NORWAY - PROGRESS REPORT ON MARINE MAMMALS 2015

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I INTRODUCTION

This report summarises Norwegian research on pinnipeds and cetaceans conducted in 2015 and conveyed to the compilators. The research presented here was conducted at, or by representatives and associated groups of,

The Institute of Marine Research (IMR);
University of Tromsø (UiT);
The Norwegian Polar Institute (NP);
University of Tromsø – The Arctic University of Norway/ Department of Arctic and Marine Biology (UIT-AMB);
Norges Arktiske Universitet, Forskningsgruppe for arktisk infeksjonsbiologi (AIB).

II RESEARCH BY SPECIES 2015

PINNIPEDS

Harp seals *Phoca groenlandica*

The use of traditional photo aircrafts to assess seal populations in remote areas, such as the West Ice, is expensive, and has also become more difficult to operate during recent years. Few airports are available in the area: Constable Point in East Greenland, Akureyri in Iceland and one primitive landing stripe on the island Jan Mayen. The latter is not even always available. The Greenland airport is the main base – due to the ice conditions this arrangement requires that fuel for the operation is shipped to Constable Point the autumn before the surveys are carried out. With funding from the Norwegian Research Council (NRC), IMR has now started experiments with alternative (and cheaper) methods to perform photo based aerial surveys of seals in the West Ice. Two research survey have been carried out to the West Ice, the first in March 2014 using KV *Svalbard*, the second in March 2015 using MS *Bjørkhaug*. The aim of the surveys was to test the usefulness of UAVs (Unmanned Aerial Vehicles), operated by the Northern Research Institute (Norut), to perform aerial photographic surveys of **harp** and **hooded seal** whelping patches on the drift ice. Two drones were tested: One small (wingspan 2.10 m) with electromotor and one larger (wingspan 3.80 m) petrol-driven UAV. Digital cameras were used, and the largest UAV was also instrumented with thermal infrared (IR) camera. Both aircrafts were launched by a mechanical launcher from the ship deck. The smaller UAV could be landed on KV Svalbard's helicopter platform, while the larger had to be landed on ice floes, preferably at least 80 m long and 20 m wide. Both UAVs fly along predefined transects and altitudes, but changes can be implemented throughout the flight using satellite based communication. The UAVs are landed manually. The main aim of the investigations in 2014 was to explore various survey altitudes and camera settings to obtain an optimal altitude and camera set up for photographing seal pups. Simultaneous use of digital and IR cameras enabled exploration of combinations of those to detect and classify seals. Experience obtained from using the UAVs, and the quality of the images taken, were promising. Both harp and hooded seals, including pups, were easily identified on the images taken at an altitude of 300 m (the usual altitude for photographing during traditional surveys). Images from the IR camera did not improve the photo analyses. In 2015, we aimed also to test UV-cameras. Unfortunately, however, the largest UAV (including the equipment) was lost due to technical problems. Nevertheless, the experience obtained during the two surveys show that it is necessary to develop a system that enables us to land a relative large UAV on the helicopter platform. The ice conditions in the West Ice seal whelping patches usually implies small and uneven ice floes which

make it difficult to land the UAV. It is important to improve the range of the largest UAV. Also, technical improvements on the UAV and equipment are necessary to be able to operate in cold and windy conditions. (IMR)

Manual analysis of images obtained in aerial photographic surveys is extremely time consuming and costly, and involves subjective human interpretation by trained experts. For this reason, the UAV project, also aims at developing methodology for automating the process of counting seals from aerial images. This will be achieved through the development of new image analysis and pattern recognition techniques tailored to detect **harp** and **hooded seals** in digital color images. This part of the work occurs in close cooperation with the Norwegian Computing Center, Oslo. (IMR)

The population model used in current management of the Barents Sea / White Sea **harp seal** populations is a deterministic age-structured population dynamics model. Available fecundity data are included in the model as a known quantity and no uncertainty around the measurements has been accounted for. The scarce available data on fecundity makes the model stiff and unable to fit to variations in the observed data, and the resulting confidence intervals are likely to be underestimated. Norwegian scientists have suggested an improvement to the population model to make it more flexible in capturing the dynamics of the observed pup production data. They accounted for the temporal variation in fecundity using a state-space approach, and assumed the fecundity to be a stochastic process that was integrated with the age-structured population dynamics of the current management model. Due to the limited availability of fecundity data for the Barents Sea / White Sea population, fecundity information from the Northwest Atlantic harp seal population was used. Summary statistics for the Northwest Atlantic time-series, such as autocorrelation and variance in fecundity, were used as prior distributions in the state-space model. The state-space model was more flexible than the deterministic model and provided a tight fit to the survey pup production estimates as it captured the sudden drop in the survey estimates from 2004 and 2005. The state-space model provided a higher estimate of current population size but also a much higher associated uncertainty. The current management model predicted that the pup abundance will have a slight increase over the next 15 years, whereas the state-space model predicted that the pup abundance will increase substantially. The state-space model show some promising results and might be a step forward towards more realistic modelling of the population dynamics of the Barents Sea/White Sea harp seal population.

Studies of **harp seals** and **hooded seals** from the Greenland Sea stock were conducted during a research cruise with R/V “Helmer Hanssen” to the Greenland Sea between 16 March and 1 April 2015. Altogether 5 adult and 6 newborn hooded seals, and 5 adult and 5 newborn harp seals, were culled for various scientific purposes:

i) onboard electrophysiological experiments and sample collections, for studies of mechanisms underlying neuronal tolerance to lack of oxygen (hypoxia) (in collaboration with Dr. T. Burmester, Zoologisches Institut und Museum, Universität Hamburg, Germany and Dr. J. Larson, Psychiatry College of Medicine, University of Illinois, Chicago);

ii) studies of adaptations to fasting in hooded seal pups (the role of the liver as an energy store from birth via weaning and throughout the post-weaning fast);

iii) the role of leptin and its correlation to changes in blood energy substrates (glucose, free fatty acids, ketone bodies) during lactation and fasting in hooded seal pups;

iv) the role of exogenous water sources (snow/ice, sea water) for maintenance of water homeostasis and the potential occurrence of metabolic depression during the post-weaning fast in hooded seal pups;

v) anatomical studies of the respiratory tract and lungs of harp and hooded seals, for quantification of lung capacity and dead space (for assessment of buoyancy in relation to diving energetics) and for detailed studies of the nasal cavity and its complex turbinate structures, for subsequent modelling and assessment of its role in heat and water conservation;

vi) collection of gastrointestinal systems, gut content, blood samples and whiskers + lower jaws of adult and new-born harp and hooded seals, for studies of the ontogeny of gut function and of seal whisker growth and age determination, the latter for assessment of the potential for use of whisker chemical composition as indicator of diet/habitat selection of seals;

vii) collection of tissues and immune studies of harp and hooded seals for contaminant analysis, histopathological examinations and disease surveillance (in collaboration with Dr. R. Dietz and PhD-student Jean-Pierre Desforges at Aarhus University, Denmark);

viii) studies of the functional anatomy of the hooded seal aorta, histology and pressure. (UIT-AMB)

The described field research was combined with research-based teaching given to 19 students that participated on the cruise, which represents a mandatory part of the course "Arctic Biology" (BIO-2310) at the University of Tromsø -The Arctic University of Norway. (UIT-AMB)

Post mortem sampling of stomachs of 53 harp seals (*Phoca groenlandica*), both pups (n = 5), yearlings (n = 43) and adults (n = 5), sacrificed during commercial hunting in April-May was performed in 2014. These stomachs and their content are currently subjected to PCR analysis for the detection of marine *Brucella* spp. at the Federal Institute for Risk Assessment, Berlin, Germany (AIB, UiT)

In the natural environment, pathology in seals due to infection with *B. pinnipedialis* has not been documented. A lack of intracellular survival and multiplication in hooded seal macrophages *in vitro* indicates that *B. pinnipedialis* does not cause chronic infections in hooded seals (*Cystophora cristata*) and additionally is *B. pinnipedialis* from hooded seals shown to be avirulent in an established mouse model. An age related serological and bacteriological pattern for *B. pinnipedialis* in hooded seals might point to a transient infection of environmental origin, possibly through the food chain. (AIB, UiT). The reduced virulence of the marine mammal brucellae (harbour seal and harbour porpoise strain) were further confirmed in the established BALB/c mouse model. (AIB, UiT)

To investigate if multiplication could take place in other hooded seal cell types, primary epithelial cells from hooded seal were isolated, verified to express the epithelial marker cytokeratin and challenged with three different strains of *B. pinnipedialis*; *B. pinnipedialis* sp. nov., *B. pinnipedialis* hooded seal strain B17, and *B. pinnipedialis* hooded seal strain 22F1. All strains were steadily eliminated and the amounts of intracellular bacteria were reduced to less than one third by 48 h post infection. Intracellular presence was verified using immunocytochemistry. The findings in this study contribute to substantiate the hypothesis that seals may not be the primary host of *B. pinnipedialis* and that the transmission to seals are caused by other species in the marine environment. (AIB, UiT)

Present studies aim to provide knowledge of a possible environmental niche of *B. pinnipedialis*. In an extended *in vivo* infection including 360 Atlantic cods (*Gadus morhua*), fish were infected intraperitoneally with 10^8 *B. pinnipedialis*. This experimental infection had an extended length to further evaluate the chronicity of the infection, as well as investigation of possible contamination of naive uninfected in-contact fish. Tagged uninfected in-contact cod were kept with infected cod. Uninfected control cod were kept in separate tanks. The effect of increased water temperature in the development of disease following infection with *B. pinnipedialis* hooded seal strain was also examined. The experimental infection was run at 6°C and 15°C, mimicking Arctic water and increased water temperatures expected in the Northern Atlantic during the 21st century (International Panel on Climate Change scenarios). (AIB, UiT)

Results show that at 6°C, viable bacteria were found in the blood of all infected cod at all times post infection (pi) (day 1, 7, 14, 21, 35, and 49). Neither gross pathology nor mortality were recorded in fish kept at 6°C. Anti-*Brucella* antibodies were detected earlier at 15°C than at 6°C. At 15°C, bacteria were eliminated more quickly, however mortality was observed between day 7 and 20 pi in 5/60 fish. No *B. pinnipedialis* was cultured from these 5 dead fish. At 15°C, 1/60 fish in the uninfected in-

contact group died at day 9 and 1/60 fish in the uninfected control group died at day 21. *Brucella pinnipedialis* was not isolated from any of the uninfected in contact fish regardless of the water temperature. Our findings suggest a possible trade-off between immunocompetence and other vital functions at sub-optimal temperatures and raise questions on the influence of increased water temperatures in the oceans and the emergence of diseases in aquatic ectotherms. (AIB, UiT)

Complementing research investigating the environmental niche includes survival studies of marine *Brucella* spp. in a seawater model and protein expression profiling (proteomics) during starvation, performed by our collaboration partner in Germany (Federal Institute of Risk Assessment (BfR), Berlin). These results will be communicated during 2016. (AIB, UiT)

Hooded seals *Cystophora cristata*

Joint analyses of Norwegian and Russian data on female **hooded seal** reproductive biology in the Greenland Sea are under completion for publication. Ovary data collected in breeding patches from 1958 to 1999 show an estimated age at first birth of about 5 years up to 1980, and a slight increase to 5.5 years for the rest of the period. This is significantly higher than the minimum age at first birth in hooded seals of 4 years estimated for ovary data collected in breeding patches near Newfoundland during the period 1967-1973. This suggests that female Greenland Sea hooded seals may have been resource limited throughout the study period and that the modeled population reduction up to 1980 has not resulted in increased per capita resource availability. This was a period of dramatic increases in commercial fisheries landings of many species known to be preyed upon by hooded seals, e.g., Greenland halibut, redfish and capelin. Even if some of these fisheries may have been sustainable from a fisheries point of view, reductions in standing stock may still have reduced the availability of many fish species to their natural predators. Changes in ice conditions may also affect the energy balance of ice associated seals. (IMR). For more about surveys, diet and reproductive research, see under harp seals. (IMR)

Studies of **hooded seals** and **harp seals** from the Greenland Sea stock were conducted during a research cruise with R/V "Helmer Hanssen" to the Greenland Sea between 16 March and 1 April 2015, as detailed above. (UiT, AMB)

Harbour seals *Phoca vitulina*

Harbour seals were counted along the entire mainland Norwegian coast at known haul out sites during the moulting period from mid-August to early September 2011-2015. In 2011 and 2012, moulting areas from Rogaland to Finnmark counties and in Østfold county were covered by aerial photo surveys flown at altitudes of approximately 245-275 m during low tide (± 2 hours). Surveys in Østfold county were flown at approximately 90 m. The small tidal amplitudes in Østfold permitted counts to be carried out during day time irrespective of the tidal cycle. Usually three independent surveys were conducted. Visual counts using binoculars from small boats and land were also carried out in areas not covered by aerial surveys, or where results from the aerial surveys seemed to be incomplete. The surveys revealed a total minimum population of 7642 harbour seals along the mainland Norwegian coast in 2011-2015. In western Finnmark, 395 harbour seals were counted in 2013. West Finnmark was not covered in the two previous surveys. The count of 7247 harbour seals (not including West Finnmark) seems to be a small increase compared to 6938 in 2003-2006, but lower than 7465 in 1996-1999. (IMR)

The EPIGRAPH project (2008-2011) was built as a comparative study of the ecosystems of two major fjords in Norway: the Porsangerfjord and Hardangerfjord. The project has had a wide focus on all levels of the ecosystem, including, in Porsangerfjord, a study on the ecological role of the top-predator thought to be the most influential in the area: the **harbour seal**. The coastal cod stock of the Porsangerfjord has drastically declined in the 1980s and never fully recovered since. A population of harbour seals, known to be resident in the fjord all year round, has been hypothesized to act as predator-pit for cod in the area, affecting its lack of recovery. To understand the role of these seals in this local marine ecosystem, their foraging behaviour was investigated by assessing the presence of

preference for certain prey and the behavioural response to the seasonal dynamics of prey distribution in the fjord.
The movement patterns of individual harbour seals (n = 15) were followed between 2009 and 2013. The data obtained (*i.e.* GPS location, time-depth dive profiles, etc.) were first thoroughly analyzed to provide a robust interpretation of the behavioural patterns of activities of the single individuals and identify the methodological caveats in the detection of foraging behaviour. Among the major results, two types of resting behaviour at sea were described, in the form of prolonged periods at surface but also as resting dives, a behavior never documented before for this species. The patterns of activity suggested that harbor seals mainly forage during daylight in autumn and spring in this area. The foraging locations identified were then compared to the availability of potential prey in the fjord (*i.e.* herring, capelin, small and large codfish and sculpins). The availability of prey was assumed to be dependent on their biomass densities, their distance from the seals' haul out sites and the accessibility of the areas where prey was located. The latter could be restricted for example by the presence of sea ice in winter and spring. Results on the analyses of prey selection suggested that harbour seals in Porsangerfjord preferred small size fish (< 25cm). Small codfish was preferred during autumn, but a response to the presence of pelagic fish was seen when the latter aggregated to overwinter in cold deep waters in the inner parts of the fjord. The formation of ice in these areas during the winter season, however, provoked a shift in preference to small codfish, due to the sudden inaccessibility of the pelagic fish. A strong reversed trend was observed in late spring when the ice melted and pelagic fish was preferred again. The results suggest the preference for small aggregated fish close to the haul out areas. The impact of harbour seals on the cod population of Porsangerfjord can be therefore hypothesized to change across seasons and to be lowered by the availability of highly aggregated pelagic fish during winter and spring. (IMR, UiT)

Grey seals *Halichoerus grypus*
In Norway, a population model is used to describe the dynamics of the Norwegian **grey seal** population based on data from pup counts covering the entire grey seal distributional area in 1996-2008. The model also requires estimates of natural mortality and female reproductive rates, but since empirical data on these parameters were outdated or absent, they were estimated by the model using a Bayesian approach. Model runs indicated an increase in abundance of the total Norwegian grey seal population in the 30 most recent years, suggesting a total of 7120 (5710 - 8540) animals (1+) in 2011. Including an estimated pup production of 1620 (95% CI 1410-3050), a total of 8740 (95% CI 7320-10170) animals was obtained for 2011. However, new boat based surveys carried out in the entire area from Froan in Sør-Trøndelag to Lofoten in Nordland in 2014-2015 showed a significant decrease in pup production and yielded numbers ranging between 34.8% and 47.5% of the counts from 2007-2008. In Finnmark the pup production in 2015 was approximately equal to the results in 2006. Including these new pup counts in the population model, and assuming the same population sizes in 2016 as in 2006-2008 for the counties Troms and Rogaland, the current total number of grey seals in Norway was estimated to 3850 animals (95% CI: 3504-4196). (IMR)

Other species
Research vessels, coastguard vessels and other providers have collected incidental observations of marine mammals. Recorded data include date, position, species and numbers. During 2015, 41 pinniped observations were recorded. Of these, only 2 observations were recorded as **harp seal** groups, but many of the 27 groups recoded just as "seals" are probably this species. Otherwise, 2 **bearded seals**, and 7 **walrus** groups were recorded. (IMR)

CETACEANS

Minke whales *Balaenoptera acutorostrata*
During the periods 22 June to 30 August 2015, a sighting surveys was conducted with the chartered vessel M/S *Fisktrans* in the Norwegian Sea and the Jan Mayen area. The areas which were covered were the IWC *Small Area EW* (Norwegian Sea and coastal Norway) and parts of *CM* as a contribution to the extension surveys of NASS-2015. This was the second year of the six-year program 2014-2019 to cover

the northeast Atlantic to provide a new abundance estimate of **minke whales** every sixth year as part of the management scheme established for this species. A total of 4,343 nautical miles was surveyed with independent double platforms on primary effort. During primary search effort, the number of observations from the primary platform was 59 sightings of **minke whales**. Sightings of other cetacean species include **fin whales** (55 primary sightings), **humpback whales** (14 primary sightings), **killer whale** (22 primary sightings), **blue whale** (2 primary sightings), **Lagenorhynchus dolphins** (43 primary sightings), and **sperm whale** (38 sightings) (IMR).

Minke whale catch data for the 2015 season have been computerised and evaluated. (IMR)

Other species
Research vessels, coastguard vessels and other providers have collected incidental observations of marine mammals. Recorded data include date, position, species and numbers. During 2015 a total of 636 cetacean observation incidents have been reported. The most frequently observed species were **minke whales** (137 groups), **Lagenorhynchus dolphins** (137), **fin whales** (48), **humpback whales** (83), **killer whales** (74), **harbour porpoises** (64 groups), **blue whales** (1), **sperm whales** (10), **long-finned pilot whales** (35), **bottlenose dolphins** (3), **sei whales** (3), **common dolphins** (5 groups) and **beluga** (5). (IMR)

During 2015 photo IDs have been collected from more than 300 **humpback whales** during field work and from incidental sources. In addition, biopsy samples have been collected from 71 humpback whales. (IMR)

Climate warming may both enhance northward expansion of temperate species from lower latitudes and change the distribution of resident species at higher latitudes. This may present challenges both for newcomers and residents. Cod abundance has increased, and its range has extended northwards in the Barents Sea in recent years. One implication of this is a new overlap of feeding grounds with **minke whales** and **harp seals**, two other important top predators in the area. It has been shown that both these mammal species have exhibited declines in body condition in recent years, and competition for food with the increasing cod stock is suggested as a possible explanation. (IMR)

Significant change in the distribution and abundance of several **cetacean species** during recent decades has been shown ina Icelandic waters as well as in the Norwegian Sea. It is observed that whale species have the capability to rapidly perform shifts in distribution and abundance patterns strongly associated with adaptive search behaviour in relation to both changing levels of abundance of their prey and increased sea surface temperatures. (IMR)

A study based on data from the joint Norwegian-Russian ecosystem surveys in the Barents Sea has compared acoustic surveys of krill with observed distribution of **minke**, **fin** and **humpback whales**. Fin whale densities were positively and linearly associated with krill abundance, and higher than average densities of humpback whales were found in areas with high krill abundance. No association was found between minke whales and krill. Densities of all three whale species were also positively associated with capelin, another target species of the ecosystem surveys. For fin and humpback whales, the effects of capelin and krill on whale densities appeared to be principally separate and additive, although there was some evidence for a stronger effect of krill at low capelin densities. In terms of their preference for krill and capelin, these whale species appeared to be flexible, opportunistic predators. (IMR)

III ONGOING (CURRENT) RESEARCH

PINNIPEDS

Walrus *Odobenus rosmarus*

Field work was carried out in the area of northern Spitsbergen and north-western parts of Nordaustlandet in Svalbard in July and August 2015, where 20 male **walruses** were equipped with newly developed GPS-loggers. These were attached to the tusks of the animals and are designed to store 1 GPS position per hour for at least 5 years. Data must be downloaded to stationary receiving stations placed on the five camera masts used for camera surveillance of walrus haul-out behaviour (see below) or to mobile stations brought along in the field. Various blood and other tissue samples were also collected from these walruses for various studies of health, pollution, diet etc.

The camera surveillance of **walrus** haul-out sites continued. Digital cameras taking pictures hourly were deployed on 5 different walrus haul-out sites during the period late June - early October to study haul-out behaviour and potential impact of visiting tourists to these sites. (NP)

Antarctic fur seals *Arctocephalus gazella* and Southern elephant seals *Mirounga leonina*:
Expedition to Bouvetøya December 2014-february 2015. CEMP monitoring of Antarctic fur seals. Also, several scientific projects initiated on these two seal species on tracking, diet, population dynamics, pollution, genetics and others. (NP)

Publication of **hooded seal** reproduction data (historical as well as new, sampled in 2008 and 2010) from the Greenland Sea are in progress. (IMR)

Analyses of historical and new data on demography and reproduction of **harp seals** in the Greenland Sea and Barents Sea / White Sea are in progress. (IMR)

Collection of material to assess efficiency and animal welfare issues in the Norwegian commercial sealing of **harp seals** in the Greenland Sea in April/May was started in 2013 and is still in progress. (IMR)

Ship based registrations of **grey seal** pups, including tagging, counting and staging of pups, will be conducted in Troms and Finnmark during the period November-December 2016. This is the third of a four-year program aimed to provide a new abundance estimate for the species along the entire Norwegian coast from the county Rogaland in the south to Finnmark county in the north. All known and many other potential whelping areas along the Norwegian coast will be surveyed. (IMR)

Tagging of **harbor seals** with GSM tags will be conducted in southern Norway (Skagerrak) in August. The project will occur in cooperation with Swedish scientists. (IMR)

Final analyses of **grey seal** diet data from the Norwegian coast are in progress, an article will be submitted. (IMR)

Publication of results from genetic and population studies of **harbour** and **grey seals** is in progress. (IMR)

Previous studies in **hooded seals** have shown that their brain is unusually tolerant to lack of oxygen (hypoxia). Electrophysiological and biochemical studies of *in vitro* neuronal responses to hypoxic insult have been continued using fresh brain tissue from **hooded seals**, as part of ongoing collaborative studies (with Dr. T. Burmester, University of Hamburg, Germany, and Dr. John Larson, Psychiatry College of Medicine, University of Illinois, Chicago) on the tolerance to hypoxia and to reactive oxygen species in the brain of diving mammals. Investigations into the *hippocampus* and its responses to hypoxia have been conducted (including onboard experiments with samples from adult hooded seals during a research cruise with *F/F Helmer Hanssen* to the Greenland Sea) to elucidate how neural function, including synaptic transmission, is affected under these conditions. These studies are part of a PhD-project. (UIT-AMB)

Various studies of adaptations to fasting in **hooded seal** pups were continued, based on samples collected in the field. These studies include investigations into

- the role of the liver as an energy store from birth via weaning and throughout the post-weaning fast;

- the role of leptin and its correlation to changes in blood energy substrates (glucose, free fatty acids, ketone bodies) during lactation and fasting;
- role of exogenous water sources (snow/ice, sea water) for maintenance of water homeostasis and the potential occurrence of metabolic depression during the post-weaning fast

These projects all represent M.Sc. projects for 3 students, 2 of which completed their studies in 2015. Results are under way. (UIT-AMB)

One adult and two yearlings (b. 2014) **harp seal** that were captured in 2014 in the Greenland Sea have been trained intensively to perform various tasks on command, which is a necessity for studying various aspects of their energetics, with the ultimate goal of obtaining more precise assessments of food requirements of harp seal populations. The studies involve parallel accelerometer and respirometer studies in a large net pen with a respirometer dome installed, established in nearby Kaldfjorden as part of the COEXIST project (funded by the Norwegian Research Council). Here and at the research animal facility at UIT-AMB, studies of the buoyancy, feeding, diving and swimming behaviour of harp seals are also made, in part carried out by two M. Sc. students as part of their theses work. Collected data are currently being analysed (Akvaplan-niva/UIT-AMB)

Blood and other tissue samples were collected from harp and hooded seals during a research cruise with *F/F Helmer Hanssen* to the Greenland Sea. These samples have been further processed regarding contaminant analyses, histopathological examinations and disease surveillance, by Dr. R. Dietz and PhD-student Jean-Pierre Desforges at Aarhus University, Denmark. The work is collaboration between Department of Bioscience at Aarhus University, Denmark, and UIT-AMB.

CETACEANS

Comparison of the ecological role of **minke whales** and **harp seals** in the Barents Sea, using fatty acid composition and stable isotopes, are in progress. Material for the study was collected in 2011. (IMR - UIT - NPI - APN)

Sampling of **minke whale** stomach contents and life history parameters will be performed during the commercial hunt in June. (IMR)

Studies of **harbor porpoise** ecology and population biology will be initiated in 2016. Samples will be obtained from bycatches. (IMR, UiT)

The **white whale** programme continued in 2015. The purpose of this programme was 1. Determine space use (satellite telemetry) over the entire annual cycle - to discern how these whales move in relation to sea ice, bathymetry, glacier fronts and oceanographic conditions, 2. Assess diet via stable isotope and fatty acid analyses bases on blood and blubber samples from live-captured whales, 3. Update the general health status of Svalbard's white whales based on screening of serum samples, 4. Conduct a screening of levels of various pollutants based on blood and blubber samples from live-captured whales. A total of 13 animals have been instrumented and sampled for blood and blubber for the various aspects of this programme so far. (NP)

Three acoustic recorders (AURALs) listening for **bowhead whales Balaena** *mysticetus***, white whales** *Delphinapterus leucas* **and narwhals** *Monodon monoceros* (but also other species- and anthropogenic sounds) was deployed autumn 2014 and was retrieved during autumn 2015. One AURAL was deployed in the Framstrait, one on the continental slope north of Svalbard, one in the mouth of Kongsfjorden and one north of Rijpfjorden. Data was downloaded and the AURALs redeployed. (NP)

A combined aerial and boat survey for whales along the ice edge north of Svalbard was conducted in connection with the large polar bear survey NP conducted in August 2015. The whale survey especially targeted **bowhead whales, white whales** and **narwhals**. (NP)

Biopsies for various investigations (genetics, diet and pollution) was collected from blue, fin and humpback whales in the Svalbard area. Some **blue** and **fin whales** were in addition equipped with satellite tags to track their movement patterns. (NP)

Abundance data collected during recent sightings surveys on large whales and odontocetes are being analysed with respect to distribution and trend information. Whale sightings collected during ecosystem surveys are analysed with respect to relative abundance and distribution patterns. (IMR)

Local abundance, migration and habitat use of **humpback whales** in the Barents Sea are studied based on photo ID (IMR) and population structure by genetic analyses of biopsy samples (IMR and University of Gröningen, Palsbøll).

IV ADVICE GIVEN AND MANAGEMENT MEASURES TAKEN

Sealing

Advice on the management of harp and hooded seals is based on deliberations in the ICES / NAFO / NAMMCO Working Group on Harp and Hooded Seals (WGHARP). WGHARP met during 26-30 August 2013 at PINRO, Murmansk, Russia, to assess the status and harvest potential of stocks of Greenland Sea harp and hooded seals and harp seals in the White Sea. Since a new abundance estimate for harp seals in the White Sea, based on Russian aerial surveys in 2013, became available in 2014, the group met again during 17-21 November 2014 in Quebec City, Quebec, Canada, to finish the assessment of this particular stock. The advice given by ICES in September 2013, based on the 2013 WGHARP meeting, and the additional information given by WGHARP in 2014, were used by the Joint Norwegian-Russian Fisheries Commission to establish management advice for 2016.

The basis for the advice was a request from Norway in September 2012 where ICES was requested to assess the status and harvest potential of harp seal stocks in the Greenland Sea and White Sea/Barents Sea and of the hooded seal stocks in the Greenland Sea, and to assess the impact on the harp seal stocks in the Greenland Sea and the White Sea/Barents Sea of an annual harvest of: 1) Current harvest levels; 2) Sustainable catches (defined as the fixed annual catches that stabilizes the future 1+ population); 3) Catches that would reduce the population over a 10-year period in such a manner that it would remain above a level of 70% of current level with 80% probability.

ICES have developed a Precautionary harvest strategy for the management of harp and hooded seals. The strategy includes two precautionary and one conservation (limit) reference levels. The reference levels relate to the pristine population size, which is the population that would be present on average in the absence of exploitation, or a proxy of the pristine population (which in practical terms is referred to as the maximum population size historically observed, N_{max}). A conservation, or lower limit reference point, N_{lim}, identifies the lowest population size which should be avoided with high probability. The first precautionary reference level is established at 70% (N_{70}) of N_{max}.When the population is between N_{70} and N_{max}, harvest levels may be decided that stabilise, reduce or increase the population, so long as the population remains above the N_{70} level. ICES has suggested that this could be done by designing the TAC to satisfy a specific risk criterion which implicate 80% probability of remaining above N_{70} over a 10-year period (extended to a 15-year period by WGHARP in 2014). When a population falls below the N_{70} level, conservation objectives are required to allow the population to recover to above the precautionary (N_{70}) reference level. N_{50} is a second precautionary reference point where more strict control rules must be implemented, whereas the N_{lim} reference point (set by ICES at 30% (N_{30}) of N_{max}) is the ultimate limit point at which all harvest must be stopped.

The ICES management of harp and hooded seals require that the populations in question are defined as “data rich”. Data rich stocks should have data available for estimating abundance where a time series

of at least three abundance estimates should be available spanning a period of 10-15 years with surveys separated by 2-5 years, the most recent abundance estimates should be prepared from surveys and supporting data (e.g., birth and mortality estimates) that are no more than 5 years old. Stocks whose abundance estimates do not meet all these criteria are considered "data poor", and should be managed more conservatively.

Population assessments were based on a population model that estimates the current total population size, incorporating historical catch data, estimates of pup production and historical values of reproductive rates. The modelled abundance is projected into the future to provide a future population size for which statistical uncertainty is provided for various sets of catch options. In case of "data poor" populations, catch limits are estimated using the more conservative Potential Biological Removal (PBR) approach.

Using the population assessment model, the size of the **Greenland Sea harp seal** population was estimated as 627 410 (95% C.I. 470 540 – 784 280) animals in 2013. ICES consider this population to be data rich, and above the N_{70} level (i.e., more than 70% of known maximum abundance measured). Thus, it is appropriate to provide catch advice using the assessment model and to apply the Precautionary harvest strategy. Current catch level will likely result in an increase in population size of 21% over the 10 years period 2013-2023, whereas a catch of 14 600 1+ animals, or an equivalent number of pups (where one 1+ seal is balanced by 2 pups), per year would sustain the population at present level over the same period. Catches that would reduce the population over a 10-year period in such a manner that it would remain above a level of 70% of current level with 80% probability are 21 270 1+ animals, or an equivalent number of pups (where one 1+ seal is balanced by 2 pups), in 2014 and subsequent years. Any allowable catch should be contingent on an adequate monitoring scheme to detect adverse impacts before it is too late for them to be reversed, particularly if the TAC is set at a level where a decline is expected.

Recent Russian aerial surveys of the **White Sea/Barents Sea harp** seal stock suggest that there may have been a drop in pup production of since 2003. As a result of the 2009 and 2010 surveys, ICES have suggested that the reduced pup production observed since 2004 does not appear to be a result of poor survey timing, poor counting of imagery, disappearance or mortality of pups prior to the survey or increased adult mortality. The most likely explanation for the change in pup production seems to be a decline in the reproductive state of females.

The population assessment model used for the White Sea/Barents Sea harp seal population provided a poor fit to the pup production survey data. Nevertheless, ICES has decided to continue to use the model which estimated a total 2015 abundance of 1 368 200 (95% C.I. 1 266 300 – 1 509 378). The modelled total population indicates that the abundance decreased from 1946 to the early 1960s, but has generally increased since then. Based on current data availability, this population is considered to be "data poor". The equilibrium catch level is 19 200 1+ animals, or an equivalent number of pups (where one 1+ seal is balanced by 2 pups), in 2015 and subsequent years. The PBR removals are estimated to be 33 500 (14% pups) seals. This catch option indicates a 23% reduction of the 1+ population over the next 15 year period. Despite the fact that this population is now classified as data poor, ICES expressed concerns over the high removals and declining population resulting from the PBR estimations, and concluded that the estimated equilibrium catches were the most preferred option.

Results from the most recent (2012) pup survey suggest that current **Greenland Sea hooded seal** pup production remains very low, and lower than observed in comparable surveys in 1997, 2005 and 2007. Due to some uncertainty regarding the historical data on pregnancy rates, the population model was run for a range of pregnancy rates (assuming that 50%, 70% or 90% of the mature females produced offspring, respectively). All model runs indicated a population currently well below N_{30} (30% of largest observed population size). Recent analyses have indicated that pregnancy rates have remained rather constant around 70% in the period 1958 – 1999. Using this scenario, the model estimates a 2013 total population of 82 830 (95% C.I. 67 104 – 98 573). Following the Precautionary harvest strategy

and the fact that the population is below N_{lim}, ICES recommend that no harvest be allowed for Greenland Sea hooded seals at this time.

Traditionally, both Russia and Norway have participated in the sealing operations in the West Ice and the East Ice and have, therefore, allocated quotas on a bilateral basis in negotiations in the Joint Norwegian-Russian Fisheries Commission. However, the Russians cancelled their sealing operations in the West Ice in 2001. The Norwegian shares of the 2016 quotas would be the total TAC of harp seals in the West Ice. In the East Ice, the Norwegian quota was set at 7,000 harp seals.

In 1996 new regulations for the **coastal seal hunt**, including catch reports, were introduced. Quotas were set based on the available information on seal abundance along the coast. In 2003, quotas were increased substantially compared to the recommendations based on scientific advice, when they were set at 1186 grey seals (25% of abundance estimate) and 949 harbour seals (13% of abundance estimate). In 2003-2010, annual catches varied between 302-516 grey seals and 457-905 harbour seals. In 2010, new management plans for harbour and grey seals were implemented. The goal is to ensure sustainable populations of grey and harbour seals within their natural distribution areas. Regulating measures should be designed to ensure that they have the greatest impact in areas where there is documented significant damage to the fishing industry caused by seals. Target population sizes were decided to be 7000 harbour seals counted during moult and a grey seal population producing 1200 pups annually along the Norwegian coast. Hunting quotas should be set in order to regulate the seal populations in relation to the target levels. For 2011, quota for harbour seals was set to 460 and 230 seals were taken. For grey seals recommended quota was 460, set quota was 1040 but only 111 grey seals were taken. Compensations paid for shot seals were stopped for 2011. For 2012, 2013, 2014 and 2015, recommended and set quotas were 460, 482, 425 and 455 harbour seals, respectively, and 460 grey seals in all years. Compensations paid for shot seals were again introduced in 2012 (250 NOK/seal): 355 harbour seals and 64 grey seals were taken in 2012; 483 harbour seals and 177 grey seals in 2013; 406 harbour seals and 213 grey seals in 2014; 297 harbour seals and 81 grey seals in 2015.

Whaling

At the IWC Annual Meeting in 1992 Norway stated that it intended to reopen the traditional **minke** whaling in 1993. So far, IWC has accepted the RMP developed by its Scientific Committee as a basis for future management decisions but has not implemented the procedure. The Norwegian Government therefore decided to set quotas for the 1993 and following seasons based on RMP, with parameters tuned to the cautious approach level as expressed by the Commission and using the best current abundance estimates as judged by the IWC Scientific Committee. In recent years research has been conducted on modification and retuning of the procedure to other target levels than the original 0.72, chosen by the Commission.

At, in principle, regular intervals an *Implementation Review* of the RMP for a specific species and management area is conducted. During such reviews the input data as well as biological information including genetics are critically evaluated and conditioned for simulation trials of management scenarios. There is an ongoing review within the IWC Scientific Committee which is expected to be finalised in summer 2017. So far it has been concluded that there is a single panmictic minke whale population in the Northeast Atlantic and new abundance estimates have been approved for use in RMP. From the 2008-2013 period the total estimate for the surveyed areas is 100 615 (cv 0.17), of which 89 623 (cv 0.18) animals are in the Eastern area.

Starting in 2009, a new five-year block quota was set with an annual total catch quota of 885 animals of which 750 could be taken within the Northeastern stock area (the E Small Areas, i.e. the EW, EN, ES and EB Small Areas) and 135 within the CM area of the Central **minke whale** stock. The catch quotas are set for each of the five management areas, and the whaling within an area is stopped when

this quota limit is reached. On the other hand, untaken quotas may be transferred to following years within the period which the block quota is set for.

For 2015 the total catch quota was set to 1286 **minke whales** (including transfers), the same as for 2013. The catching season opened April 1 and was closed medio September 2014.

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VI APPENDIX 1 – CATCH DATA

Sealing

Norwegian catches in the Greenland Sea (West Ice) in 2015 was taken by one vessel, whereas no Russian seal vessels participated in the area. Due to the uncertain status for the Greenland Sea hooded seals, no animals of the species were permitted taken in the ordinary hunt operations in 2015. Only a few animals were taken for scientific purposes. The 2015 TAC for harp seals in the Greenland Sea was set at 21 270 1+ animals (where 2 pups balance one 1+ animal), i.e. the removal level that would reduce the population with 30% over the next 10-year period.

A possible reduction in harp seal pup production in the White Sea may have prevailed after 2003. Due to concern over this, ICES recommended that removals be restricted to the estimated sustainable equilibrium level of 17,400 1+ animals (where 2 pups balance one 1+ animal) in the White and Barents Sea in 2015. The Joint Norwegian-Russian Fisheries Commission has followed this request and allocated 7,000 seals of this TAC to Norway.

Table VI.1 shows the Norwegian catches of harp and hooded seals in 2015. The total quotas given were not fulfilled in any area: In the West Ice, only 8% of the given harp seal quota was taken. Russian sealing in the White Sea in 2015 was planned to be continued using the new boat-based approach introduced in this catch in 2008. The catch, using ice class vessels fitted with small catcher boats, would focus primarily on weaned pups (beaters), to a much less extent on adult seals. No white-coats would be taken. A ban implemented on all pup catches prevented Russian hunt in the White Sea during the period 2009-2014. This ban was removed before the 2015 season. Unfortunately, however, the availability of ice was too restricted to permit sealing, resulting in no commercial Russian harp seal catches in the White Sea in 2015. Also, no Norwegian vessels aimed for the hunting area in the southeastern Barents Sea (the East Ice) in 2015.

Table VI.1. Norwegian catches of harp and hooded seals in 2015. 1+ means one year old or older seals.

Catching area:	*The West Ice*					*The East Ice*
Species	Pups	1+	Total	Pups	1+	Total
Harp seals	2,144	93	2,237	0	0	0
Hooded seals	5	6	11			

Whaling

After a temporary suspension, the traditional small type Norwegian **minke whaling** was again permitted in 1993 and quotas were implemented based on the Revised Management Procedure (RMP) developed by the International Whaling Commission's (IWC) Scientific Committee. The RMP allocates catch quotas to specific management areas. There are five such management areas within the region of interest to Norwegian whalers. The present areas are a revision of the original implementation and introduced by the IWC/SC at their Implementation Review of North Atlantic minke whales conducted at the 2003 Annual Meeting and later kept at the Implementation Review made in 2008. The areas are (1) the Svalbard-Bear Island area (coded ES), (2) the eastern Barents Sea (EB), (3) the Norwegian Sea and coastal zones off North Norway, including the Lofoten area (EW), (4) the North Sea (EN) and (5) the western Norwegian Sea-Jan Mayen area (CM).

In total, 21 vessels participated in the 2015 season of whaling and the catching period was 1 April to mid September. Table IV.2 shows the number of minke whales taken by area in the 2015 season. The quotas are given as five-year block quotas but is not fully utilised in all areas. There are several reasons for that, including problems with processing the catches and accessing remote areas like the Jan Mayen area and the eastern Barents Sea. The present quota period started in 2009 and is given as annual basic quotas of 885 animals within Medium Area E and 135 whales within the Small Area CM, plus numbers not taken in previous years. The 2014 total quota of 1286 minke whales was prolonged for the 2015 season.

Table VI.2. Quotas and catches of minke whales in 2015 by management area as defined in RMP.

2015	Management area					
Small-type whaling	EB	EN	ES	EW	CM	Total
Catch	93	4	426	137	0	**660**
Quota						1286
Stock area	Northeastern				Central	

VII APPENDIX 2 – BY-CATCH DATA

Harbour porpoises, grey and **harbour seals** are incidentally caught in coastal gillnet fisheries. The bycatch rate of harbour porpoises in gillnet fisheries for cod and angler fish is estimated by General Additive Models from data collected by a monitored segment (the Coastal Reference Fleet, CRF) of the fleet of small vessels (less than 15 meter total length) operating in the coastal zone. The landings statistics provided by the Directorate of Fisheries are used to extrapolate to entire fisheries. The total estimate for the period 2006-2014 is 29,942 porpoises (bootstarp-generated CV 0.10) in the gillnet fisheries for cod and monkfish. The average annual bycatch is therefore 3,327 porpoises for this period.

The bycatch of grey and harbour seals can be estimated from mark-recapture data. The total harvests of grey and harbour seals are known since 1997. We assume equal proportions of tagged animals among harvested seals and bycaugth seals. Therefore:

Total bycatch = Tagged bycatch x Total harvest / Tagged harvest.

For grey seals this resulted in a total bycatch of 8379 for the period 1997-2014, with an average annual bycatch of 466 seals. The total bycatch of harbour seals for the period 1997-2014 was 9989 resulting in an average annual bycatch of 555 seals. The bycatch of grey seals is about twice the current annual harvest (240 seals) and the bycatch of harbour seals is about 125% of the current harvest.

Bycatches of grey and harbour seals in gillnet fisheries for cod and monkfish can also be estimated based on data from the CRF. The same procedure as for harbour porpoise is used. For the nine-year period 2006–2014, the total predicted harbour and grey seal bycatches were 4312 animals and 755 animals, respectively. The bootstrap-generated CVs were 0.14 for harbour seals and 0.47 for grey seals. This yields an average annaual bycatch of 479 harbour seals and 84 grey seals. The ratio between bycaught grey and harbour seals estimated from CRF data is very different from the ratio generated by mark-recapture data. Most grey seals are bycaught during the first few months after birth. There is a possibility that young grey seals are misidentified as harbour seals by the CRF. This will be further explored and discussed with the CRF. (Arne Bjørge, IMR).