Copenhagen 30 April 2023

WK Doc HS8 WKREF3 2022 – ver1

**Trends in sea mammals fish consumption in the NEA Atlantic since 1960.**

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**Citation**: Sparholt, H. Cordier, A. J. R., and Olesen, S. L. 2022. Trends in sea mammals fish consumption in the NEA Atlantic since 1960. WK Doc HS8 WKREF3 2022, ICES working group document.

**Introduction**

Sea mammals are important elements in the NEA Atlantic marine ecosystem. They predate on commercial fish species and are competing for the same food resource. It is therefore important for fisheries management to take account of this when deciding on the harvest strategy of the commercial fish stocks. In the present study we examine the scientific literature to find out the level and the trend in consumption by sea mammals of commercial fish species. If there is an increasing trend in sea mammal biomass, then productions models for the commercial fish stocks should take this into account and it will reduce the sustainable yield of fish that can be harvested.

**Material and methods**

We went through the peer reviewed scientific literature and the science literature from NAMMCO ( [www.nammco.no](http://www.nammco.no)), the IWC (www.iwc.int), ICES ([www.ICES.dk](http://www.ICES.dk)), and peer reviewed scientific papers in general.

Skern-Mauritzen *et al.* (2022) gives a very comprehensive and up to date account of the present marine mammal abundance, consumption and fish removals in the Nordic and Barents Seas. The areas considered are shown in Figure 1.

Table 1 gives abundance by species by area. Harp and hooded seals are the most abundant seals. Dolphins, pilot whales, minke whales and fin whales are the most important whales.

The diet composition of by mammal species is given in Table 2. It is obvious that fish and cephalopods constitute a large part of the diet and thus potentially impact the commercial fishery potentials.

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| Figure 1. Map of the Northeast Atlantic. Blue polygons indicate the ICE, GN, and BS regions. The red lines indicate fisheries statistics areas for reported fisheries catches. From Skern-Mauritzen *et al.* (2022). |

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| **Table 1.** Abundances and C.V. for marine mammal species included in consumption estimates in the ICE, GN, and BS. From Skern-Mauritzen *et al.* (2022). |
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| **Table 2**. Diets (prey species/categories along the X-axis) of marine mammal species used in estimation of prey consumption. Each horizontal line shows one observed diet of the taxon. Dot sizes reflect proportional use (range 0–1). From Skern-Mauritzen *et al.* (2022). |
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Marine mammals in the ICE, GN, and BS consume 13.4 million tonnes of prey per year. It is especially harp seals, pilot whales, minke whales, fin whales and humpback whales that contribute to the total consumption. About half of this is fish species, that are also commercially harvested. Fisheries removed 4.16 million tonnes per year. Obviously, changes in marine mammal abundance could influence the fish production of the ecosystem that is available to the commercial fishery.

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| **Figure 2.** Estimated mean annual consumption (in 1000 tonnes) by (a) marine mammal species and (b) taxonomic groups in the ICE, GN, and BS regions. Error bars indicate 95% CI. Note that mean and upper CI for fin whales, and upper CI for harp seals and pilot whales extends beyond the scale of the Y-axis (in a); therefore, these values are provided in the graph. From Skern-Mauritzen *et al.* (2022). |

The mammal consumption by prey species shows that the commercial important fish species: sandeel, herring, capelin, gadoids, and cephalopods are heavily predated (Figure 3).

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| **Figure 3.** Estimated marine mammal prey consumption. Boxplots [the box indicates the median (line) and the 25th and 75th quartiles], whiskers reflecting minimum (Q25-1.5∗(Q75–25) and maximum Q75 + 1.5∗(Q75–25) values. Red lines indicate mean annual fisheries removals. From Skern-Mauritzen *et al.* (2022). |

**Marine mammal spatial distribution**

According to Magera *et al.* (2013): “*Overall, our results show that many formerly depleted marine mammal populations are recovering*.” They refer to the global situation. In the Northeast whaling ended already in the beginning of the 1900s and we will in the following review scientific information about trends in the stocks of the various marine mammal species. We will focus on the species most important for the potential competition with the commercial fisheries.

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| Minke whales. Summer distribution in the North Atlantic, showing sightings and effort from all North Atlantic Sightings surveys, 1987 – 2015, as well as 2007 CODA and SNESSA surveys. Not all areas were surveyed each year. | Minke whale global distribution. Adapted by Nina Lisowski from Würsig,B., Thewissen, J.G.M. and Kovacs, K.M. Editors (2018) "Encyclopedia of Marine Mammals", 3rd ed. Academic Press, Elsevier: San Diego. CA. Copyright Elsevier: San Diego. Ca. Copyright elsevier: http://www.Elsevier.Com |
| **Figure 4.** Minke whale spatial distribution.From NAMMCO and IWC. | |

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| Summer distribution of fin whales in the North Atlantic, showing sightings and effort from all North Atlantic Sightings surveys, 1987 – 2015, as well as 2007 CODA and SNESSA surveys. Not all areas were surveyed each year. | Fin whale global distribution. Adapted by Nina Lisowski from Würsig,B., Thewissen, J.G.M. and Kovacs, K.M. Editors (2018) "Encyclopedia of Marine Mammals", 3rd ed. Academic Press, Elsevier: San Diego. CA. Copyright Elsevier: |
| **Figure 5.** Fin whale spatial distribution. From NAMMCO and IWC. | |

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| Summer sightings of humpback whales during all NASS from 1987-2015. Black lines indicate areas surveyed (not all areas surveyed in each year). | Humpback whale global distribution. Adapted by Nina Lisowski from Jefferson, T.A., Webber, M.A. and Pitman, R.L. (2015). “Marine Mammals of the World: A Comprehensive Guide to Their Identification,” 2nd ed. Elsevier, San Diego, CA. Copyright Elsevier: http://www.elsevier.com |
| **Figure 6.** Humpback whale spatial distribution.From NAMMCO and IWC. | |

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| Summer distribution of long-finned pilot whales in the North Atlantic, showing sightings from all North Atlantic Sightings Surveys, 1987 – 2015, as well as 2007 CODA and SNESSA surveys. | Pilot whale global distribution. Adapted by Nina Lisowski from Würsig,B., Thewissen, J.G.M. and Kovacs, K.M. Editors (2018) "Encyclopedia of Marine Mammals", 3rd ed. Academic Press, Elsevier: San Diego. CA. Copyright Elsevier: http://www.elsevier.com |
| **Figure 7.** Long-fines pilot whale spatial distribution. From NAMMCO and IWC. | |

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| Killer whale sightings during North Atlantic Sightings Surveys from 1987-2015. Not all areas were surveyed each year. | Killer whale global distribution. Adapted by Nina Lisowski from Würsig,B., Thewissen, J.G.M. and Kovacs, K.M. Editors (2018) "Encyclopedia of Marine Mammals", 3rd ed. Academic Press, Elsevier: San Diego. CA. Copyright Elsevier: http://www.elsevier.com |
| **Figure 8.** Killer whale spatial distribution. From NAMMCO and IWC. | |

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| **Harbour porpoise Sightings during all NASS** | **Harbour porpoises are found in coastal waters of the sub-Arctic and predominantly cool temperate waters of the North Atlantic and North Pacific, although they are also found off the north west coast of Africa. They frequently visit shallow bays, estuaries, tidal channels less than 200m in depth and have also been known to swim up rivers. The majority of sightings occur within 10km of land and, although there is some evidence of north-south migrations, most harbour porpoise appear to have preferred habitat encompassing a broad area. https://uk.whales.org/** |
| **Figure 9.** Harbour porpoise spatial distribution.From NAMMCO and IWC. | |

**Trend in stock size over time*.***

*Fin whales*

Fin whale numbers, uncorrected for perception and availability biases, increased from 3,600 (CV=0.18) in 1987 to 14,000 (CV=0.18) in 2001, a rate of increase of 10% p.a. (95% CI: 6% – 14%) (Víkingsson *et al.* 2009). Abundance increased still further in 2007 and especially 2015, when it was about twice that estimated in 2001, suggesting that the fin whale stock is still growing in this area. There was no detectable trend in abundance in other areas covered by the NASS over the period 1987-2001 (Víkingsson *et al.* 2009).

The area west of Iceland includes the former whaling grounds and recovery from whaling certainly explains part of the increase in abundance. However, modelling of the population (IWC 2016) suggests that it should already have largely recovered from whaling. Other factors (including immigration from other areas and changes in carrying capacity) may therefore also be involved.

**Table 3**. Fin whales at Est Greenland and Iceland. From NAMMCO, https://nammco.no/fin-whale/#1475844082849-433d5060-e5a9.

| **YEAR** | **REGION** | **ABUNDANCE ESTIMATE** | **95% CONFIDENCE INTERVAL** |
| --- | --- | --- | --- |
| 1987 | WI+EG | 3,607 | 2,537 - 5,132 |
| 1989 | WI+EG | 6,006 | 3,468 - 10,401 |
| 1995 | WI+EG | 13,726 | 8,667 - 21,740 |
| 2001 | WI+EG | 14,021 | 9,550 - 20,586 |
| 2007 | WI+EG | 16,991 | 11,735 - 24,600 |
| 2015 | WI+EG | 27,843 | 19,693 - 39,366 |

*Minke whales*

The abundance of minke whale have been relatively stable since the 1980s (Table 4).

**Table 4.** Abundance of minke whale in the northeast Atlantic. For definition of stocks see the above map; CMA, IWC Central Medium Area, with putative stock boundaries; A/S, aerial or shipboard surveys; Bias, correction bias: - a, availability and p, perception; CI, confidence interval. CA, Canada; GL, Greenland. From: https://nammco.no/common-minke-whale/#1475844082849-433d5060-e5a9.

| **YEAR/SURVEY** | **A/S** | **ABUNDANCE** | **BIAS** | **CV** | **95% CI** |
| --- | --- | --- | --- | --- | --- |
| 1988–89/NASS | S | 67,380 | p | 0.19 | 44,060–92,181 |
| 1995/NILS | S | 118,299 | a.p | 0.10 | 92,213–136,337 |
| 1996–2001/NILS | S | 107,205 | a.p | 0.13 | 83,180–138,169 |
| 2002–2007/NILS | S | 108,140 | a.p | 0.23 | 69,299–168,752 |
| 2008–2013/NILS | S | 100,615 | a.p | 0.11 | 81,154–124,743 |

*Pilot whales*

The abundance estimates of pilot whales have fluctuated widely over the years and have large uncertainties (Figure 10). NAMMCO conclude that there are *“…no evidence of any trend in pilot whale numbers in the Northeast Atlantic over the 28-year period from 1987 to 2015*”.

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| **Figure 10.** Pilot whale abundance. From Pike *et al.* (2019). |

*Humpback whales*

According to NAMMCO (www. <https://nammco.no/humpback-whale/#1475844082849-433d5060-e5a9>) : “*Humpback whale numbers appear to have grown rapidly in some areas of the North Atlantic. Under ideal conditions, humpback whale populations can grow at an annual rate of about 11% (Heide-Jørgensen et al. 2012). Aerial surveys conducted around Iceland between 1986–2001 indicated a rate of increase of about 12% per year, however that increase seems to have slowed or stopped since 2001 (Pike et al. 2019, 2020b). A similar rate of 9.4% per year has been observed off West Greenland between 1984–2007 (Heide-Jørgensen et al. 2012), however the most recent estimate from 2015 is lower (Hansen et al. 2018). Numbers in the Northeast Atlantic off Norway have increased dramatically, with estimates from recent surveys being more than double that observed in the 1996-2001 series and more than ten times that estimated in 1995 (Øien 2009, Leonard & Øien 2020a,b). Taken together, these estimates suggest a substantial increase in humpback whale numbers in most areas of the North Atlantic in the late 20th and early 21st centuries.”*

According to Leonard & Øien (2020): “*We have found that the abundance of humpback whales in our study area (*Ed. Northeast Atlantic*) has increased dramatically since earlier surveys. We estimate 9,749 (CV=0.34, 95% CI: 4,947–19,210) and 12,411 (CV=0.30, 95% CI: 6,847–22,497) humpback whales in 2002–2007 and 2008–2013, respectively. Previously, the survey in 1996–2001 estimated 4,695 (uncorrected, CV=0.39, 95% CI: 2,124–10,378), while the synoptic survey in 1995 estimates just 1,059 (uncorrected CV=0.25, 95% CI: 645–1,738)… Notably, block NVS was not surveyed in 1995, which estimated the highest abundance of humpback whales in 1996–2001 (3,246 CV=0.51, 95% CI: 1,137–9,264). The consistency we find in our estimates suggests the increase may have stabilized, which is a conclusion that is also supported by the most recent survey-cycle estimate from 2014–2018, published concurrently, of 10,708 (CV=0.39, 95% CI: 4,906–23,370) humpback whale…”*

*Harbour porpoise*

According to ICES (2021): **“***The abundance of cetaceans in the North Sea is monitored during aerial and boat-based sightings surveys, with corrections to take account of the detectability of the animals (Hammond et al., 2002). Harbour porpoise population size was assumed to be constant over the period* (Ed. 1963-onwards) *and set to the average of the number of porpoises in the North Sea proper in the two SCANs years (224 100). According to Skern-Mauritzen et al. 2022 they consume 3.1 kg per day per individual which gives an annual consumption of about 225 kt per year of which fish is a substantial part in the North Sea.* “

**Conclusion**

Marine mammals in the ICE, GN, and BS consume 13.4 million tonnes of prey per year. About half of this is fish species that are also commercial harvested. Fisheries removed 4.16 million tonnes per year. Obviously, changes in marine mammal abundance could influence the fish production of the ecosystem that is available to the commercial fishery. However, it seems that at least since the 1980s, the abundances of the major mammal species eating fish, has been rather stable.

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