

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 compilers. 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:

- 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);
- 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;
- 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);
- 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));
- 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 November. 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 during 1999–2010 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 \geq 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 **harbour 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/nettrapper/rappport-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 Fram Strait September 2019. The tag was deployed from a helicopter with FF Kronprins Haakon as a base ship. A biopsy 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 Fram Strait from a helicopter with FF Kronprins Haakon as a base ship. These will be used for genetic and diet studies. (NP).

White whales (*Delphinapterus 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 was 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 these 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 satellite 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 satellite 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 N_{30} (30% of largest observed population size). Recent analyses have indicated that pregnancy rates have remained rather constant around 70% in the period 1958 – 1999. Using this scenario, the model estimates a 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.

V PUBLICATIONS AND DOCUMENTS

Peer reviewed

- Ahonen, H., Stafford, K. M., Lydersen, C., de Steur, L. and Kovacs, K. M. 2019. A multi-year study of narwhal occurrence in the western Fram Strait - detected via passive acoustic monitoring. **Polar Res.** 38, art. no.3468: 1-14, doi: 10.33265/polar.v38.3468.
- Alvira-Iraizoz F, Nordøy ES (2019) Evidence of seawater drinking in fasting subadult hooded seals (*Cystophora cristata*). *J Anim Behav Biometeorol* 7:52-59 doi.org/10.31893/2318-1265jabb.v7n2p52-59

- Blanchet, M.-A., Primicerio, R., Frainer, A., Kortsch, S., Skern-mauritzen, M., Dolgov, A.V. and Aschan, M. 2019. The role of marine mammals in the Barents Sea food web. *ICES Journal of Marine Science* 76 (Supplement 1): i37-i53. <https://doi.org/10.1093/icesjms/fsz136>
- Blévin P, Aars J, Andersen M, Blanchet M-A, Hanssen L, Herzke D, Jeffreys RM, Nordøy ES, Pinzone M, de la Vega C, Routti H (2019) Pelagic vs coastal – key drivers of pollutant levels in Barents Sea polar bears with contrasted space-use strategies. *Environ Sci Technol* <https://doi.org/10.1021/acs.est.9b04626>
- Cleary, A. C., Bester, M., Forcada, J., Goebel, M., Goldsworthy, S. D., Guinet, C., Hoffman, J. I., Kovacs, K. M., Lydersen, C. and Lowther, A. D. 2019. Prey differences drive local genetic adaptation in Antarctic fur seals. **Mar. Ecol. Prog. Ser.** 628: 195-2019.
- Hamilton, C. D., Kovacs, K. M. and Lydersen, C. 2019. Sympatric seals use different habitats in an Arctic glacial fjord. **Mar. Ecol. Prog. Ser.** 615: 205-220.
- Hamilton, C. D., Lydersen, C., Fedak, M. A., Freitas, C., Hindell, M. A. and Kovacs, K. M. 2019. Behavioural ontogeny of bearded seals *Erignathus barbatus* through the first year of life. **Mar. Ecol. Prog. Ser.** 627: 179-194.
- Hamilton, C. D., Vacquie-Garcia, J., Kovacs, K. M., Ims, R. A. and Lydersen, C. 2019. Contrasting changes in space use induced by climate change in two Arctic marine mammal species. **Biol. Lett.** 15, art. No. 20180834.:1-4, doi:10.1098/rsbl.2018.0834.
- Harcourt, R., Sequeira, A.M.M., Zhang, X., Roquet, F., Komatsu, K., Heupel, M., McMahon, C., Whoriskey, F., Meekan, M., Carroll, G., Brodie, S., Simpfendorfer, C., Hindell, M., Jonsen, I., Costa, D. P., Block, B., Muelbert, M., Woodward, B., Wiese, M., Aastrup, K., Biuw, M., Boehme, L., Bograd, S. J., Cazau, D., Charrassin, J-B., Cooke, S. J., Cowley, P., de Bruyn, N.P.J., du Dot, T.J., Duarte, C., Eguiluz, V. M., Ferreira, L. C., Fernandez-Gracia, J., Goetz, K., Goto, Y., Guinet, C., Hammill, M., Hays, G. C., Hazen, E. L., Holland, K., Huckstadt, L. A., Huvaneers, C., Iverson, S., Jaaman, S. A., Kittiwatanawong, K., Kovacs, K. M., Lydersen, C., Moltmann, T., Naruoka, M., Phillips, L., Picard, B., Queiroz, N., Reverdin, G., Sato, K., Sims, D. W., Thorstad, E. B., Thums, M., Treasure, A. M., Trites, A. W., Williams, G.D., Yonehara, Y. and Fedak, M. A. 2019. Animal-borne telemetry integral to the ocean observing toolkit. **Front. Mar. Sci.** 6:326:1-21, doi.10.3389/fmars.2019.00326
- Jourdain, E., Karoliussen, R., de Vos, J., Zakharov, S.E., Tougaard, C. 2019. Killer whales (*Orcinus orca*) feeding on lumpfish (*Cyclopterus lumpus*) in northern Norway. *Marine Mammal Science* 2019:1-14. DOI: 10.1111/mms.12618.
- Jourdain, E., Ugarte, F., Vikingsson, G.A., Samarra, F.I.P., Ferguson, S.H., Lawson, J., Vongraven, D., Desportes, G. 2019. North Atlantic killer whale *Orcinus orca* populations: a review of current knowledge and threats to conservation. *Mammal Review* 49 (2019): 384-400.
- Lone, K., Hamilton, C. D., Aars, J., Lydersen, C. and Kovacs, K. M. 2019. Summer habitat selection by ringed seals (*Pusa hispida*) in the drifting sea ice of the northern Barents Sea. **Polar Res.** 138, art. no. 3483: 1-10, doi: 10.33265/polar.v38.3483.
- Menze, S., Zitterbart, D., Biuw, M. and Boebel, O. 2019. Estimating the spatial distribution of vocalizing animals from ambient sound spectra using widely spaced recorder arrays and inverse modelling. *Journal of the Acoustic Society of America* 146: 4699-4717. <https://doi.org/10.1121/1.5139406>
- Moore, S.E., Haug, T., Vikingsson, G.A. and Stenson, G.B. 2019. Baleen whale ecology in arctic and subarctic seas in an era of rapid habitat alteration. *Progress in Oceanography* 176: 102118. 15 pp. <https://doi.org/10.1016/j.pocean.2019.05.010>
- Mul, E., Blanchet, M.-A., Biuw, M. and Rikardsen, A. 2019. Implications of tag positioning and performance on the analysis of cetacean movement. *Animal Biotelemetry* 7: 11. <https://doi.org/10.1186/s40327-019-0173-7>
- Nakagawa, T., Subbey, S. and Solvang, H.K. 2019. Integrating Hawkes process- and biomass models to capture impulsive population dynamics. *Dynamics of Continuous, Discrete and Impulsive Systems Series B: Applications and Algorithms* 26: 153-170.
- Nilssen, K.T., Lindstrøm, U., Westgaard, J.I., Lindblom, L., Blencke, T.-R. and Haug, T. 2019. Diet and prey consumption of grey seals (*Halichoerus grypus*) in Norway. *Marine Biology Research* 15: 137-149. <https://doi.org/10.1080/17451000.2019.1605182>

- Routti, H., Diot, B., Panti, C., Duale, N., Fossi, M. C., Harju, M., Kovacs, K. M., Lydersen, C., Scotter, S. E., Villanger, G. D. and Bourgeon, S. 2019. Contaminants in Atlantic walrus in Svalbard Part 2: Relationships with endocrine and immune systems. **Environ. Pollut.** 246: 658-667.
- Scotter, S. E., Tryland, M., Nymo, I. H., Hanssen, L., Harju, M., Lydersen, C., Kovacs, K. M., Klein, J., Fisk, A. T. and Routti, H. 2019. Contaminants in Atlantic walrus in Svalbard Part 1: Relationships between exposure, diet and pathogen prevalence. **Environ. Pollut.** 244: 9-18.
- Solvang H.K. and Subbey, S. 2019. An improved methodology for quantifying causality in complex ecological systems. PLoS ONE 14(1): e0208078. <https://doi.org/10.1371/journal.pone.0208078>
- Vacquié-Garcia, J., Lydersen, C. and Kovacs, K. M. 2019. Diving behaviour of adult male white whales, *Delphinapterus leucas*, in Svalbard, Norway. **Polar Res.** 38, art. no. 3605: 1-12, doi: 10.33265/polar.v38.3605.
- Verfuss, U. K., Aniceto, A. S., Harris, D. V., Gillespie, D., Fielding, S., Jiménez, G., Johnston, P., Sinclair, R.R., Sivertsen, A., Solbø, S.A., Storvold, R., Biuw, M., Wyatt, R. (2019). A review of unmanned vehicles for the detection and monitoring of marine fauna. Marine Pollution Bulletin, 140. <https://doi.org/10.1016/j.marpolbul.2019.01.009>

Others

- Ahonen, H., Lydersen, C., Steur, L. de, Kovacs, K. M. and Stafford, K. M. 2019. Arctic «unicorns»-year-round residents of western Fram Strait. **Fram Forum 2019**, In Brief: 122-123.
- Ahonen, H., Stafford, K., Lydersen, C. and Kovacs, K. M. 2019. Inter-annual variability in acoustic detection of blue (*Balaenoptera musculus*) and fin whale (*B. physalus*) 20 Hz calls in the Northeast Atlantic High Arctic. **World Marine Mammal Conference**, Barcelona, Spain, 9-12 Dec. 2019.
- Ancieto, A.S., Biuw, M., Kettmer, L.E., Lindstrøm, U.L., Pedersen, G., Primicerio, R., Camus. 2019. Autonomous detection of humpback whales - migration and distribution in relation to Norwegian spring spawning herring. 23rd Biennial Conference on the Biology of Marine Mammals, Barcelona, Spain, 9-12 December 2019.
- Andersen, M., Kovacs, K. M. and Lydersen, C. 2019. Svalbard ringed seal (*Pusa hispida*) demography in a time of habitat change. **World Marine Mammal Conference**, Barcelona, Spain, 9-12 Dec. 2019.
- Aoki, K., Isojunno, S., Bellot, C., Iwata, T., Kershaw, J., Martin-Lopez, L.M., Ramp, C., Biuw, M., Akiyama, Y., Swift, R., Wensveen, P., Narazaki, T., Sato, K., Miller, P.M. 2019. Photogrammetry supports tag-derived tissue density as a proxy for body condition: Seasonal and locational changes in body condition of humpback whales on their feeding grounds 23rd Biennial Conference on the Biology of Marine Mammals, Barcelona, Spain, 9-12 December 2019.
- Bengtsson, O. 2019. Ringed seal (*Pusa hispida*) diet on the west coast of Spitsbergen, Svalbard, Norway. MSc. Thesis, Univ. Tromsø, Norway: 1-42.
- Biuw, M., Frie, A.K., Kristiansen, M., Poltermann, M., Øigård, T.A., and Haug, T. 2019. The 2019 abundance of harp seals (*Pagophilus groenlandicus*) in the Barents Sea / White Sea. ICES WGHARP WP SEA 251. 14 pp.
- Biuw, M., Gjelland, K.Ø., Swift, R., Kleivane, L., Iwata, T., Broms, F. and Miller, P. 2019. Seasonally recurring prey superabundance events. 23rd Biennial Conference on the Biology of Marine Mammals, Barcelona, Spain, 9-12 December 2019.
- Biuw, M., Haug, T. and Øigård, T.A. 2019. The 2019 abundance of hooded seals (*Cystophora cristata*) in the Greenland Sea. ICES WGHARP WP SEA 248. 6 pp.
- Biuw, M., Haug, T. and Øigård, T.A. 2019. The 2019 abundance of harp seals (*Pagophilus groenlandicus*) in the Greenland Sea. ICES WGHARP WP SEA 250. 14 pp.
- Biuw, M., Øigård, T.A., Nilssen, K.T., Stenson, G., Lindblom, L., Poltermann, M., Kristiansen, M. and Haug, T. 2019. Estimation of pup production of harp and hooded seals in the Greenland Sea in 2018. ICES WGHARP WP SEA 247. 31 pp.

- Ciccione C (2019) Brain capillarization in diving mammals: a selection of staining and quantification methods. UiT – the Arctic University of Norway. M.Sc. thesis.
- Everett, A., Kohler, J., Sundfjord, A., Kovacs, K. M. and Lydersen, C. 2019. Where seals dare. **Fram Forum 2019**, Research Notes: 112-117.
- Frie, A.K. 2019. A 2018 update and reassessment of reproductive parameters of Northeast Atlantic harp seals (*Pagophilus groenlandicus*). ICES WGHARP WP SEA 252. 13 pp.
- Frie, A.K. and Haug, T. 2019. Changes in female age distribution parameters of severely declining Greenland Sea hooded seals 1958-1999: Clues to ecosystem impacts on a large piscivore marine mammal? 2019 IMBeR Open Science Conference, Brest, France, 17-21 June.
- Gonzalez, A. P. 2019. Drones and marine mammals in Svalbard. MSc. Thesis, Univ. Tromsø, Norway: 1-45.
- Gonzalez, A. P., Kovacs, K. M., **Lydersen, C.**, Ims, R. A. and Lowther, A. 2019. Look up: potential impacts of UAVs on Arctic Marine Mammals. **World Marine Mammal Conference**, Barcelona, Spain, 9-12 Dec. 2019.
- Grecian, W.J., Biuw, M., Boehme, L., Buchanan, P., Folkow, L., Goulet, P., Haug, T., Jeffrey, R., Jonsen, I., Mahaffey, C., Nordøy, E., Rosing-Asvid, A., Stenson, G., Tagliabue, A. and Smout, S.C. 2019. The response of harp seals to long-term changes in Arctic sea-ice cover. 23rd Biennial Conference on the Biology of Marine Mammals, Barcelona, Spain, 9-12 December 2019.
- Hamilton, C., Lydersen, C., Aars, J., Biuw, M., Boltunov, A., Born, E., Dietz, R., Folkow, L., Glazov, D., Kettner, L., Laidre, K., Øien, N., Nordøy, E., Rikardsen, A., Rosin-Asvid, A., Semenova, V., Shpak, O., Wiig, Ø. And Kovacs, K. M. 2019. Marine mammal “hotspots” in the Greenland and Barents Seas as revealed by satellite tracking since 2005. **World Marine Mammal Conference**, Barcelona, Spain, 9-12 Dec. 2019.
- Haug, T., Biuw, M. and Zabavnikov, V. 2019. Norwegian and Russian catches of harp and hooded seals in the Northeast Atlantic in 2017-2019. ICES WGHARP WP SEA 249. 2 pp.
- Hobbs, R. C., Reeves, R. R., Prewitt, J. S., Desportes, G., Breton-Honeyman, K., Christensen, T., Citta, J. J., Ferguson, S. H., Frost, K. J., Garde, E., Gavrilov, M., Ghazal, M., Glazov, D. M., Gosselin, J.-F., Hammill, M., Hansen, R. G., Harwood, L., Heide-Jørgensen, M. P., Inglangasuk, G., Kovacs, K. M., Krasnova, V. V., Kuznetsova, D. M., Lee, D. S., Lesage, V., Litovka, D. I., Lorenzen, E., Lowry, L. F., **Lydersen, C.**, Matthews, C. J. D., Meschersky, I. G., Mosnier, A., O’Corry-Crowe, G., Postma, L., Quakenbush, L. T., Shpak, O. V., Skovrind, M., Suydam, R. S. and Watt, C. A. 2019. Global review of the conservation status of monodontid stocks. 2nd Int. Workshop Beluga Whale Res. & Conserv. March 12-14, 2019, Mystic Aquarium, Mystic, CT, USA.
- Hoff, Mariana L.M.; Scheuplein, Rabea; Folkow, Lars; Burmester, Thorsten. Pyruvate dehydrogenase in the brain of diving and terrestrial mammals. 10th International Congress of Comparative Physiology and Biochemistry; 2019-08-05 - 2019-08-09
- Jourdain, E., Karoliussen R., de Vos, J., Zakharov, S.E., Tougaard, C. 2019. Killer whales (*Orcinus orca*) feeding on lumpfish (*Cyclopterus lumpus*) in northern Norway. Marine Mammal Science 2019; 1-14. DOI: 10.1111/mms.12618.
- Kettner, L.E., Rikardsen, A., Mul, E., Broms, F., Biuw, M., Blanchet, M.A., Zerbini, A., Fagerheim, K.A., Øien, N. 2019 Long-distance migration of eastern North Atlantic humpback whales revealed by satellite tracks. 23rd Biennial Conference on the Biology of Marine Mammals, Barcelona, Spain, 9-12 December 2019.
- Kovacs, K. M., Heide-Jørgensen, M. P., Vacqui-Garcia, J., Shpak, O., Glazov, D. and Lydersen, C. 2019. Where to find Spitsbergen bowhead whales – and why? **World Marine Mammal Conference**, Barcelona, Spain, 9-12 Dec. 2019.
- Kovacs, K. M., Vaquié-Garcia, J. and Lydersen, C. 2019. White whales in - a conservation concern. 2nd Int. Workshop Beluga Whale Res. & Conserv. March 12-14, 2019, **Mystic Aquarium, Mystic, CT, USA.**
- Krüger, Alana; Fabrizius, Andrej; Mikkelsen, Bjarni; Siebert, Ursula; Folkow, Lars; Burmester, Thorsten. Molecular mechanisms of hypoxia tolerance in the whale brain. 113th Annual Meeting of the German Zoological Society; 2019-09-07 - 2019-09-12

- Madsen, R. G., Rasmussen, M. H., Olsen, M. T., Lydersen, C., Vikingsson, G., Kovacs, K. M., Palner, M. K. H., Bertelsen, J. L., Jacobsen J. S., Jørgensen, M. S., Whittaker, M., Jacobsen, T., Scott, J. and Iversen, M. R. 2019. The migratory movements of blue whales (*Balaenoptera musculus*) inhabiting Arctic and Sub-Arctic areas of the Northeast Atlantic. **15th Danish Mar. Mammal Symp.**, 23 Jan. 2019, Odense, Denmark.
- Lindstrøm, U., Skern-Mauritzen, M., McBride, M., Kovacs, K. M., Øien, N., Lydersen, C. and Vikingsson, G. 2019. Marine mammal consumption and fisheries removals in the Nordic and Barents Seas. Proc. 18th Russian-Norwegian Symp, Murmansk, 5-7 June 2018. **IMR/PINRO Joint Rep. Ser.** No 1-2019:187-189.
- Llobet, S. M. 2019. Bearded seal vocalisations across seasons and habitat types in Svalbard (Norway). MSc. Thesis, Univ. Tromsø, Norway: 1-34.
- Louis, M., Skovrind, M., Castruita, J. A. S., Garilao, C., Kaschner, K., Gopalakrishnan, S., Haile, J., Lydersen, C., Kovacs, K. M., Garde, E., Heide-Jørgensen, M. P., Postma, L. Ferguson, S., Willersley, E. and Lorenzen, E. D. 2019. Impact of past climate changes on narwhal population structure and demographic history. **World Marine Mammal Conference**, Barcelona, Spain, 9-12 Dec. 2019.
- Lowther, A., Lydersen, C. and Kovacs, K. M. 2019. Antarctic fur seal males: tourists, trouble makers or an appropriate sentinel of the Antarctic marine ecosystem? **World Marine Mammal Conference**, Barcelona, Spain, 9-12 Dec. 2019.
- Lühmann, K., Lille-Langøy, R., Øygarden, L., Götsch, A., Kovacs, K.M., Lydersen, C., Tartu, S., Goksøyr, A. and Routti, H. 2019 In vitro modulation of transcriptional activity of nuclear receptors in whales by environmental pollutants. **SETAC Europe 29th Annual Meeting**, 26-30 May 2019, Helsinki, Finland.
- Malde A (2019) Development of diving capacity and behaviour in harp seal (*Pagophilus groenlandicus*) weanlings from the Greenland Sea stock. UiT – the Arctic University of Norway. M.Sc. thesis.
- Marcos Suárez, M., Rivera-León, V.E., Schleimer, A., Lopes, X.M., Aguilar, A., Barco, S.G., Berrow, S., Borrell, A. Bloch, D., Clapham, P.J., Bastos, E.D., Fossi, M.C., Gauffier, P., Giard, J., Hao, W., Haug, T., Heide-Jørgensen, M.P., Kovacs, K.M., Landry, S., Larsen, F., Lydersen, C., Martín, V., Mattila, D.K., Mikkelsen, B., Oosting, T., Pace III, R., Pampoulie, C., Panigada, S., Panti, C., Prieto, R., Raga, J.A., Ramp, C., Robbins, J., Ryan, C., Sears, R., Sigurjónsson, J., Silva, M.A., de Stephanis, R., Simon, M., Skaug, H.J., Urbán, R.J., van der Zee, J., Verkuil, Y.I., Vikingsson, G., Witting, L., Wenzel, F.W., Øien, N., Bérubé, M., and Palsbøll, P.J. 2019. Heteroplasmy; detection, verification and recurrence in baleen whales. 23rd Biennial Conference on the Biology of Marine Mammals, Barcelona, Spain, 9-12 December 2019.
- Moan, A., Bjørge, A. 2019. Using acoustic alarms on gillnets to reduce harbour porpoise bycatch in Norwegian fisheries. 23rd Biennial Conference on the Biology of Marine Mammals, Barcelona, Spain, 9-12 December 2019.
- Mul, E., Blanchet, M.A., Biuw, M., Rikardsen, A. 2019. Herring fisheries attract killer whales in northern Norway 23rd Biennial Conference on the Biology of Marine Mammals, Barcelona, Spain, 9-12 December 2019.
- Øien, N. 2019. Report of the Norwegian 2018 survey for minke whales within the Small Management Area EN – the North Sea and fjord surveys for harbor porpoises in western Norway. SC/68A/ASI/06. 10 pp.
- Pajmans, A., Stoffel, M., Bester, M., Cleary, A., Bruyn, P. J. N. de, Forcada, J., Goebel, M., Goldsworthy, S., Guinet, C., **Lydersen, C.**, Kovacs, K. M., Lowther, A. and Hoffman, J. 2019. The genetic legacy of extreme exploitation in a polar vertebrate. **World Marine Mammal Conference**, Barcelona, Spain, 9-12 Dec. 2019.
- Rikardsen, A., Blanchet, M.A., Biuw, M., Præbel, K., Øien, N., Mul, E., Kettner, L.E., Vogel, E., Ramm, T., Førde, A., Kramvig, B., Kristoffersen, B., Broms, F. 2019. WhaleFeast - Ecological, commercial and social implications of the recent extreme winter arrivals of herring and whales in Northern Norway 23rd Biennial Conference on the Biology of Marine Mammals, Barcelona, Spain, 9-12 December 2019.

- Ropert-Coudert, Y., Van de Putte, A. P., Bornemann, H., Charrassin, J-B., Danis, B., Hückstadt, L. A., Jonsen, I. D., Lea, M-A., Reisinger, R. R., Thompson, D., Torres; L., Trathan, P. N., Wotherspoon, S., Ainley, D. G., Alderman, R., Andrews-Goff, V., Arthur, B., Bester, M. N., Boehme, L., Bost, C-A., Boveng, P., Cleeland, J., Costa, D. P., Crawford, R., Rosa, L. D., de Bruyn, P. J. N., Delord, K., Descamps, S., Double, M., Fedak, M., Friedlander, A., Gales, N., Goebel, M., Guinet, C., Goldsworthy, S., Hinke, J., Jerosch, K., Kooyman, G. L., Kirkwood, R., Kovacs, K. M., Lawton, K., Lowther, A., Lydersen, C., Lyver, P., Makhado, A. B., Muelbert, M., Nachtsheim, D., Nordøy, E. S., Olmastroni, S., Phillips, R., Pistorius, P., Plötz, J., Pütz, K., Ratcliffe, N., Ryan, P. G., Santos, M., Southwell, C., Staniland, I., Takahashi, A., Tarrow, A., Trivelpiece, W., Weimerskirch, H., Wienecke, B., Raymond, B. & Hindell, M. A. 2019. Retrospective Analysis of Antarctic Tracking Data to identify areas of ecological significance in the Southern Ocean. **Dimensions of biodiversity: Scientific research to further the goals of IPBES**. Sci. Conf. CNRS-Paris, April 25-26, 2019.
- Roquet, F., Biuw, M., Block, B., Boehme, L., Cazau, D., Charrassin, J.-B., Costa, D., de Bruyn, N. P. J., Guinet, C., Hammill, M., Harcourt, R., Hindell, M., Hückstädt, L. A., Jeanniard du Dot, T., Kovacs, K. M., Lowther, A. D., Lydersen, C., McMahon, C., Muelbert, M. M. C., Ohshima, K. I., Picard, B., Reverdin, G., Stenson, G. B., Treasure, A. M., Trites, A., Williams, G. D. and Fedak, M. A. 2019. Animal-borne instruments: Monitoring the physical and biogeochemical properties of the ocean using bio-logging technologies. **OceanObs'19**, Sept. 16-20, 2019. Honolulu, HI, USA.
- Schleimer, A., Aguilar, A., Barco, S. G., Degollado, E., Berrow, S., Bloch, D., Borrell, A., Fossi, M. C., Gauffier, P., Giard, J., Hau, W., Heide-Jørgensen, M. P., Kovacs, K. M., Landry, S., Larsen, F., Lydersen, C., Martin, V., Michaud, R., Mikkelsen, B., Pampoulie, C. S., Panigada, S., Panti, C., Prieto, R., Raga, J. A., Ramp, C., Rivera-Leon, V. E., Robbins, J., Ryan, C., Sears, R., Sigurjonsson, J., Silva, M., Simon, M., Stephanis, R. de, Urban, J., Vikinsson, G., Wenzel, F., Witting, L., Øien, N., Palsbøll, P. and Berube, M. 2019. Population structure characterised by high within-area relatedness in North Atlantic and Mediterranean Sea fin whales (*Balaenoptera physalus*). **World Marine Mammal Conference**, Barcelona, Spain, 9-12 Dec. 2019.
- Skovrind, M., Haile, J., Castruita, J. A. S., Westbury, M., Knudsen, S. W., Gopalakrishna, S., Louis, M., Heide-Jørgensen, M. P., Glazov, D., Meschersky, I., Rozhnov, V., Shpak, O., Tarasyan, K. K., Litovka, D., Chernetsky, A. D., Krasnova, V. V., Ferguson, S., Postma, L., Kovacs, K. M., Lydersen, C., Kashner, K., Garialo, C., Dalen, L. and Lorenzen, E. 2019. Pan-Arctic population structuring and demographic history of belugas inferred from mitochondrial genomes. **World Marine Mammal Conference**, Barcelona, Spain, 9-12 Dec. 2019.
- Smout, S., De La Vega, C., Jeffreys, R., Stenson, G., Frie, A.K., Kershaw, J. 2019. Analysis of Growth Layer Groups in harp seal (*Pagophilus groenlandicus*) teeth reveals temporal changes in Stable Isotope ratios. 23rd Biennial Conference on the Biology of Marine Mammals, Barcelona, Spain, 9-12 December 2019.
- Solvang, H., Haug, T. and Øien, N. 2019. Recent development in temporal and geographical variation in body condition of common minke whales (*Balaenoptera acutorostrata acutorostrata*) in the Northeast Atlantic. IWC SC/68A/EM/02. 17 pp.
- Stafford, K. M., Kovacs, K. M., Lydersen, C. and Wiig, Ø. 2019. Extreme diversity in the songs of Spitsbergen's bowhead whales. **Fram Forum 2019**, In Brief: 98-99.
- Stenson, G.B. and Haug, T. 2019. Harp seals: Monitors of change in differing ecosystems. 2019 IMBeR Open Science Conference, Brest, France, 17-21 June.
- Suarez, M., Rivera-Leon, V. E., Schleimer, A., Lopes, X. L., Aguilar, A., Barco, S. G., Berrow, S., Borrell, A., Bloch, D., Clapham, P., Degollado-Bastos, E., Fossi, M. C., Gauffier, P., Giard, J., Hao, W., Haug, T., Heide-Jørgensen, M. P., Kovacs, K. M., Landry, S., Larsen, F., **Lydersen, C.**, Martin, V., Mattila, D., Mikkelsen, B., Oosting, T., Pace, R. M., Pampoulie, C. S., Panigada, S., Panti, C., Prieto, R., Raga, J. A., Ramp, C., Robbins, J., Ryan, C., Sears, R., Sigurjonsson, J., Silva, M., Simon, M., Stephanis, R. de, Skaug, H. J., Urban, J., Zee, J. van der, Verkuil, Y. I., Vikingsson, G., Witting, L., Wenzel, F., Øien, N., Berube, M. and Palsbøll, P. 2019. Heteroplasmy; detection, verification and recurrence in baleen whales. **World Marine Mammal Conference**, Barcelona, Spain, 9-12 Dec. 2019.

- Ullmann J (2019) The respiratory physiology of the harp seal (*Pagophilus groenlandicus*). Total lung capacity, anatomical dead space, and ventilator response to exercise and diving. UiT – the Arctic University of Norway. M.Sc. thesis.
- Ullmann, J., Biuw, M., Blanchet, MA., Acquarone, M., Folkow, L. 2019. The respiratory physiology of the harp seal (*Pagophilus groenlandicus*): Total lung capacity, anatomical dead space, and ventilatory response to exercise. 23rd Biennial Conference on the Biology of Marine Mammals, Barcelona, Spain, 9-12 December 2019.
- Vaquíé-García, J., Lydersen, C., Marques, T. A., Andersen, M. and Kovacs, K. M. 2019. First abundance estimate of the Svalbard white whale population, *Delphinapterus leucas*, Norway. **2nd Int. Workshop Beluga Whale Res. & Conserv.** March 12-14, 2019, **Mystic Aquarium, Mystic, CT, USA. Also presented at World Marine Mammal Conference**, Barcelona, Spain, 9-12 Dec. 2019.
- Viberg, K., Lühmann, K., Lille-Langøy, R., Øygarden, L., Kovacs, K. M., Lydersen, C., Karlsen, O. A., Routti, H. and Goksøyr, A. 2019. *In vitro* modulation of transcriptional activity in nuclear receptors of fin and blue whales by environmental pollutants. **20th International Symposium on Pollutant Responses in Marine Organisms (PRIMO20)**, May 19-22, 2019 Charleston, SC, USA.
- Vogel, E., Rikardsen, A., Øien, N., Similä, T., Mul, E., Biuw, M., Kettner, LE., Strøm, J., Blanchet, MA. 2019. Impact of herring spawning events on killer whale migratory behaviour. 23rd Biennial Conference on the Biology of Marine Mammals, Barcelona, Spain, 9-12 December 2019.

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 of 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.

<i>Catching area:</i>	<i>The West Ice</i>			<i>The East Ice</i>		
	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					
<i>Small-type whaling</i>	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.

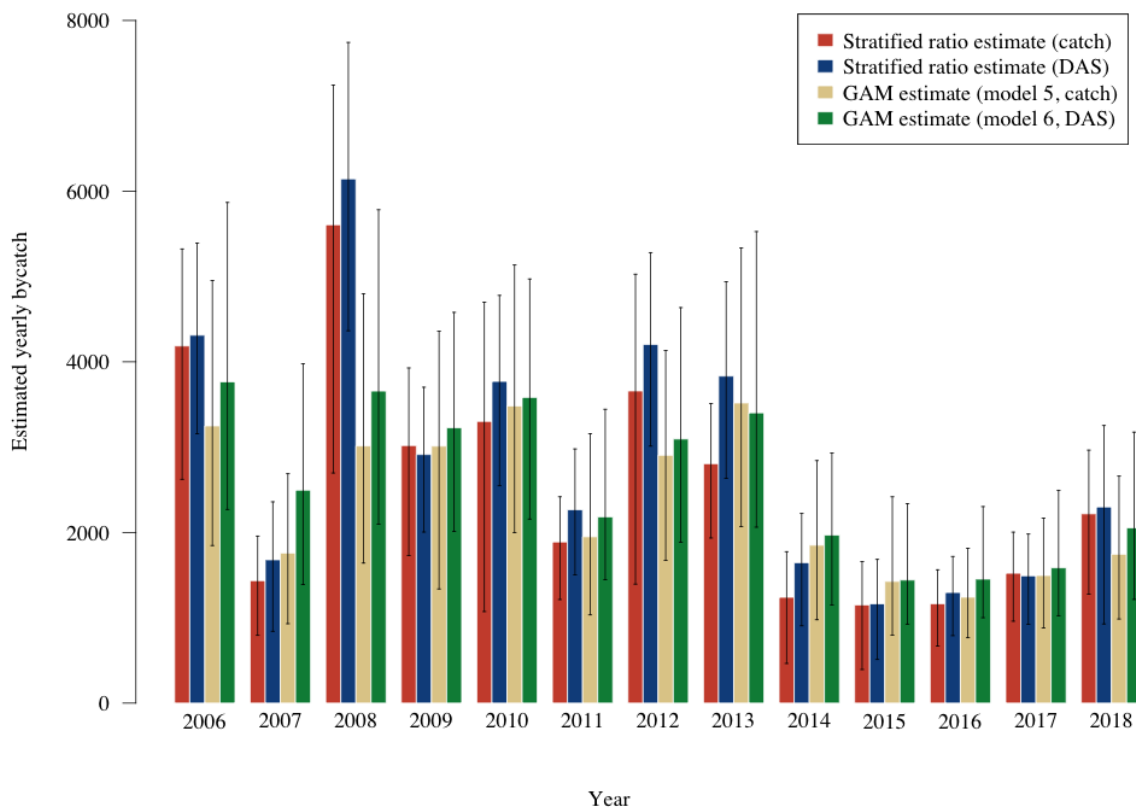


Figure 1: Total bycatch of harbour porpoises in all fishery groups per year, estimated using both a catch-based and a days at sea-based stratified ratio estimator (red and blue bars), as well as the corresponding GAMs (brown and green bars). Vertical lines indicate 95% confidence intervals around the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