Cod reproductive ecology - DTU Orbit (13/12/2018)

Cod reproductive ecology: Effect of dietary fatty acids on ovarian maturation, spawning time and quality of eggs and larvae

In recent decades, Baltic cod has experienced a period of low recruitment. In the same period the pelagic Baltic Sea ecosystem experienced a regime shift, due to hydrographic changes, affecting all trophic levels. The rationale for the thesis is built on the hypothesis that the regime shift has resulted in decreased dietary value of clupeids in terms of lipid content and essential fatty acids (EFA) which originates from phytoplankton and is transferred up through the food web. Clupeids are main prey for cod in the Central Baltic Sea and a decreased dietary value is hypothesised to affect cod reproduction. The overall objective of the thesis is to investigate the role of lipids in reproduction of cod (Gadus morhua) in the Central Baltic Sea. The first objective is to examine the seasonal variation in content of lipid and EFA in whole prey species of cod (Paper I). The second objective is to investigate the variation in lipid content, EFA and antioxidants of female Baltic cod gonads and livers during the reproductive cycle (Paper II) and to examine whether there is a deficiency in lipid energy and dietary EFA that could explain the delayed spawning time observed in the Baltic cod (Paper III). The third objective is to investigate experimentally if EFA levels, comparable to those observed in Baltic clupeids, delayed timing of spawning and influenced egg production and quality in cod (Paper IV). The study combines field data of cod and its main prey species; sprat (Sprattus sprattus), herring (Clupea harengus) and the isopod Saduria entomon from the Baltic Sea sampled during 2002-2004 and 2008-2009 in different seasons and experimental data of farmed broodstock cod. Lipid composition of whole prey species and ovaries and livers of cod in different maturity stages were analyzed and lipid composition in samples of mature cod was compared with samples of North Sea cod with no delay in spawning time. A feeding experiment was carried out to test the dietary effect of different levels of the essential polyunsaturated n-6 arachidonic acid (ARA) and n-3 eicosapentaenoic acid (EPA) on spawning period, realized fecundity, and egg and larval quality under controlled conditions. Lipid content and fatty acid composition (FAC) differs significantly between sprat, herring and S. entomon (Paper I). Sprat has in general high lipid content and proportion of the monounsaturated fatty acid, oleic acid, compared to herring, which in contrast, has high proportion of the polyunsaturated fatty acid, docosahexaenoic acid (DHA). This suggests that sprat feeds more on the copepods Pseudocalanus sp. than herring which mainly feeds on Temora longicornis. Hence, altered ratios of sprat and herring abundance available for cod may impact lipid content and FAC in cod. High proportions of ARA, EPA and the antioxidant, astaxanthin, in S. Entomon, compared to 9 clupeids, render it a valuable constituent in the diet of Baltic cod. However, the abundance of S. Entomon has declined in recent decades in the Baltic. FAC of ovary and liver varies with maturity stage in Baltic cod (Paper II and III). Low content of ARA in sprat and herring in spring and summer is reflected in cod ovaries and coincide with the timing of the maturation period of cod in the Central Baltic Sea (Paper I and II). Fatty acids trophic markers indicates that dinoflagellates dominated during the years examined which may have resulted in a reduction of ARA level in both sprat and herring compared to periods with domination of diatoms (Paper I). No limitation in lipid energy is evident in Baltic cod but a deficiency in ARA is indicated (Paper II). Selective retention of ARA in ovaries during ovarian maturation is evident (Paper II) but despite mobilization of ARA from liver, the level is not sufficient to keep up with the requirement in ovaries and ARA decreases in late maturation and during spawning. The antioxidants α-tocopherol and astaxanthin accumulates in cod ovaries compared to prey and decreases in late maturation and spawning due to antioxidant protection activity (Paper II). ARA level, important for eicosanoid activity, is lower in ovaries of Baltic Sea cod than in North Sea cod (Paper III), indicating that this fatty acid may be important for spawning time. However the spawning period is not influenced by different ARA levels and EPA/ARA ratios in farmed cod (Paper IV). Uptake of DHA, EPA and ARA into cod eggs from broodstock diet is highly efficient (Paper IV). Diet with low EPA/ARA ratio has significantly higher realized fecundity and eggs from fish fed a diet with high ARA level has higher fertilization success and survival to 8 days post hatch compared to fish fed low level of ARA. The combined results strongly indicate that the low ARA levels in Baltic cod ovaries, reflecting ARA levels in prey, result in low fertilization success and survival of eggs and larvae. This PhD provides novel information about lipid dynamics in Baltic sprat and herring which is important because these species occupy a central position in the Baltic ecosystem. The results contribute to a better understanding of the lipid requirements and fatty acid mobilization during maturation in cod but do not explain the delayed spawning time in Baltic cod. The improved knowledge of the effect of dietary EFA on realized fecundity and egg and larval quality in cod is of great importance for estimating recruitment but also to cod farming because egg quality in cultured cod is one of the limiting factors for successful mass production of fish fry. EFA proved a useful tool as trophic markers in the Baltic Sea ecosystem and the results indicate that EFA may also be useful as ecosystem state indicators.

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Coastal Ecology
Contributors: Røjbek, M., Støttrup, J.
Number of pages: 199
Publication date: 2012

Publication information
Place of publication: Charlottenlund
Publisher: DTU aqua. National Institute of Aquatic Resources
Original language: English
Electronic versions:
Maria_thesis_final_260612.pdf