NORWAY - PROGRESS REPORT ON MARINE MAMMALS 2020

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I INTRODUCTION

This report summarises Norwegian research on pinnipeds and cetaceans conducted in 2020 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); https://www.hi.no/hi
The Norwegian Polar Institute (NP); http://www.npolar.no/no/
Norwegian Orca Survey, Andenes (NOS); https://www.norwegianorcasurvey.no/
University of Tromsø – The Arctic University of Norway/ Department of Arctic and Marine Biology (UIT-AMB); *Research group Arctic Chronobiology & Physiology* (ACP)

II RESEARCH BY SPECIES 2020

PINNIPEDS

In September 2016, a marine ecosystem survey covered all trophic levels from phytoplankton to seals in the Arctic Ocean to the west and north of Svalbard. At the ice edge, 26 **harp seals** were sampled to assess whether recent environmental changes had affected their diets and body condition by comparing current results with previous investigations conducted 2-3 decades ago in the northern Barents Sea, when the ice edge was located much further south. Current results suggest that the body condition was slightly but significantly lower for one year and older seals in 2016 compared with seals sampled in the early 1990ies. Furthermore, previous findings were confirmed that polar cod and the pelagic hyperiid amphipod *Themisto libellula* still dominate the seal diet. One consequence of current ice edge localisation north of Svalbard is that the water depth underneath is now 500 m and deeper, and this probably explains the absence of bottom associated species, and the presence of species such as Atlantic cod and blue whiting as alternative species in addition to polar cod and *T. libellula*. The stable isotope data also suggest possible long-term importance in the seal diet of *T. libellula* and of low trophic level benthopelagic prey such as the squid *Gonatus fabricii* over mid-trophic level pelagic fishes, but with a strong component of small, benthopelagic fish such as blue whiting. The long-term importance of pelagic crustaceans was also suggested from the fatty acid analyses. Assessment of the abundance of prey showed that *T. libellula* was by far the most abundant prey species in the upper water layers, followed by krill (mainly *Thysanoessa inermis*), Atlantic cod and polar cod. Prey-preference analyses indicated that polar cod was the most preferred prey species for the seals. (IMR)

In another study of food web structure and species trophic position, **harp** and **ringed seals** were used as a model for determining trophic position across large spatial scales in the Arctic. Stable nitrogen isotopes ($\delta^{15}N$) in seawater nitrate ($\delta^{15}N_{NO3}$) and seal muscle amino acids ($\delta^{15}N_{AA}$) were determined to independently characterize the base of the food web and the trophic position of harp and ringed seals across the Arctic and sub-Arctic, demonstrating a direct link between $\delta^{15}N_{NO3}$ in seawater and $\delta^{15}N_{AA}$ in predators. Our results show that the spatial variation in $\delta^{15}N_{AA}$ in seal tissue reflects the $\delta^{15}N_{NO3}$ endmembers in Pacific *versus* Atlantic waters. This study provides a reference for best practice on accurate comparison of trophic position in predators and as such, provides a framework to assess the impact of environmental and human-induced changes on ecosystems at pan-Arctic scales. (IMR)

Harp seals are the most abundant marine mammal in the North Atlantic. As an ice obligatory predator, they reflect changes in their environment, particularly during a period of climatic change. As the focus

of a commercial hunt, a large historic data set exists that can be used to quantify changes. There are three populations of harp seals: White Sea/Barents Sea, Greenland Sea and Northwest Atlantic. The objective of this study was to review their current status and to identify the factors that are influencing population dynamics in different areas. Although important historically, recent catches have been low and do not appear to be influencing trends in either of the two northeast Atlantic populations. Massive mortalities of White Sea/Barents Sea seals occurred during the mid 1980ies due to collapses in their main prey species. Between 2004 and 2006, pup production in this population declined by 2/3 and has remained low. Body condition declined during the same period, suggesting that ecosystem changes may have resulted in reduced reproductive rates, possibly due to reduced prey availability and/or competition with Atlantic cod. The most recent estimate of pup production in the Greenland Sea also suggests a possible decline during a period of reduced hunting although the trend in this population is unclear. Pupping concentrations are closer to the Greenland coast due to the reduction in ice in the traditional area and increased drift may result in young being displaced from their traditional feeding grounds leading to increased mortality. Reduced ice extent and thickness has resulted in major mortality of young in the Northwest Atlantic population in some years. After a period of increase, the population remained relatively stable between 1996 and 2013 due to increased hunting, multiple years with increased ice-related mortality of young seals, and lower reproductive rates. With a reduction in harvest and improved survival of young, the population appears to be increasing although extremely large interannual variations in body condition and fecundity have been observed which were found to be influenced by variations in capelin biomass and ice conditions. Each of these populations has been impacted differently by changes in their ecosystems and hunting practices. Identifying the factors influencing these three populations, a better understanding of how species may respond to changes that are occurring in their ecosystems is gained. (IMR)

The 2020 annual UiT research cruise with *R/V "Helmer Hanssen"* for studies of **harp seals** and **hooded seals** from the Greenland Sea stocks was cancelled, due to the covid-19 pandemic. University of Tromsø - The Arctic University of Norway. (UIT-AMB-ACP).

Harbor seals assessments were carried out along the entire mainland Norwegian coast during molt in 1996-1999, 2003-2006 and 2008-2015. In 2016, new harbor seal counts along the coast started in south, Norwegian Skagerrak, and have continued along the coast north to ca 70°N (Troms area) in August-September 2020. Next August the ongoing counting period will be finished in the northeastern area, Finnmark. Results show that numbers of harbor seals in Norwegian Skagerrak have increased to approximately the levels before the PDV-outbreak in 2002. At the west coast south of Stad (62°N) the numbers are 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. (IMR)

Grey seal pup counts in Lofoten (Nordland county) in October showed that the pup production has almost doubled from 66 pups in 2015 to 121 pups in 2020, which is 87% of the highest count (139) in 2008. In late autumn 2021, the grey seal pup production will be estimated in Troms and Finnmark, which will finish the grey seal pup counts along the Norwegian coast in the period 2017-2021. (IMR)

Harbor seals are piscivorous predators that can come into conflict with fisheries. Recently, as the Skagerrak and Kattegat population of harbor seals has increased, claims have emerged that seals are depleting coastal cod populations. The diet of harbor seals in Norwegian Skagerrak was investigated based on otolith identification from scats. The overall seal diet included 20 different fish species/groups. The most important prey (combined index Qi) were haddock/pollack/saithe (32.7%), genus Trisopterus (Norway pout/poor cod/bib, 12.5%), plaice (12.4%) and herring (10.0%). Plaice also had the largest biomass (24.1%). Gadoids and pleuronectids comprised 88.6% of the diet (combined index Qi) and 87.1% in terms of biomass. Cod constituted 0.7% (combined index Qi) of the overall diet and 2.3% in terms of biomass. Fish length estimates showed that seals generally prefer small fish below minimum allowed landing size. Estimated total amount of fish consumed was 315 tons per year and was dominated by non-commercial species. Annual cod consumption was an

estimated 7.1 tons, representing 5% of annual cod landings, suggesting that competition between local fisheries and harbor seals is limited. (IMR)

Walrus (*Odobenus rosmarus)*
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. The receiving stations were visited and serviced summer 2020 and GPS data from walruses were collected. This project is mainly funded by the Norwegian-Russian Environmental Commission in addition to internal funding. (NP).

Ringed seals (*Pusa hispida)*
Twenty-five 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. (NP).

CETACEANS

Minke whales (*Balaenoptera acutorostrata)*
During the period 9 June to 3 August 2020, a sighting surveys was conducted with the chartered vessel *Acc Mosby* in the Norwegian Sea area - the IWC *Small Area EW*. In addition, several fjord systems, including Vestfjorden in northern Norway, received coverage as part of a feasibility study of surveying for harbour porpoises in inner coastal waters. This was the first 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. A total of about 3,600 nautical miles was surveyed with independent double platforms on primary effort in the three blocks EW1-EW3, as we were unable to cover the survey block EW4. During primary search effort, the number of observations from the primary platform (crow's nest) was 196 sightings of **minke whales**. Sightings of other cetacean species include **fin whales** (83 primary sightings), **humpback whales** (10 primary sighting), **sperm whales** (72 sightings), **Lagenorhynchus spp. (**78 primary sightings, of which 72 were **white-beaked dolphins,** 1 was a **white-sided dolphin** and 5 were unidentified to species), **killer whales** (30 primary sightings) and h**arbour porpoise** (43 primary sightings). (IMR).

Minke whale catch data for the 2020 season have been computerised and evaluated. (IMR).

Bowhead whales (*Balaena mysticetus*)
A satellite tag was deployed on 1 bowhead whale in the Framstrait September 2020.The tag were deployed from a helicopter with FF Kronprins Haakon as a base ship. A, biopsiy for genetic studies was also collected from this individual. (NP).

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 2020 at various locations in the Svalbard area. (NP).

Narwhals (*Monodon monoceros*)
Biopsies from 1 narwhal were collected in the drifting ice in the Framstrait from a helicopter with FF Kronprins Haakon as a base ship. These will be used for genetic and diet studies (NP).

Sperm whales (*Physeter macrocephalus*)
Satellite tags were deployed on 7 sperm whales on the west coast of Spitsbergen. Tags were deployed from a helicopter with Polarsyssel as a base ship. Biopsies were collected from 5 of these individuals for various studies (NP)

Fin whales (*Balaenoptera physalus*)
Biopsies for various investigations (genetics, diet and pollution) were collected from 12 fin whales off the coast of Prins Karls Forland, Svalbard. Collections were conducted from a helicopter with Polarsyssel as a base ship (NP).

Total body mass and increase over the feeding season is important for estimating energy deposition used in ecological modelling. Weighing total whales is difficult, even in parts, while measurements of length, girth and blubber thickness can easily be obtained from catches at sea. The exponent for predicting total body mass from body length has been studied in many species and in a joint study by Icelandic and Norwegian scientists data on **common minke whales** in the North Atlantic are added from previous Icelandic and Norwegian research catches. The exponent was found to be not significantly different from 3 as is expected if there is little change in shape with growth. The exponent for how blubber mass increases with length was estimated to be significantly lower than 3. In addition, seasonal changes in body mass and in the parts of muscle, blubber and visceral fat are reported. In all cases a significant increase over the season was detected, in particular for the mature animals, and also in blubber thickness and girth measurements, particularly in girth at the posterior part of the body. Pregnant females had significantly more blubber than other whales. These results agree with studies on blubber thickness measurements and tissue energy content of the Icelandic whales and observed changes in the ecosystem around Iceland during the research period 2003 to 2007. (IMR, NPI)

Activities on humpback and killer whales in 2019-2020 have focussed on fieldwork in the Kvænangen region. The 'Whaletrack' and 'Whalefeast', managed by the University of Tromsø, have deployed a large number of satellite transmitters over many years, and these data are now worked up by a large number of PhD and MSc students at the university. Here, researches at IMR are actively participating and contributing to student supervision, this work has resulted in 2 published research articles, one completed PhD thesis and two completed MSc theses. One of the MSc theses has been accepted (with minor revisions) in Marine Ecology Progress Series (MEPS), with expected publication in early 2021. (IMR, UiT)

In January and February 2019, the International Synoptic Krill Survey of Area 48 was carried out to obtain updated estimates of krill abundance and distribution almost 2 decades after the previous synoptic survey in 2000. As part of this latest survey, observers from IMR and partner institutions (British Antarctic Survey) were accompanying three of the five survey vessels (R/V Kronprins Haakon, F/V Cabo de Hornos and RRS Discovery), and were responsible for carrying out visual observations of key krill-dependent **marine mammal species** throughout the surveys. Analyses of these data have focussed on fin whales, a major krill predator in the region for which abundance estimates are old and extremely unreliable. A manuscript will be submitted early in 2021, which will show that the estimated fin whale abundance is at least 10 times greater than the latest estimate from 2000, suggesting that they may be close to estimated pre-whaling abundance. During the 2019-2020 season, two students from the University of Tromsø undertook marine mammal and seabird observations from Hurtigrutens cruise vessels Fram and Midnatsol. For training and educational purposes, one student on each vessel was accompanied by one experienced MMO, and subsequent analyses of these datasets will result in MSc theses at the university. One of these have recently been submitted to the university, covering whale sightings and focusing on the seasonal dynamics of humpback whale presence and distribution around the Antarctic Peninsula. The other thesis, covering seabirds, will be submitted before summer 2021. (IMR, UiT))

Fin whales (*Balaenoptera physalus*) and humpback whales (*Megaptera novaeangliae*) are commonly found in the Norwegian Sea during the summer months. Records from around 1995 to 2004 show that their distribution patterns were mainly associated with those of macro-zooplankton. More recent studies conducted from 2009 to 2012 demonstrate marked shifts, with fin whale distribution related to pelagic fish distribution, decreasing densities of humpbacks, and increased densities of toothed whales. During the same period, historically large abundances of pelagic planktivorous fish in the Norwegian Sea were reported. The goals of this study were to examine the summer distribution of fin and humpback whales from 2013 to 2018 and to assess the potential association between distribution and environmental impact

factors. Results suggest a pronounced northerly shift in distribution for both species, a feeding hotspot for fin whales at the shelf area between Svalbard and Norway, and one near Bear Island for humpback whales. Fin whale distribution was associated with that of blue whiting (*Micromesistius poutassou*) and capelin (*Mallotus villosus*), whereas humpback whale distribution was associated with that of euphausiids (*Meganyctiphanes norvegica, Thysanoessa longicaudata and T. inermis*), capelin, and herring (*Clupea harengus*). However, a significant negative spatial correlation was found between whale occurrence and the widely expanding population of northeast Atlantic mackerel (*Scomber scombrus*). The results of this study suggest that the prey composition of fin and humpback whales in recent years contain a large proportion of fish. The apparent northerly shift in the distribution of these whale species is largely determined by the availability of prey, but it likely is also impacted by direct or indirect interspecific interactions, especially with killer whales (*Orcinus orca*). Such large-scale pronounced changes in distribution seem to confirm a high degree of plasticity in fin and humpback whale feeding in the Norwegian Sea. (IMR).

Killer whales (*Orcinus orca*)
Since 2013, year-round efforts in the field had documented killer whale dietary habits in all seasons in northern Norway, which had resulted in several publications (Jourdain & Vongraven 2017; Jourdain et al. 2017; Jourdain et al. 2019). In 2020, we published the results from the analysis of dietary markers (stable isotopic values and contaminants) in skin and blubber samples of killer whales for which diet was known from field records. Our findings confirmed that Norwegian killer whales constitute a generalist population characterized by inter-group variations in dietary habits. Importantly, there seems to exist some sort of ecological gradient with fish-specialists on one end, and others that specialize, to some extent, on pinnipeds over a lifetime on the other end. Our results confirmed that the seal-eating killer whales sampled so far include fish in their diet and are therefore not prey-specialists.

Other species
In August-October 2020 marine mammal observers were onboard the vessels participating in the **Barents Sea ecosystem survey** which is a joint effort with Russia. In total, 4159 individuals of twelve species of marine mammals were observed. As in previous years, white-beaked dolphin (*Lagenorhynchus albirostris*) was one of the most common species (about 26% of all individual registrations). However, the observation of a large wintering aggregation (about 2,000 individuals at a density of about 200-300 individuals/km) of white whales south of Franz Josef Land made that species most numerous (48% of all individuals). Although in modest numbers, the toothed whales were also represented by sperm whales (*Physeter macrocephalus*), harbour porpoises (*Phocoena phocoena*), and killer whales (*Orcinus orca*) besides the numerous white-beaked dolphins. The sperm whales were observed in the western areas of the Barents Sea, west of 35°E, and in the deeper waters off the continental slope. The baleen whale species **minke** (*Balaenoptera acutorostrata*), **humpback** (*Megaptera novaeangliae*) and **fin** (*Balaenoptera physalus*) whales were abundant and comprised about 21 % of the total animals registered. These species were often found together in aggregations and overlapping with capelin and polar cod. (IMR).

Research vessels, coastguard vessels and other providers have collected incidental observations of marine mammals. Recorded data include date, position, species and numbers. During 2020 a total of about 800 cetacean observation incidents have been reported. (IMR).

During 2020 the collection of photo IDs from **humpback whales** during field work and from incidental sources has been continued. (IMR).

III ONGOING (CURRENT) RESEARCH

PINNIPEDS

Data for assessment of biological parameters (growth, condition, age at maturity, fertility) were collected from 176 **harp seal** females during Norwegian commercial sealing in the West Ice in 2019 – analyses are in progress. (IMR)

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)

Collect new data on biological parameters for **harp seals** in the East Ice during the commercial hunt 2021. (IMR)

Tagging with satellite based tags, **harp seals** in the White Sea - funding secured, will be attempted in April/May 2021. (IMR)

Ship based counting of **harbor seals**, using electronic helicopter drones with camera, will be conducted in North Norway (Finnmark) in September 2021. This will continue the work further south in 2020, aimed to provide a new abundance estimate for the species along the entire Norwegian coast. (IMR)

In September- November 2020, 5 **harbor seals** were tagged (GPS phone tags) in Norwegian Skagerrak, 1 in the east area (Hvaler) and 4 in the west part (Telemark). (IMR)

DNA samples from **harbor seal** pups were sampled in Møre and Romsdal and in Troms in June 2020. Such sampling will be continued next year in Finnmark, which hopefully will provide enough samples to explore potential genetic segregations of harbor seals along all the Norwegian coast north of Stad (62°N). (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 remarkably tolerant to lack of oxygen (hypoxia). Various analyses related to the biochemical and metabolic adaptations of brain tissue – as compared to in similar tissue in various non-diving mammalian species (mice, rats, ferret, reindeer) - have been continued, in part in collaboration with Drs. C. Gessner & T. Burmester, University of Hamburg, Germany. The overarching aim of the studies is to elucidate mechanisms underlying tolerance to both hypoxia and to reactive oxygen species, in the brain of diving mammals. The current focus is to establish seal brain cell cultures in order to a) allow more continuous access to material for detailed cellular studies than that based on harvest of fresh tissue from newly killed animals and b) to reduce the need to cull seals for access to study material. This will also allow more detailed and directed studies on how the unusual labour division that has been observed between brain neurons vs. glia cells in the seal brain may, in fact, promote hypoxia tolerance. (UIT-AMB-ACP)

Analyses of previously collected data on tissue levels of contaminants of **harp seals** and on digestive system anatomy and function in **hooded seals,** were completed and described in new papers. Data from previous tracking studies of Antarctic **crabeater seals** have also been published in metadata analysis publications (see V Publications and documents). (UIT-AMB-ACP).

CETACEANS

Manuscripts on the feeding ecology, life history and ecological role of **harbor porpoises** is in preparation and will be submitted during the Spring 2021. (IMR, UiT)

Autumn (August-September) surveys to assess the oceanographic and ecological conditions in the Arctic Ocean (between Svalbard and the ice edge further north; the SI_ARCTIC project at IMR, were conducted during 2014-2017. Visual observations of all **marine mammals** were conducted along all sampling transects, and publication of analyses of possible associations between **baleen whales** and their prey are in progress. (IMR)

Sampling of **minke whale** stomach contents and life history parameters will be performed during the commercial hunt in June 2021. (IMR)

Investigation for directional associations among fin whale, krill, and oceanographic factors is in progress for a data set collected during an international synoptic krill survey in the Scotia Sea west of the Antarctic Peninsula.(IMR) Analysis to investigate spatial associations among their preys, and oceanographic variables is in progress for a data set collected during ecosystem survey in the Barents Sea.(IMR)

Previous studies in pinnipeds show that their brain is remarkably tolerant to lack of oxygen (hypoxia). Various analyses related to the biochemical and metabolic adaptations of brain tissue – as compared to in similar tissue in various non-diving mammalian species (mice, rats, ferret, reindeer) - have been conducted. Comparisons have also been made with cetaceans (**killer whale, long-finned pilot whale, minke whale, bowhead whale**), in collaboration with the lab of Dr. T. Burmester, University of Hamburg, Germany. (UIT-AMB; ACP).

GENERAL

Norwegian Orca Survey have been sampling stranded marine mammals in Norway since 2015. In 2020, after an unusual high number (20+) of cetaceans stranded in northern Norway (March-May), NOS managed to sample many of the carcasses washed ashore. As part of a project in collaboration with the University of Oslo and the Norwegian University of Life Sciences (funded by ARKTISK 2030), all samples were analyzed for chemical pollution. The project will provide novel baseline knowledge available to the working groups of the Arctic Council and to be used for further international contaminant regulation work of REACH and the Stockholm Convention. Results are underway and should be published in a near future (NOS).

2020 marked the 8th year of year-round data collection by NOS in northern Norway: photo-id, biopsies, predatory records. In 2020, we also finished matching the current killer whale ID Catalogue (2007-present) with historical catalogues (1986-2005) held by colleagues Tiu Similä, Sanna Kuningas, Dag Vongraven and Anna Bisther. Mark-recapture analyses of this dataset spanning 4 decades, and publications, are underway. NOS has established a sighting network and a citizen-science project in several regions in southern Norway to monitor killer whale presence and ecology there. The ID Catalogue and database have also been kept up to date in 2020. (NOS).

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. Analyses to estimate the abundance of other cetacean species observed during these surveys have been performed and have now been published. (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 2021.

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 2021 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.

Coastal seals

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 moult 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 2021 for **harbor seals** in Norway are 257 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.

Seals in Svalbard

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. 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. The most recent review for North Atlantic common minke whales was conducted over the period 2014-2017. 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. (IMR).

Starting in 2016, a new six-year block quota 2016-2021, was set with an annual total catch quota of 880 animals of which 710 could be taken within the Northeastern stock area (the E Small Areas, i.e. the EW, EN, ES and EB Small Areas) and 170 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 may be transferred to following years within the period which the block quota is set for.

For 2021 the total catch quota, including transfers, has been set to 1278 minke whales. This was the same as the quotas set for each of the years 2018 - 2020. 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 are consistently larger than the abundance estimates without ME correction (Solvang et al. *acceptance* in 2020)

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VI DATA REPORTING TO NAMMCO COMMITTEES

Sealing

Harp and hooded seals

Norwegian catches in the Greenland Sea (West Ice) in 2020 was 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 2020. The 2020 catch volume for harp seals in the Greenland Sea was set at 11,548 animals of all ages. Total catches in 2020 were 10,284 (including 2,341 pups) harp seals (Table VI.I).

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 49th Joint Norwegian-Russian Fisheries Commission (JNRFC) supported this ICES recommendation for 2020 and Russia alloted 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. This ban was removed before the 2014 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 2015-2020. No Norwegian vessels participated in the area in 2020.

Table VI.1. Norwegian catches of harp and hooded seals in 2020. 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	2,341	7,943	10,284	0	0	0
Hooded seals	0	0	0			

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 2010-2019, annual harbor seal quotas ranged between 425

and 485 animals, while annual catches were 159-511 harbor seals. In 2020, the quota was 467 harbor seals and 391 were taken in the hunt.

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 2018-2019. Annual catches were 33-216 grey seals in 2012-2019. In 2020, the catch quota was again 200 animals and 19 grey seals were taken.

Seals in Svalbard

In 2003-2019, total annual **ringed seal** catches in Svalbard ranged between 15 and 78 animals. In 2020, 60 ringed seals were taken in the hunt. In addition, 2 ringed seals were shot in North Norway.

The number of **bearded seals** taken annually in Svalbard in 2003-2019 ranged between 2 and 34 animals, and the number taken in the 2020 hunt was 15 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 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 Reviews made in 2008 and 2014-2017. 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 2020 season of whaling and the catching period was 1 April to 20 September. Table VI.2 shows the number of minke whales taken by area in the 2020 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 2016-2021. The calculated annual basic quota for this period is 710 animals within Medium Area E and 170 whales within the Small Area CM, giving a total of 880 minke whales. The total catch in the 2020 season was 503 whales and the quota for 2020 was set to 1278 minke whales, including transferred unused catches in the E area.

Table VI.2. Quotas and catches of minke whales in 2020 by management area as defined in RMP.

2019	Management area					
Small-type whaling	EB	EN	ES	EW	CM	Total
Catch	178	34	230	61	0	**503**
Quota	1108				170	1278
Stock area	Eastern				Central	

VII BY-CATCH DATA (*Arne Bjørge, IMR*)

Bycatch of harbour porpoise, grey and harbour seals

Harbour porpoise, harbour and grey seals are incidentally caught in coastal gillnet fisheries. The average annual estimated bycatch is 2 674 porpoises for the entire period 2006-2018. Four methods have been used to derive at this estimate (Fig. 1) and the CV varied from 0.07 to 0.17 for the four different estimates.

For harbour and grey seals, the estimated are more uncertain and bycatches are in the hundreds per year. A method for Remote Electronic Monitoring (REM) is currently under development for improving the estimate of seal bycatch.

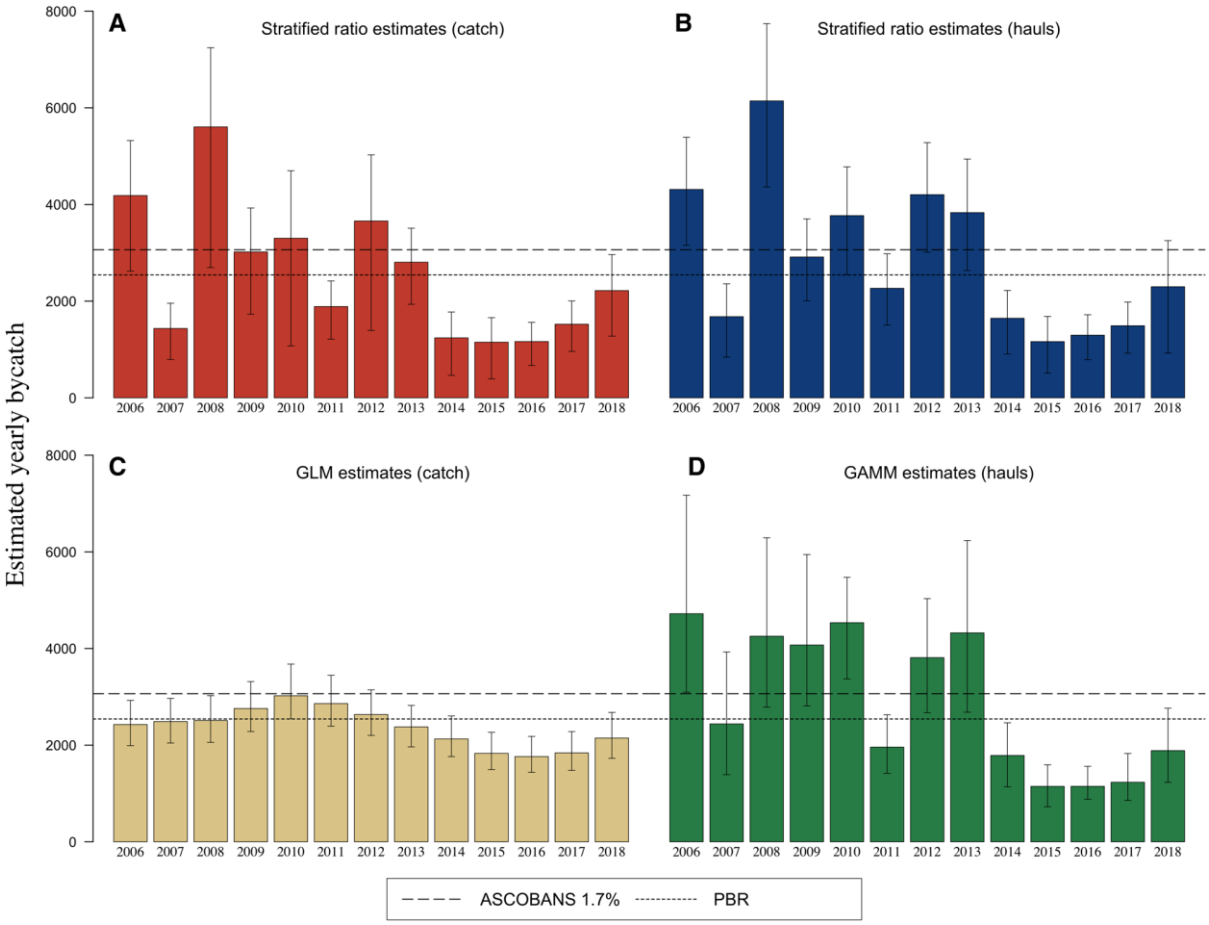

Figure 1. Total bycatch of harbour porpoises in all fishery groups per year, estimated using catch-based and haul-based stratified ratioestimators (a and b), as well as GLM © and GAMM (d) approaches. Vertical lines indicate 95% Cis around point estimates. Dashed and dotted lines represent the ASCOBANS 1.7% limit and the PBR, respectively. After Moan & al. 2020).

Harbour porpoise bycatch mitigation

Experiments (2017-2019) with two types of Acoustic Deterrent Devices (ADDs), called pingers, resulted in 70-100% reduction in bycatch of harbour porpoise. About 900 porpoises are taken yearly as bycatch in Vestfjorden (Statistical area 00), that is about every third porpoise bycaught in Norway. Based on the results of there experiments, and a recommendation from the Norwegian Scientific Marine Mammal Advisory Board, the Ministry of Trade, Industry and Fisheries decided that pingers will be mandatory during the cod fishery in Vestfjorden from January 1st, 2021. If the pinger efficacy in the full-scale fishery is similar to that in the experiments, this has the potential of bringing bycatch levels well below the Potential Biological Removal (PBR) limit.