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Report of the NAFO Working Group on Reproductive Potential

by

Ed Trippel (Chair)

The establishment of the Working Group on Reproductive Potential followed a recommendation of the Symposium on *"Variations in Maturation, Growth, Condition and Spawning Stock Biomass Production in Groundfish"* hosted by NAFO Scientific Council from 9-11 September 1998, Lisbon, Portugal. The Working Group is comprised of members representing 9 countries (Canada, Denmark, Iceland, Ireland, Norway, Russia, Spain, United Kingdom, and USA).

The 5<sup>th</sup> Meeting of the NAFO WG on Reproductive Potential was held at Fisheries and Oceans Canada, Institut Maurice Lamontagne Mont-Joli, Québec, 20-23 October 2005. A total of 10 of the Working Group members were in attendance: Yvan Lambert (Canada), Joanne Morgan (Canada), Rick Rideout (Canada), Ed Trippel (Canada), Loretta O'Brien (USA), Hilario Murua (Spain), Jonna Tomkiewicz (Denmark), Peter Wright (UK), Tara Marshall (UK), and Nathalia Yaragina (Russia). Local arrangements were provided by Yvan Lambert and were greatly appreciated.

Significant progress on the second set of ToRs was achieved, both during the meeting and intersessionally. A brief summary of progress and future plans of each ToR are given below.

**ToR 1: Co-Leaders: Jonna Tomkiewicz (Denmark) and Jay Burnett (USA)**

**Complete inventory of available data in standardized format on reproductive potential for fish stocks of the North Atlantic and Baltic Sea.**

Members: everyone

The objective is to extend the tabulated information to comprise pelagic and demersal fish stocks in the North Atlantic, the Baltic Sea and the Western Mediterranean Sea. A total of 224 stocks have been identified, most of which have contributors. The existing 53 stock tables need to be updated to reflect the modified tabular format. Some of the data comprehensive ICES stocks will be completed with the assistance of the UNCOVER program funded by the European Commission. The resulting inventory of data is to be made available on both NAFO and ICES websites. It is anticipated that data collection phase will be completed by late 2006. Once completed, information in tables will be analysed in 2007 and a manuscript prepared in 2008 on the degree to which these data are used in standard stock assessments.

**ToR 2: Co-Leaders: Yvan Lambert (Canada) and Gerd Kraus (Germany)**

**Explore the use of correlation analysis to estimate the reproductive potential of fish stocks having limited data availability.**

Members: Hilario. Murua (Spain), Nathalia Yaragina (Russia), Gudrun Marteinsdottir (Iceland), Peter Wright (UK), Peter Witthames (UK)

### **ToR 3: Co-Leaders: Hilario Murua (Spain) and Gerd Kraus (Germany)**

**Model the inter-annual and inter-stock variability in size-dependent fecundity for stocks having multiyear estimates.**

Members: Olav Kjesbu (Norway), Peter Witthames (UK), Rick Rideout (Canada), Tara Marshall (UK), Yvan Lambert (Canada), Gudrun Marteinsdottir (Iceland)

These above two terms of reference are related and have been joined.

The objectives of these two ToRs are to (i) identify patterns of variation in fecundity between different stocks of the same species, (ii) find environmental and biological factors that explain these patterns of variation and (iii) assign data poor stocks to environmental data groups and apply fecundity models of rich stocks of the same environmental data group to predict fecundity. A presentation on the approach and preliminary findings on Atlantic cod fecundity was given at the 2005 ICES Annual Science Conference in Aberdeen, Scotland. At the WG meeting in Mont Joli further questions were addressed including are all fecundity data on cod included, is the formulation of explanatory variables complete, is discriminant analysis the best approach, and is it possible to apply the same approach to other species? Some additional cod fecundity data are being accumulated and additional variables such parameters of the von Bertalanffy growth curve and size at 50% maturity are being used to help predict size-specific fecundity. It is expected that the analysis will be completed by October 2006 and a manuscript a year later. Additional species being considered include small pelagics anchovy and sprat.

### **ToR 4: Co-Leaders: Tara Marshall (UK) and Joanne Morgan (Canada)**

**Explore how the current use of biological reference points and medium-term projections can be adapted to include new information on reproductive potential.**

Members: Loretta O'Brien (USA), Chris Chambers (USA), Hilario Murua (Spain), Gudrun Marteinsdottir (Iceland), Gerd Kraus (Germany), Coby Needle (UK)

Alternative indices of reproductive potential will be estimated that include: SSB estimated using knife-edge or constant maturity ogive, SSB with year- or cohort-specific maturity ogives, female-only spawner biomass and total egg production. The stocks to be examined include six cod stocks (Northeast Arctic, Icelandic, Baltic, Georges Bank, Northern Gulf of St. Lawrence and 3NO) and two other stocks (3LNO American plaice and Northern hake).  $B_{lim}$  will be estimated for each index using a standard approach. Short-term projections will be conducted to determine whether there are differences among alternative indices in rate of rebuilding (if the stock is below  $B_{lim}$ ) or increase (if the stock is within safe biological limits). The purpose is to show that different estimates of reproductive potential will produce different perceptions of the status of a stock and its ability to rebuild/grow. Once this work is completed examination will be made of how the alternative indices affect the slope at the origin of stock-recruit curves. By October 2006, short-term (t year) projections will be run using either a deterministic or stochastic approach at  $F = 0$  and a range of  $F$  values. Manuscript is to be prepared for 2007.

### **ToR 5: Co-Leaders: Peter Wright (UK) and Chris Chambers (USA)**

**Explore the consequences of fishery-induced changes in the timing and location of spawning to reproductive success.**

Members: Jonna Tomkiewicz (Denmark), Saborido Rey (Spain), Rick Rideout (Canada), Ed Trippel (Canada), Gudrun Marteinsdottir (Iceland) and Joanne Morgan (Canada)

A review has been made of inter-annual variation in spawning times and possible causes, in particular effects of changes in age or size structure of stocks. Evidence from studies has shown that protracted spawning may be adaptive if selection on birth date is non-random.

A second manuscript is planned to document age/size related differences in spawning times for 10 groundfish stocks. Duration of spawning times in relation to stock demography will be estimated. An analysis will be

undertaken to assess whether this temporal variable is related to recruitment variation. Relevance will also be explored on seasonal spawning closures and fixed closures over time. This work is being led by Peter Wright with data compilation being carried out and literature review completed.

A simulation framework is being developed to evaluate the consequences of different spawning times via cohort simulation. In this framework key parameters are being varied to determine their effects on offspring fitness and population size. This latter work is being led by Chris Chambers and a post-doctoral student. Preliminary findings presented at 2005 Annual Meeting of the American Fisheries Society.

**ToR 6: Co-Leaders: Fran Saborido Rey (Spain) and Joanne Morgan (Canada)**

**Provide recommendations for the collection of required data in existing research surveys, sentinel fisheries and captive fish experiments that are required to improve annual estimates of reproductive potential for stocks varying in data availability.**

Members: Anders Thorsen (Norway), Rick Rideout (Canada), Ed Trippel (Canada), Jonna Tomkiewicz (Denmark) and Jay Burnett (USA).

Type, quantity and quality of data that are needed to be collected to estimate reproductive potential will be identified. The importance as well as difficulty in sampling the variables will be considered. Sampling strategies will differ depending on the variable of interest. The frequency and sampling intensity needed when sampling maturity, with Baltic cod being used as a case study, will be reviewed with the intention of producing a publication: "Sampling intensity and frequency needed for estimating reproductive potential". In Mont Joli, the feasibility of holding a workshop led by Jonna Tomkiewicz on histological techniques for use in maturity identification was considered. The Workshop would take place in 2007 or 2008. The workshop approach may extend beyond histology. The fecundity sampling approach has been previously completed by Hilario Murua and co-authors and will be further evaluated by the project Reproduction and Stock Evaluation for Recovery (RASER).

**ToR 7: Co-Leaders: Loretta O'Brien (USA) and Nathalia Yaragina (Russia)**

**Explore the effects of the environment on Stock Reproductive Potential and how these relate to ToRs 2, 3 and 4.**

Members: Chris Chambers (USA), Gerd Kraus (Germany), Rick Rideout (Canada), Yvan Lambert (Canada), Olav Kjesbu (Norway), Anders Thorsen (Norway), and Tara Marshall (UK).

Life history models will be used to estimate the intrinsic rate of increase ( $r$ ) and net reproductive rate ( $R_0$ ) which will act as metrics to determine how environment influences stock reproductive potential (SRP). A total of 8 cod stocks will be compared (Northern Gulf of St. Lawrence, Northeast Arctic, Georges Bank, Gulf of Maine, Baltic, Icelandic, Flemish Cap, and Irish Sea). A literature review will be made for established relationships affecting reproduction, i.e., growth rate changes as temperature increases/decreases. Assimilate environmental time series, e.g., temperature, salinity, oxygen, age diversity that likely influence reproduction for each stock. Conduct simulations/scenario modeling and report preliminary findings at 6<sup>th</sup> WG Meeting in Iceland and complete manuscript in 2007.

**Future WG Activities**

The format for publication of results for the second set of ToRs will likely include both peer and nonpeer reviewed outlets and has yet to be determined for each specific ToR. Based on timing of completion, some manuscripts may be presented at the 2007 NAFO-led symposium on Reproductive and Recruitment Processes in Exploited Marine Fish Stocks.

The 6th Meeting of the NAFO Working Group on Reproductive Potential will be held in Klauster and Reykjavik, Iceland, during 17-21 August 2006. Dr. Gudrun Marteinsdottir (Iceland) has kindly agreed to help coordinate local arrangements with the support of the Marine Research Institute.

A Workshop was identified in ToR 6 which will be further discussed at the 6<sup>th</sup> WG Meeting.