Project information

Keywords
Harbour porpoise, ecological role, life history, bycatch

Project title
The role of harbour porpoise in Norwegian coastal marine communities

Year
2018

Project leader
Ulf Lindstrøm

Geographical localization of the research project in decimal degrees (max 5 per project, ex. 70,662°N and 23,707°E)
The distribution of the bycaught harbour porpoises collected in 2016 and 2017 range from 59°N and 8°E to 70.10°N and 29°E

Participants

Active participants:

Ulf Lindstrøm, Anne K. Frie, Maria Quintela, Kirsteen MacKenzie, Arne Bjørge (Institute of Marine Research)

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Bjorn M. Jenssen (Norwegian University of Science and Technology)

Genevieve Desportes (North Atlantic Marine Mammal Commission, NAMMCO)

Flagship
Fjord and Coast

Funding Source

FRAM centre (Fjord and Coast)

Summary of Results

Project activity

No animals was collected in 2018. Instead, the project has prioritized data analysis, outreach and, planning and organising of a workshop (Title: Joint IMR/NAMMCO international workshop on the status of the harbour porpoise in the north Atlantic) which will take place in Tromsø (Fram centre), 3-7 December 2018. The planning of this workshop constitutes a significant part of the project activity in 2018.

Results

The main sub-objectives, as stated in the project application, was to: i. estimate harbour porpoises use and consumption of prey, ii. analyse harbour porpoises life history (age, growth, reproduction) and collect data on population structure (genetics) and pollution (heavy metals and PCB’s), iii. assess the impact of harbour porpoises on various ecosystem properties, iv. assess the effect of changes in ecosystem properties on feeding ecology, life history traits, v. assess the impact of bycatch on the population dynamics of harbour porpoise

Distribution of harbour porpoise

A total of 73 and 61 bycaught harbour porpoises were collected in September-October 2016 and February-April 2017, respectively (Fig. 1). In 2016 and 2017, the majority of porpoises were bycaught in Vestfjorden (52%) in area IV and Varangerfjorden (41%) in area VI, respectively.

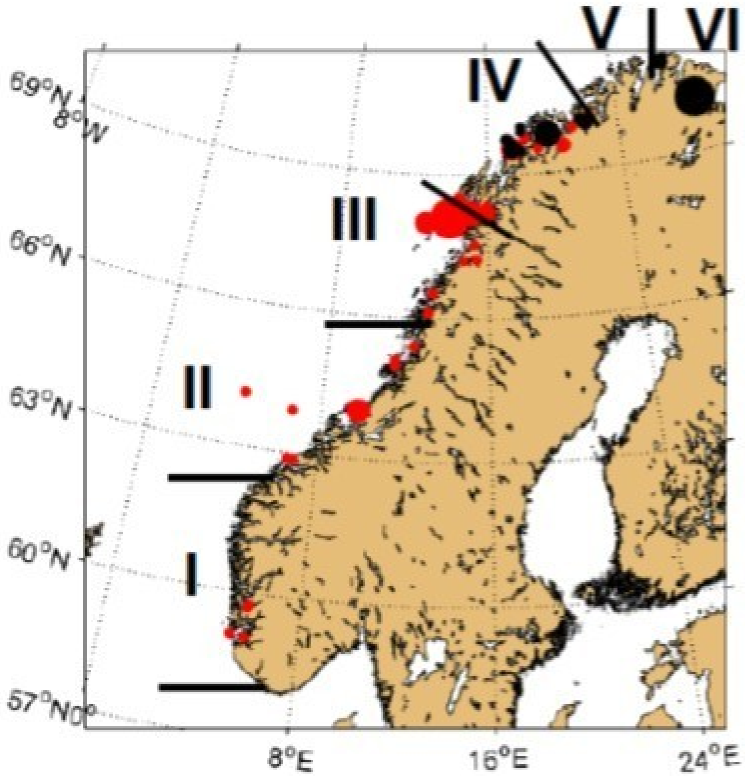


Figure 1. Distribution of bycaught harbour porpoises in six sub-areas in Norwegian coastal waters in September-October 2016 (red circles) and February-April 2017 (black circles). Size of the circles is proportional to number of animals.

i. Harbour porpoise use and consumption of prey

The gastrointestinal contents and the stable signatures of the 134 harbour porpoises, bycaught in gillnets along the coast of Norway (Fig 1), was analysed in 2018. The preliminary results presented below is part of a master thesis.

A total of 19 prey species were identifies in the gastrointestinal tracts of the 134 harbour porpoieses sampled in 2016 and 2017. The proportion of empty gastrointestinal tracts was higher in 2016 (31.5%) compared with 2017 (6.6%). The diet composition of the 134 harbour porpoises, collected during Autumn 2016 and Spring 2017, shows that saithe was by far the most important prey (32-90%) (Fig. 2). Capelin, herring, Norway pout and blue whiting also contributeb importantly to the harbour porpoise diet depending on area. The results also show that there was relatively little spatial variation in diet composition; saithe dominated in all areas but sub-area VI, in which capelin dominated. Also, the diet data from sub-area IV indicate there is little seasonal variation in their diet composition; saithe dominated in both Autumn (September-October) and Spring (February-April), followed by blue whiting during Autumn (18%) and herring during Spring (15%). The relative small spatial variability in diet composition, based on the stomach contents, is also supported by the stable isotope analysis (Fig.3); all the confidence ellipses (95%) overlap. This suggests harbour porpoise prey use is relatively homogenous in both time and space. The size of the ellipse, which indicate the niche breath, suggest that harbour porpoises have broader diet niche some areas (areas 2 and 3). We also explored the relationships between the harbour porpoise body length and $\delta^{15}N$ and trophic level of the stomach contents and $\delta^{15}N$ (not displayed). These relationships were not significant suggesting there is no ontogenetic shift in diet composition and there is no relationship between short- and long-term diet composition in terms of trophic level, respectively. Interestingly, there was a significant positive relationship between both latitude and $\delta^{13}C$ and harbour porpoise body length and $\delta^{13}C$. This may indicate that animals move south as they grow or feed more benthic as they grow or both?

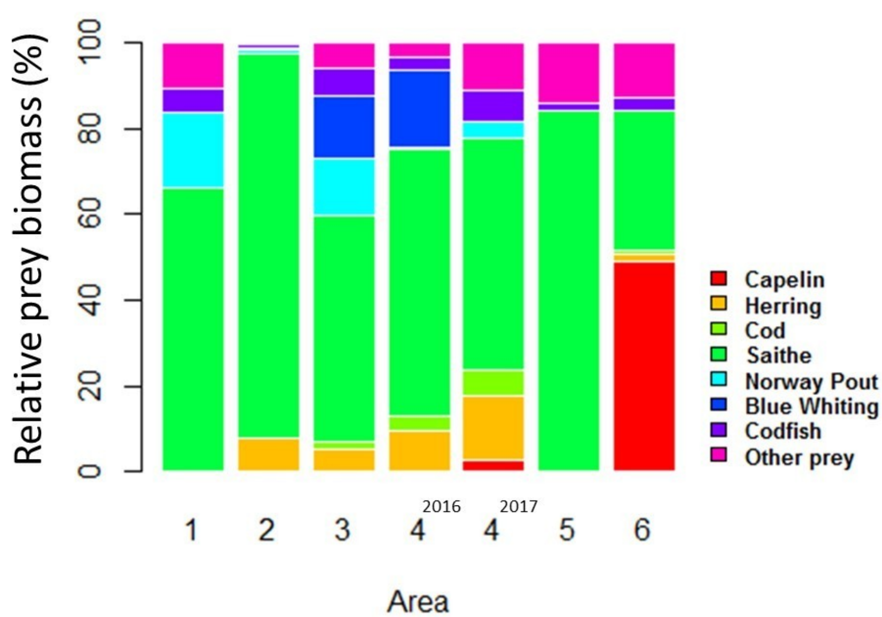


Figure 2. The diet composition (% prey biomass) of 134 harbour porpoises, sampled in Autumn 2016

and Spring 2017, in six sub-areas along the coast of Norway.

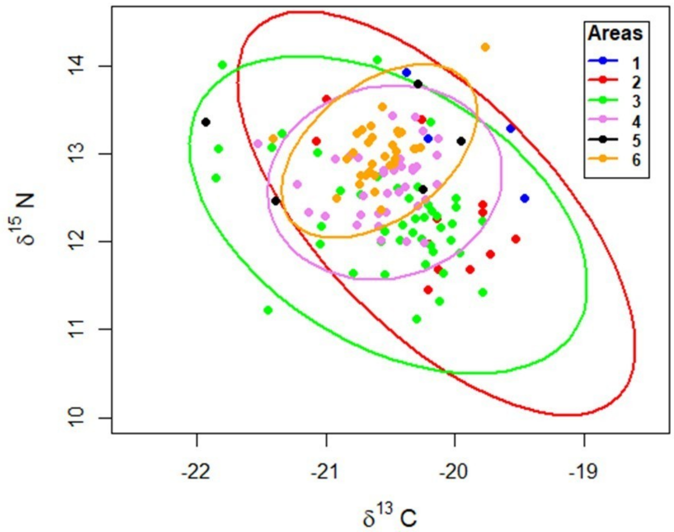


Figure 3. Stable isotope composition ($\delta^{13}C$ and $\delta^{15}N$) in harbor porpoises, incidentally caught in Autumn 2016 and Spring 2017, in six sub-areas along the coast of Norway. The 95% confidence ellipses are plotted with the data.

This study supports a previous diet study (Aarefjord and Bjørge 1995) in that HPs feed almost exclusively on fish. However, the prey composition in these studies differ. In contrast to our study, in which saithe dominated the overall diet, capelin, herring and, to some extent, whiting dominated the diet composition in the late 1998's. This appears to be in line with prey resource situation in the 1980's, when the saithe stock was at a much lower level compared with today; the spawning stock biomass was ca. 5 times lower than today (ICES 2017). The stable isotope results of this study supports a previous stable isotope study (Fontaine et al. 2007), in that the $\delta^{13}C$ decline with latitude. In contrast to our study, there was a significant spatial variability in the study by Fontaine *et al*. (2007).

ii. Growth and life history of harbour porpoise (Phocoena phocoena) in Norwegian waters

The preliminary results presented below is part of a master thesis (Cervin 2018).

The sex and age distribution of the bycaught animals differed between the two sampling periods (Fig. 4). The age distribution is biased towards younger animals in both years but particularly in 2016; the oldest animals in 2016 were 6 years old whereas in 2017 14 animals were older than 6 years. Given that 11 of these individuals were males, there might be sexual segregation in the distribution harbour porpoises.

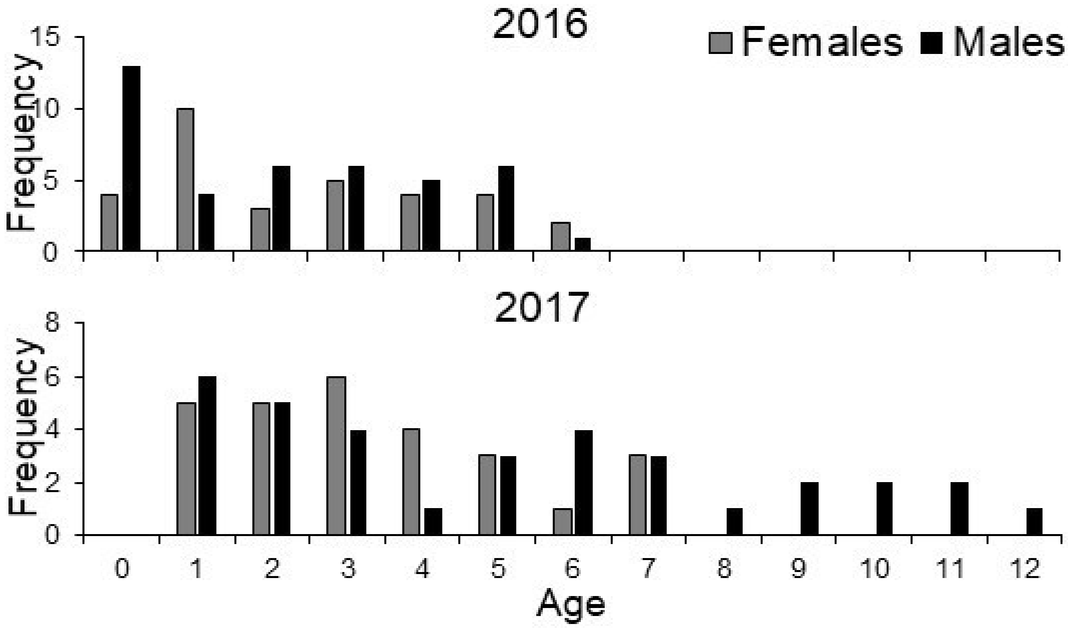


Figure 4. The age distribution of 73 and 61 harbor porpoises bycaught in gillnets in September-October 2016 and February-April 2017, respectively.

The growth of harbour porpoises was analyzed by fitting von Bertalanffy growth models ($L_t=L_\infty(1-e_{-kt})$) to the data. L_t, L_∞ and k denote length at age t, asymptotic average length and growth rate, respectively. Females grow both faster and longer than the males (Fig. 5); the asymptotic length in females and males were 166 cm and 149 cm, respectively. These estimates are slightly higher than estimates reported in other studies; males ranged from 142 to 148 cm whereas females ranged from 153 cm to 163 cm. It should be pointed these studies have not used the same model formulation which implies that the model parameters (k and L_∞) are not fully comparable.

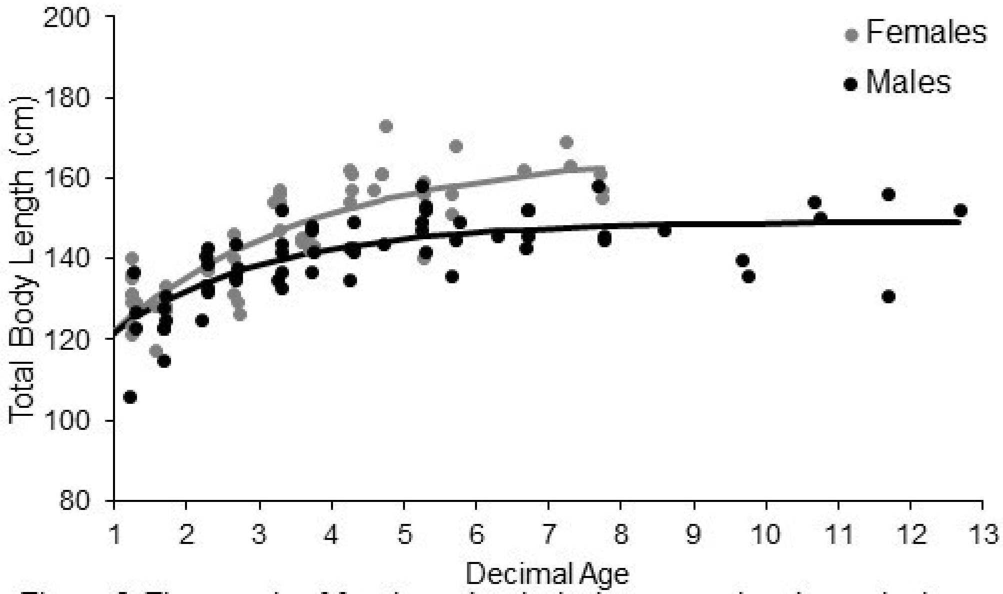
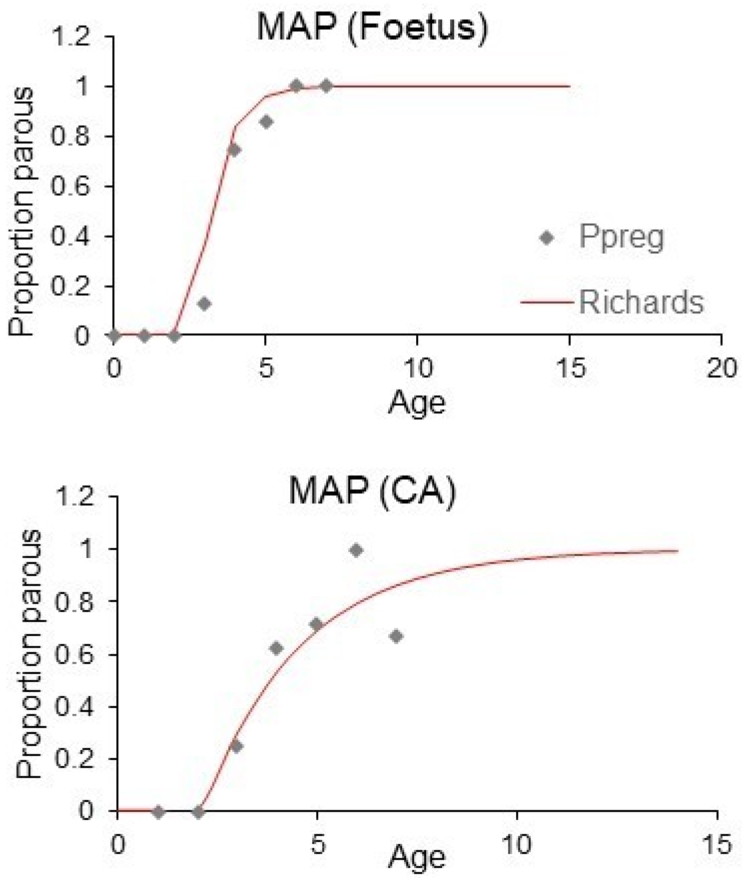


Figure 5. The growth of female and male harbour porpoises bycaught in Norwegian waters in September-October 2016 and February-April 2017. The lines represents the fitted von Bertalanffy growth model (see text).

Results from the analysis of reproductive status of female harbour porpoises using three methods suggest that females become sexually mature between 4 and 5 years of age (Fig. 6) whereas males become sexually mature at ca. 3 years of age (Fig. 7). These results are in line with other studies of harbour porpoise reproduction which range from 2 to 3 years in males and 3.5 to 4.5 years in females.



Method	MAP (SD)
Foetus	4,48 (0,81)
CA	5,08 (0,67)
Back-calculations	4,07 (1,27)

Figure 6. Mean age at first reproduction (MAP) of female harbour porpoises bycaught in Norwegian waters in September-October 2016 and February-April 2017 using foetus (upper panel), corpora albicantia (CA, lower panel) and back-calculations (age minus number of CA).

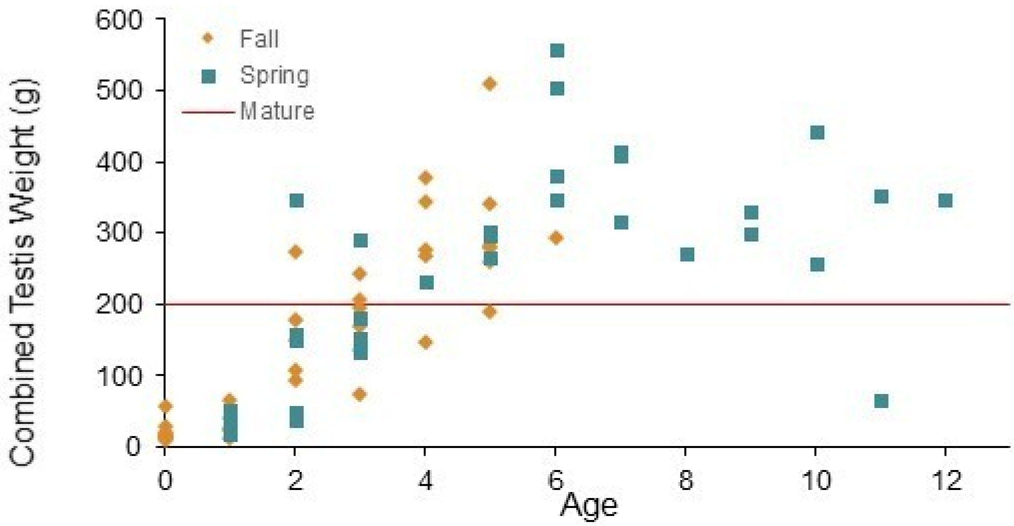


Figure 7. Combined testis weight as a function of age in male harbour porpoises bycaught in Norwegian waters in September-October 2016 and February-April 2017. The horizontal line represents the combined testis weight (>200 g) above which males are assumed to be sexually mature.

iii/iv/v. The role harbour porpoises in coastal marine communities; top-down and bottom-up effects

To explore this objective an existing food web model (Ecopath with Ecosim; Christensen et al. 2005) from the Ullsfjorden ecosystem (Pedersen et al. 2008) was parameterised to the Vestfjorden ecosystem. Vestfjorden was chosen as a model area simply because it appears to be a hot-spot area for harbour porpoises and because there is more porpoise data (abundandance, diet and lifehistory) from the area. Resource data, collected during the annual coastal survey (October-November) and the Lofoten cruise (March-April) was used to derive input data to the model with respect to fish density (tonnes/km^2).

Because the model is still under development and the simulation work has just started only some preliminary results from one simulation will be presented; the effect of reducing the fishing effort on fish stocks that are caught in the gillnet fishery by 50%. A 50% reduction in the fishing effort resulted in a 20-25% increase in the harbour porpoise biomass and a 10-15% increase in the group “Other large fish” which comprise the following groups: Long rough dab *Hippoglossoides platessoides*, Plaice *Pleuronectes platessa*, Dab *Limanda limanda*, Atlantic wolffish *Anarhichas lupus*, Lemon sole *Microstomus kitt*, Witch flounder *Glyptocephalus cynoglossus*, Tusk *Brosme brosme*, Ling *Molva molva*, Atlantic halibut *Hippoglossus hippoglossus*, Redfish (*Sebastes* spp.) and Lumpfish *Cyclopterus lumpus*. In contrast, small haddock (

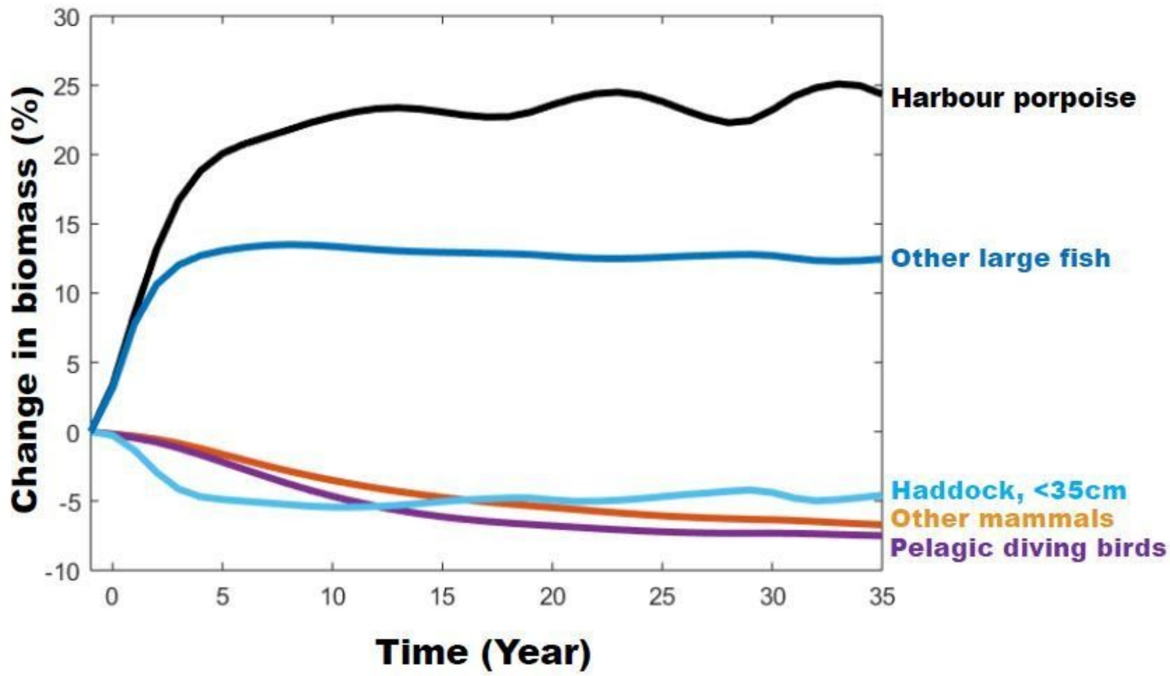


Figure 8. Changes in biomass of species and functional groups due to a 50% reduction in fishing effort on fish stocks that are caught in the gillnet fishery. Groups that changed less than 5% were not included in the figure.

Population structure of harbour porpoises coastal Norwegian waters

Quintela *et al*. (2018, unpublished) studied a total of 134 individuals (58 females and 76 males) that were bycaught at the Norwegian coast during 2016 and 2017, within a latitudinal range from 59.07°N to 71.05°N. In addition, 21 of the females were bearing fetuses of unknown sex, which were excluded from the population structure analyses. Quintela *et al*. estimated the population structure using STRUCTURE (Pritchard *et al.* 2000) and traditional F_{ST} approach (Weir & Cockerham 1984). STRUCTURE v. 2.3.4 was used to identify genetic groups under a model assuming admixture and correlated allele frequencies from a number of clusters ranging from 1 to 5. STRUCTURE output was then analysed using the *ad hoc* summary statistic ΔK of Evanno *et al*. (2005), together with the four statistics (MedMed, MedMean, MaxMed and MaxMean) implemented in StructureSelector (Li & Liu 2018). Finally, ten runs for the selected K were averaged with CLUMPP v.1.1.1 (Jakobsson & Rosenberg 2007) using the FullSearch algorithm and the G' pairwise matrix similarity statistic, and were graphically displayed using barplots.

Genetic differentiation among putative groups was tested via pairwise F_{ST} in ARLEQUIN v.3.5.1.2 (Excoffier *et al.* 2005), and statistical significance was calculated after 10000 permutations. Vitassign software was used to detect paternity in a scheme allowing for all possible combinations of couples within the females and males of the present study. None of the males sampled was identified as the father of any of the 21 fetuses, according to Vitassign, not even when allowing for 2 mismatches.

Preliminary results, indicate there are two genetically different clusters (P=0.02) that overlap in space (Fig. 9), with almost identical number of individuals in each cluster (N=66 and N=68). Given the high similarity (FST=0.022) between the clusters we conclude that there is no spatial structuring of the harbour porpoises in coastal Norwegian waters. To properly resolve the population structure of harbour porpoises in coastal Norwegian waters more DNA samples, from both Norwegian waters and other areas (e.g. Iceland, Greenland, North Sea etc.) are needed

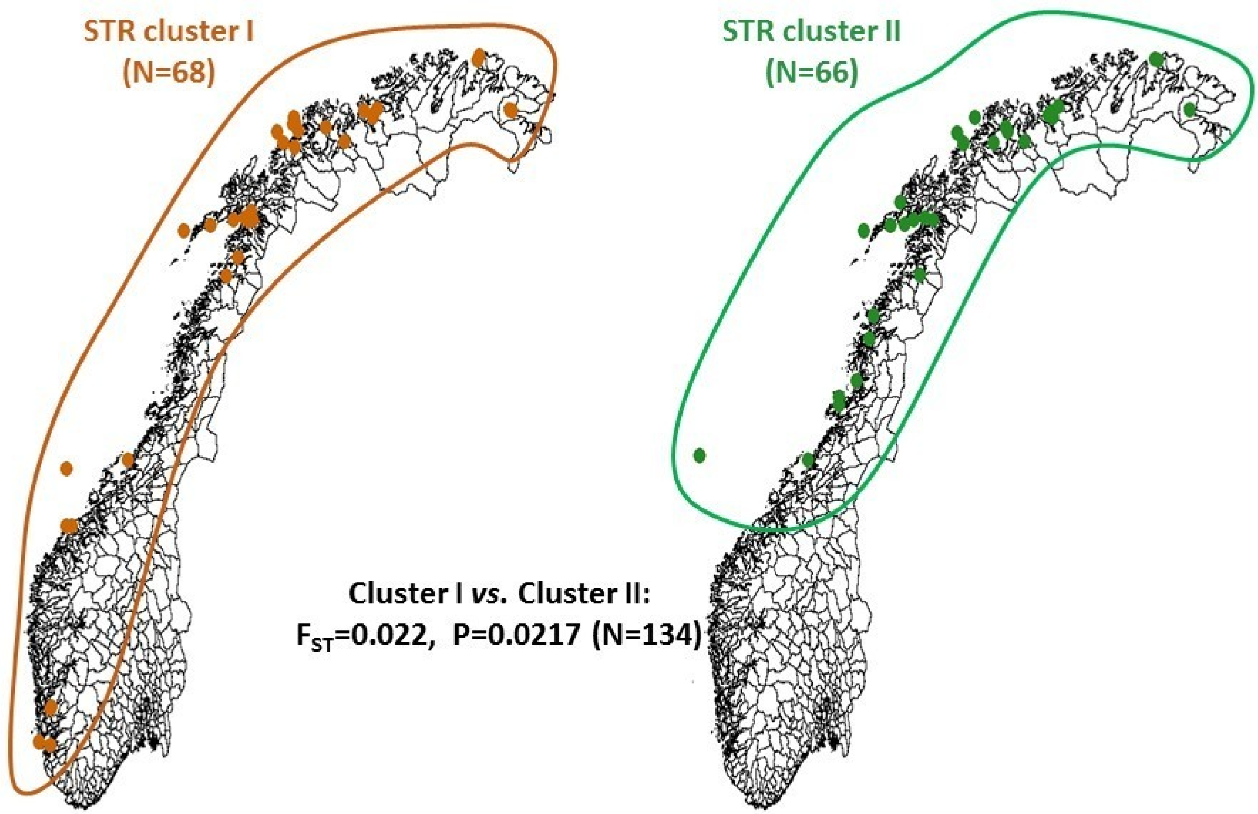


Figure 9. Population structure of harbour porpoises in coastal Norwegian waters. Geographical distribution of harbour porpoises belonging to two putative clusters.

Analysis of essential and non-essential chemical elements in harbour porpoises in coastal Norwegian waters

The text below is taken from a master thesis (Kropidlowska 2018).

In 2016 and 2017, 134 specimens of harbour porpoises (*Phocoena phocoena*) were collected along Norwegian coast. Concentrations of various chemicals (Ag, Al., As, Au, B, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cs, Cu, Fe, Hg, K, La, Li, Mg, Mn, Mo, Na, Nb, Nd, Ni, P, Pb, Pr, Rb, S, Sb, Se, Si, Sm, Sn, Sr, Th, Ti, Tl, U, V, W, Y, Zn, Zr) were quantified in the muscles and livers by ICP-MS.

In comparison to other areas relatively low concentrations of hazardous elements were found in the muscles and livers of Norwegian porpoises. Increasing levels of Cd and As determined in populations from northern part of Norway could be related to their distinct feeding preferences. Significant relationships of Hg with Ag and Li were found in hepatic and muscle tissue, whereas Se was strongly correlated ($p<0.001$) with most of toxic elements such as Ag, Cd, Hg, Pb, Sn. Statistically significant negative relations for Cu between Ag and Cd were probably related to competitive binding to metallothionein. The body length was found to be significantly ($p<0.001$) related to Ag, Au, Bi, Cd, Ce, Co, Cs, Hg, Mo, Nd, Pb, Pr, Sb, Se, Sm, Sn, V, Zr, whereas Ca and Cu revealed negative significant relations. The differences between females and males were found for several elements. Au, Ag, As, Cu Ba, Cs in liver and Ti, Cu, Sb, Rb in muscle was higher in females than males, whereas males had higher content of Se and Ni in liver and Sn in muscle. Hepatic tissue reached commonly higher concentration than muscle with exception of Al, Cr, Cs, K, Mg and Ni. The values obtained from spatial differences demonstrate that there is a large variability in the accumulation of essential and toxic metals.

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Master and PhD-students involved in the project

Two master students connected to the project graduated in 2018 (see below) and one will graduate in May 2019:

2018:

- Linnea Cervin, Msc 2018, Arctic University of Norway (UiT). Title: Life history of harbour porpoise (Phocoena phocoena) in Norwegian coastal waters.
- Joanna Kropidlowska, Msc 2018, Norwegian University of Science and Technology (NTNU). Title: Essential and non-essential chemical elements in the muscles and liver of harbour porpoises (Phocoena phocoena) from the Norwegian coastal coastal waters

2019:

- Camille Sainte-André, Msc 2019, Arctic University of Norway (UiT). Title: Feeding ecology of harbour porpoise (*Phocoena phocoena*) in Norwegian coastal communities.

For the Management

This project may have important implications for conservation and management of marine resources in Norwegian coastal communities because the U.S. National Oceanic and Atmospheric Administration (NOAA) Fisheries issued a final rule in 2017 to implement import provisions of the Marine Mammal Protection Act (MMPA). The rule aims to prohibit seafood imports from countries where fisheries kill more marine mammals such as whales and dolphins than U.S. standards allow. NOAA has established a five year exemption period that allows foreign harvesting nations time to assess their marine mammal stocks, estimate and lower their bycatch, and develop regulatory programs in order to meet the new criteria on an ongoing basis.

Harbour porpoises (Phocoena phocoena) are abundant but very vulnerable to incidental catches in gillnets. According to ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas) the annual bycatches should not exceed 1.7% of the best population estimate (ASCOBANS, 2000). It is unknown whether the high bycatch rate (3000 animals/year) in the Norwegian fishery is sustainable because knowledge on population size along the entire Norwegian coast is still lacking but the FRAM project MULTI-PORPOISE aim to estimate the number of harbour porpoises in Norwegian coastal waters.

Published Results/Planned Publications

The following publications are in prep. and planned to be submitted in 2019.

1. Growth and lifehistory of harbour porpoises in the north Atlantic (Cervine et al.)

2. Prey consumption by harbour porpoises in Norwegian coastal marine communities (Sainte-André et al.)

3. Population structure of harbour porpoises in north Atlantic[1] (Quintela et al.)

4. The potential role of harbour porpoises in Norwegian coastal marine communities (Lindstrøm et al.)

5. Essential and non-essential chemical elements in harbour porpoises in Norwegian waters. (Jenssen et al.)

6. The status of harbour porpoises in the north Atlantic[2] (Lindstrøm et al.)

[1]The title depend on whether we can get DNA samples from harbour porpoises in other areas. If not the title will be "Population structure of harbour porpoises in Norwegian coastal waters"

[2]The status report will be one of the deliverables of the workshop.

Communicated Results

The results have been and will be communicated on:

- The flagship "Fjord and Coast" Dialogdagen Tromsø 16-17 October 2018
- 18th Russian-Norwegian symposium, Murmansk, 5–7 June 2018 (Influence of Ecosystem changes on harvested resources in high latitudes): Title: “The role of harbour porpoise in Norwegian coastal marine communities”
- The joint IMR/NAMMCO International workshop, Tromsø, 3-7 December 2018 (The status of harbour porpoises in the north Atlantic): Title: “The population structure of harbour porpoises in Norwegian coastal waters”

Interdisciplinary Cooperation

This is a broad ecological project that covers range of topics such as food web modelling and interaction, feeding ecology, life history, population structure, pollutants and, indirectly, animal health status.

Budget in accordance to results

The budget in 2018 (400.000 kr) has not been in accordance with the activity and deliverables in 2018. Without the internal support by IMR (430.000 NOK) it would not have been possible to fulfill the tasks/deliverables in 2018

Could results from the project be subject for any commercial utilization

No

Conclusions

Preliminary conclusions with respect to feeding ecology, growth and life history, population structure, essential and non-essential chemicals of harbour porpoise may be summerised as:

- The diet of harbour porpoise is dominated by codfish (mainly saithe and blue whiting) and pelagic fish (capelin and herring),
- The diet appears to be relatively consistent in time and space and, this is in line with the stable isotope results which indicate similar trophic position in space,
- The harbour porpoises in this study appears to grow slightly thinner than porpoises from other areas,
- The female and male harbour porpoises in this study were sexually mature at ca. 4-5 and 3 years of age, respectively, which is in line with other studies,
- The concentration of essential and non-essential chemicals is low in harbour porpoises in Norwegian water compared to other areas. It appears to be spatial variation in these chemicals and, the concentration of cadmium, vanadium, mercury and selenium increase by length.
- Two genetically different clusters, that overlap in space, emerge from the gentical analysis. Because the difference between the two clusters is very small, more data are needed to resolve the population structure of harbour porpoises in Norwegian coastal waters.
- A reduction in the effort of the gillnet fishery may have a significant possitive effect on the harbour porpoise density, which in turn may have a negative effect on its competitors (e.g. other marine mammals and pelagic diving birds) and prey.