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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.

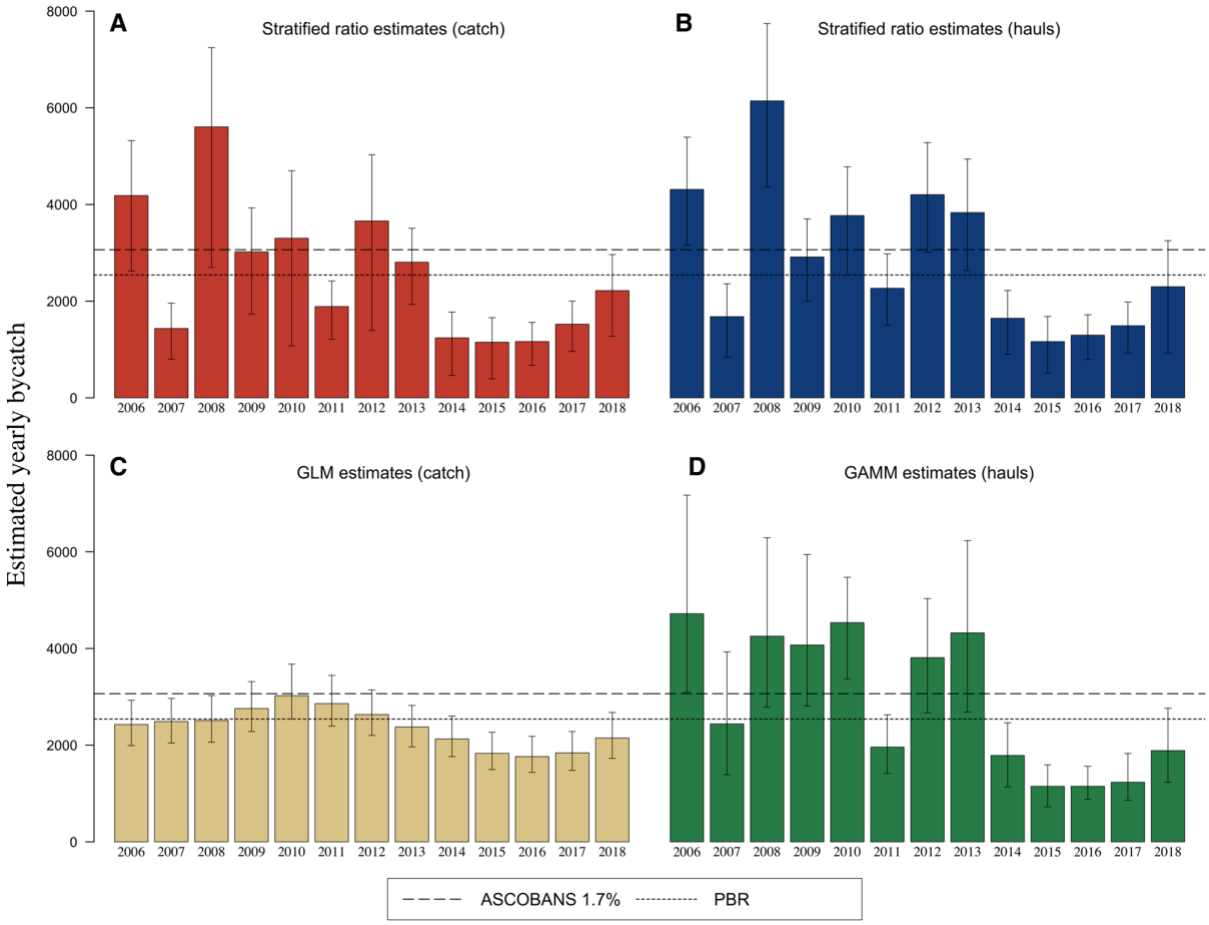

Figure 1. Total bycatch of harbour porpoises in all fishery groups per year, estimated using catch-based and haul-based stratified ratioestimators (a and b), as well as GLM © and GAMM (d) approaches. Vertical lines indicate 95% Cis around point estimates. Dashed and dotted lines represent the ASCOBANS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

NORWAY - PROGRESS REPORT ON MARINE MAMMALS 2019

Compiled by Nils Øien & Tore Haug

I INTRODUCTION

This report summarises Norwegian research on pinnipeds and cetaceans conducted in 2019 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/
The Arctic University of Norway, Forskningsgruppe for arktisk marin systemøkologi (UiT-AMSE); https://uit.no/om/enhet/forsiden?p_dimension_id=88165
Norwegian Orca Survey, Andenes (ORCA); 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 2019

PINNIPEDS

Harp seals *Pagophilus groenlandicus*
Studies of **harp seals** and **hooded seals** from the Greenland Sea stock were conducted during a research cruise with *R/V "Helmer Hanssen"* to the Greenland Sea between 15 and 30 March 2019. Altogether 9 adult and 7 new-born hooded seals, and 8 adult and 6 new-born harp seals, were culled for various scientific purposes:

i) sample collections for studies of mechanisms underlying neuronal tolerance to lack of oxygen (hypoxia) (in collaboration with Drs. C Gessner/T. Burmester, Zoologisches Institut, Universität Hamburg, Germany);
ii) studies of developmental changes in resting metabolism of newborn hooded seals, from birth to weaning, in part to elucidate how deposition of large fat (blubber) supplies affect their energy expenditure;
iii) dissection of nursing hooded seal pups; to investigate how energy from the lactating seal mother is deposited into the various internal organs, the total muscle mass and the blubber of the feeding pups, and how such energy deposition changes over time with changing environmental condition (time series data from 2006 until present);
iv) collection of various tissue samples for studies of patterns of entry and accumulation of mercury (Hg) in animals with extreme physiology such as harp and hooded seals. The integration of carbon, nitrogen and sulfur stable isotopes, Hg species levels and for the first time Hg stable isotopes will be used to understand (1) how the ecology (feeding behavior and distribution) of each species influence Hg uptake in adult seals and (2) how Hg is remobilized in their tissues and transferred to their offspring during key physiological processes such as lactation and fasting (in collaboration with Marianna Pinzone and Krishna Das (Laboratory of Oceanology, ULg, Belgium), Rune Dietz (Department of Bioscience, Arctic Research Center, Aarhus University, Roskilde, Denmark));
v) development of photometric method to predict body condition of adult harp seals based on external appearance, for use in future studies of the ecology and energy balance of harp seal stocks (in collaboration with Dr. J. Grecian SMRU/University of St. Andrews).
vi) Additionally, 6 weaned hooded seal pups were live-captured and transported to Tromsø, where they were maintained in approved sea-water seal tanks at Department of Arctic and Marine Biology, UiT, for use in further studies of adaptations to diving and diving-induced hypoxia.

The described field research was combined with research-based teaching given to 20 students that participated on the cruise, which represents a mandatory part of the course "Arctic Biology" (BIO-2310) at the University of Tromsø -The Arctic University of Norway. (UIT-AMB-ACP).

Hooded seals *Cystophora cristata*

Studies of **hooded seals** and **harp seals** from the Greenland Sea stock were conducted during a research cruise with R/V "Helmer Hanssen" to the Greenland Sea, between 15 and 30 March 2019, as detailed above. (UIT-AMB-ACP)

In the period 18 - 31 March 2018 aerial surveys were performed in the Greenland Sea pack-ice (the West Ice), to assess the pup production of the Greenland Sea populations of **harp** and **hooded seals**. One fixed-wing aircraft, stationed in Akureyri (Iceland), was used for reconnaissance flights and photographic surveys along transects over the whelping areas. A helicopter, operated from the expedition vessel (KV *Svalbard*) also flew reconnaissance flights, and was subsequently used for monitoring the distribution of seal patches and age-staging of the pups. The reconnaissance surveys were flown by the helicopter (18 – 22 March) and the fixed-wing aircraft (18 - 31 March) in an area along the eastern ice edge between 68°40'and 74°47'N. The ice cover was narrow and the edge closer to the Greenland coast in 2018 compared to previous survey years. The reconnaissance surveys were adapted to the actual ice configuration, usually flown at altitudes ranging from 160 - 300 m, depending on weather conditions. Repeated systematic east-west transects with a 10 nm spacing (sometimes 5 nm) were flown from the eastern ice edge and usually 20-30 nautical miles (sometimes longer) over the drift ice to the west. On 27 March, two photographic surveys were flown to cover the entire whelping patch area which was a little more than 60 nm in south-north direction. Due to fog in the northwest areas, these areas had to be re-visited with new transect surveys the following day (28 March). To define the transect lines for this second survey day, data from the ice-deployed GPS beacons were used to account for the ice drift between the two days. In total, 5104 photos were taken during the surveys (3016 photos on 27 March; 2088 photos on 28 March). Combining data from the two survey days gave an estimated pup production of harp seals of 54 181 (SE=9 236, CV=17%), which is significantly lower than estimates obtained in similar surveys in 2002, 2007 and 2012. Estimated hooded seal pup production was 12 977 (SE=1 823, CV=14%) which is lower than estimates obtained from comparable surveys in 2005 and 2007 but comparable with the estimate from the most recent survey in 2012. Current status and catch options for the stocks of harp and hooded seals are being assessed by incorporating the pup production estimates into population models. (IMR).

The mean age of maturity (MAM) for Barents Sea/White Sea **harp seals** was estimated at 6.9±0.9 years for 168 females collected during the 2018 molting period in the southeastern Barents Sea. This estimate is not significantly different from the previous estimate from 2006, but about a year lower than the values observed in the early 1990s. The estimated pregnancy rate for the 2018 Barents Sea/White Sea sample was 0.91±0.06. This is the highest pregnancy rate among the available estimates for this population, but it is only significantly different ($P<0.001$) from the minimum value of 0.68 from 2006. Estimates of pregnancy rates are based on the presence/absence of a regressing *corpus luteum* in ovaries examined during the molting period and may be overestimates as they may not take potential late term abortions into account.

Harbor seals were counted along the entire mainland Norwegian coast at known haul-out sites during the molting period from mid-August to early September 2011-2016. In 2011 and 2012, molting areas from Rogaland to Finnmark counties and in Østfold county were covered by aerial photo surveys. Usually three independent surveys were conducted. In 2016, an electric drone (helicopter) was used to photograph harbor seal colonies along the Norwegian Skagerrak coast. Visual counts using binoculars from small boats and land were also carried out in areas not covered by aerial surveys, or where results from the aerial surveys seemed to be incomplete. The surveys revealed a total minimum population of 7712 harbor seals along the mainland Norwegian coast in 2011-2016. In western Finnmark, 395 harbor seals were counted in 2013. West Finnmark was not covered in the two previous surveys. The count of 7317 harbor seals (not including West Finnmark) seems to be a small increase compared to 6938 in

2003-2006, but slightly lower than 7465 in 1996-1999. In 2017, 2018 and, counting surveys (drone and visual counts) were conducted from the southernmost peak (Lindesnes) in Norway and along the west coast, including the counties Vest-Agder, Rogaland, Sogn & Fjordane,Møre & Romsdal and Trøndelag. The total numbers of harbour seals in each of the counties from Møre and southward were approximately similar with the results in the previous counting period (2011-2015) but increasing in Trøndelag. In the southern Oslofjord 5 harbour seals were tagged with GPS phone tags in mid Nowember. The seals have since tagging been moving more into the Oslofjord and some south to Swedish areas. (IMR).

To obtain knowledge of feeding habits and prey consumption of **grey seals**, data were sampled in selected areas along the Norwegian coast. Prey were recovered from 182 grey seal gastrointestinal tracts and 199 faecal samples, collected during1999–2010 in Finnmark, Nordland and Rogaland counties. The most important prey were saithe *Pollachius virens*, cod *Gadus morhua* and wolffish *Anarchichus* spp. Wolffish was mainly eaten by seals ≥ five years old. Otherwise, the data did not suggest important temporal or spatial variations between the main prey items in the grey seal diet. However, capelin *Mallotus villosus* was eaten during spring in Finnmark suggesting that seasonally abundant pelagic fish species could be regionally important. Total annual grey seal consumption of various species was estimated using bio-energetic modelling. The input variables were seal numbers, energy demands, diet composition in terms of biomass and energy densities of prey species. Assuming the observed grey seals diet composition in the sampling areas were representative for the diet along the Norwegian coast, the mean total annual consumption by 3850 grey seals was estimated to be 8084 tons in Norwegian waters; saithe (3059 tons), cod (2598 tons) and wolffish (1364 tons) were consumed in highest quantities. (IMR, UiT).

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 2019 and GPS data from walruses were collected. This project is mainly funded by the Norwegian-Russian Environmental Commission. (NP).

Ringed seals (*Pusa hispida)*
Twenty-three 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 18 June to 12 August 2019, a sighting surveys was conducted with the chartered vessel *Acc Mosby* in the Svalbard area - the IWC *Small Area ES*. In addition, the fjord *Balsfjord* in northern Norway received coverage as part of a feasibility study of surveying for harbour porpoises in inner coastal waters. This was the last year of the six-year survey period 2014-2019 to cover the northeast Atlantic to provide a new abundance estimate of **minke whales** every sixth year as part of the management scheme established for this species. A total of 3,729 nautical miles was surveyed with independent double platforms on primary effort in the four offshore blocks ES1-ES4. During primary search effort, the number of observations from the primary platform (crow's nest) was 78 sightings of **minke whales**. Sightings of other cetacean species include **fin whales** (174 primary sightings), **humpback whales** (97 primary sighting), **Lagenorhynchus spp. (**198 primary sightings, of which 159 were **white-beaked dolphins** and 39 were unidentified to species), **sperm whales** (15 primary sightings), **Northern bottlenose whales** (3 primary sightings) and h**arbour porpoise** (1 primary sightings). In Balsfjorden 52 primary observations were made of harbour porpoises. In addition, 56 harp seals were recorded around Svalbard. (IMR).

Minke whale catch data for the 2019 season have been computerised and evaluated. (IMR).

During the commercial catch operations on feeding grounds in Norwegian waters, body condition data (blubber thickness and girth) have been collected from 13,216 **common minke whales** caught in 1993-2018. Using this time series to investigate associations between body condition and time/area in minke whales, several statistical approaches were applied. The analyses revealed a significant negative trend from the start until 2015. After 2015, the trend was reversed and body condition values increased significantly. It has previously been suggested that there may be a link between the decreased minke whale body condition and the abundance of the Barents Sea cod stock which increased to a record high level between 2006 and 2015. Recruitment to the cod stock in more recent years has been low with a subsequent and continuous decrease in the total stock after 2015 to a current level which is presumably approximately 60% of the 2015 level. Interestingly, the observed common minke whale body condition was at its lowest in 2015, whereafter it has increased. This may support a connection between cod abundance and feeding conditions for other top predators such as common minke whales. (IMR).

A joint paper was issued with a first review of baleen whale ecology in high-latitude marine ecosystems of both the north Atlantic and north Pacific. Oceanographically, these sectors offer four contrasting habitats to baleen whales: (i) a broad-deep-strait and deep-shelf inflow system in the Northeast Atlantic (NEA), (ii) a combination of inflow and outflow systems north of Iceland in the central North Atlantic (CNA), (iii) an outflow shelf and basin in the Northwest Atlantic (NWA), and (iv) a narrow-shallow-strait inflow shelf system in the Pacific sector. Information on baleen whale ecology from visual and passive acoustic surveys, combined with available telemetry and diet studies, show contrasting patterns of baleen whale occurrence among sectors. In brief, arctic and subarctic waters in the Atlantic sector support a far greater number of seasonally migrant baleen whales than the Pacific sector. Thousands of **humpbacks, fin** and **common minke** whales occupy the diverse habitats of the Atlantic sector. These species all exhibit flexible diets, focused primarily on euphausiids (krill) and forage fishes (e.g., capelin, herring, sand lance), which are now responding to ecosystems altered by climate change. Conversely, the Pacific sector supports a far greater number of arctic-endemic **bowhead whales** than the Atlantic sector, as well as a large population of seasonally migrant **gray whales**. Currently, differences in migratory timing and, to a lesser extent, foraging behaviors, serves to restrict prey competition between the arctic-endemic bowhead whale and seasonally migrant baleen whale species in both sectors. Regional aspects of changes in prey type and availability will likely impact future migratory timing, habitat selection, body condition and diet of baleen whales. Tracking variability in these attributes can provide valuable input to ecosystem models and thereby contribute the sentinel capability of baleen whales to forecasts of future states of high latitude marine ecosystems. (IMR).

The "*weShare*" project examines the causes and consequences of the massive herring superabundance events that took place in the Kaldfjord/Vengsfjord system over 5 winter seasons between 2013 and 2017. The project has 1) carried out extensive and repeated echosounder surveys for herring approximately monthly every season (Oct-Feb) to study the dynamics and estimate the biomass of herring, 2) used advanced electronic accelerometer/camera tags, attached with suction cups to ~25 **humpback whales**, to study in detail their foraging behavior, estimate their prey consumption rates, and estimate their body condition, 3) carried out a pilot study to evaluate the use of aerial drones to estimate whale abundance, and 4) supported the collection of photo IDs of humpback whales. Details of the project were presented in previous annual reports, and here we focus on highlights from 2019.
No new field activities have been undertaken since the whales moved north towards Skjervøy in 2017-2018. 1) Echosounder data for herring have been processed and converted to spatial time-dynamic maps of estimated herring abundance and distribution throughout the fjord system, using novel state-of-the-art spatiotemporal modelling tools. These are used to provide an estimate of changes in abundance both throughout and between seasons. 2) We have developed a novel approach for detecting feeding events of humpback whales from both high-resolution 3D acceleration data and from 2D time-depth dive data. This approach can be used to pinpoint feeding lunges in space and time and can be converted to herring consumption estimates by linking it to the underlying spatiotemporal maps of herring abundance and distribution. Preliminary results from this work was presented at the 2019 World Marine Mammal Conference in Barcelona, Dec 2019 (Biuw et al. 2019). One Master's student is currently working full-time on further refining these analyses. 3) The pilot study on the use of drones for whale monitoring made direct contributions towards a review paper on the use of autonomous vehicles for the monitoring

and detection of marine fauna (Verfuss et al. 2019). 4) Work on the photo-ID database has been continued, mainly through the RFFNOR funded Whalefeast project. One masters student is now assisting the catalogue curator, to bring the catalogue up-to-date and available for analyses. (UiT, IMR).

Studies **harbour porpoise** ecology and population biology, based on samples obtained from bycatches in 2016 and 2017, were continued in 2018 and 2019. In December 2019, a workshop report on the "Status of Harbour Porpoises in the North Atlantic" was published. Also, two manuscripts on pollutants and population structure were submitted and both has been accepted for publication. The conclusions of the first study can be summarized as follows: The concentrations of phthalate metabolites were higher in animals inhabiting waters adjacent to areas with higher human activity and populations. The amount of phthalic acid was negatively associated with the body size, while gender differences were not identified. The study indicates that the harbour porpoise can be potentially used as tracers of phthalate (plasticizers) pollution in the marine environment. As for the second study, it was concluded that the 134 individuals analyzed did not reveal any spatial structure i.e. only the existence of one population of harbour porpoise in Norwegian coastal waters. However, a more extensive sampling, both in terms of numbers of individuals and in geographic scope, preferably covering both sides of the Atlantic, would be essential to elucidate the genetic structure of harbour porpoises. (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. Initial results suggest a close correspondence between the distribution of krill and the distribution of whale sightings, with clear hotspots being encountered within the Bransfield Strait, around South Georgia and in the main krill fishing areas north of the South Orkney Islands. Early results are presented in the cruise report (https://www.hi.no/hi/nettrapporter/rapport-fra-havforskningen-en-2019-21). In total, 1241 whales, 670 seals and 492 penguins were recorded, with **humpback** and **fin whales** being by far the most dominant species. Humpback whales dominated in Bransfield strait and along the north coast of South Georgia, while fin whales dominated around the South Orkneys. Large mixed groups of fin and humpback whales were recorded in a region southwest of South Georgia, in a distinct patch to the NE of South Georgia, and along the southern flank of the shelf break south of the South Orkneys. Sightings for fin whales, and to some degree humpback whales, were sufficient for obtaining reasonable abundance estimates for the Scotia Sea region. These estimates are currently being validated and will be presented at the SORP (Southern Ocean research programme) workshop in association with the International Whaling Commission meeting in May 2020. While results for humpbacks agree well with recent reports about this species having recovered to close to pre-whaling numbers, our results for fin whales suggest that also this species has undergone a dramatic recovery in recent decades. (IMR).

Food safety and development of PCB methodology: Norwegian and Icelandic authorities have since 2015 participated in trilateral meetings, at different levels, between Norway, Iceland and Japan regarding the regulations for import of whale products to Japan. In 2019 the work and discussions in the trilateral meetings held in Tokyo in February 2019 between Japan, Iceland and Norway have resulted in several agreements related to whale meat and health supplements from whale products. In 2020 IMR in cooperation with other institutions and industry plan to initiate research projects on health effects of whale products. (IMR).

Other cetaceans

Killer whales (*Orcinus orca*)

The review on current status of knowledge and threats to North Atlantic killer whale populations, as ordered by NAMMCO in 2018, was published in *Mammal Review* (Jourdain et al. 2019a). (ORCA).

As part of an ongoing research project on killer whale foraging ecology in Norway, photo-identification data and prey remains have been collected throughout the year in Andenes since 2013. Molecular identification of prey species foraged upon in spring enabled documenting a new prey species to this killer whale population: the lumpfish (*Cyclopterus lumpus*). More specifically, 75 photo-identified killer whales have returned to Andfjord in spring for temporary residency and foraging upon lumpfish as the fish migrates to coastal habitats for spawning. These whales are also known to be herring-eaters from winter observations in the same years. This study is therefore the first documentation of individual killer whales seasonally switching between alternative resources. Results were published in *Mammal Science* (Jourdain et al. 2019b). (ORCA).

As a multi-disciplinary approach to the investigation of ecological variations in killer whales, dietary markers were used in biopsy samples of killer whales for which sighting and predation history were available. Results were used to supplement field observations and to further conclude on level of specialization on pinniped prey. Results will be available in 2020. (ORCA).

In collaboration with Fiskeridirektoratet, NOS successfully rescued a pair of mother-offspring killer whales that was naturally entrapped in Sildevannet on Lille-Skorøya in November 2019 (ORCA).

Bowhead whales (*Balaena mysticetus*)
A satellite tag was deployed on 1 bowhead whale in the Framstrait September 2019.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 2019 at various locations in the Svalbard area. (NP).

Narwhals (*Monodon monoceros*)
Biopsies from 6 narwhals 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).

White whales (*Delpinapterus leucas*)
NOS was charged by Fiskeridirektoratet to monitor and feed Hvaldimir, the beluga whale, when he was in the harbor of Hammerfest in May-July 2019. The intervention aimed at promoting the whale's welfare and assisting the town in handling the situation. A flexible food base allowed a quick recovery in the animal's body condition and promoted more active behaviors. Monitoring of Hvaldimir's activities using camera tags (attached with suction cups) suggested increasing interest for live fish and foraging attempts. Hvaldimir left Hammerfest on July 19 and has been swimming on his own ever since. NOS is remotely monitoring Hvaldimir's whereabouts and has gone onsite regularly for visual assessments of body condition and collection of fecal samples (ORCA).

Blue and fin whales (*Balaenoptera musculus and B. physalus*)
Satellite tags were deployed on 25 fin whales on the west coast of Svalbard with Polarsyssel as the base ship. All tags were deployed from a helicopter. In addition, biopsies for various investigations (genetics, diet and pollution) were collected from one blue and one fin whale. (NP).

Other species
In August-October 2019 marine mammal observers were onboard the vessels participating in the **Barents Sea ecosystem survey** which is a joint effort with Russia. In total, 2750 individuals of ten species of

marine mammals were observed. As in previous years, white-beaked dolphin (*Lagenorhynchus albirostris*) was the most common species (about 60% of all individual registrations). This species was widely distributed in the survey area. The highest densities of this species apparently overlap with the distributions of herring, capelin, polar cod, juvenile cod and other fishes in the survey area. 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 deep waters along the continental slope but also within the Barents Sea proper west of 29°E. A group of 6 killer whales eas observed in the northern Barents Sea at 79°45'N-41°33'E. The baleen whale species **minke** (*Balaenoptera acutorostrata*), **humpback** (*Megaptera novaeangliae*) and **fin** (*Balaenoptera physalus*) whales were abundant as 25 % of the total animals registered belonged to these species. These species were often found together in aggregations. In 2019, unlike in previous years, baleen whales were observed mainly south of 78°N due to low concentrations of capelin in the north.

Research vessels, coastguard vessels and other providers have collected incidental observations of marine mammals. Recorded data include date, position, species and numbers. During 2019 a total of about 800 cetacean observation incidents have been reported. (IMR).

During 2019 the collection of photo IDs from **humpback whales** during field work and from incidental sources has been continued. (IMR).

III ONGOING (CURRENT) RESEARCH

PINNIPEDS

Previous studies in **hooded seals** have shown that their brain is remarkably tolerant to lack of oxygen (hypoxia). Biochemical and transcriptomic studies have been continued using sampled brain tissue from **hooded seals**, as part of ongoing collaborative studies with Drs. C. Gessner & T. Burmester, University of Hamburg, Germany, to elucidate mechanisms underlying tolerance to both hypoxia and to reactive oxygen species in the brain of diving mammals. Studies thus far show that multiple factors are involved, including an enhanced cerebral capillary density in seals compared to in non-diving mammals (M.Sc. thesis by C. Ciccone – see V. PUBLICATIONS). Current focus of investigations 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. Attempts are also made to establish differential neuronal and glia (astrocyte) cell cultures, to allow more detailed and directed studies of 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 metabolic data that were collected from **hooded seal pups** during a research cruise with *R/V "Helmer Hanssen"* to the Greenland Sea in 2019 are not yet completed, as is also the case with collected time-series data on variations in pup body composition dating back to 2006. (UIT-AMB-ACP)

Six weaned **hooded seal pups** that were live-captured during a research cruise with R/V "Helmer Hanssen" to the Greenland Sea in 2019 were trained to cooperate in planned studies of changes in cerebral blood circulation during diving using PET-scanning (in collaboration with Dr. Rune Sundset at the University Hospital of Northern Norway (UNN)). Pilot studies showed that the animals had not achieved an adequate level of tameness to allow PET-measurements and further test using light sedation in conjunction with measurements showed that such medication compromised their diving physiology. Further attempts to meet research aims require that theses logistic issues are somehow resolved (UIT-AMB-ACP)

Blood and other tissue samples collected from **harp** and **hooded seals** during a research cruise with *R/V "Helmer Hanssen"* to the Greenland Sea in 2019 have been subject of extensive analyses of mercury and other compounds in the SODYMARS project, by Drs. M. Pinzone and K. Das (Laboratory of Oceanology,

ULg, Belgium), and Dr. R. Dietz at Aarhus University, Denmark. The work is collaboration between named institutions and UIT-AMB-ACP.
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 are in progress. (IMR)

Collect new data on biological parameters for **harp seals** in the East Ice during the commercial hunt 2020. (IMR)

Tagging with sattellite based tags, **harp seals** in the White Sea - funding secured, will be attempted in April/May 2020. (IMR)

Ship based counting of **harbour seals**, using electronic helicopter drones with camera, will be conducted in North Norway (Nordland and Troms) in September. This will continue the work further south in 2019, aimed aimed to provide a new abundance estimate for the species along the entire Norwegian coast. (IMR)

Tagging with sattellite based tags, **harbor seals** in the outer Oslofjord is planned during autumn in 2020. (IMR)

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

Manuscripts on the feeding ecology, life history and ecological role of **harbour porpoises** is in preparation and will be submitted during the Spring 2020. (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. (IMR)

CETACEANS

A collaboration was undertaken between NOS and UiO aimed at investigating pollution patterns in stranded cetaceans in Norway. Results are underway. (ORCA).

Data collection and cataloguing of individual killer whales are maintained. Mark-recapture analyses are ongoing. (ORCA)

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 is starting this summer. Analyses to estimate the abundance of other cetacean species observed during these surveys have been performed and will soon be 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 in late October 2019, based on the report from the 2019 WGHARP meeting. The Joint Norwegian-Russian Fisheries Commission used the results from the 2019 WGHARP meeting to establish preliminary management advice for 2020.

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 WGHARP suggested that the impact of using only the aerial survey estimates (including also a survey estimate from 1991) should be explored. WGHARP 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 consensus in WGHARP 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, WGHARP agreed 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, WGHARP 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, WGHARP 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, WGHARP 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}, WGHARP 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 2020 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.

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 2020 the total catch quota, including transfers, has been set to 1278 minke whales. This was the same as the quotas set for 2018 and 2019. The catching season opens April 1 and are closed medio September.

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VI APPENDIX 1 – CATCH DATA

Sealing

Harp and hooded seals

Norwegian catches in the Greenland Sea (West Ice) in 2019 was taken by 2 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 2019. Only 22 animals (whereof 14 were pups) were taken for scientific purposes. In addition, one adult hooded seal was taken in the ordinary hunt, presumably because it was misidentified (as a harp seal) before being shot. The 2019 TAC for harp seals in the Greenland Sea was set at 26 000 1+ animals (where 2 pups balance one 1+ animal), i.e. the removal level that would reduce the population with 30% over the next 15 year's period.

A possible reduction in harp seal pup production in the White Sea may have prevailed after 2003. Due to concern over this, ICES recommended that removals be restricted to the estimated sustainable equilibrium level of 10,090 1+ animals (where 2 pups balance one 1+ animal) in the White and Barents Sea in 2019. The Joint Norwegian-Russian Fisheries Commission (JNRFC) supported this ICES recommendation and Russia allots 7,000 harp seals to Norway for removals.

Table VI.I shows the Norwegian catches of harp and hooded seals in 2019. The total quotas given were not fulfilled in any area: In the West Ice, only 22% of the given harp seal quota was taken. 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 2015-2019. However, one Norwegian vessel, hunting in the southeastern Barents Sea (the East Ice) in 2019, took a total og 602 (including 34 pups) harp seals. This represented only 6% of the identified sustainable level.

Table VI.1. Norwegian catches of harp and hooded seals in 2019. 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	2,168	3,636	5,804	34	568	602

Hooded seals	14	8	22			

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 2010-2018, annual harbor seal quotas ranged between 425 and 485 animals, while annual catches were 159-511 harbor seals. In 2019, the quota was 476 harbor seals and 448 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. Annual catches were 33-216 grey seals in 2012-2018. In 2019, the catch quota was again 200 animals and 58 grey seals were taken.

Seals in Svalbard

In 2003-2018, total annual **ringed seal** catches in Svalbard ranged between 15 and 78 animals. In 2019, 69 ringed seals were taken in the hunt. In addition, 4 ringed seals were shot in North Norway.

The number of **bearded seals** taken annually in Svalbard in 2003-2018 ranged between 2 and 34 animals, and the number taken in the 2019 hunt was 11 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, 12 vessels participated in the 2019 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 2019 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 2019 season was 429 whales and the quota for 2019 was set to 1278 minke whales, including transferred unused catches in the E area.

Table VI.2. Quotas and catches of minke whales in 2019 by management area as defined in RMP.

2019	Management area					
Small-type whaling	EB	EN	ES	EW	CM	Total
Catch	110	3	241	75	0	**429**

Quota	1108	170	1278
Stock area	Eastern	Central	

VII APPENDIX 2 – BY-CATCH DATA (*Arne Bjørge, IMR*)

Bycatch of harbour porpoises, grey and harbour seals

Harbour porpoises, harbour and grey seals are incidentally caught in coastal gillnet fisheries, and the total annual bycatches of the three species are assumed to be in the order of 3000, 600 and 500 animals, respectively. Large-mesh, bottom-set gillnets for cod and monkfish in the Norwegian coastal zone constitute most of these bycatches. Data collection for monitoring marine mammal bycatches in these two fisheries continued in 2019. Revised estimates of harbour porpoise bycatch for the period 2006-2008 and new estimates for the entire period 2006-2018 have been submitted for *peer review* publication.

Figure 1 shows the estimated total yearly harbour porpoise bycatch in all gillnet fisheries from 2006 to 2018, including estimates using catch landed and days at sea as proxies for fishing effort. The catch-based estimates were consistently lower than the corresponding days at sea-based estimates, except in 2017, when the catch-based stratified ratio estimate was slightly higher. There was great variation in the magnitude of the yearly estimates, with estimates ranging from 1151 to 6144 porpoises per year. However, the yearly estimates from the four approaches shown in Figure 1 agreed fairly well and were not significantly different. The total yearly bycatch has decreased since 2008, when it was at the highest. The bycatch estimates for 2014 to 2017 on the other hand were particularly low. In 2018 however, the bycatch was again higher than in the preceding four years.

Averaging the yearly bycatch estimates gave an annual mortality of 2,571 porpoises (using catch as effort, 95% CI 2,131 – 2,831) and 2,886 porpoises (using days at sea as effort, 95% CI 2,576 – 3,142) for the stratified ratio estimator. For the best GAM the corresponding estimates were 2,358 porpoises (using catch as effort, 95% CI 1,991 – 4,119) and 2,609 harbour porpoises (using days at sea as effort, 95% CI 2,114 – 3,942). The four estimates were not significantly different.

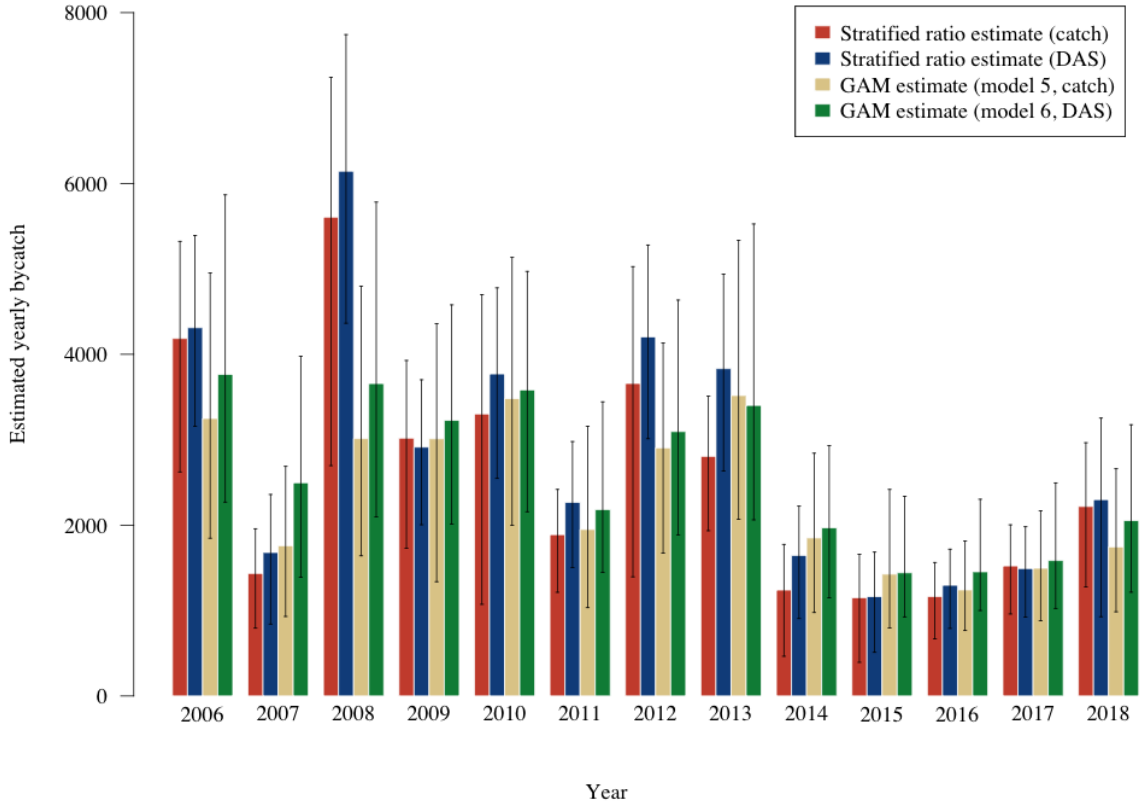

Figure 1: Total bycatch of harbour porpoises in all fishery groups per year, estimated using both a catch-based and a days at sea-based stratified ratio estimator (red and blue bars), as well as the corresponding GAMs (brown and green bars). Vertical lines indicate 95% confidence intervals around the point estimates.

Harbour porpoise bycatch mitigation

Experiments with two types of Acoustic Deterrent Devices (ADDs), called pingers, on large-mesh gillnets in the coastal zone were continued in 2019. The first experiments used Future Oceans' porpoise pinger that emited a 10kHz, 132 dB signal every four seconds. The Fishtek Marine's banana pinger emits randomized signals with frequency between 50 to 120 kHz and 154dB every four to twelve seconds. Both pinger types were attached to the cork line at 200m intervals.

Both pingers gave significant reduction (70-100% reduction) of harbour porpoise bycatches compared to nets without pingers. However, the Future Oceans 10kHz pinger resulted in a threefold increase in harbour seal bycatches. We therefore immediately changed to Future Oceans 70 kHz pingers which is outside the audible frequency range of seals. The inflated bycatch of seals was eliminated and the same reduction of harbour bycatches were obtained. The pinger experiments have resulted in a recommendation to Norwegian fisheries authorities regarding use in commercial fisheries. The results of the pinger experiments will be submitted for peer review publication in 2020.