NORWAY - PROGRESS REPORT ON MARINE MAMMALS 2022

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I. INTRODUCTION

This report summarises the bulk of Norwegian research on pinnipeds and cetaceans conducted in 2022 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): www.hi.no
The Norwegian Polar Institute (NPI): www.npolar.no
University of Tromsø – The Arctic University of Norway, Department of Arctic and Marine Biology, Research group Arctic Chronobiology & Physiology (UiT-AMB-ACP): http://arcticchronobiologyandphysiology.blogspot.com/
University of Tromsø – The Arctic University of Norway, Department of Arctic and Marine Biology (UiT): www.uit.no
University of Oslo (UiO): www.uio.no
Akvaplan-niva (APN): www.akvaplan.niva.no
Directorate of Fisheries, Sea Surveillance Unit (SSU): www.fiskeridir.no
Norwegian Orca Survey (NOS): www.norwegianorcasurvey.com
Whale2Sea (W2S): www.whale2sea.no

II. RESEARCH BY SPECIES 2021

PINNIPEDS

Harp (Pagophilus groenlandicus) and **Hooded seals** (Cystophora cristata)

The assessment model currently in use for **harp** and **hooded seals** is a deterministic, age-structured population model. It uses historical catch data, reproductive data, and estimates of pup production to estimate the current total population. Development of these models was initiated when pup production estimates became available in the late 1980s – subsequently the availability of data has increased, and the time series now spans more than 30 years. The deterministic model treats several of the input data as exactly known (e.g. reproductive parameters) and interpolates these data linearly across periods when observed data are lacking. In addition, it only estimates three parameters: initial population size and pup and adult mortalities. The model is therefore very inflexible, and unable to adequately account for rapid changes in e.g. pup production. While the model appears to give a relatively reliable reflection of current population status, it obviously fails to generate reliable future population trajectories over time. ICES and NAMMCO have recommended that further model development should be undertaken to improve its performance and a formal benchmark process is now underway and will be concluded within 2023. A first modelling workshop with seal scientists from the entire North Atlantic, was held in the autumn of 2020 to discuss current models and suggest ways of improvements. One way forward considered was to link the seal models more tightly to other ecological variables, for example variations in important prey species (such as capelin and young age classes of cod) and competitors (such as older cod). The work with model development continued by correspondence in 2021, progress and results has been discussed in digital meetings throughout 2022. The ICES facilitated benchmark process for harp seals was formally started during an online kick-off meeting, on December 8, 2021. This meeting laid out the agenda for a full year of preparatory work that was intended to lead up to a face-to-face benchmark meeting in December 2022. However, due to various causes, this process has been delayed by approximately 6 months, to May 2023. The aim of the benchmark process is an improved assessment approach centred around a modified version of the existing population model. Based on this improved assessment model, the research team will then meet to discuss the validity of existing reference points and harvest control rules, and the potential need to update these. Finally, the Joint ICES/NAFO/NAMMCO Working Group of Harp and Hooded Seals (WGHARP) will meet during autumn in 2023 to implement the new management tools and to discuss and include new data. However, due to the current situation in the Ukraine and the bi-lateral (Norway-Russia) responsibility of these seal populations, Norway will likely not ask for new advice for the management of harp and hooded seals from ICES this year. (IMR)

Photographic and visual aerial surveys were conducted off Newfoundland and Labrador (”the Front”), and in the Gulf of St. Lawrence (“Gulf”) in March 2017 to estimate pup production of Northwest Atlantic **harp seals**. Traditionally, harp seals whelp in three general areas; the southern Gulf of St. Lawrence, the northern Gulf of St. Lawrence, and off the east coast of Newfoundland and Labrador. After extensive reconnaissance, four whelping areas were identified: one in each of the southern and northern Gulf, and two at the Front. A total pup production in 2017 of 746,500 (SE=89,900, CV=12%) was estimated, the lowest since 1994. Given the unusual ice conditions, distribution of whelping seals, and timing of pupping, assessing the results of the 2017 surveys relative to other estimates of pup production in the Northwest Atlantic is challenging and indicates the ongoing difficulties of assessing a population that is being impacted by climate change. (IMR)

A 2022 survey of **harp** and **hooded seal** pup production in the Greenland Sea was carried out to obtain updated estimates to be used to assess current status of these two seal stocks. Since a similar survey in 2018 indicated a 40% reduction in harp seal pup production since the 2012 survey, and the continued lack of increase in pup production of the severely depleted hooded seal stock despite its protection from hunting since 2007, a new survey after a period of only 4 years was urgent. The survey was carried out using well established methodologies for these species, including 1) reconnaissance of the drift ice breeding habitat from a helicopter based on the research icebreaker RV ”Kronprins Haakon” and a fixed-wing aircraft stationed at Constable Pynt in East Greenland, 2) deploying GPS beacons around the identified breeding areas to monitor its displacement in the East Greenland Current, 3) carrying out staging surveys to monitor the pup age structure and estimate the optimal day of pup counting as well as correction factors accounting for pups not present on the ice at the time of counting, and 4) conducting aerial photographic surveys using the fixed-wing aircraft. Ice conditions in the Greenland Sea were similar as those experienced in 2018, with a relatively narrow band of pack ice over the shelf break near the coast of East Greenland. Seal whelping patches were initially discovered on March 21 and 22, within an area stretching from 72°53’N / 16°42’W in the north to 71°51’N / 17°30’W in the south. Five GPS beacons were deployed at the main whelping patches within this area, allowing us to track the continuous drift due to strong northerly winds during the period between initial reconnaissance and the final pup counting. Pup staging surveys were carried out on March 22, 23, 25, 28 and 30, providing us with a solid dataset with which to assess the development of pup age dynamics, determine the optimal day for photographic surveys, and to estimate correction factors to account for pups absent from the ice during the photographic surveys. The final photographic surveys were carried out on March 27 in a relatively narrow (20-30 nm) N/S band stretching from 71°00'N / 20°00'W in the NE to 69°34'N / 20°36'W in the SW. In total, 2,463 images were obtained during the aerial photographic survey, and following pre-processing (georeferencing and orthorectification), these have now been analyzed both manually and using dedicated machine learning systems, to determine the number of pups present in images. Results will be used to estimate the total 2022 pup production for each species and will also be combined with estimates from previous years to estimate the population sizes using the dedicated population dynamics model. The entire updated dataset will be made available to the upcoming ICES benchmarking meeting for harp and hooded seal population modelling, and results will finally be evaluated at the upcoming meeting of the ICES WGHARP working group in 2023. (IMR)

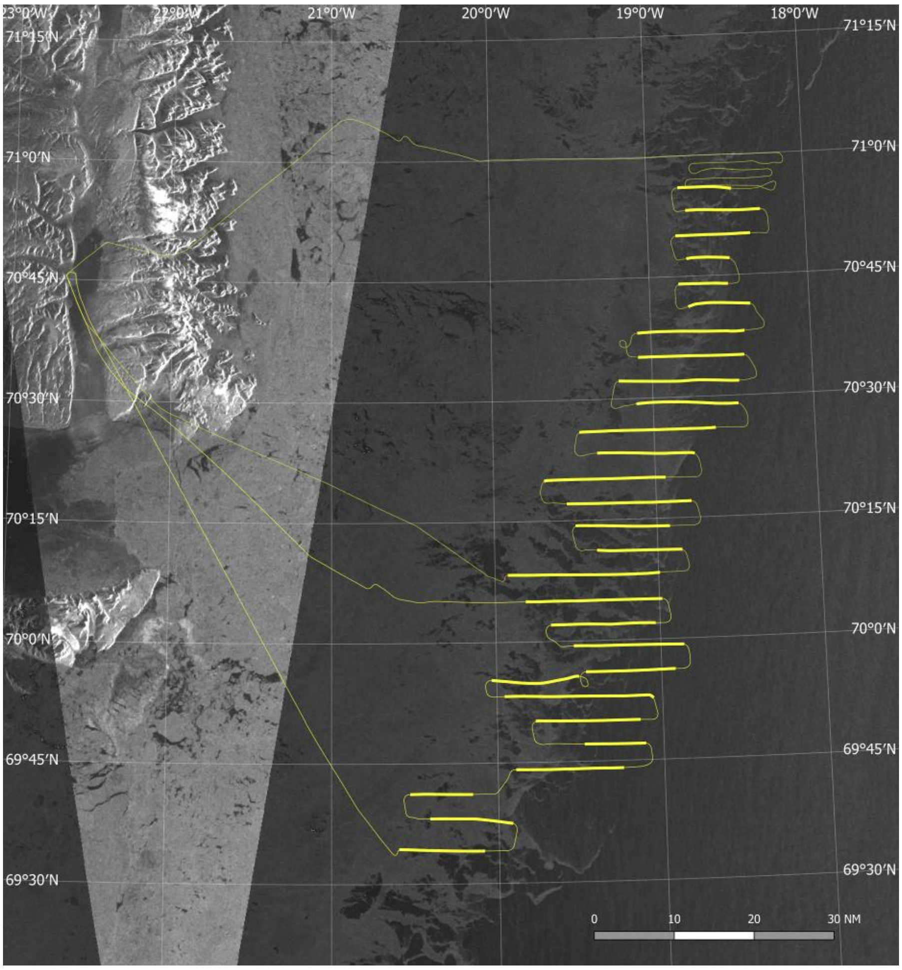

Photo transects flown during the harp and hooded seal survey in the West Ice on 27 March 2022. Ice conditions are shown under the transects.

The assessment model currently in use for **harp** and **hooded seals** is a deterministic, age-structured population model. It uses historical catch data, reproductive data, and estimates of pup production to estimate the current total population. Development of these models was initiated when pup production estimates became available in the 1980s – subsequently the availability of data has increased, and the time series now spans more than 30 years. The deterministic model treats several of the input data as exactly known (e.g. reproductive parameters) and interpolates these data linearly across periods when no data are available. In addition, the model only estimates three parameters: initial population size and pup and adult mortality. It is therefore very inflexible, and unable to adequately account for rapid changes in e.g. pup production. While the model appears to give a relatively reliable reflection of current population status, it obviously fails to generate reliable future population trajectories over time. ICES and NAMMCO have recommended that further model development should be undertaken to improve its performance. A first modelling workshop, including seal scientists form the entire North Atlantic, was held in the autumn of 2020 to discuss current models and suggest ways of improvements. One way forward considered was to link the seal models more tightly to other ecological variables, for example variations in important prey species (such as capelin) and competitors (such as cod). The work with model development continued by correspondence in 2021. In addition, ICES has facilitated the establishment of a benchmark process for harp seals. A kick-off meeting for this benchmark process was held in early December 2021, which laid out the agenda for the preparatory work leading up to a face-to-face benchmark meeting, tentatively planned for May 2023. The envisaged outcome of this benchmark meeting will be an improved assessment approach centered around an improved model. Progress during 2022 has led to a series of alternative model formulations that allow fecundity and mortality to be modeled as functions of variability in prey (capelin) and predators (cod). Preliminary results are encouraging. Based on this improved assessment model, the benchmark team will meet to discuss the validity of existing reference points and harvest control rules, and the potential need to update these. Finally, the Joint ICES/NAFO/NAMMCO Working Group of Harp and Hooded Seals (WGHARP) will meet during autumn in 2023 to implement the new management tools, to discuss and include new data, and to develop new advice for the management of harp and hooded seals. (IMR)

Combining unique 60-year records from compound specific $\delta^{15}N$ biomarkers on **harp seal** teeth alongside state-of-the-art ocean modelling, a significant decline in the $\delta^{15}N$ values was observed at the base of the Barents Sea food web from 1951 to 2012. This strong and persistent decadal trend emerges due to the combination of anthropogenic atmospheric nitrogen deposition in the Atlantic, increased northward transport of Atlantic water through Arctic gateways and local feedbacks from increasing Arctic primary production. The results suggest that the Arctic ecosystem has been responding to anthropogenically induced local and remote drivers, linked to changing ocean biology, chemistry and physics, for at least 60 years. Accounting for these trends in $\delta^{15}N$ values at the base of the food web is essential to accurately detect ecosystem restructuring in this rapidly changing environment. (IMR)

The development of migratory strategies that enable juveniles to survive to sexual maturity is critical for species that exploit seasonal niches. For animals that forage via breath-hold diving, this requires a combination of both physiological and foraging skill development. A tagging experiment assesses how migratory and dive behaviour develop over the first year of life for a migratory Arctic top predator, the **harp seal**, tracked using animal-borne satellite relay data loggers. Similarities in migratory movements and differences in diving behaviour was revealed between 38 juveniles tracked from the Greenland Sea and Northwest Atlantic breeding populations. In both regions, periods of resident and transitory behaviour during migration were associated with proxies for food availability: sea ice concentration and bathymetric depth. However, while ontogenetic development of dive behaviour was similar for both populations of juveniles over the first 25 days, after this time Greenland Sea animals performed shorter and shallower dives and were more closely associated with sea ice than Northwest Atlantic animals. Together, these results highlight the role of both intrinsic and extrinsic factors in shaping early life behaviour. Variation in the environmental conditions experienced during early life may shape how different populations respond to the rapid changes occurring in the Arctic Ocean ecosystem. (IMR, UiT)

During the 2022 UiT research cruise with *R/V "Helmer Hanssen",* studies of **harp seals** and **hooded seals** from the Greenland Sea stocks were conducted (UiT-AMB-ACP):

- Four adult **hooded seals** and four pups were culled and used for further studies of mechanisms underlying the high tolerance to lack of oxygen (hypoxia) in this species. Brain samples (visual cortex, hippocampus) were subjected to cell dissociation, for culturing and subsequent separate studies of glia cells (astrocytes) vs. neurons. These activities aim to allow future detailed genetic/molecular studies of different brain cell types and their functional characteristics, without the need to cull additional seals to access fresh brain tissue. Parallel to this, tissue samples were collected for electron microscopic (EM) studies of mitochondrial densities in astrocytes vs. neurons. Cell-specific studies are important in disentangling the metabolic roles of two key neural cell types and by what mechanisms they contribute to the high cerebral hypoxia tolerance that is typical of diving mammals (University of Hamburg, UiT-AMB-ACP).
- Four **hooded seal** pups were used in surgical procedures in a pilot study that aimed to investigate cardiovascular and renal adaptations to diving-induced bradycardia & ischemia in pinnipeds. Animals were successfully maintained in full surgical anaesthesia while being instrumented for monitoring of vital parameters and for various interventions. Follow-up studies are planned (UiT-IMB, UiT-AMB-ACP).
- Four **harp seal** pups and five **hooded seals** were opportunistically sampled for studies of signs of viral infections, including covid (Veterinary Institute, Tromsø, UiT-AMB-ACP)
- Additionally, six weaned **hooded seal** pups were transported to the AMB research animal facility on the UiT campus, for use in projects that investigate thermoregulatory, diving and seasonal & diurnal rhythmicity adaptations (UiT-AMB-ACP).

Other seals (Harbour, Grey, Ringed, Bearded seals and Walrus)

Harbour seals assessments were carried out along the entire mainland Norwegian coast during molt in 1996-1999, 2003-2006, 2008-2015 and 2016-2021. Results show that numbers of harbor seals in Norwegian Skagerrak have increased to approximately the levels before the PDV-outbreak in 2002. On the west coast south of Stad (62°N) the numbers were slightly lower than in the first counting period 1996-1999. North of Stad, harbor seals have decreased in numbers in the counties Møre and Romsdal, Trøndelag and Nordland compared with results in 1996-1999. In Troms, the numbers increased from ca 560 in 1996-1999 to ca 990 in 2008-2015 but was reduced to 760 in 2020. In Finnmark, the total harbor seal numbers increased by 14% after 2008-2015 to ca 1120 in 2021. The total minimum numbers of harbor seals were ca 6960 along the Norwegian coast in 2016-2021, which is close to the Target Level of 7000 harbor seals. New harbor seal counts along the coast started Norwegian Skagerrak in 2022, which showed a significant increase in harbor seal numbers in the eastern part of that area. The number of seals had approximately doubled since 2016. Tagging experiments showed migrations between the counties in Skagerrak and to Sweden and Denmark. The large increase in seal numbers is most probably due to increase in the Østfold and Vestfold populations and in addition migrations from Swedish areas, where the abundance of seals are higher. (IMR)

Grey seal pup production was estimated in Troms and Finnmark in November-December 2021, which finished the grey seal pup counts along the Norwegian coast in the period 2017-2021. Preliminary results showed a reduction of pups born in Troms by ca 25% from 65 pups in 2016 to 49 pups in 2021. Grey seal pup production in Finnmark increased by ca 10% from

206 pups in 2015 to 226 pups in 2021. In November-December 2022, grey seal pups were counted at the small breeding colony on the Tjør Islands in Rogaland County, where usually 30-40 pups are born annually. In 2022, 37 pups were born. Total grey seal population modelling will be carried out in 2023. (IMR)

Considerable progress has been made towards producing habitat-based predictions of the at-sea distribution of **grey and harbour seals** in Norwegian coastal waters. This work leverages fitted habitat models for these species that were developed as part of a recent study in the UK (http://hdl.handle.net/10023/21558) based on extensive tracking studies. The idea is to apply the original models to Norwegian environmental data and seal abundance data to produce a raster grid with habitat suitability indices (HSI) and at-sea relative probability of occurrence for grey and harbour seals. Preliminary model runs have given sensible results. Pending some further work (e.g., data verification), final modelling results should be forthcoming in 2023. Both the at-sea distribution and the HSIs for grey and harbour seals constitute highly useful estimates, e.g., for entanglement mortality estimation (results may be helpful in evaluating individual species identifications in coastal reference fleet data, which are uncertain). (IMR, UiO)

Forty **walruses** were previously equipped with GPS loggers (20 in 2014 and 20 in 2015) on their tusks. These loggers log one GPS position per h and download these data to receiving stations that are places on different haul-out sites (in masts that were initially deployed for a camera surveillance project). The longevity of the batteries in the loggers should be minimum 5 years. Some of the receiving stations were visited and taken down (end of project) autumn 2022 and collected data from this whole project are currently under analysis. This project is mainly funded by the Norwegian-Russian Environmental Commission in addition to internal funding. (NPI)

To study potential impacts of tourist visitations on **walrus** haul-out sites in Svalbard, camera surveillance was initiated on the haul-out site at Poolepynten, Prins Karls Forland. This is the haul-out sites that has the most visitations in Svalbard and cameras taking pictures every 15 mins were deployed from May to October. Dynamics in haul-out numbers will be studied in relation to visitations to explore potential impacts. (NPI)

As part of a Norwegian Research Council funded project entitled: Arctic marine mammals in a time of climate change: a Kongsfjorden Case Study (ARK) **ringed**, **bearded** and **harbour seals** are equipped with biologging instruments in Kongsfjorden to study space use and potential competition in this fjord where it seems like the more temperate species (harbour seals) are taking over the area from the more Arctic species (ringed and bearded seals). SMRU tags are used that record and transmit (via UHF to a station on a mountain in the fiord) a GPS position every time a seal is at the surface and also transmits data from every dive, which provides a spatial and temporal resolution of the data that is necessary for this study. One ringed, one bearded and 15 harbour seals were captured and instrumented. From all animals, samples of blood and blubber were also collected for studies of diet, pollution and health. (NPI)

Ringed seals in all ice-covered areas in Isfjorden, Svalbard, were surveyed with drones in May/June for hauled-out ringed seals (and any other marine mammals hauled out here). This is the start of a new time series to monitor ringed seal population trends in selected fjords in the archipelago. (NPI).

In addition, 25 **ringed seals** were collected from the Isfjorden area, Svalbard, to the Norwegian Environmental Specimen Bank. Data on morphometrics, age, sex and various tissue are delivered to this Specimen Bank. (NPI).

CETACEANS

Minke whales (*Balaenoptera acutorostrata*)

During the period 8 June to 2 August 2022, a sighting surveys was conducted with the chartered vessel *M/S Stålbas* in the areas around Svalbard and in the Norwegian EEZ of the Barents Sea. The Varanger fjord also was covered as part of a feasibility study of surveying for harbour porpoises in inner coastal waters. This was the third year of the six-year survey period 2020-2025 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. (IMR)

A total of about 3,954 nautical miles was surveyed with independent double platforms on primary effort in the survey blocks combined. During primary search effort, the number of combined observations from the two platforms was 231 sightings of **minke whales**. Sightings of other cetacean species include **fin whales** (119 primary sightings), **humpback whales** (297 primary sighting), **blue whales** (6 sightings), **sei whale** (2 sightings), **sperm whales** (21 sightings), white**-beaked dolphins** (1522 sightings), **killer whales** (10 primary sightings) and h**arbour porpoise** (188 primary sighting). (IMR).

Minke whale catch data for the 2022 season have been computerised and evaluated. (IMR).

The new abundance estimates of Northeast Atlantic minke whales based on the survey cycle 2014-2019 were discussed at the IWC Scientific committee (IWC/SC) meeting in May 2022 and approved for use in the Revised Management Procedure. (IMR)

The Norwegian DNA register for harvested minke whales is based on genotyping at ten microsatellite loci. An update of earlier analyses over the recent 15 years 2004 and 2007-2020 revealed a total lack of temporal differentiation, in alignment with the results obtained for the period 2004 and 2006-2010. Likewise, no genetic differentiation was detected across Small Management Areas, thus also supporting previous results. The temporal follow-up presented confirms the idea of minke whales in the NE Atlantic being a panmictic entity. However, given that the suite of microsatellites used screens a very small proportion of the genome, a different outcome can never be ruled out when using powerful genomic tools with higher discriminating capacity. (IMR).

At an IWC/SC workshop in May 2022 the Implementation Review considering North Atlantic minke whales was conducted. The new abundance estimates and other relevant available parameters were found to be in accordance with the conditioning and data space modelled at earlier Implementation Reviews. The Committee therefore concluded that the RMP Implementation Review for North Atlantic common minke whales was completed. Last year annual quotas for the period 2022-2027 were calculated as 664 minke whales for the *E Medium Area* and 253 minkes for the *Small Area CM* (Jan Mayen) based on the 2014-2019 abundance estimates. After the completion of the Implementation Review these quota calculations are still valid and will form the basis for quota advice in coming years. (IMR).

Ahead of the implementation review of North Atlantic Minke Whale in May 2022 (IWC/SC), a simulation study implemented by a computer program, Rgadget (Elvarsson and Lentin, 2022) was considered together with Icelandic colleagues. The fundamental framework has been prepared but cannot be applied until the complete database from the section of IWC Database is at hand. Furthermore, the statistical methodologies for trend modelling (Solvang and Ohishi 2023), categorical data analysis (Solvang et al. 2021) and spatio-temporal modelling (Solvang et al. 2022) have been developed to investigate variations of temporary tendencies and relations among biological communities, oceanographic factors, and marine mammals in the ecosystem. These approaches are in process and are expected to result in new applications in 2023, for investigating unexpected tendency or increasing impact from human activities. (IMR).

The common **minke whale** is a migratory species, and the summer period is generally characterized by intensive feeding and consequently seasonal fattening at high latitudes. The fat deposited is stored as energy reserves for overwintering at lower latitudes where feeding is supposed to be greatly reduced. It is therefore expected that their body condition on the summer feeding grounds will reflect foraging success during their most intensive feeding period and thus indicate how well the high latitude ecosystems can support the populations. During the commercial catch operations on feeding grounds in Norwegian waters, body condition data (blubber thickness and girth) have been collected from 13 937 common minke whales caught during the period 1993-2020. To investigate associations between body condition and area usage in minke whales, we applied three statistical approaches: regressions, canonical correlations, and spatiotemporal effect estimations. The analyses revealed a significant negative trend in blubber thickness from 1993 until 2015. After 2015, the trend was reversed, and blubber thickness values increased significantly. It has previously been suggested that there may be a link between the decreased minke whale blubber thickness and the abundance of the Northeast Arctic cod stock which increased to a record high level between 2006 and 2013. Recruitment to the cod stock in more recent years has been low with a subsequent and continuous decrease in the total stock after 2013 to a current level which is presumably approximately 60% of the 2013 level. Interestingly, the observed common minke whale body condition was at its lowest in 2015, after which it has increased. This may support a connection between cod abundance and common minke whale body condition. (IMR)

As part of the Arctic 2030 project on Stranded whales and the Nansen Legacy project, UiO has published data on legacy and emerging contaminants in **minke whale**. In their study, they analyzed 64 lipophilic persistent organic pollutants (POPs), including four emerging brominated flameretardants (BFRs) that were analyzed in the blubber, liver and muscle of 17 adult common minke whales (*Balaenoptera acutorostrata*) from the Barents Sea to investigate occurrence and tissue partitioning. In addition, the concentration of 14 per and poly-fluorinated alkyl substances (PFAS) and 17 metals were quantified in the muscle of nine female-fetus pairs to investigate placental transfer. Legacy lipophilic POPs were the dominating compound group in every tissue, at generally lower levels compared to previous studies from 1992 to 2001. The emerging BFRs hexabromobenzene (HBB) and pentabromotoluene (PBT) were detected in minke whales for the first time, in low levels compared to the legacy POPs. Nine PFAS were detected, with higher levels of perfluorooctane sulfonate (PFOS) than in 2011 in the same population, whilst levels of Hg were comparable to 2011. Levels of lipophilic contaminants were higher in blubber compared to muscle and liver on both a wet weight and lipid adjusted basis, but tissue partitioning of the emerging BFRs could not be determined due to the high number of samples below the limit of detection. The highest muscle ΣPFAS levels were quantified in fetuses (23 ± 8.7 ng/g ww), followed by adult males (7.2 ± 2.0 ng/gg ww) and adult females (4.5 ± 1.1 ng/g ww), showing substantial placental transfer from mother to fetus. In contrast, Hg levels in the fetus were lower than the mother. All levels were below thresholds for risk of health effects in the whales, as well as EU metal concentration limits in food for human consumption. (UiO, NMR)

Humpback whales (Megaptera novaeangliae)

In the northern hemisphere, **humpback whales** typically migrate between summer/autumn feeding grounds at high latitudes, and specific winter/spring breeding grounds at low latitudes. Northeast Atlantic (NEA) humpback whales for instance forage in the Barents Sea and breed either in the West Indies, or the Cape Verde Islands, undertaking the longest recorded mammalian migration (~ 9 000 km). However, in the past decade hundreds of individuals have been observed foraging on herring during the winter in fjord systems along the northern Norwegian coast, with unknown consequences to their migration phenology, breeding behavior and energy budgets. A first complete migration track (321 days, January 8th, 2019—December 6th, 2019) is now presented of a humpback whale, a pregnant female that was equipped with a satellite tag in northern Norway. It is shown that whales can use foraging grounds in the NEA (Barents Sea, coastal Norway, and Iceland) sequentially within the same migration cycle, foraging in the Barents Sea in summer/fall and in coastal Norway and Iceland in winter. The migration speed was fast (1.6 ms-1), likely to account for the long migration distance (18 300 km) and long foraging season, but varied throughout the migration, presumably in response to the calf's needs after its birth. The energetic cost of this migration was higher than for individuals belonging to other populations. The results indicate that large whales can modulate their migration speed to balance foraging opportunities with migration phenology, even for the longest migrations and under the added constraint of reproduction. (IMR, NPI, UiT)

Singing behaviour by male **humpback whales** has traditionally been associated with low-latitude breeding grounds. However, in recent years, this vocal behaviour has been increasingly reported outside these areas. All singers in a given population sing the same version of a song and this song is continually evolving over time with modifications on different levels within the song structure. Tracing changes in whale song will help to undercover the drivers underlying this vocal display and contribute to the understanding of animal culture and its evolution. To determine the progressive changes in songs found on a subarctic feeding ground and migratory stopover, a detailed analysis of humpback whale song recordings from Northern Norway was conducted. Passive acoustic data from the Lofoten-Vesterålen Ocean Observatory (LoVe), collected using a bottom-moored underwater hydrophone, were used from January - April 2018 and January 2019. Two measures of the song structure were examined: (1) sequence similarities using the Levenshtein distance and (2) song complexity using a principal component analysis (PCA). In total, 21 distinct themes were identified which presented highly directional, structural changes over time. Two themes from 2018 reoccurred in 2019, whereas all other themes in 2019 appeared to be evolved versions of 2018 themes. All songs grouped into three general clusters, reflecting the rapid evolution over the study period. With all sampled animals singing the same version of the song, this might indicate that the singers are either from the same breeding population or that song learning occurred before the study period. Song complexity appeared to follow the trend of song progression; songs became more complex as they evolved over the months in 2018 and decreased in complexity between the years, returning to a more simplified song in 2019.

The results confirm that humpback whale song exhibits a rapid progression on a shared subarctic feeding ground, with strong potential for song exchange and opportunities for cultural transmission between populations in the North Atlantic. (IMR, UiT)

From 2016-2021 a satellite tracking study was conducted to track **humpback whales** over long distances (see: https://en.uit.no/prosjekter/prosjekt?p_document_id=505966). In total, about 50 individuals was tagged at the coast of northern Norway and in the northern Barents Sea (10). Many of these whales were followed from their main feeding areas and all the way down to their tropical breeding areas, including one that was followed for a full year circle back to where it was originally tagged. Much of the data is still in the publication process, but have given a lot on new insight into the long-distance migration behaviour of humpback whales, including important feeding area, migration corridors, arrival/departure times, swimming speed, feeding behaviour in relation to food sources etc. These studies have also been combined with extensive ID-pictures and biopsy samples (sex and pregnancy rates, contaminants, diets). Together these have identified a connection between the northern Barents Sea area and the autumn and early winter feeding on herring in northern Norwegian fjords, where possibly 10-15% of the whales feeding in the northern Barents Sea seem to use the coast of northern Norway as a stop-over area before they continue to Caribbean waters. Females are dominating in the stop-over area in Northern Norway, many of them pregnant. They possibly uses this area to refuel or get additional energy before they start their southern mating migration. Unpublished data also show that these whales mainly belong to two genetically different groups, the largest possibly breed in Caribbean waters and the smaller outside Cap Verde in West Africa. In the last three years, UiT and IMR have equipped many humpbacks with short terms CatCam tags (suction cup tags with video, acoustics and dive behaviour parameters) in the fjords of northern Norway during November and December. These data will be used both to map their natural feeding behaviour and study how they react to sounds that are used to keep the whales away from fishing gears so that they do not get entangled. (UiT)

In the last three years, UiT and IMR have equipped many **humpback whales** with short terms CatCam tags (suction cup tags with video, acoustics and dive behaviour parameters) in the fjords of northern Norway during November and December, and at the coast of Møre (February). These data will be used both to map their natural feeding behaviour and study how they react to sounds that are used to keep the whales away from fishing gears so that they do not get entangled. (UiT)

Humpback and **killer whales** (Orcinus orca)

Fishery inspector logbooks were used to estimate fishing gear interaction rates for **humpback** and **killer whales** in Norwegian purse seine fisheries for herring from 2011 to 2020. Estimated rates were applied to fisheries data to estimate fleet-wide totals. Estimates showed that in a 10-year period, a total of 78 humpback whales, 95% CI [41, 145] and 100 killer whales, 95% CI [63, 176] were entrapped in purse seines. Most whales were disentangled alive, with an estimated mortality of 5%, CV 0.69, 95% CI [0.0, 11.8] and 6%, CV 0.48, 95% CI [0.3, 11.9], respectively. The average yearly mortality over the study period was thus approximately 0.60 killer whales and 0.39 humpback whales corresponding to 0.008% and 0.007% of the respective abundance estimates for these whale species in Norwegian waters. Given the Potential Biological Removal sustainability limits of 98 humpbacks and 161 killer whales per year, it may be concluded that, by itself, the average yearly mortality incurred by these whale populations by Norwegian fisheries does not constitute a significant risk to either of these species, but bycatch in Norwegian purse seine fisheries may not be the only source of anthropogenic mortality. (IMR, UiO)

Experiments were carried out in November/December 2022 to test acoustic deterrent devices (ADDs) to minimise the risk of **humpback** and **killer whales** getting entangled in herring purse seines. While data analyses are now ongoing, preliminary analyses show conclusively that the ADDs are very effective in scaring away killer whales from fishing vessels. The experiment has also shown that humpback whales show a response to specific ADDs optimised for this species, but that the sound levels are currently not sufficient to be effective as a deterrence. During 2023, further tests of ADDs operated onboard fishing vessels themselves aim towards developing practical systems that can be operated effectively during real fishing activities. In addition, results from the 2021 and 2022 field seasons will be analysed, to form the basis of a report to be submitted to the funders and to the Norwegian Directorate of Fisheries. (IMR, UiT)

From 2015-2021 a satellite study was conducted to track **killer whales** over several months and on long distances. UiT (in cooperation with IMR and Akvaplan-Niva) have totally tagged about 50 individuals, mainly during early winter in northern Norwegian fjords, but also at Vesterålen, Vestfjorden and Møre later in the winter and into the summer. These whales were tracked up to 115 days and have revealed a lot of new information, including on their area use, migrations, prey selection (fish and seals), how they relate to prey fields (herring and seals) and fishery interaction. These studies have also been combined with extensive biopsy sampling (sex, contaminants, diets). The results have shown that fish eating killer whales are closely related to the seasonal changes in herring aggregations in the northern Norwegian fjords and at the continental shelf of Norway. In contrast, individuals that also feeds on marine mammals (e.g. seals) have a much more coastal shore oriented behaviour. The studies have also identified that many individuals specialise in feeding around herring fishing boats when they are around. We have also identified high contaminants concentrations in many killer whales, with level much higher than other arctic marine mammals (including polar bears). (UiT, IMR, APN)

As part of an ongoing long-term effort to study **killer whale** feeding ecology in Norway by Norwegian Orca Survey (NOS), multi-sensory camera tags with integrated 4K video were deployed at herring wintering grounds, in Vengsøyfjord in 2016 and in Kvænangen (Troms) in 2017. Feeding behavior and prey profitability were investigated for five adult male killer whales. Video recorded two killer whales engaged in carousel feeding, and two engaged in seiner feeding (i.e., feeding on herring discards around purse seiner vessels). The feeding behaviors identified from the video data allowed for determination of associated kinematic signatures, which were used to further identify and characterize carousel feeding and deep feeding dives over the entire logger duration. Prey consumption during on camera feeding bouts was also measured to calculate profitability of feeding bouts for the different behaviors. Average number of prey consumed per minute was 1.08 ± 0.43 for carousel feeding and 0.43 ± 0.07 for seiner feeding (n = 122 prey capture events). Using kinematic data, a total of 18 carousel feeding bouts and 206 deep feeding dives were identified. Whales spent at least 37%–65% of time over 24 hr feeding. Using field metabolic rate estimates from the literature and the energetic content of herring caught locally, killer whales required an estimated 285–578 herring/day to balance daily energy requirements. The results were published in Marine Mammal Science (Matika et al. 2021). (UiO, NOS)

<u>Harbour porpoise</u> <u>(Phocoena phocoena)</u>

An in-silico simulation study was conducted using an individual-based modelling (IBM) approach to explore how **harbour porpoise** population dynamics in Norwegian waters are affected by bycatches in coastal gillnet fisheries. In this study, fine-scale movements of harbour porpoises were simulated in a landscape where gillnets were set and hauled every day. Porpoise movements were based on an existing IBM that was parameterized based on extensive modelling and tracking studies in Danish waters. Gillnet quantities, types, locations, and other properties were modelled based on observed fishery data, using different subsets of data to simulate scenarios of relatively low and high fishing effort. Scenarios also included the use of acoustic deterrent devices (pingers) on gillnets in a subset of the fisheries to reduce the risk of bycatches. Simulation results under different scenarios were compared against a baseline model that was calibrated so that the long-term spatial structure reflected results from recent abundance surveys. Results showed that using pingers in high bycatch gillnet fisheries can reduce harbour porpoise bycatches by up to 24.7%. However, if the total gillnet fishing effort (which is recently decreased compared to pre-2014 levels) returns to a level corresponding to the average level between 2006 and 2018 and remains at this level, the results suggested that the population of harbour porpoises in Norwegian waters would decrease to 45% of the current abundance, and that pingers would not be enough to prevent the population from declining. However, pingers could reduce the decline substantially. Using pingers in large mesh gillnet fisheries would have the largest mitigative effect, potentially reducing the long-term decline to 53% of the current abundance. Using pingers in cod winter fisheries similarly has the potential to slightly reduce the decline to 47% of the current abundance. It should be noted however that the modelling approach and the simulation results are preliminary, pending further refinement and verification. (IMR, UiO)

Due to little prior knowledge, a study aimed to investigate the health status of bycaught **harbour porpoises** from the northernmost Arctic Norwegian coastline was conducted. Gross, histopathological and parasitological investigations were conducted on 61 harbour porpoises accidentally captured in fishing gear from February to April 2017 along the coast of Northern Norway. Most animals displayed a good nutritional status, none were emaciated. Pulmonary nematodiasis (*Pseudalius inflexus*, *Halocercus invaginatus* and *Torynurus convolutus*) was found in 77% and associated with severe bronchopneumonia in 33% of the animals. The majority (92%) had parasites in the stomach and intestine (*Anisakis simplex* sensu stricto (s. s.), *Pholeter gastrophilus*, *Diphyllobothrium stemmacephalum*, *Hysterothylacium aduncum* and *Pseudoterranova decipiens* s. s.). The prevalence of gastric nematodiasis was 69%. In the 1st stomach compartment *A. simplex* s. s. was found in 30% of the animals, causing severe chronic ulcerative gastritis in 23%. *Campula oblonga* infected the liver and pancreas of 90% and 10% of the animals, respectively, causing severe cholangitis/pericholangitis/hepatitis in 67% and moderate pancreatitis in 10% of the animals. Mesenteric and pulmonary lymphadenitis was detected in 82% and 7% of the animals, respectively. In conclusion, the major pathological findings in the investigated Arctic porpoises were parasitosis in multiple organs with associated severe lesions, particularly in the lung, liver and stomach. The animals were generally well nourished and most showed freshly ingested prey in their stomachs. The present study indicates that the harbour porpoises were able to tolerate the detected parasitic burden and associated lesions without significant health problems. (IMR)

<u>Sperm whales</u> <u>(Physeter macrocephalus)</u>

Three male **sperm whales** stranded on the island of Andøya in North Norway in 2020. This created an opportunity to do gross necropsies with a focus on stomach contents as the diet of sperm whales in Norwegian waters is poorly understood, and also to study potential presence of marine debris. Four new prey types for sperm whales in Norwegian waters were identified: angler fish, cod, cartilaginous fish and *Histioteuthis* sp. In general, the results support earlier studies of male sperm whale diet in high latitude foraging grounds in North Atlantic consisting of a mixture of Cephalopods and meso- and bathypelagic fish. The only type of marine debris found was a fishing line. The age of the whales, based on estimates from teeth, was 25, 45 and 49 years. The size of all individuals was smaller than the median length based on whaling data for these year classes in Iceland in 1970s. (IMR,W2S)

UiT have in cooperation with Whale2Sea (Andenes) and NPI since 2020 tagged almost 30 male **sperm whales** with satellite tags along the continental shelf edge vest of Svalbard (7) and outside Andenes (>20). Some of these individuals have been followed for >8 months. Additionally, several biopsies, faecal samples, ID-photos (tails) and acoustic recordings have been collected parallel to this. We have also used CatCams (video suction cup tags) on several de-predating individuals around Greenland halibut fishing boats at the continental shelf edge. The project is still ongoing but have already revealed a lot of new knowledge related to these whales seasonal area use, their (surprisingly) long distance mating migration (almost to the Caribbean), fishery interaction, diving behaviour and diet. (UiT, NPI, W2S)

Other species (Baleen, Bowhead, White, Fin, Blue and Narwhals)

To understand how large-scale climate fluctuations during the post-LGM (Last Glacial Maximum) affected **baleen whales** and their prey, an extensive, large-scale analysis of the long-term effects of the post-LGM warming on abundance and inter-ocean connectivity in eight baleen whale and seven prey (fish and invertebrates) species were conducted across the Southern and the North Atlantic Ocean; two ocean basins that differ in key oceanographic features. The analysis was based upon 7032 mitochondrial DNA sequences as well as genome-wide DNA sequence variation in 100 individuals. The estimated temporal changes in genetic diversity during the last 30,000 years indicated that most baleen whale populations underwent post-LGM expansions in both ocean basins. The increase in baleen whale abundance during the Holocene was associated with simultaneous changes in their prey and climate. Highly correlated, synchronized and exponential increases in abundance in both baleen whales and their prey in the Southern Ocean were indicative of a dramatic increase in ocean productivity. In contrast, the demographic fluctuations observed in baleen whales and their prey in the North Atlantic Ocean were subtle, varying across taxa and time. Perhaps most important was the observation that the ocean-wide expansions and decreases in abundance that were initiated by the post-LGM global warming, continued for millennia after global temperatures stabilized, reflecting persistent, long-lasting impacts of global warming on marine fauna. (IMR, NPI, UiO)

Seven acoustic recorders (AURALs) listening for **bowhead whales**, **white whales** and **narwhals** (but also other species- and anthropogenic sounds) were served and redeployed during autumn 2022 at various locations in the Svalbard area. (NPI).

Biopsies from 4 **fin whales** were collected in the Isfjorden/Forlandssundet area in Svalbard These will be used for genetic and diet studies. (NPI)

In August-October 2022 marine mammal observers were onboard the vessels participating in the **Barents Sea ecosystem survey** which is a joint project with Russia. For the area surveyed by Norway a total of 2064 individuals were registered in 561 observations; this included 11 identified species and some pinnipeds and cetaceans not identified to species. As in previous years, white-beaked dolphin

(*Lagenorhynchus albirostris*) was one of the most common species (about 70% of all individual registrations) with a high density in the central Barents Sea and west off Spitsbergen. Other toothed whales represented but in modest numbers were sperm whales (*Physeter macrocephalus*), harbour porpoises (*Phocoena phocoena*), and killer whales (*Orcinus orca*). The baleen whale species **minke** (*Balaenoptera acutorostrata*), **humpback** (*Megaptera novaeangliae*), and **fin** (*Balaenoptera physalus*) whales were abundant in the Barents Sea especially north of 76°N. These species were often found together in aggregations and overlapping with capelin. Also, a **blue** whale (*B. musculus*) was observed in the north-eastern Barents Sea. (IMR).

Research vessels, coastguard vessels and other providers have collected incidental observations of marine mammals. Recorded data include date, position, species, and numbers. We are working with an app-based system for recording these types of observations. (IMR).

Estimates of abundance of harbour porpoise (*Phocoena phocoena*) in Norwegian fjord systems were presented to the NAMMCO working group on harbour porpoises in November 2022. (IMR).

PINNIPEDS AND CETACEANS

Environmental change and increasing levels of human activity are threats to marine mammals in the Arctic. Identifying marine mammal hot-spots and areas of high species richness are essential to help guide management and conservation efforts. Herein, space use based on biotelemetric tracking devices deployed on 13 Arctic species (**ringed seal, bearded seal, harbour seal, grey seal, ribbon seal, spotted seal, harp seal, hooded seal, walrus, polar bear, bowhead whale, narwhal, white whale,** total = 2115 individuals) from the circumpolar Artic between 2005 and 2019 is reported. Getis−Ord *Gi** hotspots were calculated for each species as well as all species combined, and areas of high species richness were identified for summer/autumn (Jun−Nov), winter/ spring (Dec−May) and the entire year. Hotspots and areas with high species richness occurred within the Arctic continental-shelf seas and within the marginal ice zone, particularly in the “Arctic gateways” of the north Atlantic and Pacific oceans. Summer hotspots were generally found further north than winter hotspots, but there were exceptions to this pattern, including bowhead whales in the Greenland-Barents Seas and species with coastal distributions in Svalbard, Norway, and East Greenland. Areas with high species richness generally overlapped high-density hotspots. Large regional and seasonal differences in habitat features of hotspots were found among species but also within species from different regions. Gap analysis (discrepancy between hotspots and IUCN ranges) identified species and regions where more research is required. The hotspots identified herein are also important habitats for seabirds and fishes, and thus conservation and management measures targeting these regions would benefit multiple groups of Arctic animals. (NPI, IMR, UiT, UiO)

In a recent study, scientists from Norway, Iceland and the Faroes assessed prey consumption by the **marine mammal community** in the entire northeast Atlantic [including 21 taxa, across three regions: (I) the Icelandic shelf, Denmark Strait, and Iceland Sea (ICE); (II) the Greenland and Norwegian Seas (GN); and (III) the Barents Sea (BS)] and compare mammal requirements with removals by fisheries. To determine prey needs, estimates of energetic requirements were combined with diet and abundance information for parameterizing simple allometric scaling models, taking uncertainties into account through bootstrapping procedures. In total, marine mammals in the ICE, GN, and BS consumed 13.4 [Confidence Interval (*CI*): 5.6–25.0], 4.6 (*CI*: 1.9–8.6), and 7.1 (*CI*:2.8–13.8) million tons of prey per year. Fisheries removed 1.55, 1.45, and 1.16 million tons per year–1 from these three areas, respectively.

While fisheries generally operate at significantly higher trophic levels than marine mammals, it was found that the potential for direct competition between marine mammals and fisheries is strongest in the GN and weakest in the BS. Furthermore, the results also demonstrate significant changes in mammal consumption compared to previous and more focused studies over the last decades. These changes likely reflect both ongoing population recoveries from historic whaling and the current rapid physical and biological changes of these high-latitude systems. It is argued that changing distributions and abundances of mammals should be considered when establishing fisheries harvesting strategies, to ensure effective fisheries management and good conservation practices of top predators in such rapidly changing systems. (IMR, NPI)

An update on the state of the knowledge of health risk associated with Hg concentrations in Arctic marine and terrestrial mammal species is given. Using available population-specific data post-2000, the ultimate goal is to provide an updated evidence-based estimate of the risk for adverse health effects from Hg exposure in Arctic mammal species at the individual and population level. Tissue residues of Hg in 13 species across the Arctic were classified into five risk categories (from No risk to Severe risk) based on critical tissue concentrations derived from experimental studies on **harp seals** and mink. Exposure to Hg lead to low or no risk for health effects in most populations of marine and terrestrial mammals, however, subpopulations of polar bears, **pilot whales**, **narwhals**, **beluga** and **hooded seals** are highly exposed in geographic hotspots raising concern for Hg-induced toxicological effects. About 6% of a total of 3500 individuals, across different marine mammal species, age groups and regions, are at high or severe risk of health effects from Hg exposure. The corresponding figure for the 12 terrestrial species, regions and age groups was as low as 0.3% of a total of 731 individuals analyzed for their Hg loads. Temporal analyses indicated that the proportion of polar bears at low or moderate risk has increased in East/West Greenland and Western Hudson Bay, respectively. However, there remain numerous knowledge gaps to improve risk assessments of Hg exposure in Arctic mammalian species, including the establishment of improved concentration thresholds and upscaling to the assessment of population-level effects. (IMR, NPI, UiO)

A field trial was conducted to determine the effect of acoustic deterrent devices (ADDs, or pingers) on **harbour porpoise** and **harbour seal** bycatch in three Norwegian commercial gillnet fisheries targeting cod, saithe and monkfish. Catch data on 3500 net-km-days were collected by 8 fishing vessels operating gillnets in high bycatch regions over two years. A total of 20 harbour porpoises and 9 harbour seals were bycaught, with 19 harbour porpoises and 6 harbour seals taken in control (non-pingered) nets. Bycatch was modelled using a generalized additive mixed modelling approach and fitted with penalized maximum likelihood. Modelling results indicated that using pingers on gillnets reduced the risk of bycatching a harbour porpoise by an estimated 94% (95% confidence interval CI 77–100%) compared to ordinary pinger-free nets. The effect of pingers was not significantly different between different fisheries. The pingers also had no significant effect on catch rates of fish (Wilcoxon rank sum test, $p = 0.24$) or harbour seals (Wilcoxon rank sum test, $p = 0.19$). Self-reported pinger-associated extra time costs on day-to-day fishing operations were low, averaging about 2.8 min per operation. These results add to a growing body of scientific evidence that pingers can lead to substantial reductions in harbour porpoise bycatch rates in gillnet fisheries, and that extra time costs associated with operating nets with pingers are low. (IMR, UiO)

A recent paper aims to report on developments in the quantitative assessment of welfare outcomes in wild mammals killed via rifle shooting, and modern explosive harpoon grenades used in the killing of whales. Time to death (TTD) and instantaneous death rate (IDR) are widely accepted ante-mortem variables for assessing the duration of suffering during the killing process. The addition of post-mortem assessments allows for validation of TTD and IDR, thus providing a more accurate appraisal of animal welfare during hunting. While this combined assessment for large cetaceans has been implemented since the 1980s in the Norwegian minke whale hunt, it is reported that this approach has been implemented in studies of the Icelandic minke and fin whale hunts, as well as the Canadian and Norwegian commercial harp seal hunts. Additionally, this approach has been incorporated into welfare studies in terrestrial herbivore management programmes. Quantitative welfare assessment during hunts is capable of effectively evaluating the weapons used and judging modifiable variables such as projectile choice, optimal shooting procedure, as well as identifying areas for improvement in hunter training. In moving towards a standardised approach for welfare outcome assessment, an established framework can effectively allow all hunts to be contrasted and allow for identification of optimal strategies that minimise animal suffering. (IMR)

III. ONGOING (CURRENT) RESEARCH

PINNIPEDS

Publication of **hooded seal** demographic and 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 conducted in 2013 and 2014 – publication of the data is in progress. (IMR)

Tagging with satellite based tags, **harp seals** in the White Sea - will be attempted by Russian colleagues in April/May 2023. (IMR)

A new aerial survey to assess the pup production of **harp** and **hooded** seals was conducted in the Greenland Sea in 2022, analyses of data are in progress. (IMR)

Ship based counting of **harbour seals**, using electronic helicopter drones with camera, will be conducted in Southwest Norway in September 2023. (IMR)

Sampling of DNA from harbor seal pups along the Norwegian coast was completed in June 2022. The samples will be analyzed in 2023, and the results will be published.

In autumn in 2022, 9 harbor seals were tagged (GPS phone tags) in Norwegian Skagerrak. When all data are received, the results will be published, including telemetry data on harbor seals sampled earlier in that area.

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

Studies into mechanisms that may underlie the remarkable tolerance to lack of oxygen (hypoxia) that is characteristic of diving mammals in general, and of **hooded seals** in particular, have been continued. We aim to conduct cell-specific studies (i.e., characterizing functional traits of neurons vs glia cells (astrocytes)) by a) establishing seal brain cell-specific cultures; b) conducting transcriptomics studies based on laser-captured microdissected (LCM) cells, or c) through single-cell-transcriptomics. The various approaches all aim to assess mitochondrial function in a comparative context; both with regard to potential differences between cell types (neurons vs. astrocytes) in the pinniped brain and also through between-species studies, all in an attempt to identify and better understand adaptive mechanisms that enable diving mammals to tolerate exposure to severe diving-induced hypoxia. (UIT-AMB-ACP, in collaboration with University of Hamburg).

CETACEANS

Manuscripts on the feeding ecology, life history and ecological role of **harbour porpoises** is in preparation and will be submitted in 2023. (IMR, UiT)

Biopsies will be sampled from **minke whales** to establish a database for mark-recapture estimates based on use of the DNA register on caught minke whales (IMR).

Publication of ecological data (stomach contents, fatty acids, stable isotopes) from sampling of **minke whales** in 2016-2021 is in progress. (IMR, NPI)

Experiments aimed to test methods to avoid whales (**humpback** and **killer** whales) in purse seine fisheries were conducted in Troms in December 2022. During 2023, further tests of ADDs operated onboard fishing vessels will be done. In addition, results from the 2021 and 2022 field seasons will be analysed. (IMR, UiT)

Existing data on the dive behaviour of **humpback whales** that were tagged and tracked by UiT-AMB-AMSE (Rikardsen) in collaboration with IMR (Biuw) have been analyzed with regard to surfacing and breathing rates, as part of a MSc-project aiming to model energetics of humpback whales (completed in 2022). Project co-supervision by IMR and UiT-AMB-ACP.

Behavioural data collected from **minke whales** that were attempted live-captured as part of the Norwegian Defense Research Establishment (FFI)-led SOST (US Subcommittee on Ocean Science and Technology) minke whale project, form part of a MSc-project that was completed in 2022. The project aimed to assess the animal welfare aspect of attempts to live-capture large cetaceans, as well as identifying new opportunities for gaining new insights into the physiology of these animals based on successful live-capturing. The project was co-supervised by FFI and UiT-AMB-ACP.

Data on chlorinated paraffin, dechlorane and legacy contaminant levels, as well as dietary tracers (stable isotopes of nitrogen and carbon), in **humpback whales**, **sperm whale**, **harbour porpoise**, **harbour seal**, **fin whale**, **pilot whale**, **bottlenose whale**, **white beaked dolphin**, **minke whales** and **killer whales,** is being prepared for publication as part of the Arctic 2030 project on Stranded whales (UiO, NOS, IMR), and will be presented at the conference of the Society of Environmental Toxicology and Chemistry in May 2023. (UiO)

As part of the UiO based Norwegian Research Council project "MULTIWHALE - Effects of multiple stressors on Norwegian **killer whales**" we study the cumulative effects of multiple anthropogenic stressors on the health, demographics and trend of an ecologically structured killer whale population in Norway. Biopsy sampling and drone work for a behavioural study was completed in 2022. Analysis of population genomics, hormones, mercury, various dietary markers in biopsy samples, and in contemporary and historical killer whale teeth from dead specimens (isotopes and mercury), is ongoing. (UiO)

General

The collection of data on incidental observation of marine mammals will be continued. Participation of marine mammal observers on the annual ecosystem surveys in the Barents Sea has been established as part of the general survey procedure. (IMR).

The mosaic sighting survey program (NILS) for estimating abundance of minke whales in the period 2020-2025 was started in summer 2020, covering parts of the Norwegian Sea. In 2021 the program continued with surveying the Jan Mayen area – SMA CM and in 2022 the program covered the Norwegian EEZ of the Barents Sea (SMA EB) and parts of the Svalbard area (SMA ES). In 2023 the North Sea will be covered (SMA NS). (IMR).

IV. ADVICE GIVEN AND MANAGEMENT MEASURES TAKEN

Sealing

Harp and hooded seals

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 2-6 September 2019 at IMR in the Fram Centre in Tromsø, Norway, to assess the status and harvest potential of stocks of Greenland Sea harp and hooded seals and harp seals in the White Sea. New advice was given formally by ICES 31 October 2019, based on the report from the 2019 WGHARP meeting. The Joint Norwegian-Russian Fisheries Commission used the advice from ICES to establish management advice for 2023.

The basis for the advice was a request from Norway in October 2018 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 15-year period. 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 strictly 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. PBR was developed by the United States for the management of marine mammals, primarily for use to assess sustainability in bycatches.

The 2018 pup production estimate for **Greenland Sea harp seals** is significantly lower than the previous survey estimates and represents an apparent drop of almost 40% from 2012. Using a combination of mark-recapture based (1983-1991) and aerial survey based (2002-2018) pup production estimates, the assessment model suggests a current (2019) abundance of the total Greenland Sea harp seal stock which is 426.808 (95% C.I. 313.004-540.613) animals. There is considerable uncertainty in the mark-recapture (MR)-based pup production estimates used in the model, and ICES suggested that the impact of using only the aerial survey estimates (including also a survey estimate from 1991) should be explored. ICES also raised concerns regarding the reliability of some of the reproductive parameters that have been measured at sparse intervals throughout the time period from 1946 to the present. To explore the impact of using different reproductive data, the group suggested that the model be run with fecundity fixed at the long-term mean from all sampling, (F=0.84), and with maturity curves being combined to a single curve representing the mean maturity throughout the time period. The final set of models considered were therefore:

1) All pup production estimates included (except the aerial survey estimate from 1991). This is similar to all past assessments.
2) Pup production estimates from aerial surveys only (including 1991);
3) Same as scenario 2), with constant F=0.84 and a single maturity curve.

The three runs resulted in some differences in estimated population trajectories, but the estimates of the 2019 population size were relatively consistent between runs.

In ICES terminology the Greenland Sea harp seal population is data rich. Nevertheless, given the apparent significant drop in pup production between the 2012 and 2018 surveys, the unexplained variability in the MR estimates, the poor fit of the model to all historical pup production estimates, and the subsequent uncertainty regarding model-based trajectories and projections, the conclusion by ICES was that management recommendations for this population should not be based on model projections at this stage. Because the model estimates of current population size were very similar and appeared to be robust to the assumptions of the various runs, ICES suggested that catch options should be based on the estimate of current pup and adult population sizes through the PBR framework. Given the very small difference in estimated current population size irrespective of model run, and similarity between PBR estimates based on these population estimates, ICES suggested that the PBR based on the averaged population estimates (and associated averaged CVs), be used when providing catch scenarios. Using the traditional PBR approach in this way, removals were estimated to be 11.548. Using a multiplier to convert age 1+ animals to pups is inappropriate for the PBR removals.

Recent Russian aerial surveys of the **White Sea/Barents Sea harp** seal stock suggest that there may have been a sudden reduction in pup production after 2003. ICES have suggested that the reduced pup production 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 decided to continue to use the model which estimated a total 2019 abundance of 1.497.190 (95% C.I. 1.292.939-1.701.440). The modelled total population indicates that the abundance decreased from its highest level in 1946 to the early 1960s, where after an increase has prevailed. Current level is 74% of the 1946 level. The last available information about the reproductive potential for this population is new and based on data from 2018. But the last pup production estimate is from 2013, i.e., more than 5 years old, and the population is considered “data poor”. In such cases ICES recommend use of the PBR approach to estimate catch quotas. Given the uncertainty regarding the current status of this population, ICES suggest the application of a more conservative PBR approach in which the upper limit for removals were estimated to be 21.172 seals. Using a multiplier to convert age 1+ animals to pups is inappropriate for the PBR removals.

Results from the most recent (2018) pup survey suggest that current **Greenland Sea hooded seal** pup production remains at the same very low level as in 2012, 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 50%, 70% or 90% of the mature females produced offspring, respectively). All model runs indicated a population currently well below N30 (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 2019 total population of 76.623 (95% C.I. 58.299-94.947). Following the Precautionary harvest strategy and the fact that the population is below N_{lim}, ICES suggest 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 2023 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.

<u>Coastal seals</u>

A new management system for coastal seals was introduced in 1996. Hunting quotas on **harbor** and **grey seals** were set based on best available information on seal abundance along the coast. The regulations also included catch reports. The new management regime required increased survey effort along the Norwegian coast to be able to give advice on catch levels. In 2003, quotas were increased substantially compared to the recommendations based on scientific advice, when they were set at 1186 grey seals (25% of the abundance estimate) and 949 harbor seals (13% of the abundance estimate). Also, compensation paid for shot seals, which included sampling of age and body condition data, were introduced and lasted until 2014 (except in 2011). In 2010, management plans for harbor and grey seals were implemented, aimed to ensure sustainable populations of both species 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 harbor seals counted during molt and a grey seal population producing 1200 pups annually along the Norwegian coast. Hunting quotas should be set to regulate the seal populations in relation to the target levels. Target levels can be adjusted based on new knowledge on seal populations.

Suggested quotas in 2023 for **harbor seals** in Norway are 346 animals. For **grey seals** a quota of 200 animals, distributed with 60 in Rogaland (southern Norway) and 140 in Troms and Finnmark (northern Norway), is recommended. Due to a severe reduction in pup production in recent years, no grey seal hunt is allowed in Trøndelag and Nordland (mid Norway) in 2021.

<u>Seals in Svalbard</u>

Since a main purpose of managing animal species in Svalbard is to protect naturally occurring species, hunting must not affect the stocks. Controlled and limited hunting is allowed for some species, including **ringed** and **bearded seals**. To hunt in Svalbard, documentation of an accepted big-game-proficiency test (annual rifle shooting test) is required. The two seal species cannot be hunted in national parks / nature reserves. They are also protected during the darkest period (December-January) and in the breeding period. Catch reports are mandatory.

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 in lieu of the current Moratorium. 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 the Norwegian application of the RMP, a tuning level (long-term target) of 0.60 has been used in recent years.

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. The most recent review for North Atlantic common minke whales was conducted in 2022. 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 2014-2019 period, the total estimate for the surveyed areas is 149 722 (cv 0.152), of which 104 692 (cv 0.172) animals are in the Eastern area. (IMR).

After the end of the quota period 2016-2021, a new six-year block quota was calculated which included the new abundance estimates based on the survey period 2014-2019. The annual total catch quota 2022-2027 was estimated as 917 animals of which 664 animals could be taken within the **North-eastern stock area** (the E Small Areas, i.e. the EW, EN, ES and EB Small Areas) and 253 within the CM area of the Central **minke whale** stock. The catch quotas are set for each of the five management areas, and untaken quotas can be transferred to following years within the period which the block quota is set for.

The total catch in the Medium Area E in 2022 was 581 animals, leaving a rest quota of 83 animals for transfer. No catches were taken in the Jan Mayen area. Thus, for 2023 the total catch quota, including transfers, will be set to 1000 minke whales of which 747 animals can be taken in are E and 253 animals in area CM (Jan Mayen block). The catching season opens April 1 and are closed medio September. The guidelines for sightings surveys are established by IWC Scientific Committee and distance and angle experiments are routinely conducted as part of the surveys with the aim of estimating bias and variability in measurement error (ME). A simulation-based correction method has previously been applied to the abundance estimates; however, the isolated effect of distance and angle ME was not explicitly quantified. For the challenge, multiplicative/additive ME error models were considered. The approach confirmed that the abundance estimates obtained by taking ME into account are consistently larger than the abundance estimates without ME correction (Solvang et al. 2021).

Bycatch

Pingers became mandatory on gillnets in Vestfjorden from January 1st to April 30th 2021. This pinger mandate was continued in 2022. Initial evaluations indicated a number of practical problems with the pingers (e.g. water intrusion and damage to the outer housing) when they were used in commercial fisheries. Phone-interviews of a random sample of 30 fishers conducted after the cod fishing season in 2021 suggested that the efficacy to reduce porpoise bycatch was less than what was demonstrated in the previously reported field trials from 2018-2020. The IMR is working on an evaluation of the effect the pinger mandate has had on the levels of bycatches of harbour porpoises in Vestfjorden. Data from the Coastal Reference Fleet vessels that operated gillnets in Vestfjorden in 2021 and 2022 will be used to evaluate the effect. It is recommended that the control of the compliance to the pinger mandate is intensified in 2023 in combination with fines if violations are observed.

V. PUBLICATIONS AND DOCUMENTS

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VI. DATA REPORTING TO NAMMCO COMMITTEES

Sealing

Harp and hooded seals

Norwegian catches in the Greenland Sea (West Ice) in 2022 were taken by 3 vessels, whereas no Russian seal vessels participated in the area. Due to the uncertain status for Greenland Sea hooded seals, no animals of the species were permitted taken in the ordinary hunt operations in 2022. Only 14 animals (whereof 10 were pups) were taken for scientific purposes (Table VI.I). The 2022 catch volume for harp seals in the Greenland Sea was set at 11,548 animals of all ages. Total catches in 2022 were 1,421 (including 74 pups) harp seals.

The last ICES recommendation (from 2019) for catch of harp seals in the White and Barents Sea was set at 21,172 animals of all ages. The 51st Joint Norwegian-Russian Fisheries Commission (JNRFC) supported this ICES recommendation for 2022 and Russia allocated 7,000 harp seals to Norway for removals. A ban implemented on all pup catches prevented Russian hunt in the White Sea during the period 2009-2013. Despite this ban being removed before the 2014 season, there have been no commercial Russian harp seal catches in the White Sea in 2015-2022. No Norwegian vessels participated in the area in 2022.

Table VI.1. Norwegian catches of harp and hooded seals in 2022. 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	74	1347	1421	0	0	0
Hooded seals	10	4	14			

Coastal seals

In 2003-2009, total annual **harbor seal** hunting quotas ranged between 704 and 989 animals, while annual catches were 538-905 harbor seals. In 2010-2020, annual harbor seal quotas ranged between 425 and 485 animals, while annual catches were 159-511 harbor seals. In 2021 and 2022, the quotas were reduced to 257 and 268 harbor seals, respectively. 238 were taken in the hunt in 2021, 251 in 2022.

In 2003-2011, recommended quotas on **grey seals** were 355-460 animals but set annual quotas were 1040-1536. Annual catches ranged between 111 and 516 grey seals in that period. Set grey seals quotas were 460 animals in 2012-2014, but due to observations of declines in grey seal pup production the quotas were reduced to 315 grey seals in 2015, 210 animals in 2016-2017 and 200 animals in 2018-2022. Annual catches were 19-216 grey seals in 2012-2021. In 2022, a catch of 113 grey seals were taken.

Additional hunt on the Norwegian coast in 2022 include 3 ringed seals and 2 harp seals shot in North Norway.

Seals in Svalbard

In 2003-2021, total annual **ringed seal** catches in Svalbard ranged between 15 and 78 animals. In 2022, 59 ringed seals were taken in the hunt.

The number of **bearded seals** taken annually in Svalbard in 2003-2021 ranged between 2 and 34 animals, and the number taken in the 2022 hunt was 17 bearded seals.

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 *Small Management Areas (SMA)*. 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

Reviews made in 2008, 2014-2017 and 2022. 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, 13 vessels participated in the 2022 season of whaling and the catching period was 1 April to 25 September. Table VI.2 shows the number of minke whales taken by area in the 2022 season. The quotas are given as six-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. Unused quotas can be transferred to the following year. The present quota period is 2022-2027. The calculated annual basic quota for this period is 664 animals within Medium Area E and 253 whales within the Small Area CM, giving a total of 917 minke whales. The total catch in the 2022 season was 581 whales and the quota for 2022 was set to 917 minke whales.

Table VI.2. Quotas and catches of minke whales in 2022 by management area as defined in RMP.

2022	Management area					
Small-type whaling	EB	EN	ES	EW	CM	Total
Catch	162	31	68	320	0	**581**
Quota	664				253	917
Stock area	Eastern				Central	