Chapter 29 NATO Advanced Research Workshop

Logistics for Future Jan Mayen Island Research

Results from NATO Advanced Research Workshop

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Abstract: A NATO Advanced Research Workshop explored the possibility of establishing an international station for multidisciplinary research on Jan Mayen, a remote Norwegian volcanic island situated in the Nordic Seas. Twenty two scientists from different disciplines shared opinions and were informed by six governmental representatives from Norway. Following the discussion of scientific options, the participants agreed that the infrastructure that may be evacuated when a Loran-C station expires, may serve research of local, regional, hemispheric and Global importance. The buildings should be maintained during the International Polar Year 2007-08 and in the years to follow. Recommendations were made with regard to scientific priorities and logistics for support from Norway and for operations on the island itself.

Key words: volcanology, climate change, thermohaline circulation, marine ecosystem, island ecology, biogeography, living resources, cultural heritage

1. INTRODUCTION

A NATO Advanced Research Workshop was organised in Oslo, Norway, 11-15 November 2003 to perform a feasibility study on whether existing infrastructure on Jan Mayen Island may be used as an international research station for multi-disciplinary purposes. One of the incentives was that the

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Loran-C navigation system is outdated and may be closed down, leaving a number of buildings unoccupied (Fig. 1). This situation created public and governmental concern (Anon. 2003, Tviberg 2004) and an interest in scientific research as a relevant future activity on the island was expressed.

To identify scientific problems that could be addressed by research activities on Jan Mayen and its oceanic surroundings, the participants were carefully selected according to their scientific training and experience (Table 1). Some were highly experienced from previous polar fieldwork and able to address particular Arctic problems that could be solved by adding observations from the Jan Mayen area, or that were unique in an Arctic context. Others were selected for their particular expertise, and were asked to identify more universal scientific problems that could improve the understanding within their scientific field by making observation on or at the island.

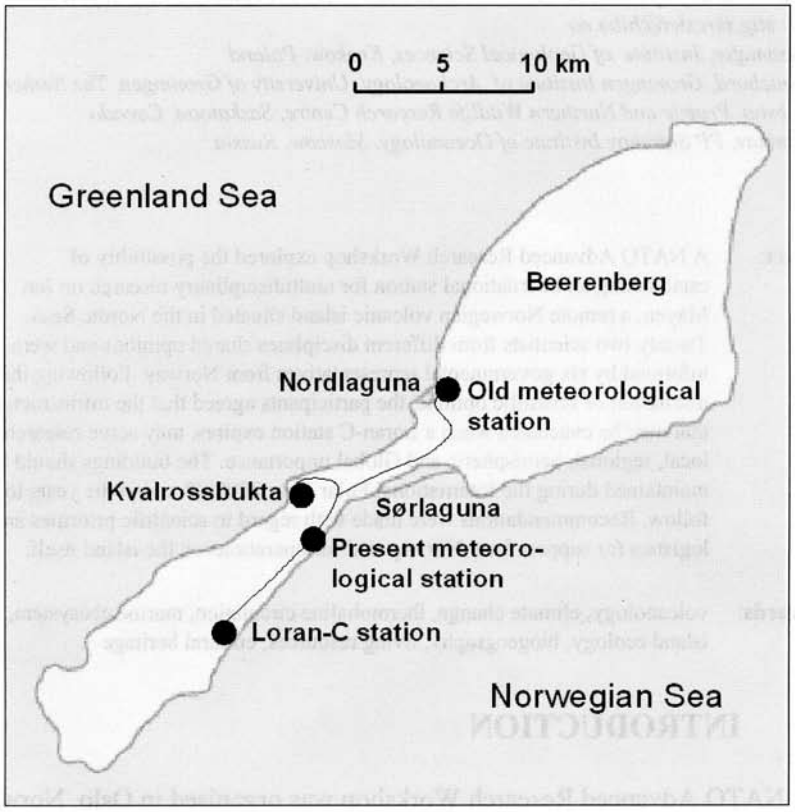

Figure 1. Jan Mayen Island with some place-names and the roads (curved lines) that interconnect maintained infrastructure. Nordlaguna and Sørlaguna are the two largest lakes on the island.

Table 1. Key participants in the NATO Advanced Research Workshop on a Joint International Scientific Observation Facility on Jan Mayen Island, Oslo 11-15 November 2003. *) Countries that are now full members of NATO. **) Co-Directors.

NATO Country Participants		Partner Country Participants	
Canada	Hobson, Keith A	Estonia*	Vana, Marko
	Rouvinen-Watt, Kirsti	Lithuania*	Stankunavicius, Gintautas
Germany	Hirche, Hans-Jürgen	Poland*	Birkenmajer, Krzysztof**
Netherlands	Hacquebord, Louwrens		Glowacki, Piotr
Norway	Barr, Susan		Piechura, Jan
	Gabrielsen, Geir W		Węslawski, Jan M
	Gulliksen, Bjørn	Russia	Byshev, Vladimir I
	Hagen, Jon OM		Klyashtorin, Leonid B
	Skreslet, Stig**		Melnikov, Igor A
United Kingdom	Shimmield, Graham B		Romanov, Vladimir F
	Walne, Anthony W	Ukraine	Kyyak, Volodymyr G

During one of the sessions, the invited scientists were provided with back-ground information from Norwegian governmental bodies involved in national administration and management (Table 2).

In their talks and in a number of working groups and plenary discussions the invited specialists identified scientific problems and observation methods potentially applicable to Jan Mayen research. They identified features unique to Jan Mayen and referred to its isolated position as an asset in large-scale local, regional, hemispheric or Global research. The present account is an edited version of group reports and notes made during the NATO ARW discussions.

Table 2. Governmental representatives providing information to the NATO Advanced Research Workshop on a Joint International Scientific Observation Facility on Jan Mayen Island, Oslo 11-15 November 2003.

Name	Affiliation
Bjørge, Arne	Institute of Marine Research, Bergen
Hov, Øystein	Norwegian Meteorological Institute, Oslo
Hubert-Hansen, Jan P	Norwegian Directorate for Management of Nature, Trondheim
Orheim, Olav	Norwegian Polar Institute, Tromsø
Skagestad, Odd G	Norwegian Ministry of Foreign Affairs, Oslo
Tviberg, Leif K	Norwegian Ministry of Fisheries, Oslo

2. GENERAL INCENTIVES

Jan Mayen Island attracts scientists from different fields of science (Skreslet 2004a). They often search for the unknown that may be revealed as unique in such remote places. This is a legitimate scientific driving force involving the need to gain new knowledge and understanding of complex systems.

The geographical isolation from all continents makes Jan Mayen unique. It represents a barrier for immigration of species, not only for terrestrial plants and invertebrate animals, but also for sessile marine invertebrates that only spread to new places by planktonic larvae. Human presence and other effects of anthropogenic activities may have opened the door for increased immigration of alien species, but the inaccessibility of Jan Mayen's shores and the risks of landing have restricted even that to a minimum. That may now be changing, because of the greater mobility of tourists travelling by cruise ships and seagoing private yachts.

There is an increased scientific awareness of decreasing biodiversity and the need for protection of nature, as well as our cultural heritage. It goes beyond the interest of individual scientists and is a growing political concern for nations that manage the heritage of the commons. The need to document a particular object or interest calls for the application of particular methods that have been developed by different scientific disciplines. However, the uniqueness of Jan Mayen is not just a conglomerate of results from random human impact, but also an effect of natural processes that are particular to the island and due to its geographical position.

The island is coupled to atmospheric circulation that makes the North American continent rather than Eurasia a source of direct atmospheric influence (cf. Skreslet 2004a, Vana 2004). On the other hand, it has a unique geographical position in relation to oceanic water movements from two directions (Piechura 2004). It is situated at the terminal ends of both the outflow of polar water from the Arctic Ocean and the northbound flow of Atlantic water. Jan Mayen is also positioned where Greenland Sea Deep Water is generated (Fig. 2). Thus, the island sits on geological structures at the proximal end of the World Ocean's Thermo-Haline Circulation (Skreslet 2004a) that is one of the processes that has to be studied to generate a universal understanding of Global climate, both on short- and long-temporal scales.

Each particular feature that is related to Jan Mayen Island, whether it is local, regional or Global, calls for disciplinary science. Disciplines may document information that seems important only to the specialist, but they also contribute to the understanding of coupled processes that are important both to the ecologist and the public at large.

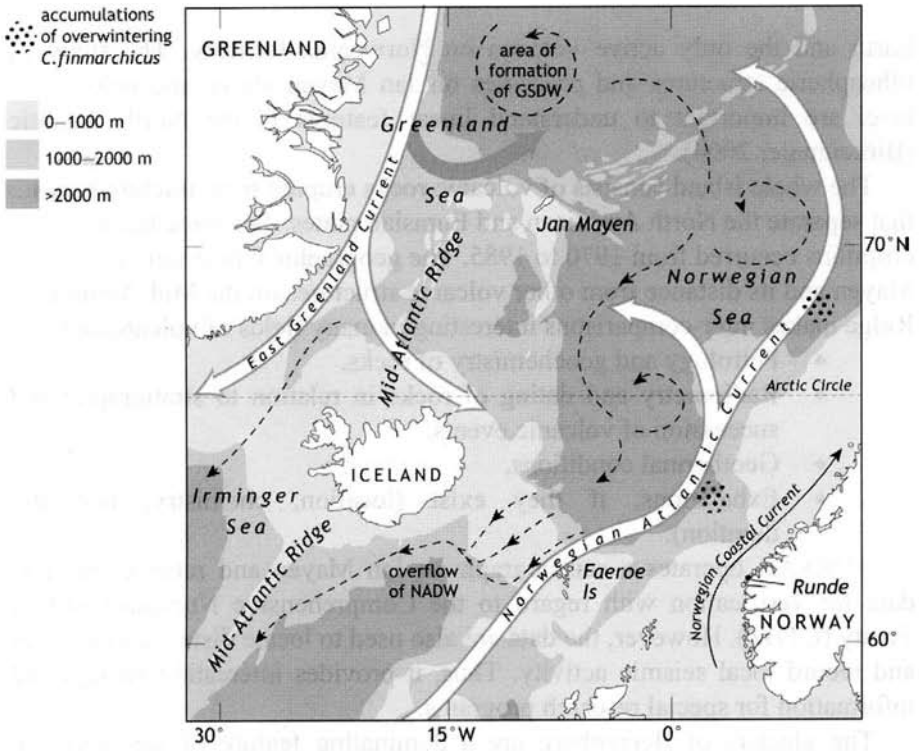

Figure 2. Jan Mayen Island in relation to bottom topography and currents in the Nordic Seas Basin. Unbroken arrows: surface currents. Dashed arrows: flows of Greenland Sea and North Atlantic Deep-Water. Two important wintering habitats of *Calanus finmarchicus* are indicated (Golmen and Skreslet 2004).

At present rather few scientific disciplines have been applied on Jan Mayen Island and in its shelf waters. Most have been allowed access for only brief periods. The knowledge of Jan Mayen biota and signs of past and present influence is therefore very incomplete (Gabrielsen *et al.* 1997).

3. SOME DIMENSIONS OF JAN MAYEN SCIENCE

3.1 The Geological Perspective

Beerenberg that rises 2277m above sea level is the dominating geological structure on Jan Mayen. It is the northernmost active subareal volcano on

Earth and the only active volcano on Norwegian territory. The study of lithospheric structures and processes on Jan Mayen above and below sea-level are important to understand linear features in the North Atlantic (Birkenmajer 2004).

The whole island consists of volcanic rocks erupted from fracture zones that separate the North American and Eurasian plates. The three latest eruptions occurred from 1970 to 1985. The geographical position of Jan Mayen and its distance from other volcanic structures on the Mid-Atlantic Ridge makes inter-comparisons interesting in many fields of volcanology:

- Petrology and geochemistry of rocks.
- Radiometry and dating of rocks in relation to stratigraphy and succession of volcanic events.
- Geothermal conditions.
- Exhalations, if they exist (location, chemistry, intensity, duration).

NORSAR operates a seismograph on Jan Mayen and receives seismic data for verification with regard to the Comprehensive Nuclear-Test-Ban Treaty (CTBT). However, the data are also used to locate distant earthquakes and record local seismic activity. Thus, it provides interesting background information for special research programs.

The glaciers of Beerenberg are a dominating feature of the Nord-Jan landscape (Hagen 2004). A complete understanding of the geomorphology will require:

- Studies of glacial deposits and the succession of their forms, supported by radiometric dating.
- Positioning measurements of advances and retreats of glaciers.

The permafrost on Jan Mayen probably varies in distribution and thickness due to different dynamic forcing factors like glaciological effects on soils, effects of regional and local climate, and volcanic activity.

Human activities on Jan Mayen have not been seriously endangered by volcanic activity or earthquakes (Barr 2004b). However, to be prepared for potential hazards (Birkenmajer 2004), some studies should be put on the agenda for future research:

- Evaluation of historical data in a geological context.
- Identify locations that may represent danger due to fault lines, avalanches and lahars.
- Calculation of risks related to future earthquakes, eruptions, and fumes.
- Planning of emergency actions based on predictions.

3.2 Global Geophysical Connections

Models that simulate atmospheric circulation in the Arctic are calibrated against meteorological data in crucial geographical points of interaction. Jan Mayen is positioned in an area where Arctic air meets air that blows in from the North Atlantic. The dynamic processes that results in this area of interaction reflects those in the North Polar region as well as forcing factors located at lower latitudes. Meteorological observations from Jan Mayen (Hov 2004) are therefore important for the understanding of geophysical processes on the northern hemisphere. Historical time series that document the variability of such processes are of importance to the calibration of numerical models developed for scientific simulation studies or for prognostic service. The validation and continuous refinement of such models needs access to standard meteorological data and special test parameters from Jan Mayen would be highly appreciated by the international community of meteorological scientists (Romanov 2004).

There are few meteorological stations in the Nordic Seas. Observations from Jan Mayen are therefore very important in the observation of atmospheric pressure gradients that define the weather in northern Europe (Stankunavicius 2004). The reliability of long-term weather forecasting will rely on analyses that take into account oceanographic forcing of atmospheric processes. Long-term oceanographic observations in the Barents Sea have proved to be of great interest in studies of atmospheric processes (Byshev *et al.* 2004). Similar studies in Jan Mayen waters would be of equal value.

Jan Mayen has a key position in relation to two water masses of Global importance (Piechura 2004). Its north-western side is exposed to the surface outflow of fresh water and sea ice from the Arctic Ocean, while its south-eastern side is exposed to inflow of Atlantic surface water. Thus, the two sides represent different regimes of air-sea interaction that influence the local and regional climate.

Seasonal and inter-annual changes in the advection of Arctic and Atlantic water cause the stratification and turbulence of the lower atmosphere to vary. Some changes are recorded by precipitation stored in the ice-cap of Beerenberg that rises 2277m. The base of the volcano is influenced by temperate and humid air. Radiation of heat from the top of this layer causes condensation of vapour, which results in cloud and fog formation that is a dominant feature of the island and its surroundings. The resulting decrease in solar radiation at lower altitudes causes abnormal ablation, i.e. reduced melting of glaciers at altitudes of 200-400m (Hagen 2004). On the other hand, the clouds reduce the radiation of heat from the sea surface and interfere with thermal conditions in the water column, which influences its stratification, turbulent processes in the mixed layer, and the formation of deep water. Thus, the geophysical processes involved in air-sea

interactions around the island are important to understand, especially in relation to the Thermo-Haline Circulation (conveyor-belt) of the World Ocean.

The glaciers of Beerenberg contain a potential archive of data time series that directly represent or are proxies for geophysical processes of universal scientific interest. Information contained in ice at different altitudes may represent different atmospheric processes with particular spatial scales, and thus, different geographical origin. The lower locations are probably influenced by the regional oceanic regime more than the upper locations that may rather be affected by hemispheric tele-connection, e.g. with the North American continent.

The large amount of drift-logs that have accumulated on Jan Mayen Island represents another archive of information. Most logs have probably originated from Russian rivers, but a fraction has also been transported from rivers in Alaska and northern Canada. Identification of species, growth ring studies, radiocarbon dating, and analyses of oxygen isotope ratios in logs can be useful methods in palaeo-climate studies that, on Jan Mayen, involve advection of water between the Arctic Ocean and the Nordic Seas.

3.3 Biogeographic and Ecological Relations

The geophysical fronts that occur between masses of air and seawater in the Jan Mayen area also develop contrasts in biogeographic features (Gulliksen *et al.* 2004, Hirche 2004, Kyyak 2004). Their geographical position shifts with time and creates a changing physical environment that favours some species but not others.

Most marine species within the blend of Arctic, boreal and endemic organisms (cf. Skreslet 2004b) that live in the sub-arctic transitional zone could become elements of the marine flora and fauna of Jan Mayen. However, only migratory species, or the ones with life stages that can survive long-term transportation by advection of seawater volumes, being frozen into or being attached to sea ice (Melnikov 2004) or other floating objects, may disperse from the continents' coastal and shelf waters to the island.

Juveniles of endemic species in the sub-arctic transitional zone are supposed to be genetically adapted to an environment that fluctuates over a wide range, from typical Arctic to Atlantic conditions. Endemic sessile species like the Iceland scallop (*Chlamys islandica*) may therefore be expected to remain as a stable fraction of the island's benthic communities. However, if the intra-specific range of genotypic capabilities is subject to environmental selection, the DNA profile of endemic species may be

expected to change with time and even between age-groups within populations. More typical Arctic and boreal species may rather be subject to periodic recruitment and presence, according to their vulnerability to physical changes in the sub-arctic environment.

Several migratory fish and marine mammals are present in Jan Mayen waters to feed between reproduction periods elsewhere within the Nordic Seas. Some are subject to commercial exploitation and their population ecology is fairly well monitored by ICES (International Council for the Exploration of the Sea) and managed by NEAFC (North-East Atlantic Fisheries Commission). There is far less information on other abundant species of fish and invertebrates that are not exploited, although they may represent major elements in the food chains of exploited stocks. They may be important prey to foraging seabirds and force the reproductive success of seabirds nesting on Jan Mayen. Research on such species may hold keys to the understanding of the occurrence of toxins observed in biological material from the island (Gabrielsen *et al.* 1997).

Terrestrial communities on Jan Mayen may have been established by immigration of species that have drifted by air, ice, drift-logs or other floating objects, or introduced by birds or human visitors, a process that applies to plants (Kyyak 2004) as well as animals. The communities are clearly influenced by the combined effects of geology and climate of Jan Mayen. The volcanic rocks are porous and subject to fog and rain with dissolved seawater constituents that cause chemical erosion. The water itself also causes erosion when it freezes and expands in pores and crevices in the rocks. Sand that results from mechanical erosion is itself an erosive force that grinds on rocky surfaces when it is swept over the landscape by winds. The environment is hostile and will only accept immigrants with particular tolerances, which to some extent accounts for the low biodiversity.

Water is not stored in the porous soil but may accumulate on top of the permafrost layer (Skreslet 2004b) where it may be available to plants. However, landscape forms with heavy carpets of moss (Gabrielsen *et al.* 1998) may absorb water and serve as moist and humid habitats for vascular plants and animals.

A few ponds and lakes occur on the island and may to some extent have been populated by invertebrates brought in by birds from continental habitats or from ponds on melting sea ice. However, the poverty of the Nordlaguna invertebrate fauna (Skreslet 2004b) may indicate either that such immigration is insignificant or that the oligohaline fluctuations of the lake water prevent survival of marine as well as freshwater species. In recent years, climatic change may have caused increased incidents of sea-water overflow to Nordlaguna with corresponding reductions of the land-locked population of arctic char (*Salvelinus alpinus*). This fish population is also under influence of toxic substances brought into the lake's food-web by

seabirds (Gabrielsen and Strøm 2004). An understanding of the origin of toxins will require more knowledge on the genetic structures of seabirds in the Nordic Seas in general and the population ecology of seabirds nesting on Jan Mayen in particular. The tracing of toxin pathways through the food-web may be achieved by new scientific methods (Hobson 2004).

The communities of organisms on the island and in benthic communities of its littoral and sub-littoral zones (Weslawski 2004) may be subject to temporal variability. The abundance of each species may be periodical and related to the fluctuating physical environment, or due to long-term trends related to climate change or direct human presence. The uncertainty of the relative importance of factors may be an incentive for the management sector in Norway to establish routine ecological monitoring programs that accumulate time-series of biotic and abiotic data. The resulting time series may serve scientific purposes if the observations are frequent and systematic, and if the methods are subject to strict control and the objects are allowed to remain unchanged for long periods of time.

The scarcity of terrestrial mammals on Jan Mayen is an interesting scientific feature. Only the arctic fox (*Alopex lagopus*) has been observed in any abundance (Rouvinen-Watt 2004), but even this species may be a periodic member of the community. It appears to have been absent during the Dutch whaling in the 17th century (Hacquebord 2004). At present, there is no permanent population, although it was quite abundant during the first half of the 20th century. Intensive trapping may be the main reason for its subsequent extinction (Gabrielsen *et al.* 1997) but other factors may have been involved (Rouvinen-Watt 2004). These factors could be canine diseases from dogs kept in human settlements or non-degradable toxins accumulated in seabirds (Gabrielsen et al. 1997) used by foxes thereby reducing the chances of population growth. Decadal-scale reduction of sea ice cover may have reduced fox access to food resources of seal carrion (placentas from birth lairds, or carcasses from polar bear kills) left on the ice. Decades with reduced ice thickness and only brief seasonal presence of ice at the shores of the island would reduce new immigration and probably increase the loss of individuals that stray from the island onto the drift-ice.

The present status of arctic fox on Jan Mayen should be systematically studied to document any signs of new immigration. An annual census of tracks in systematically selected snow-covered areas should be performed to observe signs of immigration in periods when drift-ice reaches the shores. The present absence of arctic fox on Jan Mayen allows for comparative ecological studies on effects of arctic fox predation on bird populations in other parts of the Arctic. Such a study would also serve as a reference to studies of a new predation regime if arctic fox should again occur in substantial numbers.

According to historical sources, many polar bears occurred on the island in the winter and during summer periods when ice-drifts allowed access (Hacquebord 2004). Nowadays polar bears are rare at Jan Mayen, probably due to the decreased transportation of drift-ice to the island. However, today the settlement is situated on the south-eastern shore, while most previous settlements were on the north-western side that is more ferquently in contact with drift-ice. To avoid records of visiting polar bears and arctic fox from being biased by shifting observation points, automated stations could be established at strategic localities to record moving objects identified by infrared video equipment.

Jan Mayen is situated in an area where polar water and Atlantic water meet (Piechura 2004). Each water mass carries different species of plankton that sustain the region's food web (Hirche 2004) and either source may introduce toxins that found in local sea-birds and fish (Gabrielsen *et al.* 1997, Gabrielsen and Strøm 2004, Skreslet 2004b). The contaminants may follow intricate pathways being transported from their sources by plankton that enter local food-chains or are carried by migrating fish, birds or mammals from distant feeding habitats. To unravel how different organisms of the basin-scale ecosystem distribute contaminants will require sophisticated scientific methods. However, the use of stable isotopes in studies of food-webs has proved very useful to establish trophic relationships among organisms. The method may be applied on the Jan Mayen food web to study very interesting ecological relationships (Hobson 2004) and can contribute to the understanding of contaminant fluxes in the Arctic in general.

3.4 Opportunities from Data Time-Series

The long series of meteorological data acquired on Jan Mayen from 1921 is an advantage to investigations of climate change and variability in the Arctic. Their use in time series analyses is obvious, but they may also be used to calibrate information in ice core samples from Beerenberg glaciers. However, interesting constituents in ice cores like tele-commuted aerosols (Vana 2004) of marine and terrestrial origin (gasses, ions, minerals, organic matter) have not been subject to attention in the meteorological sampling routines.

Areas that have a heavy vegetation of moss may provide cores of permafrost that contain layers of organic matter. They could contain records of changes in the flora of the island (pollen, spores, radiocarbon age, oxygen isotope ratios as indication of local climate). The bio-indicators would supplement information from ice-cores sampled at higher altitudes.

Studies of recent and contemporary climate change and variability can be performed more effectively by establishing sampling and measurements that generate running time-series. Changes in the biology of terrestrial plants and invertebrates (reproduction, growth, and mortality) are good indicators of climatic influence on local biota. The geographical expansion or decrease in the extension of populations is an indication of general climatic change in the island's ecosystem. That also applies to the small populations of terrestrial birds, but their population success may be more dependent on the presence or absence of arctic fox.

Climate effects on local biota could also be studied in the ecosystem of Nordlaguna. There, careful annual sampling of gonads from a limited number of small mature arctic char, and monitoring of their physical environment could indicate annual variability in reproduction due to climatic factors. Back-calculation of body length increments from the width of ring structures in their otoliths would add information on environmentally induced growth. However, the lake ecosystem is influenced by the import of biomass provided by seabirds that forage on the elements of the marine food-web (Skreslet 2004b), which may conceal effects of climate.

The flora and fauna of the marine littoral and upper sub-littoral zone is influenced by wave action and grinding of floating sea ice (Weslawski 2004). Apart from such biota, the local benthic fauna and the physical environment do not reflect local climatic influence, and is rather being subject to basin-scale changes. However, this is exactly why the assemblages of marine species of Jan Mayen are so interesting. Planktonic juveniles of benthic animals may be members of basin-scale populations and recruited from assemblages that reproduce elsewhere around the periphery of the Nordic Seas (Gulliksen *et al.* 2004). Thus, the communities may change in composition, according to periodic changes in the large-scale advection of seawater of Arctic or Atlantic origin. Accordingly, long periods with a predominant import from either source would result in major changes. Investigations of the local growth and reproductive capacity of sessile marine organisms may reveal geographical changes in oceanic fronts around the island.

The growth and decline in seabird populations follow the availability of food. Thus, effects of climate on the food web seem to alter the abundance of prey (Klyashtorin and Lyubushin 2004) and possibly affect reproduction and mortality rates in bird populations. However, modern fishing exploits many of the major seabird prey populations that dominate the ecosystem. That makes the cause of any changes in seabird populations uncertain with regard to natural forcing factors. Fishing may reduce the abundance of planktivorous fish that provide prey for some birds, while the same reduction releases a predation pressure on plankton populations that is a

food source for planktivorous birds (Skreslet 2004b). Other seabirds may profit from dead fish and fish remains that are thrown overboard from fishing vessels. Irrespective of such anthropogenic interference within the ecosystem, performance of a periodic census of nesting seabirds is a strong method for testing the ecological status of regional marine biota (Gabrielsen and Strøm 2004).

4. MANAGEMENT

4.1 Environmental Protection

Norwegian environmental authorities have adopted an action plan for protection of nature and the cultural heritage on Svalbard and Jan Mayen (Anon. 2000, Hubert-Hansen 2004). The knowledge of the environmental status of Jan Mayen is incomplete and not good enough to serve as a baseline for environmental management. The action plan was meant to upgrade the database, but so far difficult weather conditions and lack of logistics have prevented the plans from being carried out.

Although there are not enough local resources and means to prevent public access to the island, the Norwegian Ministry of Justice allows only authorized landings. The NATO ARW participants agree that scientific considerations are in accordance with strict regulation of public presence. Long-term studies of subtle ecological changes that are due to changes in the physical environment or relations between organisms may be totally disturbed by unregulated human impact. There is also a danger that instruments located in remote places may be destroyed or influenced by unauthorized human contact.

Because scientific considerations favor restrictions in public access, manned research programs may become an integrated part of authorized logistics that restrict human interaction with biota. A long-term scientific program will require that the scientific observations leave the least possible effects on the nature of Jan Mayen. Therefore, automated instruments and television cameras will be normal parts of the logistical set-up. Installment, inspection and maintenance in places away from the coastline will have to be made in rational ways by use of vehicles, snowmobiles, and helicopters, depending on landscape considerations. Both observations from automated stations and excursions by researchers may help in the monitoring and control of unauthorized activities.

In some locations it would even be necessary to establish an area of total exclusion of activities (including other scientific activities) to prevent

contamination of sites for detailed geochemical studies of pollutants, or disturbance of long-term experiments.

4.2 Synergies of Science and the Cultural Heritage

Most human presence leaves unavoidable marks in the natural environment, sometimes creating a cultural landscape with pronounced examples of present or past infrastructure. Given time, many objects rise into the rank of becoming part of the cultural heritage. That is now the case with remains and buildings from periods of Dutch whaling, Norwegian arctic fox trapping, scientific expeditions, meteorological observations, warfare, military intelligence, and navigation service. Some are left to decay ("die in beauty"), because they are in a state beyond repair. Others may still serve human use, provided new activities are allowed to take responsibility for repairs and maintenance that do not degrade their historical values (Barr 2004a).

"Ishavsforeningen Jan Mayen" is an association of previous crew contingents. They perform voluntary maintenance of buildings under supervision of "Riksantikvaren" (Barr 2004a). Thus, they have maintained buildings located near Nordlaguna, on the lower slopes of Beerenberg (Anon. 2003). The infrastructure originally served the functions of nautical radio communication (Jan Mayen Radio) and meteorological field work. Some of the buildings are now fully repaired and may serve scientific purposes. They may be feasible for installment of automated instruments that monitor the local climate and physical variables in the sea, and in Nordlaguna. There is sufficient space to establish a multi-purpose field laboratory that could serve geological and biological investigations. The buildings may also serve as base-camp and emergency lodging for scientists or technicians who perform excursions with snowmobiles and helicopters onto the Beerenberg glaciers.

The present Loran-C facility that is situated at Sørlaguna represents a historical document from the Cold War era. Parts of it could be best maintained as such by serving new functions related to scientific activities. The buildings contain ample space for a variety of functions, but their quality may not meet modern health requirements and new standards of living.

Norwegian authorities will have to consider measures that meet all legal requirements related to management of nature, cultural heritage, and individual health. That may be decisive for the continued use and protection of existing infrastructure (Skagestad 2004).

5. JAN MAYEN RESEARCH LOGISTICS

5.1 Governmental Power and Responsibilities

"Fylkesmannen i Nordland" (County Governor of Nordland) who holds a governmental office in Bodø is the acting Governor of Jan Mayen. His office handles applications to land on the island and organises the monitoring of the Jan Mayen environment. He is responsible for the national administration of the island, but violation of Norwegian law by residents or visitors is handled by the Chief-of-Police in Bodø. Both authorities enforce their power by delegation to the Chief-of-Command on the island (Skagestad 2004).

The Norwegian Polar Institute is given the national mandate to organise polar research funded by Norway, which also includes Jan Mayen. The institute will therefore be involved in expeditions or campaigns with official Norwegian participation. It will also be involved in the planning and operation of logistics associated with a research station on the island.

5.2 Transportation to and from Jan Mayen Island

Most of the transportation to Jan Mayen goes from Bodø, a town in northern Norway, either by chartered ships or by airplanes. Civil air companies that operate long-range propeller crafts have some times been chartered but most of the flights are now made by C-130 Hercules operated by the Norwegian Air Force.

The standards of Bodø airport allow for international flights with airplanes up to the size of C-5A Galaxy that is the largest airplane operated by US Air Force. However, large or heavy cargo may also be transported by railroad to Bodø from any European country or transit harbour.

Bodø harbour has governmental priority and is the national port for shipping to the Norwegian Arctic, including Svalbard. The logistics contain interconnected terminal structures for the different means of transportation at land, sea and air, which allows for rational transfer between them. Thus, operators who transport cargo to Jan Mayen, preferably use this harbour for loading. For such reasons Bodø serves port functions for many national and foreign research vessels that receive cargo and exchange crew and scientists between cruises in the Nordic Seas.

Bodø Regional University operates the 29.4m (346t) research ship, R/V "Oscar Sund", that is well equipped for expeditions to and around Jan Mayen. It is classified for navigation in sea with <60% ice cover, and can carry cargo amounting to 150 tons (150m^3). The vessel's bunker capacities

for fuel and water allows for continuous and unsupported operations for more than 30 days and it is certified for continuous navigation with a crew of four including a cook. There are cabins for six scientists, but the capacity is under expansion to 16. Its standard equipment for research operations comprises a split capstan winch for bottom and pelagic trawling to about 1000m depth, one ordinary winch with 2000m wire for light gear, and one winch with 1000m self-supporting cable for CTD, net-sondes and other towed instruments. The electronic instruments comprise a SBE25 SeaLogger and SBE32 carousel with 12 Niskin water samplers, Simrad EK500 Scientific echo sounder with integrator, and Scanmar acoustic trawl sensors. One wet lab and two dry labs provide ample space for work with samples. The university supports the Governor of Jan Mayen in scientific matters and may on request provide research assistance for him and other parties going to Jan Mayen.

Future coordinated international research operations on Jan Mayen would be facilitated by an organized logistical home-base that served and coordinated transportation. That could even apply to handling of visas to Norway and permits for visits to Jan Mayen. It should have at its disposal warehouse facilities that allow for collection, storage and loading of cargo transported to Jan Mayen, as well as for international distribution of cargo sent as shiploads from the island. It could also receive and distribute equipment for repairs and maintenance. As such, it would be rational to have that home-base established in Bodø.

5.3 Accommodation and Work Conditions

The demand for privacy may be met with private sleeping and bath rooms. The work should be organised according to a fixed schedule with daytime routines and if necessary, fixed change of watches. That will allow for fixed meals and proper work conditions for the cooking and mess personnel.

Some field work will be carried out over a couple of days in camps with varying standards of living and will require personal adjustment to work operations and weather conditions. Field researchers must therefore expect to prepare their own food and accept that sleeping conditions and hygiene is a matter of personal adaptation. However, researchers should at any time be able to require support that brings them back to security and comfort at the main station.

Health care is related to adequate nutrition, physical exercise and general well-being. Modern food requirements consider fresh vegetables and fruits

as vital constituents in the daily intake of food. Regular transport of food supplies is therefore essential to operations even in remote research stations.

Weather conditions on Jan Mayen make outdoor exercise difficult and even risky during winter time. Rooms for indoor sports and fitness training allow the permanent crew to master general tasks as well as avoid accidental strain.

General well-being is related to the balance of privacy with social activities. Good living quarters should optimise this balance. However, proper leadership and careful selection of personnel with proper psychological profiles is equally important.

5.4 Local Transportation

Field operations will require transportation on land and at sea. Vehicles on wheels may only operate on prepared roads in the middle parts of the island. Transportation on the Beerenberg volcano can occur by skis, sledges and snow-scooters year round in high altitudes. In lower altitudes, and in the lower mountain range in the south, this is only possible when snow is present during winter. In periods with little snow and in summer, these areas can only be reached by foot. Environmental considerations (cf. Huberth-Hansen 2004) will not allow use of all-terrain vehicles (ATV). The assistance of a helicopter would be very feasible and valuable from any point of view.

Boats may navigate around the island when the sea is not ice-covered. However, the open sea and sudden katabatic winds from Beerenberg represent a hazard for navigation with open-decked boats. Solid amphibians and dinghies (zodiacs) may be much safer, but should not be used unless assisted by a ship or a helicopter in stand-by state.

5.5 Communication

Fog, blizzards and sandstorms frequently reduce the visibility on Jan Mayen and may sometimes require rapid retreat to the station. All field operations should therefore be assisted by positioning instruments (GPS), even in the neighbourhood of the research station. All personnel should carry portable satellite telephones and all vehicles should be equipped with radios for communication with the coastal radio station in Bodø. This precaution is not only necessary in cases of lost communication with the research station, but also if the research station should be evacuated in cases of emergency like fire, earthquakes or volcanic eruption.

5.6 Risky Operations

Some research will involve activities that represent risks. Both diving and mountaineering require skills and good equipment. The activities should be allowed but must be supported by firmly established regulations. Only certified and physically well trained personnel should do such work. Stand-by systems should be established to perform rescue operations if necessary. Equipment and trained personnel for first-aid treatment should be available and prepared to function until assistance from outside takes over the responsibility.

5.7 Health Care and Medical Help

Irrespective of how well research operations in remote places may be organised and equipped, accidents may require medical treatment. It is therefore essential to have adequately trained medical personnel permanently stationed on the island. Advanced surgery and follow-up hospital treatment should be available by transportation to Norway. Ships may be deployed from the Norwegian Coast Guard Base in Sortland, northern Norway. The transfer of patients from Jan Mayen to the ship may be performed at sea by the ship's helicopter. The helicopter may also transfer patients from the ship to the proper hospital, but at present the operation will require that patients stay on board the ship for some time. If the Coast Guard would permanently station a helicopter with crew on Jan Mayen, the ship could be used as a platform for the transfer of patients from one helicopter to another. That would reduce the patient's experience of seasickness and agony and cut the transportation time from a day or two to a number of hours.

5.8 Environmental Protection

Norwegian authorities will not allow any activity that disturbs the nature of Jan Mayen or objects of cultural heritage (Huberth-Hansen 2004). All sampling will have to be authorised.

All field equipment and refuse from field activities will have to be brought back to the research station for authorised disintegration or transportation back to Norway. However, automated stations that replace frequent traffic and wear on the landscape should be regarded as authorised parts of the cultural landscape and encouraged as being in accordance with the environmental policy.

5.9 Interaction with Tourism

Jan Mayen is remote and therefore an exotic place for tourists. At an increasing rate cruise-ships and large pleasure crafts have been observed to land people on-shore, even for excursions to the top of Beerenberg. Such activities may be detrimental to field research on the island. Sensitive equipment may be destroyed or record substances that cause bias in time series. Traffic may impact biota being studied. The general logistics of Norwegian presence on the island should therefore restrict such unauthorised activities. Authorisation should be strictly enforced and authorised landings by tourists should be channelled to a specified area where the scientific field work, as well as the general work at the station, is not disturbed.

6. A CALL FOR INTERDISCIPLINARY COOPERATION

Specific scientific campaigns to Jan Mayen Island should not expect to find special research equipment that is typical or unique to their disciplines. A permanent research station should rather be equipped to provide general support that is relevant to all operations, in order to reduce costs. Thus, the permanent station will provide subsistence, lodging, laboratories, and logistics for transportation, field operations and routine measurements. The scientific support system will therefore not require a permanent staff of fully qualified scientists within particular disciplines. The crew of researchers should rather consist of scientifically trained technical assistants up to the level of M.Sc. Their responsibilities would be to serve routine observations in field and laboratories, and assist visiting specialists that perform specific scientific work. That would be equivalent to the system adopted at the Polish research station in Hornsund, Svalbard (Glovacki 2004).

Both permanent and visiting scientific personnel should not waste time in being responsible for daily subsistence and maintenance routines. However, they should at any time be physically fit and prepared to take part in operations that require extra manpower. They will also have to accept responsibilities related to safety precautions and rescue operations.

6.1 Quality of Living Support

The permanent station should be well equipped with living quarters that allow for privacy. That includes private toilet, shower and closets. Common fitness rooms and sauna should be standard requirements, and a small

swimming pool should be considered. Mess quarters must contain common living rooms and other social zones (TV room, cinema theater, bar, library, etc.). A well equipped kitchen manned with a qualified chef is mandatory for the well-being of research personnel.

Living quarters and laboratories in satellite stations will have simpler qualities and some field work will be based on camping in tents. In such circumstances scientists must perform or organize their own subsistence according to their personal requirements. However, all field campaigns must include common safety logistics with precautions that secure life and health of personnel who perform any kind of authorized scientific activity.

6.2 Standard Research Logistics

Research operations based on Jan Mayen will be field-based, but with a minimum effort of man-power. High-tech equipment installed in automated stations on land or attached to buoys and submerged rigs at sea will be paramount. Remotely operated or self-navigating vehicles for use on land and in the sea will probably reduce the demand for presence and transportation of scientific and technical personnel. However, some research tasks can only be solved by the presence of human skills, for observations, recovery of samples and data, and maintenance of equipment. These tasks require particular infrastructure and logistical procedures.

From a scientific point of view, laboratory facilities on Jan Mayen may not be very sophisticated, but they should be robust and match functional standards found in good research laboratories on the Norwegian mainland.

Wet laboratories should have taps with running freshwater and seawater. Temperature controlled cabinets for physiological work with terrestrial and aquatic organisms should be available. Dry labs for microscopy and analytical chemistry would be in demand from many disciplines of science, as well as workplaces for computer work and administration of projects.

Access to a well equipped workshop for electronic and mechanical construction and maintenance of scientific equipment cannot be overemphasized.

Maintenance of vehicles and other large units should be left with mechanical engineers who are part of the permanent crew of technicians. They should be qualified to maintain remotely operated monitoring stations on land and at sea. Two should have certificates for scientific diving to do maintenance, perform routine sampling and assist in specific diving operations. The technicians should also assist in transportation, including the piloting of helicopters and hovercrafts, and the driving of snowmobiles

and trucks. They should also maintain the airstrip and be involved in procedures for landing and take-off of airplanes.

The operation of a research vessel will be mandatory for research on Jan Mayen. A well equipped ship about 30m long and with a gross tonnage of >300 tons, should be available at the island from May to September. It should only leave its station in the Jan Mayen area once every month for its home base in Norway to refuel, exchange crew and freight scientific cargo and research personnel. Underway, oceanographic observations should be made according to a standardized marine research program. To optimize ship time, observation schedules should use equipment that record data while the ship runs at full speed. Ship-mounted acoustic instruments, like the acoustic Doppler current profiler (ADCP), and echo integrators that record plankton and fish, and towed instruments like yo-yo instruments equipped with electronic, acoustical and optical sensors, and the SAHFOS Continuous Plankton Recorder (Walne and Reid 2004) are recommended.

The technical operation of the research vessel will not be a responsibility of the manager of the Jan Mayen research station, because the Law of the Sea leaves the ultimate command with the captain. However, the research manager will be responsible for planning of the schedule for normal scientific operations that the ship will serve in Jan Mayen waters.

6.3 Transportation Logistics

Large parts of Jan Mayen are under environmental protection, which will not allow free use of vehicles (Hansen 2004). However, there are a few main roads or tracks that are parts of the cultural landscape. Transportation with trucks and cars will therefore be available to some destination points. One is the road from the Loran-C station on the eastern side of the island to Kvalrossbukta on the western side. The other runs along the island to the old meteorological station at Nordlaguna. The maintenance of these two roads is important to minimise the impact on the nature, and also to secure rational scientific operations. All-terrain vehicles (ATV) should be limited to beaches where waves and wind rapidly wipe out any sign of traffic.

The use of snowmobiles and snow-scooters will usually not be possible on terrain in low altitudes, because the snow is readily swept away by wind. They may be used on the Beerenberg glaciers all year round. Thus, the buildings at Nordlaguna could be used as base-camp for such excursions. However, air-lift operations will be in demand from many disciplines.

A helicopter should be permanently stationed on the island. For the support of most scientific operations, a small craft may be sufficient. It would be used to deploy and maintain automated field stations at various places, exchange members of field parties, carry supplies, and perform

rescue operations. However, it should be emphasised that helicopter flights may be prevented by fog, blizzards, sand-storms, and not least, strong catabatic winds from Beerenberg.

A larger helicopter with radar and other instruments for blind flying, and advanced equipment for rescue operations would greatly improve the safety precautions. It would allow more field-work to be done by use of ski-doos or hovercrafts in the drift-ice during winter, and during summer excursions with inflated crafts along the shores, without the assistance of a ship. Taking into consideration that Norway holds sovereignty over the Jan Mayen fisheries zone, the authorities may consider the possibility of deploying a Norwegian Coast Guard helicopter on the island. Its main purpose would be to control traffic in territorial waters, prevent unauthorised landings, support commercial fishing expeditions, and assist scientific operations.

A Coast Guard helicopter on Jan Mayen would be able to meet Coast Guard ships mid-way to Norway and transfer personnel who need hospital care or other service that will not be available on Jan Mayen.

Scientific personnel that install new equipment or train technical crew in new observation procedures would prefer short stays on the island. A frequency of two flights per month with C-130 Hercules for exchange of personnel and to renew supplies would be desirable, but may not be very realistic, due to the weather conditions. However, to increase the frequency of flights to Jan Mayen, the present airstrip should be upgraded to an airfield equipped with instrument landing support for aircrafts.

6.4 Particular Equipment Needs

Diving might become an important research activity at Jan Mayen. Some will occur from ships, but most operations may occur from land or from small boats in shallow water, as a permanent year-round activity. Sampling of organisms from marine benthic communities (Gulliksen *et al.* 2004) or in association with drift-ice (Melnikov 2004) may become routine, as well as inspection and maintenance of automated or remotely operated sensors. To be prepared for uncontrolled ascents from even shallow depths, diving operations from both ships and land should be supported by a portable decompression unit. It should be stored and operated in a heated room at the research base, but with an option to be removed for transportation by helicopter, airplane or ship in case of the need for prolonged medical treatment at a hospital.

There is a range of other support systems that should be available at a research base on Jan Mayen such as 1) satellite receiving station, 2) computer servers with Internet access, 3) data network with connecting

points for laptops in sleeping rooms, living rooms and labs, 4) freezing and refrigerated rooms for storing of ice cores, botanical and zoological samples, and of archaeological material. Light microscopes with digital camera and a set of balances with different sensitivity and weighing range should be available at any time.

Standard electronic instruments should only be generally available if they are operated at year-round frequencies that ensure routine maintenance. That applies to 1) electrical aerosol spectrometer (EAS), 2) meteorological field instruments, 3) an instrument to measure black carbon content, 4) oxygen analyzer, 5) solar radiation measurer rations, 6) portable CTD (Conductivity, Temperature, Depth recorder, e.g. Sea-Bird Electronics SBE11 Sea-Logger), 7) an auto-analyzer or other instruments for chemical analyses of e.g. plant nutrients and pigments,.

Some items of field equipment should be available for routine work as well as more specialized work, like 1) CRREL SIPRE ice corer, 2) portable power stations, 3) diving equipment including air compressor, 4) walkie-talkies, 5) GPS instruments, etc.

6.5 Sites Requiring Special Attention (Hot Spots)

The top and the crater of the Beerenberg volcano are of particular interest for making meteorological and glaciological observations, and sampling of long-range aerosols and air plankton. Glacier sites at lower altitudes are interesting for the monitoring of their mass balance and contained oceanic aerosols (Hagen 2004).

The newest lava grounds above (Birkenmajer 2004) and below sea level (Gulliksen *et al.* 2004) are still under colonization and of particular interest to biogeographers who study the distribution of terrestrial and marine species. These places should be frequently visited to gain knowledge on geological and geomorphologic processes, as well as on the biota that establish themselves on new ground and sea-bottom.

Seabird colonies and sheltered littoral sites should be frequented to observe biogeographical changes related to oceanographic variability, climate change and toxic anthropogenic influence (Gabrielsen and Strøm 2004, Weslawski 2004).

For the study of terrestrial biota 40 representative areas of 20x50m should be selected and given particular protection. The biota should be different kinds ranging from barren ground to areas with thick vegetation layers (cf. Kyyak 2004).

Kvalrossbukta and Titeltbukta are of particular importance for archaeological studies (Hacquebord 2004). These places are also good localities for studies of near-shore marine biota.

Nordlaguna that contains a population of land-locked char is feasible for the study of trophic interaction between oceanic and oligohaline systems (Skreslet 2004b).

6.6 Support Observations

Several research operations will bring particular instruments but may request standard support observations from other disciplines. These may be meteorological observations at different heights, seawater temperature and salinity, tidal range, wave height, solar radiation, aerosol information (pH etc), and samples of particulates. Therefore, a standard monitoring program should be established to generate time series that may serve reference purposes, equivalent to routines at the Polish station on Svalbard (Glowacki 2004).

Research operations on Jan Mayen would benefit from information supported from new satellites (e.g. Cryosat and Icesat) for the regional mapping of cloud cover, sea ice extent, wave height, position of oceanographic fronts etc. Sites of deep water convection and variability could be monitored with certain satellite techniques (AVHRR, SAR, SeaWifs). The Aster satellite may allow collection of data in the visual wavelengths at smaller scales suitable for terrestrial cryogenic studies, ecology and geomorphology. Routine sampling of data that calibrate satellite monitoring in the Jan Mayen area may also serve to secure data in periods when fog and clouds prevent information from satellites.

6.7 Ecological Basin-Scale Network

Most of the natural immigration of species to Jan Mayen probably originates from shelves around the Nordic Seas Basin. Both terrestrial and marine organisms may be subject to advection of surface water towards the island (Fig. 2). The most important source regions may be the coasts of Norway and Greenland. The newly established research station at Zackenberg on North-East Greenland, and a planned research station at Runde in western Norway have strategic geographical positions that could provide reference data of particular interest for Jan Mayen research. However, coastal research performed at universities, institutes, laboratories and research stations by all nations around the Arctic Mediterranean is of relevance to Jan Mayen studies. Logistical links for exchange of data should therefore be established.

7. BASIC OBSERVATIONS FROM 2005 ONWARDS

The present meteorological observations on Jan Mayen will be continued with more or less the same number of personnel. Some of the support functions provided by the Loran-C personnel will have to be continued as well. That may result in some surplus work capacity that can serve additional functions, like serving equipment and protocols for routine scientific observations.

Since 1972, "Norsk Kartverk" (The Norwegian Mapping Authority) has performed periodical gravitational studies on Jan Mayen, and since 1994 established permanent monitoring of the relative sea level. The geodetic network of trigonometric points is now monitored by satellite technology and included in the national framework. At present, the organisation investigates the possibility of establishing a permanent geodetic observatory for measurement of the geoid, rift spreading and relative sea level change in this region (Harsson, personal communication). That will add to the permanent meteorological observations made on the island since 1921, and the local seismic monitoring established by the University of Bergen, Norway.

"Fylkesmannen i Nordland", the acting Governor of Jan Mayen Island, has enforced some environmental observations to be made by the crew stationed on the island. That will be continued and may even be expanded.

All permanent measurements will probably be incorporated in protocols enforced on Norwegian personnel attached to the meteorological station when the Loran-C system is terminated in 2005. Thus, there may be a redefinition of key skills of the future staff, and their role. Inclusion of advanced scientific equipment may require particular technical qualifications that are now not present. However, once a permanent crew of a sufficiently qualified permanent staff is present, additional science programmes can be established as expeditions or campaigns that top the multidisciplinary monitoring activity. Such expeditions should conform to high international standards.

8. INCENTIVES OF PARTICIPATING NATIONS

The participants of the NATO ARW were asked to identify national research strategies and interests that support the establishment of a permanent research base on Jan Mayen. They were also asked to identify how initiatives from the ARW could be forwarded to gain support from governmental authorities. The opinions are personal and do not necessarily express official national consent.

8.1 Canada

The past decades have seen considerable research and development in the field of eco-toxicology in polar environments, both marine and terrestrial. This work has resulted in expertise in stable-isotope, trace elements, molecular, and contaminant flux and mechanisms relative to polar marine food-webs, particularly those associated with the upper trophic levels. As such, Canadian participation in trophic-related studies associated with Jan Mayen is possible.

Remote sensing is also an area of expertise that can potentially be contributed from Canada. The Greenland current off eastern Canada is an area of oceanographic interest in Canada and this provides a natural link to Jan Mayen research.

8.2 European Union

At the European level, several opportunities for improved co-operation and co-ordination exist:

- Marine oceanographic expeditions. The UK, Germany, Poland and Norway will endeavour to publish their Arctic cruise programmes with the objective of identifying collaborative opportunities in waters around Jan Mayen Island.
- A web-site should be established allowing partner nations to contribute details of proposed work and identify links of interest. The website should also provide details and logistics concerning scientific support on Jan Mayen Island.
- The opportunity to obtain EU funding under a call dedicated to the 4th International Polar Year 2007-2008 (IPY 2007-2008) will be examined.
- The logistics and technology required to install and maintain ocean monitoring instruments will be evaluated.

8.3 Norway

The meteorological station on Jan Mayen will continue as a manned activity. The monitoring work delegated from Norwegian management authorities to the personnel will probably continue. It may be better structured and appear as a permanent activity that may be expanded. Thus, the staff of technicians may expand and include personnel with scientific training at the M.Sc. level.

The environmental action plan for Jan Mayen is overdue. The environmental authorities will probably support expeditions that may fulfill the program in the near future.

From a scientific point of view, governmental investments should not be allocated to dismantle the existing Loran-C infrastructure that may be feasible for international scientific use in the IPY 2007-2008. No building should be dismantled before its physical structures have been documented. The authorities may accept to postpone dismantling for some time to gain time for planning and funding of costly removal of debris from Jan Mayen. It would also allow more time for identification of new governmental responsibilities and construction of new infrastructure that adopts modern standards.

The Norwegian scientists who assist the Governor of Jan Mayen in scientific matters, and work with Jan Mayen projects at the University of Tromsø will cooperate to make scientific activities on Jan Mayen an official affair in Norway. They are encouraged to work for the establishment of a multidisciplinary expedition to Jan Mayen in advance of the IPY 2007-2008, preferably in collaboration with the international community. They will report to cooperative scientific organizations in Norway to gain wider support from the national research communities.

8.4 Poland

The Polish Academy of Sciences, especially the Institutes of Geophysics (IGFPAS) and the Institute of Oceanology (IOPAS), and the Polish Universities, would like to participate in an internationally coordinated research on Jan Mayen. Its surrounding waters are of particular interest to Polish scientists, for the recognition of climate change, and Earth and marine science. For such cooperation Polish facilities in the Arctic might be considered (Polish Polar Station Hornsund in Svalbard, and the research vessel "Oceania").

Polish research groups are ready to provide:

- Sampling and analytical equipment
- Field equipment
- Data analysis in Polish labs
- Time/personell costs covered for Polish participants
- Ship time of "Oceania" up to 6 days for joint marine program
- Data processing, scientific paper production

Furthermore the Polish scientists propose:

- Data exchange between the stations on Jan Mayen and Hornsund (especially data on natural environment and pollutants)

- Exchange visits for Norwegian scientists in Hornsund and r/v "Oceania" for a equivalent time in Jan Mayen facilities

8.5 Russia

As a member of the international World Ocean Circulation Experiment (WOCE), Russia has conducted time series observations during 15 years along N 60° in the Greenland Sea. Currently, physical, chemical, and geological data sets are available. In the context of recent Global climate change, Russia may be expected to continue oceanographic research in the North Atlantic based on national sources. However, Russian use of facilities on Jan Mayen would be very feasible, and should preferably occur in cooperation with NATO countries under the umbrella of international programmes like GLOBEC, CLIVAR etc.

8.6 Ukraine

Scientists in Ukraine have conducted Alpine vegetation research for 120 years. During the last 40 years, long-term ecological research of plant communities has been established on the population and community levels. It was recently established that a number of Arctic-alpine species are common to terrestrial ecosystems in the Carpathians and on Jan Mayen (Kyyak 2004). This feature can be used as a bio-indicator control of climate change in the Jan Mayen region and on the northern hemisphere.

9. RELEVANT INTERNATIONAL ORGANISATIONS

Actual scientific research is mostly funded from national sources. National initiatives may be formally coordinated with other nations, but are very often based on informal communication and exchange of practical information, material or data between individual scientists. However, much science is founded on international agreements based on formal exchange of information in international meetings and congresses.

Numerous scientific organisations are involved in Arctic research, both on national and international levels. The international research organisations are usually grouped in intergovernmental and nongovernmental organisations that cooperate in many ways that are not always evident.

9.1 Intergovernmental Organisations

Typical intergovernmental organisations have been established by agreement among nations. The nations are represented by delegates who have the mandate to express national interests and agree on terms negotiated during the meeting. There are a lot of organisations that relate to Arctic research, but most of them may be addressed through cooperation with a few large ones dealt with here.

9.1.1 Arctic Council

The Arctic Council was established as late as 1998 by eight nations having their own territories inside the Arctic. However, several non-Arctic states, intergovernmental, inter-parliamentary and nongovernmental organisations participate as observers. Several programs that are relevant to Jan Mayen science occur under the umbrella of the Arctic Council:

- AMAP (Arctic Monitoring and Assessment Programme).
- CAFF (Conservation of Arctic Flora and Fauna).
- PAME (Protection of the Arctic Marine Environment).
- ACIA (Arctic Climate Impact Assessment).

9.1.2 International Council for Exploration of the Sea

ICES give advice to the North-East Atlantic Fisheries Commission (NEAFC) and coordinate marine science that supports management of exploited living marine resources. Its activities are increasingly under development towards multi-species management and ecosystem analyses.

The ICES Cod and Climate Change Program has been assigned to a working group (ICES WGCCC) from 1992. It has been approved as one of the regional programs within GLOBEC and will continue its work until 2009 when GLOBEC will be officially ended. It will be associated with any engagement of ICES in the IPY 2007-2008.

9.1.3 North Atlantic Treaty Organisation

Since World War II, the Arctic has been a region of manoeuvre for armed forces that protect national interests. Some nations with territories inside the Arctic still maintain their status as neutral. Others have recently become members of NATO to participate in common defence actions (Table 1). However, the organisation has now accepted the Russian Federation and other former members of the Soviet Republic as Partner Countries that cooperate to decrease strategic tensions and promote national cooperation on several levels.

One of the instruments to increase hemispheric security is to stimulate contact and cooperation between scientists, organised by the NATO Scientific and Environmental Affairs Division. The priorities of the division change with the strategic decisions made within the alliance. Thus, international terrorism has at present been placed first on the agenda. However, climate change and other environmental threats that may promote conflicts of interest and destabilise relations between nations, are elements that fit into the next points of priority.

NATO will probably not directly support specific campaigns related to Jan Mayen research, but Collaborative Linkage Grants may possibly support planning processes where NATO and Partner Country members participate. Visiting Specialists may possibly qualify for funding when they train technical staff or fellow scientists in particular methods used in campaigns or monitoring.

The organisation may possibly support Advanced Study Institutes and Advanced Research Workshops that address Global environmental problems being reasons for doing research on the island. The geographic position of the island in relation to crucial meteorological and oceanographic processes that forces the World climate may warrant funding.

Any priority expressed by Partner Countries comes high on the list.

9.1.4 United Nations

UN organises scientific activities on behalf of member nations. Several of its organisations are involved in programs that apply to Jan Mayen:

- IOC (Intergovernmental Oceanographic Commission) is organised under the umbrella of United Nations. It assists governments in scientific matters related to marine environmental protection, fisheries and ecosystems, climate change, oceanic observing and monitoring, etc.
- WMO (World Meteorological Organisation) is established to coordinate, standardise and improve meteorological activities world wide. Thus, the meteorological station on Jan Mayen reports data within the WMO network and the activity occurs according to standards defined by the organisation.

9.1.5 European Science Foundation

ESF organises science within the European Union. In the 6th framework that is under development, one of seven programs concerns "sustainable development, Global change and ecosystems". Among several aspects ESF addresses biodiversity, climate research, coastal zone management, and

marine research. One board in particular may become involved in the coordination of research related to the 6th framework and how it may relate to Jan Mayen research:

- EMB (ESF Marine Board) is not directly addressing Arctic research but the science plan (Boissonnas and d'Ozouville 2001) expresses interest in geophysical processes and living resources, biodiversity and anthropogenic effects that are unavoidably related to the Jan Mayen region. The science plan is comprehensive with respect to use of new technology for marine science.

9.2 Non-Governmental Organisations

Scientific NGOs are established by scientists or their organisations to support scientific incentives and have no direct obligations to governments. However, they may receive governmental funding and have considerable impact on the initiation and planning of governmental research established to develop the national economies and serve the management.

9.2.1 Arctic Ocean Sciences Board

AOSB is a non-governmental body that includes members and participants from research and governmental institutions in 17 countries. It addresses some missions that are particularly relevant to research on Jan Mayen:

- encouraging and supporting science-led international programs by offering planning, coordination and access to funding and logistics.
- establishing means of initiating and maintaining observational systems and the data produced

9.2.2 International Council of Scientific Unions

ICSU is the largest of the international scientific NGOs. It represents research in the university and institute sector. Among its committees are:

- IASC (International Arctic Science Committee), an organisation with 18 member countries. Arctic and non-Arctic countries are member based on their Arctic research programs. IASC has asked for ICSU membership recently.
- IUGG (International Union of Geodesy and Geophysics).

- SCOR (Scientific Committee for Oceanographic Research), an interdisciplinary committee that promotes international research programs, and is an advisory organ for UNESCO and IOC.

9.2.3 Other NGOs

Several international NGOs have been established by scientists who organises themselves on the basis of an individual membership:

- EFMS (European Federation for Marine Science and Technology Societies) is an organisation of national associations and societies that organise individual oceanographers in Europe. One of its roles is to take part in scientific decision-making that influences the establishment of framework programs for research in the European Union.
- EPB (European Polar Board).
- IUBS (International Union of Biological Science).
- IUCN (International Union for Conservation of Nature).

9.3 Relevant International Programs

Several intergovernmental and non-governmental organisations have common scientific problems on their agenda and therefore cooperate within international research programs. That is the case with some programs that address cases relevant to the Nordic Seas:

- ACIA (Arctic Climate Impact Assessment) is an initiative of the Arctic Council and IASC and executed together with CAFF and AMAP (Arctic Monitoring and Assessment Program). In 2004 ACIA will release its first comprehensive synthesis of the consequences of changes in climate and UV radiation in the Arctic. Follow-up programs may be expected and Jan Mayen could be a very particular and interesting point of reference.
- A station on Jan Mayen could also play an important role in CEON (Circumpolar Arctic Environmental Observatories Network) a joint project of IASC and FARO (Forum for Arctic Research Operators).
- CAFF (Conservation of Arctic Flora and Fauna) is developing a program to monitor circumpolar biodiversity. Jan Mayen may be a very feasible place to study the dynamic development of biota

subject to seasonal and inter-annual changes as a consequence of alternating Arctic and Atlantic influence.

- GLOBEC (Global Ocean Ecosystem Dynamics) was initiated by SCOR and IOC but is now part of IGBP (International Geosphere-Biosphere Programme) that is organised by ICSU.
    - ESSAS (Ecosystem Studies of Sub-Arctic Seas) is a new initiative that may become a hemispheric project within GLOBEC and will be of particular relevance to the Jan Mayen issue.
    - ICES/GLOBEC CCC (Cod and Climate Change) is one of nine programs where the International GLOBEC addresses how Global change may affect the abundance, diversity and productivity of marine populations.
    - IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) project is presently being implemented by IGBP in cooperation with SCOR. Its goal is to understand how interactions between marine biogeochemical cycles and ecosystems respond to and force Global change. The Greenland Sea is a carbon sink and Jan Mayen is an appropriate place to monitor the hemispheric hydrological cycle, and study the fluxes of natural and anthropogenic chemicals. Zooplankton populations in the Nordic Seas have roles in the transfer of geochemicals in marine food-webs that are essential to production of human food in the North Atlantic. Thus, IGBP should be made aware of the potential for data acquisition and science in the Jan Mayen area, and its potential importance to IMBER.

10. RECOMMENDATIONS

The NATO ARW participants found that the establishment of an international station on Jan Mayen Island would involve scientific and logistical aspects, as well as political issues.

10.1 Priority Fields in Jan Mayen Science

Among the scientific problems that should be addressed on Jan Mayen Island are:

- General island biogeography and ecology (dispersion, colonisation).
- Airborne transport of pollutants.

- Integrated volcanological studies.
- Model study of colonisation of a remote Arctic island by diaspores that involves:
    - Their origin.
    - Transportation (wind, ocean currents, birds).
    - Effects of anthropogenic perturbation.
- Growth experiments with biological material from drift-wood and birds together with modelling of wind circulation.
- Formation, growth and transport of natural and anthropogenic aerosols and their role in cloud formation and climate change in the marine Arctic.
- Interdisciplinary study on the levels and impacts of environmental pollutants in the Jan Mayen ecosystem.
- Determination of a climate signal in the atmosphere/ocean system within the Jan Mayen region.
- To assess the carbon export from the Arctic Ocean by drift-ice in terms of ecological carbon sequestration in the Jan Mayen area.
- To intensify oceanographic research in adjacent marine areas (during the IPY 2007-2008 in particular), with special attention to:
    - Fresh-water balance.
    - Deep convection and deep water formation.
    - Mass and energy transport
    - Dynamics of the main currents, meso-scale features in particular.
- To better understand processes, their variability and consequences for the THC (Thermo-Haline Circulation) in the North Atlantic.
- History of the human occupation of the island and its impact on Jan Mayens environment.
- The role of Jan Mayen in the international polar years (IPYs).

10.2 Logistics

To develop interests for research on Jan Mayen the participants suggested:

- Expansion of the ongoing Norwegian meteorological observations.
- Provision of logistics & facilities for international expeditions:
    - Regular and reliable air transport of personnel, equipment and supplies. Upgrading of landing facilities.
    - Accommodation on-site.
    - Regular CTD and current measurements required within Jan Mayen region.

- Free access to long-term time-series on the temperature, atmospheric circulation and other climatic indices at Jan Mayen, Arctic, North Atlantic and the northern hemisphere.
- IPY 2007-2008 expedition with core group on Jan Mayen for longer time, and several groups for a shorter time. The approach should be multidisciplinary, but with regard to marine science restricted to inter-tidal work and reconnaissance for later, more extensive work. 12 people in 3 months for baseline surveys, sampling, and observations.
- Establishing permanent instrumentation, some oceanographic work starting now.
- The regional expedition activity in the Jan Mayen region should be accompanied with the current coordinated efforts in many countries with regard to diagnostic analyses of collected data aimed at modelling.
- Establishment of seasonal time series observations in transect "Jan Mayen - Greenland".
- High resolution coupled modelling atmosphere-ocean-ice as a tool for research.

10.3 Political Issues

The NATO ARW became well informed on national political and administrative issues related to Jan Mayen (Skagestad 2004) but did not have the qualifications to clearly identify political instruments that would facilitate the establishment of a scientific research base on the island. However, it is obvious that international research on the island needs to be organised within an intergovernmental scientific body. Being subject to trans-Atlantic natural processes and raising interests of nations on both sides of the ocean, the participants raised the question that NATO may serve a key role in this regard. However, nongovernmental organisations that represent the international scientific community should also become involved. The International Committee for Science (ICSU) plays a central role in this respect.

The participants expressed no opinions on how a Jan Mayen research base would fit into the Norwegian governmental structure. However, they strongly recommended that the Norwegian plans for a Jan Mayen environmental conservation management programme (Huberth-Hansen 2004) should be clarified as soon as possible and come to a reality well before 2007. The rationale is that the planning of the logistics for the 4th International Polar Year campaign in 2003-2004 will have to take into consideration adjustments that do not challenge environmental regulations.

10.4 Base-Line Census of Jan Mayen 2005 and/or 2006

The topography of Jan Mayen Island and the shallow parts of its shelf is well described and documented in maps. Otherwise, the existing general knowledge of Jan Mayen is weak and fragmentary and not very fit for deduction of new and interesting scientific hypotheses.

To provide a better base of information that may facilitate planning of more comprehensive scientific efforts, the NATO ARW pointed to the need for a base-line census that may reveal information being complementary to the knowledge that already exists (Gabrielsen *et al.* 1997).

The geomorphology of the landscape is known in some detail (Birkenmajer 2004), which is also the case with biota on the middle part of the island where human activities have been centered. Cliffs and rocky beaches make the northern and southern coastlines much less accessible. Therefore, the knowledge of their biota of terrestrial plants, invertebrates and birds are incompletely described. That is also the case with cultural remains.

Observations made from ships have been easier to make. Thus, the location of seabird colonies are known (Gabrielsen and Strøm 2004), but the abundance estimates of nesting pairs (Gabrielsen *et al.* 1997) are very inaccurate and need updating by inspection at closer range.

Several marine investigations have been made around the island, from ships and by diving (Gulliksen *et al.* 2004). The composition of the benthic fauna is therefore fairly well known, and fisheries resources of prawn (*Pandalus borealis*) and Iceland scallop (*Chlamys islandica*) on the island's shelf have been subject to investigations and management. However, marine biota in the inter-tidal zone and in the upper parts of the sub-littoral zone that can only be investigated by close visual inspection or by samplers operated from small boats remain to be investigated (Weslawski 2004). That is also the case with the geomorphology of beaches and inter-tidal rocks.

Most observations that have been made on Jan Mayen Island are old and may not adequately represent the present state. That is the case with several conditions related to management. The Norwegian authorities have planned to update knowledge by making new observations in a limited monitoring program (Anon. 2000). However, due to the lack of reliable logistics, these observations have not been made. If they are not made in 2004, it would be feasible to organize a more comprehensive expedition that combines the monitoring with a supplementary baseline census in 2005 or 2006. Such an expedition would serve valuable functions as an introduction to the IPY 2007-2008.

The NATO ARW recommended that a symposium could be organized in 2006 to summarize the information that exists in present data bases and the

data that may emerge from new monitoring and a baseline census. The scope of the symposium should be to:

1. Identify time-series of parameters that have been or are presently being accumulated in data bases.
2. Suggest variables for which new time-series are needed.
3. Discuss standardization of measurements.

10.5 IPY Expedition or Campaign in 2007-08

An expedition to Jan Mayen Island in the 4th International Polar Year 2007-2008 (IPY 2007-2008), would allow studies of seasonal changes in many variables. Each would be interesting from a local and disciplinary point of view, but priority should be given to those that are more universally interesting, on regional or Global scales. They should also be used to initiate or modernize multi-year time-series.

During the IPY 2007-2008 routine observations in physical, chemical, and biological oceanography should be made year round, by automated observation facilities moored near-shore, and by short excursions with appropriate transportation technology, when the weather and safety precautions permit. However, the core activity would be interdisciplinary research vessel cruises made in three transects: From Lofoten in Norway to Jan Mayen, from Jan Mayen to Svalbard, and from Jan Mayen to Greenland (cf. Piechura 2004). The section from Jan Mayen to Greenland, i.e. across the East Greenland Current, should preferably be compared with observations from two parallel transects: From Svalbard to Greenland, and from Iceland to Greenland (cf. Melnikov 2004).

The IPY should plan to stimulate an intensification of the temporal and spatial dimensions of ongoing time-series to establish reference points in the periphery of the Nordic Seas. Thus, the program on Jan Mayen should be linked to other oceanographic work, at Zackenburg in Greenland, and field stations in Iceland, the Faeroes and Norway, including Svalbard. The Russian observations in the Kola section (Byshev *et al.* 2004) are obviously valuable as reference material.

In marine international programmes the freshwater balance, salt and heat transport, and deep water formation are linked to the ASOF programme. This follows the VEINS programme of which results have not been fully released. In the context of IPY 2007-2008, the marine activity should be linked to international scientific research objectives (Shimmield 2004). This would allow for access to costly data acquired from satellites and airborne observation platforms. During an IPY expedition to Jan Mayen, the work on the island in the fields of glaciology, geomorphology, geophysics, geochemistry, and ecology should be organized as an interdisciplinary

campaign to optimise investment (Glowacki 2004). Process studies should be conducted in the context of routine observations (e.g. meteorology data). Jan Mayen should be proposed as a special site in the context of a wider Arctic observations network within the IPY 2007-2008 that will be aimed at the Arctic climate structure. Jan Mayen Island represents a key location in this structure, e.g. where oceanic and atmospheric synoptic activity is focused. It is an area of intense variability where observational data will make an important contribution to calibration and verification of existing models (Romanov 2004). Thus, the IPY 2007-2008 campaign should test observation procedures that may be included in a permanent research program established at an observatory on Jan Mayen.

The program of an IGY 2007-2008 campaign to Jan Mayen should have some elements on the priority list:

- Volcanological investigations (cf. Birkenmajer 2004).
    - Magma chemistry.
    - Temperature and composition of exhalations.
    - Study of tectonic elements, faults and fractures by aerial photography and terrestrial mapping.
    - Submarine mapping of the Beerenberg volcano's base by multi-beam sonar and video recording. Fractures in the Mid-Atlantic Ridge to the north possibly include hydro-thermal vents with active geochemical processes going on. The depth range of such processes may be studied along the submarine slope that descends from the sea surface level.
- Cryosphere: permafrost, snow and ice.
    - Reconstruction of recent climate change (glacier mapping; ice coring) and trends in pollution levels. This will require one season to identify the best site with respect to temperature variation and glacier dynamics (cf. Hagen 2004).
    - Ongoing climate change should be monitored from one glacier by conducting mass balance observations, meltwater etc.
    - Distribution of permafrost across the island should be mapped. The complexity of the permafrost development will take into account the high heat flux from the island. This will allow the active layer to be identified. It is recognised that the active layer links to the NAO.
    - Elevation data (Beerenburg transect) for collection of snow samples will allow the estimation of marine boundary layer effects.

- Geomorphology (cf. Birkenmajer 2004).
  - Landform study of the Quaternary deposits.
  - Establishment of links to glaciology.
- Sediment/soil geochemistry reconstruction.
  - Collection of cores for dating of environmental change and sediment fluxes.
  - Palaeo-reconstruction of pollutants, fluxes etc. linked to the Arctic coastal basin dynamics projects.
- Airborne elements sampled from volumes of air, snow, freshwater and soil (cf. Kyyak 2004, Vana 2004):
  - Aerosols (seawater ions, contaminants).
  - Atmospheric plankton (seeds, pollen, juvenile spiders etc).
- Search for terrestrial or freshwater organisms that are immigrants in sea ice and drift-logs (cf. Kyyak 2004).
- Characteristics of the oceanic system (cf. Byshev *et al.* 2004, Gulliksen *et al.* 2004, Hov 2004, Melnikov 2004, Piechura 2004, Skreslet 2004b, Weslawski 2004):
  - Correlations of local air-sea interaction (meteorology, sea-surface exchange, thermal radiation, phase-shifts in water)
  - Seawater geophysics (seasonal stratigraphy, turbulence, deep-water formation).
  - Marine geochemical elements (cycling of plant nutrients, pollution in seawater and sea ice, import by advection of seawater).
  - Seasonal changes (phytoplankton blooms, reproduction periods in holoplankton and zoobenthos).
  - Allochthoneous invasions of plankton (phenotypic morphs, generation or population switches expressed by lipid profiles, alien larvae etc.).
  - Satellite location of drift-ice and oceanic fronts to identify seal reproduction and seabird foraging habitats, combined with *in situ* studies of trophic interaction with prey.
- Phenology of terrestrial plants, birds and selected marine taxa, including clutch initiation, life cycles and trophic position (cf. Gabrielsen and Strøm 2004, Gulliksen *et al.* 2004, Hobson 2004, Kyyak 2004).
- Growth, reproductive capacity etc. in organisms related to climate change (physiology of local morphs).

- Human dimension on Jan Mayen and the role of the island in the International Polar Years (Barr 2004a, 2004b, Hacquebord 2004).

10.6 Monitoring Program after IPY 2007-08

An inclusion of Jan Mayen Island in the IPY 2007-2008 may promote a more lasting inclusion in the framework of AMAP (Arctic Monitoring and Assessment Program), but this possibility is to be decided by Norwegian authorities (cf. Skagestad 2004). Steps should also be taken to identify the variety of current networks and ensure that measurements at Jan Mayen will be included. The NATO ARW identified several fields of disciplinary work.

10.6.1 Lithospheric Observations

Volcanic activity with periodic eruptions of lava from fissures on Jan Mayen is a consequence of regional tectonic processes at the northern end of the Mid-Atlantic Ridge. Observations that record such changes not only explain the local geology, but also contribute to the universal understanding of processes that work on larger scales. The geodetic, geological and seismological monitoring that already exists is valuable and should be continued, but new time-series should be established. The magnetic field is very complex in this region and information of Global interest may result from routine monitoring.

For the safety of personnel moving around on the island, the slope stability of mixed layers of snow, ice, lava, and mud should be monitored. Earthquakes, eruptions and toxic fumes represent hazards that may be expected to occur and should be monitored as a safety precaution as well as from a scientific point of view (Birkenmajer 2004).

10.6.2 Meteorology

The present meteorological observations on Jan Mayen (Hov 2004) are expected to continue for reasons of regional weather forecasting. The service should also include new routine measurements. Due to the cloudy conditions on Jan Mayen, optical techniques will not be so useful. However, collection of precipitation will serve monitoring of pollutants like pH, particulates, black carbon, metals, and aerosol size distribution (cf. Vana 2004). Such observations should be linked to the Arctic network that is based in Rovaniemi. It coordinates the atmospheric monitoring of long range

pollutants transported to the Arctic (bulk aerosol deposition; ionic composition).

Scientific studies of the local climate in different places of the island should be included in the meteorological work. This is because the meteorological service may support scientific logistics that require weather forecasts in particular localities. It may also identify back trajectory projections that recognise local effects, and identify peak episodes in deposition of acid rain that have an impact on local ecosystems and environmental geochemistry.

Measurements in remote places of the island should be operated by automated stations that transmit data by ground-based links or by satellite. Some data may be sent to the manned base station on Jan Mayen, while other data may preferably be sent directly to users world-wide. On Jan Mayen such stations will be subject to strong winds, sand erosion and icing. They will therefore require repair, routine inspection and maintenance. Some stations may be accessed by trucks or snowmobiles, while others may require transportation by boat or helicopter.

10.6.3 Oceanography

Geophysical routine measurements in the sea should preferably be performed by sensors carried by moorings and offshore monitoring stations operated from the land base. However, ships are needed to establish and maintain automated stations, and their instruments should be controlled and calibrated by standardised ship-based methods. Monitoring of the air-sea interaction should be established as a scale of variation that represents the meso-scale variability of the atmosphere, for instance the Rossby radius of deformation in the marine boundary layer. This would require uninterrupted measurements of characteristics which record regional and local effects. These measurements must be linked into a wider observing network. Parameters will include temperature, salinity, etc from moorings over long periods of time.

Chemical and biological oceanography can increasingly be performed by automated sensors, and optical and acoustic instruments (Boissonnas and d'Ozouville 2001). They may use moored stations as platforms and communicate by cables or acoustic transfer of data. However, the promising development of self-navigating remotely operated vehicles (ROVs) opens the possibility for unmanned cruises with sensors to geographical positions and depths that are not accessible by manned platforms. Still, many highly relevant measurements rely on ship-borne samplers like water-bottles, traps, nets, trawls, dredges and corers. Some kinds of sampling require visual observation of organisms, like in diving-based studies of sympagic (under-

ice) communities (Melnikov 2004), and observations and sampling of sea-birds, seals and whales.

Ships are the best platforms for routine surveys of rather conservative features. However, hovercrafts may be useful when drift-ice enclose the island and prevents adequate navigation. Helicopters that should be kept for safety precautions are also feasible for spotting of non-conservative features, e.g. aggregations of foraging birds in oceanic fronts, lairds of juvenile seals on drift-ice etc.

11. ECONOMY

The NATO ARW participants were not prepared to estimate costs associated with maintenance or building of infrastructure, and running costs associated with scientific operations. However, they drew attention to the standards that they are acquainted with during previous Arctic field campaigns and would accept the infrastructure standards that are presently prevailing on Jan Mayen. They understood that the removal of buildings from Jan Mayen would require considerable governmental expenses and found that to be detrimental to Arctic science.

The participants also noted that several nations operate research vessels on a regular basis in the Nordic Seas. Thus, joint international scientific work on and around Jan Mayen is a matter of international agreements rather than being a matter of new and large expenses to Norway per se.

National and international funding agencies should be notified of the potential for doing science on and around Jan Mayen when the Loran-C activity expires. International organisations that fund scientific cooperation should be invited to consider the inclusion of a Jan Mayen research station in their future programs.

It was understood that Norway runs inadequate transportation logistics for scientific operations on Jan Mayen, and that extra costs will be required. However, the geographic position of the island may be so important for future international research on Global scientific issues that other nations may be prepared to contribute logistical funding, if the station may be given a trans-national rather than national status.

12. CONCLUSION

The participants concluded that an increased scientific research activity on Jan Mayen Island will be of significant importance to the future

understanding of Arctic ecology and geophysical feed-back couplings in Global geophysical processes. They expressed willingness to share this responsibility with Norwegian colleagues.

The recommendations from the NATO ARW must be made available to the Norwegian inter-ministerial group that is planning the use of the Loran-C infrastructure that is left vacant on Jan Mayen Island after 2005 (Tviberg 2004). The communication with Norwegian authorities should be followed up on higher administrative levels, by formal contacts with the Norwegian Ministries of Science, Environment, Fisheries, Defence, and Foreign Affairs, the Norwegian Research Council, and the Governor of Jan Mayen.

The participants agreed to inform their respective institutes and motivate national non-governmental bodies to consider scientific efforts on Jan Mayen. National scientific organisations are expected to bring forward the issue in international organisations.

The NATO Scientific and Environmental Affairs Division is expected to consider the results from the Advanced Research Workshop in Oslo within its bodies. It is hoped that the organisation will make steps to facilitate the inclusion of a Jan Mayen research station in the network of collaborating international institutions and organizations in Europe, Asia and North America.

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