DNR 2005-0030

Environmental Impact Assessment

SWEDISH POLAR RESEARCH SECRETARIAT
SWEDISH ARCTIC RESEARCH PROGRAMME
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CONTENTS

NON-TECHNICAL SUMMARY

Beringia 2005 is the name of the Swedish polar research expedition to the Arctic in 2005. The expedition will use the icebreaker Oden as an operational platform, the ship will cross the Arctic, travelling from Scandinavia to Chukotka, the Bering Strait and Alaska. On the way back to Scandinavia, Oden will meet up with the coast guard cutter Healy from USA in a joint operation to the North Pole. In parallel, there will be terrestrial field camps in both Russia and the United States.

From a logistical point of view there are three major components of the expedition, ship cruise with the icebreaker Oden across the Arctic and in the Bering Strait region, a Kamchatka expedition and semi-permanent field camps along the route. From a scientific point of view there are two main components: marine sciences and tundra ecology. The Marine research will examine the role of the Arctic Ocean in the climate system and the terrestrial research will focus on the causal processes in the Beringian biocomplexity.

The environmental impact assessment shows that the expeditions' environmental impact will be low and/or negligible. Minor and transitory negative impacts can be expected from the logistic activities, mainly due to the usage of fossil fuels, which will result in emissions to air. Best possible waste management techniques will be used. Fuel, chemicals and other hazardous materials will be handled with care and not dispersed into the environment.

Negative environmental impacts from the scientific research are likely to be negligible. Indirectly, several of the scientific projects on Beringia 2005 will increase general understanding of certain parameters important for the global change processes. This will eventually have a positive impact on the environment by scientifically documenting the changes in environment and making scenarios for the likely future impacts on a larger scale for the global environment.

As a conclusion, there is no reason not to carry out the Beringia 2005 expedition from an environmental point of view.

1. INTRODUCTION

The Swedish Polar Research Secretariat (SPRS) is a governmental agency under the Ministry of Education, Research and Culture. The Secretariat promote and co-ordinate Swedish polar research and development. One of the main tasks for SPRS is. to organise research expeditions to the Arctic and Antarctic regions.

SPRS is planning an expedition lasting from July to September 2005 within the Swedish Arctic Research Programme (SWEDARCTIC) entitled Beringia 2005. The expedition is a co-operation between SPRS and Swedish National Maritime Administration where the icebreaker Oden will be used as the operational platform. Beringia 2005 will be carried out with scientific and logistical counterparts from both Russia and the United States.

Twenty-six Swedish projects form the basis for the scientific program of Beringia 2005, and the expedition can be seen as a completion of SPRS earlier tundra ecology efforts: Tundra Ecology 1994 along the entire Euro Siberian Arctic coast, and Tundra Northwest 1999 along the Canadian Arctic archipelago and Nunavut.

The scientific framework for Beringia 2005 is based on interests expressed by scientists and representatives of research organisations in Sweden, Russia and the United States. The Marine research will examine the role of the Arctic Ocean in the climate system, and the terrestrial research will focus on the causal processes in the Beringian biocomplexity. Beringia is a region with high biodiversity and play an important role in biogeography and evolution of species.

2. DESCRIPTION OF THE ACTIVITY

Beringia 2005 is made up of three major components, ship cruise in the Arctic Ocean, semi-permanent field camps in Chukotka and Alaska, and a terrestrial field expedition to Kamchatka. On Oden's return to Scandinavia, she will make a transect across the Arctic Ocean, and pass by the North Pole in a joint mission with U.S. Coast Guard Cutter Healy.

2.1 SCIENTIFIC AIMS

From a scientific point of view, Beringia 2005 has two main components: tundra ecology and marine sciences. The scientific program includes the following fields:

- *Terrestrial research: Beringian biocomplexity - causal processes*
  - Biodiversity - patterns and evolution
  - Ecosystem trophic interactions
  - Migration
  - Biogeography - past and present

- *Marine research: The role of the Arctic Ocean in the climate system*
  - Water mass variability and circulation patterns
  - Atmosphere-ocean interactions
  - Geology and geophysics of the Arctic Ocean
  - Biogeochemical cycles
  - Land-shelf-basin interactions

The terrestrial research has the aim to cover a large geographical area in a single season. When Oden cruise the Bering Strait region, a terrestrial part of the expedition will travel along the eastern coast of Kamchatka, from Petropavlovsk to Anadyr. In parallel, field camps will be stationed in Alaska and on the Chukotka Peninsula. The tundra ecosystem will be investigated from many different perspectives such as ecology, evolution, biodiversity, biogeography and migrations of species, as well as human dimensions and native cultures.

The Arctic seas remain largely unexplored, the marine and atmospheric science projects onboard Oden will further investigate Arctic's role in the global climate system. This includes such diverse topics as water circulation patterns, geophysics, atmosphere-ocean interactions and land-shelf-basin interactions.

More information about Beringia 2005 and the research programmes can be found on the SPRS website at www.polar.se.

2.2 GEOGRAPHICAL AREAS OF INTEREST

Geographically the expedition covers a very large area. Oden will circum-navigate the Arctic Ocean, travelling from Scandinavia along the northern coasts of Siberia to Chukotka, the Bering Strait and Alaska. On the return Oden will make a transect across the Arctic Ocean, and pass by the North Pole and the cruise ends in Longyerbyen at Svalbard.

In parallel there will be a number of terrestrial research sites from southern Kamchatka to south-central Chukotka, and a semi-permanent camp in the Yukon-Kuskokwim Delta of Alaska.

The areas of current interest are shown in figure 1, detailed maps of the proposed research sites are found Appendix I.

2.3 EXPEDITION SCHEME

The expedition is divided into six legs within three areas and all participants will not be onboard at the same time. The crew on Oden and will rotate and researchers will be exchanged between the different legs.

Leg	General description	Prel. Date
1	Marine research during transit from Scandinavia along the northern sea route to Pevek, Chukotka Peninsula. No, or limited, station time.	Jul 6 – Aug 3
2A	Terrestrial research at selected sites along the north slope of the Chukotka Peninsula (incl. Wrangel Island) and the north slope of Alaska. Short visits (2-3 days) at sites ashore, from the vessel.	Jul 24 – Aug 17
2B	Marine research from the ship might be possible during the time, and in the area, under 2A above.	Aug 3 – Aug 17
2C	Terrestrial research at selected sites on the Kamchatka and Chukotka Peninsulas. Visits of 2-5 days at each site. Based on excursions from Petropavlovsk and Anadyr, respectively.	Jul 4 – Aug 17
2D	Semi permanent field camp in the Yukon-Kuskokwim Delta, Alaska.	Aug 1 – Oct 15
3	Marine research along a transect from northern Alaska over the polar basin to Scandinavia. Part of this voyage will be made in cooperation with the Healy.	Aug 19 – Oct 25

2.4 NUMBER OF PARTICIPANTS

The total number of participants is 162 (+crew), of who are 122 scientists, 23 logistics/technicians, 9 artists or teachers, 6 journalist, and 19+ ship-crew.

Figure 1. *Top map shows the general route of the ice-breaker Oden, i.e. the northern sea-route, Beringia, and the transpolar return. Below are the specific areas of investigation for leg 2A, 2C, and 2D, i.e. the terrestrial parts.*

3. DESCRIPTION OF THE ENVIRONMENT

The main geophysical characteristics of the Arctic are low temperatures with pronounced seasonal variations in climate, including a large variation in the solar radiation between the long night of winter and the long day of summer, and the extended periods of ice and snow cover. On land the temperatures vary greatly through the seasons, and permafrost strongly influences soil formation, vegetation structure, and hydrological processes [EEA]. Common Arctic environmental features are summarised in box 1.

Box 1. Common arctic features
(Source: Guidelines for Environmental Impact Assessment (EIA) in the Arctic)

Climate, geographic and geological features
- extent of ice-cover on waters
- typified by cold areas (cryosphere)
- sink for airborne/waterborne pollutants
- slow break down of contaminants
- large variations in conditions between years

Ecosystems and biological resources
- young ecosystems and numerous sensitive areas
- sharp gradients in the environment and ecosystems both in time and space
- low productivity levels in general, but some areas of very high productivity
- short food chains
- slow recovery/regeneration rates
- risk of irreversible processes/cascades (e.g. as a consequence of erosion)
- low carrying capacity
- high concentration of stocks (groups of certain species)
- biodiversity at genetic and landscape levels
- unspoilt landscapes that are large enough to allow ecological processes and wildlife populations to fluctuate naturally

Socio-cultural and economic features
- cultural variability: indigenous/other local/settler population
- high percentage of local inhabitants are dependent on renewable resources
- extensive (vs intensive) patterns of land use – forestry, herding, hunting
- areas of very low to very high population densities
- growth of industrial development and exploitation of non-renewable resources

Knowledge of the systems
- lack of baseline environmental knowledge
- traditional knowledge

3.1 MARINE ENVIRONMENT

Arctic sea temperatures are more stable than land temperatures throughout the year. Sea ice development strongly influences the marine ecosystem dynamics. The Barents and Kara Seas are among the largest shallow continental shelf seas in the world. Due to influxes of warm air and water from the south, these areas are generally the mildest and most humid parts of the Arctic.

These ocean and air currents, along with the Transpolar Current flowing out from the Arctic Basin make the area a "sink" for long-range contaminants and pollutants. The geophysical characteristics of the arctic seas also contribute to large-scale deep-water formation east of Iceland and Greenland. The function of these seas as a CO2 sink, along with their large areas with high albedo caused by ice and snow, are important features affecting the global climate system and the regulation of the greenhouse effect [EEA].

The Bering Sea is a northern extension of the north Pacific Ocean, bordered to east by Alaska, and to the west by Russia's Chukotka and Kamchatka Peninsulas. To the south the Bering Sea is framed by the arc of the Alaska Peninsula, the Aleutian Islands, and Russia's Commander Islands. The Bering Sea ecoregion also encompasses the southern Chukchi Sea, due to the many species that migrate through the Bering Strait as well as the oceanographic processes that link the Chukchi and Bering Seas.

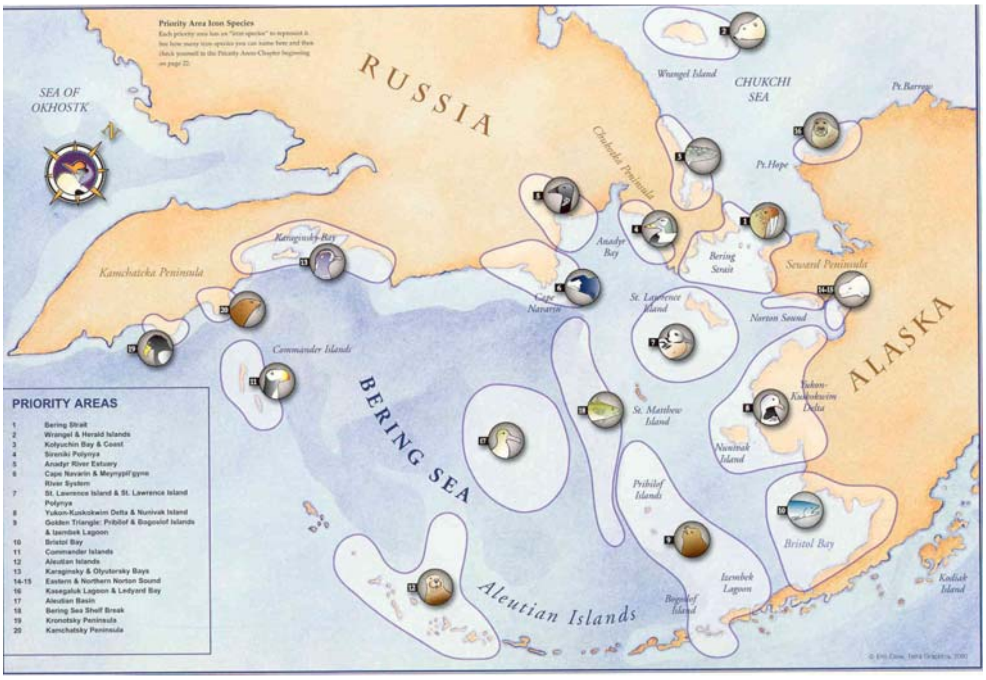

Figure 2. *Map of Bering Sea Ecoregion [Source: ref].*

The Bering, Beaufort, Chukchi Seas and Barents Sea ecoregions are among the worlds most diverse and richest subpolar and polar marine ecosystems. Covering almost 2.6 million square kilometres, the Bering Sea supports huge populations of fish and shellfish, birds, whales, dolphins, porpoises, walrus, sea lions, seals and over 80% of the world's population of breeding female polar bears [wwf 1 och 2]. The distribution of marine mammals and birds is clustered, with species tending to occur in areas where primary production is enhanced due to oceanographic features such as coastal up welling areas, submarine canyons, shelf break [polarbiology].

The Bering Strait is a focal point for the migration and summer foraging of thousands of birds. Birds migrate from wintering grounds in the Americas, Asia, and Europe to breed in Arctic regions. Nearly 3.3 million seabirds nest on the eastern coast of this peninsula. Species include spectacled eiders, common and thick-billed murres, parakeet auklets, tufted and horned puffins, red-legged kittiwakes and pelagic cormorants. Birds found in this ecoregion are often well adapted to life near the water [5, 6].

More than 50 percent of the United States and Russia's annual fish catch come from the Bering Sea. The sea is home to 402 species of fish (65 families), of which 50 species and 14 families are harvested commercially. One of the largest salmon runs in the world is found in the Bering Sea.[WWF 1 &2]

However, the Bering Sea is faced with significant and disturbing changes. Steep declines in some marine mammal populations, fluctuations in seabird populations, and the reduction or collapse of certain commercially important crab and fish stocks are a major cause for concern. The major threats include fisheries mismanagement (habitat disturbance, large-scale illegal fishing, and in some cases overfishing), introduction of non-native species, pollution (ranging from marine debris to Persistent Organic Pollutants, coastal mining and oil spills), and climate change [5, 6].

3.2 TERRESTRIAL ENVIRONMENT

Terrestrial research will take place in field camps in Chukotka (figure 3) Kamchtka (figure 4) and Alaska (figure 5 and 6). A general description of the environment of the areas is presented below.

3.2.1 The Chukotka Region

The Chukchi region encompasses a number of climate zones, so a variety of distinct forest and tundra environments can be found here. Common in the tundra areas are modest stands of bushy alder, dwarf cedar and sedge, and a ground cover including low-bush cranberries and blueberries. In the open tundra, and in particular in alpine and arctic regions, a variety of low bush, grasses, mosses and lichens dominate the landscape [5, 6].

The northern tundra supports a striking diversity of plant life which belies the apparent poverty of the living landscape, more that 900 free-standing plant species and more than 400 species of moss and lichen can be found in Chukotka. Even the harsh, high arctic landscape on Wrangel Island, Chukotka's northernmost territory supports 385 plant species, a significantly richer level of diversity than can be found on any other landmass at an analogous latitude [5,].

Figure 3. *Map of Chukotka [Source: ref].*

The fauna of the Chukotka region is also very diverse, and has much in common with the fauna of neighboring Alaska. Many animals within this complex are unique in the Russian North, and do not occur west of Chukotka. Chukotka's rivers and lakes are home to 30 species of freshwater fish, of which salmon, cisco, char, grayling, northern pike, smelt, dog-fish, whitefish. Approximately 220 bird species are native to Chukotka, including tundra ptarmigan, ducks, geese, and swans in inland areas, and seagulls, murres, loons along the coasts and in coastal cliff rookeries [].

Species included in Russia's Red Book (Russia's list of protected and endangered animals) are the polar bear, dall sheep, the narwhal, humpback, grey and blue whales, the ringed seal and 24 bird species [].

Ship traffic through the Bering Strait and along a proposed northern transportation route could disturb and pollute natural resources. Oil and gas exploration are potential threats as well. On a larger scale, climate change could alter ice habitats [].

3.2.2 The Kamchatka region

The Kamchatka region is one of the Earth's most spectacular and pristine natural areas. Volcanic eruptions, earthquakes, and tidal waves continually modify the dynamic landscape. The result is a globally distinctive collection of meadow and taiga landscapes with an abundance of animal life.

The taiga and grasslands are home to a diverse range of Palaearctic flora and mammal populations of remarkable size and the world's greatest known diversity of salmonid fish. Mosaics of tundra and taiga habitats support 29 species of rare and endemic plants.

Figure 4. *Map of Kamchatka [Source: ref].*

Kamchatka contains major bird migration staging areas, large seabird colonies and a diversity of birds of prey. Half the global population of both Stellar's Sea Eagle and the Aleutian tern are found within the site. [REF WWF2]. The peninsula is famous for its population of Kamchatka brown bear, the largest bear in Eurasia, which occur in unusual abundance and size. Other mammal species include Kamchatka marmot, Okhotsk subspecies of wild reindeer, and Kamchatka subspecies of sable. [REF 2].

Habitats in the Kamchatka taiga and grasslands are relatively intact and undeveloped due to low human population density. However, big-game hunting and poaching of brown bears threaten one of the world's most intact populations of this species. REFERENCE WWF 2.

3.2.3 The northern coast of Alaska

The Arctic Coast, stretching along the northern coast of Alaska and into the Yukon and the western Northwest Territories, is uniquely complex in dynamic ecological relationships and processes and surprisingly rich in wildlife species. The physical characteristics of the ecoregion were largely shaped over geologic time scales by periodic glacial events [10,11]. The entire ecoregion barely rises above sea level, never exceeding 200 m in altitude, and remains very wet, despite very little precipitation. Low gradation of slope and continual permafrost prevent efficient drainage and ensure wet conditions during the short Arctic summer [10].

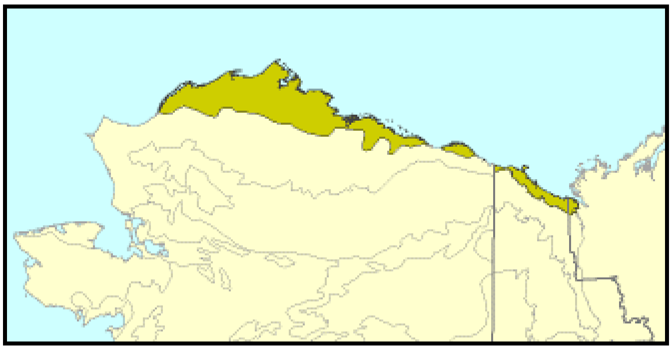

Figure 6. *Map of northern Alaska [Source: ref].*

Permafrost underlies most of the Arctic Coast ecoregion, which remains frozen over 9 months of the year. The ice extends as much as 600 m underground with an active layer of less than 1 meter that thaws in the summer months. The influence of ice in the Arctic Coastal Plain makes the ecoregion susceptible to irregular landforms resulting from the melting of ground ice [10,11].

The flora on the wet tundra communities is dominated by sedges, rushes, mosses, lichens, and willows. The fauna consists of many species of nesting waterfowl in the numerous lakes and ponds of the Arctic coastal plain. Brant and common eider are prevalent in this area. Seabirds such as the pomarine jaeger, glaucous gull, and black guillemot are characteristic breeders. The semipalmated sandpiper is a common breeder in this section. The breeding range of the rare curlew sandpiper is limited to the tundra adjacent to the coast. Characteristic mammalian predators include Arctic foxes throughout the Section and polar bears in the vicinity of the coast. The musk ox was extirpated in the 1850's and 1860's; reintroduction efforts began in 1969 [11].

3.2.4 The Alaska Beringia Tundra

The Beringia tundra ecoregion occupies much of the Bering Sea coast of Alaska and is composed of two distinct ecoregions - Beringia Lowland Tundra and Beringia Upland Tundra. The two ecoregions leapfrog along the coastline and are generally separated by lowland versus upland conditions. Lowlands, shallow to gently rolling hills, and broad valleys punctuated by upland areas and steep, rugged mountains, characterize the ecoregion. The elevational gradient runs from sea level on the Bering Sea coast, through 500 m in the hills, up over 1500 m in the mountains [10].

Many peaks and ridges still contain glacial cirques. Drainage is poor in the lower elevations and wet soils are common. Lakes and ponds are also prevalent in the low-lying areas, and wetlands cover over half of the lowland surface. Climatic conditions in the Beringia tundra reflect the transition from maritime to continental characteristics, as well as the latitudinal and elevational gradients. Permafrost is largely unbroken in the northern areas, especially on the Seward Peninsula, and exists sporadically in other parts of the ecoregion [10].

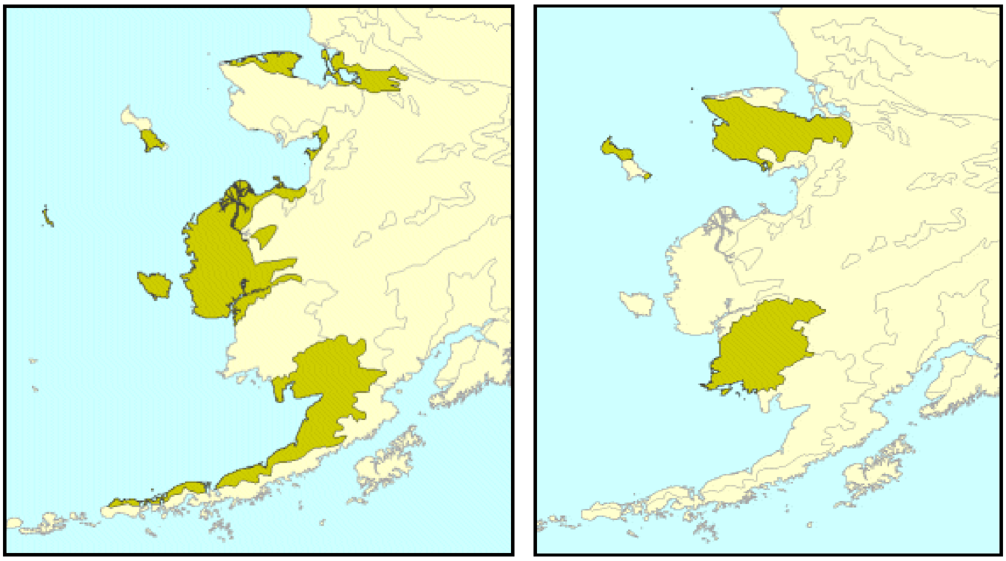

Figure 6. *Map of Beringia lowland (left) and upland (right) tundra [Source: 10].*

Since standing water is almost always present, communities consisting of sedge mats predominate the wet tundra flora. Peat ridges, drainage ways, and polygonal features provide better drainage upon which woody plants like white spruce, willows, alder, and paper birch occur. The fauna consists of spectacled eiders, ruddy turnstones, and black turnstones are common breeding birds in the lowland tundra portions of this Section. The rare Arctic loon breeds only in western Alaska and is characteristic of this area. The snowy owl is the major avian predator and, with the Arctic fox, preys on populations of Alaskan hares [11].

Wilderness in Alaska remains relatively intact with large areas of adjoining habitat. High conservation values are associated with the regions, particularly regarding the variety of breeding bird species. Substantial ecological research has been conducted in the region and adjacent oceans, providing certain data, information, and expertise that may prove critical to conservation work.

However, recovery from impacts along the Arctic Coast, as with many tundra ecosystems, is extremely slow, placing tighter constraints than are usual upon resource managers and conservation scientists. Development and resource exploitation is a major threat to the region, mining and road building are likely to continue more or less unhindered.

3.3 CURRENT THREATS TO THE ARCTIC ENVIRONMENT

The Arctic is home to many people and many distinctive cultures. The human presence has been an integral part of ecosystems across much of the

Arctic for millennia, a fact that must be recognized in efforts to understand and manage the region's "natural" systems and landscapes. (REF CAFF)

Heavily polluting activities in the North such as mining and oil development have damaged or devastated surrounding areas. Long-range pollution, in the form of heavy metals, persistent organic pollutants, radionuclides, and other substances, has reached every part of the Arctic. Some freshwater systems are stressed as a consequence of acid rain. A number of environmental contaminants are found at relatively high levels in some species but their long-term biological and ecological effects are as yet unknown. (REF CAFF)

A wide range of policy instruments will need to be utilised if both conservation and sustainable development in the Arctic are to be possible. Currently, the gravest threats to the Arctic environment are of transboundary origin. International co-operation is vital for substantiating Arctic environmental values and for safeguarding the sustainable development of these last pristine wilderness areas.

The main current threats to the Arctic environment are considered to be [EEA, WWF]:

- Habitat fragmentation, degradation, or destruction
- The potential for radioactive contamination
- Introduction of alien species and diseases
- Over-harvesting of biological resources
- Long-range pollution transport
- Climate change
- Ozone depletion, UV-radiation
- Cumulative impacts
- Persistent organic pollutants
- Oil pollution
- Tourism in vulnerable areas

4. ENVIRONMENTAL IMPACT ASSESSMENT

The following section is a summary of considerations and evaluations that have been done when assessing the impacts of the planned activities associated with the proposed expedition Beringia 2005.

The methodology follows to a large extent the Arctic Council's *Guidelines for environmental impact assessment (EIA) in the arctic* and the Council of Managers of National Antarctic Programs *Guidelines for Environmental Impact Assessment (EIA) in Antarctica*.

4.1 ENVIRONMENTAL PRINCIPLE FOR THE EIA PROCESS

According to the *Protocol on Environmental Protection*, all activities in the Antarctic region (south of 60°S) must be preceded by an EIA. Since a similar agreement for the Arctic region is lacking, Swedish expeditions to the Arctic will in most respects adhere to the intent of the *Protocol on Environmental Protection*.

That is, if the EIA indicates that a proposed activity is likely to have no more than a minor and/or transitory impact, the activity may proceed, provided that appropriate procedures, which may include monitoring, are put in place to assess and verify the impact of the activity.

4.2 LEGAL FRAMEWORK

The Arctic is not protected by the same rigorous set of international agreements as the Antarctic. All land areas and location of maritime boundaries in the Arctic fall under the sovereignty of one of the eight Arctic states. Therefore, national domestic laws contain the primary legal controls on the environment in the Arctic. However, international environmental laws and principles have achieved an increasing role in the Arctic.

Compliance with national laws and international agreements is the minimum level of environmental management. All activities during Beringia 2005 must be carried out in accordance with relevant national and international regulations and recommendations. The ships' Masters and Expedition Leaders are responsible for the compliance with laws and regulations.

An overview of treaties and agreements that adhere to the expedition is found in Appendix II.

4.3 SCOPE OF THE EIA

The issues covered by this EIA encompass parts having to do with the scientific programmes and SPRS logistic activities during Beringia 2005. The logistical activities do not cover transportation to and from the expedition in connection with rotation of scientists and crewmembers.

The EIA does not go into depth with impacts deriving from Oden since a comprehensive EIA was conducted in 1991 before the icebreaker's first scientific expedition in Arctic waters. The EIA was undertaken because of concerns about the effects of underwater noise, ballast waters, interference with marine mammals and exhaust emissions. For questions regarding the impact of Oden's operation in Arctic, please consult these reports [xx and xx].

The artist programme is not further analysed, since the primary analysis made of the programme showed that the resulting environmental impact was supposed to be negligible.

4.3.1 Definition of terms

The following terms are used in the impact assessment [ref comnap].

Cumulative impact:	The combined impact of past, present, and reasonably foreseeable activities. These activities may occur over time and space and can be additive or interactive/synergistic.
Direct impact:	A change in the environmental components that result from direct cause-effect consequences of interaction between the environment and outputs.
Impact:	A change in the value or resources attributable to a human activity. It is the consequence of an agent of change, not the agent itself.
Indirect impact:	A change in environmental components that results form interactions between the environment and other impacts (direct or indirect).
Mitigation:	The use of practices, procedure or technology to minimize or prevent impacts associated with proposed activities.
Output:	An *output* is a physical change (e.g. movement of sediments by vehicle passage, noise) or an entity (e.g. emissions, an introduced species) imposed on or released to the environment as the result of an *action* or an *activity*. Outputs can also be defined as by-products of the activity (or action) and can include emissions, dust, mechanical action on substrate, fuel spills, noise, light, electromagnetic radiation, wastes, heat, introductions of alien species, etc
Unavoidable impact:	An impact for which no further mitigation is possible.

4.4 IDENTIFICATION OF ENVIRONMENTAL OUTPUTS

The basic information is collected from scientists and personnel at the Swedish Polar Research Secretariat's Logistics Centre. All principal investigators for the projects have provided information in a logistic enquiry. In order to get detailed information about the sites, the secretariat has been on several reconnaissance trips to the areas that Beringia 2005 plans to visit.

4.4.1 Identification of environmental outputs from logistics

The logistical actions and activities from Beringia 2005 that potentially might result in an environmental impact have been identified and listed in table 1 below. A distinction has been made between direct and indirect impacts.

Table 1. *Identification of action/activities from beringa 2005 that might result in environmental outputs. Legend: X=direct impact (X)=indirect impact*

Action/activity	Identified outputs								
	Emission to air	*Emission to land*	*Emission to sea*	*Emission to water*	*Physical disturbance*	*Depletion of nat. resources*	*Disturbance of flora & fauna*	*Degradation of aesthetic values*	*Introd. of alien inv. species*
LOGISTICS									
Fuel usage and management	X	(X)	(X)	(X)		X			
Transportations	(X)				X		X	X	(X)
Chemical usage and management		(X)	(X)	(X)			X		
Waste and Sewage management		X	(X)	(X)		X			
Power & heat generation	(X)							X	
SCIENCE									
Sampling, collection of biota					X		X		(X)
Chemical usage and management		(X)	(X)	(X)			X		

4.4.2 Identification of environmental outputs from research projects

Through an enquiry, a summary of each project, description of methods and research areas as well as an individual self-assessment of the projects environmental impact has been done by the principle investigators (PI). The enquires made it possible to identify activities from the scientific projects that potentially might have an environmental impact, see table 1 above.

The environmental information from the research projects are found in Appendix III, and summarised in a few words below:

1. ***The biogeochemical cycle of organo-halogens in the high Arctic and along the Siberian shelf***
   Action/Activity: Air sampling, Chemical usage
   Impact: Minor

2. ***Bird migration, orientation and species diversity under polar conditions; the Siberian-American migration systems***
   Action/Activity: Radar tracking, Field observation, Blood and feather sampling of live birds, Bird faecal sampling, Chemical usage
   Impact: Minor

3. ***Marinkemiskt projekt (främst kolcykeln)***
   Action/Activity: Seawater sampling, Chemical usage
   Impact: Minor

4. ***Oceanografiskt projekt (fys & kem)***
   Action/Activity: Seawater sampling, Chemical usage
   Impact: Minor

5. ***A: Transport and fate of biogeochemically important constituents through arctic estuary-shelf slope systems and; B: The use of 231 Pa/230-Th ratio as particle flux tracer***
   Action/Activity: Seawater sampling, Sediment sampling, Chemical usage
   Impact: Minor

6. ***Evolutionary consequences of the Pleistocene glacial cycles; concerted versus independent response on arctic species***
   Action/Activity: DNA sampling from dead animals (Fur, Tissue, Blood, Faecal and Intestines)
   Impact: Minor

7. ***Linking eurasian and amerasian records to constrain the palaeoenvironmental and tectonic evolution of the Arctic Ocean***
   Action/Activity: Sampling of sediments onboard Healy
   Impact: Minor

8. ***Beringian terrestrial palaeoecology***
   Action/Activity: Limnic sediment sampling, Plant sampling
   Impact: Minor

9. ***Mammalian herbivore communities and their food plants; a comparative approach – Scandinavia and Kamchatka***
   Action/Activity: Field observations, Plant sampling, Faecal sampling
   Impact: Minor

10. ***Migration and evolution of arctic plants in response to past climate change***
    Action/Activity: Plant sampling, Chemical usage
    Impact: Intermediate

11. ***Museum collections and preparations of specimens***
    Action/Activity: Fish, birds and small mammals will be collected, Chemical usage
    Impact: Intermediate

12. ***Surface-water biogeochemistry and air-sea exchange of CO2 in the Bering Sea and Chukchi Sea***
    Action/Activity: Seawater and Ice sampling, Chemical usage
    Impact: Minor

13. ***Biogeographical pattern regarding the diversity, distribution and regulation of arctic willows and insects***
    Action/Activity: Plant sampling, Insect collection, Chemical usage
    Impact: Minor

14. ***Kvävefixering i växtsuccessioner under olika störningsregimer***
Action / Activity: Plant sampling, Soil sampling
Impact: Minor

15. ***Selective degradation of enantionmers of chiral organic contaminants in Arctic lakes and air-sea exchange and budget of organic contaminants in the Arctic ocean and adjacent seas***
Action / Activity: Seawater sampling, Ice and brine sampling, Limnic plankton sampling, Limnic sediment sampling, Marine sediment sampling, Air sampling, Soil sampling, Plant sampling, Faecal sampling, Chemical usage
Impact: Minor

16. ***Herbivory and plant biodiversity in an arctic environment***
Action / Activity: Field observations, Plant Sampling
Impact: Minor

17. ***Circumpolar transport and air-surface exchange of mercury after spring-time atmospheric surface layer mercury depletion incidences***
Action / Activity: Air sampling, Seawater sampling, Snow- and ice sampling, Chemical usage
Impact: Minor

18. ***Migration routes, fuelling and trans-oceanic flights of Arctic shorebirds***
Action / Activity: Field observations, Blood and feather sampling of live birds, Collection of birds
Impact: Minor

19. ***Förekomst av zoonotiska mikroorgansimer i Arktiska djurpopulationer***
Action / Activity: Blood sampling of live birds, Bird faecal sampling , Tick collection, Bacterial cultivation, Hazardous Waste generation
Impact: Minor

20. ***Arctic Alaska-Chukotka microplate***
Action / Activity: Field observations, Rock sampling
Impact: Minor

21. ***Marine biogeochemistry***
Action / Activity: Seawater sampling, Chemical usage, Hazardous Waste generation
Impact: Minor

22. ***Intraguild interactions – the role of mesopredators in the arctic ecosystem***
Action / Activity: Field observations, Faecal sampling, Prey remains (bone, tissue)
Impact: Minor

23. ***Dissolved organic matter (DOM) in the Arctic Ocean***
Action / Activity: Seawater sampling, Chemical usage, Hazardous Waste generation
Impact: Minor

24. ***Nutrients, suspended biomass and plankton in the upper waters of the Arctic Ocean***
Action / Activity: Seawater sampling, Marine plankton sampling, Chemical usage
Impact: Minor

25. ***Bird orientation at high geographic and geomagnetic latitudes***
Action / Activity: Field observations, Blood and feather sampling of live birds, Collection of birds, Hazardous Waste generation
Impact: Minor

26. ***Food, predation and UV as drivers for benthic-pelagic coupling in arctic freshwater systems***
Action / Activity: Lake water sampling, Limnic plankton sampling, Limnic sediment sampling
Impact: Minor

4.5 ANALYSIS OF ENVIRONMENTAL IMPACTS

The identified outputs have to be considered and their impact evaluated in the context of the environment they take place in. Examples of sensitive areas demanding particular attention are found in box 2.

Box 2. Areas demanding particular attention in the Arctic
(Source: Guidelines for Environmental Impact Assessment (EIA) in the Arctic)

Areas or sites of great sensitivity or unique geomorphological characteristics:

- permafrost terrains and insulating layers, unique permafrost land forms
- wet tundra
- coastlines
- thermoabrasion coastlines
- timberline forests
- large deltas
- soils and waters prone to acidification, in some cases alkalinization
- continental dunes
- ice-edges, leads, polynyas
- glacier rivers
- glaciers, eskers

Areas of special importance to wildlife:

- fish spawning and nursery areas
- denning areas for large predators and rearing areas for for other animals
- seal pupping areas
- marine mammal migration routes
- migrating and calving areas for moose and caribou
- nesting, rearing and staging areas for waterfowl and other birds

Areas with valuable, sensitive and representative biotopes:

- palsa bogs
- snowbed habitats
- eutrophic, calcareous tundra heaths
- tundra steps
- vegetation on scree slopes
- calcareous rock walls

Areas of spiritual, cultural and other socio-economic value as well as areas of special importance for traditional resource use:

- sacred and spiritual places
- burial grounds
- traditional trails, fishing or hunting campsites
- marine mammal harvest areas
- reindeer round-up sites

The degree of impact also depends upon their nature (i.e. type, extent, intensity, etc.) and the sensitivities and values of the surrounding environment. Following terms have been used for considering the impacts [X]:

Negligible:	No impact identified, environmental values not present.
Minor:	Impact is irregular and natural processes will recover within the season. The loss of the environmental elements would at the most have short time bearings on the local environment, e.g. immediate surrounding area of the field camps or around the waters flanking Oden.
Intermediate:	Impact is regular and natural processes will take years to recover. The loss of the environmental elements could have bearings on the regional environment, e.g. the Kamchatka peninsula, or effects have bearing on the planned research projects.
High:	Impact is permanent. The losses of the environmental elements have significant bearings for the overall environment in Arctic.

4.5.1 Emissions to air

Beringia 2005 will cause emissions to air from logistical activities due to the combustion of petroleum hydrocarbon fuels. The associated potential impacts from are increased concentrations of greenhouse gases and aerosols in the atmosphere, contributing to e.g. human induced climate change, acidification, and altering the physical and chemical properties of the local environment.

Main source of the emissions to air will originate from the internal combustion engines on Oden, but also from land transports, ancillary equipment such as Zodiacs, airborne transports as well as the use of generators and heaters operated for the field camps. Table 2 presents the estimated fuel usage calculated on the proposed operating time for ships, helicopters, vehicles and equipment used during Beringia 2005. Table 3 presents the calculation of associated air emissions that will be released to the atmosphere.

Table 2. *Estimated fuel consumption during Beringia 2005.*

Fuel	Fuel usage	Operating time	Total Consumption
Bunker oil (Oden)	40 tonnes/day	90 days	3600 tonnes
Marine diesel (Oden)	2 tonnes/day	50 days	100 tonnes
Petrol (Zodiac)	2 litres/hour		
Mobile diesel (generator)	5 litres/hour		
Jet A1 (Helicopter)			
Petrol (Tractors, ATW)			
Other (?)			

Table 3. *Estimated air emissions from Beringia 2005. Legend: EF= emissions factor (kg/l) Est.= Estimated emissions. Source: EPA, Sweden.*

Air pollutant	Oden		ATW		Generators		Helicopters		Total emissions
	EF (kg/l)	Est. (kg)	EF (kg/l)	Est. (kg)	EF (kg/l)	Est. (kg)	EF (kg/l)	Est. (kg)	Est. (kg)
Carbon oxides									
Sulfur Oxides									
Nitrogen oxides									
Particulate matter									

Biggest source of air emissions is bunker oil. The bunker oil purchased will meet specifications concerning lowest sulphur content. Emissions to air are expected to be transitory and dissipate as negligible concentrations along the expedition route around the field and camps. Hence, the associated environmental impacts are considered to be acceptable.

4.5.2 Emissions to land, seawater and inland water

Emissions to land and seawater will mainly result from the discharge of wastewater in areas where the natural conditions permits such discharges. Generated wastewater and pollutant loadings during Arctic Ocean Expedition in 1991 were 700 tons grey water, containing 25 kg phosphorus and 12 kg sodium meta silicates. No untreated black water was released from Oden.

According to the EIA for Oden from 1991, the occurrences of these emissions were demonstrably less than the carrying capacity of the receiving environment. Wastewater releases from the marine activities during Beringia 2005 will be about the same extent, and thus their impact is expected to be low and/or transitory.

Wastewater generation from the fieldwork during Beringia 2005 have been roughly estimated. Wastewater production in the field camps fluctuate a great deal, by using a model developed for the United States Antarctic Programme (USAP), each person at a remote location in Antarctica generates on average 6.9 litres of wastewater per day. Accordingly, pollutant loadings have been calculated using per capita loading factors developed by the USAP model for the field party of Beringia 2005. Results are shown in table 4.

Table 4. *Estimated wastewater from Beringia 2005 field party and associated pollutant loadings. Source pollutant loadings: NSA, USA.*

	Kamchatka	Anadyr	Alaska	Total
Person days in field				
Wastewater generated				
Suspended solids				
Biological Oxygen Demand				
Ammonia Nitrogen				

Wastewater from field parties will consist of sewage and grey water (containing fresh water and trace residues of soap, food particles, cleaning materials, and personal care products). Optimum wastewater management techniques will be implemented based on available resources (e.g., storage containers, cargo space) and could include a combination of discharge for greywater and containerization for urine and human solid waste. Wastewater may not be discharged to the tundra or inland waters. Thus, impact from wastewater releases to land from the field activities is expected to be low and/or transitory.

During the expedition fuel and other hazardous materials will be handled or transferred on a daily basis and in that way creating a potential for accidental releases. In general, accidental releases occur most often during equipment refuelling activities caused by mechanical failures or operator error. Quantity of accidental spills of fuel or chemicals are likely to be very limited and locally defined, associated impacts are therefore considered to be minor.

Accidental releases involving the catastrophic and irretrievable loss of equipment, fuel, other hazardous material, or wastes would result in a long-term impact unless the condition of the lost materials permits subsequent recovery. Since accidental releases are not planned, their frequency, magnitude, and composition are difficult to project in advance.

4.5.3 Physical disturbance of land

Fieldwork will occur on terrestrial areas. Physical disturbance (i.e., terrain alteration) of the ground will be a certain outcome resulting from the use of transport capabilities and installing research equipment on bare ground around the research sites.

Driving over bare-ground with motor vehicles has a markedly negative effect on soil and vegetation in the Arctic. The effects will lead to soil compaction and changed water infiltration rate. The active permafrost layer is damaged and vehicle tracks expose the ground to erosion. Soils are the basis of the terrestrial ecosystem. It is the substrate that supports the extant biological communities and is key to their survival. The degree of damage depends on the form and frequency of traffic and varies with soil type. Tracks "heal" to a very limited extent, a report from Norway showed that tracks made on Svalbard in the 1980's were almost unchanged more than twenty years later [15].

Hence, driving on bare ground on the tundra will be restricted. Local guides will be used that know the terrain and vehicles so that impact is minimised. However, it is difficult to assess the impact from vehicle usage, the activity is not planned by SPRS, hence the form and frequency are difficult to project in advance.

4.5.4 Depletion of natural resources

The welfare of human societies and all ecosystems is directly linked to a sustainable use of natural resources. The key elements are the utilization of natural resources at a sustainable level with a focus on minimizing depletion and the reduction in input of pollutants to these resources.

Reducing pollution and on the same time ensuring a safe working environment is an important issue for SPRS. Dangerous goods are substances that may pose a risk to health, property, or the environment while in transport, and/or are listed in IATA. Transport of dangerous goods is associated with particular risks because of the properties of the transported substances, being flammable, corrosive, etc. When shipping such substances, it is imperative to follow applicable regulations, and cargo securing is an extremely important safety measure that must always be performed correctly. The consigner has the primary responsibility to ensure that the dangerous goods are correctly classified, packed, marked and documented.

Hazardous materials shall be stored with secondary containment, and spill clean up materials available close to the working space in order to prevent pollutants entering the environment. An overview of projected chemical usage from research projects is found in table 5. Impact on receiving environment from chemical usage is considered to be low since the risk of pollution from a chemical spill is very limited and do not contain large quantities.

Table 5. *Projected use of chemicals in Beringia 2005's research programme.*

Chemical	Quantity	Comment
Polonium (209 Po)	0.1 Pc	Licensed Isotopes used for samples, surplus brought back to be retrograded in Sweden.
Tritium (H3) marked aminoacids and sugars	< 10 mCi	Licensed Isotopes used for samples, surplus brought back to be retrograded in Sweden.
Carbon 14	<10 mCi	Licensed Isotopes used for samples, surplus brought back to be retrograded in Sweden.
Formaldehyde	26 l	Absorbing material in proximity of working place. Hazardous waste.
Mercury	10 g	Environmentally hazardous
Tin chloride	1 kg	
Lugol's solution	1 l	
Sulfuric acid copper(2+) salt (1:1)	60 g	Environmentally hazardous
Antimony Natrium tartrate	20 g	
Benzenesulfonamide, 4-amino-	130 g	
1,2-Ethanediamine	100 g	
Molybdic acid, diammonium salt	160 g	
Methane, dichloro-	50 l	
Acetic acid, trichloro-	5 l	Environmentally hazardous
Pentane	2 l	Environmentally hazardous
Magnesium chloride oxide	1.5 kg	
Ammonium chloride	250 g	
Sodium hydroxide	1.1 kg	
Hydrochloric acid	30 l	
Sulfuric acid	2 l	
Phosphoric acid	3.5 l	
Nitric acid	3 l	
L-Ascorbic acid	250 g	
Propanoic acid	5 l	
Ethandioic acid	500 g	
2-Propanone (Acetone)	13 l	
Ethanol	40 l	
Methanol	10 l	
Methane, sulfinylbis- (DMSO)	7 l	
Sulfurous acid, disodium salt	200 g	
Potassium iodide	250 g	
Manganese chloride (MnCl2), hyd-rate	2 kg	
Phenol, 2-methoxy-4-methyl- (Creosol)	100 g	
Sodium chloride	3.5 kg	
Standarder och standardlösningar		
Nitrogen	500 l	200 atm
Helium	130 l	200 atm
Argon	400 l	200 atm
Reference/standard gases for GC	80 l	200 atm
CFC standard gas for GC	14 m3	

4.5.5 Disturbance of flora and fauna

As for the marine flora and fauna, the issue were considered in the EIA produced for Oden 1991, and it was concluded that the Oden's impact on flora and fauna is minor or negligible. Disturbance of the terrestrial vegetation cover will be a certain outcome resulting from driving on bare ground. The effects are manifested as direct damage to vegetation which is torn and crushed, biomass is usually markedly reduced, the species total drops and composition changed.

Exportation and importation of genetic resources will be done through sampling of plankton (in water samples) and macro flora and fauna that will be brought back to Sweden for later analysis. No rare or protected species will be sampled. The numbers of samples are considered to be low and will have no bearings on the long time effect on population or ecosystem level of the proposed species. An overview of sampling is found in table 6.

Table 6. *Projected sampling of biota during Beringia 2005.*

Project title	Export/Import of genetic resources
Bird migration, orientation and species diversity under polar conditions; the Siberian-American migration systems	Spillningsprov från fåglar för födovalsbestämning
Leg1: Marinkemiskt projekt (främst kolcykeln); Leg3: Oceanografiskt projekt (fys & kem)	(plankton)
1. Transport and fate of biogeochemically important constituents through arctic estuary-shelf slope systems and 2. The use of 231 Pa/230-Th ratio as particle flux tracer	(seawater and sediment)
Evolutionary consequences of the Pleistocene glacial cycles; concerted versus independent response on arctic species	Insamlig av DNA från djur som avlivats, hittats självdöda, hårprover samt spillning.
Beringian terrestrial palaeoecology	(peat and lake sediment), Växter, (Angiospermae)
Mammalian herbivore communities and their food plants; a comparative approach – Scandinavia and Kamchatka	Växter (Fanerogamer) i torkat skick - några få kg per lokal, Spillning i torkat skick - ca 500 g per lokal
Migration and evolution of arctic plants in response to past climate change	Kärlväxter (Fanerogamer och Kärlkryptogamer)
Plats för konservator; insamling till Naturhistoriska riksmuseet	Hela individer av Aves, Mammalia, Pisces
Surface-water biogeochemistry and air-sea exchange of CO2 in the Bering and Chukchi Sea	(seawater)
Biogeographical pattern regarding the diversity, distribution and regulation of arctic willows and insects	Växter (blad) och insekter (Salicaceae, Hymentoptera: Tenthredinidae)
Kvävefixering i växtsuccessioner under olika störningsregimer	Jordprover, Växtdelar (Leguminosa, Alnus, Myrica)
Selective degradation of enantionmers of chiral organic contaminants in Arctic lakes and air-sea exchange and budget of organic contaminants	(Vatten, havsvatten, sediment, jord, plankton, spillning) växter
Herbivory and plant biodiversity in an arctic environment	Kärlväxter (Fanerogamer och Kärlkryptogamer)
Circumpolar transport and air-surface exchange of mercury	(vatten, snö, is)
Migration routes, fuelling and trans-oceanic flights of arctic shorebirds	blod, fjädrar, spillning (ett prov per fågel, ca 1000 prover)
Aviär influensa, enterala bakterier och fästingburna infektioner i Arktis	spillning, blod, isolerade bakterier (ca 1000 prover)
Intraguild interactions – the role of mesopredators in the arctic ecosystem	Faeces and prey remains, i.e. bones and tissue
Dissolved organic matter (DOM) in the Arctic Ocean	Vatten, och dess lösta föreningar/kolloider/mikrober
Nutrients, suspended biomass and plankton in the upper waters of the Arctic Ocean	(vatten - phytoplankton, zooplankton)
Bird orientation at high geographic and geomagnetic latitudes	Blod, fjädrar, levande fåglar - (Oenanthe oenanthe, Ryssland) or (Zonotrichia leucophrys; Alaska) or (Calidris sp.)
Food, predation and UV as drivers for benthic-pelagic coupling in arctic freshwater systems	vatten, plankton (Crustacea)

The terrestrial research and logistic activities will also produce noise that might have an effect on wildlife. Logistics recommendations include minimizing disturbance to wildlife by managing the type and frequency of logistical support. The disturbance is transitory and will probably not have any significant impact.

4.5.6 Degradation of aesthetic and cultural values

Most of the planned expedition route for Oden and terrestrial research sites lies far from known traditional hunting grounds, travel routes, or living areas of indigenous people. However, in Kamchatka (especially around Ossora) and Chukotka extra awareness is needed for movement in the field. Consultation with local guides and park rangers shall be done in order not to interfere with traditional hunting/fishing grounds and travel routes [RAIPON].

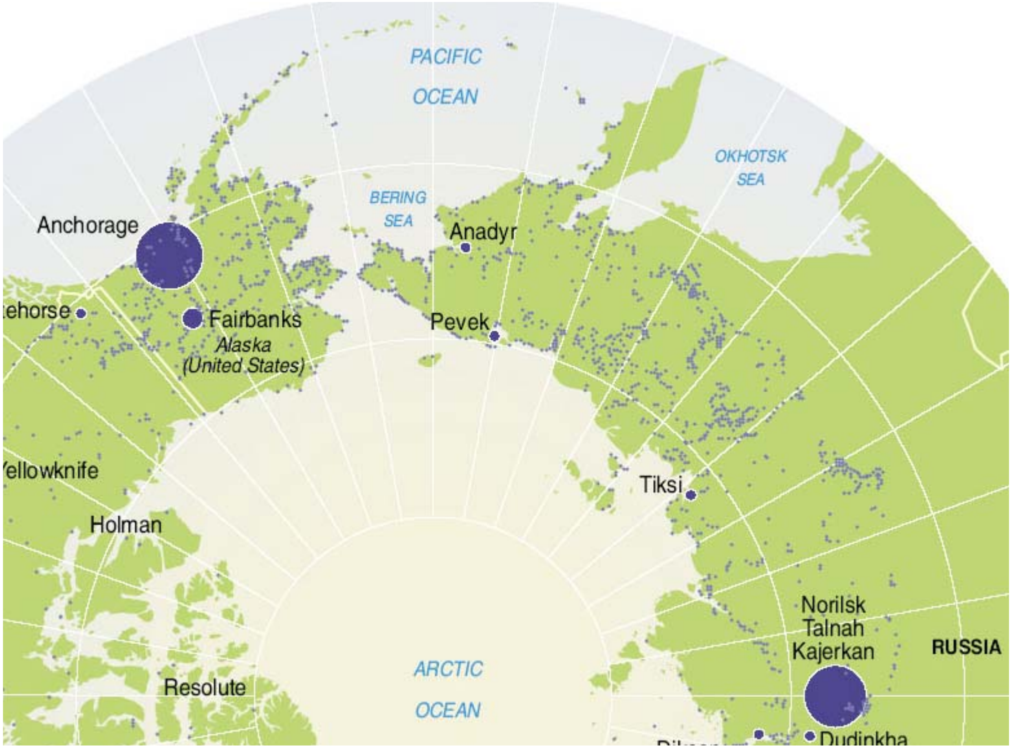

Figure XX. *Indigenous settlements in the Arctic. Settlements are usually located in resource-strategic positions, with territoriality and social networks adapted to the movements of reindeer/caribou or the seasonal abundance of sea mammals. Most indigenous settlements are small, consisting of only a handful of people. Notice that many dots simply represent seasonal settlements and camps and not established communities [Source VAT].*

Potentially Beringia 2005 may leave behind signs of human presence in the visited areas, e.g. blown away waste or tracks from vehicles, which will negatively affect the aesthetic values of the wilderness in the local area. Decommissioning of the research sites involves restoring the site to its original condition to the maximum extent practicable. It is difficult to project the impacts sine SPRS ambition is not to leave any signs behind of activities taking place during Beringia 2005.

4.5.7 Introduction of alien invasive species

Invasive alien species are non-native species that are introduced deliberately or unintentionally outside their natural habitats where they become established, proliferate and spread in ways that cause damage to both the environment and human interests. Introduction of alien invasive species is recognized as one of the greatest biological threats to the environment and economic welfare of the planet []. Accidental introductions of non-native species it is not possible to project in advance.

4.5.8 Cumulative impacts

In the Arctic, cumulative impacts are of special concern because of the sensitivity of the area and the long recovery times. Research expeditions are transient and low in frequency for the projected geographical areas covered by Beringia 2005.

The research sites have been carefully selected since one of the interesting scientific points is that they are pristine. Emissions to air and land will add to the cumulative effects. Although potentially detectable on a short-term basis, the resulting emissions are not expected to accumulate to levels that would alter the physical and chemical properties of the terrain and create adverse environmental impacts.

The scientific programmes are not considered to result in outputs that can contribute to any cumulative impacts. Hence, cumulative impacts on the marine and terrestrial environment are considered as negligible, any effects being less than minor or transitory. However, it is not known how long it will take eventual fuel spills, tracks from vehicles or eventual remains of spilled wastewater etc., to be degraded.

4.6 CONSIDERATION OF ALTERNATIVES

The EIA process shall always assess the consequences of alternatives to planned activities. This is especially important when the planned activities might produce impacts in especially sensitive areas. The current EIA describes possible alternatives based on the conditions likely to prevail during Beringia 2005.

4.6.1 No action alternative

The zero alternative entails no activities being carried out in the area, which would be the case if Beringia 2005 is cancelled. This alternative would have no direct consequences for the environment.

However, since one important goal of the expedition is to understand processes involved in climate change, cancelling Beringia 2005 would lead to the loss of an opportunity to scientifically collect and documenting important data.

Consequently, Beringia 2005 will increase general understanding of certain parameters important for the understanding of processes behind global change and the Earth System. Indirectly the expedition will probably lead to a positive effect on the environment through the researchers making scenarios for the likely future impacts on the global environment based on scientific results from Beringia 2005.

4.6.2 Alternative locations

One of the overall objective of SWEDARCTIC is to contribute to a better understanding of the Arctic influence on the world's climate and environmental systems. This is a wide-range task that covers almost all fields of science and engages roughly 200 Swedish scientists involved in polar research. The research is not possible to conduct elsewhere than in the polar areas.

4.6.3 Alternative planning

The terrestrial research has the aim to cover a large geographical area in a single season. Therefore it is not possible with another time plan. Also, the terrestrial research sites have been carefully selected, weighing scientific values against environmental and social concerns, aesthetic and cultural values technical feasibilities and logistical constraints.

5. MITIGATIONS

In order to avoid and minimise local impact on sensitive areas mitigations and good operational routines are needed. A standard environmental risk analysis approach has been used to identify the activities that have the highest potential impact on the receiving environment, the analysis is presented in Appendix IV. From an environmental point of view, the activities that need most consideration during Beringia 2005 are related to:

- Chemical usage and management
- Fuel Usage and Management
- Waste and Sewage management

5.1 Chemical usage and management

During expedition to the polar areas, it is anticipated that chemicals and other hazardous materials would be handled on a daily basis thereby creating a potential for accidental spills. The risk of an accidental release to the Arctic environment may also be realized from the catastrophic failure of a fuel drum, other chemical storage container, or a vehicle used during field trips.

Logistics recommendations include planning for safe handling of chemicals and hazardous materials, transportation of dangerous goods, and arranging appropriate transportation to the research sites and using reliable vehicles to minimize opportunities for spills and leaks [FKH].

The containers used for chemicals and hazardous material on Beringia 20005 must be structurally compatible with their contents and able to withstand the physical and environmental conditions to be encountered during the fieldwork. Containers must be suitable for use in polar conditions and compliant with industry standards designed to protect hazardous material containers exposed to handling and transportation. All containers must be carefully labelled. Hazardous materials are preferably stored with secondary containment.

In the event of an accidental release, specific response actions and resources will be available to facilitate cleanup and removal of contaminated media to the maximum extent practical. All participants are instructed to clean up spills immediately, observing occupational and health precautions. Spills will be absorbed with inert material (e.g. vermiculite, sand or earth), and then placed in suitable containers and carefully labelled. Containers will be retrograded in country of origin. All accidental releases shall be documented and reported to the Expedition Leader.

PIs are responsible for ensuring that the disposal of dangerous goods and hazardous substances is carried out in accordance with existing international and national regulations. Any person who is required to arrange transport of dangerous goods and hazardous substances in a vehicle is responsible for ensuring that companies hired for transport of dangerous goods are suitably qualified and hold the appropriate licence for carrying out the transport. All PIs must also be familiar with and abiding by the Swedish requirements for transport of hazardous substances.

Oden crew are responsible for ensuring that appropriate fire protection equipment of the type and size stipulated by the local authority or current standards is kept and maintained in the vicinity of the location where dangerous goods/hazardous substances are held. Such equipment must be readily accessible, and staff trained in its use. All entries and hallways should be kept free of obstacles at all times.

5.2 Fuel Usage and Management

In general, accidental releases occur most often during equipment refuelling activities caused by mechanical failures or operator error. In the case of any oil spill, after the safety of personnel is ensured, an initial assessment of the spill should always be made. The health and safety of personnel is paramount in the case of an oil spill.

The general response strategy is to contain and recover oil spills where practical. As much oil as possible should be removed immediately after the spill, and any remaining oil is left to degrade naturally. The use of dispersants and burning at the site is not allowed, and a large-scale clean-up operation may cause more environmental damage than the oil itself.

Emergency spill response actions should not be undertaken in extreme weather conditions or during periods of darkness, unless the situation has been fully assessed by the expedition leader and deemed safe. Inhalation of hydrocarbon fumes can cause headaches and nausea: these are short-term effects. For spills of more than 200 litres, clean-up personnel should consider using facemasks, if such are available, until the fumes have disappeared. Fuel and oil can be a skin irritant. Severe reactions can lead to dermatitis. If possible, clean-up personnel should wear rubber gauntlets to protect hands and arms during clean-up operations.

5.3 Waste and Sewage management

Logistics recommendations include minimizing waste generation and planning for safe handling of hazardous wastes. Biological degradation is a slow process in the Arctic due to the cold and dry climate; all biodegradable products should therefore be treated as non-biodegradable.
As a general rule, the less waste produced the less waste needs to be handled and disposed of. Waste disposal has both environmental and financial costs that can be reduced by minimising the waste costs that can be reduced by

minimising the waste volume. Operation procedures focus on storage, handling, and documenting hazardous waste, solid waste, and wastewater as necessary. Field camp design principles minimizing the size, number of structures, and footprint of the camp, while designing space for proper storage and separation of waste [FCH].

SPRS staff will handle all waste, both at Oden and in field camps, in accordance with the waste management systems for the expedition. All waste, sludge etc. will be discharged ashore for later destruction. All hazardous waste/contaminants must be sorted, properly packed, sealed and labelled according to existingregulations. Liquid waste is collected to proper containers i.e. bottles or plastic cans.

All radioactive material must be returned to the country of the research project's origin for proper disposal. All science personnel are to ensure that, if possible, all radioactive material is returned packaged in the same container as it was transported to Antarctica in, or that suitable containers (polythene bags, polydrums, etc.) are brought along for this purpose.

All waste shall be removed at the end of the expedition unless prevented by a weather-related emergency. Decommissioning of the field camps involves restoring the site to its original condition to the maximum extent practicable. The camp leader shall make prior leaving the site, an ocular inspection of the field camp area. Inspection is looking for accidental releases, and that all designated pollutants and wastes are removed. All spills must be documented and reported to the Expedition Leader.

5.4 Other

Environmental awareness
A key phrase in all activities in the Polar Regions is "protect the environment". The polar environment is often in itself very severe, and plants and animals often live at their (climatic) distributional limits. A small disturbance may destroy what has taken hundreds or even thousands of years to build up (e.g. moss and lichen communities), or even cause irreparable damage. You must therefore always give a little extra thought to what you are doing when visiting the Polar Regions [FKH].

Underwater noise
Polar environments are naturally noisy areas. However, the vessel captain is required to be familiar with environmentally sensitive areas in the sailing area, and is to exercise special caution in such areas.
Introduction of invasive alien species

In view of the increasing recognition of the risk caused to Arctic values by the introduction alien invasive species, practical measures need to be identified and implemented to avoid any accidental introductions.

There will be no exchange of ballast water from Oden during the Arctic operations, since this is considered to be the primary routes for introduction of marine species. For terrestrial researchers, filed clothing and boots may carry species or seeds non-native to the areas they are visiting. Preventative action of goods and people will have to include actions taken at points of departure (airports, ports, field camps etc.) such as equipment, boot and clothing decontamination, a ban on the landing of viable seed and fungal products from Oden to ashore and the phytosanitary treatment of timber (including solid wood packing material) to be taken ashore from Oden.

6. MONITORING

There is no need for a specific monitoring programme for Beringia 2005. General environmental data will be collected in order to follow up the impacts from the expedition on identified environmental values. Suggestions for data to be collected are:

Data	Comment
Tonnes carbon dioxide released	Measure emissions to air from the combustion of fossil fuels
Accidental release of chemicals measured in litres	Measure eventual pollution of natural resources
Solid and hazardous waste measured in cubic metres	Waste management
Photo documenting all sites before and after	Documenting eventual physical disturbance of land

7. GAPS IN KNOWLEDGE AND OTHER UNCERTAINTIES

The current understanding of many aspects of Arctic biology and ecology is relatively poor. The identification and classification of Arctic species, especially invertebrates and microorganisms, is at a rudimentary stage. Ecological processes that govern life in Arctic soils, in the Arctic Ocean, and at the ice edge are only beginning to be understood. Information on the status and trends of Arctic fauna is fragmentary at best, and almost entirely non-existent for flora [CAFF].

Advances in understanding of Arctic ecology often lead to more and more difficult questions. Much more monitoring is required to track trends in basic environmental parameters in the Arctic. More research is needed to document the species found in the Arctic and their genetic diversity, the ways that species interact locally and across ecosystems, and the ways that species interact with and respond to the physical environment [CAFF]. Access to and logistics in remote Arctic areas are a major challenge to researchers. New techniques, including remote sensing, and further studies will shed light on these critical areas.

Knowledge of the environment will never be sufficient to accurately predict the exact impacts of a project. Nonetheless, the limits of current knowledge must be recognized before potentially harmful development is undertaken. We must tread carefully where the consequences of our actions cannot be foreseen.

8. CONCLUSIONS

The expeditions activities considered having potential for environmental impact has been identified. In general, all environmental outputs resulting from Beringia 2005 are considered to be important, reflecting the susceptibility of the environment from human activities in the Arctic. However, in the context of this initial environmental evaluation, assuming that activities take place in the scale as planned, the associated environmental impact is considered to be relatively low and reversible, i.e. at most the outputs from the expedition might only have bearings on the local environment on a short time scale.

The logistics activities connected with Beringia 2005 will be relatively limited, as the planned scientific programmes will only entail minor logistics activities (exception made for Oden itself). Impacts from the identified outputs have been assessed to have no more than a minor or transitory impact. Transportations will however produce emissions, and Oden will be the major source of air pollution. However, air emissions resulting from the combustion of fuel during Beringia 2005 are not expected to adversely impact human health or the receiving environment. Therefore, impacts from air emissions are considered to be negligible. Disturbance of landforms from driving on bare ground is the one impact that needs to be restricted. The situation depends on the situation and prevailing circumstances, and the expedition leader must give prior permission to all use of vehicles in the field.

Cumulative impacts on the marine and terrestrial environment are considered as negligible, any effects being less than minor or transitory. Since the planned expedition route lies far from the traditional hunting grounds, travel routes, or living areas of any indigenous people, Beringia 2005 is unlikely to interfere with the interests of indigenous people.

To sum up, activities and actions during Beringia 2005 are likely to have less than minor or transitory impacts on the receiving environment. Therefore, the SPRS concludes that there are no reasons why the expedition should not be carried out as planned.

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APPENDIX I MAPS OF PROPOSED RESEARCH SITES

APPENDIX II LEGAL FRAMEWORK

APPENDIX III ENVIRONMENTAL RISK ANALYSIS

APPENDIX IV SCIENTIFIC PROGRAMMES ENQUIRY