



UiT Norwegian Centre
for the Law of the sea

Marine Mammal Student Symposium

Abstracts of the Student Presentations

Morning Session

Mana Tugend - *Legal policies on plastic pollution in relation to marine mammals in the Arctic*

Plastic pollution is a conservation and welfare concern threatening the marine biota, including marine mammals, notably through entanglement, ingestion and as a vector for toxins, pathogens and alien species. The legal framework applicable to marine plastic pollution is fragmented between international, regional, national and local policies. The presentation gives an overview of the plastic challenge in the Arctic in relation to marine mammals from a legal standpoint.

Eivind Stensrud - *Developing methods to unveil marine food webs structures using metabarcoding using harbour seal as a biosampler*

Using the intestine of the harbour seal and conducting eDNA/metabarcoding with two different primers, one targeting fish, and one universal primer, targeting all eukaryotic organism. Combined with additional diet markers as stable isotopes, there should be possible to detect primary, secondary and perhaps tertiary consumption, allowing to recreate marine food webs structures.

Emma Vogel - *Killer whale movements on the Norwegian shelf are associated with herring density*

(Authors: Emma F. Vogel, Martin Biuw, Marie-Anne Blanchet, Ian D. Jonsen, Evert Mul, Espen Johnsen, Solfrid Sætre Hjøllø, Morten Tange Olsen, Rune Dietz, Audun Rikardsen)

Killer whales *Orcinus orca* have a cosmopolitan distribution with a broad diet ranging from fish to marine mammals. In Norway, killer whales are regularly observed feeding on overwintering Norwegian spring spawning (NSS) herring *Clupea harengus* inside the fjords. However, their offshore foraging behavior and distribution is less well understood. In particular, it is not known to what degree they rely on the NSS herring stock when the herring move to deeper offshore waters. Satellite telemetry data from 29 male killer whales was analyzed to assess whether their offshore foraging behaviour is linked to herring distribution. Unlike most marine predator-prey studies that use indirect proxies for prey abundance and distribution, our study utilized two herring density estimates based on (1) direct observations from acoustic trawl survey data and (2) simulations from a fully coupled ecosystem model. Mixed effects models were used to infer the effect of herring density and light intensity on whales' movement patterns. Our results suggest that killer whales follow NSS herring over more than 1000 km from their inshore overwintering areas to offshore spawning grounds. All whales changed from fast directed, to slow non-directed movement when herring density increased, although individuals had different propensities towards movement. Our data indicated that whales continue to feed on herring along the Norwegian shelf. We conclude that NSS herring constitutes an important

prey resource for at least some killer whales in the northeastern Atlantic, not only during the herring overwintering, but also subsequently throughout the herring spawning migration period.

Hannah Kriesell - *Masking effects of seismic air guns on baleen whale communication*

Previous studies investigated the impacts of air gun blasts during seismic acquisition on cetaceans and have described avoidance behaviour, changes in vocalization rates, and auditory masking effects. Most of the work focused on behavioral responses based on visual observations or experimentally acquired hearing thresholds or temporary threshold shifts. Meanwhile, recent geophysical studies provide new insights into physical aspects of seismic sound generation and propagation, e.g. the emission of high frequencies (>5kHz) resulting from ghost cavitation and frequency-dependent amplitudes of air gun arrays fired at long distances (10-100km) with increasing water depth.

To understand potential masking effects of air gun noise on blue whale vocalizations in deep waters, we modeled the vocalization signal that a conspecific blue whale would be exposed to in a scenario where an air gun is being fired. The air gun source signals were acquired during a seismic test survey where the shooting vessel was equipped with three conventional air gun subarrays, and several shot lines crossing vertically above a stationary hydrophone permanently placed at the sea floor. We use Antarctic blue whale signals for the acoustic masking simulations. The received signal consisting of whale call and seismic air gun noise is then generated based on a geometrical propagation model, considering the bathymetry and sound profile of the area of interest. Planned experiments using acoustic tags on killer and humpback whales in Norwegian waters to study the soundscape and acoustic communication of these animals is briefly discussed.

Pierre Bories - *A deep dive into fat: Investigating blubber lipidomics fingerprint of killer whales and humpback whales in northern Norway*

(Authors: Pierre Bories, Audun H. Rikardsen, Pim Leonards, Aaron T. Fisk, Sabrina Tartu, Emma F. Vogel, Jenny Bytingsvik, Pierre Blévin)

In cetaceans, blubber is the primary and largest lipid body reservoir. Our current understanding about lipid stores and uses in cetaceans is still limited and most studies only focused on a single narrow snapshot of the lipidome. We documented an extended lipidomics fingerprint in two cetacean species present in northern Norway during wintertime. We were able to detect 817 molecular lipid species in blubber of killer whales (*Orcinus orca*) and humpback whales (*Megaptera novaeangliae*). The profiles were largely dominated by triradylglycerols in both species and to a lesser extent, by other constituents including glycerophosphocholines, phosphosphingolipids, glycerophosphoethanolamines and diradylglycerols. Through a unique combination of traditional statistical approaches, together with a novel bioinformatics tool (LION/web), we showed contrasting fingerprints composition between species. The higher content of triradylglycerols in humpback whales is necessary to fuel their upcoming half a year fasting and energy-demanding migration between feeding and breeding grounds. In adipocytes, we assume that the intense feeding rate of humpback whales prior to migration translates into an important accumulation of triacylglycerols content in lipid droplets. Upstream, the endoplasmic reticulum is operating at full capacity to supply acute lipid storage, consistent with the reported enrichment of glycerophosphocholines in humpback whales, major components of the endoplasmic reticulum. There was also an enrichment of membrane components which translates into higher sphingolipids content in the lipidome of killer whales, potentially as a structural adaptation for their higher hydrodynamic performance. Finally, the presence of both lipid-enriched and lipid-depleted individuals within the killer whale population in Norway suggests dietary-specialization, consistent with significant differences of $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ isotopic ratios in skin between the two groups, with higher values and a wider niche for the lipid-

enriched individuals. Results suggest the lipid-depleted killer whales were herring-specialists, while the lipid-enriched individuals might feed on both herrings and seals.

André Moan - *Estimates of humpback (*Megaptera novaeanglia*), minke (*Balaenoptera acutorostrata*) and killer whale (*Orcinus orca*) fishing gear interactions in Norwegian fisheries suggest low anthropogenic mortality*

Using bycatch data from inspector logbooks and from the Norwegian high seas reference fleet, we are looking at bycatches and entrapments of large cetaceans by large Norwegian vessels (length overall ≥ 15 m) using pelagic fishing gears such as purse seines, trawls and hook lines. We use bycatch and entrapment rates from observed data to estimate rates and totals for the unobserved segment of the large vessel Norwegian fishing fleet. We also estimate mortality rates of fishing gear interactions for these species and compare these with the relevant potential biological removal to assess population level effects of bycatches.

Marianna Pinzone - *Temporal mercury contamination and ecological shift in two Arctic Phocidae: the hooded seal *Cystophora cristata* and the ringed seal *Pusa hispida**

(Authors: Marianna Pinzone, Alexis Trinquet, Liz Loutrage, Bruno Delille, Sylvain Bérail, Emmanuel Tessier, Rune Dietz, Igor Eulaers, Erling S. Nordøy, Tore Haug, Gilles Lepoint, David Amouroux, Krishna Das)

Stable isotope ratios of carbon (C), nitrogen (N) and sulfur (S) (expressed as $\delta^{15}\text{N}$, $\delta^{13}\text{C}$ and $\delta^{34}\text{S}$ in ‰) have proved to be very successful tracers of marine mammals' ecology and were extensively used in this field. In the same way, the analysis of mercury (Hg) stable isotopes (expressed as $\delta^{202}\text{Hg}$ and $\Delta^{199}\text{Hg}$ in ‰) have been recently confirmed as a valuable tool for tracing mercury sources in the marine environment and biota. In the framework of the ongoing climate change the Arctic ecosystem is experiencing, it is very important to assess the potential effects on Hg exposure and accumulation rates. Arctic marine mammals are optimal sentinels species because of their high trophic levels. Moreover, they are commonly harvested by both Indigenous and commercial hunters.

Our main objective was to assess a temporal shift in the trophic ecology and Hg accumulation in Arctic seals and compare the trends between an endemic species (the ringed seal *Pusa hispida*) and a subarctic species (the hooded seal *Cystophora cristata*).

We measured Hg concentrations as well as C, N, S and Hg stable isotope ratios in muscle tissue of ringed seals and hooded seals harvested from 1985 to 2019. We quantified species isotopic niches with the SIBER model in R. Our first finding suggests a shrinking of the trophic diversity of our seal species, resulting from a larger overlap (and competition) between seals and a shift in $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ ranges (habitat use) in time. The second finding shows a different trend in Hg accumulation between the ringed and the hooded seal, as a result of changes in their trophic ecology. Finally, Hg stable isotopes ratios show a change in the source of exposure to Hg with time. Our study confirms that Hg and trophic temporal trends are species-specific.

Meghan Van Ruiten - *Multiple movement modes of Norwegian killer whales*

Spatial ecology and movements of animals contributes to our understanding of intra- and inter-specific interactions and ecosystem dynamics and can inform conservation efforts. Over the last decade, large numbers of Norwegian killer whales have been found feeding on high concentrations of over-wintering Norwegian spring spawning (NSS) herring (*Clupea harengus*) in fjords of northern Norway, before following the herring south to southern spawning grounds. There are many gaps in

our understanding of the fine-scale movement patterns and habitat use within and among individuals. Here we assessed 13 killer whale satellite tracks and classified five different movement modes by applying a behavioral change point analysis (BCPA) to segment the tracks into meaningful movement segments. Then we defined candidate movement modes and their correlating mathematical equations between net squared displacement (NSD) and time and fitting each candidate equation to each segment's NSD data. We found that 93.17% of total segments were successfully classified into candidate movement modes. Results show that Norwegian killer whales employ a range of different behaviors when feeding on and following the NSS herring overall adding to understanding of seasonal movements and habitat use. This study also suggests that individual variations in movement patterns and habitat use could highlight a killer whales movement capabilities or flexibility.

Olha Polishchuk - *Aboriginal Subsistence Exception in the Regulation of Marine Mammals in the Arctic*

Afternoon Session

Nicolai Scherдин - *Assessment of Bearded Seal and Ringed Seal Stocks in the North Atlantic*

Bearded and ringed seals are both pagophilic seals with a circumpolar distribution. Both species, in particular the ringed seal, are thought to be abundant in the Arctic and are hunted throughout their ranges - there is currently very little data to support this thesis, though. Reliable regional abundance estimates are unavailable, which means population trends are too. This complicates assessing stocks, which further complicates assessing sustainability of hunts, the impact of climate change and more. This presentation will give an overview of the current available knowledge and what information is needed to assess the species in the North Atlantic.

Léa Bouffaut - *Opportunistic eavesdropping: how can Ocean Bottom Seismometers contribute to the Passive Acoustic Monitoring of Baleen Whales?*

Over the last decade, the opportunistic use of broadband Ocean Bottom Seismometer (OBS) recordings has been highly beneficial for baleen whales studies as they regularly record their stereotyped calls ([10-40] Hz). Often deployed in remote areas, OBSs offer additional and often unprecedented locations for acoustic data collection. The long-term, widespread networks are then ideal for passive acoustic monitoring. Examples based on data collected within the Western Indian Ocean Sanctuary by the RHUM-RUM seismic network show that recordings from a single OBS are sufficient to determine the acoustic presence of a species and estimate the range of a calling individual. Additional information arises from increasing the number of sensors, e.g., localization and tracking, essential for animal counting. The broader configuration (network covering an area of 2000x2000 km²) showed the studied species' repartition and migration patterns. These recordings from the bottom of the ocean shed new light on the study of BWs and, more generally, low-frequency sounds in this area.

Saskia Martin - *Whale songs: Humpback hits from Northern Norway*

Male humpback whales (*Megaptera novaeangliae*) are known to produce long complex series of sounds with a hierarchical structure, called song. Singing behaviour has traditionally been associated with low latitude breeding grounds but is increasingly reported outside these areas. This acoustic behaviour is believed to play a role in reproduction, and the function of songs outside of traditional breeding areas may serve as an opportunistic mating strategy or intra-sexual display.

This study provides the first report of humpback whale song in the subarctic waters of Northern Norway using a long-term bottom-moored hydrophone. Data processed included the months January

– June 2018 and December 2018 – January 2019. Out of 189 days with recordings, 79 days were identified with humpback whale songs. Singing was heard between January – April 2018 and December 2018 – January 2019, with a peak in February 2018. The results show that the Norwegian Sea is an area with a large occurrence of humpback whale communication and cultural transmission events, spanning months of winter and spring. The presence of singing activity on a non-breeding ground and as far North as at a latitude of 68°N provoke further investigation of the importance of this area above the arctic circle. Given this species is known to exhibit feeding behaviour in this area, a possible relation between vocal displays such as singing and feeding needs to be focused on as well as how the plasticity of humpback whale song might relate to environmental conditions.

Manon Seyssaut - *The protection of marine mammals in the Central Arctic Ocean from a legal perspective*

The presentation will focus on the legal framework that exists in the Central Arctic Ocean for the protection of marine mammals. Aware that few species live in that area, the research contributes to developing the discussion in order to improve the conservation of species by integrating the precautionary approach.

Anaïs Remili - *Individual Prey Specialization Drives PCBs in Icelandic Killer Whales*

Interindividual variation in prey specialization is an essential yet overlooked aspect of wildlife feeding ecology, especially as it relates to intrapopulation variation in exposure to toxic contaminants. Here, we assessed blubber concentrations of an extensive suite of persistent organic pollutants in Icelandic killer whales (*Orcinus orca*). Polychlorinated biphenyl (PCB) concentrations in blubber were >300-fold higher in the most contaminated individual relative to the least contaminated, ranging from 1.3 to 428.6 mg·kg⁻¹ lw. Mean PCB concentrations were 6-to-9-fold greater in individuals with a mixed diet including marine mammals than in fish specialist individuals, whereas males showed PCB concentrations 4-fold higher than females. Given PCBs have been identified as potentially impacting killer whale population growth, and levels in mixed feeders specifically exceeded known thresholds, the ecology of individuals must be recognized to accurately forecast how contaminants may threaten the long-term persistence of the world's ultimate marine predator.