

# Environmental conditions, population density, and prey type influence the lipid reserves of Baltic herring in the northern Baltic Sea

Change of climate is expected to influence the energy content of fish by affecting the environmental conditions where lipids are produced, transferred, accumulated and consumed. We examined the lipid content of the Baltic herring (*Clupea harengus membras*) spawning in the Archipelago Sea during a period of declining salinity, high variability in temperature, and increasing population size in the Bothnian Sea. Contemporary samplings of zooplankton in the feeding area (Mäkinen et al. 2017) enabled comparisons of fatty acid (FA) composition between herring and its prey *Limnocalanus macrurus*, which forms a major source of energy in the Bothnian Sea in May-June (Rajasilta et al. 2015).

## 45% REDUCTION IN SPAWNING HERRING LIPID RESERVES

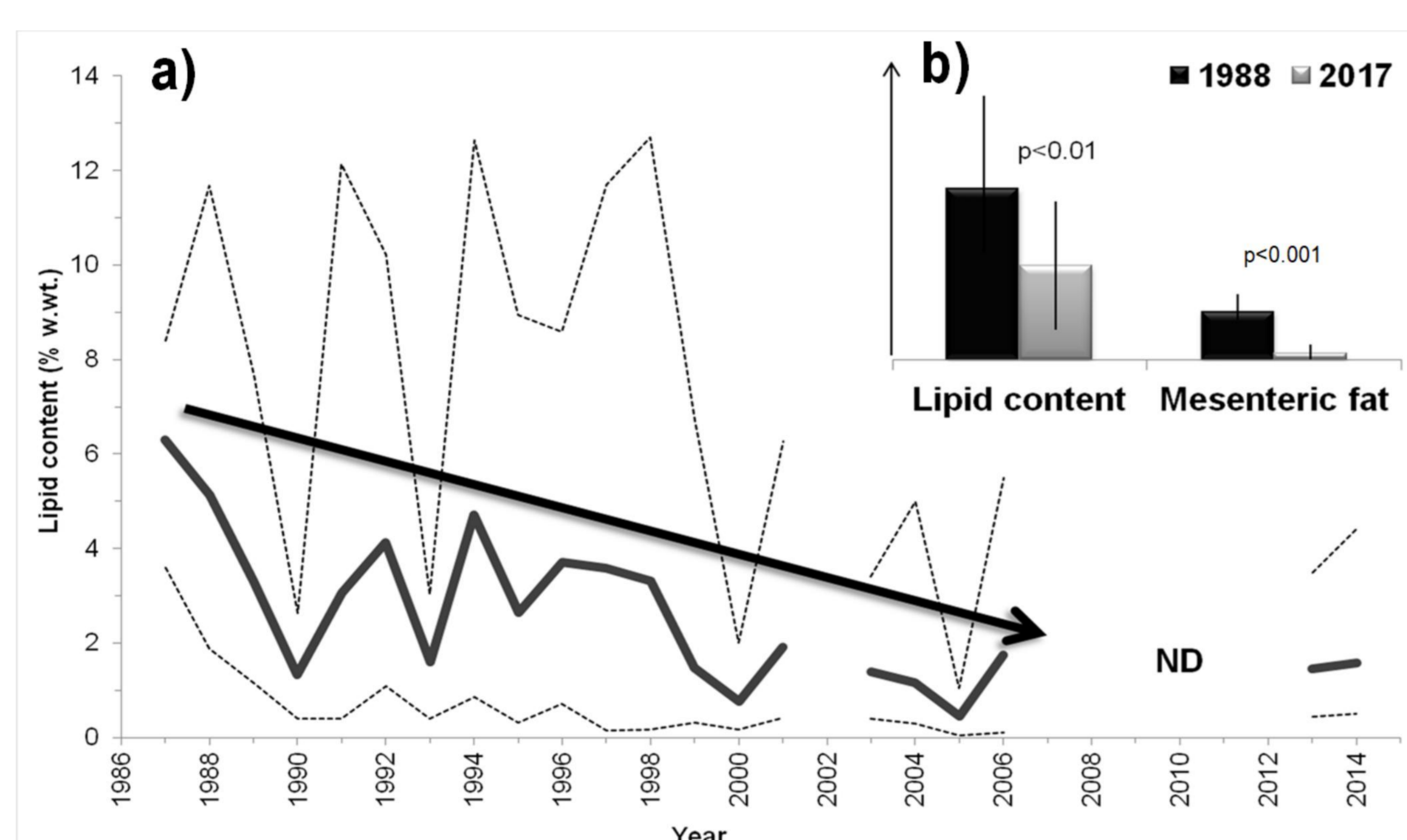
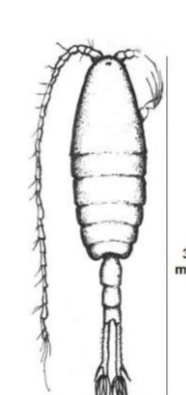


Fig. 1 A) Lipid content (% wt.w) of spawning female herring during 1987-2013 & 2013-2014 (black solid line) together with linear trend line (black arrow) and min and max values (black dashed line). B) Lipid content and mesenteric fat (% w.wt.) of overwintering herring in outer archipelago in 1988 and 2017. ND= No Data.

## LIMNOCALANUS - A MEDIATOR OF PUFA FROM SPRING BLOOM TO HERRING?



- Herring contained a high proportion of polyunsaturated fatty acids (PUFA), EPA and DHA. The proportion of these essential FA (EFA) has increased since 1976 (Linko et al. 1976)
- Lipids of herring contained 70% the same FA as those of *Limnocalanus*, but their relative proportions were not equal
  - ~30% dissimilarity between herring and *Limnocalanus* FA, explained by the FA 16:0, "Others", 18:1(n-9), EPA, DHA, 16:1(n-7), 18:2(n-6) (in decreasing order of importance)
- As an abundant and high-quality prey, *Limnocalanus* has most likely improved the survival of adult herring, resulting in the population growth
- Methods: FA analysed with modified Folch method and Gas chromatography with flame ionization detection (GC-FID), data analysed with Pearson correlation, One-way analysis of similarity (ANOSIM) and Similarity Percentage analysis (SIMPER)

- The average lipid content of spawning female decreased from 5-6 % (w.wt.) to 1.5 % (w.wt.) during 1987-2006, and remained also low in 2013-2014
- High interannual variation, indicating an increasing trend in the variability of the lipid content during 1987-2006
- Explained by decreasing surface water salinity (20 m), increasing stock size and decreasing Jan-Apr surface temperature (20 m)
- Decrease also visible in lipid content and mesenteric fat of herring overwintering in the outer archipelago in 1988 vs. 2017
- Methods: Lipid extraction with Soxhlet method, data analysed with Generalised Linear Mixed models (Procedure Glimmix in SAS 9.3), Pearson product-moment correlation and Student's t-test

## POTENTIAL IMPLICATIONS TO HERRING STOCK AND FOOD WEBS

- Results indicate to increased energy consumption and prolonged starvation in the spawning population and possibly also in the population, overwintering in the Archipelago Sea
- Possible explanations are changes in osmoregulation, higher wintertime basic metabolic needs, increased wintertime swimming activity, and increased interspecific feeding competition.
- The initial size of the lipid depositions is determined by the quantity and quality of food in the feeding area, therefore, the increase of *Limnocalanus* is likely to play an important role
- Climate models predict a further decline of salinity and increase of temperature → Negative effects on lipid reserves likely to continue
- Low lipid content of herring can reduce female offspring production, modify migratory patterns, affect predator populations and reduce the concentration of lipophilic toxic compounds in food webs
- Increased abundance of high-quality prey may have caused also positive effects for herring at the spawning time when the requirement of EFA is particularly high in females

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The long-term study is part of **Herring Project**, conducted in the Archipelago Research Institute since 1984

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