Simon Fraser University
School of Resource and Environmental Management

Advanced Methods in Fisheries Assessment

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Meeting times: Thursday 10:30 – 2:20 Fisheries Computer Lab

Office hours TBA

Objectives of the course

After completing the course, students will:

1. possess fundamental skills in population dynamics modeling, parameter estimation and statistics, and harvest policy analysis in support of fisheries management decisions;
2. be able to develop simulation analyses to assess bias and precision of stock assessment methods and harvest recommendations;
3. apply critical evaluation skills to advice derived from fisheries stock assessments;
4. characterise and communicate risks and the consequences of uncertainty in fish stock assessments;
5. communicate practical advice to non-technical audiences.

Style of the course

The course covers the range of topics commonly encountered in modern stock assessments for marine and freshwater fisheries (although these topics are readily extended to assessment of terrestrial and marine wildlife as well). Non-linear parameter estimation and the performance of population dynamics and statistical models are the core themes that span these topics. Classroom discussion and hands-on computer lab sessions develop the biological, mathematical, and statistical background required for fisheries modelling and management as well as simulation approaches for performing and evaluating stock assessments. Course material and assignments are based on issues and approaches relevant to the management of marine and freshwater fisheries.

Main topics covered in REM 614

Quantitative Methods

1. Linear and non-linear parameter estimation methods for population dynamics models
2. Analytical and numerical maximum likelihood methods
3. Bayesian estimation
4. Open- and closed-form multivariable optimization

5. Modelling and estimation in MS Excel, R, and AD Model Builder software
6. Estimator performance testing using parametric and non-parametric bootstrapping

Stock assessment models and techniques
1. Stock-recruitment analysis
2. Closed and open population depletion estimators
3. Deterministic and stochastic population dynamics models
4. Mixed-error stock assessment models
5. Closed-loop harvest strategy evaluation
6. Area-under-the-curve escapement estimation
7. Statistical catch-at-age and Stock Synthesis methods
8. Retrospective analysis
9. Fisheries risk assessment
10. Passive and active adaptive management

Recommended Texts:
The following represent the most useful texts for quantitative modeling and assessment of fisheries and wildlife resources.

Hilborn, R. and Walters, C.J. 1992. *Quantitative Fisheries Stock Assessment: choice, dynamics, and uncertainty*. Kluwer Academic Publishers, Norwell, MA. (This is the basic reference text on fisheries stock assessment. It is written in a very accessible way)

Hilborn, R. and Mangel, M. 1997. The Ecological Detective.

Quinn, T. and Deriso, R.B. 1997. Quantitative fish dynamics.

Walters, C.J. 1986. Adaptive management of renewable resources.

Williams, B.K., Nichols, J.D., and Conroy, M.J. 2002. Analysis and management of animal populations. Academic Press, San Diego, CA. Note: this book contains both basic and advanced sections on topics ranging from parameter estimation and survey design to optimal control and adaptive management. It is the most comprehensive book available on population assessment.

Bolker, B. 2009. Ecological models in R.

Clark, J.S. 2007. Models for ecological data.

Student evaluation and grading
Evaluation will be based on five assignments involving the development and application of stock assessment techniques to either fake or real data. Most assignments will involve data analysis, population dynamics and statistical model formulation, computer implementation, and report writing. Grading is based on technical competence, critical evaluation, and communication.

Prerequisite courses

Students in this course should have basic knowledge of Fisheries Science and Management, Applied Ecology, and Statistics. Courses such as REM 613 (Fisheries Stock Assessment), REM 611 (Applied Population and Community Ecology), and REM 612 (Simulation Modelling in Natural Resource Management) provide most of the necessary background. Although not required, students who are not familiar with basic probability, likelihood, and Bayesian methods are also encouraged to take at least one upper level or graduate course in either Basic Probability, Risk Assessment (e.g., REM 625) or Experimental Design (e.g., STAT 650). We currently use R statistical software and MS Excel for quantitative work, although others such as Mathcad, Maple, AD Model Builder or Visual Basic could be used. Beginning in Fall 2012, there will be tutorials for using AD Model Builder.

Example Literature

The following are examples of advanced topics in stock assessment that should become accessible (i.e., readable, understable, workable) to students during and after completion of REM 614. Papers marked with "*" will be used to guide class discussion and assignments. Additional literature will be provided as needed.

*Schnute, J. and Richards, L. 1995. Influence of error on population estimates from catch-age models. CJFAS 52:2063-2077

Walters, C.J. and Punt,A. 1994. Placing odds on sustainable catch using virtual population analysis and survey data. CJFAS 51: 946-958.

Botsford, L.W. and Wickham, D.E. 1978. Behaviour of age-specific, density-dependent models and the Northern California Dungeness Crab fishery. J. Fish. Res. Board Can. 35: 833-843.

*Schnute, J.T. and Richards, L.J. 2001. The use and abuse of fishery models. CJFAS 58: 10-17.

Parma, A.M. and Deriso, R.B. 1990. Experimental harvesting of cyclic stocks in the face of alternative recruitment hypotheses. CJFAS 47: 595-610.

Meinhold, R.J. and Singpurwalla, N.D. 1983. Understanding the Kalman Filter. The American Statistician 37(2): 123-127.

*Walters, C. 1998. Evaluation of quota management policies for developing fisheries. 55: 2691-2705.

Parma, A.M. 2002. Bayesian approaches to the analysis of uncertainty in the stock assessment of Pacific halibut. AFS Symposium 27: 113-136.

Walters, C.J. 1987. Non-stationarity of production relationships in exploited populations. CJFAS 44:156 – 165

Cooke, J.G. 1999. Improvement of fishery-management advice through simulation testing of harvest algorithms. ICES J. of Mar. Sci. 56: 797-810 (see other references in this ICES issue).

*Walters, C.J. 1989. Value of short-term forecasts of recruitment variation for harvest management. CJFAS 46: 1969-1976.

Link, M.R. and Peterman, R.M. 1998. Estimating the value of in-season estimates of abundance of sockeye salmon (Oncorhynchus nerka). CJFAS 55: 1408-1418.

Walters, C.J. and Bonfil, R. 1999. Multispecies spatial assessment models for the British Columbia groundfish trawl fishery. CJFAS 56: 601-628.

Martell, S.J.D. and Walters, C.J. 2001. Implementing harvest rate strategies by directly monitoring exploitation rates and estimating catchability changes. Bull. Mar. Sci. 70: 695–713.
Walters, C.J. 2004. Simple representation of the dynamics of biomass error propagation for stock assessment models. CJFAS 61: 1061–1065.
McAllister, M. and Kirkwood. 1998. Using Bayesian decision analysis to help achieve a precautionary approach for managing developing fisheries. CJFAS 55: 2642–2661
*Schnute, J.T. and Kronlund, A.R. 2002. Estimating salmon stock-recruitment relationships from catch and escapement data. CJFAS 59: 433-449.
Myer, R. and Millar, R.B. 1999. Bayesian stock assessment using a state-space implementation of the delay-difference model. CJFAS 56: 37-52.

Readings by topic. Journal articles shown in **bold** are required reading. Normal font and text references are optional. Readings on topics outside this list may be assigned as needed.

1. Depletion models
   Hilborn and Walters 1992: Ch 12

2. Stock-recruitment analysis (A2)
   Hilborn and Walters 1992: Ch 12
   Schnute and Kronlund 1996. A management oriented approach to stock recruitment analysis. CJFAS 53: 1281-1293
   Myers et al. 1999. Maximum reproductive rate of fish at low population sizes. CJFAS 56: 2404-2419.

3. Omniscient manager simulation/Open form optimization
   Martell, Walters, and Hilborn. 2008. Retrospective analysis of harvest management performance for Bristol Bay and Fraser River sockeye salmon (Onchorhynchus nerka). CJFAS 65: 409-424.
   Walters 1989 Value of short-term forecasts of recruitment variation for harvest management. CJFAS 46: 1969-1976
   Cochrane and Starfield 1992. The potential use of predictions of recruitment success in the management of the south African anchovy resource. S. Afr. J. Mar. Sci. 12:891-902.

4. Area-under-the-curve escapement estimation
   Hilborn et al. 1990. Estimating spawning escapments from periodic counts: a comparison of methods. CJFAS 56: 888-896.
   Holt and Cox. 2008. Evaluation of visual survey methods for monitoring Pacific salmon (Oncorhynchus spp.) escapement in relation to conservation guidelines. CJFAS 65: 212-226

5. Risk assessment in fisheries
   Francis and Shotton 1997. "Risk" in fisheries management: a review. CJFAS 54:1699-1715.
   Francis 1992. Use of risk analysis to assess fisheries management strategies: a case study using orange roughy on the Chatham Rise, New Zealand. CJFAS 49: 922-930.

Cordue and Francis 1994. Accuracy and choice in risk estimation for fisheries assessment. CJFAS 51: 817-829.

6. Mixed-error production models

Punt 2003. Extending production models to include process error in the population dynamics. CJFAS 60: 1217-1228.

Schnute and Kronlund 2002. Estimating salmon stock-recruitment relationships from catch and escapement data. CJFAS 59: 433-449. (ignore Kalman Filter sections)

7. Statistical catch-age and Stock Synthesis

Schnute and Richards 1995. The influence of error on population estimates from catch-age models. CJFAS 52: 2063-2077.

Methot 1989. Synthetic estimates of historical abundance and mortality for northern anchovy. American Fisheries Society Symp 6: 66-82.

8. Closed loop feedback simulation

Cox and Kronlund 2008. Practical stakeholder driven harvest policies for groundfish fisheries in British Columbia, Canada. Fisheries Research 94: 224-237.

Kronlund et al. 2012. Can. Tech. Rep. Fish. Aquat. Sci. 3001. 37 pgs.

9. Adaptive management

Walters 1992. Perspectives on adaptive policy design in fisheries management. Jain and Botsford [eds], Applied Population Biology, 249-262. Kluwer Ac. Pub.

Collie and Walters 1993. Models that "learn" to distinguish among alternative hypotheses. Fisheries Research 18: 259-275.

Collie and Walters 1991. Adaptive management of spatially replicated groundfish populations. CJFAS 48: 1273-1284.

10. Multi-species assessment

Collie and Gislason 2001. Biological reference points for fish stocks in a multispecies context. CJFAS 58: 2167-2176.

Walters et al. 1997. Structuring dynamics models of exploited ecosystems from trophic mass-balance assessments. Rev in Fish Biol Fisheries 7: 139-172. (original Ecosim paper!)