Research outputs:

**Fecundity regulation, maturation progression and spawning fidelity in relation to size, condition and age of Baltic herring (Clupea harengus L.)**

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Organisations: National Institute of Aquatic Resources, Section for Marine Ecology and Oceanography
Contributors: Bucholtz, R. H., Nyengaard, J. R., Andersen, J. B., Tomkiewicz, J.
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**Oogenesis, fecundity and condition of Baltic herring (Clupea harengus L.): A stereological study**
Herring (Clupea harengus) is a capital breeder that stores energy reserves in muscle tissue. Individual potential fecundity relies on the size and weight of female fish. Poor condition during the maturation process can lead to a heavy down-regulation of fecundity through atresia and, in the extreme, cause skipped spawning. Herring in the Central Baltic Sea exist in a variable environment where food availability fluctuates substantially. Compared to other herring populations their condition is generally poor. In the present study, the oocyte dynamics and fecundity in relation to the condition of Central Baltic herring was investigated. A modern stereological method, the physical fractionator, was used to quantify the number of oocytes in previtellogenic (PG), cortical alveoli (CA) as well as successive vitellogenic (VT1 and VT2) stages in central Baltic herring during ovarian maturation. The potential fecundity, i.e. the number of VT2 oocytes, was low compared to other Atlantic stocks but the relative potential fecundity was higher. The latter decreased by 71% when comparing early-maturing individuals with CA oocytes and late-maturing individuals with VT2 oocytes, suggesting a substantial down-regulation of fecundity. Although determined as spring spawners by otolith hatch type, 15% of the randomly sampled females were characterized by oocytes in CA stage in the prespawning period, indicating skipped spawning. The condition of these females was poor, which might have resulted in skipped spawning. Ovary weight was a good predictor of potential fecundity within maturing stages of females. Combined with estimates of skipped spawning, this ovary weight could be used to estimate egg production thereby improving Central Baltic herring stock-recruitment models.

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**Publication information**
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Stereology as a tool to assess reproduction strategy and fecundity of teleost fishes: Integrated studies in Central Baltic herring (Clupea harengus L.)

In fish stock assessment, spawning stock biomass (SSB) is used as an index of stock reproductive potential (SRP), and proportionality is assumed between SSB and recruitment, i.e. offspring production. SSB is calculated as the sum of biomass proportions of sexually mature individuals per age group. However, evidence that SSB is not a reliable SRP indicator has accumulated over the past decades. The SSB estimation does not consider individual differences in fecundity, skipped spawning, timing of spawning or differences in reproductive traits between sexes, which may all fluctuate significantly, influenced by individual physiological condition. The Central Baltic herring has experienced a radical decline in SSB over the past decades. This is mainly due to overfishing. However, significant changes in Baltic Sea salinity and temperature have also altered herring prey composition and abundance, while reduction in the number of cod has caused sprat numbers and thereby food competition to increase. Together, this has resulted in a significant drop in Central Baltic herring physiological condition. The influence which this lowered condition may have on herring SRP, in terms of increased down-regulation and thereby lowered fecundity, skipped spawning and timing of spawning, has not been investigated and is not considered in assessment of the stock.

The objective of the study was two-fold. Firstly, improve methods for quantification of oocyte recruitment dynamics by adapting and applying modern stereological methods to assess fecundity and reproductive strategies. The strength of the stereological method being that, in combination with conventional histological analysis, quantification of all oocyte categories is possible, as well as registration of qualitative characteristics relating to spawning history of individuals, and further that statistical evaluation of estimates and method is possible. Secondly, apply the stereological methods to fill in gaps in knowledge about Baltic Sea herring reproductive strategy under current environmental conditions, including oocyte recruitment pattern, fecundity determination and down-regulation, skipped spawning and spawning fidelity, and to understand how factors like condition may influence individual decision making and fitness regarding these reproductive traits. The stereological methods applied in this project constituted a powerful set of tools for quantification of oocyte dynamics in fish and were successfully implemented in herring ovaries for quantification of both oocyte numbers and sizes as well as total volume fraction of atretic oocytes, introducing a negligible error to the total variance of estimates. The histological nature of the stereological methods facilitated a ready validation of maturity data, distinguishing first time spawners from repeat spawners, as well as a ready recognition of ongoing oocyte recruitment in early maturity stages, early stage atresia, POFs and residual eggs.

Analyzing a sample of females all collected during a short time frame in March 2008 covering various stages of maturation progression, we saw that oocyte recruitment followed the characteristic pattern of an iteroparous total spawner with determinate fecundity and group synchronous oocyte development. However, a significant fecundity down-regulation was apparent, which followed a three-step mechanism, resulting in low potential fecundity, but high relative potential fecundity compared to other herring stocks. Individual maturation progression revealed a substantial number of specimens with early developing ovaries, thereby being skipped or delayed spawners in accordance to the spring spawning season. Individual condition generally did not appear to influence fecundity regulation, but showed a strong correlation with degree of maturation progression, skipped or delayed spawners having significantly poorer condition than specimens expected to spawn during the spring spawning season. Results further indicated, that spawning occurs throughout the year in the Central Baltic herring population and that spawning time appears to be independent of individual hatch type, but rather relying on especially condition, but also size and age. Bioenergetic modeling showed that an individual condition factor threshold may control timing of spawning. These results may all influence Central Baltic herring SRP

General information
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Cut & count - stereology as a tool to understand fish biology

Gonadal maturation of herring (Clupea harengus L.) assessed by histological and macroscopic characteristics

Oocyte recruitment dynamics and fecundity regulation in Baltic Sea herring (Clupea harengus L.)

Quantification of oocytes using design-based stereology
Biological observations on the mudskipper Pseudapocryptes elongatus in the Mekong Delta, Vietnam

Aspects of the population biology of the mudskipper, Pseudapocryptes elongatus, (Cuvier, 1816) were studied in Bac Lieu Province in the Lower Mekong Delta, Vietnam, including sex ratio, length-frequency distribution, sexual dimorphism, hepatosomatic index (HSI), female gonadosomatic index (GSI), gonad histology, fecundity and some observations on post-larvae and juveniles. In the population studied the sex ratio was skewed toward males. Females had a shorter mean length and a lower mean growth rate than males. No mature males or females were observed among mudskippers sampled in estuarine canals from February to May 2004 during the dry season. It is suggested that P. elongatus migrates to the sea to spawn later in the year after onset of the wet season. Salinity tolerance was evaluated in a 96-h experiment. This showed that P. elongatus is remarkably euryhaline and able to survive in salinities ranging from freshwater to 50 ppt. Gut content analysis revealed that P. elongatus is a herbivore, feeding mainly on pennate diatoms (93% of the diet).

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Development of a manual to determine gonadal maturity of herring (Clupea harengus L.)

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Contributors: Bucholtz, R. H., Tomkiewicz, J., Dalskov, J.
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Estimating oocyte numbers in the ovaries of teleost fish

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Contributors: Bucholtz, R. H., Tomkiewicz, J., Andersen, J. B., Nyengaard, J. R., Gundersen, H. J. G.
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Manual to determine gonadal maturity of Baltic herring

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Projects:

Stereology as a tool to assess reproduction strategy and fecundity of teleost fishes
Bucholtz, R. H., PhD Student, National Institute of Aquatic Resources
Tomkiewicz, J., Main Supervisor
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