

# An illustrated manual for macroscopic determination of Baltic cod reproductive status

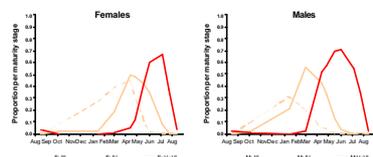
Jonna Tomkiewicz, Gerd Kraus,  
Friedrich W. Köster & Cordula Schmitz

The manual has been elaborated with the purpose to improve determination of Baltic cod (*Gadus morhua* L.) reproductive status and thereby the data basis for estimation of spawning stock size and reproductive potential. The macroscopic determination is based on a 10-level index scale applied by the Danish Institute for Fisheries Research (DIFRES) and the Institute for Marine Sciences (IFM) onboard research vessels. The method considers that macroscopic staging is a rapid method in the field, but that validation by more accurate measures is a necessity to ensure data quality. The photo documentation of the various stages aims at reducing deviations caused by subjective judgement and thereby further improving the quality of data.

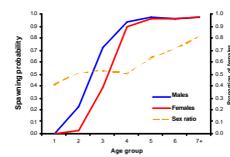
The macroscopic scale divides the reproductive cycle into 10-stages for females and males, respectively. The stages consider the developmental steps from juvenile to adult, the annual spawning cycle and reproductive malfunction. The stages represent 6 different phases of the reproductive cycle:



The fine grading of the scale is useful in studies of reproductive potential allowing a more accurate estimation of the proportion of spawners and population fecundity than traditional maturity ogives. Maturity data to estimate spawning stock size are collected during the Baltic International Trawl Survey (BITS) in March and applied by the ICES Baltic Fisheries Assessment Working Group.

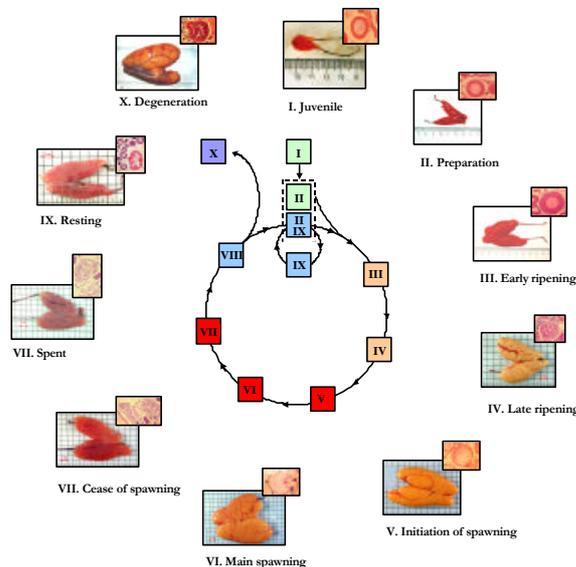


The optimal time to estimate the proportion of spawners in the stock is in February-March, when ripening is progressed, but before spawning migration. Collection of maturity data during the BIT survey in March is optimising data quality.



A spawning probability function is defined as the proportion of ripening and ripe specimens (Stage III-VI) at size or age in the stock prior to spawning. Spawning probability is preferable to a maturity ogive, because skip of spawning (Stage IX) and reproductive disturbances (X, VII, VIII) as well as immature are excluded. Differences in timing of sexual maturation and the skewed sex ratio emphasise the need for sex specific maturity data.

Collection of data on reproductive status to estimate spawning stock size require research surveys with a representative coverage of the stock. The manual is suggested for use onboard national research vessels during the BITS survey in March to standardise collection of maturity data used by ICES in assessment of Baltic cod. The spawning probability is suggested as replacement of maturity ogives to improve estimates of spawning stock size and reproductive potential.

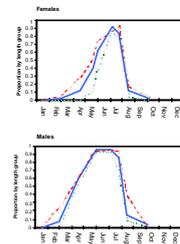
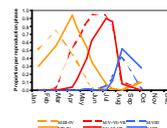


### Female reproduction cycle

The 10 reproductive stages of the maturity scale for females have been characterised through histological analysis of oocyte and ovarian development. Stage related macroscopic characteristics have been identified from photographs of histologically analysed ovaries taken prior to preservation. In the manual, different photos of identical stages illustrate the variability.

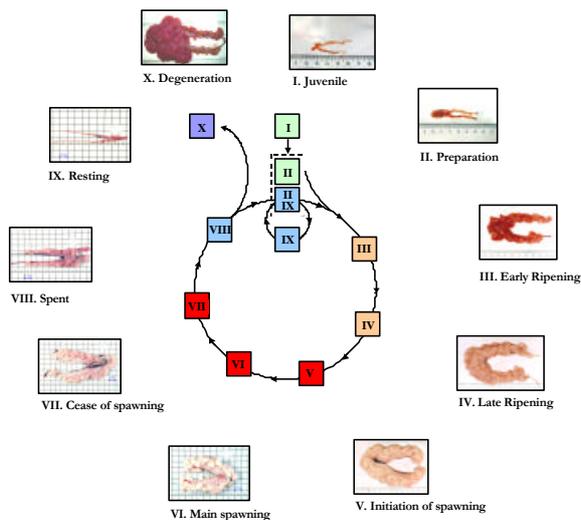
The macroscopic maturity staging has been used during two international research projects on cod reproductive potential, i.e. Cod Recruitment in the Baltic (CORE) and Stock Recruitment in the Baltic (STORE). Sampling was conducted during standard research surveys (BITS) combined with project specific surveys to cover the annual reproductive cycle and identify timing of spawning for different stock components.

The onset of the ripening process is identical for the sexes, but duration of the ripening phase (stages III-IV) is longer for males than for females. This results in a later onset of spawning and a shorter duration of the spawning phases (stages V-VII) for females, because spawning ends around the same time for both sexes (Stage IX).



The duration of the spawning phase depends on fish size. Larger fish start spawning earlier and tend to continue longer, but the peak spawning time is similar. The difference in spawning duration with size is particularly pronounced for females. The higher egg production of larger females will increase the effect of changes in female stock composition on the temporal egg production during the spawning season.

The differences in spawning time of various stock components affect the distribution pattern of the stock, because cod in spawning condition aggregate in deeper areas, while non-reproducing specimens prefer more shallow areas. This in combination with the sex and size specific differences in timing of spawning results in that males dominate the spawning areas in the early spawning season, while females dominate late in the season due to scarcity of large males. This distribution pattern affects the effectiveness of management measures such as spatial and temporal closures of the fishery to protect the actively spawning stock.



### Male reproduction cycle

The reproductive stages of the male maturity scale are based on their typical appearance as illustrated by the photos. The male spawning stages have been documented by shipboard fertilisation experiments to ensure that the separation between ripening and spawning stages is similar for males and females. Histological analysis to further validate stages is ongoing.

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## Abstract

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### **An illustrated manual for macroscopic determination of Baltic cod reproductive status**

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A manual to determine the reproductive status of female and male cod has been developed considering that macroscopic staging is a rapid method in the field, but that histological validation is a necessity to ensure data quality. The reproductive cycle is divided into 10-stages, which are defined macroscopically and illustrated for different sizes of females and males. The female scale has been characterised histologically and related macroscopic traits derived from comparison between morphological characters and gross appearance of gonads from photographs taken prior to preservation. The male spawning stages have been documented by shipboard fertilisation experiments to ensure that the separation of maturing and ripe stages is similar for males and females. The comparative micro- and macroscopic studies serve to ascertain a reliable interpretation of stages in relation to phases in the reproductive cycle including juvenile, preparation, ripening, spawning, recovery and deviations from normality. The photo documentation of the various stages aims at reducing deviations from subjective judgements and thereby further improve the accuracy of data. The fine grading of the scale is useful in studies of reproductive potential, but also for sampling of data to estimate spawning stock biomass the method is advantageous as it is rapid and allows staging of a large number of fishes relative to histological analysis.

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