

## Theme Session on Advances in Reproductive Biology: Methodology and Applications for Fisheries Science (Q)

### ICES CM 2005/Q:01

#### Interannual changes in the time of spawning of sprat in the Gotland Basin (Eastern Baltic Sea) in relation to the hydrographical conditions and the structure of spawning stock

Andrei Makarchouk

The time of peak spawning for sprat (*Sprattus sprattus balticus* Schneider) in the central and southern parts of the Gotland Basin (Eastern Baltic Sea) has been calculated for the period from 1973 to 2004, using the Latvian Fish Resources Agency's database on ichthyoplankton. Sprat has a very extended spawning season, but maximum abundance of sprat eggs in this region was observed mainly in the middle of June. The time of spawning altered from year to year, but no clear trends could be traced. The time of peak spawning shifted slightly to a later time in the 1980s, but returned to the earlier time in the 1990s. Some significant correlations were found between the time of peak spawning and the severity of the previous winter, as well as the water temperature in the mean depth of eggs. The time of spawning also depended on the age structure of the spawning stock: first-time spawners tended to spawn at the end of the season, while a greater number of old fish in the spawning stock led to earlier spawning.

Keywords: sprat, peak of spawning, interannual changes, Eastern Baltic.

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### ICES CM 2005/Q:02 Withdrawn

### ICES CM 2005/Q:03

#### Horse mackerel fecundity in relation to lipid content

C. J. G. van Damme, L. Dransfeld, A. T. G. W. Eltink, M. Krüger-Johnsen, J. R. Pérez, J. Ulleweit, and P. R. Witthames

During the 2004 mackerel and horse mackerel triennial egg survey the fecundity of horse mackerel (*Trachurus trachurus* L.) was estimated using a new gravimetric and image analysis system. The fecundity estimates and mean oocyte diameters showed great variation between and within different institutes. Horse mackerel fecundity increased during the spawning season and showed no decline at the end of the spawning season. This indicates that this species is likely to be an indeterminate spawner. The lipid content was estimated from whole horse mackerel collected three months prior to and during the spawning season. The lipid content rapidly decreased

during the period of ovary development prior to the onset of spawning, but remained rather constant during spawning. A relationship between fecundity and lipid content could not be found.

Annual lipid content estimates collected in successive years might provide an index for changes in fecundity in succeeding years. The sampling needs to be carried out prior to the onset of spawning, when the fat content is highest.

Annual stomach contents estimates collected in successive years might provide an index for food availability and feeding success. The stomach analyses carried out in 2004 indicated that horse mackerel was feeding only at a low level during the spawning period.

Keywords: horse mackerel, *Trachurus trachurus*, fecundity, gravimetric analyses, lipid content, feeding, indeterminate spawning.

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### ICES CM 2005/Q:04

#### Historical variation in reproductive output of cod in Icelandic waters

Guðrún Marteinsdóttir

Traditionally, spawning stock biomass (SSB) has been used in stock-recruitment models as a proxy for reproductive potential, with the implicit assumption of proportionality between total egg production and SSB. However, an increasing number of studies have demonstrated that SSB is not an accurate measure of reproductive potential. Fundamental variables that affect the reproductive potential of fish stocks (i.e. time, duration and amplitude of spawning, and offspring size and viability) have been found to vary with age, size, and condition of spawning fish, as well as spawning experience. In this study, the influence of maternal effects on such variables as size and age at maturity, time and duration of spawning, potential, actual, and relative fecundity, egg size, egg density and hatching success, larval size, larval feeding, larval growth and survival, is reviewed for Atlantic cod (*Gadus morhua* L.). Based on these results, the stock recruitment relationship of the Icelandic cod stock will be re-examined. Proxies of reproductive potentials will be re-estimated, and in an effort to explain a greater proportion of the variation in recruitment than demonstrated previously with traditional models, the relative contribution of maternal effects will be evaluated.

Keywords: reproductive potential, egg production, maternal effects, recruitment.

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## ICES CM 2005/Q:05

### **Systematic bias in estimates of reproductive potential of cod stocks: implications for stock/recruit theory and management**

C. T. Marshall, C. L. Needle, A. Thorsen, O. S. Kjesbu, and N. A. Yaragina

Stock/recruit relationships using spawning stock biomass (SSB) to represent reproductive potential assume that the proportion of SSB comprised of females and the relative fecundity (number of eggs produced per unit mass) are both constant over time. To test these constancy assumptions female-only spawner biomass (FSB) and total egg production (TEP) were estimated for the Northeast Arctic cod stock over a 56-year time period (1946–2001). Over a 56-year time period FSB/SSB varied between 24 and 68% and the variation was systematic with length such that SSB became more female-biased as the mean length of spawners increased and more male-biased as mean length decreased. Over the same time period, relative fecundity of the stock (TEP/SSB) varied between 115 and 355 eggs g<sup>-1</sup> and, like FSB/SSB, was significantly, positively correlated to the mean length of spawners. To correct for this source of systematic bias FSB and TEP were evaluated as possible replacements for SSB in the stock/recruit relationship for Northeast Arctic cod. Both indices gave a different interpretation of the recruitment response to reductions in stock size (over-compensatory) compared to that obtained using SSB (either compensatory or depensatory). Biological reference points were estimated for each of the different stock/recruit relationships using piecewise linear regression. There was no difference between SSB and FSB in the assessment of stock status, however, in recent years (1980–2001) TEP fell below the reference point more frequently than SSB fell below. This suggests that using SSB as a measure of stock reproductive potential may lead to overly optimistic assessments of stock status.

Keywords: cod, stock/recruit relationships, biological reference points, reproductive potential, sex ratios.

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## ICES CM 2005/Q:06

### **Reproductive adaptations of haarder (*Liza haematocheila*) to the new environment of the Russian South Seas**

Svetlana Pianova

We have analysed reproductive adaptations of mullet haarder to the new environment during the adaptation period to an intensive fishery. It was introduced from the Far East and naturalised into the Black Sea and the Sea of Azov. The population approached commercial abundance which provided a TAC of 8 000 t in 2004. We have analysed fish collected in 1997–2002 from both inhabited areas. Introduction of this fish species into the low latitudes resulted in a rise of fish weight from 0.96±0.10 kg to 3.56±0.23 kg and fecundity at 22%, one year early maturity and increase in vitellogenic oocyte diameters at 48.2% on the average. The spawning period began 1–1.5 months earlier and lasted longer in the introduction area, from April to July. Native fish formed two portions of oocytes in the ovaries, but only the first portion developed after resorption. The small-sized oocytes generation cannot be realised because of the unfavourable temperature conditions. Introduced fish had three-portion spawning as all tropical water mullets do. The oocyte diameters decreased after every ovulation because of the reduction of the plastic reserve. The appearance in cytoplasmic oocytes of giant nucleolus (6.03–9.01 x 10<sup>-6</sup> m in diameter) is coupled with the changing of biosynthesis activity and the oogenesis divergence under the contaminated environment. There were amitotic oocytes in the ovaries of native fish. We concluded that South Seas haarder testes have juvenile protogynous hermaphroditism. All fry are originally female, two-year juveniles are hermaphrodites, later some fish become males. These reproductive characteristics are adaptations to warmer climate conditions.

Keywords: mullet haarder, reproduction, adaptations, gametogenesis, spawning, ovaries, hermaphroditism.

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## ICES CM 2005/Q:07

### **Temporal variation in reproductive investment of cod and haddock in the North Sea**

P. J. Wright

The recent decline in many fish stocks has been accompanied by marked changes in age at maturity and both phenotypic plasticity and size-dependent genetic selection has been invoked to explain such changes. However, there is little information on whether other

components of reproductive investment have changed as would be expected from life-history theory. Moreover, given the spatial variation in both long-term fishing pressure and environment influences, it is possible that temporal responses may vary within a stock region. This study explored how reproductive investment in both cod and haddock has changed between a period of historic high and recent low spawning-stock size. Maturity ogives indicated that both cod and haddock in the coastal waters off Scotland now mature at a smaller size and younger age than they did in the 1970s. Both cod and haddock from this region are now more fecund than 30 years ago. In contrast, there was little temporal difference in the reproductive traits of these species from the northern North Sea. Nutritional influences on maturity and fecundity, particularly liver condition, were also evident from the study. However, the temporal and spatial differences in fecundity–size relationships were not consistent with a change in growth conditions, as there has been a significant decrease in body condition in recent times in both species from the Scottish coastal region. Our findings regarding the temporal change in reproductive investment in the Scottish coastal region appears consistent with genotypic changes in life-history traits predicted to arise from intense periods of size-selective mortality.

Keywords: life-history theory, maturation, fecundity, cod, haddock.

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### **ICES CM 2005/Q:08**

#### **Spatial and temporal variability in Baltic sprat (*Sprattus sprattus balticus* S.) batch fecundity**

Holger Haslob, Jonna Tomkiewicz, and Hans-Harald Hinrichsen

Batch fecundity of Baltic sprat (*Sprattus sprattus balticus* S.) during peak spawning time was investigated in relation to fish length and weight applying the hydrated oocyte method. A time-series of five years in three different areas of the Central Baltic, the main spawning areas of the Baltic sprat stock, was established. Additionally, sprat batch fecundity was analysed over a whole spawning season for the year 2005 in the Bornholm Basin. Analysis of Covariance (ANCOVA) showed significant differences in batch fecundity of Baltic sprat between areas and years. To detect possible causes for this variation in batch fecundity different environmental parameters such as hydrography, food availability, and stock density were tested. The data obtained in this investigation were used to develop a predictive model of Baltic sprat batch fecundity. Coupling these results with existing ichthyoplankton survey and stock structure data will allow applying the daily egg production method. The suitability of utilizing

this method in order to retrospectively estimate sprat stock development in the Central Baltic is discussed.

Keywords: Baltic sprat, hydrated oocyte method, batch fecundity, daily egg production method.

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### **ICES CM 2005/Q:09**

#### **A bet hedging strategy for hake enables maximum viable egg production**

Aisling Lannin, E. Rogan, and P. Connolly

In recent years the management of the northern hake stock has been dominated by uncertainty over the state of the stock, recruitment success, and the need for EU recovery plans. There are important spawning and nursery areas for northern hake off the south west of Ireland in the ‘biologically sensitive area’ established by the EU in 2003. The reproductive biology of hake was investigated in this area by tracking maturity stages in the population and oocyte stage abundance in individual ovaries using histological techniques.

The results indicated pre-spawning and post-spawning stages present in the population over a prolonged period of 6 months. Furthermore, a variety of mature oocyte stages were present in ovaries of similar maturities over the entire year. Hake display a protracted spawning season with the asynchronous spawning pattern representing an individual level response that feeds into an overall stock response. The protracted spawning season coupled with the asynchronous mechanism underpin the quantity and quality of egg production in the hake stock. Hake employ a ‘reproductive bet hedging strategy’, spreading reproductive effort over time to protect eggs and larvae against adverse environmental conditions and food availability. Against the backdrop of climate change, this strategy may ensure a higher probability of spawning success and lead to a ‘greater recruitment stability’ in the stock.

Keywords: hake, reproductive strategy, asynchronous spawning, recruitment, oocyte dynamics.

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## ICES CM 2005/Q:10

### The potential importance of the paternal contribution to the 'Stock Reproductive Potential' of North-East Arctic cod (*Gadus morhua*)

Richard D. M. Nash, Olav S. Kjesbu, Anders Thorsen, Merete Fonn, and Maria Krüger-Johnsen

Over the years there has been a growing interest in determining the real stock reproductive potential (SRP) as a means of understanding the dynamics of a fish population. For the purposes of assessment the spawning stock biomass (SSB) is generally used, however, this is not a good descriptor for processes types of population modelling. In general, the focus in SRP studies has, with a few notable exceptions, been on female fecundity and realised egg production. In NE Arctic cod, potential egg production for the stock has been estimated over the years 1946 to the present. In this paper we present preliminary data on the total viable sperm production, estimated for the same years. There have been large changes in the total sperm production, which to a certain extent reflects changes in the mature biomass of the stock. Since 1946 there have also been changes in mean length of mature males and females, with a tendency toward smaller fish in the most recent time period. With the relatively large decline in mean size of mature females and the tendency to mature at a smaller size in the latter years the mature fish of both sexes are now of a similar mean size. The relationship between mean size of mature males and females is substantially different than when the stock was large in the late 1940s. This could have implications for fertilisation success, a factor that is dependent on the dynamics of both sexes.

Keywords: Barents Sea, North-East Arctic cod, stock reproductive potential, paternal effects.

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## ICES CM 2005/Q:11

### Fisheries-induced life history evolution reduces per-biomass egg production of the Northeast Arctic cod stock

Christian Jørgensen, Bruno Ernande, and Øyvind Fiksen

Age and size at maturation has declined for several fish stocks over the last decades. Knowing that these traits may evolve rapidly in response to the selection pressures exerted by human fisheries, we explore reproduction and maturation changes for the Northeast Arctic stock of Atlantic cod *Gadus morhua*. We use a mechanistic and physiologically realistic model where energy allocation between growth and reproduction depends on three individual states: age (in months, thus including seasonality), length, and stored energy. Food intake varies stochastically. Under the historic fishing regime

that targeted mainly mature cod, maturation was late (10.2 years, 117 cm, and 20.8 kg). Recent trawling has increased juvenile and immature mortality, and we find that the evolutionary endpoint under today's fishing regime implies much earlier maturation at a smaller size (4.9 years, 51 cm, and 1.6 kg). Among the consequences of earlier maturation is a decrease in the stock's per-biomass potential for egg production. As a result, fisheries-induced life history evolution will systematically reduce the slope of SSB-egg-production diagrams with time. If today's fishing continues, the predicted evolutionary endpoint will produce only 60% of the eggs for the same biomass when compared with the historic population.

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## ICES CM 2005/Q:12

### Estimation of potential and realised fecundity of fish

Anders Thorsen, O. S. Kjesbu, and P. R. Witthames

This presentation will deal with recent advances in methodology for estimating the standing stock of fecundity and loss of potential fecundity through follicular atresia for application in determinate and indeterminate spawning fish. A procedure for taking gravimetric samples at sea will be described and how the efficiency of counting or follicle size measurement can be automated through image analysis aided by staining. The application of the Autodiametric method (Thorsen and Kjesbu, 2001), in cod and horse mackerel will be presented with an overview of how the data can be acquired, either through open source image analysis software available for PC and Mac, or through software available commercially for PC users. An Unbiased Stereometric procedure will be contrasted with traditional histological methods to estimate follicular atresia.

Keywords: image analysis, fecundity, atresia.

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## ICES CM 2005/Q:13

### How variable is the fecundity within and between cod stocks?

Yvan Lambert, Olav S. Kjesbu, Gerd Kraus, Gudrun Marteinsdottir, and Anders Thorsen

Stock reproductive potential is determined by the number of fish at age, sex ratio, proportion of mature female at age, and fecundity. Fecundity data, which are fundamental in estimating egg production are not collected routinely for most fish stocks. Thus, variability in fecundity is largely ignored in the estimations of

reproductive potential. The objective of this study was to identify patterns of variation in fecundity within and between different stocks of cod (*Gadus morhua*) and to explore biological and/or environmental factors that explain these patterns of variation. A review of fecundity data for cod of different stocks and years was made. The examination of fecundity at size indicated a very large variability in the fecundity of cod between stocks and years. The fecundity of a 55 cm cod varied from 225 000 eggs to 1 600 000 eggs. Baltic and North Sea cod stocks were very distinct from the others, highest fecundity-at-size notwithstanding years being observed for these stocks. A different pattern of variation was observed for the other stocks. Temporal variation in the fecundity appeared as important, or even more important than differences associated with stocks. Without excluding genetic differences, variations in the environmental conditions and fishing pressure could possibly explain much of the variation in the fecundity of these stocks. At a smaller scale, it also appears that the increase in the reproductive investment with age/size can differ between stocks and years. Thus, routine measurement of fecundity should be essential in estimating reproductive potential of cod.

Keywords: fecundity, *Gadus morhua*, spatial and temporal variation, environmental influences.

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#### ICES CM 2005/Q:14

##### **Timing and determination of potential fecundity in Atlantic cod**

Jon Egil Skjæraasen, T. Nilsen, and O. S. Kjesbu

Finding reliable predictors of fecundity is fundamental to our understanding of stock-recruitment and hence fisheries management. For cod (*Gadus morhua*), stock-recruitment models have evolved from relationships between spawning stock biomass and recruitment to models that also include age, condition, and lipid energy of the spawning stock. Egg production in cod is a time-consuming process where energy is transferred from the liver and white tissue to the developing oocyte. Since cod produces a determinate amount of eggs prior to the onset of spawning, it is possible that energy reserves of individual cod at a particular time largely determine the final egg production. In the laboratory we exposed female cod to two different photoperiods to induce different spawning seasons. At the onset of spawning the potential egg production was determined by image analysis. By using weight and length as predictors of fecundity we found that egg production in both groups was best explained by their status 3–4 months before the onset of spawning. This is around the presumed onset of vitellogenesis. We suggest that using data of energy status of wild populations around the onset of vitellogenesis could improve estimates of potential

fecundity and ultimately stock-recruitment relationships.

Keywords: cod, timing, fecundity.

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#### ICES CM 2005/Q:15

##### **European hake, *Merluccius merluccius*, spawning biomass assessed by an egg production method in the Bay of Biscay**

H. Murua, P. Álvarez, M. Korta, and L. Motos

The ICES triennial egg survey, although primarily focused on mackerel and horse mackerel, provides a unique opportunity to gather information on the egg production of any fish population matching the spawning area within the spatiotemporal sampling limits of the survey. This is the case of hake in the Bay of Biscay, whose spawning timing and area is in accordance with the season when ICES triennial egg survey is carried out. Therefore, the egg production records from the ICES Triennial Survey may be used as abundance indices of the spawning population and, in combination with fecundity estimates, absolute estimates of SSB may be potentially attained. The aim of this presentation is to present the results of the application of the egg production method to hake in the Bay of Biscay in 2004. In addition, the results will be compared with the results obtained from current assessment methodologies (VPA-based assessment) as well as an appraisal of the reliability and accuracy of parameters estimation of the method, and an evaluation of the feasibility of applying such a method to hake in the Bay of Biscay will be carried out.

Keywords: European hake, Bay of Biscay, batch fecundity, egg production, SSB.

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#### ICES CM 2005/Q:16

##### **Effects of proximate composition on fecundity and reproductive potential of *Merluccius merluccius* (L., 1758) at the Galician Coast**

Rosario Domínguez, F. Saborido-Rey, H. Murua, and I. Medina

Potential and batch fecundity has been estimated in european hake (*Merluccius merluccius*) at the Galician coast from 1999 to 2004. It is known that female fish proximate composition may act as a determining factor in reproductive success and egg production. Energetic

components (lipids, proteins, and glycogen) of different body tissues (liver, muscle, and gonad) have been determined. Fecundity and atresia intensity variations are analyzed in relation to proximate composition and other maternal features, to determine the reproductive dynamics along the reproductive cycle, more specifically:

- Observing female energetic stores influence (quantitative and qualitatively) on potential, relative, and batch fecundity and consequently on reproductive potential.
- Establishing fish proximate composition significance on atresia levels determination and the occurrence of skip spawners.
- Defining new models (equations) that include bioenergetics effects on fecundity estimates.

Keywords: fecundity, atresia, proximate composition, bioenergetic, *M. merluccius*.

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#### ICES CM 2005/Q:17

##### **Impact of individual morphological and physiological characteristics on the sexual maturation of the European eel (*Anguilla anguilla*)**

Caroline Durif, Sylvie Dufour, and Pierre Elie

Since the 1980s worldwide populations of eels declined steeply. Only causes related to their freshwater life phase have been identified and studied, as the oceanic life phase of eels (sexual maturation and spawning) remains inaccessible to human observation. Eels display great differences in condition and size when they leave the freshwater system and coastal waters for their spawning grounds in the Sargasso Sea. They may also be at different stages of the silvering process (pre-migratory metamorphosis). Such high variability may have an effect on the eel's subsequent maturation capacity. The objective of this study was to describe the variability in maturation capacity of eels and to relate this variability to their initial physiological and morphological characteristics. Three sets of experiments took place (each one for approximately 21 weeks) in which sexual maturation was induced in female silver eels from different locations using weekly standardized gonadotropin injections. External parameters of eels were measured every week, and several individuals were sacrificed once a month for blood and gonad sampling. A maturation index was designed, based on gonad weight, vitellogenine level, and standardised body measurements. Results showed that individual response to gonadotropin injections was highly variable. Individuals with a high maturation index had the highest initial condition factor and were the most advanced in the silvering process. Furthermore, highest gonadal yield was obtained in eels measuring over 700 mm body length. These results are

important for management purposes as they give indications on the eels that will most successfully contribute to the spawning stock.

Keywords: *Anguilla anguilla*, sexual maturation, maturation capacity, silver stage, biometry.

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#### ICES CM 2005/Q:18

##### **An integrated historic perspective of female fecundity of the common squid *Loligo vulgaris* from Portuguese waters**

João Pereira, Ana Costa, and Sílvia Lourenço

Although not the most economically important of the Portuguese cephalopod species, the common squid is a shared resource that is taken by fisheries from the southern coast of the UK and southern North Sea to the southern coast of Portugal. Its biology has been the subject of much research in European waters, and occasional fecundity estimates are not new to the species. To date, however, no long-term study has provided a more general perspective of the evolution of fecundity in time and no attempt has been made to compare those data to environmental information. The aim of the research reported presently is thus to fulfill those gaps in the knowledge of the species, presenting results of female fecundity estimates that cover the period spanning the 1990s and the present decade. The trends verified are discussed in relation to the patterns of SST observed in the area and to the NAO index during the same time period.

Keywords: female fecundity, SST, NAO, time-series, *Loligo vulgaris*, Portuguese coast.

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#### ICES CM 2005/Q:19

##### **Temporal and spatial variation in fecundity of Irish Sea plaice**

James Kennedy, Peter R. Witthames, and Richard D. M. Nash

There is an increasing need to have information on the biology of stocks to understand their population dynamics. In addition quantification of the variability in biological characteristics with a management unit (possibly due to sub-stocks) and between years is essential. Irish Sea plaice (*Pleuronectes platessa*) are one such stock and are currently managed as a single unit, whereas there is evidence that it probably consists of at least two semi-isolated stocks. In order to model these

stocks accurately greater information is needed on the interannual variability in reproductive dynamics in each individual stock. The current study examined the reproductive investment (fecundity) over a number of years in the Irish Sea using fish caught during the spawning season in Liverpool Bay, Cumbrian coast, and the western Irish Sea. Fecundity estimates were also taken during September 2003, which is during the period in which oocyte recruitment takes place. A relative condition factor was estimated for each fish using those caught in 2001 as a baseline. Fecundity estimates taken in September 2003 were significantly higher than estimates taken during the following spawning season, indicating that fecundity was down-regulated during maturation. However, during spawning the level of follicular atresia was almost undetectable. Significant differences in fecundity and condition were found between areas and also between years. The highest fecundity was from the Cumbrian coast in 2000 with the lowest from the western Irish Sea in 1995. Condition factor appeared to be the main influence on relative fecundity at both the individual and population level, with relative fecundity increasing with condition.

Keywords: Irish Sea plaice, *Pleuronectes platessa*, fecundity, condition, atresia.

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## ICES CM 2005/Q:20

### Reproduction to recruitment to recovery? Significance of parental effects to marine fish stocks

E. A. Trippel

The declines in population sizes of cod (*Gadus morhua*) and of many other fish species in the North Atlantic and Baltic Sea are of large concern to the economies of coastal communities that rely upon their productivity and sustainability. The rebuilding of these stocks is dependent on recruitment, which in turn is partly dependent on successful reproduction. This paper outlines possible pathways and processes that an 'individual' encounters as it is generated by its parents and passes from larva to juvenile to adult. The fish life cycle, and in particular the new knowledge gained recently about spawning, gametes, and early life stages will be appraised in light of the threats encountered and the capacity of individuals to overcome them as a function of parental phenotype and genotype. Successfully rebuilding a depleted population is not a certainty and can be seriously hampered by compensatory mechanisms. Favourable parental, larval, and juvenile environmental conditions may be a necessity to rebuild stocks near historical low levels.

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## ICES CM 2005/Q:21

### Impact of mass atresia in reproductive ecology, maturity ogive, spawning migration and population dynamics on *S. mentella* and *S. marinus* in Icelandic waters

Fran Saborido-Rey, H. Murua, D. Garabana, and T. Sigurdsson

Generalized or mass atresia in determinate spawner fish is not well documented, although it has been reported in some species. In redfish it has been rarely studied, but in this paper it is known that mass atresia is a common feature in the two main redfish species inhabiting Icelandic waters. Mass atresia has been observed both at the previtellogenic stage and during vitellogenesis. Its presence during vitellogenesis means unavoidably that this fish will not spawn, since there is not sufficient time to develop another clutch of oocytes. Oocyte development in relation with atresia intensity has been studied during the year and in different areas around Iceland to study its impact on:

- a) The reproductive strategies of the species regarding maturation, ripening, and the condition factor.
- b) Skip spawners are not immature fish, but inactive since they are not contributing to egg production. Thus, different maturity ogives can be built with drastic difference between them. Since inactive mature females may look macroscopically as immature, important historical errors have been found when comparing size at maturity among areas or species.
- c) In Iceland redfish migrates for maturing and spawning. Mass atresia affects the migration pattern, since first-time spawners failing to mature and skip spawners remain in the area of origin and do not migrate.
- d) The impact of the above-mentioned features on population dynamics and survey estimation is further discussed.

Keywords: mass atresia, skip spawning, Iceland, redfish, *S. mentella*, *S. marinus*.

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## ICES CM 2005/Q:22

### When it comes to recruitment variation in Icelandic herring, it is the eggs of the repeat spawners that make the difference

Gudmundur J. Oskarsson and Christopher T. Taggart

One of the many competing hypotheses postulated to explain recruitment (R) variation in fish addresses maternal factors and how they may operate at the stock and individual level of female spawners and subsequently propagate to R. We estimate total egg production (E; number of eggs) in Icelandic summer-spawning herring over the period 1962 through 2000 by using stock-related data, virtual population analyses (VPA) data, and individual fecundity estimates that rely on total length and Fulton's K ( $\text{g cm}^{-3}$ ). The influence of egg atresia on individual fecundity estimates is found to be trivial. The frequency distribution of K for pre-spawning female herring collected in 1999 and 2000 for the fecundity determination is shown to be virtually identical to that for pre-spawning herring collected during the 1962 through 2000 period. Generalized Linear Models indicate that maternal effects are of significance in explaining VPA-based recruitment-at-age-3 (R), where the best model, one that explains 58% of the variation in R, includes E constrained to the repeat spawners only. Additionally, the North Atlantic Oscillation winter-index, averaged over the 3 years subsequent to year-class formation, is of minor significance in explaining R. Total egg production, E, from recruit spawners contributes nothing to the explained variation. We argue that stock assessment in herring would be better served, especially where recruitment potential (i.e., sustainability) is of consequence, by focussing on the spawning potential of the repeat spawners and not on the total spawning stock biomass. After all, it would be a more precautionary and risk-adverse approach to management.

Keywords: herring, recruitment, fecundity, body condition, egg production, repeat spawners, management.

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## ICES CM 2005/Q:23

### Timing of Baltic cod spawning and spawner demography

Jonna Tomkiewicz and Gerd Kraus

The peak egg production of Baltic cod (*Gadus morhua*) has changed in recent time from March–April to July–August. We analysed the Baltic maturation pattern and timing of spawning in relation to spawner demography on the basis of Baltic trawl surveys covering different seasons during the years 1995–2004. The timing and duration of the ripening and spawning periods varied relative to size for both sexes. Large-sized cod

commenced the ripening process earlier than smaller cod, started spawning earlier, and the spawning season was longer. The timing of peak spawning did not differ significantly among different size groups, but the duration of the ripening process was considerably longer for females than for males. Male migration thus commenced earlier than the females, resulting in high male abundance in the spawning area during the early spawning period. Later in the spawning period female abundance exceeded male due to scarcity of large-sized males in the stock. The female spawner size composition thus seems to influence the duration of the spawning period, while changes in spawner demography do not seem to be the cause of the changes in peak spawning time. This altered behaviour affecting the survival probability of eggs and larvae tends largely to be environmentally driven through changes in food quality and energy allocation.

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## ICES CM 2005/Q:24 – Poster

### Approach to the realized fecundity of *Nephrops norvegicus* in the Porcupine Bank

Isabel González Herraiz and A. C. Fariña

There is a vast literature on biology and fisheries of Norway lobster *Nephrops norvegicus* in the Northeast Atlantic. It points to a high variability in the fecundity of *Nephrops* throughout its geographical range of distribution, but fecundity data on *Nephrops* from the Porcupine Bank (W. Ireland) are still lacking.

Since the middle of the past century the Spanish trawl fleet has been fishing for a bottom mixed fishery in this area, taking *Nephrops* as a target or bycatch species. But only recently, since 2001, the area has been surveyed annually by the Spanish "R/V Vizconde de Eza", providing suitable material and direct data. From survey samples collected in 2001 and 2002, the realized fecundity of the *Nephrops* in Porcupine Bank was estimated based on the number of eggs attached to the pleopods of ovigerous females in the initial stage of the incubation period. The number of eggs per brood was related to the abdomen width, carapace length, and weight. Estimates ranges of potential and effective fecundity were hypothesized in line with the egg loss referenced for *Nephrops* from other Atlantic areas.

Keywords: *Nephrops*, realized fecundity, Porcupine Bank.

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## ICES CM 2005/Q:25

### Staging and ageing the degeneration of postovulatory follicles for the Bay of Biscay anchovy (*Engraulis encrasicolus*)

A. Alday, A. Uriarte, M. Santos, I. Martín, A. Martínez de Murguía, and L. Motos

In order to use postovulatory follicles (POFs) for the estimation of spawning frequency, it is necessary to divide the deterioration and resorptive processes of the follicle into a series of distinct histological stages, each with an assigned age and duration. Recently a revision of the classification key of POFs into stages has been proposed for the Bay of Biscay anchovy (up to 7 stages) according to criteria solely based on their degeneration characteristics. This procedure allows splitting the process of staging POFs from that of ageing. In this work we apply those new POF stages to describe the degeneration of POFs in time in several captivity experiments of anchovy carried out during spawning, using either tanks onboard commercial bait fish tuna boats (in 1990) or land-based aquaria (2001). Finally, the validity of the degeneration rates resulting from these experiments was checked against screening of field samples according to the new stage key.

Results from the analysis of tank experiments and field samples were consistent in suggesting that degeneration rates of POFs could occur faster than previously believed for the Bay of Biscay anchovy. This may lead to review of the ageing procedures for POFs in this anchovy. However, the validity of the above results at temperatures lower than 17°C (SST) is still under study. The degeneration stages of POFs based solely on their histological characteristics is of interest to other teams aiming at determining the spawning frequency of small pelagic fishes, since applying them to a 24-hours daily cycle of samples can give firm indication about the duration of the first phases of degeneration of POFs.

Keywords: post ovulatory follicles, gonad cycle, spawning frequency, anchovy.

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**ICES CM 2005/Q:27 Withdrawn**

## ICES CM 2005/Q:28 – Poster

### Maturity classifications in herring – results of an exchange of digital images of gonads

Else Torstensen

Doubts and difficulties in the maturity staging of herring have been discussed by the ICES PHERS since the end of the 1990s. A first survey of the agreement in the maturity classifications between the laboratories taking part in the summer acoustic surveys for North Sea herring took place in 2004. The exchanged classifications were based on digital photos of gonads, representing a wide range of stages for both sexes.

The main purposes of the exchange were:

- To study the usefulness of digital photos as a tool for classifications of maturity stages;
- To analyse the agreement of maturity classifications between the participants.

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## ICES CM 2005/Q:29 – Poster

### Variability in size at maturity of European hake (*Merluccius merluccius*) at Bay of Biscay and Galician Coast

Rosario Domínguez, María Korta, Hilario Murua, F. Saborido-Rey, and Iñaki Quincoces

Length-at-maturity may be used as an indicator parameter of fish stock health and of their degree of exploitation, since length-at-maturity decreases have been recorded in highly exploited fish populations. In this study, female maturity ogive has been estimated using histological analysis. A comparative analysis of size-at-maturity of European hake has been made during 2003–2004 between two areas: the Bay of Biscay and the Galician Coast, corresponding respectively to the Northern and the Southern stock. The purpose of this work is to:

- Study maturity curve and length at maturity ( $L_{50}$ ) for both areas and years.
- Study the variation of  $L_{50}$  between both areas and years.

Keywords: maturity ogive, length-at-maturity, European hake, *M. merluccius*.

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## ICES CM 2005/Q:30 – Poster

### Sexual maturity of male *Nephrops norvegicus* (L.) in the Irish Sea

Nuala McQuaid and Richard Briggs

Size at onset of maturity was estimated for male *Nephrops* from primary sexual characteristics and from morphometric traits. Maturity estimated from primary sexual characteristics based on histological examination of the gonad indicated sexual maturity at 15.1 mm carapace length. Morphometric maturity, or change in allometric growth of body parts, was estimated from appendix masculina and cutter claw lengths from two sites in the Irish Sea. Two regression techniques were used to estimate morphometric maturity and the results compared. Estimated sexual maturity from morphometric characteristics ranged from 25.9–31.0 mm CL.

Keywords: crustaceans, reproduction, maturity.

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## ICES CM 2005/Q:31 – Poster

### On fecundity of *Sebastes viviparus* from the North East Arctic

Konstantin V. Drevetnyak and A. I. Kluev

In 2000 and 2001, 38 females of ovoviviparous redfish (*Sebastes viviparus*) collected in Norwegian and Barents Sea were examined to study their fecundity. Fish were aged from otoliths. The estimated mean gonadosomatic index (GSI) was 4.9% (range 2.0–8.8%). Fecundity ranged between 1900 and 29 000 eggs per female. The fecundity-length, fecundity-weight, and fecundity age relationships were estimated.

Keywords: Barents and Norwegian Sea, fecundity, gonadosomatic index, *Sebastes viviparus*.

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## ICES CM 2005/Q:32 Poster

### Improving the consistency in the assignment of maturity stages

Hans Gerritsen and D. McGrath

Reliable determination of maturity stages is essential to monitor annual changes in the proportion of mature fish and the reproductive potential of a stock. Visual

examination of the gonads is the only practical method to process large numbers of fish, but the assignment of maturity stages can be somewhat subjective. This study examined the variability between and within people assessing the sex and maturity stages of plaice (*Pleuronectes platessa* L.) and whiting (*Merlangius merlangus* L.) using a 6-stage maturity scale. Variability was high for some maturity stages, even within operators, while other maturity stages were assigned quite consistently. Most variability appeared to be random and not due to differences in interpretation of the scale. The study concludes that some maturity stages were not defined objectively enough to be assigned consistently, even when the same fish were assessed repeatedly by the same operator. Therefore concise, well-defined maturity scales are preferable over scales that distinguish a larger number of maturity stages.

Keywords: reproduction, maturity scale, operator error, observer bias.

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## ICES CM 2005/Q:33 – Poster

### *S. mentella* maturity ogive in the Irminger Sea and Iceland waters

Fran Saborido-Rey, R. Dominguez, D. Garabana, and T. Sigurdsson

Maturity processes have been studied in *S. mentella* in the Irminger Sea and on the continental slope of Iceland as part of a large project on *Sebastes mentella* in the North Atlantic. In this area, different phenotypes have been described as potentially different stocks, the so-called *oceanic* and *deepsea* types. One of the reported differences between the studied stocks is based on different maturity ogives, suggesting that the *deepsea* type matures much faster than the *oceanic* one. In this paper the maturity ogives are estimated and the differences between maturity ogives analyzed, using different criteria both macroscopic and microscopic based on histological analysis. In addition, and considering that most of the fish inhabiting the Irminger Sea are sexually mature, maturity ogives based on histological sections have been used to determine the maturity ogives in the previous spawning season, when recruit spawners become mature. Statistical analyses are performed to conclude that differences between phenotypes are less than previously reported, and considering the sampling design and the year effect, no significant differences between them was found. Comparison with similar data from the shelf of Iceland showed no differences between the two areas. Based on macroscopic observations size-at-maturity in Iceland is

lower than reported. The paper also suggests that using macroscopic observations on the maturity might be misleading due to the reproductive behaviour of redfish.

Keywords: maturity ogive, Irminger Sea, Iceland, redfish, *S. mentella*, oceanic, deepsea.

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**ICES CM 2005/Q:36 – Poster**

**New atretic structures identified in ovary of European hake (*Merluccius merluccius*, L. 1758) in Galician coast**

Rosario Domínguez and F. Saborido-Rey

The study of follicular atresia occurrence and intensity in fish ovaries is a key factor to estimate realized fecundity

and hence stock reproductive potential. These structures are the consequence of a rapid degenerative process by which oocytes at different stages are lost from the ovary. They have been classified according to their resorption state in alfa-, beta-, and gamma-atresia. In the present study new atretic structures that have never been cited before for this species are described. In these structures, hypertrophied connective tissue grows around atretic oocytes, getting into cysts. The aims of this poster are:

- Describing morphology of these structures;
- Analysing the relation between the occurrence of these structures, body size, condition and reproductive cycle stage;
- Estimating their influence on the reproductive potential of *M. merluccius* in Galician waters.

Key words: atresia, connective tissue, cyst, reproductive potential, *M. merluccius*.

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