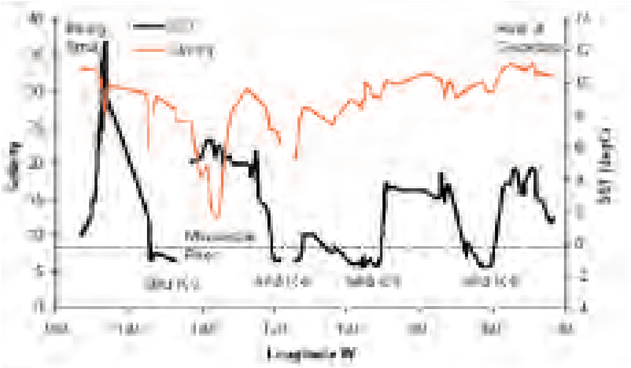
The automated *p*CO_2 instrument has been successfully used for automatic measurements in open water since 1995, and this is the first time it has been used for sea ice conditions. For the continuous *p*CO_2 measurements, seawater was pumped with a flow rate of approx. 15 l min^{-1} into a CO_2 equilibrator (tandem type combined with a static mixer type manufactured by Kimoto Electric Co., LTD [Kimoto and Harashima 1993, Harashima et al. 1997]), passing through a thermosalinograph (Fig. 2). The mole fraction of CO_2 (xCO_2) in dry air, expressed by part per million (ppm), was continuously measured every minute by a non-dispersive infrared detector (NDIR, LiCOR®, model 6262, Lincoln, USA). Four CO_2 standard gases and zero gas (0, 250, 350, 450, 550 ◂atm) were used for calibration. *p*CO_2 in air was alternately measured with the same instrument. Sea surface salinity and temperature were continuously measured. An oxygen sensor (Aanderaa) was used to measure dissolved oxygen continuously every min-ute. The oxygen values were compared to the values obtained from the discrete samples analysed with the Winkler method.

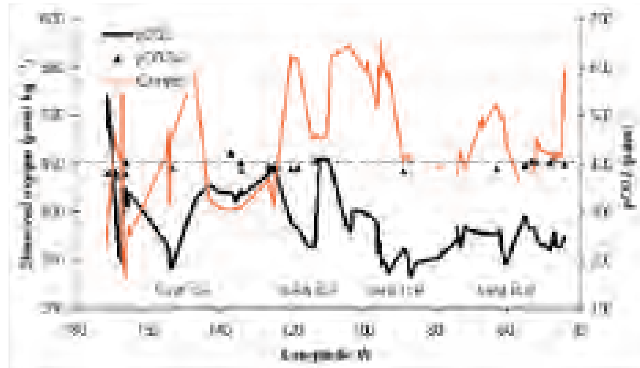
The methods for the additional CO_2 system parameters measured onboard the ship:

- total dissolved inorganic carbon, C_T : coulometric titration with photometric detection
- total alkalinity, A_T: potentiometric titration with hydrochloric acid
- pH: diode-array spectrophotometer with m-cresol purpur indicator
- dissolved oxygen: Winkler titration with photometric detection

Water samples for the following chemical parameters were collected for analyses onshore:

- nitrate, phosphate and silicate
- bottle salinity.





Left - Figure 3
Preliminary results of surface water salinity and temperature (SST) from Greenland to Bering Strait. Black line is surface water temperature and grey line is salinity. Negative SST corresponds to sea ice.

Right - Figure 4
Preliminary results of surface water pCO_2 and dissolved oxygen from Greenland to Bering Strait. Black line is pCO_2 in seawater, and grey line is dissolved oxygen. Black dotted line in figure illustrates pCO_2 in air.

Preliminary results

Using 1-minute readings of surface water pCO_2 and oxygen, in addition to sea surface salinity and temperature (SST) as well as pCO_2 in air, we gained insight into the magnitude of the zonal variability in these parameters along the cruise track (longitude from right to left in Figures 3 and 4). Preliminary data showed rapid changes in the pCO_2 and oxygen values (Fig. 4), likely related to physical fronts, river runoff and changing sea-ice conditions (Fig. 3). Surface water pCO_2 was generally below the atmospheric values for the entire route. However pCO_2 was lowest and oxygen highest in the ice-covered areas (Fig. 4), implying biological CO_2 drawdown under the sea ice. Further interpretation of the data is in progress.

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Genom Berings sund strömmar nordligt Stillahavsvatten, rikt på näringsämnen, till Arktis. På våren bildas ett stabilt ytvattenskikt genom färskvattentillförsel från flodvatten och issmältning. Skiktningen gynnar den biologiska produktionen i de grunda shelfhaven, då koldioxid (CO_2) tas upp av växtplankton. För att återställa jämvikten i havets CO_2-system tar havet upp CO_2 från luften, vilket försvåras på grund av isens utbredning i stora delar av den Arktiska oceanen. En av målsättningarna med projektet är att studera hur havsis, flodvatten och biologisk produktion påverkar havets CO_2-system i de arktiska shelfhaven, främst i den kanadensiska delen av Arktis och i Tjuktjerhavet. Med hjälp av ett automatiserat instrument för analys av pCO_2 utfördes mätningar kontinuerligt varje minut i både luften och i ytvattnet. Havsvatten pumpades in från ett vattenintag på botten av Odens skrov in till instrumentet för att mäta pCO_2 i vattnet. Utbytet av CO_2 mellan hav och luft kunde sedan bestämmas. För att förstå hur de biologiska och fysiska processerna påverkar CO_2-gasutbytet analyserades ytterligare parametrar i ytvattnet; temperatur, salthalt, totalt löst oorganiskt kol (CT), total alkalinitet (AT), pH och löst syrgas. Preliminära resultat visar att ytvattenhalterna av CO_2 och syrgas varierade kraftigt utmed rutten längs Nordvästpassagen, från södra Grönland till Berings sund. Det berodde framförallt på variation i salthalt och temperatur (olika fronter) och isförhållanden. Generellt var pCO_2 lägre i havet än i luften, framförallt i de istäckta områdena där de lägsta värdena av pCO_2 uppmättes i ytvattnet. Detta sammanföll med höga syrgashalter, vilket indikerar en intensiv biologisk produktion under isen. Ytterligare behandling av data och tolkningar av resultat pågår.

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Environmental pollution in the Arctic: Chemicals and other stuff

Aim

The main goal of this project was to investigate the occurrence, circulation, and fate of organic environmental pollutants in the Arctic. As a side project we also investigated the occurrence of plastic debris in the sea.

It may be difficult to believe that compounds that you can hold as a powder in the palm of your hand can be transported via the air to remote areas. Nevertheless we find today organic contaminants – such as the well known persistent organic pollutant DDT – in all parts of the world, even the parts most remote from the emission sources.

A small proportion of almost all organic compounds occur in the air as a gas. The proportion of any compound in the gas phase will be higher in warm climates than in cold. The global distribution is thought to occur by a temperature driven process in which compounds in the gas phase are "drawn" to the cold polar areas (AMAP 1998). This is called "The Cold Wall Effect" and is similar to what happens when frost accumulates on the cold surface of an ice cream container that is taken out of the freezer on a warm summer day. The water vapour in the air condenses on the cold surface and creates a local depletion of water vapour close to the ice cream container so that more water vapour is "drawn" from the surrounding air towards the container.

The current interest in organic contaminants in the Arctic started in the late 1980's when it was found that people living in the Arctic have much higher levels of persistent organic pollutants in their bodies than those living in industrialised areas. Recent findings also indicate that some populations of polar bears have such high body burdens of PCB that this affects their reproduction negatively. However, as the Arctic is difficult to access, our knowledge and understanding of the processes that govern the transport of pollutants to and from the Arctic is still fragmentary. We also need to know more about the degradation processes and rate of degradation of organic pollutants in the Arctic. These processes and rates are important to understand the ultimate fate of the contaminants and the time scale of the problem.

Collecting water samples from a melt water pool on the ice. Photo: Gunnar Kihlberg.

Another aspect that is of increasing importance is to study "new" contaminants. These are not necessarily new in the sense that their production has started recently; many of them are anthropogenic compounds that have been present in the environment for a long time, but that no one has measured in the field previously. These include some persistent organic pollutants, e.g. brominated flame-retardants with structures related to PCB and DDT, but also currently used pesticides.

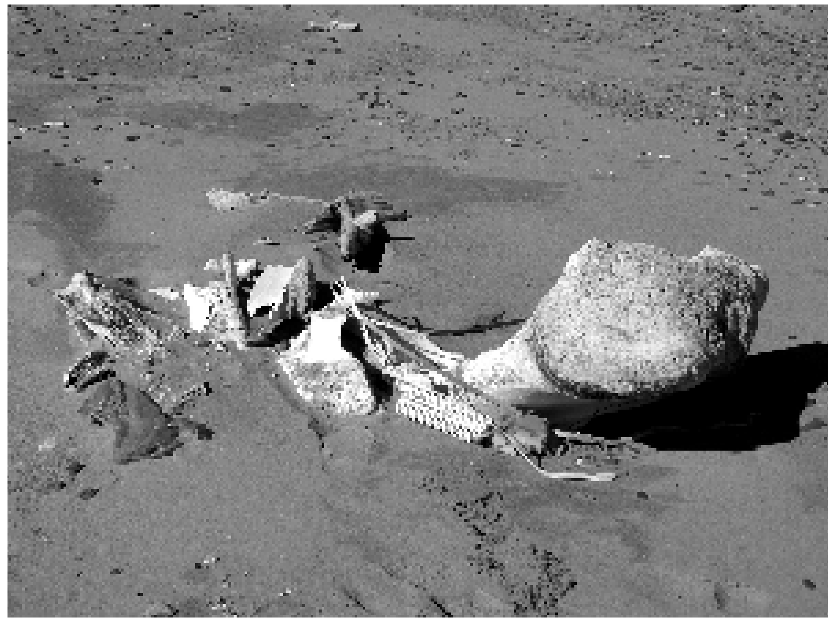

Figure 1
Plastic debris intangled with the jawbone of a whale at Toygunen, north of Kolyuchin Bay. Photo: Henrik Kylin.

Work on board

Our work on the expedition was mainly aimed at sampling air and water for determination of a wide variety of persistent organic pollutants. It is important to sample both water and air to understand the circulation of the pollutants in the area visited. Most of the work was at sea, but during leg 2 we also sampled lake and pond water and plankton. The air sampling is done by sucking large volumes of air (~1 000 m^3 per sample) through a sampling train consisting of a filter to catch the particle and two polyurethane foam plugs on which the gaseous compounds of interest are sorbed. The water samples were extracted according to the same principle, but here the water was pressed through the sampling train (a filter and a polymeric sorbent) using nitrogen gas.

Of particular interest are the hexachlorocyclohexanes, a persistent compound class that includes the insecticide lindane. The particular interest tied to these compounds is their use as model compounds; they are relatively easy to determine in water samples of moderate size (4–10 litres) so we can obtain many data points to include in our models. For the other classical persistent compounds we took samples of up to 200 litres or more to obtain reliable data on their concentration in Arctic waters. These samples will also be screened for compounds which were previously thought to be of anthropogenic origin, but which now actually seem to be natural products with properties very similar to the classical persistent compound.

We were the first expedition through the Canadian Arctic to include perfluorinated compounds in our sampling scheme. These are compounds with a wide technical use, e.g. in fire fighting foams and in the textile industry. The one that has gained most interest, perfluoro-octanesulphonic acid (PFOS), is amphiphilic, i.e. it has one water-soluble end while the other is fat-soluble. This was thought to be too water-soluble to accumulate in biota, a presumption that has proved to be utterly wrong. We find PFOS and other similar compounds in biota in the Arctic, so it is important to also understand its dispersal in the water environment.

We also collected samples that will allow the determination of currently used pesticides. Surprising little interest has been given to these compounds outside of the traditional agricultural areas, but when we start looking we find an increasing number of compounds in unexpected places.

Air samples were collected from the North Sea to Beringia, while surface water samples were taken along the entire Oden cruise. Pond water was collected in Chukotka and on Wrangel Island, while a number of deep water profiles were obtained at different locations along the cruise track.

The air and surface water data will be used to calculate the current balance of air transport and deposition/revolatilization of selected contaminants. The deep-water profiles are of particular interest to estimate the microbial degradation rate of chiral compounds. During the expedition Arctic Ocean 1996 we developed a method to use the degradation of chiral compounds to estimate their degradation rate. A chiral compound has a "left-handed" and a "right-handed" form that are physically and chemically similar, but that may have different biological effects and degradation rates.

Lars-Anders Hansson collecting zooplankton samples from a pond at Kolyuchin Bay. The zooplankton will be analyzed for their content of organic pollutants. Photo: Henrik Kylin.

By measuring the two forms separately we can construct a clock to estimate the microbial degradation rate (Harner et al. 1998). The particular hope for this expedition is that we can – together with data from Arctic Ocean 2002 – use the "ventilation age" of the calculated CFC data (obtained by other research groups) to calibrate our calculations of the degradation rates. This should give added value compared to data obtained from expeditions where no CFC data have been available.

At the time of writing this report no results from Beringia 2005 are yet completed; it will take a couple of years before all samples have been analysed.

Plastic debris

As a side project we also studied the occurrence of plastic debris along the cruise track and on a shore in Chukotka. Plastic debris in the oceans is an increasing environmental problem (Derraik 2002). In parts of the Pacific there are six times more miniscule plastic particles than zooplankton of the same size! Marine birds, turtles, and mammals ingest the plastic debris, leading to starvation because of a full stomach.

Organic environmental pollutants, such as PCB, may also be sorbed to plastic debris. The debris may, therefore, serve as a conveyor for pollutants into organisms.

There are inventories of plastic debris from the shores of some sub-Antarctic islands, but little previous information on the situation in the Arctic Ocean. With the help of the ornithologists constantly on watch for birds, we counted floating plastic debris along the cruise track from Gothenburg to Beringia; plastic debris was found even in the ice far north of Wrangel Island. On a 2.4 km stretch of the shore at Toygunen we found 663 objects of plastic debris (Fig.1)! This included a Swedish made rucksack. It is an indication of the seriousness of the problem that even the shores of the Chukchi Sea, which is ice covered during much of the year, is severely contaminated by plastic debris.

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Organiska miljögifter av typen DDT och PCB finns idag spridda till alla delar av jorden, även till polartrakterna där de aldrig använts. Detta beror på en i grunden temperaturdriven process där miljögifter "dras" mot polerna från utsläppsområden i varmare trakter, ungefär på samma sätt som när det bildas kondens och frost på ett glasspaket man tar ur frysen en varm sommardag. Vår huvudsakliga forskning under Beringia 2005 har rört närmare studier av hur miljögifter beter sig i Arktis, hur de kommer dit och vad som händer med dem när de väl är där. För att undersöka detta tog vi prover på vatten, luft, sediment, jord m.m. och försöker spåra hur miljögifterna fördelar sig mellan dessa olika typer av prover. Vi har även inkluderat flera "nya" substanser. Dessa kan i och för sig ha använts under lång tid, men av olika skäl inte kommit in i analysprogrammen tidigare. Bland dessa märks flera bromerade och fluorerade substanser, men även moderna bekämpningsmedel. Under expeditionen samlades mer än 400 prover för olika typer av miljögifter. Dessa kommer att genomgå flera olika typer av undersökningar under kommande år innan resultaten är färdiga. Som ett sidoprojekt har vi även inventerat plastskräp i havet och på stränderna. Plastskräp är ett ständigt växande problem och orsakar bl.a. att havsfåglar svälter ihjäl eftersom de inte kan äta när krävan är full av plast. Delar av expeditionsrutten innehöll förvånansvärt mycket plast med tanke på hur långt norrut vi har rört oss. Och plastskräp återfanns i isen även långt norr om Wrangels ö.

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The study of biogeochemistry of organic matter in the Arctic Ocean during leg 1 of Beringia 2005

55 surface water samples were collected from an in-line pumping system for determination of concentrations of total organic carbon (TOC), dissolved organic carbon (DOC) and dissolved organic nitrogen (DON), nutrients, and dissolved inorganic carbon (DIC). Samples for determination of DIC C-13 values were also collected. Samples represent water masses encountered throughout the transect and include ice melt, Mackenzie river plume water, open ice regions, regions without ice cover and the open North Atlantic.

Water samples for detailed characterization of organic material were collected from 11 stations, including ice melt, Mackenzie river plume water, open ice regions, regions without ice cover and the open North Atlantic. Determinations will include: size fractionation (>0.2 µm, 3 kD to 0.2 µm, and <3 kD), aggregation properties of whole samples and size-fractionated samples, concentrations of particulate organic carbon (POC), POC C-13, dissolved neutral aldoses, total neutral aldoses, dissolved amino acids, total amino acids, DOC, and DON, and DOC-C13 values.

Large volume air samples were collected throughout the transect from July 6 to July 28, 2005. Each sample was collected for approximately 24 hours. Pre-combusted glass fiber filters will be extracted for concentration determinations of various particulate fluorinated compounds and we will also attempt to determine the particulate organic carbon concentration of these particles. Air traps and filters have been extracted to date and are being analysed by GC-MS in Toronto Ontario, Canada by our collaborator Dr. Tom Harner at Environment Canada.

In addition, 20 surface water samples were extracted onto C-18 disks in order to concentrate dissolved organic material and determine its structural characteristics. Samples included open Atlantic surface waters, Arctic surface waters, ice melt and Mackenzie river plume samples. The samples are being analysed using electrospray ionization Fourier transform ion cyclon resonance mass spectrometry by Dr. Elizabeth Kujawinski at the Woods Hole Oceanographic Institute and the results are pending.

Under etapp 1 av expeditionen Beringia 2005 tog vi en mängd prover av vatten och luft för att undersöka hur flödet av ämnen mellan land, flod och hav fungerar i Arktis. De floder som mynnar ut i Arktiska oceanen för med sig ämnen från inlandet som påverkar kemiska processer i havet. Omfattningen av detta återstår att kartlägga och proverna analyseras fortfarande.

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Accumulation of neurotoxic mercury (Hg) into the ice-covered Arctic

Aim

It has been elucidated that high levels of neurotoxic mercury (Hg) in the Arctic are caused by a rapid, near-complete depletion of Hg in the atmospheric boundary-layer, occurring episodically during the polar spring (Schröder et al. 1998). Upon reaction with reactive bromine species (such as Br, BrO), hundreds of tons of Hg-II are perennially deposited on frozen surfaces. The relative magnitude of this sink is huge, resembling 30–40% of the current global deposition (Ariya et al. 2004). To some degree a back-reduction of Hg-II to Hg° occurs, resulting in re-cycling of volatile mercury to the atmosphere (Sommar et al. 2004). However it can not compensate for the total deposition, and a net assimilation into the food chain occurs. The fate of Arctic mercury – after the enhanced deposition ending in May – is largely indefinite with reference to transport and transformation. The Beringia 2005 expedition, taking place a few months after the period of elevated deposition of Hg around the polar basin, offered an unique opportunity to sample vast until now unprobed exposed areas. The main objectives were to estimate the spread of mercury in the Arctic environment and to investigate the lability of the deposited Hg-II compounds with respect to reduction and methylation (to methyl-Hg).

Fieldwork

Using icebreaker Oden as a platform, continuous measurements of airborne mercury (mercury vapour and tiny fractions of Hg-II(g) and mercury species attached to particles (Hg-p)) and some related long-lived gases (CO, O_3) were performed during nearly three months en route. Automated instruments, with a time resolution of 10 minutes and less, sampled air taken well above the surrounding constructions. Surface water transferred to the main lab (on deck 1) was analysed continuously for dissolved mercury vapour (DGM) by using a method further developed from the equilibration device described in Gårdfeldt et al. (2002). By knowing the distribution of DGM in air and surface water, implicated one-sided outflow of mercury from the oceans can be quantified. The performance of the equilibration device was steadily positively verified on a single sample basis by stripping the mercury vapour from solution (manual method). DGM in other matrixes (vertical profiles of oceanic water, ice, snow and brine) was analysed by the manual method as well. Matching samples of mercury fractions (total-Hg and methyl-Hg) less sensitive for transformation were preserved by the addition of ultra-pure sulphuric acid and stored cold for future analysis. These three

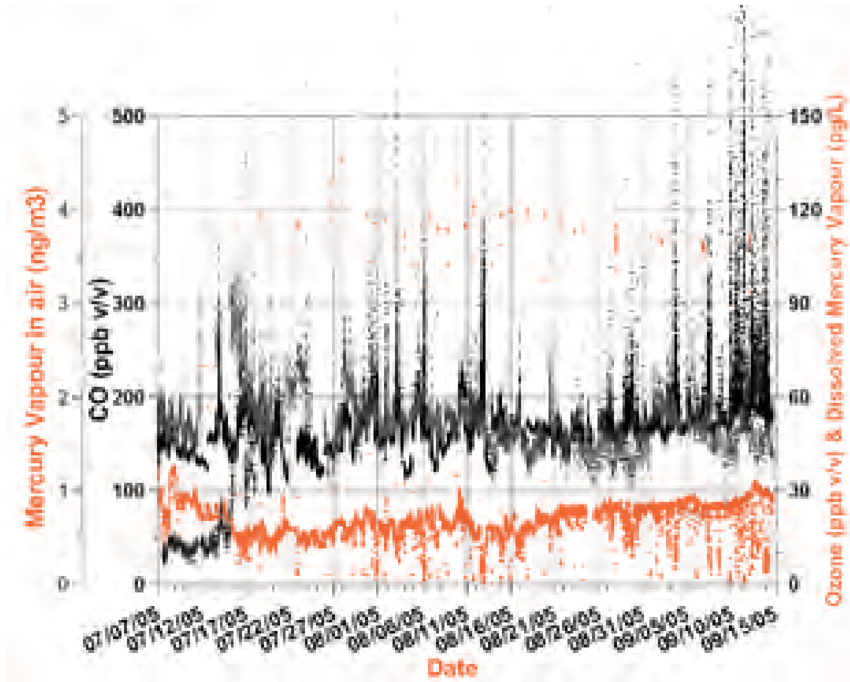


Figure 1
Temporal distribution of airborne Hg, O_3 and CO as well as volatile mercury in surface water (not complete).

mercury fractions were sampled at about 55 stations generally comprising six depths vertically through the water column, most intense during the trans-polar section. With the help of expertise from the halocarbon group (Abrahamsson), vertically resolved brine samples within certain ice flows were obtained. In addition surface snow and melt pond water were probed. Our large set of samples is also made up of deep oceanic sediments obtained from the research group onboard USCGC Healy, intended for future analysis.

Preliminary results

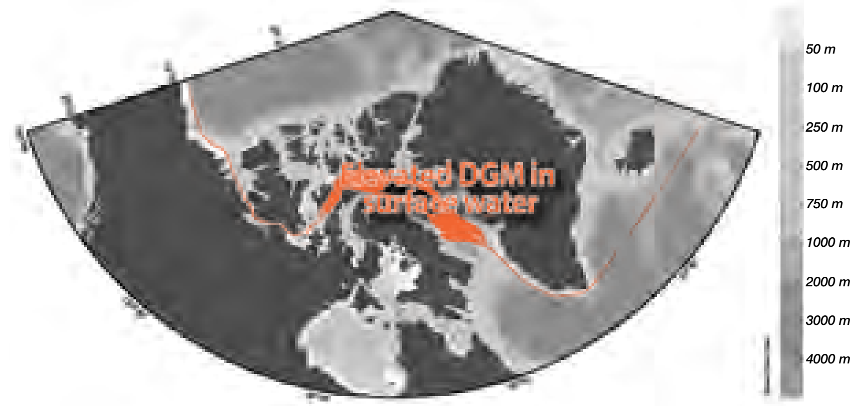
The large number of samples collected have so far, for obvious reasons, only been analysed for their volatile mercury components (total-Hg and methyl-Hg remaining). However after extensive data processing and evaluation, we may on an incomplete basis report some interesting findings concerning volatile mercury.

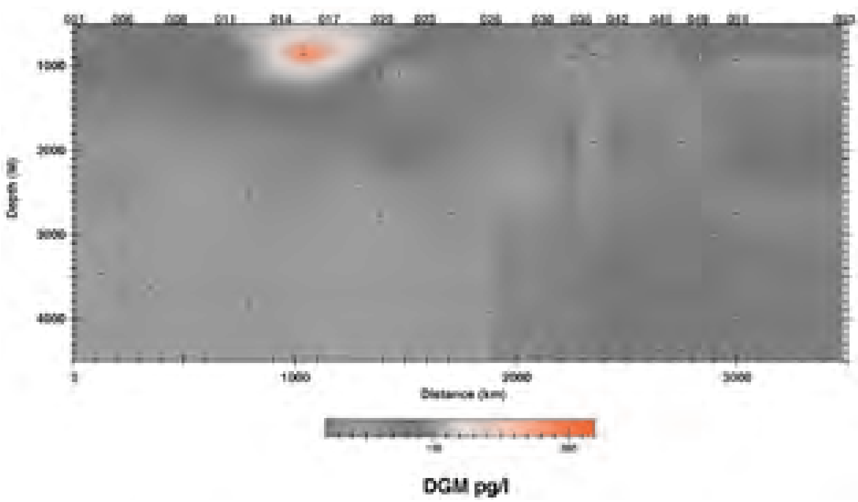
Leg 1

Initially during the Atlantic transect we were able to establish the concentration levels of mercury vapour, carbon monoxide and ozone typical for the ambient mid-hemispheric background (Fig. 1). As can been seen in Figure 1, several sharp features in CO and matching dips in the concentration of ozone are present in the running data. This is largely due to interception of emissions from the ship itself and is in general a marker for local combustion. From this perspective it is fortunate to observe that neither the concentrations of mercury in the gas-phase nor those attached to particles are notably influenced by the ship's plume. On the contrary, strongly correlated elevated levels of mercury and carbon monoxide were observed in certain coastal industrialized destinations of the Beringia region (Fig. 1). The striking aspect of Figure 1 is, however, the rapid increase of volatile mercury in surface water when entering ice-covered waters of the Canadian Arctic archipelago (e.g. Baffin Bay; see Fig. 2). The five to ten-fold increase in the surface-DGM causes strong supersaturation. When Oden breaks up the ice, as seen in Figure 1, a fraction of the Hg° pulse is spilled into the air samples. The Arctic Seas encountered with high DGM levels during Beringia 2005 essentially overlap with locations where observations of elevated BrO have been made from satellites (Richter et al. 2002). Interestingly, our novel data on DGM in the Arctic Seas will enable us to address and quantify the degree of recycling of mercury to the troposphere.

Leg 2–3

The data made available during the two more recent legs of the expedition comprise, in addition to air and surface water, ice and vertical ocean profiles. Analysis of DGM in ice samples (brine) frequently indicates levels that surpass those measured in the underlying surface sea water. In turn, along the trans-arctic oceanic section the highest levels of DGM were encountered in surface water, indicating the impact of the atmosphere and/or light-driven chemistry (Fig. 3). From Figure 3 an apparent inverse relation between DGM and the residence time of the water mass is implied. However, as we are lacking the distribution of total mercury at the time of writing, it appears presumptuous at this stage to say anything definite about this part of the arctic mercury cycle. Another issue worth looking into that turned up is the source distribution of arctic mercury. Moderate CO and Hg° concentrations during the second part of August (shown in Fig. 1) appear to coincide with prevailing atmospheric transport from Eurasia. By evaluating the Hg°/CO ratio we will hopefully be able to put constraints on the growing Asian emissions of mercury.





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Top - Figure 2
Preliminary location of elevated DGM in surface water during leg 1.

Bottom - Figure 3
Preliminary distribution of volatile mercury along a vertical section of the Arctic Ocean.

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Orsaken till förhöjda halter av kvicksilver (Hg) i Arktis är massivt atmosfäriskt nedfall. Denna kemiska sänka av Hg^0, modulerad av halten av oxiderande bromföreningar, tillför frusna marina områden i Arktis hundratals ton Hg under polarvåren. Reduktion av oxiderat Hg (Hg-II) i hav/snö/is följt av import till atmosfären har observerats. Graden av denna återförsel av Hg^0 är ganska okänd, men den kan inte uppväga det totala nedfallet, och därför nettoackumuleras Hg i Arktis och tas upp i näringskedjorna. Expeditionen Beringia 2005 innebar en unik chans att sondera Hg i havsis, snö, havsvatten, sediment och luft i Arktis. Mängder av prover (>50 000) samlades in under juli–oktober 2005, och de borgar för att vi ska kunna utöka vår kunskap om Hg i Arktis kraftigt. Beroende på vilka forskningsanslag vi får ska vi försöka analysera proverna för att få svar på följande komplexa frågor:

- Hur heterogent är nedfallet av Hg-II?
- Labiliteten av deponerat Hg-II med avseende på reduktion/metylering i olika matriser?
- Omsättningen av Hg^0 i ytvattnet?
- Påverkan av cirkulation och kemi, fördelat mellan fraktionerna Hg^0, Hg-II och metyl-Hg över vattenmassor i Ishavet?
- Hur påverkas luften i Arktis av Hg från källor i Asien gentemot från Europa och Nordamerika?

En detaljerad budget för kvicksilver i det arktiska landskapet ska upprättas och vi har också för avsikt att göra en kvantitativ bestämning av Hg-ackumuleringen i Arktis. Hittills analyserade prover indikerar en kraftig övermättnad av Hg^0 i stora istäckta områden, särskilt i samband med stora råksystem (sk. polynyas).

Recent changes in land cover and carbon balance in Beringia

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Introduction and experimental rationale

Recent and persistent changes in climate and human land use in Beringia are amongst the most dramatic on the globe. Significant stores of global soil organic carbon exist in this region, and understanding how changes in ecosystem productivity interact and potentially offset the balance and stability of the soil carbon reservoir is of utmost importance to global change science. Net losses of carbon to the atmosphere as carbon dioxide and methane could enhance greenhouse warming.

In arctic terrestrial ecosystems the dynamics of carbon cycling is strongly related to patch-scale land cover type and site history. Patch-scale Land Cover Change (LCC) (on the order of metres) represents an alteration in the competitive interaction of plant species responding differentially to a range of strongly coupled biological and physical factors. Although these characteristics of tundra ecosystems have been recognized for some time, advances in new technologies – such as the development of high-spatial resolution multispectral satellite sensors, declassification of former military spy satellite imagery and improved access to historical aerial photography – have greatly improved the capacity for determining patch-scale patterns of LCC at high northern latitudes. When coupled to studies examining the exchange of greenhouse gases (GHGs – namely carbon dioxide and methane) across the land-atmosphere boundary in different land cover types, deterministic modelling techniques can be used to estimate the relative impact of LCC on ecosystem carbon balance at the landscape level. *The key objective of this project is to determine the patterns of decadal time scale LCC at multiple sites in the Beringia region and to assess the probable impact that these changes have had on ecosystem carbon balance*. This study is in-part a geographical extension of research conducted by Christensen and others during the Swedish-Russian Tundra Ecology expedition 1994.

Methods

During a three-week period spanning late July to mid-August 2005, five research areas in the Russian Far East were sampled as a part of the Swedish Polar Research Secretariat's Beringia 2005 expedition. The expedition afforded a unique opportunity to examine ecosystem structure and function efficiently and effectively at multiple sites throughout the poorly studied western Beringia region. Most sites were visited for a two-day period. Dry, moist and wet land cover types were selected at each visited location, based on the following criteria:

- Ease of access
- Lack of obvious vulnerability to coastal effects and human disturbance
- Size and homogeneity of the land cover patch.

CO_2 and CH_4 fluxes were measured using a sealed plexiglass chamber and an alloy chamber base. CO_2 flux was measured as pictured (moist land cover type Wrangel Island) using a closed-path Infrared Gas Analyser. Headspace samples were extracted for post-expedition CH_4 flux analysis. An automatic weather station monitored high temporal resolution bio-climatological data. Photo: David Lin.

For each land cover type, three flux-chamber bases of around 50 50 cm were situated to mark the nine primary sampling plots. In addition a number of complementary measurements were recorded to accurately characterize each land cover type at each site. These included detailed accounts of the cover and abundance of plant functional types in each plot, active layer depth, water table depth and soil horizon. A generalized site description was also compiled.

At most sites an automatic weather station was established in the moist land cover type during the site visit. Photosynthetically Active Radiation (PAR), solar radiation, air temperature, relative humidity, barometric pressure, wind speed/direction, soil temperature and soil water content were logged at ten second intervals using an Onset Computers' HOBO weather station. Soil volumetric water content was measured at each plot using a portable Spectrum TDR probe.

CO_2 fluxes were measured using a closed path Li-Cor 6200 Infrared Gas Analyser. A clear plexiglass chamber was placed on top of the alloy chamber base marking each plot. Measurements were made under full sun, two shade treatments and complete darkness in order to generate a Light Use Efficiency (LUE) curve for each plot. Gross Ecosystem Exchange (GEE) was determined by subtracting the dark measurement (Ecosystem Respiration: ER) from each of the light measurements (Net Ecosystem Exchange: NEE). Following measurement of CO_2 flux, headspace samples were extracted from the plexiglass chamber at set time intervals using a syringe and transferred into evacuated glass vials for laboratory analysis following the expedition. CH_4 analysis was performed by Teh and Rhew at the Atmospheric Biochemistry Laboratory of UC Berkeley.

Hyperspectral Reflectance was recorded at each plot using a PP Systems UniSpec single channel spectral analysis system. This data was used to calculate a Normalized Difference Vegetation Index (NDVI), which is an index of vegetation greenness and commonly used in the arctic as a proxy for aboveground productivity and photosynthetic carbon uptake potential. NDVI calculations $((R_{800}-R_{680})/(R_{800}+R_{680})$ where $R = \text{Reflectance}_{\text{wavelength(nm)}})$ are sensitive to the spectral properties of plant pigment absorption within the visible light range and reflectance in the near-infrared range.

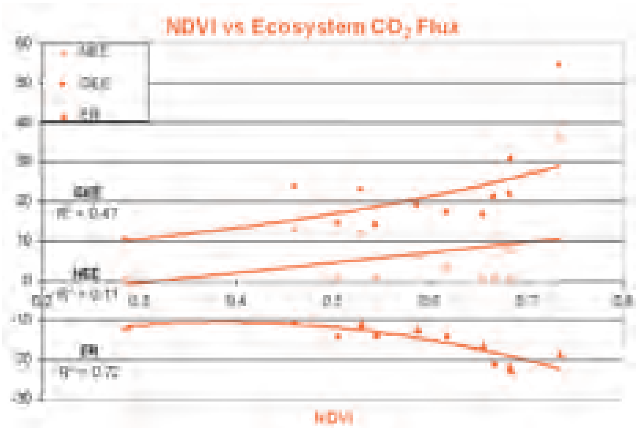
Aboveground plant biomass was harvested for all plots for post sampling sorting and analysis. Tundra monoliths measuring 25 25 25 cm were extracted from the first three sites visited. Monoliths were transported from the icebreaker Oden to Lund University where they are being maintained in growth chambers in preparation for a series of controlled experiments that will be conducted by Christensen. The experiment will also include monoliths collected recently by Christensen in Greenland and Scandinavia.

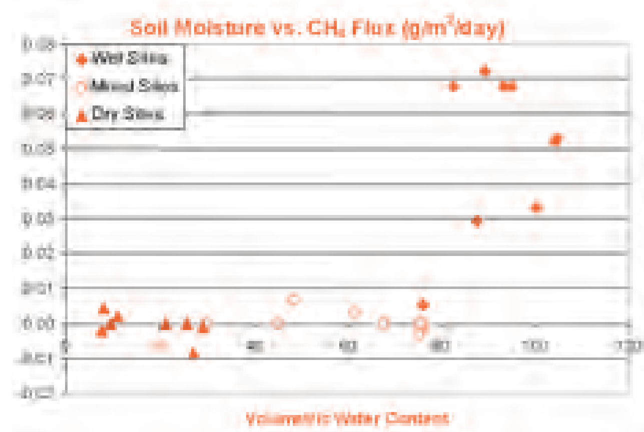
Preliminary results and discussion

Most correlations between temperature and CO_2 flux showed little significance and are not reported here. Mean daily PAR was calculated for all sites and daily NEE was calculated using correlation indices derived from LUE models (not shown). This allows for normalizing of PAR for all sites and land cover types so that the carbon fixing potential of each land cover type at each site can be determined independently of prevailing light conditions and compared between sites. Dry and wet sites were the least and most productive land cover types at each location visited respectively (Table 1). Differences in the carbon fixing capacity of different land cover types illustrate the potential of land cover change to alter regional carbon balance. If there has been an expanse of dry tundra then it is likely that the carbon fixing potential of the region has reduced. Patterns in productivity are similar to those reported elsewhere in the Arctic. While wet sites show the greatest CO_2 fixing potential, they were also the greatest sources of CH_4 emission (Fig. 2). Efflux of CH_4 only occurred at plots with

Site	Dry	Mesic	Wet
1	0.15	0.49	7.04
2	0.10	0.10	0.64
3	3.58	8.52	39.20
5	-1.55	14.17	13.16

Table 1
Daily Net Ecosystem Exchange (NEE)(g/m^2/day) calculated using LUE models for each plot and mean daily PAR arbitrarily chosen for Site 1 (592). Positive numbers indicate carbon uptake.





soil volumetric water contents above 80%. This could represent a threshold point at which tundra soils become anaerobic, permitting methanogenesis to occur. NDVI was most strongly correlated with ER, and showed weaker correlations with GEE and NEE.

Future work

The wealth of data collected from this trip has yet to be fully processed and analysed. Samples being sorted for above ground plant biomass estimates are almost complete. Analysis of soil peat samples are underway and will be completed by early 2006. Future data analysis will explore factors controlling carbon uptake storage and loss in dry moist and wet land cover types and multivariate models of carbon uptake potential will be developed. During summer 2006, high spatial resolution satellite imagery will be acquired for the sites visited and Land Cover Change assessments will be derived through intercomparison with historical declassified military imagery and archived aerial photographs. Deterministic models of carbon uptake potential will be run on the multitemporal land cover classifications in order to assess the probable impact of land cover change on ecosystem carbon fixing potential. The field component of the research conducted during the Swedish Beringia 2005 expedition will be repeated at multiple sites in Alaska during summer 2006. When combined with similar Land Cover Change assessments and modelling of carbon uptake potential as described above, we hope to be able to synthesize the likely impact of land cover change on ecosystem carbon balance at multiple sites throughout the Beringia region.

Acknowledgements

This project is supported by the US National Science Foundation Grant OPP 0454997. We are extremely indebted to the generous support, hospitality and collegiality of the Swedish Polar Research Secretariat and their staff who worked tirelessly to support the Beringia 2005 expedition.

Left - Figure 1
Correlation between component CO_2 flux and Normalized Difference Vegetation Index (NDVI). Net Ecosystem Exchange (NEE), Gross Ecosystem Exchange (GEE), Ecosystem Respiration (ER). GEE = NEE-ER.

Right - Figure 2
Relationship between soil water content and ecosystem methane (CH^4) exchange. Positive values indicate plots which were net sources of methane to the atmosphere.

Huvudmålet med detta projekt (finansierat av US National Science Foundation) är att hitta ett mönster för tidsmässiga förändringar av landtäckning på ett flertal platser i Beringia-området, och att ta reda på vilken effekt dessa förändringar har inneburit för ekosystemets kolbalans. Fem platser i östra Ryssland provtogs under Polarforskningssekretariatets expedition Beringia 2005. Torr-, fuktig respektive våtmark valdes ut vid varje plats som besöktes. På dessa marktyper uppmättes sedan meteorologiska standardparametrar, flödet av CO_2 och CH_4 mellan mark och atmosfär, hyperspektral reflektion, jordfuktighet, grundvattennivå och landtäckning av växter, och detaljerade platsbeskrivningar nedtecknades. Vi samlade också in ovanjordisk biomassa och intakta monoliter från de flesta platserna. Torr- och våtmark var de minst respektive mest kolproduktiva landtäckningstyperna på varje besökt plats, vilket väl visar hur förändringar i landtäckning kan förändra kolbalansen i en region. Utflöde av CH_4 fanns bara på ställen där markvattenvolymen överskred 80 %/m^2. Analysen av insamlade data och prover pågår fortfarande.

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Sources of methane and nitrous oxide to the coastal Arctic Ocean

Rationale

Methane (CH_4) is a climatically active trace gas, emitted to the atmosphere from the marine environment. Methane is a greenhouse gas and further participates in tropospheric ozone regulation, indirectly controlling the 'self-cleaning capacity' of the atmosphere by removing hydroxyl radicals (•OH) (Crutzen 1991). Due to source-sink imbalances tropospheric CH_4 has doubled during the past 200 years. This increase accounts for ~15% of the net heating perturbation since the 1800s.

Glacial-interglacial covariance of CH_4 and temperature (Ehhalt et al. 2001, Dlugokencky et al. 1994) reveals a potential role for CH_4 in climate shifts (Nisbet 1992, Kennett et al. 2000), and one region in which this link may involve strong feedbacks is the Arctic (Ehhalt et al. 2001). Potential sources of CH_4 include riverborne inputs from sediments (thermogenic and biogenic) as well as the water column biogenic production, while sea–air exchange and microbial processes act as sinks. There is a considerable lack of evidence on the relative strength of these sources and sinks in the Arctic Ocean, therefore our overall objective was to collect preliminary data on CH_4 distribution and dynamics in Arctic waters during leg 1 of Beringia 2005 (Göteborg, Sweden to Barrow, Alaska, USA). This has led to successful international collaboration between Göteborg and Newcastle Universities, the Swedish Polar Research Secretariat and the UK Natural Environment Research Council, which funded this study. Given the context of this work in the wider 'carbon cycling' project led by Prof. L. Anderson, we anticipate the results of this study to carry added value for the scientific community as well as for decision-making bodies.

Specific aims

1. To determine CH_4 concentrations in surface seawater, in water column profiles and in air during leg 1 of Beringia 2005.
2. To identify potential sources and sinks of CH_4 by determining:
   a. the associated $\delta^{13}C$ isotopic signatures of dissolved-CH_4 (thermogenic CH_4 has enriched ^{13}C isotope abundance compared to biogenic CH_4),
   b. bacterial abundance and
   c. dissolved silicate concentration (as a tracer of freshwater inputs from rivers).
3. To estimate sea-to-air CH_4 fluxes based on gas transfer models and to provide preliminary yet highly novel information on the CH_4 budget of the Arctic Ocean and its potential role in climate change.

Fieldwork description

Dissolved CH_4 and N_2O in surface seawater were determined in 154 samples by gas chromatography following headspace equilibration according to established

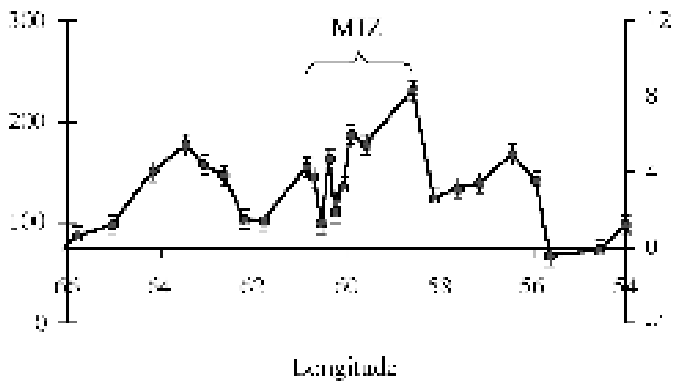

Figure 1
Methane (% saturation, circles and black line) and Sea Surface Temperature (°C, grey line) against latitude. These data were collected along the Beringia 2005 leg 1 cruise track between July 14th and July 16th in Baffin Bay. The Marginal Ice Zone front (MIZ, evidenced by the sharp decrease in temperature) is marked.

techniques (Upstill-Goddard et al. 1996). In order to distinguish between thermogenic and biogenic sources of methane we collected 40 seawater samples for the determination of their δ¹³C isotopic signatures of dissolved CH_4. In addition we collected 28 samples for bacterial enumeration as an indicator of bacterial abundance and a further 62 samples for the determination of silicate in seawater as a tracer of river inputs. In addition we carried out a limited number of opportunistic incubations of seawater, sea ice, melt water and snow in order to ascertain the potential for biogenic CH_4 production from these environments.

Preliminary results

The stable isotope, bacterial and silicate samples were transferred to our laboratory in Newcastle for pending analysis. Our preliminary results are therefore limited to underway surface seawater-dissolved CH_4 concentrations, determined onboard the icebreaker Oden.

We found large variations (up to four-fold) in surface-dissolved CH_4 along the Beringia 2005 leg 1 cruise track. Surface seawater was thus undersaturated in places and oversaturated in others with respect to equilibrium with the atmosphere. (Dissolved CH_4 is here expressed as % saturation with respect to atmospheric equilibrium, i.e. at <100%, CH_4 from the atmosphere will dissolve in seawater and at >100%, CH_4 will come out of solution and vent to the atmosphere.) Figure 1 shows data from a section of Baffin Bay along the Beringia 2005 leg 1 cruise track. This figure highlights the spatial heterogeneity of the distribution of dissolved CH_4 along the cruise track, possibly reflecting the dynamic nature of CH_4 cycling in the Arctic Ocean compared to other oceans at lower latitude. This is likely linked to ice conditions. Temporal and seasonal variability in ice conditions may act as a seal for sea–air exchange of dissolved gases as well as provide an ever-changing substrate for biological activity, thereby creating 'patchiness' in the distribution of dissolved CH_4. This link can be seen in Figure 1 as high dissolved CH_4 saturation associated with the Marginal Ice Zone (MIZ, latitude 58-61°W). This is a highly productive environment where increased biological activity likely leads to biogenic CH_4 production and hence elevated saturation in seawater. Further high methane saturation between 62°W and 65°W is likely due to restricted sea–air exchange under consolidated pack ice and therefore accumulation of CH_4.

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Källor av metan och kväveoxid i arktiska kustvatten

Metan och kväveoxider är starka växthusgaser och de produceras i marin miljö med lämpliga egenskaper för de orsakande processerna. Vidare finns stora mängder metan lagrat i permafrostområden såväl i mark som i grunda havsområden i Arktis. Målsättningen med detta projekt var att studera halterna av metan och kväveoxid i havsvatten och överliggande atmosfär under etapp 1 av expeditionen Beringia 2005. Resultaten visar att metanhalterna varierade mycket i ytvattnet, med både undermättade och övermättade områden. Detta beror med största sannolikhet på variationer i biologisk aktivitet. Det område som visar störst övermättnad är den marginella iszonen, ett område som också har hög biologisk primärproduktion.

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Microbial loop in the Arctic Ocean

The aim

The arctic pelagic ecosystem has historically been used as an example of the short and simple classical food chain. During the last decades the importance of the microbial food web (loop) has been documented for several arctic ecosystems (Rivkin et al. 1991, Nielsen and Hansen 1995, Hansen et al. 1996, Nielsen and Hansen 1999). The microbial loop is known as the pathway for dissolved organic matter (DOM) through the bacterial and microzooplankton communities to higher trophic levels. This pathway is considered important for carbon and nitrogen transport in the pelagic environment (Azam et al. 1983). Oceanic DOM represents one of the largest active reservoirs of organic carbon on earth (Hedges 1992) and is important for understanding global carbon cycles and changes in the concentration of atmospheric carbon dioxide, the most critical greenhouse gas on our planet (Nagata 2000). In the open ocean, accumulation of DOM is ultimately due to the uncoupling of biological production and consumption processes. The dominant oxidizers of marine DOM are heterotrophic bacterioplankton. Thus factors that prevent rapid microbial utilization of "freshly produced" DOM result in its accumulation (Carlson 2002). Thingstad et al. (1997) proposed a hypothesis called the "malfunctioning microbial loop". This hypothesis proposes that competition for limiting nutrient and grazing pressure reduce bacterioplankton growth rate, biomass and carbon demand to levels that allow accumulation of biodegradable dissolved organic carbon (DOC) during biologically productive seasons. Low temperatures have also been suggested as a mechanism that inhibits bacterial growth and may foster DOM accumulation (Carlson 2002). From studies in the Arctic Ocean it has been shown that even though high bacteria activity was measured there were also high concentrations of DOM and DOC. These results raise questions about the general relationships among primary producers, DOM fluxes and concentrations and bacterial activity in perennially cold waters (Rich et al. 1997).

The aim of this study was to investigate the microbial loop in the Arctic Ocean and how the consumption of dissolved organic carbon is regulated by the bacterial growth and also their regulation mechanisms such as grazing from heterotrophic nanoflagellates. We also aimed to determine basic biological parameters that can act as a background data for future scientific work in an area with little data available.

The fieldwork

The main work was concentrated on the water samples from the rosette. Water samples were taken from 5–8 depths

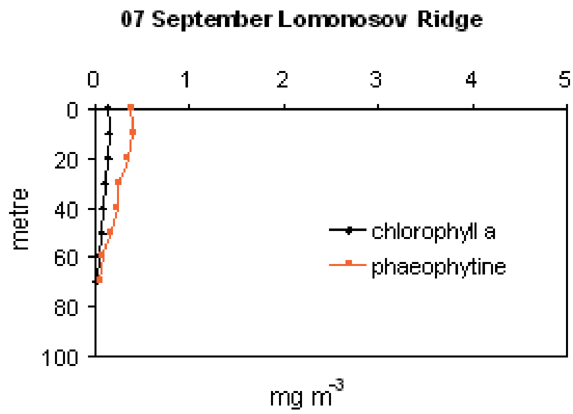

Figure 1
Concentrations (mg m-3) of chlorophyll *a* pigment and phaeophytine pigment at the station 07 September (Lomonosov Ridge).

from the top 200 meters and analysed according to Table 1. At three stations experiments were performed with water from the productive zone to describe the regulation mechanisms of the bacterial community. In addition 4–6 different types of samples from 9 ice stations were analysed according to Table 2.

Preliminary results

Most of the samples taken on the expedition have not yet been analysed. Available data are Chlorophyll *a* concentrations, which were analysed onboard icebreaker Oden. The results indicate a general low biomass across the Arctic Ocean; see Figure 1 as an example. It is important to remember that low biomass does not mean low production. The profiles show reduced nutrients in the surface waters at some stations and indicate that primary production has been going on. Also the results show that phaeophytine concentrations were higher than chlorophyll *a* concentrations at most stations and depths. This can indicate that secondary production was high and explain why the biomass was not higher. The zooplankton samples show that there were copepods and some jelly fish present. Later analyses of phytoplankton, nanoflagellates and ciliates will show the status of the phytoplankton and potential microzooplankton grazers.

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Table 1
Suspended profile stations where the following samples were taken: Chlorophyll *a* and phaeophytine (Chl), Biogenic silica (BSi), Particulate carbon and nitrogen (C/N), Bacteria biomass (BaB), bacteria production (BaP), phytoplankton fixation (Phyto), staining of nanoflagellates with DAPI (Da), zooplankton samples (Zoo) and Experiment (Exp).

Date	Station and	(~depth m)	Description	Samples
21 August	4	(~2 000)	Shelf slope	Chl, BSi, C/N, BaB, BaP & Phyto
23 August	8	(~3 900)	Canada Basin	Chl, C/N, BaB, BaP, Phyto & Da
25 August	12	(~3 800)	Canada Basin	Chl, BSi, C/N, BaB, BaP, Phyto & Da
29 August	17	(~4 000)	Canada Basin	Chl, BSi, C/N, BaB, BaP, Phyto, Da & Exp
01 September	23	(~1 700)	Alpha Ridge	Chl, BSi, C/N, BaB, BaP, Phyto, Da & Zoo
07 September			Lomonosov Ridge	Chl, BSi, C/N, BaB, BaP, Phyto, Da & Exp
16 September		(~4 500)	Amundsen Basin	Chl, BSi, C/N, BaB, BaP, Phyto, Da, Zoo & Exp
18 September			Gakkel Ridge	Chl, BSi, C/N, BaB, BaP, Phyto & Da

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Date	Station	Samples
26 August	1	BaB, BaP & Da
01 September	2	BaB, BaP & Da
04 September	3	BaB, BaP & Da
05 September	4	BaB, BaP & Da
06 September	5	BaB, BaP & Da
08 September	6	BaB, BaP & Da
12 September	7	BaB, BaP & Da
14 September	8	BaB, BaP & Da
18 September	9	BaB & Da

Table 2
Ice stations where the following samples were taken: Bacteria biomass (BaB), bacteria production (BaP) and staining of nanoflagellates with DAPI (Da).

Deltagandet i expeditionen Beringia 2005 ingår i en doktorsavhandling med fokus på det mikrobiologiska kretsloppet i arktiska ekosystem. Olika biologiska prover togs under expeditionen för att undersöka det mikrobiologiska kretsloppet och för framtida forskning. Prover av fytoplankton, biomassa, bakteriell biomassa och bakterieproduktion togs, liksom prover av heterotrofiska nanoflagellater (som livnär sig på bakterier) och ciliata (som livnär sig på nanoflagellater). De begränsade resultat som hittills är klara visar att biomassan av fytoplankton är allmänt låg i Norra ishavet. Halterna av phaeophytin-pigment var högre än chlorophyll *a*-pigment, vilket indikerar en sekundärproduktion. När alla prover är analyserade kommer man att kunna uppskatta betydelsen av det mikrobiologiska kretsloppet i Norra ishavet.

Beringia 2005 Theme B

Ecology and evolution

The Beringia region supports a remarkable biodiversity, with the largest concentration of breeding shorebirds in North America, large numbers of otherwise rare marine and terrestrial mammals, and one of the most productive fisheries remaining on Earth. The region also contains a plethora of Arctic plant species, which reflects a history featuring glacial refugia and recurring landbridges between Asia and America. The name *Beringia* was coined in 1937 by the Swedish botanist Eric Hultén, recognizing the importance of this area in the evolution and distribution of Arctic species. Nevertheless many aspects of the evolutionary ecology of Chukotka, Kamchatka and Alaska remain unexplored to this day.

The scientific theme presented here focuses on tundra ecology, evolution and biocomplexity as explored during the Beringia 2005 expedition. In July and August 2005 the icebreaker *Oden* visited research sites on both sides of the Bering Strait, from Provideniya in easternmost Russia, via Wrangel Island to Barrow in northern Alaska. Simultaneously another group of researchers visited a number of sites on the peninsula of Kamchatka, from Petropavlovsk to Karaginsky Island. A third group explored the region of Anadyr in Chukotka, while a fourth was stationed in the Yukon-Kuskokwim delta in Alaska. Thus we covered in a single season habitats from the Arctic shores at 73ﬄN down to the coastal tundra of southern Kamchatka at 53ﬄN. The entire region spanned 3 000 km from East to West and 2 000 km from North to South. This provided an excellent opportunity to compare interactions between productivity and biocomplexity in a range of tundra habitats. The tundra ecosystems were investigated from the different perspectives of population ecology, systems ecology, molecular ecology, evolution of species, animal behaviour, biodiversity, biogeography and animal migration. For many of the projects, new findings from this expedition extend and complete the data sets collected during previous Swedish expeditions in the Russian and Canadian Arctic, *Tundra Ecology 1994* and *Tundra Northwest 1999*.

Several projects studied the interactions between plants and animals, such as the relation between plant diversity and mammalian herbivores, and interactions between plants and insects. One interesting result was that some insects which parasitize on tundra plants are themselves being parasitized by other insects to the extent that up to 90% of their larvae are being killed. In Kamchatka, the brown bear is the most common large herbivore; in some areas there were visual signs of bear activity every 17 metres.

One study looked at the disturbance of plant communities and the importance of nitrogen fixation in the process of growth and recolonization of vegetation. Other aspects of species interactions ranged from niche overlap and coexistence of large predators to behavioural interactions between shorebird species. Lake plankton have to adapt to the extreme UV light conditions of the Arctic. It was found that *Daphnia* plankton not only turn red as a response to intense sunlight, but also quickly move away from UV light when not acclimatized to it.

Much remains to be explored regarding the intriguing mechanisms of navigation and energy budgets of birds, both in the Arctic and on their long-range migrations down to Australia and New Zealand. Observations and experiments on orientation behaviour were carried out in the Beringia region and across the entire Arctic Ocean, studying how birds use visual or magnetic cues for navigation. Radar and visual observations from the ship revealed that during the most intensive passage up to 11,000 birds per hour passed the ship, some at an astonishing 4 600 m above sea level. Migrating birds may also affect human societies, for example by spreading diseases such as influenza. This was the theme for a project on viral and microbial infections in birds, tying together human medicine and the behavioural ecology of birds.

Beringia 2005

Forskarrapporter Cruise Reports

B

Ekologi och evolution
Ecology and evolution

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Bird migration and species diversity under polar conditions: the Siberian – American migration systems

Background and objectives

Extensive studies of bird migration patterns based on field observations and tracking radar registrations have been conducted during earlier expeditions to Siberia in 1994, the central Arctic Ocean in 1996 and arctic Canada in 1999 (e.g. Gudmundsson and Alerstam 1998, Alerstam and Gudmundsson 1999 a, b, Alerstam and Jönsson 1999, Alerstam et al. 2001, Gudmundsson et al. 2002, Hedenström et al. 2002, Green et al. 2004). Among the significant results of these studies are the discovery of important bird migration systems between Siberia and Alaska/Canada across the Arctic Ocean, and the demonstration that flight routes closely resemble great circles, as predicted if the birds use for their orientation a sun compass without compensating for the longitudinal time shift. In addition biogeographical analyses have indicated that possibilities and constraints associated with the birds' migratory performance have an important influence on the biodiversity and distribution of arctic birds (Henningsson and Alerstam 2005 a, b).

We had two main objectives for our studies during the Beringia 2005 expedition:

1. To study and document bird species richness and relative species abundance by intensive field observations during the entire journey of the icebreaker Oden and at the coastal field sites that were visited during this journey. The route of the icebreaker provided an excellent and unique opportunity to explore and compare biogeographical features of pelagic bird diversity in little explored and remote areas of the Arctic.
2. To investigate the extent and exact routes of bird migration in the Siberian–Alaskan region by the use of tracking radar onboard the expedition ship. This would fill in the gap in such studies from the Beringia region that was not covered on our earlier expeditions to Siberia and Canada, respectively. These radar measurements will be used to test hypotheses about orientation principles and to evaluate flight conditions, including the effects of weather and wind, for the unique bird flights across wide expanses of the Arctic Ocean.

Methods

The number of species and individuals of birds were recorded from the outer deck daily. Special emphasis was put on counting birds in the mornings in a standardized way so as to be able to compare days. Birds were detected and identified with the aid of binoculars and spotting scopes (20–60). The start and finish times of each standardized count were then translated to positions and distances travelled with the aid of the ships' navigation system.

Counts were performed both when the ship was stationary and when it was moving. In addition to this, a daily species list was kept, including all species observed during the standardized counts as well as all additional species observed.

On land sites the observers recorded species and counted the number of individuals along a path walked. The position and time at each start-, finish- and turning point were noted.

Two tracking radar stations were installed on the 4th deck of Oden, on the port and starboard sides respectively, with a partly overlapping horizontal field view of about 240ffl each. The two stations (type PV 301 and PV 882) had similar technical performances, with wavelength 3 cm, peak power about 200 kW and a pencil beam width of about 1.65ffl. New software was developed to record and store radar data every second, along with simultaneous information from two tilt sensors recording the levelling of the ship and updating the position, direction and movement of the ship every 5 seconds from the Oden network. Winds at different altitudes were measured by releasing and tracking helium balloons that carried an aluminium foil reflector. Both radar stations were sometimes operated simultaneously, but this was not possible in poor visibility when only one of the stations could be used because of interference with the ship's radar system. The radars permitted tracking of individuals or flocks of birds, mostly in the range of 3–10 km from the ship, up to maximum ranges of 15–20 km. Targets were tracked for at least 20 seconds and normally for 60–300 seconds. Altitude, speed and direction of movement were calculated based on position data averaged during 10 seconds intervals, after taking into account the levelling, direction and movement of the ship. The overall mean altitude, ground speed, and vertical speed for each target were obtained by averaging the data for all available 10 second intervals. Track directions were calculated as mean vectors in a corresponding way. Samples of echo signatures, allowing analysis of wingbeat patterns, were also obtained for many targets.

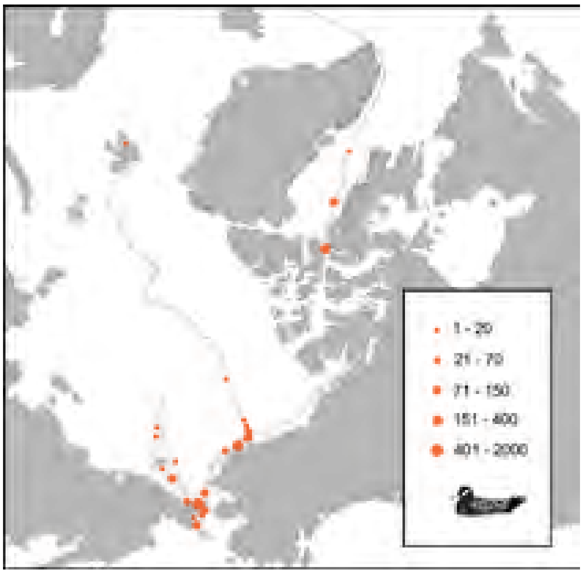
Figure 1
Total number of bird species observed from Oden along different segments of the entire expedition journey from Sweden to Svalbard. The inserted map shows the number of species recorded at five tundra sites visited for fieldwork during the Oden journey.

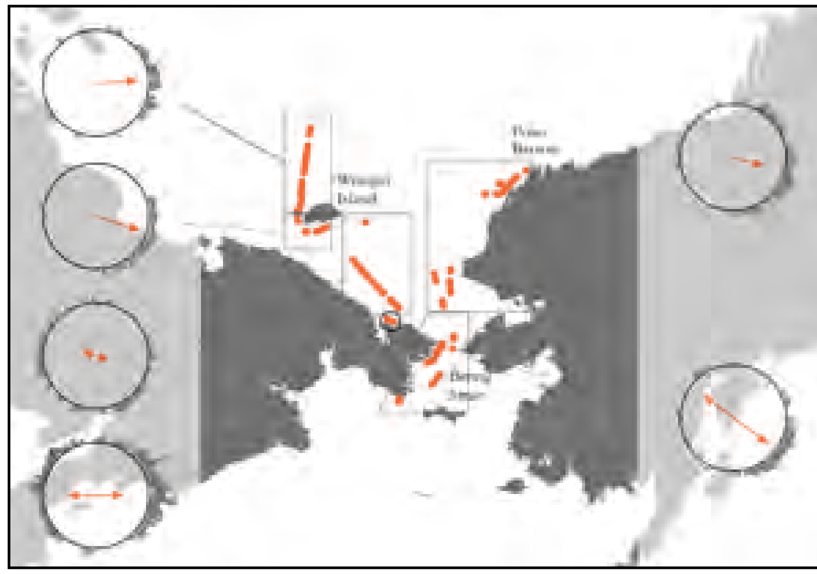
Preliminary results

Pelagic bird diversity

An overview of the variation in numbers of species along the entire passage is shown in Figure 1. Enclosed in the boxes are the numbers of species observed along the track corresponding to each box. Although each box represents different amounts of counts and days, the figure gives an idea of the broad structure of the species richness variation along the track. Particularly high numbers of species were detected in the area of the Bering Strait and southern Chukchi Sea. Especially abundant were alcids such as crested and parakeet auklets, horned and tufted puffins, and also short-tailed shearwaters and northern fulmars occurred in impressive numbers. This region is characterized by highly productive waters and may therefore host a diverse pelagic bird community. A spillover effect from the more southerly Bering's sea, which is even more nutrient rich and known as one of the most diverse regions in the Northern Hemisphere for alcids and other pelagic species, may also contribute to the high diversity observed in the Bering's strait and Chukchi sea. Furthermore, the region is transected by a massive autumn migratory highway of birds, particularly shorebirds, skuas and passerines. These are migrants of both Siberian and American origin who also contribute to the high diversity in the Bering Strait area.

Especially noticeable are the low numbers of both local birds and transient





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Left - Figure 2
Locations and numbers of grey phalaropes *Phalaropus fulicarius* recorded from Oden during the entire expedition journey.

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Right - Figure 3
Locations and flight directions of migrating birds as recorded in the Beringia region by tracking radars placed onboard Oden. Red dots on the map show locations of tracks (often overlapping locations when the ship was stationary or moving very slowly), and circular diagrams show flight directions in different regions (dots on the circle peripheries refer to track directions of individual targets, and mean directions or axes are indicated by arrows). This preliminary overview is based on 569 radar tracks of migrating birds (mostly flocks but also single birds).

migrants across the Arctic Ocean interior. The only species observed along the route across the vast packice of the central polar basin were singleton individuals of glaucous gull, grey phalarope, northern fulmar, blacklegged kittiwake and snow bunting. A dramatic increase of both individuals and species occurred only at the very edge of the packice. The hostile environment and low food availability in the packice are the likely reasons why so few species are encountered there. Radar studies from earlier expeditions have also shown a striking absence of migratory activity in the central polar basin. Although the distance across the packice would be theoretically possible to fly, at least for some shorebirds, evolution has not favoured the establishment of such routes. The birds often need to reach more favourable habitats further south to fuel up during early stages of autumn migration. Northern tundra sites may not provide enough resources to build up fat reserves for a direct barrier crossing such as a trans-Arctic Ocean flight. There may also be orientation and navigation difficulties associated with migration near the magnetic and geographic poles.

The relatively low numbers of birds seen in northwest Canada are likely a result of particularly heavy ice situation in this area during the passage.

Our observations reflect the well differentiated avifauna between the Atlantic and the Beringia side of the Northwest Passage. The ship-based observations on the Beringia side included a total of 52 species, compared to 43 on the Atlantic side. The Bering's Sea and the Atlantic had 22 species in common. Relatively higher diversity of petrels and shearwaters was recorded on the Atlantic side, while relatively higher diversity of auks was recorded on the Beringia side.

Birds at coastal wetland sites

The total numbers of species (including both local birds and transient migrants) observed on the five different land sites in the Beringia region are illustrated in the lower right corner of Figure 1. Although the number of days spent on each site differs, the observations give a general idea of the between-site variation in species occurrence during early stages of autumn migration. For instance, the most abundant shorebird species at each site were quite variable. The three most dominant shorebirds for each site were

1. western sandpiper, red-necked stint, and ringed plover on the southern Chukotka sites,
2. grey phalarope, western sandpiper and dunlin on the northern Chukotka site,
3. dunlin, red knot and ruddy turnstone on the Wrangel Island site and
4. grey phalarope, red-necked phalarope and long-billed dowitcher on the north Alaskan site.

Shorebirds constitute the largest part, in both diversity and number of individuals, of the migratory activity in these regions, as observed both on land and at sea. However other groups, such as long-distance migrant species of passerines, skuas and terns, were also represented in good numbers.

Grey phalaropes on migration

Grey phalarope was frequently encountered from the icebreaker and on land sites in the Bering Strait region. Several observations of this species were also made outside this area on leg 1 and 3. Figure 2 illustrates the location and numbers of grey phalaropes seen from the ship during the entire passage. An intense migratory activity of grey phalaropes was observed from the ship just north of the Bering Strait. During the most intensive passage, the numbers passing the ship were estimated to 11,000 birds/hour. The majority of these flocks migrated in a south-easterly direction. Grey phalaropes were also encountered in fair numbers further north in both the Chukchi and Beaufort Sea, with some extreme individuals as far north as 77°N. Most of these individuals probably had a Siberian origin and were on route to America and, like the Alaskan populations, to winter in the Pacific Ocean off the coast of South America. However the grey phalaropes encountered in Baffin Bay and Lancaster Sound (as well as on Svalbard) may belong to a different flyway with a migratory destination in wintering areas off-coast Africa in the Atlantic Ocean.

Radar records of flight patterns of birds in the Beringia region

Distributions of flight directions in six different areas of the Beringia region are illustrated in Figure 3, based on a total number of 569 radar tracks (≥ 20 seconds) that were recorded during the period 30 July–19 August. Most migrants were travelling in easterly directions from Siberia towards Alaska, as expected for many shorebird species. It is interesting to note how the mean direction changes from almost due east in the area north of Wrangel Island to southeast in the Bering Strait area. This pattern offers promising possibilities to extrapolate flight directions according to different orientation principles and to evaluate the full extent of the shorebird flyway system from Siberia towards Alaska. However to make this analysis complete it is required that the impact of wind on the birds' orientation is calculated and also that data from earlier expeditions to Siberia and Canada are included in the overall evaluation, which are the next steps in our analysis work. The easterly migration was usually occurring at considerable heights, with mean altitudes between 1 300 and 1 800 m above sea level in the northerly offshore areas and also over the Bering Strait. Maximum altitudes were between 3 500 and 4 600 m in these areas. The mean altitude of the easterly migrants was lower at the Siberian coast (the Kolyuchinskaya site), at about 900 m above sea level. In addition many tracks were easterly rather than south-easterly at this site, possibly reflecting a response by the migrants flying at moderate heights to travel parallel along the coastline which extends almost due west-east at this site.

A novel discovery was the existence of a regular and important migration in westerly directions (mean track direction about 280ffl). Some of these migrants were passerines, as determined from their characteristic radar echo signatures. The most probable species in this migratory movement were e.g. wheatear, yellow wagtail, arctic warbler, red-throated pipit and other "Old World"-species with breeding ranges extending into Alaska and with winter quarters in southern Asia and in Africa. We are looking forward to proceed with detailed analyses of the directions of these migrants in relation to the effects of wind and to the orientation principles and possible routes towards their distant wintering quarters.

The mean flight speed (ground speed) varied in different areas between 12 and 18 m/s, and this variation will be further analysed in relation to wind to reveal the true airspeeds of the migrating birds.

Conclusion

Our project has obtained a rich harvest of highly interesting and valuable field and radar observations during the Beringia 2005 expedition. On the basis of these results we hope to add new knowledge about the biodiversity and migratory behaviour of arctic birds, particularly about the evolutionary causes and orientation principles for the intriguing crossroad migration patterns in the Beringia region.

Acknowledgements

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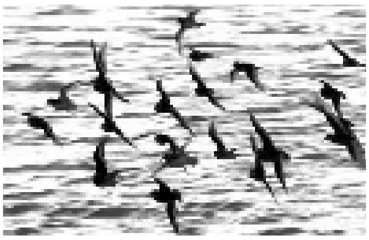
The two primary methods of the project were intensive and standardised visual observations and tracking radar registration, respectively. Photos: Johan Bäckman and Mikael Rosén.

Near Bering Strait seabird abundance reached peak levels and Oden sailed through huge flocks of short-tailed shearwater *Puffinus tenuirostris*, consisting of several tens of thousands of birds. Photo: Thomas Alerstam.



Phalaropes were among the most abundant shorebirds recorded on migration, particularly the grey phalarope *Phalaropus fulicarius* (see Fig. 2). These photos from Barrow show a flying flock of mixed grey and red-necked phalaropes and a flock of swimming and foraging adult grey phalaropes in different stages of post-breeding moult.
Photos: Thomas Alerstam.

and to Catherine Mulligan for most valuable support and electronic help for our radar work onboard Oden. We also wish to thank warmly the Swedish Polar Research Secretariat and the crew of Oden, from whom we received full support during the entire expedition.

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Fåglarnas flyttning och artdiversitet i polarmiljö: flyttningssystemen mellan Sibirien och Amerika.

Omfattande fält- och radarstudier av de arktiska fåglarnas flyttning, orientering och förekomst har bedrivits under tidigare expeditioner i Nordostpassagen 1994, Norra Ishavet 1996 och Nordvästpassagen 1999. Projektets målsättning 2005 var att genomföra utvidgade studier i Beringia-regionen för att fylla kunskapsluckan från detta område som inte besökts tidigare, och som dessutom är centralt för att förstå utvecklingen av fåglarnas flyttningssystem i ett cirkumpolärt perspektiv.

De arktiska fåglarnas artdiversitet och förekomst studerades genom systematiska fältobservationer från Oden längs hela expeditionsrutten. Två radarstationer för målföljning installerades på Oden och användes för att följa flyttande fåglar och mäta flyghöjd, hastighet och riktning. Varje individ eller flock följdes oftast under 1–5 min på 3–15 km avstånd från fartyget. Heliumfyllda ballonger användes för mätning av vindens riktning och hastighet på olika höjder.

Antalet fågelarter längs expeditionsrutten och vid fältlokaler på tundran visas i Figur 1. Artrikedomen var särskilt stor vid Berings sund, i bjärt kontrast till det extremt fattiga fågellivet i de centrala packisfyllda delarna av Norra Ishavet. Som exempel på förekomsten av en enskild art visas i Figur 2 observationerna av den brednäbbade simsnäppan. Många av simsnäpporna flyttar via Berings sund-området till vinterkvarter i södra Stilla havet, medan östligare bestånd flyttar från arktiska Kanada till Atlanten. Fördelningen av flyttfåglarnas flygriktningar enligt radarföljningar inom olika delar av Beringia-området visas i Figur 3. Bilden visar fågelflyttning på bred front i östliga riktningar från Sibirien mot Alaska (främst vadarfåglar med medelhöjder 1 300–1 800 meter över havet, upp till 4 600 m för enstaka flockar) men även västriktad flyttning från Alaska mot Sibirien (till viss del tättingar med medelhöjd omkring 900 meter över havet). Dessa resultat ger ett mycket värdefullt underlag för att närmare analysera fåglarnas kursförändringar, vindberoende och orienteringsmekanismer. Dessutom hoppas vi bidra till förståelsen av hur de storskaliga och korsande fågelflyttningssystemen i Beringia-regionen, som vi på detta sätt upptäckt och kartlagt, har utvecklats.

Plant–herbivore systems in Kamchatka

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Kamchatka is a peninsula of approximately the same size as the Scandinavian Peninsula. Although far away from each other on the northern hemisphere, both areas have northern connections to the mainland and a rather similar fauna and flora. However, one main difference is that Kamchatka is highly influenced by volcanic activity. Another difference is that the past vegetation in the Beringia area has been shaped by a somewhat different herbivore fauna (e.g. mega-herbivores) than has the vegetation in Scandinavia. These similarities and dissimilarities offer unique possibilities for comparative studies between Kamchatka and Scandinavia on plant – herbivore systems. Further, the fact that the two areas have rather similar natural resources but are managed within different societal systems offers many interesting comparisons.

The aims

During the Beringia 2005 expedition our main task was to perform the fieldwork in Kamchatka. Later, studies with the same methodological approach will be performed in Scandinavia and also, if possible, in Alaska.

Our aims were to:

- Estimate the abundance of different herbivores in terrestrial systems
- Estimate the impact of various functional groups of herbivores on their environment
- Collect information on plant morphological traits and to collect samples for chemical analyses
- Gather information on various land uses, especially those related to wildlife.

The sites

We studied the terrestrial habitats of four main sites:

1 **Utka River** (53°14.91’N, 156°50.61’E; approx. 170 m a.s.l., 15–19 July 2005). The area is undulating, with height differences of approx. 30 m and with bow-shaped rises, seemingly an old river landscape. The vegetation is characterized by comparatively dry mires dominated by <0.5 m tall *Myrica tomentosa* and without *Sphagna*. On higher ground are extensive *Betula ermanii* forests, seemingly untouched by forestry. Utka River is fringed by riparian forest of *Alnus hirsuta* and *Salix udensis* and of tall herb (1.5–2.0 m) meadows with *Filipendula kamchatica*.

2 **Ichinskaya Sopka Volcano** (55°46.08’N, 157°45.00’E, approx. 1 225 m a.s.l., 20–27 July). The landscape is dominated by up to 3 607 m high volcanoes with glaciers and snow-covered peaks, separated by wide U-shaped valleys with braided rivers. The whole area is

Vilyuchinskaya Sopka Volcano.
Photo: Kjell Danell.

Table 1
Mammalian herbivores observed directly or indirectly (e.g. tracks, faeces) on the four study sites on the Kamchatka Peninsula. Occurrence is marked by (•).

MAMMALIAN HERBIVORES	SITE 1	SITE 2	SITE 3	SITE 4
Voles	•	•	•	•
Mountain hare	•	•	•	•
Pika		•		
Ground squirrel	•		•	
Marmot		•		•
Reindeer		•	•	
Snow sheep		•		
Brown bear	•	•	•	•
Red fox	•	•		•

above the tree line and the vegetation is dominated by alpine dwarf-shrub heaths with dwarf willows, *Ericaceae* spp., including two small *Rhododendron* species, and lichens. In the valley bottoms on gravel and boulder-fields one can find approx. 1 m tall herbaceous grass-dominated vegetation including *Leymus interior* and *Chamaenerion latifolium*.

3 **Karaginsky Island** (58°57.84'N, 164°13.56'E, approx. 205 m a.s.l., 31 July–6 August). The interior of Karaginsky Island is mountainous, with peaks of >900 m and frequent snow beds, intersected by usually fairly narrow river valleys, occasionally widening to open meadows. Below approx. 150 m *Betula ermanii* forests can be found and on higher altitudes there are extensive impenetrable thickets of *Alnus fruticosa* or *Pinus pumila* intermixed with small areas of dry heaths with dwarf-shrubs or wet fens.

4 **Vilyuchinskaya Sopka Volcano** (52°39.059'N, 158°10.378'E, approx. 535 m a.s.l., 9–11 August). The area is situated >500 m above sea level and the highest volcanoes have snow-covered peaks, but landforms are relatively soft. The vegetation is dominated by alpine heath, with *Ericaceae* spp., dwarf willows, *Betula nana* and many herbs, e.g. *Oxytropis* sp. On lower slopes there are extensive thickets of *Alnus fruticosa* and a little *Pinus pumila*, and along rivers there are *Salix udensis* and tall herbs like *Cirsium kamchaticum*.

The herbivores

We focused on the herbivores feeding on the leaves/needles of woody plants, as well as on forbs and grasses. The main effort was directed to mammals (Table 1) and herbivorous insects (mainly sawflies, beetles and butterflies). Information on mammals was collected by systematic observations along transects, collections with traps and to some extent observations on mountain slopes with spotting scopes. Site 2 had the highest species richness of mammalian herbivores while the other three sites had lower richness.

When possible we collected insects using sweep nets and pitfall traps.

The impact of herbivores

We estimated the impact of mammalian herbivores using line transects. Our field protocol was designed to be analysed with distance sampling. Along the transects we recorded mammalian herbivory and other ecological "disturbances" by mammals.

Distance sampling does not require a certain shape or travel route. However for logistic reasons we aimed at collecting data along the sides of a triangle, terrain permitting, with equal sides of 1 km. In total we logged two triangles, or approx. 6 km, at each of the four main sites, plus an extra 1 km-transect in riverine vegetation at Site 1. When walking along the legs we recorded all signs of browsing and grazing, as well as tracks, trails, diggings, scrapings and faeces. Two persons performed the survey. The first person used the GPS to follow the pre-determined route. He furthermore surveyed the ground for faeces and tracks. The second person surveyed the ground for herbivory and all other impacts. The equilateral distance from the walked line to each observation was measured. The route and all observations, together with borders of major vegetation types were given GPS coordinates.

The data indicate that the brown bear is the main large herbivore, at least in non-alpine areas. Along a 1 km transect through riverine forests and tall-herb communities we observed a bear activity (feeding, track or faeces) every 17 m and a feeding activity every 50 m. The feeding was mainly observed on 1–4 m tall herbs like *Filipendula kamchatica*. The preliminary analyses also suggest that at Sites 1 and 4, the brown bear, in the absence of other large herbivores, causes most of the vegetation impact, both directly by grazing, and indirectly by e.g. trampling. Characteristic features of

A	
SPECIES	**HERBIVORY**
Betula platyphylla	5.46 (0.97)
Salix no. 1497	2.91 (0.83)
Betula ermannii	1.41 (0.98)
Salix udensis	1.29 (0.57)
Vaccinium uliginosum	1.21 (0.64)
Alnus fruticosa	0.74 (0.25)
Myrica tomentosa	0.70 (0.50)
Salix udensis	0.54 (0.26)
Spirea stevenii	0.45 (0.23)
Alnus hirsuta	0.45 (0.36)

B	
SPECIES	**NECROSIS**
Salix udensis	0.77 (0.31)
Alnus fruticosa	0.67 (0.22)
Vaccinium uliginosum	0.46 (0.40)
Myrica tomentosa	0.40 (0.40)
Pinus pumila	0.38 (0.27)
Leymus interior	0.22 (0.13)
Epilobium angustifolium	0.10 (0.10)
Rhododendron aureum	0.08 (0.05)
Rosa sp.	0.06 (0.05)
Larix sp.	0.06 (0.02)

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Table 2
The 10 species with most herbivory (a) and necrosis (b). Values are % of leaf area with standard error within brackets.

several other studied sites were mammal disturbances of the soil through digging and scraping. Several species, but mainly voles and ground squirrels (sousliks) are diggers. Within about 1.5 m from a 1 km long line on Site 2, we found more than 200 holes of various sizes. Transect observations of a high density of soil disturbances through digging led to an extra study to better understand the spatial distribution of holes in an alpine area (Site 2).

To estimate the insect herbivory we collected leaves of the dominant woody plants, herbs and grasses on the sites. The leaves were measured for morphological characters and we recorded length, breadth and the percentage of the leaf area affected by different types of herbivory (leaf-feeding and miners). On Site 3 we also studied the level of insect herbivory along an altitudinal gradient.

At each site we selected 10–20 of the most common or apparent plant species and sampled shoots and leaves for later chemical analyses. In all 34 species were sampled, of which 2 species were taken at all 4 sites, 4 were taken at 3 sites and the majority of species were sampled just once. Five species were trees, 6 shrubs, 6 dwarf shrubs, 14 dicotyledonous herbs and 3 graminoids. For each species leaf length and leaf width were recorded, together with % leaf area consumed by herbivores (almost exclusively insects) and % leaf area that was necrotic, possibly a sign of hypersensitive response to insect herbivory.

Loss to herbivory was low, and on average across all species 0.6% of the leaf area was eaten and 0.17% was necrotic. Susceptibility varied both between species and between sites (Tables 2 and 3). Neither herbivory nor necrosis were linearly related to leaf size, altitude or latitude when calculated across species.

Leaf width, but not length, across species was negatively correlated to altitude (at main sites: Regression analysis; $R=0.390$; $F=9.529$: $p=0.003$; $N=34$). Also within species and genera leaf size variables were in many cases negatively related to altitude (*Alnus fruticosa, Betula* spp., *Pinus pumila, Rhododendron aureum, Salix* spp., *S. arctica*).

SITE	HERBIVORY	NECROSIS
1	0.38 (0.11)	0.14 (0.05)
2	0.42 (0.10)	0.21 (0.07)
3	0.41 (0.17)	0.12 (0.04)
4	0.91 (0.19)	0.21 (0.07)

+

Table 3
Average herbivory and necrosis at the four sites. Values are % of leaf area with standard error within brackets.

The chemical defenses of plants

In order to test the hypothesis that Beringia plants have a different secondary plant chemistry we collected plant material from plants unique to Beringia and plants with a circumpolar distribution.

Relations to other projects on the Beringia 2005 expedition

To a large extent we collaborated with other projects on the Kamchatka part of the expedition and we used similar methods (estimates of herbivores and their impact; sampling of plants) to other scientists on the other legs of the Beringia 2005 expedition.

Some general impressions and ideas

Superficially the Kamchatka landscape and vegetation is rather similar to the one found in northern Scandinavia. The main difference is its volcanic origin, which has mainly affected soil properties. The Kamchatka landscape gives a “greener” impression than we see for example in the Scandinavian mountain range. On the slopes on Kamchatka there are two

Russian trucks greatly facilitated transport of food, people and equipment.
Photo: Kjell Danell.

vegetation types (the *Pinus* and *Alnus* shrubs) which do not occur in Scandinavia. Besides giving the "green" impression, they really slow down walking. The lusher impression also persists in the mountain valleys, with impressive, high herb vegetation dominated by e.g. *Filipendula kamchatika*. The biological production is high, and the extensive cover of the nitrogen-fixing alder shrubs may be one main explanation. The nitrogen fixed on the mountain slopes is slowly transported to the mountain valleys with their luxurious vegetation. Our studies were to a large extent aimed at an increased understanding of how the soil-plant–herbivore interactions may differ from Scandinavia and maybe, at a later stage, Alaska.

Kamtjatka är en halvö på andra sidan jordklotet, som vid ett första betraktande har stora likheter med Skandinavinen med dess skogar, fjäll och floder. Klimatet påminner också om det vi har. I ett viktigt avseende är Kamtjatka mycket annorlunda – landskapet präglas av aktiva och vilande vulkaner. Många intressanta jämförelser kan göras mellan de två halvöarna. Vår målsättning var att i första hand studera växtätare och hur de påverkar ekosystemen. Med olika metoder sökte vi kvantifiera förekomsten av växtätare, i första hand däggdjur men också vissa insektsgrupper samt den påverkan som de åstadkommer (konsumerade blad och andra växtdelar; gångar och andra spårtecken). Vi undersökte fyra lokaler på mellersta och södra Kamtjatka. Generellt kan man säga att växtätarsamhällena där till viss del påminner om vad vi finner i Skandinavien, t.ex. vissa gemensamma sorkarter, brunbjörn, skogshare och ren. Andra arter är gemensamma med Nordamerika, t.ex. murmeldjur, jordekorre, piphare och snöfår. Växtätarsamhällena varierade också i sammansättning mellan de fyra lokalerna. Vi sökte också kvantifiera påverkan av vissa insektsgrupper, främst då på vedartade växter (risväxter, träd och buskar). Ett preliminärt intryck är att insekternas påverkan på växterna var betydligt lägre än vad vi finner i Skandinavien i motsvarande miljöer – kanske är växterna mer kemiskt försvarade på Kamtjatka? Detta skulle möjligen kunna förklaras av att växterna i Beringia varit utsatta för en betydligt hårdare och mer långvarig påverkan från små och stora växtätare (megaherbivorer). Kemiska analyser av växtmaterialet kommer att ge oss en bättre bild av hur växt–djur-interaktionerna är i dessa miljöer. Den växtätare som idag gör största påverkan i många miljöer på Kamtjatka är brunbjörnen – i Skandinavien är det hjortdjur som älg, rådjur och ren.

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The role of medium-sized predators in the arctic ecosystem

Background

The treeless mountain tundra found along the Swedish-Norwegian border in Scandinavia constitutes a southwestern extension of the Russian arctic tundra, with species such as arctic foxes *Alopex lagopus*, reindeer *Rangifer tarandus* and Norwegian lemmings *Lemmus lemmus*. The arctic fox was much hunted in the early 20th century due to is valuable fur and the population declined rapidly. Despite protection in Sweden and Norway since 1928 and 1930 respectively, it never recovered. Present population estimates for Scandinavia total about 100 adult individuals. Increased competition with the larger red fox *Vulpes vulpes* is one factor which may have had an adverse effect on the arctic fox population and hampered its recovery. The red fox has a food niche very similar to that of the arctic fox; when it settles in an arctic fox habitat, it may monopolise the most productive areas, as it is dominant over arctic foxes in direct conflicts over e.g. dens and carcasses (Frafjord et al. 1989, Elmhagen et al. 2002). Furthermore, the red fox is a predator on arctic fox cubs and may occasionally kill even adult arctic foxes. As a consequence arctic foxes seem to avoid contact with red foxes, in particular during reproduction (Tannerfeldt et al. 2002, Dalén et al. 2004). The fact that red foxes have become more numerous in productive mountain tundra areas may therefore explain why the arctic fox has retreated to the less productive, high-altitude parts of its former Scandinavian range in the 20th century (Dalerum et al. 2002, Elmhagen et al. 2002).

The competitive relationship between arctic and red foxes in Scandinavia is by no means unique among predators. Interspecific killing, i.e. individuals of one species killing those of another, is quite common among mammalian carnivores (Palomares and Caro 1999). The risk of predation combined with competition can cause individuals of the inferior, usually the smaller, species to change their use of habitat and activity patterns. For example, it has been shown that coyotes *Canis latrans* avoid the larger wolf *Canis lupus* and that

A brown bear female strolls with her cub along the river at site 1. Photo: Bodil Elmhagen.

Tomas Karlberg at the Swedish Polar Research Secretariat assisted us during surveys. Here he is looking for patches of lush vegetation in the landscape at site 3, as such patches might be fox dens. Photo: Bodil Elmhagen.

red foxes avoid both the larger coyote and the Iberian lynx *Lynx pardinus* (Harrison et al. 1989, Thurber et al. 1992, Fedriani et al. 1999). Over the last centuries, many populations of large mammalian predators have either been reduced or gone extinct. Decreased predation and competition from large predators may lead to increased densities of medium-sized predators. This may in turn have negative effects on species diversity through increased predation on smaller prey species (Crooks and Soulé 1999).

The Scandinavian red fox population increased dramatically between 1930 and 1960 (Lindström 1989). At the same time there was a northward spread of red foxes in North America and Siberia (Marsh 1938, Chirkova 1968). Possible reasons for this range expansion are large-scale processes such as increased productivity due to climate change and/or decreased predation and competition from declining populations of wolves and lynx (Lindström 1989, Hersteinsson and Macdonald 1992). The red fox is thus becoming an important medium-sized predator in tundra habitats and this may have important ecological consequences. The largest effect should be seen on the arctic fox, but due to its larger size the red fox may also be a more severe predator on reindeer calves and geese than the arctic fox is.

Aims

The objective of this project was to investigate the role of medium-sized predators, mainly arctic and red foxes, in a terrestrial arctic ecosystem in Chukotka, Russia. The Scandinavian mountain tundra has only a remnant population of arctic foxes which is very close to extinction. It is also a disturbed ecosystem with small populations of large carnivores. In comparison the predator community in Chukotka is relatively intact and it contains both arctic and red foxes. Thus interactions between these species, as well as interactions between foxes and larger predators, should be more frequent in Chukotka. The Beringia 2005 expedition was therefore a unique opportunity to test hypotheses on species relationships. Arctic and red fox food niches should be similar in Chukotka, as they were in Scandinavia, and the species should therefore have similar habitat preferences in the absence of competition. However, being the dominant competitor, the red fox should mainly be found in relatively productive habitats. On the other hand arctic foxes should avoid confrontation with red foxes and be more numerous in relatively barren habitats, but use the more productive ones when red foxes were scarce or absent. We aimed to test these hypotheses by comparisons of arctic and red fox diets, habitat use and population densities in different areas.

Fieldwork

The fieldwork was carried out in July and August on leg 2C Anadyr of Beringia 2005. We planned to use occurrences of breeding dens and faecal droppings of each species to estimate population density, and the locations of dens and droppings to test patterns of habitat use. The faeces would also be used for later analyses of predator diets and DNA analyses would be used to determine which fox species had deposited the faecal droppings. At each study site we therefore searched the landscape on foot for fox dens and droppings, a method that had previously been used on the Swedish-Russian Tundra Ecology expedition 1994 and on Tundra Northwest 1999. Foxes often scent mark by defecating on elevated structures in the landscape, for example small mounds and peaks, and we therefore searched such places systematically. Fox dens are often covered by lush vegetation resulting from years of fertilisation by faeces and prey remains. Consequently we also looked for and visited such lush patches in the landscape.

During surveys we cooperated with the project of Anders Angerbjörn, whose participants also needed to cover large areas on foot. For reasons of security we always worked in pairs, but co-operation between projects implied that two pairs did surveys each field day, and this enabled us to cover larger areas. To compare diets with prey availability we also needed information on what small rodent species were available and in what densities. These data were also collected in co-operation with Angerbjörn's project and rodents were snap-trapped at each study site.

We worked at four study sites overall. The first was located in and close to the mountain range south of the wetland plains surrounding Anadyr. The second was situated on coastal tundra close to Anadyr where we took the opportunity to work for a day whilst waiting for transportation to the next site. Sites 3 and 4 were located in the mountain range north of the Anadyr plains. Both this and Angerbjörn's project needed to survey several areas separated by some distance. As we stayed about one week each at sites 1 and 3, we therefore used every second day to transport ourselves down a river by rubber boats to be able to cover new ground on foot on the days in between transportation.

Preliminary results and future plans

In total we found seven fox dens, of which two were inhabited. We collected single fox scats found elsewhere in the landscape, but fox densities were low. Snap-trapping revealed that rodent densities also were low. Voles and lemmings are generally cyclic in Chukotka, showing pronounced population peaks with some years interval, and we were unfortunate in visiting the region during a cyclic low. A local hunter informed us there were stray wolves in the areas we visited, and we did see wolf tracks during our surveys and collected some wolf scats. There were high densities of brown bears, *Ursos arctos*, at all study sites and at site 1 in particular. We therefore extended our research plan to also include a diet analysis of brown bears and bear faeces were collected during all surveys.

We did encounter some difficulties during fieldwork. Fox densities were low and we did not find as much fox faeces as we had hoped for. The high bear densities at site 1, in a landscape which to a large extent was covered by dense thickets of pine or broadleaf species, also made work difficult. However thanks to the high bear densities we were able to collect quite a lot of bear faeces, and in co-operation with the projects of Åsa Lindgren and Anders Angerbjörn, who also collected predator faeces, we will continue our work, aiming for a joint paper on predator diets and the role of predators in seed dispersal.

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Bodil Elmhagen walks through a thicket of alder during surveys at site 3. Even denser thickets of pine made work difficult at site 1. In the northern sites 3-4, pine thickets were replaced by the alder ones.
Photo: Swedish Polar Research Secretariat.

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Det händer att stora rovdjur som varg och lo dödar mellanstora rovdjur som rödräv, medan rödräv i sin tur kan döda den ännu mindre fjällräven. Risken att dödas eller skadas kan leda till att de mindre rovdjuren undviker att vistas i samma områden som sina större konkurrenter. Sammantaget kan det innebära att minskande stammar av ett större rovdjur medför ökande stammar av ett mindre. Under 1900-talet har rödräven spridit sig längre norrut i Ryssland och Nordamerika, något som föreslagits bero på det allt varmare klimatet samt minskade stammar av varg och lo. I Skandinavien har rödräven samtidigt blivit vanligare på kalfjället där den utgör ett hot mot den redan utrotningshotade fjällräven. Syftet med det här projektet var att undersöka relationen mellan rödräv och fjällräv i Chukotka, ett område med ett jämförelsevis intakt rovdjursamhälle. Vi planerade att jämföra tätheterna av fjällräv och rödräv i olika områden samt att undersöka vilken föda och habitat de respektive arterna föredrog. Till fots sökte vi systematiskt genom landskapet efter rävlyor och spår som spillning på tuvor, kullar och höjder där rävar ofta revirmarkerar. Tyvärr var tillgången på smågnagare, rävarnas viktigaste bytesdjur, låg och därmed även rävtätheten. Å andra sidan var det mycket gott om brunbjörn och vi utvidgade därför dietstudien till att omfatta även björn. Vi planerar nu att i samarbete med ett par andra projekt göra en gemensam studie om rovdjursdiet och rovdjurens roll som fröspridare i ett arktiskt ekosystem.

Project members

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Collecting for the Swedish Museum of Natural History

The main objective of our participation in Beringia 2005 was to secure from the biological research carried out during the expedition suitable voucher specimens to be incorporated into the scientific collections of the Department of Vertebrate Zoology at the Swedish Museum of Natural History. We had a particular interest in collecting fish and birds. The activities of other participating research groups also resulted in material that was advantageous to preserve in the museum collections for future studies. Samples will also be used as a complement to, and for comparative and systematic studies with, earlier Swedish museum holdings from the same arctic region collected by the Vega Expedition in 1878–1880, by Sten Bergman's Kamchatka expedition in 1920–1922 and by the Swedish-Russian Tundra Ecology expedition in 1994.

Material and Methods

During the expedition Peter Mortensen participated in a field group and was responsible for their Base Camp. Others in that group included Dr. Natalja Abramson, St. Petersburg and the guide Slava Nonivanov, Anadyr. Collections and preparations were undertaken in and around the Base Camps D, C and B. In addition, one day collecting was undertaken just east of Anadyr.

Fishing was by means of gill nets and rods. Large fish were individually marked, photos taken and a piece of muscle tissue was preserved in 95% ethanol. Thereafter the fish was fixed in 10% formalin. For small fish, representative whole fishes were saved in 95% ethanol and the rest were fixed in 10% formalin. Voucher material will eventually be saved in 75% ethanol.

Bird collecting was by means of mist nets and shotgun. Preserved birds were first photographed and a tissue sample was preserved in 95% ethanol. Voucher specimens were then prepared as skins or skeletons, alternatively fixed in 10% formalin later to be preserved in 75% ethanol. For some individuals only a blood sample was taken after photographing.

Since all the material was held up in St. Petersburg, the list of collected specimens is exclusively based on field notes and photographs.

Results

Unfortunately no results can be presented since, due to errors in logistics, some of the samples are still held up in St. Petersburg as we write (February 2006).

Peter Mortensen preparing the skeleton of a Harlequin Duck, *Histrionicus histrionicus*, shot by the field guide in the morning. Photo: Fredrik Dalerum.

Collection sites

Date	Site	Locality	Latitude	Longitude
22–29 July	D	Nigshekveem River	63°35'07"N	176°52'46"E
30 July		Anadyr Bay	64°33'16"N	177°25'23"E
1–8 Aug	C	Tanioren River	66°09'17"N	175°45'44"E
9–15 Aug	B	Kamtjalan River	66°16'30"N	178°09'25"E

Buff-bellied Pipit, *Anthus rubescens*.
Photo: Peter Mortensen.

Species list Beringia 2005, Anadyr, Chukotka

Bird species	Site B	Site C	Site D	Anadyr	Tissue	Skin	Skeleton	Ethanol
Anas crecca	3	-	-	-	3	-	-	-
Anthus rubescens	1	-	-	-	1	1	-	-
Calidris alpina	-	-	-	3	3	2	1	-
Carduelis flammea	-	-	2	-	2	1	-	1
Carduelis hornemanni	-	-	2	-	2	-	1	1
Carpodacus erythrinus	-	-	1	-	1	1	-	-
Emberiza pallasi	-	-	1	-	1	1	-	-
Emberiza pusilla	3	1	3	-	7	2	2	-
Emberiza rustica	-	1	-	-	1	-	1	-
Histrionicus histrionicus	1	-	-	-	1	-	1	-
Lagopus lagopus	4	-	-	-	4	-	2	-
Larus argentatus	-	-	1	-	1	1	1	-
Luscinia calliope	-	2	1	-	3	1	2	-
Luscinia svecica	-	-	1	-	1	-	1	-
Motacilla alba	-	1	-	-	1	-	1	-
Motacilla tschutschensis	2	4	-	-	6	3	3	-
Phylloscopus borealis	-	9	7	-	16	4	3	7
Phylloscopus fuscatus	-	-	3	-	3	-	-	2
Phylloscopus trochilus	-	2	2	-	4	-	-	2
Pinicola enucleator	-	-	5	-	5	2	3	-
Stercorarius parasiticus	-	1	-	-	1	1	-	-
Tringa glareola	-	1	-	-	1	1	-	-
Turdus naumanni	1	-	5	-	6	1	4	-
Xenus cinereus	-	1	-	-	1	1	1	-
	15	23	34	3	75	23	27	13

Broad white fish, *Coregonus nasus*.
Photo: Peter Mortensen.

Fish species	Site B	Site C	Site D	Tissue	Ethanol
Coregonus nasus	-	2	-	2	1
Coregonus pidschian	-	-	1	1	1
Prosopium cylindraceum	-	1	-	1	1
Esox lucius	-	1	1	2	-
Oncorhynchus gorbuscha	-	-	5	5	1
Oncorhynchus keta	-	-	4	4	1
Thymallus arcticus	6	3	4	13	4
Cottus sp.	-	1	11	12	-
Phoxinus sp.	-	-	5	5	-
Oncorhynchus sp. juv.	-	5	6	11	-
Pisces indet juv.	2	>10	>40	0	>50
	8	>23	>77	>56	>59

Syftet med Naturhistoriska riksmuseets deltagande i expeditionen Beringia 2005 var att utöka de samlingar som tidigare finns från samma geografiska område på avdelningen för ryggradsdjur vid Naturhistoriska riksmuseet. De mer betydande samlingarna kommer från Otto Nordenskjölds Vega-expedition 1878–1880, Sten Bergmans Kamtjatka-expedition 1920–1922 och Svensk-ryska tundraekologiexpeditionen 1994. Huvudintresset var att samla referensmaterial från fågel och fisk. Andra projekt i Beringia 2005 har också bidragit med material som har införlivats i riksmuseets samlingar, främst smågnagare. Allt insamlat material preparerades direkt i fält efter fotografering och DNA-provtagning, antingen som skinn, skelett eller våtpreparat. I dagsläget är inga studier möjliga, eftersom delar av materialet fortfarande kvarhålls i St. Petersburg.

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Food web composition and responses to UV radiation in arctic freshwater ecosystems

The environmental conditions for freshwater organisms in the Arctic regions are harsh, with short ice-free periods and low nutrient availabilities in the water column, as well as low temperatures and high ultraviolet (UV) radiation that reaches deep into the often clear waters (Fig. 1). These situations call for specific adaptations, for example the conspicuous red pigmentation for UV protection among herbivorous zooplankton (Hairston 1979, Hansson 2000). Most adaptations in nature are constitutive, i.e. the animal or plant is born with the adaptation and carries it throughout its lifetime. Other adaptations, however, can be turned on or off depending on whether there is use for them or not. Such adaptations are called ”plastic” or ”induced” and represent a way to reduce the cost of having the adaptation. During the Beringia 2005 expedition I specifically addressed the plastic response in pigmentation by some zooplankton in response to threats from UV radiation.

In a variable and unpredictable environment, phenotypic plasticity in morphology or behaviour may considerably improve an organism's protection against environmental threats, and thereby its fitness. Among copepods, a common zooplankter in Arctic waters, pigmentation may vary from pale white to bright red (Fig. 2). The red pigment, astaxanthin (a carotenoid of the same type that can be bought in health food stores!), reduces damage caused by UV radiation but also makes the organism more conspicuous, thereby exposing it to higher predation pressure from e.g. fish. Hence the level of pigmentation in copepods may be an inducible and adjustable defence governed by the aim to improve individual protection against prevailing threats from both predation and UV radiation (Hansson 2004). A large scale implication of such inducible defences is that these organisms may become dominant compared to competitors and predators in the future, when UV radiation, especially in Arctic clearwater lakes, may increase considerably.

Figure 1
A typical clearwater, shallow Arctic lake suffering from very high UV radiation. Photo: L-A. Hansson.

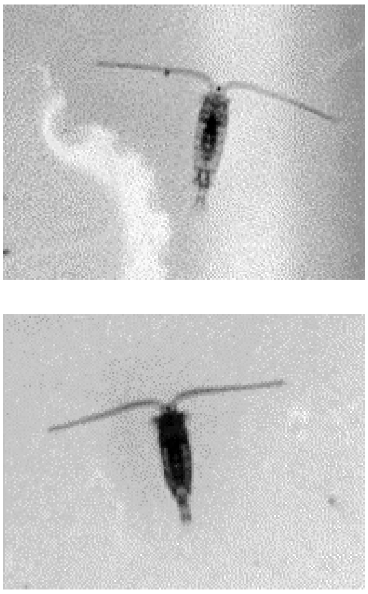

Figure 2
The plasticity in copepod zooplankter (size about 1 mm) showing a white individual that has not been exposed for UV for about a week, and an individual from the same population that has suffered from high UV radiation. Photo: L-A. Hansson.

The aim of my project was to assess the level of pigmentation among zooplankton in Beringian lakes and compare with the levels found in temperate regions. Another aim was to experimentally test the hypothesis that zooplankton can adjust their level of pigmentation in relation to UV radiation. My third aim was to perform monitoring sampling of Beringian lakes in order to add data to an international database on Arctic lakes.

Methods

In the field I took samples for zooplankton pigment analysis as well as for determination of community composition, including organisms varying in size from viruses to zooplankton with traditional methods (Hansson 2000, Bertilsson et al. 2003). The animals were frozen on board the icebreaker Oden for later analysis of pigments according to earlier tested methods (Hansson 2000, Hansson 2004). In total I sampled 17 lakes, of which some were very low productive meltwater lakes and some highly productive eutrophic lakes (Fig. 3). In lake 10 and lake 11 at Kolyuchinskaya Bay, Siberia (67°04.107'N, 173°23.200'W) live zooplankton were also sampled for the experiment performed onboard Oden. In this experiment I used aquaria with different types of plexiglass lids either letting all radiation, including UV, through, or allowing only visible light to enter the water in the aquaria. UV lamps were put above the aquaria, and in this way I created one environment that was free from UV and one where the zooplankton were exposed to about the same UV environment as in their natural environment (472 ◂W cm^{-2}). The experiment was performed in one of Oden's laboratory containers and was allowed to run for 9 days. During the cruise through Beringia the natural levels of UV-A radiation were measured on the deck of Oden 4 to 6 times a day for 10 days.

Results

The mean UV-A radiation in the Beringian area was 535 ◂W cm^{-2}, which corresponds well to the experimental intensity (472 ◂W cm^{-2}). At the time of writing this report, the pigment analyses of the zooplankton are not yet finished, but the behavioural response to UV in one of the zooplankton groups *(Daphnia)* was recorded in the experiment and found to be very strong. Hence in the treatment with ambient UV radiation the *Daphnia* showed no response in behaviour when the plexiglass lid was removed. However in the treatment where the animals, which originated from the same population, were released from UV radiation during the experiment, 98% of the individuals immediately swam towards the bottom of the aquaria upon removal of the protective plexiglass (Fig. 4). This means that those *Daphnia* which were used

Figure 3
The author processing water samples on the tundra near Barrow, Alaska. Photo: Jorge Ramos.

to UV continued to feed in the upper parts of the aquaria, whereas those that had been protected from UV during about a week had lost their ability to protect themselves, e.g. by photoprotective pigments. Hence besides pigmentation, some zooplankton may also have behavioural responses to protect themselves from dangerous radiation.

The other part of my studies, monitoring Arctic freshwater systems for the international database previously included data from the whole Arctic hemisphere, except Siberia. The successful work during the Beringia 2005 expedition now allows us to include these very important data in the database and to make them available for future scientific studies. Hence the data gathered during the Beringia 2005 expedition considerably improved our international knowledge of freshwater biology. In a broader context Arctic freshwater lakes are ecosystems we know very little about, but which can be predicted to respond strongly to large scale changes in e.g. climate, including both global warming and the increase in UV radiation due to atmospheric ozone depletion.

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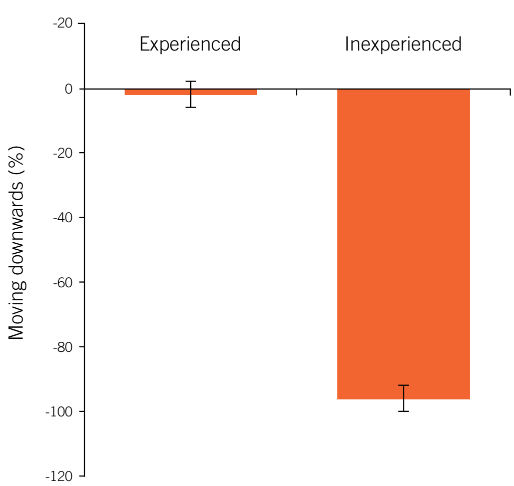

Figure 4
The portion (%) of the zooplankton genera Daphnia leaving the upper 5 centimetres of water when the aquaria lids were removed, i.e. the animals were exposed to the UV lamps. The left bar shows animals that were "used to" UV whereas the right bar shows a strong escape behaviour among Daphnia that had been protected from UV during a week.

Under expeditionen Beringia 2005 arbetade jag med att försöka förstå hur bl.a. kräftdjur klarar att skydda sig från ultraviolett strålning (UV) i de ofta grunda och mycket klara sjöarna i Arktis. Om de utsätts för UV-strålning har djuren förmåga att dels skydda sig med olika typer av pigment, alternativt att gömma sig undan den farliga strålningen genom att simma nedåt. Jag tog prover i sjöar i Sibirien och Alaska för att få en uppfattning om vilka, och hur stora mängder, pigment olika kräftdjur har i sin naturliga miljö. Dessutom genomförde jag ett experiment ombord på isbrytaren Oden där kräftdjur från samma sjö skyddades, respektive utsattes för UV. Parallellt med de specifika studierna på kräftdjurs pigmentering tog jag vattenprover, med en standardiserad metodik, som kommer att ingå i en internationell databas kring arktiska sjöars funktion. Databasen är tänkt att utnyttjas dels för grundforskning, dels för forskning kring miljöeffekter på sjöar i Arktis vid en eventuell global temperaturhöjning och uttunning av ozonskiktet.

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Biogeographical pattern of diversity, distribution and regulation of arctic willows and insects

Background and aim

Not only has Beringia provided a land bridge connecting Alaska and Siberia, but it was also a glacial refugium during the last glaciation. Beringia is therefore central for our understanding of present day arctic ecosystems. However, since this event the ecosystems on each side of the Bering Strait have diverged, and the Beringia 2005 expedition provides an unique opportunity to compare the genetic, taxonomic and functional diversity in ecosystems on both sides of the strait.

Our knowledge regarding the distribution, diversity and regulation of willows and insects in the Arctic is generally very limited. To understand ecosystem function in the Arctic we need more basic knowledge on factors influencing the distribution and regulation of populations in the Arctic. The aim of this project is to compare the diversity, distribution and trophic interactions in willow–insect-parasite systems on both sides of the Bering Strait and along a latitudinal gradient.

Willows are dominant plants in the Arctic and one of the few deciduous wood plants that occur up to the High Arctic (Danks 1981, Hjältén et al. 2003). Because of this they are a very important host for many herbivores in the Arctic (Danks 1986). Many willows have a circumpolar distribution and may differ in plant characteristics in different parts of the distribution range (e.g. Nearctic, a zoogeographical region comprising Greenland and North America, and Palaearctic, a zoogeographical region comprising Eurasia north of the Himalayas, North Africa and the temperate part of the Arabian Peninsula) (Argus et al. 1999, Skvortsov 1999). These differences are likely to have led to local adaptations in some insect herbivores, since host-associated evolutionary changes can be very specific and occur rapidly in some species, such as sawflies *(Hymentoptera tenthredinidae)* (Nyman 2000). Galling sawflies are very suitable for studying plant-herbivore–parasite interactions due to a high degree of specialisation and host specificity (Zinojev 1998, Roininen et al. 2005) and because it is very simple to determine growth and survival of larvae inside the galls and levels of parasitism by dissection of the galls.

Experience from the expedition Tundra Northwest 1999 (TNW99) suggests that galling sawflies are essentially absent, or at least very rare, in the High Arctic (above 70°N) in the Nearctic, despite the fact that their main host willows occurred up to the High Arctic (Hjältén et al. 2003). There are indications that sawflies occur further north in the Palaearctic (Roininen et al. 2002). The Beringia 2005 expedition gave an excellent opportunity to study biogeographical patterns in the distribution and regulation

Figure 1
The arctic Woolly bear *Gynaephora rossii* feeding on a willow leaf.
Photo: Joakim Hjältén.

of sawflies in a latitudinal gradient on both sides of the Bering Strait and from Japan (data sampled earlier) to the Chukotka Peninsula and Alaska.

Another important arctic herbivore is the woolly bears, *Gynaephora groenlandica* and *G. rossii*, which belong to the *Lymantriidae* family and are real arctic specialists. The developmental time of the larva is long, up to 14 years, and they seem to be able to survive bad summers almost without eating and with very little weight loss (Danks 1983, 1986). They sometimes reach extremely high densities, up to 26.4/m or 264 000/ha (Danell et al. 1999), making them the completely dominant insect herbivores in some habitats. However, our knowledge of their food preferences is limited. They are generally regarded as polyphagous (Danks 1981) but their food preferences have rarely been examined (however see MacLean and Jensen 1985).

The importance of parasitoids/predators for regulation of insect populations in the Arctic has been poorly investigated. It has been hypothesized that sawflies are mainly regulated by bottom up effects (Price et al. 1994, 1996). However, recent studies from the Palaearctic indicate that parasitoids are important mortality factors in populations of galling sawflies (Roininen et al. 2002). The Beringia 2005 expedition provided a unique opportunity to address questions regarding the regulation of sawfly populations in the Palaearctic and Nearctic.

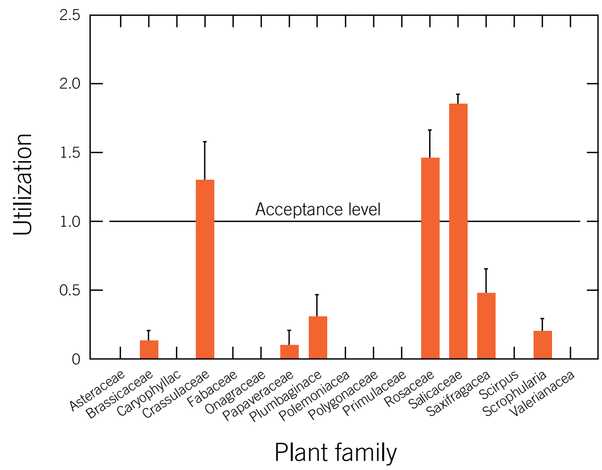
Preliminary results and discussion

1. The distribution and diversity of willows, insects and parasitoids

To determine the biogeographical patterns in the distribution of willows and gallers, we identified the willow species present, determined their abundance and the densities of sawflies on each field site (for methods see Roininen et al. 2002, Hjältén et al. 2003). We were able to collect data from nine sites, three in Alaska (Denali Highway and Barrow (two sites)) and six in Russia (Novoye Chaplino, Penkigney Bay, Yanrakinot, Lavrentia, Toygunen and Wrangel Island). Willows were found at all these sites and we collected material for analyses of DNA and chemistry from eleven willow species *(Salix chamissonis, S. reticulata, S. polaris, S. arctica, S. fuscescens, S. ovalifolia, S. lanata, S. glauca, S. rotundifolia, S. phlebophylla, S. hastata)*. Galling sawflies were found on all sites except Wrangel Island (but earlier observations suggest that gallers are present there). This suggests that both willows and their associated gallers are widely, albeit in the case of gallers (in our experience) unevenly and patchily distributed in Beringia. Parasites on galling sawflies were also present at all sites where the sawflies were found, seemingly more common and diverse at lower latitudes. However these data have not yet been analysed. Nevertheless it is likely that these unique data will provide further insight in species distribution and associations of willows, galling sawflies and their parasitoids in Beringia.

2. Host plant use of the arctic woolly bears, *Gynaephora rossii*

We collected information regarding the host plant use of *Gynaephora rossii* in the field. In addition we collected 400 individuals and did no-choice feeding experiments using 27 different plant species collected in the field. We identified three responses of the larvae: No feeding=0, tasting=1 (few bites consumed) and full acceptance=2 (most or all of the leaves consumed). The highest density of woolly bears was found on Wrangel Island and we therefore used that population in the experiment. We used 27 plant species belonging to 17 plant families in the test and presented leaves from each plant species to 10 woolly bear larvae. The results showed that the woolly bears were less generalistic than expected. They only fully accepted 8 plant species (a majority – 5 species – being willows) as food, and these came from 3 plant families *(Salicaceae, Rosaceae, Crassulaceae)* (Fig. 1).



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Woolly bear preference for plants species belonging to different plant families. Three responses of the larvae were recorded: No feeding=0, tasting=1 (few bites consumed) and full acceptance=2 (most or all of the leave consumed). This means that only three plant families (those with mean consumption values over one) can be regarded as important food plants for woolly bears.

This suggests that the arctic woolly bear probably utilizes less plant species than earlier expected. However, more detailed analyses of e.g. plant chemistry and performance of woolly bears on different plant species is needed to find the proximate reason for this host acceptance pattern.

3. Regulation of arctic sawfly populations in the Palaearctic and Nearctic

To determine regulatory/mortality factors and the diversity of parasites and predators, 100–600 galls were collected on around 25–100 randomly selected individuals per species (sample size depends on the size of the willows and the density of the gallers). The galls were opened and the survival rate and relative importance of different mortality factors, e.g. plant induced mortality and mortality due to different types of parasites and inquilines were determined (for methods see Roininen et al. 2002, Hjältén et al. 2005 manuscript). We collected and dissected 4 000–5 000 galls during the expedition to determine mortality factors and parasitism on the sawfly larva. We identified 12 different mortality factors for the larvae, 3 being related to plant responses and the rest due to parasites. The preliminary results show that the degree of parasitism is very high – around 80–90% in several of these galler populations – suggesting that parasites could play a central role in the regulation of these sawfly populations. The diversity of parasites was also high, but due to limited knowledge on these groups of insects in the Arctic we have not yet determined how many parasitoid species were utilizing sawfly gallers. However future analyses of these data will give more information on the role of parasitoids existing in populations of arctic galling sawflies.

4. Genetic diversity and chemotaxonomy and plant–animal interactions

To determine the biogeographical patterns in plant genetic and chemical diversity, we randomly selected 10 willow individuals per species on each site. However, for this purpose we specifically use species with a circumpolar distribution (distributed on both sides of the Bering Strait), *e.g. Salix polaris, S. arctica, S. phlebophylla, S. pulchra* and *S. reticulata* (Porsild and Cody 1980, Skvortsov 1999). From each individual we collected leaf and stem material for DNA analyses, analyses of plant chemistry and morphology. We will soon start conducting the molecular and chemical analyses on the 11 willow species collected during the expedition. This material, together with data collected from the Swedish-Russian Tundra Ecology expedition 1994 and the TNW 99 expedition, provides a unique opportunity to study the genetic and chemotaxonomic divergence between willow communities on both sides of the Bering Strait.

Conclusions

Despite changes in the route and logistic problems during the expedition, it provided an excellent opportunity to study ecological and evolutionary questions. Our results so far show that both willows and galling sawflies are widely distributed in the Beringian tundra biome. It also shows that the parasitic community utilizing galling sawflies is highly diverse and probably plays an important role in the regulation of sawfly communities. We also found that the arctic woolly bear probably utilizes less plant species than earlier assumed.

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Målsättningen med vårt projekt under Beringia 2005 var att studera diversitet, utbredning och samspel mellan viden, insekter och deras parasiter. Viden (Familjen Salicaceae) är den dominerade gruppen vedartade växter i Arktis, och därför också betydelsefull för många växtätare och de rovdjur och parasiter som är associerade med dem. Vi fann viden (totalt 11 arter) på alla de nio lokaler som besöktes under Beringia 2005. På alla lokaler utom en, Wrangels ö, utnyttjades videna av gallbildande växtsteklar. En mycket hög procent (80–90 % i vissa populationer) av växtstekellarverna bar parasiter. Preliminära resultat antyder att diversiteten bland parasiterna är hög men pga. bristande kunskap om taxonomin hos denna grupp av insekter i Arktis kan vi inte idag säga hur många arter som utnyttjade växtsteklarna. Våra resultat antyder dock att parasiter/parasitoider har en stark påverkan på dödligheten hos växtsteklarna och att de kan reglera deras täthet. En annan betydelsefull växtätare och arktisk specialist som studerades under expeditionen var *Gynaephora rossii*, tillhörande familjen tofsspinnare (Lymantriidae). Denna art kan ha ett larvstadium på upp till 14 år och lokalt vara mycket talrik. Vi undersökte larvernas preferens för 27 olika växtarter och fann att bara 8 arter tillhörande 3 växtfamiljer accepterades som föda. Detta visar på att arterna kan ha ett snävare födoval än man tidigare antagit.

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Plant–microbe interactions in Kamchatka

Plants are always in contact with a huge number of microbes, above and below the soil surface. Some of these microbes are beneficial, others are harmful, while the vast majority are not known to have either positive or negative effects on plants. My work in Kamchatka focused on two plant-microbe interactions that are beneficial for the plant: biological nitrogen fixation and endophytic fungi with anti-herbivore activity in grasses.

I. Biological N_2 fixation in different ecosystems

Nitrogen (N) is the plant nutrient needed in the largest amounts and N is often a limiting factor for plant growth and biomass production. This is because plants can use only a very few N compounds: ammonium (NH_4^+), nitrate (NO_3^-) and to some extent amino acids. These plant-available N sources occur only in very low concentrations in soil. However there is another possibility for some plants to obtain a useful source of N, and that is via symbiotic N_2 fixation.

Biological N_2 fixation means that N_2 in air is reduced to ammonia with the aid of a specific enzyme, nitrogenase. Only a small number of bacteria can form nitrogenase and thus fix N_2. A few genera of N_2-fixing bacteria can infect the roots of certain plants. The plant responds by forming a special structure, root nodules, where the bacteria live at a high population density and where they perform the N_2 fixation process. Most of the nearly 20,000 species of legumes can form root nodule symbioses with bacteria collectively called rhizobia. Similarly, bacteria of the genus *Frankia* initiate root nodule symbioses with so called actinorhizal plants, which comprise some 200 woody species distributed among eight plant families. Well-known examples in northern areas are the genera *Alnus, Myrica* and *Hippophaë*. For simplicity, plants having symbiosis with N_2-fixing root nodule bacteria are called N_2-fixing plants.

In the root nodules the ammonia produced by the bacteria is immediately used by the host plant. Neighbouring plants and plants occurring at later stages in a plant succession also benefit from N_2 fixation. Nitrogen originating from the fixation is delivered to the soil when dead leaves, shoots and roots are broken down in the soil. Another route is via urine and faeces when N_2-fixing plants are eaten by herbivores. Thus biological N_2 fixation is a biological N fertilization.

Aim of the work in Kamchatka

N_2 fixation has been studied mainly in species that are used in agriculture. In Scandinavia the perennial clovers *(Trifolium*

A clone of *Alnus fruticosa* on a mountain slope, Karaginsky Island.
Photo: Kerstin Huss-Danell.

spp.) and lucerne *(Medicago sativa)*, and annuals such as pea *(Pisum sativum)*, faba bean *(Vicia faba)* and vetch *(Vicia sativum)* are the most commonly used. Clovers and lucerne are characterized by a very high reliance on N_2 fixation; they often obtain more than three quarters of their N from N_2 fixation. It is not known if this is a characteristic resulting from a long period of domestication or if it is an inherent characteristic of these legume species. However surprisingly little is known about N_2 fixation in wild legumes in northern areas – do they have a similar high reliance on N_2 fixation for their needs? The question is of interest for our basic knowledge but it is also of interest to learn about wild legumes that may, in the future, become domesticated or incorporated into various agricultural systems. Learning about N_2-fixing plants in Kamchatka gives a unique opportunity to gain information about legumes that are not present in Sweden but are growing under more or less similar climatic conditions. The aim of my work in Kamchatka was therefore to collect as much information as possible about N_2-fixing plants growing in a variety of ecosystems. Data from the genera and species collected in Kamchatka will later be compared with corresponding data from Scandinavia.

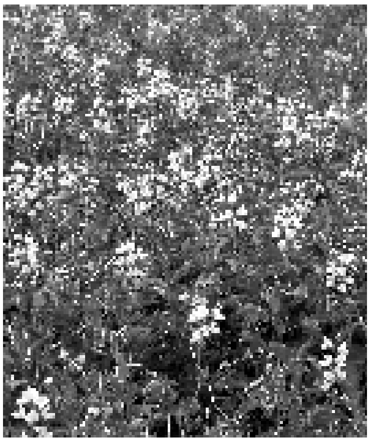
Sites

My fieldwork was done at the four main sites described in Danell et al. (page 121–124) and during brief visits to the coast of the Sea of Okhotsk, southwest of Ust'-Bolsheretsk, and to the west coast of Karaginsky Island.

Field observations and collected material

Root nodules were present in all examined plants of all legume genera, namely *Hedysarum, Lathyrus, Oxytropis, Thermopsis* and *Trifolium*. The red-pigmented interior of the nodules indicates N_2-fixing ability. *Alnus fruticosa, A. hirsuta* and *Myrica tomentosum* also had root nodules.

Lathyrus japonicus was colonizing the outermost part of the sandy shore on Karaginsky Island. *Thermopsis fabacea*, with a pronounced southwestern distribution in Kamchatka, seemed to be a strong colonizer on bare ground and an invader into coastal heaths at Sea of Okhotsk. The species both had runners and a rich seed production. Members of the genera *Hedysarum* and *Oxytropis* were studied at the sites Ichinskaya Sopka Volcano, Karaginsky Island and Vilyuchinskaya Sopka Volcano. Both genera were represented on meadow terraces close to small creeks and rivers, but *Oxytropis* was also common on heaths at higher elevation. The



Stand of *Thermopsis fabacea*, coastal heath near the Sea of Okhotsk. Photo: Kerstin Huss-Danell.

clovers *Trifolium pratense* and *T. repens* were cultivated or seemed to have escaped from cultivation. They were observed in agricultural fields, on road-sides, along paths and in villages, but were not observed in areas without agriculture or settlements.

There are several methods to quantify N_2 fixation, but in field studies in remote areas and when the fieldwork is restricted to only single short stays at each site, the only possibility is to use the so called ^{15}N natural abundance method. To apply this method I have collected samples of N_2-fixing species of *Hedysarum*, *Lathyrus*, *Oxytropis*, *Thermopsis*, *Alnus* and *Myrica*, as well as samples from a number of non-N_2-fixing herbs to serve as reference species. Chemical analyses will comprise N and other nutrients, while mass spectrometry is needed to determine $^{15}N/^{14}N$ isotope ratio. An estimate of N_2-fixation, expressed as the proportion of plant N derived from air, can then be calculated from isotope ratios in N_2-fixing species and reference species.

Different legume genera are infected by different rhizobia. This host specificity will be studied in the laboratory in those species from which I could collect seeds. If a "new" legume is to be cultivated, in an agricultural system or in soil restoration, it is essential to know which rhizobia are needed for a successful root nodule formation.

II. Endophytic fungi with anti-herbivore activity in grasses.

(In collaboration with Dr. Dawn Bazely, York University, Toronto, Canada)

Fungi of the genus *Neotyphodium* live internally, as endophytes, in the above-ground plant parts of many grasses. The fungi produce alkaloids that are toxic to herbivores – insects as well as mammals. This toxicity causes illness and even death in grazing cattle and leads to great economic losses in USA and New Zealand. The presence of *Neotyphodium* is well-known in species of *Festuca*, *Lolium* and some other grasses in warmer areas. In contrast, there is only limited information about the presence of *Neotyphodium* in Sweden and other northern areas. The endophyte can be revealed by tedious microscopy or by immunological methods. Fortunately, it has recently been demonstrated that immunological methods can also be applied to dried grass samples. This opened a unique opportunity to study the presence of endophytes in grasses in Kamchatka. I have collected and dried samples from sites with cattle grazing and horse grazing, as well as sites where no recent grazing could be observed. Results from Kamchatka and from planned collections from Scandinavia and, preferably, northern North America, will extend our understanding of this type of plant–microbe interactions considerably.

Växter är alltid i nära kontakt med olika mikroorganismer. Två växt–mikrob-interaktioner som är positiva för växten studerades på Kamtjatka under expeditionen Beringia 2005. Baljväxter och några vedartade växter såsom al och pors bildar rotknölar med kvävefixerande bakterier. Tack vare bakterierna försörjs växten med kväve, och successivt kommer detta kväve också andra växter i ekosystemet tillgodo. Information om kvävefixering hos vilda baljväxter i nordliga områden är ytterst knapphändiga. Alla baljväxter, alar och pors som undersöktes i Kamtjatka hade rotknölar. Växtprover har insamlats för kemiska analyser, inklusive olika kväveisotoper, för att kunna beräkna kvävefixeringen. Resultaten från Kamtjatka kommer att jämföras med motsvarande information från planerade studier i andra nordliga områden. Kunskap om nordliga kvävefixerande växter är betydelsefullt då sådana växter kan användas i markrestaurering och vissa former av framtida jordbruk.

Vissa, så kallade endofytiska, svampar lever inuti gräs. Dessa svampar bildar alkaloider och därmed blir gräsen giftiga för betande djur, såväl insekter som däggdjur. Giftigheten är av stor ekonomisk betydelse i varmare områden med betande boskap. Förekomsten av sådana svampar i gräs från nordliga områden är i det närmaste okänd. Gräs av olika arter har insamlats från lokaler med bete och från lokaler där bete ej kunde påvisas. Förekomst av endofytiska svampar i de insamlade och torkade gräsen studeras med en immunologisk metod.

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Herbivory and plant biodiversity in an arctic environment

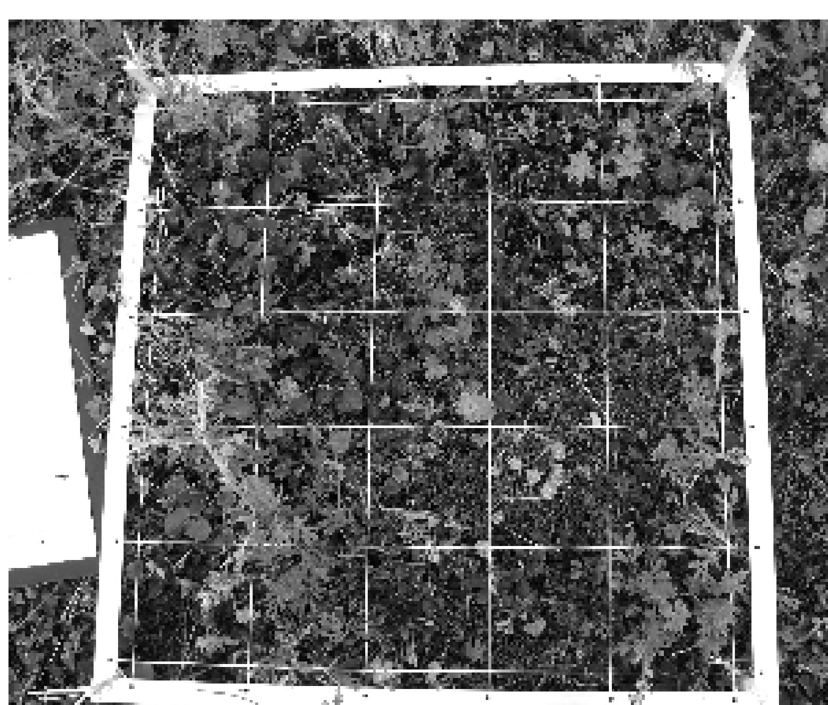
In an arctic environment, abiotic factors such as a short growing season, low temperatures, low nutrient availability and high wind velocity often have a dominating influence on plant distributions. Anyhow, biotic interactions may still play an important role in shaping plant diversity patterns. Such biotic interactions include both plant–plant interactions, i.e. competition and facilitation, and plant–animal interactions, i.e. herbivory and pollination.

Herbivory can alter plant trait distributions and population dynamics, interspecific relationships (Mulder 1999, Zimov et al. 1995) and the productivity of the community (Manseau et al. 1996, McKendrick et al. 1980) through several mechanisms, e.g. defoliation, trampling, seed dispersal, seed predation and changes in nutrient availability.

The consequences of grazing at the level of the individual plant could be the death of the plant (including seed predation), or changes in resource or biomass allocation, photosynthetic rates, reproduction and plant morphology (Archer and Tieszen 1980, Brown and Allen 1989). Several plant traits have been suggested to correlate to the ability of the plant to tolerate or resist damage. These traits include secondary substances, morphological structures (thorns, bristles, hairs, etc.), growth form and phenology. The adaptive value of these traits, and hence the abundance of species possessing them, is expected to increase with the intensity of grazing.

We thus predict that patterns of species diversity and trait distributions will vary with grazing regime and productivity gradient. In this regard it is particularly interesting that the historical and recent grazing regimes both differ considerably between the regions we visited during the expedition Beringia 2005. Historically Kamchatka has had small populations of large grazers apart from reindeers. Presently densities of reindeers are very low, and bears and

Figure 1
Plant abundance was recorded in five frames per site during the expedition. Photo: Johan Ehrlén.



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Left - Figure 2
Wet tundra near Atkasuk, Alaska.
Photo: Åsa Lindgren.

Right - Figure 3
Alpine tundra near Esso, Kamchatka.
Photo: Johan Ehrlén.

rodents are probably the most important grazers. The investigated areas consist of two different types of tundra: wet lowland tundra (Fig. 2) and a more alpine tundra type (Fig. 3). The alpine sites in Chukotka were characterized by high densities of reindeer and small mammals like hares and rodents. Wrangel Island has very high densities of muskoxen, reindeer and geese, while the alpine Alaskan sites had moderate densities of muskoxen, rein-deers and smaller mammals. The wet sites all had very low densities of larger herbivores and rodents were the dominating grazers in this tundra type in both Chukotka and Alaska.

In the field during the expedition we recorded plant community responses in terms of species diversity, abundance and the distribution of plant traits from 4 sites in Kamchatka, 4 sites in Chukotka, Wrangel Island and 4 sites in Alaska. The presence of all vascular species, mosses and lichens were recorded in five 0.5 m 0.5 m plots at each site (Fig. 1). Abundance was estimated as the frequency of occurrence in 25 10 cm 10 cm quadrates per plot. Plant biomass was sampled from each plot in order to estimate productivity. The current grazing regime was recorded at the different study sites by a system of triangle transects (1 km 1 km 1 km), where the vegetation type was noted and all animal traces (i.e. faeces, grazing, trampling, and presence) were recorded.

For all species of herbs recorded in plots we measured total height and height of flower in the field and recorded the amount of non-vertebrate grazing in 10 individuals. We also sampled 10 individuals per species that were dried and brought to the laboratory for measurement of additional traits, including specific leaf area, growth form, height, seed characteristics, allocation to reproductive/vegetative tissues and secondary substances.

Below we present some first results in terms of species diversity patterns among sites. Ultimately our aim is to link biomass (productivity) and current grazing intensity to plant species diversity and trait distributions.

A brief overview of our results gives us a composition of the different plant functional groups in the sites (Fig. 4). There are large variations in species diversity patterns but no clear differences between regions.

The wet tundra generally has lower total numbers of species, especially of vascular plants, than does the more alpine tundra (Fig. 5). The biomass from vascular plants sampled in the plots also indicates a higher productivity of vascular plants in the alpine tundra areas (Fig. 6). The low number (especially of herb species) and biomass of vascular plants in the wet tundra sites are probably not only due to the microclimate but also to difficulties to recruit in a dense moss layer, as was often the case in the wet tundra. The alpine tundra sites often consisted of southern slopes where the microclimate is optimal, and this might be especially important for non-evergreen species like herbs and grasses.

The data from the herbivory transects are yet to be analysed, but our first impression from the field is that herbivore densities are higher at the alpine tundra sites than in the wet tundra sites.

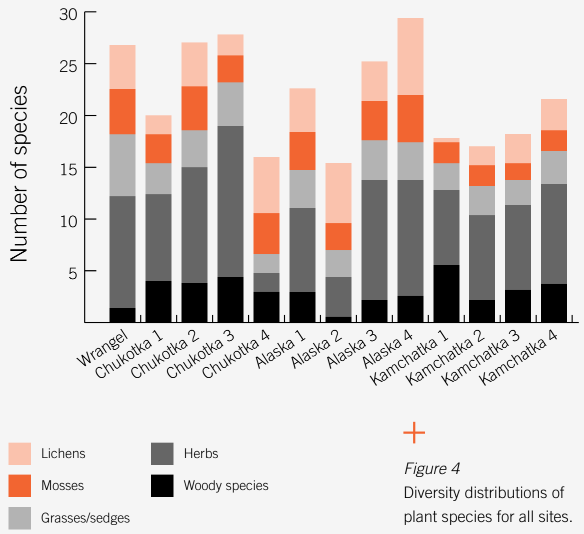

Figure 4
Diversity distributions of plant species for all sites.

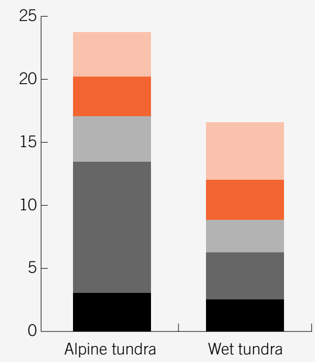

Figure 5
Plant species diversity differed between the two different types of tundra; alpine tundra and wet tundra.

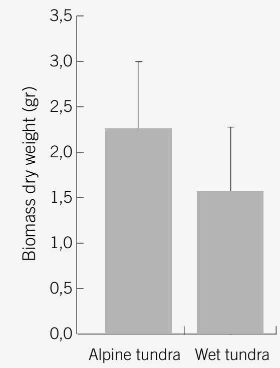

Figure 6
Vascular plant biomass in the two different tundra types.

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I karga klimat, t.ex. arktiska och alpina miljöer, är det ofta icke-biologiska faktorer som strukturerar växternas utbredning, men trots detta kan biologiska interaktioner vara mycket viktiga. I denna studie har vi fokuserat på hur växters egenskaper och utbredning påverkas av interaktioner med växtätande djur samt av produktivitet. De olika lokalerna som besöktes under expeditionen skiljer sig åt ifråga om historisk och nuvarande betesregim, och vårt mål är att koppla ihop betesregim och produktivitet (biomassa av kärlväxter) med artdiversitet, abundans och egenskaper hos växter. Mycket data kvarstår att analysera, men en snabb överblick visar att områden med fuktigare tundra innehar såväl färre arter som lägre biomassa av kärlväxter än mer alpina tundraområden.

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Getting fat in Alaska – how migratory shorebirds prepare for trans-global flights

The aim

The Arctic summer offers huge and highly productive areas for reproducing shorebirds. However, the summers are short and the breeding areas are far away from suitable wintering grounds at temperate and tropical latitudes. The birds are therefore forced to make long, rapid and demanding flights each year back and forth from the Arctic. The aim of our project was to investigate how the birds in the Arctic prepare for such long migrations and to find out which routes they take.

The Bering Strait region is at the crossroads of multitudes of migratory flyways of tundra-breeding shorebirds, from the Taymyr Peninsula in the west to central Canada in the east. There is probably no place in the world where so many exciting migratory phenomena co-occur in a relatively small region. We focussed our work on two shorebird species: the Sharp-tailed Sandpiper *Calidris acuminata* and the Bar-tailed Godwit *Limosa lapponica baueri*. Preliminary work had indicated that both species might have an extraordinary migration ecology.

The Bar-tailed Godwits breed on the tundra in western Alaska. In late summer they congregate on the rich mudflats along the Alaskan shorelines (Gill and Handel 1990), where they put on large amounts of fat fuel. Circumstantial evidence strongly suggests that in September the birds make an 11,000 km long non-stop trans-oceanic flight down to the wintering grounds in New Zealand (Piersma and Gill 1998, Gill et al. 2005). We aimed at studying the birds' preparation for the long jump, by sampling the food abundance on the coastal mudflats and by making behavioural observations of the birds. By putting radio transmitters on birds we planned to follow in detail both the departure from Alaska and the arrival in New Zealand, to seek direct evidence for the trans-oceanic flights.

Juvenile Sharp-tailed Sandpipers (also known as "Sharpies") arrive in Alaska in early September from breeding grounds in northeast Russia. They stay in Alaska for about a month to put on fuel for further migration towards wintering grounds in Australia. In contrast adult birds almost never migrate to Alaska, but rather fly a more direct route due south to Australia. Why do the juveniles make this long detour over Alaska? What do they eat and how much fuel do they put on? Do they also go for long trans-oceanic flights (as do the godwits)?

Other shorebird species were also studied, either for comparison with the godwits and Sharpies, or to be included in comparative analysis of genetic variation in arctic shorebirds.

The fieldwork

Important preparatory fieldwork in Alaska started as early as June. The main work was carried out between 20 August and 26 September 2005 in two areas of southwest Alaska: the Yukon Delta National Wildlife Refuge (YDNWR) and Egegik Bay on the Alaska Peninsula (Fig. 1). Field operations did not terminate completely until late October. The project was not represented on the icebreaker Oden.

Most of the work in the YDNWR took place at the Tutakoke River Field Camp, a tent camp situated on the coast about 500 m from the shoreline. In periods of severe tidal flooding (see below) we also worked at the Kanaryarmiut Field Station about 25 km eastnortheast of Tutakoke. One person also stayed for two weeks at Tern Mountain, an observation camp about 100 km south of Tutakoke. At Egegik, a known staging site for Bar-tailed Godwits, the scientists stayed in a small wooden hut close to a tidal lagoon, and most work was carried out in the immediate surroundings.

All transports of people and supply within the YDNWR were carried out using either float-planes or small boats with outboard engines. The float-planes belong to the US Fish and Wildlife Service (USFWS), the governmental body responsible for the management of the refuge, and therefore also our main collaborator in the YDNWR.

A large number of methods and techniques were used in the field. A major sampling scheme was launched to investigate the food base for the godwits (mud samples). The potential food for Sharp-tailed Sandpipers was collected more opportunistically, based on cues from feeding birds. Hundreds of hours were also spent looking for marked birds and collecting detailed data on feeding behaviour.

Birds were trapped in various kinds of nets and traps. Trapped birds were weighed, measured and ringed with plastic colour rings to enable recognition in the field. We also collected blood and small pieces of feather on some birds for various types of analyses. A number of Bar-tailed Godwits and Sharpies were supplied with radio-transmitters and their movements were followed locally, using hand-held receivers, automatic tracking stations and aerial surveys. A few godwits were also supplied with transmitters to be tracked by satellite. A large amount of work analysing blood and feathers for DNA and stable isotopes still remains to be completed in the lab.

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Figure 1
Map showing our Alaskan study sites.

Preliminary results

Bar-tailed Godwits

Birds of this species are among the most difficult birds in the world to trap. Despite bringing together an experienced team from literally all over the world, a combination of bad luck and extremely bad weather throughout the whole study period resulted in no birds being caught during the post-breeding period. This was a major disappointment for us all. Having trapping difficulties in mind, however, we had already marked five birds with satellite transmitters during the breeding season. In line with our bad luck in the field, all five transmitters stopped working before the birds had left Alaska. A small light in the darkness was that one of the five birds was later seen in New Zealand, proving that the birds can make the flight carrying this kind of transmitter. We will try again! Four more birds were supplied with conventional radio transmitters during the breeding season, allowing tracking while still within Alaska. Whether any of these later were picked up in New Zealand remains to be seen.

The other parts of the godwit work went very well. Thousands of mud samples were collected on the tidal shores both in the YDNWR and at Egegik (see p. 8). The preliminary view is that the Alaskan tidal flats have among the highest densities of evertebrates recorded in this kind of habitat anywhere in the world. About 30 godwits colour-ringed by colleagues in New Zealand

Figure 2
The heaviest juvenile Sharp-tailed Sandpiper ever recorded in Alaska, trapped on 26 September. This bird had most likely more than doubled its mass by putting on fat.
Photo: Åke Lindström.

and Australia were identified through telescopes, shedding new information about the migration patterns of the birds. Observations of feeding birds, combined with information from food sampling, revealed that juvenile (birds born the same year) and adult godwits were spatially segregated both on a large and small scale. Certain areas – such as the ones around Tutakoke and at Egegik – were primarily used by young birds, while the Tern Mountain mudflats held large concentrations of adults. At a local scale, young birds often fed in sub-optimal areas and then with low intake rates. Adults chose the best areas and accordingly had the highest feeding rates. This inability of juveniles may explain why it takes juveniles more time (about a month longer) to fatten up prior to the long flight and why survival is low during the godwits' first year of life. The foraging studies also revealed that prey choice differed between study sites, in a seemingly opportunistic pattern, with the most available prey being preferred.

Sharp-tailed Sandpipers

Juvenile Sharpies started to appear in good numbers around 1 September. They are much easier to trap than godwits, and 228 birds were trapped from 1–26 September. From the birds in the hand we got information about size and body mass. Birds will be sexed molecularly (from sampled blood) which will allow us to draw detailed conclusions about sex-specific patterns of behaviour. Overall, the birds roughly doubled their body mass over the study period, with a fuelling rate that was ten times higher in the second compared to the first half of September (Fig. 2).

To follow the birds' local movements we supplied 30 birds with radio transmitters. All survey data together indicated that the Sharpies were relatively site-faithful, with the majority of birds staying for a prolonged period of time until early October, when the major exodus apparently started. It seems clear from our preliminary data and observations in the field that varying parts of the diet of the Sharpies consist of seeds and invertebrates. The fact that seeds make up a considerable part of a shorebird's diet during migratory fattening is very unusual. We strongly believe that the seeds play an important role in the explanation as to why the juvenile Sharpies make this long detour via Alaska during their first autumn migration, but this remains to be properly evaluated.

Smoke, storm, rain and floods

The weather in southwest Alaska during our stay in August–September was straight out bad by almost any standards. Smoke from extensive forest fires in August covered the tundra for weeks. A more or less continuous row of lows brought strong wind and rain to an extent that we did not think was possible. Sunny calm days were simply in very short supply. This of course complicated our research efforts and was one reason why the godwit catching failed. Suitable days for mistnetting, the only possible trapping method for godwits, were very few. Two flooding events in August and early September also forced us to evacuate the Tutakoke camp for a few days each time.

As if the Arctic wanted to set an example, our stay ended somewhat prematurely because of a severe storm in late September. It coincided with the month's highest tides, which resulted in the sea rising to a level of 1.5 m above the coastal tundra, covering hundreds of km^2 of land. The accompanying waves swept our whole coastal camp away (and all the gear inside). Luckily we had then already evacuated the people and the most precious samples to higher grounds at Kanaryarmiut Field Station where we could ride out the storm in safety (Fig. 3).

Despite being smoked, rained at, blown away and flooded out, our Alaskan experience was great. We look upon our field season as being overall very successful.

Acknowledgements

We are most grateful to Mike Rearden and his personnel at the USFWS in Bethel for their superb logistic and moral support during the expedition. Additional support was kindly provided by the US Geological Survey, Alaska Science Center, Anchorage. Several people helped in the field, including Sarah Jamieson, Jesse Conklin, Patrick Lemons, Lee Tibbitts, Nils Warnock, Alexandra Hoffmann, Dan Ruthrauff, Marnie Shepherd, David Melville, Dick Veitch and Adrian Riegen. The co-operation regarding radio tracking with Phil Battley and Martin Wikelski is warmly acknowledged. Additional financial support was also given by The Dutch Science Foundation (NWO-NAP), Stiftelsen Ymer-80 and Kungl. Fysiografiska Sällskapet in Lund.

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Figure 3
During the storm surge in late September, the sea flooded hundreds of km² of tundra. This picture is taken at our escape camp, Kanaryarmiut Field Station, situated around 25 km from the coast.
Photo: Åke Lindström.

Att bli fet i Alaska – hur flyttande vadarfåglar förbereder sig inför långflygningar

Den arktiska sommarens långa dagar och rika tillgång på föda erbjuder fantastiska häckningsmöjligheter för stora mängder vadarfåglar. Men sommaren är kort och vintern hård och framåt sensommaren är fåglarnas tidtabell pressad. Vi studerade i huvudsak myrspov och spetsstjärtad snäppa, två arter av vadare som på hösten använder Alaskas rika tidvattenstränder och kustområden som språngbräda inför höstflyttningen söderut. Båda arterna övervintrar i Australien och Nya Zeeland. Vi har all anledning att tro att båda ger sig iväg på så långa non-stop-flygningar som kanske 1 000 mil över Stilla havet.

Fältarbetet utfördes i Yukon Delta National Wildlife Refuge i Alaska under augusti och september. Vi fångade fåglar för ringmärkning samt vägde, mätte och tog prover. På en del fåglar satte vi radiosändare, och vi lade mycket tid på att undersöka deras beteende och födovanor. Vi fann att tidvattensstränderna är bland de rikaste i världen när det gäller små blötdjur, och att myrspovarna var mycket duktiga på att finna de bästa platserna i området. Årsungarna av myrspov var dock sämre än de äldre fåglarna på detta. De spetsstjärtade snäpporna stannade upp till en månad inom ganska små områden och åt både små blötdjur och frön. Under denna tid var det många fåglar som mer än dubblade sin vikt genom fettpålagring.

Infectious agents in bird populations in the Beringia area

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Jorge Hernandez in the lab on icebreaker Oden. Photo: Jonas Bonnedahl.

The outbreak of influenza in Asia – along with the recent emergence of other high-profile zoonotic diseases such as West Nile virus and severe acute respiratory syndrome (SARS) – have highlighted the importance of understanding the interactions among humans, domestic animals and wildlife in the maintenance and transmission of disease. It also illustrates the need for collaboration among wildlife, agricultural and human health researchers. The participants in this project were ornithologists and also had specialisations, in medical and biological sciences, which gave the project a unique cross-disciplinary character.

The scientific focus and logistical framework for our part of the Beringia 2005 expedition were to collect faecal samples from shorebirds, ducks, geese and gulls to check for the presence of microorganisms like antibiotic resistant bacteria, *Campylobacter* spp., *Helicobacter* spp., *Salmonella* spp., *Chlamydiophila* and Avian Influenza Virus (AIV). During the last year the ongoing AIV H5N1 epizootic in Southeast Asia has expanded its host range and changed its epidemiology and epizootology. Recent reports show that H5N1 virus now infects wild sedentary and, more alarmingly, migratory birds. This is of major concern, both from a human health perspective where H5N1 possibly could start a human flu pandemic, but also from the perspective of animal health and wildlife biodiversity. The highly pathogenic H5N1 virus may pose a great threat if it is transmitted to susceptible and threatened birds and mammals. Since all AIV uses wild waterfowl as the natural reservoir, samples from ducks, geese and shorebirds from the Beringian tundra region are important epidemiological keystones in our understanding of the ecology of AIV. The tundra region of Asia, with its abundance of migratory waterfowl, has been regarded as a one of the potential foci of origin for AIV strains that later emerge in Southeast Asia. Furthermore, in theory birds that migrate from breeding grounds in Siberia to wintering areas in Europe could mix and exchange AIV with birds that have been infected in Southeast Asia, as some birds migrate to the same breeding grounds as the European birds. Thus the samples we collected are unique and highly important in an international perspective.

We participated in the Beringia 2005 expedition from July 15th to August 20th 2005. At the first site in Lorino, 115 birds of 12 species (mainly shorebirds) were sampled after capture either by funnel traps or Japanese mist nets. After getting onboard the icebreaker Oden we made two brief stops on the Siberian side, at Kolyushin

Bay and Wrangel Island, where we sampled 95 birds of 11 species and 260 birds of 4 species respectively. During the rotation in Barrow, Alaska, 202 birds of 9 species were sampled. In total, 704 samples from 24 bird species were collected, of which Snow goose *Anser caerulescens* (222 samples), Pintail *Anas acuta* (135 samples), Western sandpiper *Calidris mauri* (83 samples) and Vega gull *Larus vegae* and Glaucous gulls *L. hyperborus* (106 samples) were the most common. Furthermore some 20 samples were collected from mammals in cooperation with Professor Anders Angerbjörn from Stockholm University. From some species which are difficult to catch – e.g. ducks and geese – samples were collected directly from the ground after flushing a roosting flock of birds. All samples for virus analyses were immediately stored in a transport medium at -70ﬂC. Unfortunately, we were not allowed to export any samples associated with AIV out of Russia. These samples were stored in a -70ﬂC freezer and lifted over by helicopter to the Russian icebreaker Academic Federov for transport to St. Petersburg where they will be analysed in collaboration with Professor Oleg Kiselev at the Influenza Institute.

As we fine tuned the logistics prior to the expedition, we worked with an unbroken cold chain and had a short transportation time from the sampling in the field to the start of the analyses in the high quality laboratory facility onboard icebreaker Oden. We could therefore obtain a high resolution in the bacterial analyses and could isolate bacteria down to the species level of *Campylobacter* spp., *Salmonella* spp. and other entheropathogenic bacteria. Even if we did not find any *Salmonella* spp., we isolated numerous specimens of *Campylobacter jejuni, Campylobacter spp*. and *Escherichia coli*, primarily from the gull samples.

We believe that this project can give new insight in the ecology of influenza virus, bird borne bacteria and antimicrobial resistance and will increase the knowledge for correct risk assessment and disease control measures.

Björn Olsen with a Grey Phalarope.
Photo: Jonas Bonnedahl.

Mer än hälften av de infektionssjukdomar som drabbar människan är zoonoser, det vill säga de finns huvudsakligen hos djur och kan via olika sätt överföras till människa. De senaste årens plötsliga uppdykande av nya infektionssjukdomar – som SARS och aggressiva influensavirus – har ökat behovet av kunskap av var dessa virus finns i naturen, och hur de kan spridas till människa. Syftet med vårt deltagande i expeditionen var att ta avföringsprover från olika vattenlevande fåglar som änder, vadare och gäss från den Sibiriska och Amerikanska sidan av Beringiaområdet. Från tre platser på den sibiriska sidan och en plats i Alaska fick vi totalt ihop prover från 704 fåglar av 24 arter. Det laboratorium vi hade tillgång till på Oden gav oss unika möjligheter att hantera de bakteriologiska proverna på ett optimalt sätt. Vi kunde därför isolera känsliga bakterier som Campylobacter och Colibakterier från flera av de provtagna fåglarna. Bakterieproverna kommer att analyseras vidare med avseende på genetiska karakteristika och antibiotikaresistensmönster.

Tyvärr fick vi av oklara orsaker inte föra ut några prover som hade koppling till influensavirus från Ryssland. I samarbete med ryska forskare kommer dessa prover istället att analyseras i St. Petersburg.

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Bird orientation at high geographic and geomagnetic latitudes

The aim

Migratory birds are able to use stellar, sunset and geomagnetic information for orientation (Able 1980, Wiltschko and Wiltschko 1995). Young migratory songbirds are thought to inherit a genetic program that enables them to find both the direction and distance necessary to reach their population-specific wintering areas (for review see Berthold 1986, cf. Rabøl 1978), while adult birds to a large extent seem to navigate to reach known sites (Perdeck 1958). At high geographic and geomagnetic latitudes, orientation by both celestial and geomagnetic cues is problematic, since the midnight sun makes star navigation impossible during much of the polar summer and the geomagnetic field lines are very steep (Skiles 1985). In addition, the declination (the angular difference between magnetic and geographic North) shows large variation between nearby sites, the position of the magnetic North Pole is gradually shifting due to secular variation and diurnal variation of the geomagnetic field parmeters can sometimes be substantial during so-called magnetic storms (Skiles 1985). How migratory birds use their compasses and navigate in these High Arctic regions is the focus of this research project. During the Beringia 2005 expedition we have studied a number of related projects on avian orientation and optical phenomena:

Project 1 – Displacement experiments with migratory wheatears, *Oenanthe oenanthe* (Leg 2A, 2B, 3)
Project 2 – Optical phenomena and animal navigation in the High Arctic (Leg 3)
Project 3 – Orientation and migration in dunlins, *Calidris alpina*, and sharp-tailed sandpipers, *Calidris acuminata* (Leg 2D)
Project 4 – Migratory orientation in adult and juvenile white-crowned sparrows, *Zonotrichia leucophrys gambelli* (Leg 2D)
Project 5 – Compass calibration in Savannah sparrows, *Passerculus sandwichensis* (Leg 2D)

The experiments and measurements were performed at different sites in High Arctic Russia and North America, including sites on ice close to the magnetic North Pole and at the geographic North Pole (Fig. 1).

The fieldwork

We used circular cages, so-called Emlen funnels (Emlen and Emlen 1966; Figs. 2 and 3) to record the migratory activity and orientation of the experimental birds. Numbers of individuals and numbers of tests are given in Table 1. These cage experiments were performed under the natural migration period of the species under study and were mainly performed outdoors, or after exposure to outdoor orientation cues indoors in a tent (Table 1). In project 1,

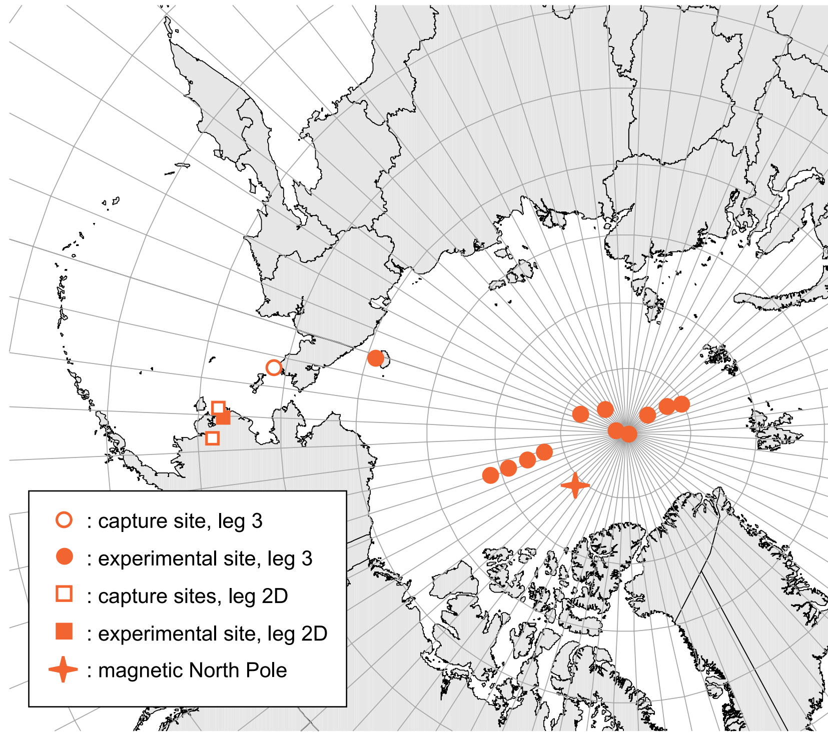

Figure 1
Map with sites where orientation cage experiments were performed with waders and songbirds. White-crowned sparrows were captured in Bethel and waders at a coastal site at Tutakoke in Alaska (open squares). At the stationary camp in Kanaryarmiut, Alaska (filled square), experiments were performed with dunlins, sharp-tailed sandpipers, Savannah and white-crowned sparrows. Experiments with wheatears captured in Provideniya, Russia (open circle) were performed at 12 sites (filled circles) from Wrangel Island and east and north across the Arctic Ocean.

where the orientation of displaced wheatears was studied on the tundra at Wrangel Island, and at locations on the ice, the birds were transported by helicopter to the study sites and exposed to the natural geomagnetic and celestial conditions for approximately 1h prior to the experiments being initiated. The birds were thereafter transported back to the icebreaker Oden, where they were kept in separate cages in an isolated container during the study period. We recorded the birds' mass (g) using a Pesola spring-balance and estimated the fat content by a 10-degree visual scale for fat classification (Pettersson and Hasselquist 1985) at capture and prior to experiments, to see how the birds prepared for migration flights by putting on fat. The birds' activity in the cages onboard the icebreaker were recorded on a computer to keep track of their diurnal activity rhythm and how that varied during the transport across time zones. We also sampled the hormones in the faeces, to look at hormone variation during the day and night and how that changed over the study period. At the beginning, middle and end of the cage experiments (leg 3, site 2 and onwards) in the field we measured the degree of polarization and the direction of the skylight polarization pattern (G. Horváth; see further below, Fig. 4).

In an opportunistic way we measured the different optical phenomena visible from the icebreaker Oden during leg 3. These polarimetric measurements were performed by Gabor Horváth with a portable full-sky (180° field of view) imagining polarimeter (fixed on a tripod with the optical axis pointed to the zenith), which could register the patterns of the radiance, degree and angle of linear polarization of the whole sky (from the zenith to the horizon) in the red (650 nm), green (550 nm) and blue (450 nm) parts of the spectrum. Evaluation of the measurements will take place in the Biooptics Laboratory in Budapest headed by Gabor Horváth. The imagining polarimetric technique is described in detail by Gál et al. (2001), and Horváth and Varjú (2003). The measurements taken onboard Oden on leg 3 covered well-known optical phenomena which have not been documented previously in the field, exemplified by halos, foggy skies above Polynyas (Fig. 5), fogbows and clear, overcast and sunlit foggy skies. Some of these optical phenomena might be important to and used by animals navigating the high Arctic, or they may simply demonstrate the physical limitations with which the animals have to cope (e.g. navigation in fog).

Preliminary results

In total we performed 1 613 orientation cage experiments with 204 individuals of three species of passerines and two species of waders during the Beringia 2005 expedition (Table 1). These birds were captured in Provideniya (64°26'N, 173°11'W) in Russia (wheatears), in Bethel (60°47.350'N, 161°46.822'W; white-crowned sparrows), Tutakoke in the Yukon Delta (61°14.793'N, 165°36.160'W; dunlins and sharp-tailed sandpipers) and at Kanaryarmiut Field Station (61°21.691'N, 165°07.706'W; Savannah sparrows) in the Yukon Delta in Alaska. The results are currently being analyzed, and they will be presented in a number of scientific papers as well as in two undergraduate projects at the Department of Animal Ecology, Lund University. In the summer and autumn of 2005 the southwest Alaska region was struck by bad weather, which had severe effects on the possibility to perform cage experiments with birds. Despite this we were able to record the migratory orientation of an impressive number of birds (Table 1). Many of these experiments showed very high and concentrated migratory activity.

Figure 2
Orientation cage experiments with displaced wheatears on the ice.
Photo: Swedish Polar Research Secretariat.

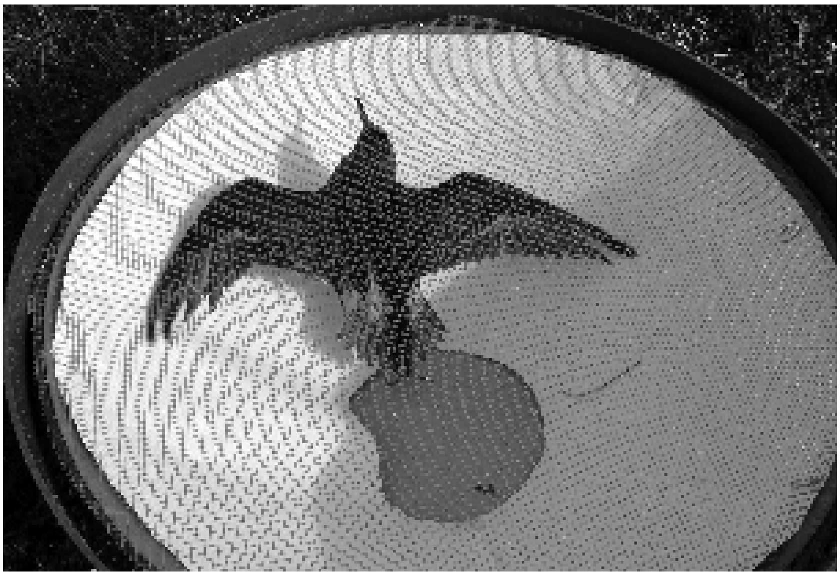

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Figure 3
Wader experiment in Alaska.
Dunlin in orientation funnel.
Photo: Johanna Grönroos.

The results will be used to answer questions related to:

- expected differences in migratory directions between different populations of birds (dunlins, and sharp-tailed sandpipers)
- expected differences in migratory directions between age groups (white-crowned sparrow), and
- whether the birds use a magnetic compass during migration or not.

Furthermore, cue-conflict experiments were performed to investigate the interrelationship and compass calibrations between sunset and magnetic compasses in the Savannah sparrow and other species (for a review on the topic, see Muheim et al. in press, Åkesson et al. 2002). The experiments performed with displaced juvenile wheatears, close to the magnetic and at the geographic North Poles (Fig. 1), will be used to evaluate the birds' ability to navigate in High Arctic regions on the basis of natural celestial skylight and steep geomagnetic field lines. Previous displacement experiments with white-crowned sparrows to nearby regions in North Canada have suggested that displaced adult and young sparrows are able to detect longitudinal displacements (Åkesson et al. 2005, Åkesson et al. 1995), and that they are also able to use their magnetic compass in steep geomagnetic fields (Åkesson et al. 2001, Sandberg et al. 1998). The wheatears' orientation will be analyzed relative to the availability of visual (sunset) orientation cues, as measured by the polarimetric method described above.

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Figure 4
Polarimeter measurements by Gabor Horváth. Photo: Susanne Åkesson.

Acknowledgements

We are grateful to the Swedish Polar Research Secretariat, Oden Crew, Kallax Flyg, FIBE AB Överkalix and Brian J. McCaffery and co-workers at the U.S. Fish & Wildlife Service, Yukon Delta National Wildlife Refuge for logistics support. This project was financed by a grant from the Swedish Research Council to S. Åkesson, covering the expenses of participation of E. I. Khlebosolov, O. Khlebosolova, R. Muheim and M. Tarka in the field.

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Species	Site	No. individuals	Total no. experiments	Exp. condition	Time period
Wheatear *(Oenathe oenanthe)*	Wrangel Island, 11 sites on ice, leg 3	17	204	Clear sky	14 Aug–21 Sept
Dunlin *(Calidris alpina)*	Kanaryarmiut, Yukon Delta, Alaska	73	252	Clear sky (83) Overcast (94) mN-90°/Overcast (24) Cue-calibration (51)	11 Aug–20 Sept
Sharp-tailed sandpiper *(Calidris acuminata)*	Kanaryarmiut, Yukon Delta, Alaska	30	117	Clear sky (30) Overcast (57) mN-90°/Overcast (30)	11 Aug–20 Sept
White-crowned sparrow *(Zonotrichia leucophrys gambelli)*	Kanaryarmiut, Yukon Delta, Alaska	32	539	Clear sky (266) Overcast (273)	13 Aug–21 Sept
Savannah sparrow *(Passerculus sandwichensis)*	Kanaryarmiut, Yukon Delta, Alaska	52	501	Simulated overcast [1)] (489) Clear sky (12)	4 Aug–21 Sept
TOTAL:		204	1613		

[1)] *The experiments were performed indoors in a tent*

Table 1
Number of orientation cage experiments performed with migratory songbird and waders under different experimental conditions, in Alaska (leg 2D), and Wrangel Island (leg 2B) and on the ice (leg 3) in the Arctic Ocean.

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Fåglar har förmågan att utnyttja stjärnor, sol och geomagnetisk information för att orientera sig under flyttning. Ungfåglar antas lita till ett medfött genetiskt program som bestämmer i vilken riktning och hur länge de skall flytta, medan gamla fåglar i huvudsak navigerar till redan kända områden. På höga geomagnetiska och geografiska breddgrader är orientering med hjälp av information från både himlakroppar och jordmagnetfält svår, eftersom midnattssolen gör stjärnnavigering omöjlig under en stor del av sommaren och jordmagnetfältet är mycket brant. Dessutom utgör den snabba förändringen i missvisning, dvs. vinkelskillnaden mellan geografisk och geomagnetisk nordriktning, mellan närliggande platser ett problem. Vi har studerat följande för att undersöka hur olika arter av flyttfåglar är anpassade till att orientera och navigera i högarktiska områden:

- hur förflyttade stenskvättor klarar av att navigera i närheten av och på den geografiska och nära den geomagnetiska Nordpolen,
- kompasskalibrering hos gulbrynad grässparv,
- skillnader i orientering mellan unga och gamla vitkronade sparvar, och
- orientering hos kärrsnäppa och spetsstjärtad snäppa på en stationär plats i Alaska.

Beringia 2005 Theme C

Geological and ecological history

The way in which the Earth's continents have moved across the face of the planet – tectonic evolution – has occasionally brought about drastic changes for all life forms. We need to understand tectonic processes in order to reconstruct our planet's environmental history, a prerequisite to make predictions of future changes in the environment. The physical history of the Arctic region is important from a geological perspective, but also for understanding climate patterns, the evolution of Arctic life forms, current plant and animal distributions and the flow of nutrients and erosion rates in the Arctic environment. On a geological time scale the Arctic Ocean of today has previously been a very different place. Fifty-five million year old samples from the bottom of the Arctic Ocean have revealed evidence of subtropical conditions with surface water temperatures of 20°C. The ocean itself started to form around 130 million years ago, when the continental plates broke up and started to drift away from each other. The aim of this theme during the Beringia 2005 expedition was to unravel geological and ecological history on many scales, from the mechanisms of large scale continental redistribution to local changes in climate and species' distributions during the last few thousand years.

The theme brought together scientists working with field methods ranging from taking sediment cores at 500–3 000 m water depth and sonar mapping of the Arctic Ocean floor to collecting rocks and plants by hand in Chukotka and digging up sediment profiles from peatlands in Kamchatka. The samples will be analysed with a variety of advanced laboratory techniques to establish sedimentation rates, ages of rock and sediment samples, geochemistry, ratios of oxygen isotopes, species composition of ancient pollen and plankton, etc. Preliminary results indicate an end to the last ice age in Kamchatka around 10,000 years ago, i.e. similar to the time it ended in northern Scandinavia. The exploration of the Arctic Ocean sea floor revealed extensive and deep glaciogenic features never previously mapped, showed pockmark fields and for the first time discovered up to 30 meter high mud waves indicating bottom currents in the deep Arctic Ocean. The rocks collected in Chukotka will be an important contribution to solving the circum-Arctic puzzle of how and when the continents opened up to form the Arctic Ocean. An important question during the joint work of icebreakers *Oden* and *Healy* near the North Pole was whether there is a "gap" in the Lomonosov Ridge, the huge submarine mountain chain which divides the Arctic Ocean. This is of great importance for deep water exchange between the Makarov and Amundsen Basins. A deep passage through the ridge was in fact demonstrated, but it turned out to be 500 m shallower than previously thought. The bathymetric maps of the Arctic Ocean must therefore now be redrawn.

The expedition also explored how evolution and distribution of species have been affected by ice ages and other climate changes in the past. Using modern genetic techniques even small fragments of tissue can be used to map an individual's evolutionary background. The setup of the Beringia 2005 expedition was well suited for projects which sampled plants and animals in order to relate geological and climatic history of the region to their phylogeny, i.e. descent. Beringian flora was sampled on the Russian side from Kamchatka in the south to Wrangel Island in the north, and in Alaska from Nome to Barrow. This was done to test Eric Hultén's proposals from 1937 on the history and evolution of the Arctic flora, in the light of new phytogeographical and molecular evidence. In a different approach zoologists compared the phylogenetic relationships between small rodents and their predators and parasites. The aim was to test the interesting idea that the degree of specialization of parasites can show how their hosts have responded to climate changes.

SWEDISH ARCTIC RESEARCH PROGRAMME

Beringia Берингия 2005

Beringia 2005

Forskarrapporter Cruise Reports

C

Geologisk och ekologisk historia
Geological and ecological history

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Evolutionary consequences of the Pleistocene glacial cycles

Scientific background

Species with sympatric geographical distributions can be expected to interact with each other in a number of ways, for example through competition, parasitism or predation. This may lead to the evolution of behavioural or morphological traits which can either facilitate or counteract these interactions. However such co-evolution also requires that the species are temporally co-distributed.

Pleistocene climatic fluctuations are acknowledged to have had a huge impact on the spatial distribution of species. Several phylogeographic studies have shown that these distributional changes have led to distinctive patterns in the species' current genetic structure (Hewitt 2000). Although it was previously thought that entire communities of species shifted their ranges in concert (e.g. Mengel 1964), recent genetic studies have suggested the opposite, namely that changes in species' distributions due to climatic fluctuations have occurred independently of each other (Taberlet et al. 1998, but see Sullivan et al. 2000). The vast majority of these studies have however been done on temperate species (e.g. Taberlet and Bouvet 1994, Santucci et al. 1998), while only a few have investigated Arctic species (e.g. Fedorov and Stenseth 2001, 2002). Thus an independent response may not necessarily be the dominant pattern in Arctic species.

One evolutionary consequence of an independent response to climatic fluctuations is that there would have been little opportunity for long-term co-evolution between species, whereas a concerted response would favour long-term co-evolution (Sullivan et al. 2000). Specialist predators and their prey could therefore possibly be predicted to have had a concerted response. On the other hand, a high degree of concerted response in arctic species would predict a higher degree of generalism in parasites, since a long-term co-distribution of potential host species would favour a high degree of interspecific transmission.

In this project we attempt to address two specific questions:

1. Which factors affect the spatial and temporal distribution of arctic species?
2. What are the evolutionary consequences of concerted vs. independent responses?

With lemmings in focus, we have several specialist predators preying on this species, e.g. the arctic fox and the snowy owl (Angerbjörn et al. 1999, Wiklund et al. 1999). On the other hand there are several other species which have more of a generalist predator response to lemmings, e.g. the red fox. The same varying relationships can be found in the relationship between ptarmigan and their predators, with especially the gyrfalcon being a specialist predator (Nyström et al. 2005). Similar relationships can also be found for lemmings and their parasites, where some are specialists, e.g. hantavirus can still switch between different rodent hosts (Vapalahti et al. 1999).

Our aim was therefore to compare the phylogenetic relationship between small rodents and their predators and parasites. However, we were also interested in the population dynamics at each site, since this can influence the presence of both predators and parasites.

Fieldwork

Our intention was to collect tissue, blood, faecal samples and intestines from several predator and prey species at a number of places throughout Beringia. Faecal samples would be used to collect DNA from the defecator. Trapping/capture of small rodents would allow sampling of both prey and parasite DNA. Samples were also to be taken from dead specimens, hair and faecal samples. Furthermore nests and dens of the concerned predators would be used to collect DNA samples from their prey. For trapping of small rodents we had two parallel setups with one systematic set of trap lines and another set of opportunistic traps. The systematic trap lines can also be used for estimates of abundance.

The fieldwork took place at 14 sites in Beringia. Four sites were visited in the Anadyr region, 5 sites in northern Chukotka including Wrangel Island and 5 sites in Alaska. The sampling was also coordinated with colleagues in Kamchatka.

Results

All together we managed to obtain a substantial set of data with more than 500 samples, including about 200 from voles (mostly *Microtus oeconomus*) and 100 from bears (faecal droppings from mostly *Ursus arctos,* but also a few from *U. maritimus*) (Table 1). For the small mammals we dissected the animals so we have frozen tissue for analyses of DNA and parasites. In some cases we will also search for bacteria and viruses.

We found fairly high densities of *Microtus oeconomus* in Chukotka (Table 2). However the density varied between habitats, as shown in Penkigney Bay at two different sites (Table 2). At Kolyushin Bay this had dropped to a very low number, indicating that there is no strong synchrony in the population phase of *Microtus oeconomus* in Chukotka. On Wrangel Island there was an early increase of lemming abundance. At one site about 20 km from the coast we trapped no animals at all, but at the coast close to the research base we found an abundance of both *Lemmus* and *Dicrostonyx,* suggesting an early increase phase of the population cycle. Here we got splendid help from a muskoxen scientist, Alexander Gzuzdev, and his dog Art. They managed to increase our sample size quite considerably. Alexander walked on the tundra and looked for fresh signs of lemmings, for example under rusty barrels. When he found some signs he called on the dog and gently lifted the barrel where the dog quickly sneaked in, took the lemming and handed it over to Alexander.

In the Anadyr area, the dominating species was *Clethrionomys rutilus* (n=32) but we also trapped one *C. rufocanus*, 2 *Sorex* sp., 5 *Microtus oeconomus* and 4 *Lemmus trimucronatus.*

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A pika, *Ochotona hyberborea.* Photo: Love Dalén.

An arctic ground squirrel, *Spermophilus paryii.* Photo: Love Dalén.

	Anadyr region	North Chukotka	Alaska	Total
PREDATORS				
Fox	36	10		46
Bear	73	25	10	108
Mustelid	2			2
Raptor	21	8	10	39
Wolf	6	3		9
Wolverine	3			3
PREY				
Lemming	4	28	35	67
Vole	51	80	65	196
Arctic ground squirrel	7	5		12
Shrew	2	4		6
Ptarmigan	9	5		14
Pika		7		7
Total	**214**	**175**	**120**	**509**

		Numbers/100 trapnights			
Site		**Trapnights**	**Microtus**	**Lemmus**	**Dicrostonyx**
Penkigney Bay	1a	105	13.5		
	1b	240	2.5		
Yanrakinot	2	305	11.8		
Lavrentia	3				
Kolyushin Bay	4	75	1.3		2.7
Wrangel Island	5	48		16.7	10.4
Barrow	6				

Left - Table 1
Number of specimens sampled for different mammal and bird groups.

Right - Table 2
Density of small rodents (number trapped per 100 trap nights) on six sites in Chukotka and Alaska.

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Arter med en sympatrisk utbredning har en gemensam evolutionär utveckling där de samverkar med konkurrenter, predatorer och parasiter. Under klimatiska fluktuationer kan man tänka sig att arter som har ett starkt samband också har utvecklats tillsammans. Här kan man tänka sig parasiter och predatorer som är specialiserade på en värd. Parasiter och predatorer som däremot har en mer generell knytning till flera arter bör istället utvecklas oberoende av sina värdarter. Vi ville testa detta på framförallt lämlar och sorkar i Beringia-området. Vi samlade in över 500 prover från en rad olika däggdjur och fåglar, framförallt från sorkar, lämlar och björnar. Från detta material skall vi extrahera DNA samt analysera förekomsten av parasiter, bakterier och virus.

Late Quaternary environmental change of Kamchatka

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Background and aims

Terrestrial vegetation at high northern latitudes is an important component of the global climate system. The changing configuration of northern biomes, particularly the position of the arctic treeline and the amount of carbon stored in frozen soils and peat deposits, is intricately linked to the heat balance of the Earth through various feedback mechanisms. Identification of the existence and timing of past episodes of climate-related vegetational change in these areas are thus of great importance in a global-change perspective.

Holocene vegetational developments in the North American Arctic and in northern Fennoscandia are relatively well known as a result of several decades of detailed palaeoecological and geochemical analyses of lake sediments and peat deposits. Fewer records have been obtained from the Russian Arctic, but it is known that considerable Holocene migration of the arctic treeline occurred, with forest extending to near the current Russian coastline between 9 000 and 7 000 years before present (BP) followed by a southward retreat to the present treeline position until ca. 3 000 BP. Based on a combination of palaeoecology and isotope palaeoclimatology, important aspects of the forcing mechanisms behind treeline advance and retreat have been clarified, and a complex interplay of direct orbital forcing and related ocean and atmosphere rearrangements is emerging as explanation.

Extreme eastern Russia is a key area in this context. However, palaeoecological data from the northeasternmost part of the Eurasian continent are scarce and are restricted to records from southern/peripheral locations. The southern peninsula of Kamchatka is probably the least studied area in the entire region. The collection of data there is important for the understanding of Holocene vegetational and climatic dynamics in the Arctic and

Coring lake sediments at Esso, central Kamchatka.
Photo: Elinor Andrén.

couplings to ocean-atmosphere rearrangements in the northern Pacific Ocean.

The project aims, therefore, to:

1. Obtain and analyse cores of lake sediment, peats and related surface samples in order to provide a dated record of Holocene (the last 10,000 years) environmental change for the Kamchatka Peninsula.
2. Investigate oxygen isotope analyses of the sediments as proxies of palaeoclimate, thus providing
   - a test for Global Circulation Model approaches to the climate of the region
   - a more immediate, regional and relevant palaeohydrological proxies as a background for other aspects of environmental change.
3. Obtain pollen and diatom analyses in order to reveal changes in vegetation and lake systems respectively. Their records will be developed independently of the oxygen isotope analyses so that the response of these systems to background climate change can be assessed.

Fieldwork

We were able to visit four field areas and obtained four long sequences of sediment from three of these: Utka, Esso, and Ossora. At Utka (53°15.44'N, 156°51.02'E), we collected a core of 5.0 m from a mire within a predominantly wooded landscape. At Esso (56°12.07'N, 158°51.49'E), we obtained a core of 3.0 m from a small lake. Near Ossora, in the far northeast of Kamchatka, we cored two lakes. The first (59°06.59'N, 163°09.15'E) yielded 7.0 m of sediment and the second (59°17.61'N, 163°07.78'E) yielded 3.0 m of sediment.

All the sediment sequences are complete and intact and have been successfully transported back to Sweden.

Results

These sites have good coverage across the range of environments on the peninsula. All the cores are rich in organic matter and well suited for the planned palaeoecological and geochemical analyses. Laboratory investigation of the sediments is planned to begin during 2006. However, we have obtained preliminary radiocarbon dates for the ages of the basal sediments of all four sequences. These are (in radiocarbon years before present) Utka: 8 165+/-80, Esso: 6 260+/-55, Ossora: 7 930+/-70 and 8 960+/-70.

These dates indicate deglaciation at around 10,000 calendar years before present (roughly as in north Sweden), and that we have complete sequences at probably all except Esso (where we were unable to penetrate a tephra layer). All sites have several tephra layers, and material from these is being characterised at the Geographical Institute in Petropavlovsk.

Additionally, we were able to observe on the ground and from helicopters (e.g. during the flight from Esso to Ossora, and Ossora to Petropavlovsk) that there are a number of other areas on the peninsula with promising lakes and mires for future study.

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Kamtjatkas historia sedan den senaste istiden är relativt välkänd ur ett vulkanologiskt perspektiv, men klimat- och miljöutvecklingen är dåligt belagd, trots dess stora betydelse i norra Stilla havs-området. Vi har påbörjat en bred och mångfacetterad undersökning av områdets paleoklimatologi och paleoekologi. Under expeditionen Beringia 2005 provtog vi borrkärnor från en torvmark vid Utka (södra delen av halvön Kamtjatka), samt sediment från små sjöar vid Esso (centrala Kamtjatka) och Ossora (nordöstra Kamtjatka). De första kol-14-dateringarna tyder på att den organiska sedimentationen i dessa områden startade för ca 10 000 år sedan, troligtvis kort efter isavsmältningen. Under de närmaste tre åren ska det provtagna materialet studeras i detalj genom

- ytterligare kol-14-datering, kompletterat med tefraanalyser för att förbättra kronologierna;
- isotopanalyser för paleoklimatiska rekonstruktioner och;
- analys av pollen och kiselalger för att klarlägga hur landvegetation och sjöekosystem har reagerat på klimatförändringar sedan isavsmältningen.

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Migration and evolution of arctic plants in response to past climate change

Beringia – a refugium for arctic and boreal biota?

The present-day arctic flora comprises approximately 1 500 species and is of relatively recent origin (Murray 1995). Throughout most of the Tertiary (65–2 Ma), forests grew at high latitudes in the Arctic (Murray 1995, McIver and Basinger 1999) and tundra did not appear until the late Pliocene (Matthews and Ovenden 1990). Initially tundra was distributed discontinuously, but a circumarctic belt was present by 3 Ma (Matthews 1979). Little is known of the origins of arctic plants, although it is supposed that many such plants are derived from ancestral stocks which occurred on high mountains from the south of Asia, as well as Europe and North America (Hultén 1937, Tolmachev 1960, Weber 1965, Hedberg 1992, Murray 1995). These mountains form part of ranges connected to the Arctic, along which plants could have migrated northwards as global temperatures dropped significantly from the mid-Miocene onwards (Lear et al. 2000, Zachos et al. 2001). In addition some arctic plants may be descended from shrubby and herbaceous elements of the Tertiary arctic forests that occupied open bog, riparian and well-drained upland habitats in the Arctic during the late Tertiary (Murray 1995). In the Quaternary (approximately 2 Ma until present), the distribution and composition of the arctic flora was greatly affected by the advance and retreat of ice sheets. Traditionally it was believed that during glacial periods all northern areas were covered by ice to a similar extent and that arctic animals and plants migrated southwards of advancing ice-sheets to survive in southern refugia (Darwin 1859, Hooker 1862). However this belief was challenged in 1937 by the Swedish botanist Eric Hultén, in his book *Outline of the History of Arctic and Boreal Biota during the Quarternary Period.* Hultén drew on geological evidence and a vast body of his own phytogeographical evidence to propose that most of Northeast Russia and Northwest America (Alaska and the Yukon) remained ice-free during Quaternary glaciations and served as a massive northern refugium for arctic and boreal biota. Hultén called this region *Beringia*. Today it is defined as the area between the River Lena (125°E long.) in northeastern Siberia to the east, the River Mackenzie (130°W long.) in northwestern America to the west, the Arctic Ocean to the north and southern Alaska and the middle Kuril Islands to the south (Abbott and Brochmann 2003).

Beringia served as a land-bridge between Eurasia and North America throughout the Tertiary until approximately 5 Ma when it was severed by the formation of the Bering Strait (Marincovich and Gladenkov 1999,

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Left - Figure 1
Dryas incisa Juz., Karaginsky Island. The species has an amphiberingian distribution with occurrences in both eastern Siberia and Alaska.
Photo: Bente Eriksen.

Right- Figure 2
Potentilla elegans Cham. and Schlechtend., Ichinskaya Volcano. The plant is mainly Asiatic but reaches Seward Peninsula in eastern Alaska.
Photo: Bente Eriksen.

2001). During the Quaternary, the land-bridge reformed during major glaciations when sea levels fell by 100–135 m (Hopkins 1973, Clark and Mix 2002). Hultén (1937) further proposed that many arctic plants obtained a circumarctic distribution early in the Quaternary period. However during each subsequent glaciation large parts of their distributions were destroyed, only to reform during interglacials through recolonization of deglaciated areas from Beringia and from southern regions. Some species would have been less successful than others at migrating back into these areas and would retain a fragmented distribution, with large gaps occurring between geographically disjunct areas.

Botanists on the Beringia 2005 expedition have sampled the Beringian flora – from Kamchatka in the south to Wrangel Island in the north on the Russian side, and from Nome to Barrow on the American side – in order to test Hultén's proposals on the history and evolution of the arctic flora in the light of new phytogeographical and molecular evidence. Among the plants specifically selected for study are *Alnus, Cassiope, Dryas* (Fig. 1)*, Empetrum, Papaver* section *Meconella, Potentilla* (Fig. 2)*, Saxifraga* section *Mesogyne, Vaccinium uliginosum* s. lat., selected species groups of the large genera *Cerastium* and *Draba* and many additional groups. Among the plants are trees as well as dwarf shrubs and herbs. One of the interesting aims of this collaborative research is to contrast the historical biogeography of different life forms.

The fieldwork

Collecting plants is a relatively uncomplicated matter in the field, but preservation of the material for the future, either as herbarium sheets or as a leaf sample for molecular analyses, requires careful processing. Elven and Solstad went to the northern sites in Chukotka and Alaska on leg 2A while Eriksen and Andersson visited Kamchatka on leg 2C. The icebreaker Oden formed a mobile platform for parts of leg 2A whereas leg 2C was based entirely on campsites. Hence the technical facilities for plant processing differed somewhat between the teams. During daily hikes on the selected sites, plants were collected and kept separate and fresh in plastic bags. At the end of the day plants were catalogued and put into plant presses for drying. Before Oden arrived, air drying was the only possibility in Chukotka, whereas on Oden the presses were placed in a drying cupboard. The Kamchatka team, lacking electricity at the base camps, used purposely designed mobile drying facilities (Fig. 3). The boxes were heated by multi-fuel kitchens and could be compacted when transported by truck or helicopter. Material for molecular analyses was picked from each voucher and quick-dried in silica gel.

Preliminary results

In Kamchatka four sites were collected: Ust'-Bolsheretsk on the southwest coast of the peninsula, Ichinskaya volcano in Central Kamchatka, Karaginsky Island off the coast in the northeast, and

Figure 3
Fieldwork in Kamchatka. Mats Andersson is handling the heaters for the plant presses. Photo: Bente Eriksen.

finally Mutnovskaya volcano south of Petropavlovsk-Kamtchatskiy in the south-east. At all sites we were able to sample plant material from some of the target species. In total 429 specimens were collected, of which 92 were preserved on silica gel for molecular analysis.

A recent paper summarizing pollen records from the Palaeoenvironmental Arctic Sciences Database into spatial-temporal patterns concludes that *Alnus*, as well as other species of trees (*Picea*, *Pinus*, *Larix*, and *Betula*), survived within the Beringian refuge during the Last Glacial Maximum (Brubaker et al. 2005). This result challenges the traditional view of Beringia as a treeless steppe. In Göteborg cpDNA micro-satellite data on material from *Alnus* will be used during the spring of 2006 to establish which of the above-mentioned hypotheses is corroborated by patterns of haplotypes. Parallel studies by quaternary geologists also participating on the Beringia 2005 expedition in Kamchatka – Bennett et al. (page 159–160) – on stratigraphic data from lake sediment cores will hopefully provide additional information on past vegetation changes to compare our data with.

In Chukotka five full sites were covered in Penkigney Bay (2 sites), Lavrentia Bay, the Kolyuchin Bay surroundings and Wrangel Island. In Alaska two site regions were covered around Barrow and in Seward Peninsula. Due to logistic problems only two sites were supported by Oden. In total 1 378 specimens were collected, of which 470 were preserved on silica gel for molecular analysis. We made a special effort to collect samples for molecular analysis in Wrangel Island as the hypothesis of the importance of this island in Beringian biogeography has been unsupported until now by molecular evidence. The material collected (both herbarium specimens and leaf samples) is already in use for numerous studies in phylogeography and systematics.

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Camp site at Karaginsky Island. The elfin forests on the mountain slopes are dominated by the conifer *Pinus pumila* Regel and the broadleaved *Alnus fruticosa* Rupr. Photo: Bente Eriksen.

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Området kring Berings sund, som var isfritt under senaste nedisningen, kallades 1937 för *Beringia* av Eric Hultén. Han lade fram en hypotes om att Beringia hade utgjort ett refugium för arktiska växter och djur under den senaste nedisningen, varifrån arterna sedan koloniserade övriga Arktis allt eftersom isen drog sig tillbaka. Med hjälp av molekylär teknik är det idag möjligt att testa om hypotesen kring den arktiska florans historia och evolution stämmer. Prover från den beringiska floran samlades in längs en geografisk gradient från Kamtjatka i söder till Wrangels ö i norr på den ryska sidan, samt i områdena kring Nome och Barrow på den amerikanska sidan av Berings sund. Totalt besöktes 11 lokaler. Antalet insamlade prover uppgår till 1 807, av vilka 562 är avsedda för molekylära studier. Bland de speciellt utvalda arter kan nämnas *Alnus*, *Cassiope*, *Dryas* (Fig. 1), *Empetrum*, *Papaver* sektion *Meconella*, *Potentilla* (Fig. 2), *Saxifraga* sektion *Mesogyne*, *Vaccinium uliginosum* s. lat., och artgrupper inom stora släkten som *Cerastium* och *Draba*. Bland dessa arter finns både dvärgbuskar och örter. Ett intressant mål för forskningssamarbetet under expeditionen Beringia 2005 är att undersöka om den historiska biogeografin skiljer sig mellan olika livsformer.

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Healy-Oden Trans-Arctic Expedition 2005 (HOTRAX '05): The geological programme

Introduction

The third leg of the Beringia 2005 research expedition consisted of a joint crossing of the central Arctic Ocean involving Swedish icebreaker Oden and U.S. Coast Guard Cutter Healy. This complete Arctic Ocean transect, also named *Healy-Oden Trans-Arctic Expedition 2005 (HOTRAX'05)*, was only the second in history made by surface vessels; the first involved the U.S. Coast Guard Cutter Polar Sea and Canadian icebreaker Louis St. Laurent in 1994. Due to the ambitious scientific agenda the two icebreakers Healy and Oden did not reach the North Pole until 12th September. This North Pole visit was later in the year than for any previous non-nuclear surface vessels. The scientific program was by-and-large divided between the two ships such that oceanography was carried out from the Oden and geology/geophysics onboard the Healy. This cruise report concerns the geological program involving 11 shipboard scientists from four countries.

Healy started the HOTRAX'05 transect on 5th August from Dutch Harbor, Alaska, and reached the first working area, the Chukchi Borderland, off the Alaskan margin, on 9th August (Fig. 1). On 20th August the third leg of Beringia 2005 with Oden commenced from Barrow, Alaska, and the oceanographic program started a transect across the Canada Basin. A rendezvous date for the two ships was agreed upon at 84°N 145°W. Subsequent to this rendezvous location on the Alpha Ridge the ships would come together and planned to depart from the North Pole in time to avoid the onset of refreeze and adverse winter conditions.

Scientific goals

The overall scientific goals for the HOTRAX'05 geological program can be summarized in five points:

1. Linking Amerasian and Eurasian marine sedimentary records to establish a pan-Arctic Quaternary stratigraphy across the entire Arctic Ocean.
2. Determine a palaeoclimate/palaeoceanography record from key areas across the Arctic Ocean, such as the Chukchi Borderland, the Mendeleyev and Alpha Ridge complex, the Lomonosov Ridge, the Gakkel Ridge and the Yermak Plateau.
3. Map glacial sea floor features along the transect to study the Arctic Ocean glacial history
4. Determine the source and extent of dirty ice in the central Arctic Ocean.
5. Map an area of the central Lomonosov Ridge – in collaboration with the oceanographers onboard the Oden – where deep-water exchange may take place between the Amundsen and Makarov basins.

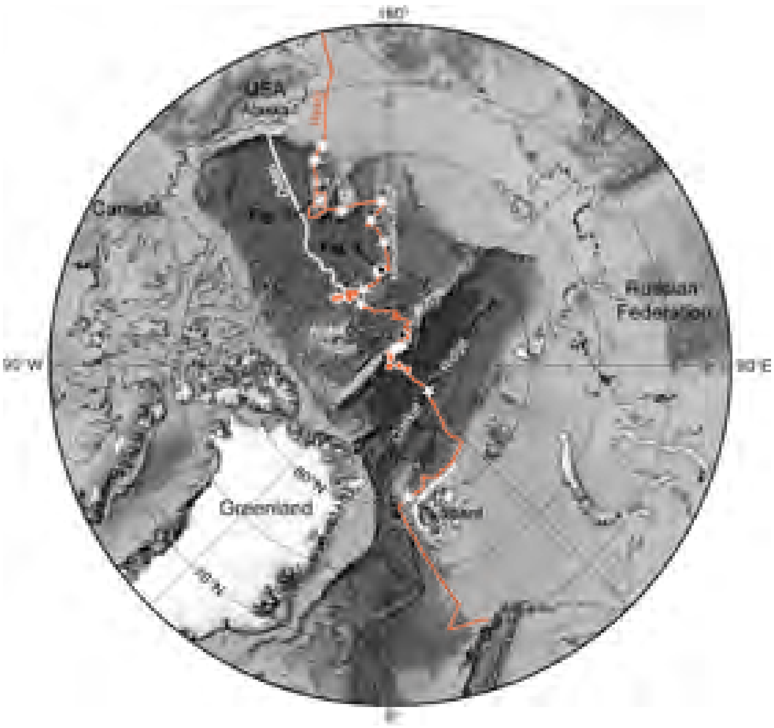

Figure 1
Map showing the two icebreakers' (Oden and Healy) transect of the Arctic Ocean. The sediment cores taken from Healy are shown as stars, CTD cast as black dots and dirty ice sampling stations as red dots.

To achieve these goals sediment cores from key locations along the transect were collected and geophysical measurements, using Healy's hull mounted chirp sonar subbottom profiler and multibeam swath bathymetric system, were carried out. The coring locations included potential high sedimentation areas, or drifts, as well as areas where earlier cores were taken and used to construct the first widely applied stratigraphic model in the central Arctic Ocean. In the Amerasian part the majority of previous cores were collected during the era of drifting ice islands and most of them are only a few meters long (e.g. Jackson et al. 1985). These cores were the basis for the development of the widely used stratigraphic model, which indicated sedimentation rates on the order of mm/ky (e.g. Clark et al. 1980). Recent studies from the Eurasian Arctic, including the results from the drilling on the Lomonosov Ridge in 2004 (Backman et al. 2005), have concluded much higher sedimentation rates on the order of cm/kyr (e.g. Jakobsson et al. 2000). The cores from the 2005 transect will be studied to develop a pan-Arctic stratigraphy in order to test these two alternative existing stratigraphic models: very slow deposition (≈ 0.1 cm/kyr) versus moderately fast accumulation (1-2 cm/kyr). First with this information established can palaeoclimate studies investigate the history of climate change archived in the central Arctic Ocean cores.

The objective of studying the Arctic Ocean glacial history is centered on the scientific question: Have immense ice shelves existed in the Arctic Ocean some time during the past glacial times? This question has emerged from the widespread presence of glacially generated features on the Arctic seafloor, for example the glacial erosion at 1 km water depth on the Lomonosov Ridge first mapped by Oden in 1996 (Jakobsson 1999, Polyak et al. 2001). Healy's chirp sonar and multibeam provided excellent tools to investigate the highs along the transect for traces of glacial activity.

Field operations and results

The sea ice conditions in the Chukchi Borderland and Mendeleyev Ridge area were light, and Healy encountered one of the most ice-free conditions for early August in this part of the Arctic ever recorded. As a consequence high-quality geophysical mapping could be performed without the large disturbances heavy ice breaking causes due to the noise it creates. However, conditions quickly changed to tougher sea ice with 9/10 cover over the Alpha Ridge and Makarov Basin. When Oden and Healy reached the Lomonosov Ridge, large open lead systems made it possible to carry out the planned multibeam mapping of the central ridge near 88°25'N where deep-water exchange has been postulated to take place. After mapping and coring the Lomonosov Ridge, ice conditions drastically changed to 10/10 cover and large patches of multiyear flows were encountered. In fact, the conditions after the North Pole were by far the hardest Healy faced during the Arctic Ocean transect, and the two icebreakers assisted each other until the pack ice margin was reached northwest of Franz Josef Land. Our goal of surveying the Langseth Ridge, an obstacle of the Gakkel Ridge presumably less than 400 m deep, could not be completed due to harsh ice conditions (Fig. 1).

Coring

The piston coring was conducted using a system designed at Woods Hole

Dennis Darby carrying out dirty ice sampling. Photo: Martin Jakobsson

Oceanographic Institute with components from both this and the Oregon State University coring equipment (see right photo p. 13). The core head weight could be adjusted, but the maximum weight of approx. 2.7 tons was used for all coring sites except for some sites during the beginning of the cruise. The maximum feasible core length that can be safely rigged on Healy is 22 m, and this requires extrusion of the core liner, largely over the ship's rail at the end of the core barrel. During the HOTRAX'05 transect a maximum of 18 m was rigged due to the cold weather – necessitating rapid removal of the PVC liner – and the stiffness of the central Arctic Ocean sediments. Subbottom chirp data were used to determine the probable stiffness of the bottom sediments and the core barrel length to be rigged.

The geological program retrieved 21 piston cores from the complete transect across the central Arctic Ocean (Fig. 1). Together with the 8 piston cores collected two months earlier in the season during Healy's first leg, also constituting a part of the HOTRAX'05 geological program, the cores averaged nearly 12 m in length. These cores provide a critically needed sample cache for both a pan-Arctic stratigraphy and a long-awaited palaeoclimate record.

A Multi Sensor Core Logger (MSCL) from Stockholm University measuring sediment physical properties (Density, magnetic susceptibility and sound velocity) was brought onboard Healy and all retrieved cores were immediately logged after retrieval. The long cores obtained along the Mendeleyev and Alpha Ridge show excellent preliminary correlations from the core logs and lithological description. A pronounced increase in sedimentation rates can be followed from the Alpha Ridge to the southern Mendeleyev Ridge where the present sea ice summer margin is approximately located. In the longer cores as many as 80 distinct cycles were described based on color changes and texture (Fig. 2). These cycles are previously described in various areas of the Arctic Ocean and have been attributed to glacial-interglacial fluctuations (e.g. Jakobsson et al. 2000). The processes behind this clearly visible sediment cyclicity are not fully understood and will be one of the main scientific targets for the post-cruise scientific work.

Multibeam mapping and chirp sonar profiling

Healy is equipped with a 12 kHz Seabeam 2112 multibeam bathymetric sonar. It has 151 acoustic beams and is capable of mapping an area underneath the ship of about 2.5–3.5 times the water depth.

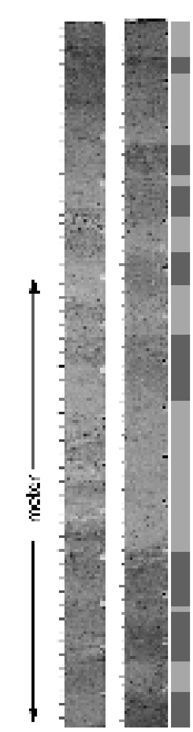

Figure 2
Two sections from core HLY0503-12JPC retrieved from the Mendeleyev Ridge (see Fig. 1). The distinct dark cycles characteristic for central Arctic Ocean sediment stratigraphy can clearly be seen. The bar shows the locations of these cycles in the right section.

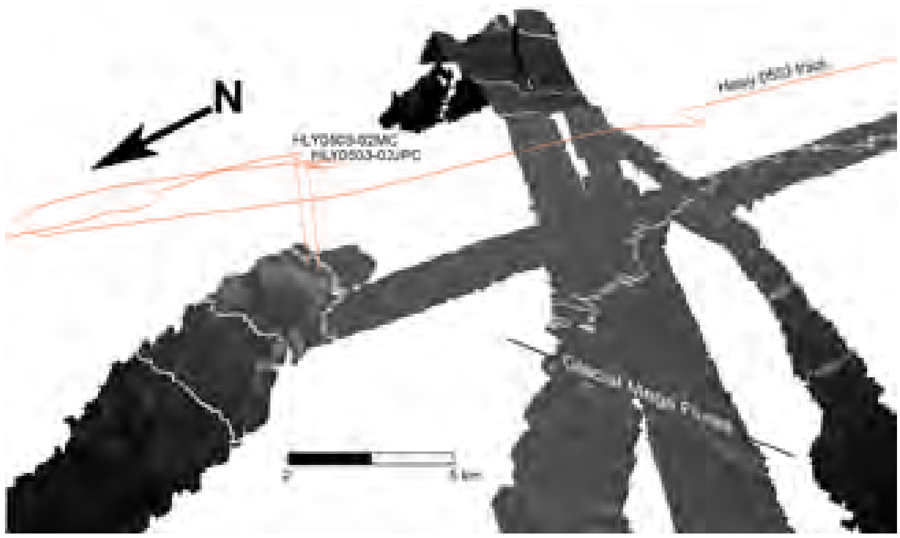

Figure 3
Multibeam data from the Northwind Ridge revealing how glacier ice has grounded on the seabed and created so called mega flutes. An approx. 10 degree offset can be seen in the directions of the mega flutes where the tracks cross each other. This is due to a temporary heading problem in the ship navigational system.

This system is analogous to using 151 echo sounders simultaneously to create a 3D image of the seafloor underneath the ship as it progresses along its track. Multibeam bathymetry was collected continuously during the nearly two month long cruise except for one day due to acquisition software problems. However the ice conditions greatly affected the quality of the acquired bathymetric data. During heavy ice breaking, noise and possibly also ice gliding underneath the hull of the ship occasionally caused complete data loss. The icebreaker also has a Knudsen 320B/R dual frequency (3.5 kHz and 12 kHz) chirp sonar subbottom profiler. Only the low frequency channel was used during the cruise since the sonar's main function was to produce subbottom information and not optimal bathymetry. About 50–100 m of subbottom penetration was commonly achieved in the Arctic Ocean sediments.

An almost complete profile along the entire Northwind Ridge was accomplished and glacial erosion was mapped with the multibeam and subbottom profiler to depths of nearly 1 000 meters, or more than 200 meters deeper than previously mapped in this area (Polyak et al. 2001). Some of these glacial features were mapped for the first time, greatly expanding the extent of grounded ice in this area (Fig. 3). Important for the Arctic Ocean glacial history was the finding of undisturbed seabed on the Mendeleyev Ridge where the shallowest mapped area was slightly deeper than 800 m. This implies that this part of the Arctic Ocean never was reached by glacier ice as thick as that over the Lomonosov Ridge or the Chukchi Borderland (e.g. Jakobsson 1999, Polyak et al. 2001).

The oceanographic measurements from the Swedish icebreaker Oden in combination with the multibeam mapping, chirp sonar profiling and coring from the Healy will help to resolve the question of the deep-water exchange between Arctic basins. The acquired data shows that the deepest passage in the Lomonosov Ridge, located on the Makarov Basin side of an intra basin in the ridge, is shallower than shown on both the International Bathymetric Chart of the Arctic Ocean (IBCAO) and the Russian bathymetric map published in 1999 by the Head Department Navigation and Oceanography (HDNO). The new maximum depth for the passage near 88°25'N in the Lomonosov Ridge is near 1 900 m instead of deeper than 2 400 m. How important this passage is for the deep water exchange remains to be resolved through a post-cruise cross-disciplinary collaboration between the scientists that were onboard the two icebreakers.

Acknowledgements
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Dennis Darby and Reidar Lövlie are handling a piston core section on the Healy icebreaker.
Photo: Martin Jakobsson.

Den tredje delen av expeditionen Beringia 2005 bestod av ett samarbete mellan den svenska isbrytaren Oden och den amerikanska isbrytaren Healy. De två fartygen korsade hela den Arktiska oceanen från Alaska till Svalbard via Nordpolen. Oden startade från Barrow i Alaska och Healy från Dutch Harbor på Aleuterna. Efter att ha arbetat oberoende av varandra under några veckor sammanstrålade isbrytarna 1 september vid 84°N för att gemensamt arbeta sig fram genom packisen under resten av expeditionen. Det geologiska/geofysiska forskningsprogrammet som beskrivs i denna rapport bedrevs från Healy där provtagning med kolvlod samt mätningar med fartygets multibeam och penetrerande ekolod utfördes. En av huvudmålsättningarna för programmet var att genom kontinuerliga provtagningar och geofysiska mätningar kunna knyta samman de miljö- och klimatarkiv som Arktiska oceanens bottensediment utgör, genom en komplett transekt från Alaska till Svalbard. Ett vetenskapligt samarbetsprojekt mellan det geologiska programmet på Healy och det oceanografiska på Oden bestod av att utforska en del av Lomonosovryggen nära Nordpolen, där det sedan länge spekulerats över att bottenvattenutbyte sker mellan de Amerasiska och Eurasiska bassängerna. Totalt togs 21 sedimentkärnor längs transekten och multibeam samt penetrerande ekolod samlades in kontinuerligt. Redan preliminära resultat visar att sedimentkärnorna går att korrelera längs transekten, dvs. ett av det geologiska projektets huvudmål. Spår från de senaste istidernas isar hittades genom multibeam-mätningar på nästan 1 000 meters vattendjup både på Northwindryggen och också på Tjuktjerplatån utanför Alaska. Ytterligare en pusselbit i den Arktiska oceanens glaciationshistoria kommer att kunna läggas.

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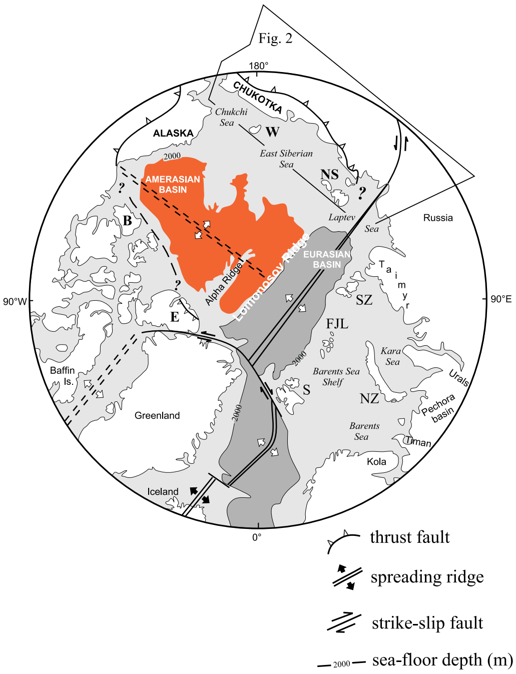
The Amerasian Basin Puzzle

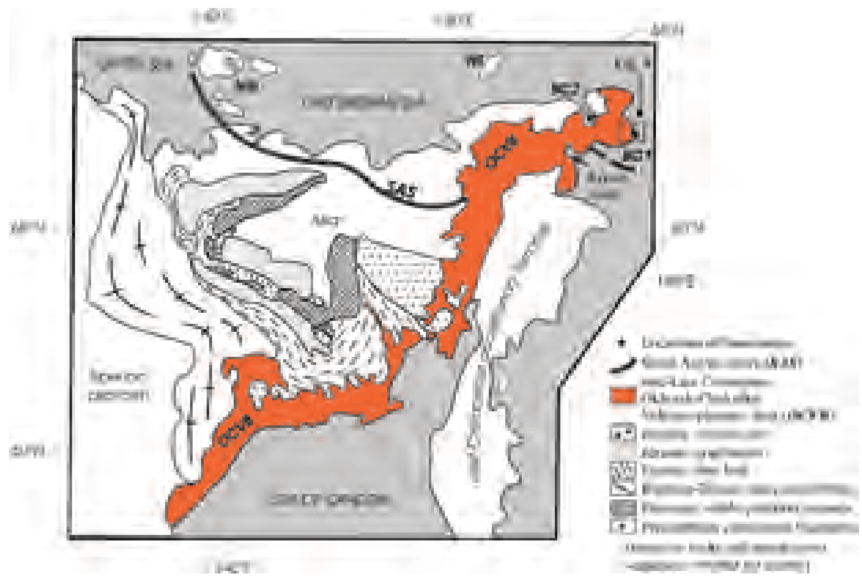
Project aims

The surface of the Earth is made of rigid plates which have been moving through time and are still in motion today. Both modern and ancient plate motions are responsible for creating the Arctic Ocean as we know it. However the 'ancient' Arctic Ocean was significantly smaller than it is today. In fact, prior to about 130 million years (Ma) ago, the Arctic Ocean did not exist!

The physical geography of the Arctic in the past (Arctic palaeogeography) is well constrained to approx. 55 Ma, based on seafloor magnetic anomalies formed during the opening of the Eurasian Basin (e.g. Jackson and Gunnarsson 1990). Our knowledge of the Arctic region, derived from magnetic anomalies associated with the opening of the Amerasian Basin at ca. 130 Ma, is poor. Prior to 130 Ma other tools than magnetic anomalies are needed for palaeogeographic reconstructions. Fortunately, tectonic processes such as collision, rifting and subsidence leave distinctive signatures in the geologic record, e.g. orogenic belts, ophiolites and oceanic basins. Using these signatures our work attempts to unravel the palaeogeographic puzzle resulting from the long and complicated tectonic evolution of the greater circum-Arctic region (see Gee 2005, Pettersson 2005, Pease 2003, Pease 2004, Gee and Pease 2000, Gee 1999). This work is also part of other international research efforts addressing the regional tectonic evolution of circum-Arctic palaeogeography: CASP (Circum-Arctic Sediment Provenance) and PLATES & GATES (Plate Tectonics and Polar Gateways).

To unravel Arctic palaeogeography we need to understand the development of the Amerasian Basin (Fig. 1). This also has important implications for global economic resources, since significant proven and potential oil reservoir rocks also occur in Arctic shelf regions, as well as for the global climate system, because cold water flowing from the Arctic and Antarctic Oceans drives global ocean circulation. During the expedition Beringia 2005 our investigations focussed on the Okhotsk-Chukotka volcano-plutonic belt (OCVB) of the Chukotka Peninsula in eastern Russia. The OCVB extends over 3 000 km across Asia (Fig. 2) and its volcanic deposits have been recognized as far away as Alaska (Bergman et al. 1995)! It was generated during the collision between oceanic and continental crust in a geologic setting similar to the modern Andean margin of South America, possibly as the result of the opening of the Amerasian Basin. Consequently this vast and largely unexplored region is important for understanding the development of the Amerasian Basin.





Left - Figure 1
Polar view of the Arctic Ocean with the Eurasian and Amerasian Basins labelled (after Jackson and Gunnarsson 1990). Chukotka, Wrangel and the New Siberian Islands are thought to have rifted from the Canadian margin during opening of the Amerasian Basin. S – Svalbard; NZ – Novaya Zemlya; FJL – Franz Josef Land; SZ – Severnaya Zemlya; NS – New Siberian Islands; W – Wrangel Island; B – Banks Island; E – Ellesmere Island. Region of Figure 2 indicated.

Right - Figure 2
Regional extent of Okhotsk-Chukotka volcano-plutonic belt (OCVB) (after Stone et al. 1992). Locations of basecamps 1 and 2 (*BC1, BC2*) shown. South Anyui suture, SAS (after Natal'in et al. 1999); NS – New Siberian Islands; W – Wrangel Island. Region of Figure 4 indicated.

Figure 3
Work Team: S. Sokolov studies marble at Novoye Chaplino; the group prepares to hike from Kolyuchin Bay (from left to right, E. Miller, M. Johnsson (SPRS), A. Gejer (SPRS), V. Pease in foreground).

Fieldseason 2005

After a flight from Stockholm via Thule (Greenland) and Fairbanks (Alaska), courtesy of a Swedish military Hercules, the expedition cleared customs in Provideniya, Russia. Our international group of experts consisted of American, Russian, and Swedish participants, as well as Swedish Polar Research Secretariat personnel (Fig. 3). We worked from two base camps, one at Novoye Chaplino and the other near Kolyuchin Bay. The expedition experienced generally fine weather at both base camps, consequently we achieved most of our scientific objectives.

On 11th July we arrived at base camp 1 in Novoye Chaplino (*BC1* on Figs. 2 and 4). Novoye Chaplino is a fishing village and staying there was luxurious: a house with electricity and hot water, plus the village boasted a general store! We worked in the surrounding region using a 4WD vehicle or an aluminium boat with a small outboard engine.

On 1st August, we relocated via helicopter to our second basecamp along the Kal'kheurerveem River, near the southern end of Kolyuchin Bay (*BC2* on Fig. 2). We spent the remainder of our field season working from this location, with plenty of time to do a thorough job. Here we experienced typical camp life with tents, sleeping bags, small gas burners for cooking, cold water baths, etc. During a few days of rain we saw the small creek next to our camp turn into an impassable torrent! We supplemented our diet with fresh mushrooms (*boletus*) and humpback salmon. Without vehicular support our work at this location required the collection of geological data and samples by hiking about 15–20 km/day. As the terrain was hilly, the hiking was strenuous.

After about 3 weeks of fieldwork, we re-joined the other Beringia 2005 participants on the Swedish icebreaker Oden. It was one of the highlights of the expedition for us, with a dramatic ship-board landing of the huge Russian MI-8 helicopter, followed by long-anticipated saunas!

Preliminary results

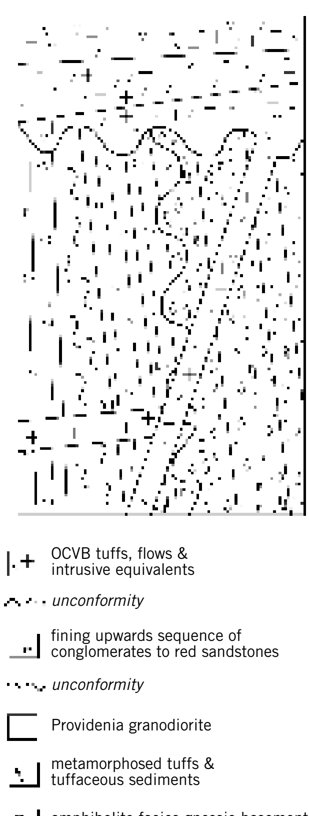
Basecamp 1. At *BC1* our research focused on exposures around Tkachen Bay and the Chaplino Peninsula (Figs. 2 and 4). Outcrop exposure is generally good, enabling us to establish *relative* age and deformation relationships (Fig. 5). A large component of our work in the coming months will be determining the *absolute* ages of these units (using radiometric dating techniques on single crystals) in order to constrain the tectonic evolution of the region. This work will be performed at Nordsim, the Nordic ion-microprobe facility in Stockholm.

At *BC1* rocks of the Okhotsk-Chukotka

Left - Figure 4
Simplified geologic map of Novoye Chaplino area superimposed on satellite image. Okhotsk-Chukotka volcano-plutonic belt (OCVB) and older basement (pre-OCVB).

Right - Figure 6
Pepperite (*BC1*). Dark, fragmented sediment scattered within a volcanic matrix (pencil for scale).

Figure 5
Schematic geologic summary of the Novoye Chaplino area, showing relative age relationships.



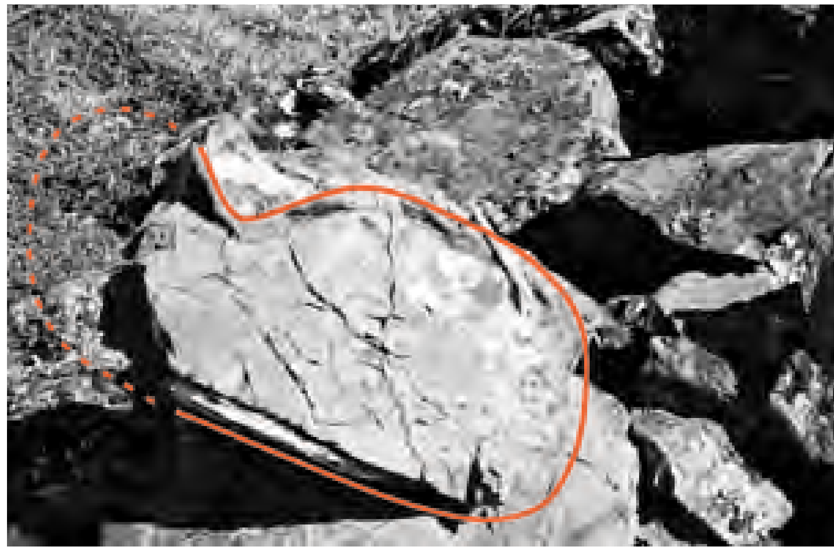
volcano-plutonic belt (OCVB) are widespread. The OCVB comprises intrusive rocks informally known as the Rumilet granites and their inferred extrusive equivalents, thick ignimbrite ash flows. New data from samples just east of our study area provide an age of about 85 Ma for Rumilet plutonism (J. Wright, unpublished data). The inferred correlative volcanic rocks in the southwestern part of the OCVB have similar ages (85–75 Ma; Hourigan and Akinin 2004), indicating that OCVB developed over a relatively short time interval. The OCVB clearly post-dates the opening of the Amerasian Basin by about 45 Ma.

Relatively flat-lying volcanic rocks of the OCVB sit unconformably on steeply dipping, metamorphosed and deformed basement (Fig. 5). This 'older' basement includes volcanic, sedimentary, and crystalline rocks of unknown age. These are intruded by plutons informally known as the Provideniya granodiorite. The volcanic rocks are composed predominantly of greenschist facies air-fall tuffs and welded tuffs, probably from a coastal setting as water-lain debris flows, isoclinal 'wet-sediment' folding, and pepperite are common within the sequence (Fig. 6). The pepperite is an important unit because it contains hematized granitic clasts at its base which can be used to determine the age of the older basement in this region. This older basement also contains both mafic and felsic igneous material metamorphosed at amphibolite facies. We do not know the time of metamorphism or tilting of these rocks, consequently determining the age of the heamatized granitic material and the crystalline basement is important for constraining the tectonic evolution of these units.

At several localities we saw magma mixing/mingling textures within Provideniya granodiorite (Fig. 7), evidence of a hybrid genesis. Provideniya granodiorite is also hornblende-bearing. Both hybrid and amphibole-bearing magmas are common features of Andean-type collision zones. New data from rocks just east of our study area indicate an age of about 120 Ma for Provideniya plutonism (J. Wright, unpublished data). It is possible that subduction-related, Andean-type magmatism generated at 120 Ma was the result of plate motion reorganization due to the opening of the Amerasian Basin at about 130 Ma. It remains to be shown whether or not this collisional setting was continuous from 120–85 Ma. Age and geochemical analyses will help to test this hypothesis.

Basecamp 2. Existing geologic maps of the region around *BC2* (Fig. 2) were contradictory, so we were not quite sure what the region had in store for us! Our research focused along the river, subsidiary drainages, and the craggy mountain tops, where exposures of fresh rock were best and it was soon apparent that the more recent (unpublished) map was correct with respect to the rocks present.

The region is characterized by a large volume of gabbro associated with minor basalt, pillow basalt (Fig. 8) and terrigenous sediment (sandstone and shale). The rocks are mapped as the Velmay Terrane (Sokolov 1992), an association of chert, basalt, and clastic sediment inferred to be about 225 Ma in age on the basis of fossils (Monotis, Holobia etc). However, we were unable to locate the cited fossil locality. South of the river, the mafic rocks and the



sediments both record a sub-horizontal foliation and kink bands. We are not yet sure of the significance of this deformation, but it may be associated with a tectonic boundary to the south. The Velmay Terrane is intruded by igneous rocks of the OCVB and is therefore older than the OCVB.

The association of gabbro and pillow-lava among clastic sediments suggests Mezosoic-age rifting, but what was rifting? We collected samples of both the mafic rocks and the OCVB in order to constrain the time of intrusion and the associated deformation here, as well as to determine the absolute age of rifting. We collected samples of sandstone from the Velmay Terrane for provenance analysis to determine what was rifting. We also collected samples of the gabbro for geochemistry in order to determine the tectonic environment in which it formed. All of this analytical work is now underway.

Concluding remarks

Our research requires patience, as we generally target a single location per year. Circum-Arctic projects cover a very large area and it takes many years to get to each important location where another piece of the puzzle can be obtained. The years 2007–2008 have been established as the International Polar Years (IPY). The IPY is designed to increase awareness of the importance of the Earth's polar regions (Arctic and Antarctic), which are significant not only for societal resources (petroleum, fishing, shipping lanes, etc.), but also for the planet's biodiversity, environmental monitoring, etc. The circum-Arctic region will continue to be a focus of our research during the IPY, when we hope to investigate the 'other side' of the Amerasian Basin in Arctic Canada.

Acknowledgments

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Left - Figure 7
Magma mingling within the Providenia granodiorite (*BC1*). Darker granodioritic material (note rounded edges) mixing with lighter granitic material (centimeter scale).

Right - Figure 8
Pillow basalt (*BC2*). Solid line approximates pillow outline (pencil for scale).

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Den arktiska palaeogeografin är av stor betydelse för såväl globala ekonomiska resurser som det globala klimatsystemet. I den arktiska regionen finns betydande påvisade och potentiella oljereservoarer samtidigt som kallvattenströmmar från de arktiska och antarktiska oceanerna driver den globala havsvattencirkulationen. Under Beringia 2005 inriktades vår geologiska forskning på ett område med yt- och djupbergarter på Tjutkerhalvön i östra Ryssland (Okhotsk-Chukotka volcano-plutonic belt – OCVB) OCVB sträcker sig 3 000 km över Asien och dess vulkaniska avlagringar har återfunnits ända borta i Alaska. OCVB bildades i samband med en kollision mellan kontinent- och oceanskorpor i en geologisk miljö som kan jämföras med dagens Anderna (Sydamerika), kanske ett resultat av öppnandet av Amerasia-bassängen. Vår forskning fokuserar på detta stora och sällan utforskade område för att öka förståelsen av utvecklingen av Amerasia-bassängen i den Arktiska oceanen.

KONST

ART

Konstnärer Artists

INTRO

Konstnärsprogrammet under Beringia 2005

Allt sedan människan började resa till polartrakterna har konstnärer varit med som deltagare i expeditioner, i begynnelsen för att arbeta med illustration och dokumentation så att det på hemmaplan kunde redovisas vad expeditionen upplevt. Polarforskningssekretariatet fortsätter denna tradition genom att bereda plats för konstnärer på svenska forskningsexpeditioner, liksom flera andra nationer också gör idag. Begreppet konstnär tolkas vidare än bildkonstnär, och under åren som sekretariatet har erbjudit konstnärplatser har dessa fyllts av personer som verkat inom de flesta av konstens domäner.

Korsbefruktning är ett viktigt ord inom Polarforskningssekretariatets konstnärsprogram; det är det som sker när forskare och konstnärer åker tillsammans på expedition, och möts och samtalar där, på helt andra villkor än de skulle göra i sin hemmiljö. Olika erfarenheter och kulturer bryts mot varandra. Måhända har korsbefruktningen betydelse för de vetenskapliga och konstnärliga projekten som pågår under expeditionen, kanske inte. Men vi vet att den påverkar alla som deltar i den.

Ibland kan inte projekt förverkligas som det var tänkt, ibland ger arbetet en annan utdelning än vad som var väntat eller exakt det man ville uppnå, och ofta inträffar något under expeditionen som leder in på nya spår, nära eller långt ifrån den ursprungliga planen.

Expeditionen Beringia 2005 hade ett omfattande forskningsprogram, men även ett stort konstnärsprogram. Ett upprop om möjlighet att ansöka om plats gjordes genom en mängd svenska konstinstitutioner och -organisationer. Det kom in 73 ansökningar, som bedömdes av en grupp med konstkunniga personer verksamma inom svenskt kulturliv. Totalt antogs nio konstnärer med sju projekt. Det som eftersöktes var en spridning mellan konstarterna, men även projekt som inte överlappade varandra till innehåll och form. Att ha en klar idé om vad man vill åstadkomma med sitt projekt är viktigt när man reser till polartrakterna – det gäller både forskare och konstnärer. Att ha en uppfattning om hur man når ut till en publik med sina erfarenheter är också av betydelse. För forskarna gäller det att publicera resultat i artiklar och fylla sin undervisning med något angeläget och intressant. För konstnärerna handlar det egentligen om samma sak, men uttrycksmedlen är annorlunda. Redovisningen av erfarenheter kanske sker i form av en utställning, en film, en konsert, en bok eller en totalupplevelse av annat slag.

De som deltog i konstnärprogrammet under Beringia 2005 var Majgull Axelsson, Bigert & Bergström (Mats Bigert ersattes av Lars Siltberg under expeditionen), Jonas Bohlin, William Brunson & Josef Doukkali, Dascha Esselius, Rose-Marie Huuva och Bea Uusma Schyffert. Här är deras berättelser om polarforskningsexpeditionen Beringia 2005.

The Artists Programme during Beringia 2005

Ever since people began travelling to the polar regions artists have been involved as members of expeditions. In the early days, their job was to illustrate and document expeditions so that the experiences could be shared with the people back home. The Swedish Polar Research Secretariat is upholding the tradition by allocating space for artists on Swedish research expeditions, as do several other nations. "The arts" is interpreted in the broad sense and is not limited to the visual arts. Over the years that the Secretariat has offered artist's places, they have been filled by people working in most artistic domains.

Cross-fertilisation is a key concept in the Swedish Polar Research Secretariat's Artists Programme. That is what happens when scientists and artists are fellow travellers on expeditions, where they meet and converse on utterly different terms than they would in their home environments. Their different worlds of experience, perception and culture contrast and intersect. Perhaps the cross-fertilisation has impact on the scientific and artistic projects carried out during the expedition, perhaps not. But we do know that the impressions on everyone involved are deep and lasting.

Sometimes projects cannot be realised as planned; sometimes the work returns dividends other than those expected or results other than those precisely intended. Quite often, things happen during the expedition that lead people down new paths, whether close to or far from the original plan. The expedition Beringia 2005 had an extensive research programme as well as an expansive artist programme. Announcements of the opportunity to apply for places were made through a number of Swedish institutions and organisations dedicated to the arts. Seventy-three applications were made, which were assessed by a committee of people knowledgeable about the arts and active in the Swedish cultural sphere. Nine artists with a total of seven projects were finally accepted. They were selected to ensure diversity of artistic disciplines and projects that did not overlap in terms of content and form.

When people travel to the polar regions, they must clearly understand what they want to accomplish with their projects – and that applies to both researchers and scientists. Knowing how to reach out to a public with their experiences is also significant. Researchers must publish their results in papers and inform their teaching with matters of importance and interest. The point is essentially the same for artists, but the means of expression differ. They may report their perceptions and experiences in the form of an exhibition, a film, a concert, a book or a consummate experience of some other kind.

The participants in the Artists Programme during Beringia 2005 were Majgull Axelsson, Bigert & Bergström (Mats Bigert was replaced by Lars Siltberg during the expedition), Jonas Bohlin, Bill Brunson & Josef Doukkali, Dascha Esselius, Rose-Marie Huuva and Bea Uusma Schyffert. Here are their stories about the polar research expedition Beringia 2005.

GULL

Majgull Axelsson
Författare
Beringia 2005, etapp 1
Göteborg–Nordvästpassagen–Barrow

Varje morgon går jag ombord igen. I samma ögonblick som jag går in i mitt arbetsrum, är jag tillbaka på Oden. Dörren ut till däck är tung, jag får hänga mig på den för att alls kunna öppna och när den väl är öppen stiger jag ut i ett moln av avgaser. Jag håller andan medan jag skyndar förbi.

Jag föredrog de disiga dagarna och därför är det de disiga dagarna jag oftast minns, de där dagarna då jag redan på morgonen klev upp på det lilla fotstödet i fören för att granska isen, och sedan blev kvar där, hängande över relingen som en unge på lekplatsen, en sådan där unge som föredrar att betrakta de andra barnens lek snarare än att själv delta. Där står jag sedan och funderar över orden och färgerna.

Det finns bara tio synonymer till ordet *blå* – inklusive indigo, kobolt och marin – och de räcker inte för att beskriva det jag ser. För att inte tala om ordet *turkos* som inte bara är ett ord som oftast associeras med prålighet och dålig smak utan som dessutom bara har en enda synonym i svenska språket. Så hur ska jag kunna beskriva det väldiga pussel i vitt och blått som vi färdas genom? Finns det alls några ord för att beskriva havet, isen och öarna? Eller de där sekunderna då jag upptäcker två små svarta fiskar i en pöl på isen, de där sekunderna innan en spricka kilar genom den vita ytan och Oden än en gång häver sig upp och tynger ner.

Jo. Det är klart att det finns. Det finns ord för allt. Å andra

AXELS

sidan kan de ibland vara lika svårfångade som polartorskar.

Så var det inte ombord på Oden. Aldrig har det varit lättare att skriva än efter en timmes ensamhet i fören. Att se isen brytas var hypnotiskt. De väldiga flaken vältrade sig ovilligt åt sidan och blottade sina lysande blå kroppar, sjönk sedan i det svarta vattnet för att sekunden senare stiga mot ytan frustande som undervattensdjur, ursinniga och hämndlystna, men ändå alldeles maktlösa. Och där någonstans började en berättelse födas, en berättelse som jag sedan kunde gå in i min hytt och börja skriva. Utanför hyttfönstret malde Odens stora kvarn vidare, men själv försvann jag in i min nya roman. *Det var en gång ett fartyg …*

Där befinner jag mig fortfarande, svartsjukt vaktande mina minnen. De är berättelsens kapital och jag tänker inte slösa bort dem. Jag har ett antal färdiga fraser som jag använder när släkt och vänner frågar om min resa, men resten, det som på ytan var alldeles odramatiskt, men som ändå var det verkligt stora, det sparar jag och gömmer.

Några månader efter hemkomsten möter jag Johan, som deltog i en annan expedition för några år sedan. Vi står i en hiss och begrundar det faktum att detta har vi upplevt och att vi sannolikt aldrig ska få uppleva det igen.

”Så vad ska man nu göra med resten av sitt liv?” säger Johan.

Jag svarar inte. För jag har faktiskt inte en aning.

lab+lab+nature+motor. 2005.

Lars Bergström
Ena hälften av konstnärsduon Bigert & Bergström
Beringia 2005, etapp 1
Göteborg–Nordvästpassagen–Barrow

Expedition 2005

Att få åka med en polarforskningsexpedition har varit en dröm sedan pojkåren då jag vandrade runt Tarfaladalens glaciärer, med packningen fylld av t-sprit och laddning till hela familjeexpeditionen av oxjärpar i folieform.

Under hela mitt konstnärliga arbete har jag haft ett stort intresse av hur man har beskrivit naturen genom kartor, foton och dioraman samt hur miljön har förändrats genom historien, till framtidens virtuella möjligheter. Att nu själv få mönstra på isbrytaren Oden – i Göteborg i högsommarsol och med vetskapen att temperaturen stadigt kommer att vandra ner mot 0° – var toppen.

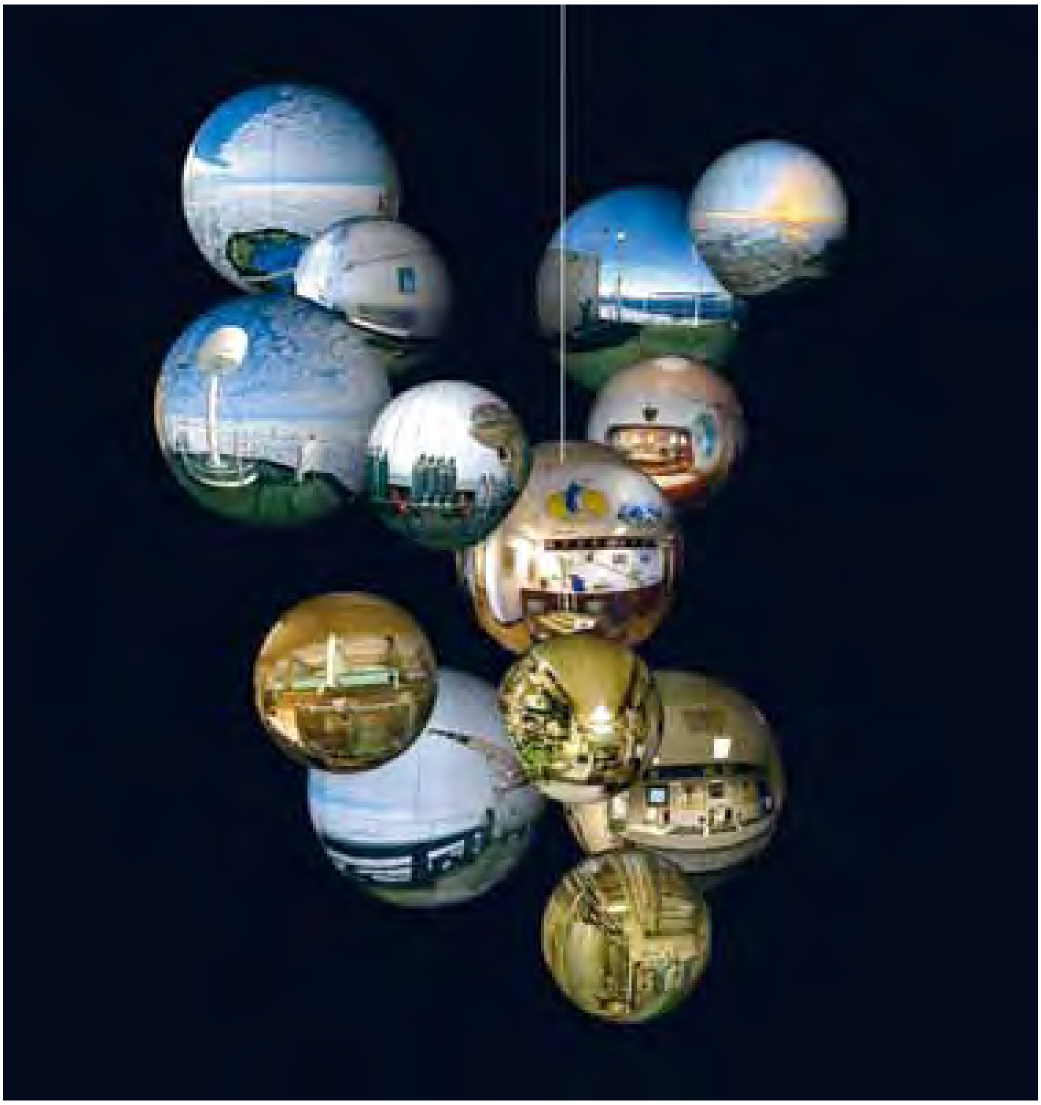
Min plan med resan var att fotografera och dokumentera hela resans klimatförändringar, forskningsverksamhet och isbrytarens olika utrymmen och funktioner. Ett samspel som måste fungera för att tillfredsställa allas intressen bakom expeditionen. Det var detta samspel jag fokuserade på, att forska om forskandet.

Jag använde mig av en teknik som gör det möjligt att sätta ihop foton till 360° 360°-bilder, bilder som monteras på klot, likt en karta på en jordglob. Klot – av t.ex. natur, laboratorium och motorrum – sätts ihop till molekylära skulpturer av förutsättningarna och sammanhanget för resan, skulpturer som kommer att ingå i en utställning på galleri Barbara Thumm i Berlin 2007 tillsammans med min kollega Mats Bigert (som Bigert & Bergström).

Livet ombord var i sig självt en studie i beteendevetenskap och socialpsykologi. Hur en grupp fungerar. Vilka som söker sig till varandra och vilka som pyser av frustration. Att varje dag stå med sin röda bricka och blicka ut över matsalen kunde resultera i långa diskussioner eller total sammanbiten tystnad som bara baren kunde ge en glipa. Resan var mycket en inre upplevelse, en storslagenhet av natur som jag är otroligt glad över att få ha varit med om.

Tack Polarforskningssekretariatet.

LARSB



expedition. 2005.

BERGST


Fotomontage: Lars Siltberg.

JONAS

Jonas Bohlin
Tonsättare
Beringia 2005, etapp 1
Göteborg–Nordvästpassagen–Barrow

Expeditionen Beringia 2005 var för mig en resa genom ett sublimt landskap i ständig förändring. Genom en tystnad som bara gick att föreställa sig ombord på isbrytaren Oden med ständigt bullrande maskiner. En vildmark som var så nära men ändå aldrig upplevdes med all bekvämlighet som fanns ombord. Det var framför allt en visuell upplevelse, en betraktelse av ett panorama. Som tonsättare intar jag gärna det betraktande perspektivet när jag skriver musik så det passade mig bra.

Det känns mycket glädjande att det här gigantiska projektet kommer att bli av. Under spelåret 2007–2008 kommer premiären att äga rum i Berwaldhallen i Stockholm.

h2o(s) The Arctic Oratorio

I projektet **h2o(s)** samarbetar författaren Majgull Axelsson, tonsättaren Jonas Bohlin och videokonstnären Lars Siltberg. Utifrån sina upplevelser av den arktiska miljön under expeditionen Beringia 2005 skapar de en komposition bestående av musik, film och text. Med sina respektive områden som utgångspunkt undersöker de vår tids dystopier.

Till följd av den stora klimatförändring vi tycks stå inför har intresset för polartrakterna under de senaste åren ökat kraftigt. Frågan om huruvida isen i Arktis kommer att försvinna debatteras ständigt. Oratoriet är den optimala formen för den dystopiska vision, berättad ur ett framtidsperspektiv, som målas i detta verk. Med nästan 130 musiker på scenen ska musiken spegla den sublima miljö som expeditionen färdades i.

h2o(s) kommer att genomföras i två steg: ett sceniskt framförande med orkester, sångsolister, kör och videoprojektioner som i steg två överförs till en DVD-produktion. Premiären sker i Berwaldhallen med Radiosymfonikerna, Radiokören och solister under spelåret 2007–2008.

Steg 1. Det sceniska framförandet
Musiken framförs av Radiosymfonikerna (90 musiker) och Radiokören (32 sångare). Dessa är placerade direkt på scenen i Berwaldhallen, körläktaren används inte. Lars Siltbergs videoverk visas på en stor, bred skärm placerad ovanför orkestern och kören. Videomaterialet utgörs av oväntade, existentiella sekvenser, bestående dels av nyproducerade bilder, dels av bilder från expeditionen Beringia 2005. Majgull Axelssons texter sjungs av sångsolisterna och kören.

Steg 2. DVD-produktionen
Musiken, texten och videoverket förs samman till en konst/musikfilm. Här finns utrymme för extramaterial. Exempelvis samtal med upphovsmakarna och exponering av material som inte fick plats under scenframträdandet.

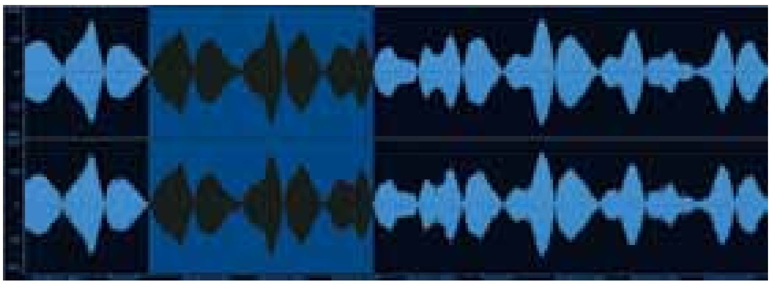
Trots att naturen i Arktis utgör fonden/utgångspunkten för projektet skiljer det sig markant från naturfilmsgenren. Verket skapas utifrån subjektiva upplevelser och tankar, utan den hänsyn för de faktiska förhållanden som, på grund av dess dokumentära karaktär, måste tas i naturfilm.

Högarktis är ett av de sista obefolkade områden som finns kvar på jorden. Detta ger det utrymme för mystik och drömmar där **h2o(s)** The Arctic Oratorio utspelar sig.

BOHL

William Brunson
Tonsättare
Beringia 2005, etapp 1
Göteborg–Nordvästpassagen–Barrow

Odens motorer – vågformen visar amplitud och tid.
Oden's engines – the waveform shows amplitude and time.



North

The North has exerted an almost magnetic attraction on me for a long time.

As a compelling idea. As an extreme and forbidding place. As an environment where survival is an ever-present factor.

It was perhaps photographs in a coffee table book, ironically about Antarctica, that sparked my curiousity as a child. Or, it was, perhaps, history lessons at school about the distant explorations of Cabot, Hudson, Franklin, Amundsen and the elusive grail of the Northwest Passage. Regardless, my fascination with northern latitudes has not only remained but grown over the years.

To participate in the Beringia 2005 expedition has been both a privilege and a deeply enriching experience. It offered the opportunity to fulfill my personal wishes while working on a creative professional project together with my friend, photographer and video artist Josef Doukkali.

From Gothenburg to Barrow, Alaska, leg 1 was a transit voyage. The concept of transit – a sustained movement from one place to another – appealed to me. I had long wanted to travel by sea across the Atlantic. I wished to measure the distance between Europe and North America in the long, rolling rhythm of the waves.

While preparing for departure, I realized, that my expectations of the voyage had no real foundation; that is, I was entering into a situation that I could not fully envision. Once aboard Oden and away, this impression was confirmed daily.

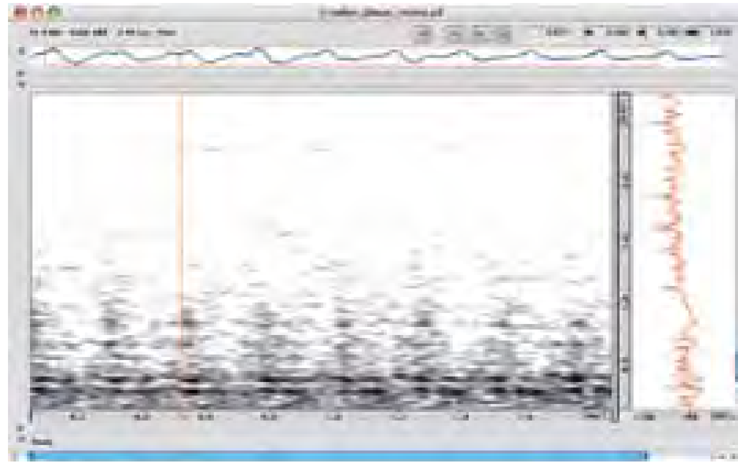
The Arctic is a place of magnificent desolation. The air is crisp and clean. The play of the midnight sun, sky, clouds and fog provide an endless spectacle of light and atmosphere. Astonishing colors of emerald green and deep turquoise water emphasize the predominate whiteness of the seascape. Distant, jagged landscapes rise above the horizon, treeless and seemingly barren. Life, however, is teeming in the water, in the air as well as on the ice and below it.

Aboard Oden, surrounded by comforts and conveniences, we are decidedly safe, warm and well-fed. It is easy to become a tourist, perhaps like passengers on the ship Aurora, which we encountered off the west coast of Greenland. We take, for instance, our scheduled arrival in Alaska for granted.

Time and again, I reflect on the dramatic backdrop of history through which we are passing. I recall sudden and violent events described by survivors of the Arctic: exploration ships are tossed about and crushed; ice floes crack without warning; men, animals and materials are swallowed by the frigid arctic sea through gaping open holes in the floating platform. I remind myself, too, that relatively few people have passed through these waters, and especially this early in the season.

Sonogrammet plottar frekvens och tid, gråskalan representerar ljudstyrkan.

The sonogram plots frequence and time, the grey scale represents sound level.



BRUN

Still, lulled by the security of our icebreaker and perhaps numbed by the overwhelming beauty of the spectacular panoramic nothingness outside, I find myself wondering, what is there left to discover? After all, satellites encircle the globe, hovering cameras can zoom in on any particular place in the world. Sensors can measure and probe to reveal tendencies and patterns in the life of our earth. Yet, almost as the thought is formed, I realize that there is still nothing like actually being there.

As we struggled through the stubborn and clinging ice of Peel Sound, an historic place of death and drama, I am told that we must be careful not to stray too far from the channel marked on the map. For beyond the charted depths, passage was uncertain. Our Canadian ”ice pilot” confirms that the ice is indeed highly unusual and carefully notes it in his log.

So, with our ship of steel, we belong after all to an age of renewed discovery. We are not looking for a passage to the Orient, but rather for answers about the quality and prospects of our life on the planet. Our researchers look for it in the ice, in the air and water. The ice tells stories. It is an interface between air and water. It makes life possible, it can destroy life. Life is fragile, yet astoundingly resilient.

Professionally, as a composer, I have collected sound samples for a future composition. Mostly noise, in endless variations. Roaming about the ship, I gathered many gigabytes of audio from Oden's numerous fans and motors as well as from the oppressive cacophony of the engine room. Outdoors, I captured the splash and crash from the water and ice along the hull and the deep sonorous clang of ice battling steel. High up by the smokestack, I recorded the near sub-sonic breathing of Oden's four engines which contrasted sharply to the miniature whirr and tick of small scientific devices.

None of this can be immediately perceived as “beautiful”. Instead I will have to work as the scientists do, extracting the essences of the sounds, separating and purifying their acoustic components. In the layers of sounds, there are hidden rhythms and sonic atmospheres to be discovered.

To capture the most subtle and most extreme sounds of the Arctic environment would have required considerable time, patience and good fortune. And, on second thought, in cases of violent and unpredictable shiftings of tons of massive ice, it is probably wisest not to be there at all.

Ironically, the alternative acoustic environment to record, had there been an opportunity to fly away from the ship, is the remarkable Arctic silence which is, once again, neither easy nor “much” to record.

All of this will result in an intermedia work for instruments, electronics and video projections in due time.

In closing, I would like to express my gratitude to the Swedish Polar Research Secretariat for making possible my participation in Beringia 2005. I also want to specially thank the crew of Oden for their professionalism and the welcoming atmosphere aboard their ship. Lastly, to all my fellow voyagers, thank you for an experience of a lifetime.

I find myself longing to return.

Josef Doukkali
Fotograf, videokonstnär
Beringia 2005, etapp 1
Göteborg–Nordvästpassagen–Barrow

JOSEF

Jag förstod redan innan jag gick på båten att det skulle kräva en inriktning på mitt arbete som samtidigt var vag och precis, detta för att kunna få en fast karaktär på det insamlade materialet överhuvudtaget. En månad på en båt utan strandhugg var vår lott under Beringia 2005. Från Göteborg den 4 juli till ankomsten i Barrow, Alaska den 29 juli via den klassiska Nordvästpassagen.

Jag valde de motiv jag tyckte låg närmast utanför oss på båten – horisonter och vädrets skiftningar. Vyerna från båten bestod för det mesta av två streck, himmel och hav, olika breda beroende på kompositionen. Det fanns en förväntan i att under resan blicka ut över en platt horisont – förr eller senare dök något upp som avtecknade sig i fjärran, närmade sig, passerade, för att till slut försvinna i fjärran. Det är klart att något förändrades hela tiden i det lilla och under vattenytan. För ögat, vid relingen på övre däck krävdes ofta avgörande fenomenologiska avvikelser från det invanda för att skapa intresse hos en betraktare som sökte förändring; valar, björnar eller isberg för att nämna några.

Forskarna och besättningen hade sina instrument för att mäta avvikelser från det förväntade och uppe på bryggan eller i labben fortgick förändringen hela tiden under resan – vi visste var vi var och oftast något om vad som fanns i vattnet vi färdades i och över.

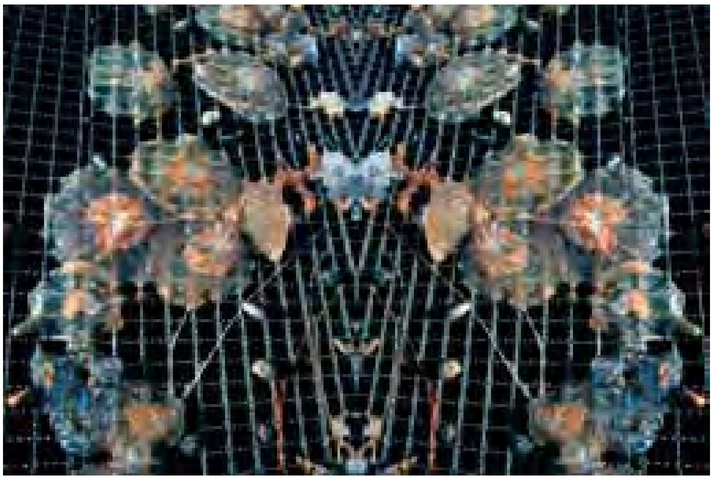
Jag samlade material med tre stillbildskameror och video samt på 16-millimetersfilm, med utgångspunkten i horisonter och de associationer framkallades av mitt eviga blickande ut över vattnen vi färdades på. Jag såg städer och människor passera; jag såg öar och fordon på isen; jag såg vädret skapa rum över vattnet med fantastiskt ljus och väggar av dimma som tycktes för evigt ogenomträngliga, men som en stund senare övergick i ett strålande solljus över blå himmel – en upplevelse utanför Grönlands sydspets.

Två starka starka bildliga inspirationskällor under arbetet har varit Caspar David Friedrichs *The Sea of Ice* från 1824 och Gerhard Richters *Seascape* från 1975.

Två skrivna källor till inspiration har varit Jean Baudrillards *Amerika* från 1986 och Paul Virilios *Försvinnandets estetik* från 1989.

Dessa verk framställer objekten – föremålen vi ser passera under färden – och deras ”triumf över vårt begär att hålla kvar synintrycket av det storslagna” för att citera Baudrillard. Mitt arbete kommer att koncentreras runt detta, som jag ser det, faktum och beräknas vara färdigt någon gång under våren 2007.

DOUK



Ur filmen *Fruits de mer* filmad i Barrow.

Landskapet i Lorino fotograferat genom en böjbar spegel.

SCHA

Dascha Esselius
Konstnär
Beringia 2005, etapp 2AB
Stockholm–Thule–Fairbanks–Tjukotka–Wrangels ö–Barrow

Mitt projekt hette *Fenomenet kyla och människans utsatthet*. Projektnamnet växte fram ur förväntan om att expeditionen skulle mötas av extrem kyla och svåra fysiska umbäranden. Det är den aura som omger polarexpeditioner. Dröm om min förvåning när vi möttes av värmebölja i Alaska och drabbades av den i Lorino på Tjuktjerhalvön. Jag skriver drabbades därför att vi var helt oförberedda. Solkräm framför allt, men även kortbyxor, baddräkt och en solhatt hade inte varit fel att ha med sig. Solen sken större delen av dygnet och det fanns ingen skugga. Jag som hade bekymrat mig så mycket och därför tänkt ut ett raffinerat system med mjuka kylväskor för att skydda mina kameror mot kyla. Mitt bagage blev därmed rätt omfattande och jag tvingades till ständig packning och ompackning av min utrustning, ledsagad av munterhet hos mina medresenärer. Alltså ingen kyla. To hell med projektet!

Jag hade med mig en inre bild, en önskan att göra en porträttserie med forskare, en och en ståendes naken på isen, liksom utlämnad till sig själv utan skydd. Jag tänkte att det kanske skulle vara svårt att få forskarna att ställa upp. Jag fick mer än tjugo anmälningar från frivilliga, men ingenstans där vi passerade var isen så tjock att det hade gått att genomföra.

Men jag grämer mig inte. Utöver digitala och analoga kameror, ljudinspelningsutrustning, bärbar dator, block och pennor släpade jag även på två stora plastspeglar som går att böja åt olika håll. Den förvrängda spegelbilden, som jag sedan fotograferar, tjänar till att ge uttryck åt upplevelsen av landskapet eller situationen. Likaså filmade jag via spegelprogrammet i den digitala videokameran. Jag har på så vis arbetat parallellt konstnärligt och dokumentärt med samma utrustning. Jag har fotograferat, filmat och tagit upp ljud där vi var, och vi var på många platser. Mjukstarten med storartad natur inlemmad i västerländsk civilisationsstruktur med bekväma hotellrum gick via Thule på Grönland till Fairbanks och Denali nationalpark i Alaska. Så långt var resan geografisk. Själva tidsresan, en ytterligare dimension som lades till, började på flygplatsen i Providenija på Tjuktjerhalvön.

Jag ångrar att jag var så laglydig och inte tog en enda bild i smyg när vi steg av Herculesplanet på flygplatsen som tycktes ligga på en platå. I fjärran såg man genom en lätt dimma snötäckta bergstoppar. Vi stod bland utspridda flygplanskroppar som verkade övergivna och ålderdomliga på något sätt, eller var det de övriga, oproportionerligt stora fordonen som tycktes ha blivit kvar från andra världskriget och som körde omkring ryckigt och stånkigt som gav det intrycket? Ett obeskrivligt förfall inbäddat i ett ljus som gav färgerna på den mest betydelselösa tingest en briljans som alltid var i samklang med övriga färger (och de var många) i denna slitna miljö. Hur var detta möjligt? Förfallets estetik driven till sin spets... Och så alla dessa soldater med sorgsna ögon i sina besynnerligt breda, platta mössor...

Jag är en stor beundrare av Andrej Tarkovskij. Jag har sett alla hans filmer flera gånger om, och nu insåg jag att Tarkovskij var en mycket större realist än man kunde ana. Att

Barrow.

Wrangels ö.

stiga av på flygplatsen i Providenija var att stiga rakt in i ett scenario av Tarkovskij. När jag sedan spelade in myggornas symfoni och bubblet i ett träsk på tundran så råkade jag även spela in vår lokale guide (den forne Afghanistansoldaten och vår beväpnade beskyddare mot isbjörnar) deklamerandes dikter rakt ut i den ljusgråa natten, ovetandes om att jag fanns i närheten med min inspelningsutrustning. Så gick det till när jag, förutom myggorna, spelade in den ryska själen.

Landskapet, träskmarken, förvånade med uppskruvade färger lika bjärta som på de lackade askarna med sagomotiv som man sålde på museet i Providenija. ”Buy Russian folklore art for dollars.” Jag blev hembjuden till en inuitfamilj i byn Novoje Chaplino, vår inkvartering mellan Providenija och tundran. De tog fram sina familjealbum och berättade om livet på denna plats som ligger insnöad från september till juni och där värmecentralen som spyr ut svart rök över den närliggande skolan är byggd av oljefat.

Livet på Oden var en lyxkryssning och kändes ännu mera så efter vistelsen i land. Då äntligen fick vi se lite is och nu vet jag att isen har alla färger, *alla*, och nog skulle jag ha velat se mer av den. Men inför oss hade vi den största och mäktigaste upplevelsen, Wrangels ö. Platsen bortom tideräkningen där allt upplöses och smälter samman, kadaver som rostiga bandvagnar. Genom allt – förmultnade skidor, avgnagda djurben, korrigerade aluminiumhinkar och kastrullock, renätna djurskinn, besynnerliga maskiner och djurkranier – växte det mängder av olikartade växter och blommor ton i ton med civilisationslämningarna och djurskeletten. Alla färger i sin yttersta briljans och i samstämdhet. Som om denna plats var vigd åt Dödens, Livets, Civilisationens och Naturens försoningsakt. Ljuset ändrade sig med obegriplig hastighet liksom vädret. Perspektiven flyttades och förflyktigades. Det som nyss var nära försvann plötsligt långt bort. Dimmorna svepte runt som slöjor, dolde det nyss sedda, avslöjade det nyss dolda. Från havet hördes ett dovt dån framkallad av isens rörelser, sprutljuden från valarna och så en stilla bäck och vildgässens rop. Ett koncentrat av allt. Så märkligt och så arketypiskt välbekant som i en sciencefictionfilm. Jag var både upprymd och förtvivlad. Hur skulle jag få med mig allt detta på bara tolv arbetstimmar?

Den näst sista anhalten var Barrow, Nordamerikas nordligaste punkt. Ett flackt landskap genomkorsat åt alla håll av oändliga rader med elledningar, allt stiligt grått i grått i dimman. Det var kallt och det blåste som sjutton. Vindljud är bra ljudmaterial att arbeta vidare med elektroniskt. Här gjorde jag flera konstfilmer med utgångspunkt från havsskum, maneter, fladdrande plastremsor och elledningar. Två filmer har jag blivit klar med, *The Lace* och *Fruits de mer*, men jag har väldigt mycket mer material att färdigställa. Må jag få ett långt liv så jag hinner ta hand om allt som jag har fått med mig.

Rose-Marie Huuva
Poet
Beringia 2005, etapp 2C
Kamtjatka

Varför

Varför
måste människan veta
hela hemligheten

Varför räcker det inte med
att se grässtrået vaja i vinden
se skönheten i blomstren på fjällsluttningen
utan att kunna de latinska namnen

Varför inte bara lyssna
på jokkarnas toner
myggornas dans på tältduken
känna doften av videsnåren
smaka på regndropparna

Beundra färgerna och mönstren
som lavarna målar på stenarna
lägga handen på den sträva klippan
och förnimma evigheten

Varför inte bara nöja sig med
att kika på murmeldjuret på stenen
att titta på jordekorrarna
som nyfiket tittar på oss

Det är vi som är den främmande arten
som trampar upp sår med våra grova skor

Människa
det är vår tids levnadsmönster
som rubbar balansen

Varför
måste människan veta
hela hemligheten

Varför denna iver
att kartlägga allt levande
dokumentera och sortera i grupper
arter och underarter
i högre och lägre raser

Varför mäta, väga
dissekera och analysera
studera i laboratoriets mikroskop

Varför hamnar allt under luppen
björnens spillning i ett provrör
och gnagarnas kött i 95-procentig sprit

Varför fraktas vattenprover
och sediment från dessa sjöar
till andra sidan jorden

Varför idogt samla
pressa och torka hundratals växter
för att gömmas i ett herbarium

Är det ett steg i karriären
är det drömmen om att bli förevigad
för den stora upptäckten

Varför
måste människan veta
hela hemligheten

Vi är ändå dömda att leva
med insikten
att vår plats är försumbar
i den stora hemligheten

Fotografi taget ur videoskiss.

Lars Siltberg
Konstnär
Beringia 2005, etapp 1
Göteborg–Nordvästpassagen–Barrow

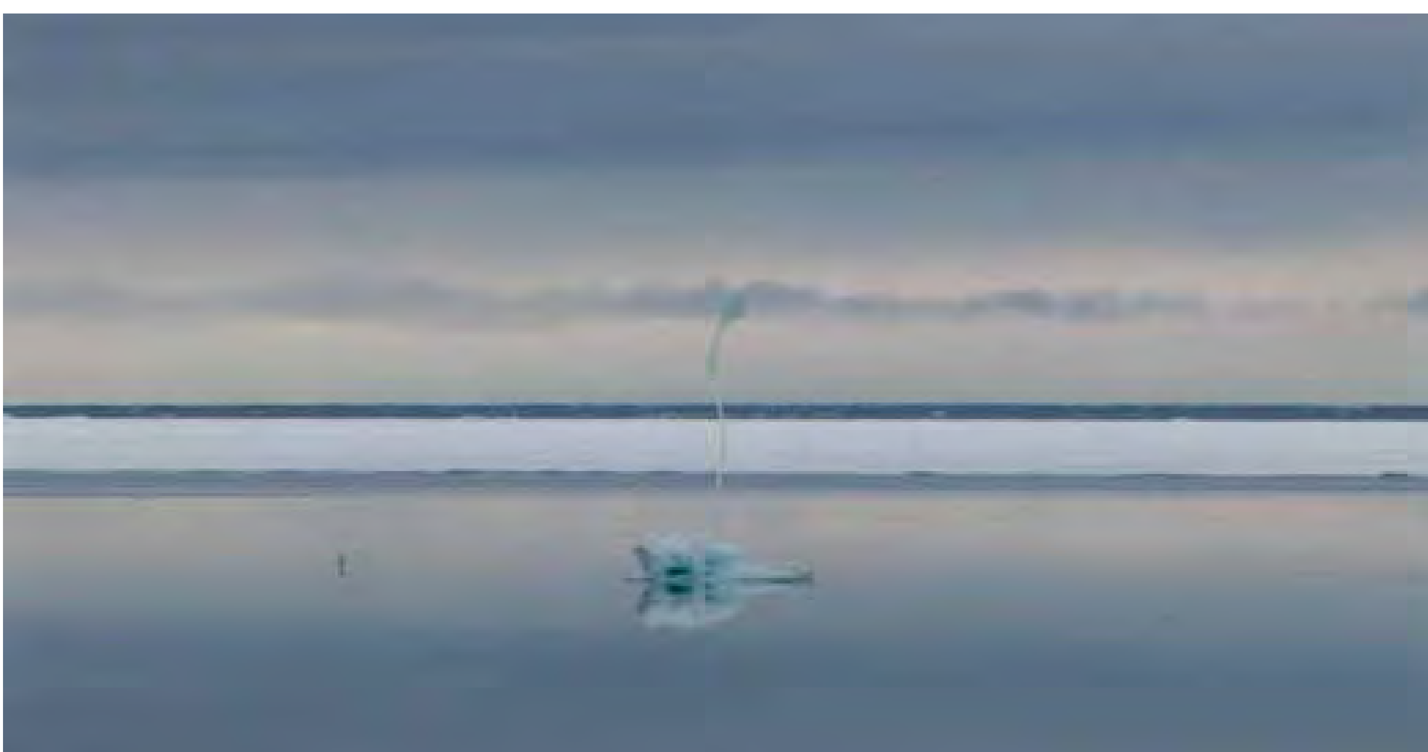
Naturbild och självbild

Medan forskarna jobbade på att lösa den samvetstyngda frågan om huruvida summan av industrialismens välståndsbringande krafter påverkat polen och klimatet så till den grad att vi i framtiden måste leva i ett tundraliknande klimat eller rentav flytta ifrån vårt land försökte jag skaffa mig ett oromantiskt perspektiv till landskapet vi åkte genom. Mitt alltför vidlyftiga mål var att söka resans innebörd genom att stå öppen inför landskapet och livet ombord.

Jag och Lars Bergström tilldelades en rymlig och ren container som arbetsplats. Den var placerad på fördäck med utsikt över fören och allt som fanns framför den. Varje dag under resan gick jag dit för att arbeta med min dator, min blick delades upp mellan LCD-skärmen och havsutsikten. När något intressant dök upp utanför sprang jag ut för att videofilma. Stormigt hav, isbjörn, eller för det mesta, plågade isformationer och islandskap dränkt i märkligt dygnetrunt-ljus. Väl tillbaka i den varma containern laddade jag in bilderna i datorn och hade då samma sak på datorskärmen som i containerfönstret. Inga nyheter alltså, jag hade genomfört en fotografisk akt, men som med all naturfotografi och naturfilm måste bilderna dramatiseras för att bli uthärdliga eller ännu bättre, intressanta. Annars fungerar de endast som ett slags bevis för hur det ser ut i området, resten blir efterhandstolkningar. Ett sätt att ge något mening är att jämföra det med något känt, t.ex. att med kontrastverkan låta naturen möta den för mig bekanta hemmamiljön, dvs. staden och civilisationen. Hur trygga skandinaver än må känna sig i förhållande till vildmark, norrsken och is så var åtminstone jag inget annat än en främling där. Trots min ovana, eller kanske tack vare den, fylldes jag snart av en vilja att hoppa av båten. Kolonisatören i mig låg nog bakom en märklig längtan om att bygga koja på isen, särskilt fantasifullt kändes det när vi gled förbi isberg. De framstod som hoppfulla autonomier med plats för enskilda boenden eller ibland med utrymme för en hel by. Här är spår från några av dessa platser.

Fotografi taget ur videoskiss.

ILTBE



Fotografi taget ur videoskiss.

Bea Uusma Schyffert
Författare, illustratör
Beringia 2005, etapp 3
Barrow–Nordpolen–Longyearbyen

Jag hade med mig över 500 pennor i olika tjocklekar och 30 sorters papper i fyra stora flyttkartonger: tjocka grafiktryckspapper, skisspapper, rullar med jätteovanligt vaxat papper från New York, sammetspapper och ritfilm. Dessutom hade jag förstås även packat flera boxar med mitt vanliga ritpapper, som jag brukar använda. Under sex veckor på båten gjorde jag enda teckning. Eller, ja. Det var mer som ett streck. (Horisont i snö.) Det var faktiskt helt omöjligt att sitta och stirra ner i ett papper när man håller på att åka båt över en hel iskontinent! Vår lilla lilla båt högst uppe på jordgloben! Jag jobbar med en bok om Andrée-expeditionen och hade planerat att rita bilder till den under resan. Istället samlade jag material på andra sätt.

För mig har det blivit stor skillnad att jobba med min bok efter att jag kom hem från Arktis: nu kan jag berätta om hur det känns när polarisen bär en, hur den svarar mot ens tyngd när man går på den. Jag vet hur det är att ligga på rygg på isen och titta upp mot himlen och hela ens synfält är vitt gnister, och istäcket är två meter tjockt och under istäcket är det 3 514 meter djupt och om jag skulle glida ner i en spricka och sjunka skulle det ta en timme för mig innan jag nådde botten och det är -1,6 grader kallt i vattnet. Jag har fotograferat isen ovanifrån, full av turkosa smältvattensjöar, när jag följde med på isrekognoscering med helikoptern. Jag kan berätta om varför man ser tre solar på himlen vid 88:onde breddgraden när ljuset bryts genom iskristallerna i luften. Om vad isbjörnar tänker på. Och om färgerna på isen! Isen är inte alls vit. Isen är alla färger utom vit. Varje morgon under sex veckor samlade jag dagens färg ur isen och skrev ut på min skrivare. Jag var tvungen att ta loss färgskrivaren ur sina gummiremmar (allt i min arbetscontainer var fastsurrat så att det inte skulle glida ner i golvet) och hålla den i famnen som en liten bebis när jag skrev ut, eftersom det annars blev underliga ljusrosa ränder över hela pappret av skaket när Oden gick genom isen.

Jag som jobbar i gränsen mellan konst och fakta hade faktiskt inte tänkt på att hela Oden skulle vara full av forskare som kunde svara på alla mina frågor. Jag kom hem igen fullastad med sjökort, iskartor, satellitbilder och långa faktalistor om allt från solens upp-och-nedgång vid Nordpolen till vattnets salthalt på olika djup i de arktiska bassängerna.

På natten till den 12 augusti 1897 slog Andrée, Strindberg och Fraenkel upp sitt tält på isen vid 81ffl57’N, 30fflE. De åt stekt isbjörnskött till middag som vanligt. De hade vandrat söderut i en månad över istäcket i hopp om att nå fast mark. Vi korsade deras rutt med Oden vid exakt den platsen, 108 år senare. Jag kollade lite förhoppningsfullt ut över isen efter några spår av dom, en försvunnen ballongkorg eller så, men jag såg inget. Jag stod där på däck i min tjocka polarjacka och försökte föreställa mig hur det skulle vara att slå upp sitt tält för natten, just här, efter 30 dagar av vadande i issörja, dragandes på en 154 kilo tung kälke, i vadmalsbyxor, stickade fingervantar och genomblöta promenadskor som aldrig torkade. Sen gick jag in och bastade. Dagens färg blev ljusgrå.

USMA

Polarforskningssekretariatet är en statlig myndighet med uppgift att främja och samordna svensk polarforskning. Det innebär bl.a. att följa och planera forskning och utvecklingsarbete samt organisera och genomföra forskningsexpeditioner i Arktis och Antarktis.

Polarforskningssekretariatet är förvaltningsmyndighet för lagen (1993:1614) om Antarktis och prövar frågor om tillstånd för vistelse eller verksamhet i enlighet med lagen.

The task of the Swedish Polar Research Secretariat is to promote and co-ordinate Swedish polar research. This means e.g. to follow and plan research and development and to organise and lead research expeditions to the Arctic and Antarctic regions.

The Swedish Polar Research Secretariat is the administrative authority for the Act on Antarctica (1993:1614) and handles permit issues for visits or activities in accordance with the Act.

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