StatMarine
Statistics for management of Norwegian marine resources

Innovation area: Marine

Key Innovator: Magne Aldrin

Partners: HI, UiO, NR

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Scope:

Develop new and powerful statistical methods for better estimation of fish stock abundance with a good evaluation of reliability. Evaluate and aid in rationalizing large and complex sampling programs for research survey and commercial catch data balanced against costs.

Results in 2012 and plans:

1. Estimating bycatch in the shrimp fishery

We have developed an innovative way to predict the (seasonally varying) map of presence of juvenile fish, based on sample data. The method outperforms current approaches, so that with the same sampling effort much more precise estimates can be obtained; alternatively, the same precision can be reached with fewer samples, reducing costs. This is used to decide whether fishing areas in the Barents Sea should be temporarily closed for shrimp fishing in periods with too many juvenile fish within the area. The results from this work were published in 2012. The approach taken in this work has great potential to optimise the monitoring of bycatch by the Directorate of Fisheries, but requires some extensions and software development. NR will discuss this with IMR and Fdir. We hope to be able to attract interest in our approach, so that it can enter the decision pipelines.

2. Estimating catch at age – ECA

We model and estimate the numbers of fish caught in each age group, based on samples from boats and hauls within boat. Previously, most of the samples were taken randomly from boats

in ports, but now most samples are from a rather small number of boats in the "reference fleet". The model is complex and the estimation is based on MCMC. It is documented in three publications and has great advantages in terms of appropriate modelling of precision and time saving compared to other methods used in Norway and rest of Europe. ECA is currently implemented as a standard tool by IMR for cod, haddock and saithe in the Barents Sea and the North Sea. IMR's goal is to implement ECA for all species assessed (by age structured models) by IMR. ECA includes features allowing the effect of errors in aging to be examined and for catch at age to be divided between difficult to distinguish stocks based on observed characteristics in otoliths. These features are not yet utilized in full but have the potential for several interesting biological results and consequently papers. It will be necessary to assist IMR in this process during the first four months of 2013. We will also investigate ways to make the approach available for other countries in Europe. In order for the method to be widely used it will require full implementation of discard estimation, which has been developed and published but never fully implemented. It is not clear how much work will be involved here. The aim is to promote ECA at IMR and worldwide as the best method for analyzing catch data. Communication and marketing efforts will be organized.

3. Design based estimation versus model based estimation of catch at age

Design based estimation is an alternative to ECA and is considered a powerful and robust method and is promoted by ICES as a framework for analyzing catch data. The main feature is that it utilizes the probability of inclusion for each object entering the analysis. The estimators often make no further assumptions and are known to be unbiased and thus robust. The model behind ECA can easily be used to simulate a fishery, which allows comparisons to be made between different analysis methods. A comparison between DBE and ECA is underway with preliminary results (using both simulated and real data) suggesting that ECA estimates have less uncertainty but no corresponding increase in bias. The first results from this comparison will be presented at an ICES workshop (WKPICS2) in Copenhagen November 6.-8. 2012. This comparison will be finalized and published to further promote and strengthen ECA as a tool for analyses.

4. Modelling survey data

Scientific surveys serve as an important data source to estimate indices of population abundance in space and time. These are a crucial input together with catch at age estimates to assess fish stocks. To improve the survey estimates and obtain realistic estimates of uncertainty, we will consider a model based approach where existing data will be used to fit spatio-temporal models similar to ECA. As a first start, we will consider using existing software such as GAM, ADMB and INLA. Also the ECA program may be utilized since the sampling strategy for survey data is similar to the landings data. The spatio-temporal models will form the basis for assessing and optimizing the survey design, leading to a more cost-effective survey strategy. This work is underway and a first draft will be available early in 2013.

5. Stock assessment using both catch and survey data

This combines results from ECA with data from research surveys for estimating the age distributed size of a fish stock. Samples from the posterior distribution of catch at age (available from ECA) are combined with a model for population abundance and survey indices to give weighted posterior samples of abundance and catch at age combined. The weights are obtained by using sequential importance sampling ideas. The theoretical foundation and implementation is almost finished and will result in a paper ready for submission in 2013. This method competes with several others, but it is the only one that builds on ECA, and we believe is the most precise one. Comparisons might be necessary. This will not become an instrument in the daily operations yet, but the aim is to come to this in some years.

6. Sampling design

Both catch and survey sampling are very expensive and can be improved by better design. By using the model behind ECA to simulate a fishery it is possible to estimate the uncertainty resulting from sampling different numbers of boats, hauls and fish. A preliminary model exists for this purpose. Given costs for the various kinds of sample it is possible to optimize catch sampling to achieve a desired level of uncertainty. This analysis will be completed in 2013. It can be extended to incorporate stock assessment modelling as described above to optimize sampling for management advice and quota setting. Work on optimizing the scientific survey depends on having completed the model for the survey data, but will be achieved by the same principles. The theoretical foundation for the simultaneous optimization of both sampling programs is in progress, but the actual implementation depends on having completed the above. This allows optimizing sampling designs across various sampling programs (including catch sampling and scientific surveys) with respect to estimates of parameters used for management advice on fish stocks obtained from the stock assessment model. Therefore it will provide guidelines on required sampling effort and design of catch sampling versus samples from scientific surveys and have significant implications for both costs as well as rationale pinpointing the main objective for sampling fish stocks.

Papers

Aanes, S., Engen, S., Sæther, B.-E., Aanes, R. Estimation of fish stock dynamical parameters from catch-at-age data and indices of abundance: can natural and fishing mortality be separated? Canadian Journal of Fisheries and Aquatic Sciences, 2007; Vol. 64: 1130-1142.

Aanes, Sondre; Nedreaas, Kjell; Ulvatn, Sigbjørn. Estimation of total retained catch based on frequency of fishing trips, inspections at sea, transhipment, and VMS data. ICES Journal of Marine Science, 2011; Vol. 68(8): 1598-1605.

Aldrin, M., Huseby, R.B., and Schweder, T. A note on tuning the catch limit algorithm for commercial baleen whaling. Journal of Cetacean Research and Management, 2008; Vol. 10: 191-194.

Aldrin, M; Mortensen, B; Storvik, G; Nedreaas, K; Aglen, A; Aanes,S. Improving management decisions by predicting fish bycatch in the Barents Sea shrimp fishery. ICES Journal of Marine Science, 2012; Vol. 69 (1): 64-74.

Bjørkvoll, EM; Grøtan, V; Aanes, S; Sæther, BE; Engen, S; Aanes, R. Stochastic Population Dynamics and Life-History Variation in Marine Fish Species. American Naturalist, 2012; Vol. 180(3): 372-387.

Hirst, D; Storvik, GO; Rognebakke, H; Aldrin, M; Aanes, S; Vølstad, JH. A Bayesian modelling framework for the estimation of catch-at-age of commercially harvested fish species. Canadian Journal of Fisheries and Aquatic Sciences, 2012; Vol. 69(12): 2064-2076.

Hjermann, Dag Øystein; Melsom, Arne; Dingsør, Gjert Endre; Durant, Joël M.; Eikeset, Anne Maria; Røed, Lars Petter; Ottersen, Geir; Storvik, Geir; Stenseth, Nils Christian (2007). Fish and oil in the Lofoten-Barents Sea system: synoptic review of the effect of oil spills on fish populations. Marine Ecology Progress Series, 2007; Vol. 339: 283-299.

Løland, A., Aldrin, M., Ona, E., Hjellvik, V., Holst, J.C. Estimating and decomposing total uncertainty for survey-based abundance estimates of Norwegian spring-spawning herring. ICES Journal of Marine Science, 2007; Vol. 64: 1302-1312.

Løland, A; Aldrin, M; Steinbakk, GH; Huseby, RB; Grøttum, JA. Prediction of biomass in Norwegian fish farms. Canadian Journal of Fisheries and Aquatic Sciences, 2011; Vol. 68(8): 1420-1434.

Otero, J; Jensen, AJ; L'Abée-Lund, JH; Stenseth, NC; Storvik, GO; Vøllestad, LA. Contemporary ocean warming and freshwater conditions are related to later sea age at maturity in Atlantic salmon spawning in Norwegian rivers. Ecology and Evolution, 2012; Vol. 2(9): 2192–2203.

Storvik, G., Hirst, D., Rognebakke, H., Aldrin, M., Aanes, S. and others from HI (2011). Catch at age. To be submitted to JASA.

Subbey, S; Pennington, M. Dealing with Complexity and Uncertainty in Stock Assessment – Application to NEA Cod (Gadus morhua) (Under review, Cand. Jour. Fish. And Aquatic Sc.)

Subbey, S; Pennington, M; Hjermann, D: A Parsimonious Approach to Estimating Spawning Stock Biomass for NEA Cod (Gadus morhua) (Under review, Cand. Jour. Fish. And Aquatic Sc.)

Villar, Jaime Otero; Jensen, Arne Johan; L'abee-Lund, Jan Henning; Stenseth, Nils Christian; Storvik, Geir Olve; Vøllestad, Leif Asbjørn. Quantifying the Ocean, Freshwater and Human Effects on Year-to-Year Variability of One-Sea-Winter Atlantic Salmon Angled in Multiple Norwegian Rivers. PLoS ONE, 2011; Vol. 6(8): e24005.

Vøllestad, Leif Asbjørn; Hirst, David; L'Abee-Lund, Jan Henning; Armstrong, John D.; MacLean, Julian C.; Youngson, Alan F.; Stenseth, Nils Chr. Divergent trends in anadromous salmonid populations in Norwegian and Scottish rivers. Proceedings of the Royal Society B, 2009; Vol. 276: 1021-1027.

Technical reports:

Aldrin, Magne; Huseby, Ragnar Bang; Simulation trials 2007 for a re-tuned Catch Limit Algorithm; NR-Note, SAMBA/12/07, 2007.

Hirst, David; Aldrin, Magne; Rognebakke, Hanne. User manual for catch-at-age program, January 2007 (R version). NR-Note, SAMBA/02/07, 2007.

Hirst, David; Rognebakke, Hanne; Storvik, Geir; Aldrin, Magne; Implementing the catch-at-age program for FRS Aberdeen, NR-Note SAMBA/09/07, 2007.

Løland, Anders; Aldrin, Magne; Steinbakk, Gunnhildur Högnadóttir; Huseby, Ragnar Bang: Prediction of biomass in Norwegian fish farms. NR-Note, SAMBA/40/08, 2008.

Rognebakke, Hanne; Hirst, David. Catch-at-age - Version 2.0: New features and validation of program. NR-Note, SAMBA/57/11, 2011.

Rognebakke, Hanne; Hirst, David; Storvik, Geir Olve. Catch-at-age - Version 2.0: Technical Report. NR-Note, SAMBA/44/11, 2011.

Rognebakke, Hanne; Hirst, David; Storvik, Geir Olve; Aldrin, Magne. Catch-at-age for multiple stocks: Modelling Skrei and Coastal Cod simultaneously. NR-Note, SAMBA/46/11, 2011.