

# Norwegian Institute for Nature Research

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# ANNUAL REPORT

# 2006



TEAMWORK



ENTHUSIASM



INTEGRITY



QUALITY

Cooperation and expertise for a sustainable future

# Cooperation and expertise for a sustainable future

## NINA's company values:

### • TEAMWORK



### • ENTHUSIASM



### • INTEGRITY



### • QUALITY



*The Norwegian Institute for Nature Research (NINA) is Norway's leading institute for applied ecological research. NINA performs short- and long-term research projects in support of local, national and international utilization and management of natural resources. The institute's highly qualified staff collaborate closely with resource users as well as research and management institutions in Norway and abroad to reach the best environmental solutions. NINA offers broad-based ecological expertise covering the genetic, population, species, ecosystem and landscape levels in terrestrial, freshwater and coastal marine environments. In addition, NINA addresses interdisciplinary issues involving both natural and social scientists.*

## Resource Mapping, Resource Use and Resource Management

NINA has a wide network and plays an important role in national and international research. Its experienced staff of researchers within the fields of natural and social sciences collaborate with 119 international institutions in 33 countries in Europe, Africa, Asia and the Americas.

### NINA FACTS:

Staff:	159 persons
Operating income:	USD 27 million
Research facilities:	7 locations in Norway
Publications 2006:	115 scientific papers 163 technical reports

### NINA'S MAJOR SERVICES:

- Research
- Dissemination of scientific results
- Environmental impact assessments
- Environmental monitoring
- Status reports
- Consultancy and evaluation
- Courses and training

NINA's expertise is directed towards basic and applied research, consultancy work, and advice to management and industry.

Selected areas related to natural resources are:

- Harvest and sustainable use of game and fish stocks
- Land use and nature management, including landscape analysis in the coastal zone and on land
- Community development and local participation in resource management
- Socio-economic issues related to subsistence, recreational and commercial use of natural resources
- Conflict resolution related to natural resource use and management
- Commercial development of biological resources
- Red-list evaluation and conservation planning
- Monitoring and time-series analysis
- Environmental databases – development, operation, use and public information
- Impact analysis and monitoring of pollution
- Environmental impact assessments

Photos: P. Jordhøy, E. B. Thorstad, K. Kringstad, T. Anker-Nilssen



The institute have well-equipped laboratories and research facilities at seven locations in Norway. NINA offers broad-based ecological expertise covering the genetic, population, species, ecosystem and landscape level, in terrestrial, freshwater, and coastal marine environments.

Photos: J. Backer, O. T. Sandlund, T. Anker-Nilssen, K. B. Strann, B. Finstad, B. K. Dervo.

## Collaborative networks

NINA has an extensive professional network in Norway and abroad:

- **ENVIRA** (The Environmental Research Alliance of Norway; [www.miljoalliansen.no](http://www.miljoalliansen.no)) consists of six institutes in addition to NINA: **NIBR** – The Norwegian Institute for Urban & Regional Research; **NIKU** – The Norwegian Institute for Cultural Heritage Research; **NILU** – The Norwegian Institute for Air Research; **NIVA** – The Norwegian Institute for Water Research; **Bioforsk** – the Norwegian Institute for Agricultural and Environmental Research; **CICERO** – Centre for International Climate and Environmental Research.
- NINA is a partner in the **ALTER-net** (A Long-term Biodiversity, Ecosystem and Awareness Research Network; [www.alter-net.info](http://www.alter-net.info)), a network of excellence consisting of 24 European research institutions in 17 countries, funded by EU's 6th framework programme.
- NINA is involved in collaborative projects and programmes with institutions in approximately ten developing countries in Central America, Africa and Asia, as well as a number of institutions in developed countries.



# Wind Power and the Environment



Photo: K. Bevanger, NINA

## Kjetil Bevanger

***NINA have been involved in surveying the environmental impact of wind power development since 1998, when, in a strategy document to the Directorate for Nature Management (DN), we suggested a dedicated R&D programme concerning this issue. Up until 2006, when funding was obtained from the RENERGI (The clean energy systems of the future) programme of The Research Council of Norway (NFR), the experience in this area has built up through investigations associated with concrete impact assessments.***

NINA's strategy document from February 1998 states the following: "In order to limit the scope and improve the quality of future impact assessments and to scale these so that they may be acceptable to both developer and public management, one should, during this early phase of 'the windmill era', invest in impact studies that are sufficient according to a broad scientific evaluation. Such studies must cover a certain timescale – before, during and after development. We propose DN takes the initiative for an R&D programme entitled 'Windmills, nature, environment and culture'".

Even if this R&D programme was not realised, NINA has since 1998 been able to produce knowledge about the environmental impacts of wind power development, primarily in relation to birds. On commission from Statkraft, the NINA report "Wind power at Smøla: Possible consequences for redlist bird species", in 1999 summarized the possible consequences of wind power development. Subsequently, a series of additional investigations were commissioned, i.e. "Development of a programme for post-investigations", "Spring appraisal of Smøla willow grouse", "Evaluation of the consequences for birds from a change of layout for Smøla wind farm stage II", and "Population investigation

of the white-tailed eagle at Smøla in 2003 related to the wind farm". Recently, NINA has also performed several impact assessment studies on wind farm plans in other locations, including northern Norway, while running continuous studies concerning the white-tailed eagles at Smøla. The project were mainly funded by the Norwegian Water Resources and Energy Directorate (NVE) and Statkraft.

Our experience in these commissioned projects has confirmed our concern in 1998, that knowledge was inadequate in order to perform proper environmental impact assessments.

Finally, in 2006 we obtained funding through NFR's RENERGI programme to develop the necessary basic knowledge. A comprehensive research effort starts in 2007 focusing on wind power and bird life. When several dead white-tailed eagles were found around the wind turbines at Smøla during the spring months of 2006, interest in the subject of wind power and bird life increased significantly in several spheres. Whether this contributed to NINA obtaining financing for the NFR project "Pre- and post-construction studies of conflicts between birds and wind turbines in coastal Norway" remains uncertain, but

it is in any case natural that white-tailed eagles will be in focus during the project. The project has also engaged a PhD student who will work on, i.a., risk analysis and population modelling in connection with birds and wind power parks.

In addition to white-tailed eagles, impact studies will focus on wetland birds, including the common snipe, the red-throated diver, the graylag goose and the Smøla/Trondheimsfjord willow grouse, with the assumption that these species may be considered as model species for their types of bird. Documentation of mortality rates will be an important component of the project, and in this area systematic use of specially trained dogs to find any collision victims is already in place. Development of technical mitigation measures will be emphasized, for example the potential associated with more visible rotor blades. Radar will be an important research technology to learn more about the ways different species react when they come close to the turbines, and how the birds move in the landscape with turbines. In the long term it will be useful to develop terrain models that may help to identify high risk areas, i.e. areas that should be avoided because the level of conflict with bird life is especially high. Collaboration partners in the NFR-project are, amongst others, SINTEF, The National Environmental Research Institute of Denmark, The University of Bristol and The Royal Society for the Protection of Birds (RSPB).



# Monitoring protected areas; the Dovrefjell case

Photo: D. Hagen, NINA

Odd Inge Vistad, Nina E. Eide and Dagmar Hagen

*There is a need for extended monitoring in protected areas in Norway. The Office of the Auditor General states that we are good at designating new areas, but not at managing them. This pilot project on monitoring the protected areas at Dovrefjell is an important step towards a more knowledge-based management of Norwegian protected areas. On assignment from Dovrefjellrådet (DFR) and the Directorate for Nature Management (DN), NINA has developed a plan and a methodology for monitoring prioritised features in the protected areas at Dovrefjell.*

There is a strong need for knowledge on conditions and human impacts in protected areas. The pressure for utilizing protected areas for tourism and other business development reinforces this need. Such knowledge will facilitate a more efficient and tailored management, the use of targeted actions, and also prove useful where there is room for sustainable development.

The NINA report "Monitoring of protected areas. A monitoring plan proposal on conservation features, outdoor recreation and human impacts in the protected areas at Dovrefjell" assumes a wide definition of 'monitoring', but prioritises aspects associated with the conservation goals for the actual protected area. One must monitor the current conditions and human impacts, as well as biological, cultural and social features. Human activity may be an important positive feature (e.g. outdoor life is a conservation goal in

national parks), but also a possible threat to certain features (e.g. impacts on flora, fauna or cultural monuments). The report suggests specific methods with instructions for monitoring attributes/targets and human impacts.

The project was initiated by DFR, who requires a better scientific base for their management of the protected areas at Dovrefjell. In addition, DN is in the process to develop a national plan for monitoring protected areas, and we were asked to provide a principal discussion and analysis of monitoring needs. Thus, the report contains a section on principles for protected areas monitoring, while the main section is a detailed monitoring plan proposal for Dovrefjell-Sunndalsfjella. According to the Office of the Auditor General (2006) monitoring of protected areas must be strengthened in order to properly assess how the prioritised features are actually faring. The manage-

ment authorities must also be able to take action when negative development is revealed. Monitoring data may also be used as positive input in the development of sustainable activities. The report further discusses what position monitoring of the protected areas should have in relation to the ongoing national monitoring programmes, and also "ideal" monitoring compared to realistic monitoring (considering present limited resources).

There have been great scientific challenges in developing the monitoring programme and in choosing/developing attributes to be measured. An important principle was to bring forth robust, but unequivocal and simple methods for registering data. This is according to DFR's premise; the local wardens must carry out most of the data collection. However, it is essential for the scientific quality and usefulness of the monitoring that experts develop the methodology and implement the necessary analysis and quality assessment of the data. Hence the professional cooperation between researchers, wardens and managers is essential in order to achieve quality monitoring, and to utilise new knowledge in practical management.

Read more in NINA Report 188 (which is in two parts: Main report and Appendix).



# Second home development – welfare invades the mountains

Photo: B. K. Dervo, NINA

Bjørn P. Kaltenborn and Christian Nellemann

*Second home use has long traditions in Norway, and the current development is increasingly making its mark on the wilderness. More cabins are being built in Norway's countryside than ever before, and there is little evidence that this trend has peaked. The prognosis is for the rate of building to continue to grow, while increasing investments are made in the market. However, there is no congruence between the rapid building and focus on the environment. While 10-15 billion NOK are invested in the building of second homes every year, the environmental and planning authorities are falling behind and are inadequately prepared for handling the consequences and long-term planning needs. During the last few years NINA has worked on analysing the effects of this activity on society and ecology.*

## Second home development is changing the mountains

Official statistics show that there are now around 6000 new second homes being built every year, many in the mountains. The actual number is probably higher because registration is incomplete. There are now around 400 000 second homes in Norway in total. We have long traditions for cabin life and the concept "hytte" (cabin) has a specific cultural meaning which invokes specific associations for most people. Many aspects of the modern use of holiday homes have little in common with the traditions of the simple cabin in the woods or the mountains. That the concept "hytte" is no longer appropriate for much of what is being built, is increasingly obvious. At the very least the concept requires a redefinition, since we know that the average second home built today exceeds the size of the average home in Norway (103 m<sup>2</sup> for cabins and 101 m<sup>2</sup> for homes in 2006). Additionally

many holiday homes are equipped with all the usual facilities and conveniences of the ordinary dwelling. More or less every new cabin development is now constructed with road access, water and sewage. In reality these are just new housing developments in a scenic setting.

The widespread desire to build second homes in the Norwegian mountains reflects a broad international trend. In many countries we see the same development where increased welfare, changing lifestyles and new ways of working lead to the building of holiday homes that are used for large parts of the year, both for holidays and as a base for work. The large second home resorts in places such as Hafjell, Geilo, Hemsedal or Hovden, are very similar to those one finds in the Alps, Canada or the United States. What consequences does this development have for the environment and for people's experiences of nature, and what does this entail for the management of the mountain areas?

## New knowledge about the effects of second home development

A cross-discipline project at NINA in the period 2000 to 2006 shows that we are facing major challenges. Much of the cabin development is carried out in areas that are particularly important in the wild reindeer migrations, winter habitat or calving areas, that is, in areas where the animals are particularly vulnerable. Research shows that the disturbance and avoidance zones are significantly wider than previously believed. Even if the reindeer now and then may come close to buildings and roads, they prefer to keep a distance of several kilometres to permanent infrastructure. This means that large mountain areas are in fact not available habitat for wild reindeer. Both the size of the second home resorts and the movement around these contributes in a major way to directing the wild reindeer to utilise areas away from such developments. The effects are much the same for domesticated reindeer as for wild reindeer, and in northern Nor-





Photo: P. Jordhøy, NINA

way estimates indicate that 1000 square kilometres of reindeer habitat is lost every year because of cabin building. Predators such as brown bears are also severely affected. Studies show that the larger second home resorts have equally disturbing effects on the bears as a residential area with 20 000 inhabitants. The displacement of older male and female bears to undisturbed areas mean that it is mostly young, inexperienced bears that come into contact with people.

There is little doubt that second home life is changing. Today most people want modern conveniences, like a road all the way to the doorstep, electricity and running water. But it is also apparent that the second home users of today comprise a more diverse group. We have many different segments of cabin users, from those that desire the simple life close to nature, to those who would rather stay in an apartment block at the timberline where one parks the car in a subterranean garage and takes the elevator to the apartment. At the same time, research shows that many of the basic motives for owning a second home remain unchanged. Most people still maintain that the central concept of cabin life is closeness to nature and that it is a place to spend time with family and friends in one's spare time, and that it provides opportunities for peace and quiet, and for engaging in outdoor activities. Generally, cabin life invokes positive associations, and it has important mental

restorative effects. The positive feelings and motives have also been identified in earlier research. But if the motives are more or less the same, it is obvious that people's ideas of contact with nature, outdoor activities and arenas for social activities have changed somewhat.

Research shows that both second home owners and other groups are concerned about this development. They maintain that the municipalities should not become too liberal in granting permission for new developments. Research also shows that a careful further development is commonly accepted, but that there is significant opposition to major changes in existing cabin areas. Not surprisingly, the degree of environmental consciousness as regards one's own activities around the second home is not particularly high, while attitudes towards development, i.e. allowing access to new users, are more negative.

### Major management challenges

Planners and managers face major challenges in this area. Today the market for second homes is one of the main economic sectors in remote areas of Norway. In many municipalities second home development is regarded as a last response to failing agricultural incomes and the exodus from the countryside. The NINA-project has documented that most municipalities with mountainous

areas in southern Norway suffer from a significant lack of personnel, competence and economic resources to adequately meet the challenge of second home development. The studies have shown that the development is most rapid along the coast and in municipalities harbouring wild reindeer. However, cooperation and coordination across municipality borders is practically non-existent. Less than 5% of the municipalities cooperate actively on second home issues. This will lead to major management conflicts in future when one may be forced to rehabilitate lost living areas, e.g. for wild reindeer.

### Further reading:

Kaltenborn, B.P., Bjerke, T., Thrane, C., Andersen, O., Nellemann, C. & Eide, N. 2005. Holdninger til hytteliv og utvikling av hytteområder. NINA Rapport 39. (In Norwegian with English summary).

Kaltenborn, B. P., Andersen, O. & Nellemann, C. 2007. Second home development in the Norwegian mountains – Is it outgrowing the planning sector. *International Journal of Biodiversity Science and Management* 3: 1-11.



# Management of large watercourses

Photo: O. T. Sandlund, NINA

## Odd Terje Sandlund

*Four of the institutes in The Environmental Research Alliance of Norway (ENVIRA) have completed a common strategic institute programme focusing on cross-disciplinary and holistic research on watercourses. The programme was carried out from 2002-2006, and focused on four main themes:*

- *River plains are a rare nature type in Norway and are liable to many different encroachments.*
- *Dams, which have local and regional effects on the aquatic ecosystem.*
- *Diffuse sources of pollution in the watercourse are difficult to control, and demand special measures.*
- *Spatial scaling of data; or what relation is there between detail and totality?*

The extent of changes on the **river plains** and processes causing change were investigated on the plains along Lågen in Ringebu. In this area the diversity of plants in the ponds on the river plain has also been studied, and a method for arriving at the most cost-effective approach to the protection of biological diversity has been employed on the data for this area. Hydrological conditions and sedimentation processes on river plains have been studied in other parts of the Glomma watershed.

The loss and deterioration of the nature types connected to river plains are more encompassing and happen more quickly than previously believed. The loss has been particularly extensive in the last 20 years as the building of floodworks and subsequent cultivation has been the most damaging interference. The Planning and

Building Act is not effective in conserving the river plain areas, because the encroachments are largely considered separately and not in connection with earlier encroachments and what remains of untouched areas. Area conservation through the Nature Conservation Act is a more effective tool to protect larger, continuous river plain areas.

Our analysis of how today's protection area covers the biological diversity of the river plain by Ringebu shows that the geographical location of the ponds is important for which organisms they contain, and that different groups of organisms are differently distributed over the river plain. A geographically wide distribution of the ponds is important in order to cover the diversity of crustacean species, for example, whereas there are fewer differences between the ponds when

it comes to aquatic plants and beetles. Important areas for flood plain biological diversity are also located outside the current protection area.

**Hydropower dams** as an impact factor has been investigated focusing on Løpsjøen dam in Søndre Rena (tributary to Glomma) as a starting point. Vegetation, plankton, zoobenthos, fish and water birds have been analysed. The results show that the establishment of a dam on the river has resulted in major ecological changes, both locally and regionally. The most important negative effect of such dams is probably associated with their impact on fish migration. On the other hand, the studies show that the dam has created a new, valuable landscape feature in the form of a shallow and productive lake, with increased biological production and new habitats for both plants and ani-





Photo: B. K. Dervo, NINA

mals. Løpsjøen has evolved into a regionally important locality for both aquatic plants and birdlife.

Under the heading **diffuse sources** of pollution, the projects have focused on constructed wetlands as a defense against diffuse run-off, cleaning ponds for run-off from roads and the use of stable isotopes to track sources and to study the processes in the drainage area.

Spatial representativity and scaling of data are methodological dilemmas of great significance in watercourse research and management. The subproject "**Spatial scaling of data**" has been a crosscutting activity in the strategic institute programme, and a variety of scientific approaches have been investigated. Our work with spatial scaling of watercourse information has combined existing knowledge from different disciplines, and thereby functioned as a cross-disciplinary and integrating activ-

ity. This contributes to the increased relevance of the published research results for watercourse management.

**Further reading:**

Sandlund, O.T., S. Hovik, J.R. Selvik, L. Øygarden & B. Jonsson (red.) 2006. Nedbørfeltorientert forvaltning av store vassdrag. – NINA Temahefte 35. (in Norwegian)

Miljøfakta nr 2, 3 (in Norwegian) and 4 (in English)



# DNA-based monitoring of large carnivores

Photo: R. Andersen, NINA

## Øystein Flagstad

*In 2001 genetic analysis of scats was adopted as a tool for monitoring the population of wolverines in Norway. The main objective was to get a better understanding of important parameters such as population size, reproduction and population structure. Since then, several thousand scat samples from southern and central Norway, as well as Jämtland and Dalarna in Sweden, have been analysed in a collaborative project with NINA and Uppsala University as the main actors.*

Recent research has shown that it is possible to identify individuals based on DNA extracted from scats, providing an opportunity for a new methodological approach to monitoring large carnivores. The DNA profile from scat samples is a unique ID-code which represents a single individual in the population. By finding scats from the same individual in several consecutive years, one can follow them over time and map their habitat use and reproduction status. The data can also be used to estimate population size, assess immigration rate, and analyze relationships among individuals. Over the last five years DNA-based monitoring has been implemented for all four large carnivores in Scandinavia. NINA has played a particularly central role in the monitoring of the wolverine population in southern Norway.

### Moderately increasing population

Analyses from six seasons of collection show that the wolverine population in southern Norway is increasing slowly, with an estimated population size of approximately 100 individuals in 2006. An alternative population estimate based on the

number of active natal dens has increased substantially faster in the same period and is now clearly higher than the DNA-based estimate (Figure 1). Plentiful food supply (small rodents) and increased tracking activities may explain the increased number of observed natal dens, but does not necessarily mean that the population as such has increased correspondingly.

### Long-distance migrations

The possibility to follow the same individual over several years has occasionally provided surprising results. In 2005, scats from a male wolverine were found in Hemnes municipality just south of Mo i Rana. Samples from the same individual had two years earlier been collected in Hedmark county, when he was a pup. His new location is situated 505 km as the crow flies from his birthplace. This is the longest documented migration distance of a wolverine ever recorded, be it in Scandinavia, Russia or North America. Another peculiar case involves a female wolverine who has been living in Bymarka by Trondheim since winter 2001/2002. Originally, she had a territory in Spekedalen in Ren-

dalen, but left this area when her cubs were killed in 2001, and migrated 145 km northwards before settling in Bymarka.

### Two sub-populations

Our data shows that there is strong genetic differentiation between wolverines in the very eastern parts of southern Norway and wolverines residing further to the west (Figure 2). The separation line follows Glomma (river), and shows that the interchange of animals in the east-west direction across Østerdalen (valley) is limited. Wolverines east of Glomma belong to the same sub-population as those found in Jämtland, Dalarna and Nord-Trøndelag, whereas the wolverines to the west constitute a genetically separate sub-population in southern Norway. Apparently, immigration to the western sub-population from the east was more frequent a few years ago, and some of these earlier immigrants have reproduced. This has contributed to maintaining the genetic variation, reducing the chances of harmful inbreeding effects in the western sub-population. Few new immigrants have been observed in recent years however, which may indi-



Photo: R. Andersen, NINA

cate a reduced immigration rate. Since the western sub-population is significantly smaller than the eastern one, immigration from the east and/or north is important for a genetically healthy population. Reduction or cessation of gene flow over time will lead to increased inbreeding with possible harmful effects. This, in turn, may have a negative effect on the long-term survival of the partly isolated wolverine population in southern Norway.

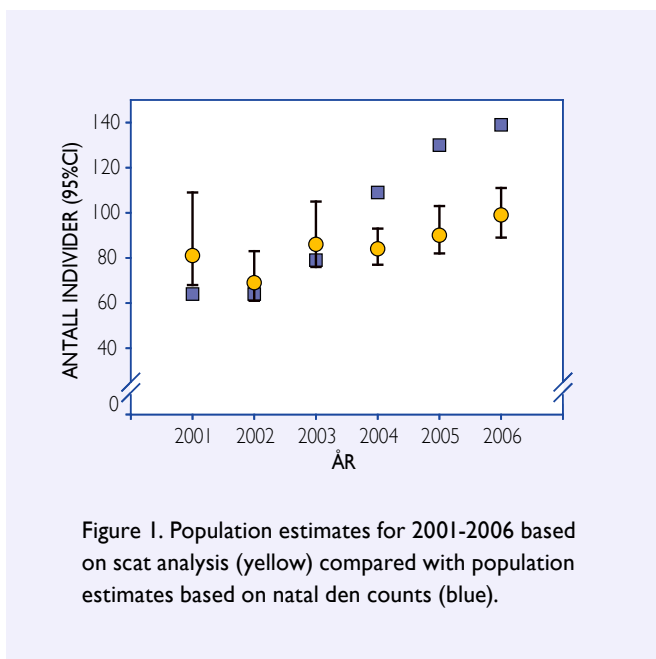


Figure 1. Population estimates for 2001-2006 based on scat analysis (yellow) compared with population estimates based on natal den counts (blue).

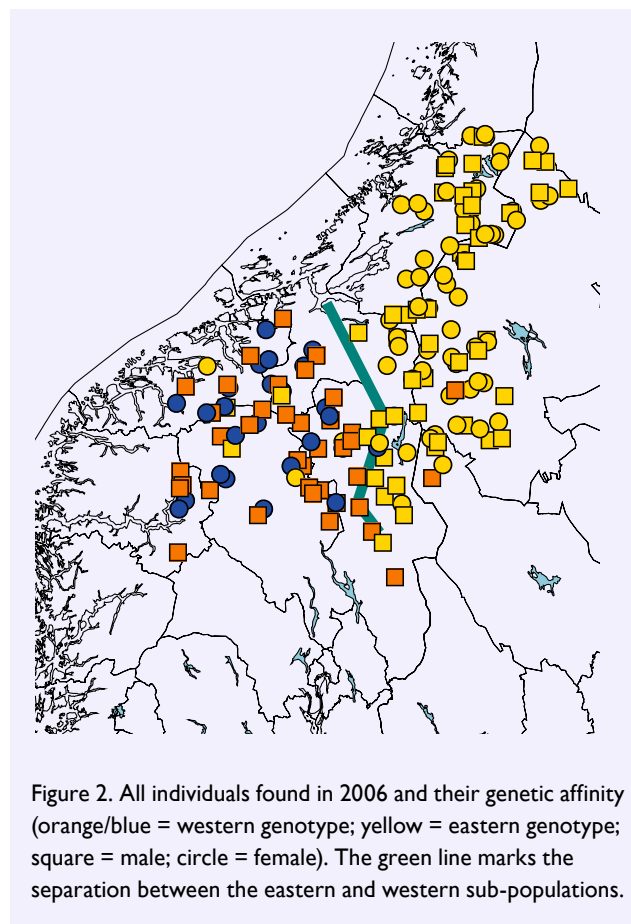


Figure 2. All individuals found in 2006 and their genetic affinity (orange/blue = western genotype; yellow = eastern genotype; square = male; circle = female). The green line marks the separation between the eastern and western sub-populations.





# Great advances in the knowledge of the relationships between wild salmon and escaped farmed salmon

Photo: E. B. Thorstad, NINA

## Lars Petter Hansen

*NINA researchers have greatly contributed to the knowledge of the effects of fish farming on wild salmon. NINA has been responsible for three international symposia on this subject, the last in cooperation with ICES and NASCO in Bergen in 2005. The reports from this symposium were published in 2006.*

The symposium in Bergen was attended by 111 participants from 17 countries, representing research institutions, management agencies, and aquaculture business. NINA researchers contributed in a significant way during the symposium, and five papers in the scientific publication proceedings from the symposium are lead- or co-authored by NINA researchers.

Since the early 1980s, farming Atlantic salmon has developed into a major industry. In 2005 approximately 0.8 million tons of salmon were produced in the North Atlantic, or approximately 380 times the reported catch of wild salmon in the same area. The effects of salmon farming on wild salmon, through diseases, parasites, genetics, and ecology are worrying, and there is a need to develop strategies to safeguard the wild salmon populations while allowing salmon farming to remain an important industry. Additionally, the interactions between wild and cultivated salmon are not limited to farming. A strategy where both risks and advantages are carefully considered is necessary also for salmon which is to be released for cultivation or

sea ranching. Since 1990 several international meetings have taken place where the theme has been to develop scientific knowledge to understand the interactions between salmon farming and wild salmon, and thus provide advice to management. The scientifically based understanding of the interactions between farmed and wild salmon has grown significantly through these years. The information presented in Bergen confirmed that farmed salmon may have a negative effect on wild salmon populations. An important development since the last symposium in 1997 was that the representatives from industry present in Bergen now accepted that this is a fact. This is important because it is a prerequisite for cooperative action. Even if cooperation has improved, it still needs to be developed further. Despite improvements in managing the interactions between farmed and wild salmon, the significant volume and the sustained growth in the farming industry demands rapid solutions. The goal must be that interaction between wild and farmed salmon must be eliminated, not only reduced.

The continued improvements in the management of the salmon lice problem depend on cooperation. Knowledge about best practice must be spread to all players. It is also apparent that there are still major challenges, especially in order to protect the populations of sea trout. Increased resistance against the various de-lousing medications is also a cause of concern for those with interests in either farmed or wild salmon.

Major progress has also been made in reducing the escape rate from farms, but relative to the number of wild salmon there are still large numbers of escapees in the sea. These escapees cause irreversible changes to the population structure and diversity of wild salmon if they are allowed to mate with wild individuals. This may have significant consequences for the ability of wild salmon to survive, reproduce and adapt to changes in the environment.

This symposium confirmed that increased efforts and improved technology to prevent escape are required. Research presented at this and earlier symposia show that we risk loss of local adaptation and diversity in wild salmon in the North Atlantic unless escapee numbers are significantly reduced. If not, sterilising farmed salmon may become necessary.



Photo: E. B. Thorstad, NINA

One must also focus on the problems in relation to undesirable release of salmon for cultivation and sea ranching.

#### **NINA's published contributions to the Bergen symposium:**

Nina and Bror Jonsson presented a very thorough literature survey of the knowledge on the ecology of farmed salmon in nature and how these affect the wild salmon populations. The conclusion is that farmed salmon compete with wild salmon for food and breeding partners. But the success of farmed salmon in nature varies, and may frequently be significantly worse than for wild salmon of the same size. This is due to physiological, ecological, behavioural, and body stature changes caused by farming. The success increases with the time the farmed salmon has been in the wild. Farmed salmon may displace, and reduce growth and survival rates in wild fish and therefore affect life history, production, and biomass.

Kjetil Hindar, Ola Diserud and collaborators have used data from studies on spawning success and survival of farmed, wild and hybrid salmon from Imsa in Norway and Burishoole in Ireland to model genetic and ecological effects of farmed salmon on wild salmon with various degrees of cross breeding with farmed salmon. The model suggests that 20% cross breeding with farmed salmon

at spawning will result in great genetic changes in the wild salmon over ten generations. The model also indicates that the damages are not necessarily restored even after many years with no influence from farmed salmon. The conclusion is that reducing the number of spawning farmed salmon in the rivers is urgent. Ola Diserud also contributed to an Irish study on the genetic effects of farmed salmon on wild salmon.

Peder Fiske, Roar Lund and Lars Petter Hansen investigated the connection between the ratio of farmed salmon in wild populations and farming activity. Significant correlations between escaped salmon in the rivers and the number of salmon in the net pens in the same counties were demonstrated. This suggests that safe zones where there is no farming activity may reduce the effects on the wild salmon in nearby rivers. There was a reduction in the correlation over time, suggesting that there has been a reduction in the number of salmon escaping at the smolt stage in later years. Salmon that escape at this stage return to the same geographic area at maturity.

Lars Petter Hansen has conducted a series of experiments by releasing tagged farmed salmon in the wild, in order to study migration and survival. Reared salmon released as smolt directly into

the sea have a relatively high rate of survival to maturity and largely returns to the same geographic area where they were released, and enter nearby rivers to spawn. Salmon fed in sea water from the smolt stage and released as post smolt directly into the sea have a low rate of survival to maturity and enter rivers farther away from the site of release than salmon released directly into the sea as smolt. Large farmed salmon that escape during the autumn or winter seem to lack homing instinct and are seemingly spread by the sea currents and may enter rivers far from the site of escape. Survival to maturity of large farmed salmon seems to be relatively low, but may increase significantly for fish that escapes shortly before maturity. Survival and migration patterns of farmed salmon are dependent on the time and life stage they escape.

#### **Further reading:**

Hansen, L.P. and Windsor, M. 2006: Interactions between aquaculture and wild stocks of Atlantic salmon and other diadromous fish species: Science and management, challenges and solutions. Convenors' report. NINA Special Report 34, 1-74.

Hutchinson, P. (Ed). 2006. Interactions between aquaculture and wild stocks of Atlantic salmon and other diadromous fish species: science and management, challenges and solutions. ICES Journal of Marine Science, 63: 1159-1371.





# Salmon lice, wild salmon and aquaculture escapees

Photo: B. Finstad, NINA

## Bengt Finstad

*The Hardangerfjord project focuses on the interchange of salmon lice between farmed and wild salmon in this fjord system. The fjord system is ideal as an investigation area because of the presence of important salmon and sea trout populations and because most of the fish farms in the fjord system cooperate on fish health. The goal is to develop a model which may explain how and why the salmon lice larvae spread the way they do under various conditions.*

The fjord dynamics in the Hardangerfjord are particularly favourable for the investigations in this project. The project, which was started in 2004, consists of a series of sub-projects:

- Registration of salmon lice on wild fish, farmed salmon and escaped farmed salmon.
  - Collect data on salmon lice numbers for all the hosts in the fjord system: Farmed fish, escaped farmed fish, wild salmon and sea trout.
  - Evaluate the success of the treatment regimes in the farms by examining the infection levels in the wild salmonids.
- Optimising the salmon lice counts and control strategies in farms.
  - Improve the quality of procedures using labrids, feeding strategies and bath treatments to reduce the salmon lice numbers in the farms.
  - Improve the salmon lice count methods in the individual farms, as well as developing further the methods for quantifying the salmon lice infection of an individual farm.
  - Investigate various strategies for utilising labrids.
- Quality in wild and farmed smolt
  - Investigate the health of wild and farmed fish in order to assess their susceptibility to salmon lice infections.
- Migration speed and migration routes of salmon and sea trout smolt in the fjord system
  - Investigate migration routes, where in the water (depth) the fish prefers to live, estimate the time the fish uses to migrate through the fjord system to the open seas using hydroacoustic tagging methods.
- The spread of salmon lice larvae
  - Investigate the number and source of salmon lice larvae in the fjord system.
  - Incorporate ongoing activities in the Hardangerfjord, both scientific and commercial, with new, expanded activity to survey the connection between farms and wild salmonids and salmon lice infections registered in these areas.
- Physical oceanographic factors that influence the spread of salmon lice in the fjord system
  - Quantify the spread of salmon lice in the Hardangerfjord based on physical oceanographic factors and meteorological conditions relative to the salmon lice source – spread potential for salmon lice

The purpose of the model developed, based on the collected data is to explain how and why the salmon lice larvae spread the way they do under various conditions. It is important to build a model where measured data agrees with what the model predicts. To achieve this, the water transport must be well described and one must have biological data for the salmon lice production potential, spread potential and infection of the fish fed into the model. Salmon lice biology and physical oceanography is a forceful combination.

A close collaboration has been established between NINA and other leading research institutions nationally and internationally in this project. The cooperation with the aquaculture business and fisheries and environment management is also vital. The results will have a great trans-ferral value for other fjord systems both nationally and internationally and may be utilised in management in order to minimise the risk of salmon lice infections on wild and farmed salmon. By developing a model which shows the spread of salmon





*Biotelemetry tracking of salmon smolts in the fjord system is an important element in the salmon lice project. Photo: Núria Plantalech Manel-la*

lice larvae, one will obtain a useful tool in the planning of where to locate farming activity. The project is set to finish in 2009 and is financed by The Norwegian Research Council, The Fishery and Aquaculture Industry Research Fund, The Norwegian Directorate for Nature Management and AquaNet Canada.

#### Further reading:

Bjørn, P.A., Finstad, B., Nilsen, R., Skaala, Ø. & Øverland, T. 2007. Registreringer av lakselus på laks, sjørørret og sjørøye i 2006. NINA Rapport 250: 1-24. (In Norwegian with English summary).

Finstad, B., Boxaspen, K.K., Asplin, L. & Skaala, Ø. 2007. Lakselusinteraksjoner mellom oppdrettsfisk og villfisk – Hardangerfjorden som et modellområde. Dahl, E., Hansen, P.K., Haug, T. & Karlsen, Ø (red.). Kyst og havbruk 2007. Fisken og havet, særn. 2. 2-2007, side 69-73. (In Norwegian).

You can also find more information on the Hardangerfjord project on [www.nina.no](http://www.nina.no)





# Are time series for seabirds useful indicators of fish recruitment?

Photo: T. Aarvak

Tycho Anker-Nilssen

*Compared with our fishery-biological traditions, Norwegian seabird monitoring is like a half-grown adolescent, and data series for the populations' demography and dietary choices are even younger. Even so, the scientific reaping in the wake of this activity indicates that an adapted status monitoring of seabirds may also be relevant to fisheries management.*

The longest time series for Norwegian seabirds concerns the nesting population of the northern gannet, which has been surveyed almost every year since the first Norwegian colony established itself at Runde near Ålesund in 1946. Systematic counts of our other cliff-nesting species did not start until the 1960s, and with few exceptions annual monitoring did not commence until the national Seabird Project was launched in 1979. Many data series were also temporarily broken when this project was ended in 1984, but since the establishment of the National Monitoring Programme for Nesting Seabirds in 1988, the population development for a reasonable selection of Norwegian seabirds has been surveyed every year. The results are reported annually and were last presented in NINA Report 203.

## Atlantic puffins in Røst – a starting point

Unfortunately, the basic demographic data series, which may help explain the

population trends that have been uncovered, are far fewer and on the whole far shorter. The longest Norwegian series are for chick growth and nesting success for Atlantic puffins in Røst, which were started in 1964, but the quality of the data from the first decade deviate from later standards. In connection with the Seabird Project in the early eighties, similar series were started for other species in Røst and on Hornøya outside Vardø, and although many of these series were interrupted in the period from 1984 to 1987, they were restarted and have been repeated annually since then.

At the end of the eighties a similar endeavor was started at Bjørnøya (Bear Island), and at the same time monitoring of the survival of nesting seabirds in the three localities mentioned was begun. With the exception of studies of common eider on Grindøya near Tromsø and of black-legged kittiwake and common eider in Kongsfjorden at Spitsber-

gen, Røst, Hornøya and Bjørnøya are the only places from which we have reasonably long time series for the population dynamics of selected seabird populations. In parallel, for several of these populations we have also studied the birds' diet in the breeding season, mainly by registering what the chicks were offered by their parents.

## Neat indicators of fish?

Even though monitoring series for Norwegian seabirds are still relatively short, especially as regards reproduction, survival and diets, analyses of these data in relation to various environmental factors have increasingly identified and documented important interactions between seabirds and their habitat. This knowledge is not only crucial to achieving the best possible management of the species in relation to national and international goals and value criteria, but the results also indicate that many seabirds may have a practical use in management as cost-effective indicators



Photo: T. Aarvak

of other marine organisms. This is also the case in relation to some of our most important fishery resources. It has been documented that several of the parameters that are surveyed for nesting seabirds may be used to develop early and reliable signals of fish recruitment. A couple of examples that build on time series data for seabirds in Røst and the Institute of Marine Research's data for Norwegian spring-spawning herring and north-east arctic pollock are good illustrations of this.

### Puffin and herring – once again

The classic example is derived from the strong co-variation between the quality of 0-group herring in the diet of the puffin chicks in Røst and the chicks' survival to fledging (Figure 1). The size of the herring the puffin offers its chick turns out to correlate well with abundance estimates of the same herring year-class in its Barents Sea nursery areas, when these are back-calculated in various models by ICES

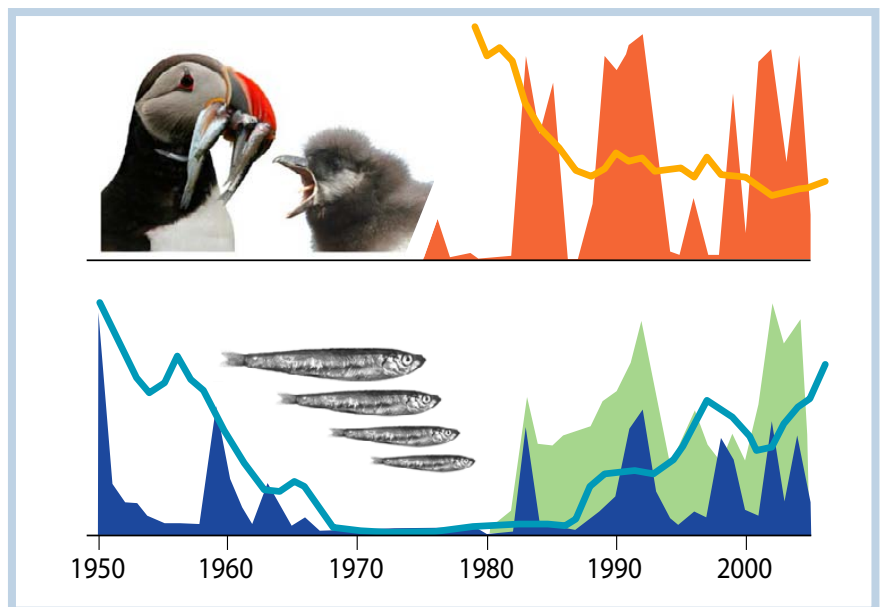


Figure 1. Chick production for the Atlantic puffins in Røst (red area, % fledging success) is largely decided by the supply of well developed herring of the same year-class. The size of the herring the puffin offers its chick (green area, % of range) is at the same time a good indicator of the year-class strength of young herring which later reaches the Barents Sea (blue area). Much of the variation from year to year is a result of climate change, but the herring year-class strength is also affected by the size of the spawning population (blue curve). The condition of the fledglings is not shown, but is well correlated with fledging success. The many failed breeding seasons led to recruitment failure and a serious drop in the puffin population in Røst (orange curve). (Sources: NINA and ICES Advice/ACFM.)





Photo: T. Anker-Nilssen

a few years later. Both for herring and puffin, much of the variation in conditions for growth of the young from year to year is a result of climate variation, as reflected in sea temperature, salinity and the NAO winter index. Combined with such physical factors, the puffins' accuracy as an indicator of herring is significantly strengthened. The relationship between herring and puffins in Røst is described in more depth in NINA Report 133.

### Seabirds and saithe – in the same way

The other example is seabirds as indicators of recruitment to the population of saithe north of 62°N. Our largest populations of European shag and black guillemot spend their entire lives within the Norwegian Coastal Current, where the kelp forest is also the nursery area for young saithe, from when they leave the pelagic waters during their first summer and until they are recruited into the commercial, pelagic population two to three years later. During this period they can not be surveyed from sea-going vessels, which prevents the calculation of fairly robust estimates of their recruitment until they have reached the age of four or five years, that is after they have also been exposed to commercial harvest. This was probably one of the reasons why the Institute of Marine Research established a new observer programme for young saithe along the coast from Møre to Finnmark in 2000, but it is still too early to test fully the precision of

the year-class strength estimates that this will provide.

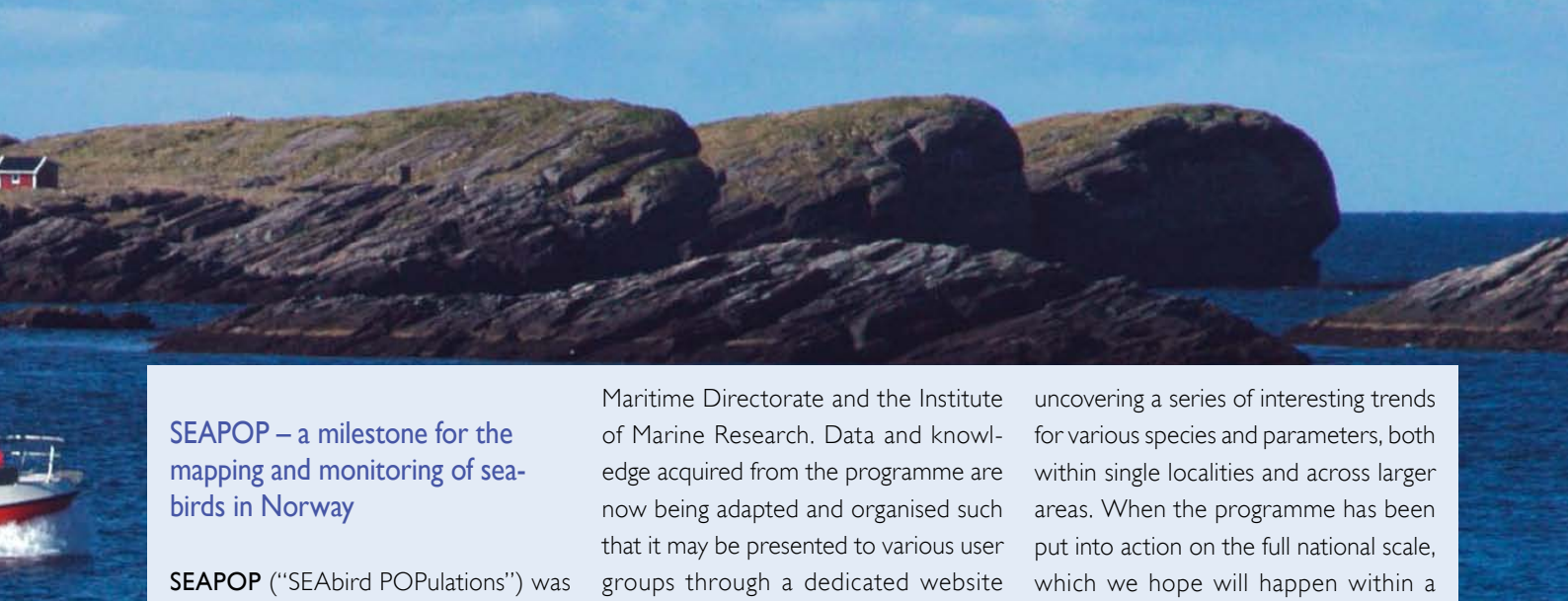
As young saithe is an important prey for a number of species of breeding seabirds, time series from the saithe's feathered predators may, however, provide equally timely and valuable information about the saithe's adolescence. In fact, data series from Røst alone show that both time of breeding and clutch size for shag and the proportion of 0-group saithe in the diet of the black guillemot may predict the recruitment to the saithe population one to two years later with reasonable accuracy. Like the example with puffin and herring, the precision is strengthened when climatic conditions, as reflected by the temperature in the coastal current, are taken into account. The relationship is still somewhat weaker than in the puffin example, which could also be expected as the time interval between the collection of seabird and fish data is even greater for saithe than for herring.

### With SEAPOP into the future

The type of data series described above is one of several main elements in the new SEAPOP programme (see info box below and [www.seapop.no](http://www.seapop.no)). With SEAPOP, the demographic monitoring of seabirds has been extended significantly, and the course is set for implementing the programme on a full national scale within the next few years. As our most visible marine animals, the population dynam-

ics and diet of seabirds may be surveyed relatively accurately with far simpler methods than for most other marine organisms. With their large ranges of movement and strong specialisation with regards to habitat and feeding preferences, seabirds show an unique ability to mirror important changes in the marine environment. The potential for developing useful indices and improving existing management models by implementing time series data from seabird monitoring is therefore great. If we take this challenge seriously, I am convinced that today's initiative in establishing a more comprehensive, long-term monitoring of seabirds which is demographically, ecologically and geographically adequate for reflecting the variation in Norwegian sea areas will soon prove its worth, even from a purely socioeconomic point of view.

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## SEAPOP – a milestone for the mapping and monitoring of seabirds in Norway

**SEAPOP** (“SEAbird POPulations”) was started in 2005 and is a holistic and long-term monitoring and mapping programme for Norwegian seabirds. The programme signifies a new initiative for these activities along the Norwegian coast, in Svalbard and in the surrounding sea areas, and will obtain and maintain basic knowledge about seabirds in order to contribute to a better management of these marine environments. A special focus is put on the collection of data important for modelling the effects of human influence and to separate these from what is primarily caused by natural variation.

From strategic considerations, e.g. to the management planning work, the effort in the first two years was limited to the area from Lofoten to the Barents Sea, but the programme is designed to be implemented on a full national scale within the next few years. The work is organised and carried out by the Norwegian Institute for Nature Research (NINA) in close cooperation with the Norwegian Polar Institute (NP) and Tromsø University Museum and is currently financed by the Ministry of Environment (MD), the Ministry of Petroleum and Energy (OED) and the Norwegian Oil Industry Association (OLF). The programme’s administration committee, in which the ministries are represented with the Directorate for Nature Management (leader) and the Norwegian Petroleum Directorate, also has members from OLF, the Norwegian Coastal Administration, the Norwegian

Maritime Directorate and the Institute of Marine Research. Data and knowledge acquired from the programme are now being adapted and organised such that it may be presented to various user groups through a dedicated website ([www.seapop.no](http://www.seapop.no)).

### Mapping

Within a period of ten years (which equals the expected validity of such data), SEAPOP aims to map the distribution of breeding, moulting, resting and wintering seabirds in numbers, time and space along all the coasts of Norway and the Svalbard archipelago. For logistical and economical reasons, the distribution of seabirds in the vast sea areas covered by the programme will primarily be modelled using inter-disciplinary data for various environmental factors of importance. This work is carried out in close cooperation with the Institute of Marine Research and is largely based on data collected on their ecosystem cruises in parts of these sea areas.

### Monitoring

The national monitoring of population development has been on-going since the 1980s and will be continued for more species and on more sites. In addition, we have expanded and adjusted the monitoring of reproduction, adult survival and diets for a selection of species at the already established key-sites of Røst, Hornøya and Bjørnøya and established three more key-sites; on Anda in Vesterålen, on Hjelmsøya west of the North Cape and on western Spitsbergen. This is necessary in order to identify as early as possible which environmental factors are affecting the populations. On the background of time series accumulated over several decades, we are now

uncovering a series of interesting trends for various species and parameters, both within single localities and across larger areas. When the programme has been put into action on the full national scale, which we hope will happen within a year or two, similar monitoring will also be established at a selection of key-sites in central and southern Norway.

### Special studies

SEAPOP will also fund a series of shorter-term projects, e.g. for resolving important questions about ecology and habitat use of seabirds that are particularly vulnerable to certain environmental influences or otherwise of particular interest or in need of protection. SEAPOP is designed throughout to cover with reasonable adequacy the most important information need of the end users. In order to enhance the cost-efficiency and precision of the programme, some effort will be spent on developing methods for automatic monitoring of various parameters.

### Publication

When it is properly established, the SEAPOP-website ([www.seapop.no](http://www.seapop.no)) will accumulate and make available a wide range of results from the programme. Even if downloading raw data will require a special license, a variety of processed information will be freely available. The website will also contain an up-to-date list of scientific publications associated with the programme, as well as summaries of the main results presented in annual reports. The first two of these reports (for 2005 and 2006) are now available for downloading in pdf-format via a link on the front page (NINA Reports 127 and 249).

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