Course Number:	**MAR 580**
Course Title:	**Advanced Population Modeling for Management of Living Natural Resources**
Instructors:	Gavin Fay, Assistant Professor School for Marine Science & Technology SMAST East 228; (508) 910-6363; gfay@umassd.edu
Class Location:	SMAST East Room 247
Class Time:	Lecture/Lab Tuesday/Thursday 9:30-11:30 Remote attendance via web using Zoom.
Student Hours:	Tue 8:30-9:30, Wed 13:00-15:00, Thu 8:30-9:30, and by appointment

Course Description: Instruction, demonstration and exercises in advanced statistical methods for estimation of population models for management of living natural resources. Principles of statistical inference and process-based model building recognizing uncertainty will be outlined. A wide range of population assessment methods will be developed through statistical programming and applied to fisheries and marine mammal data sets to fit complex nonlinear models by estimating values for parameters and associated uncertainty. State of the art programming software for implementing these models, including Template Model Builder, Automatic Differentiation (AD) Model Builder, and STAN will be used for class labs and assignments for both maximum likelihood and Bayesian estimation. The course is designed to train students to "have the ability to conduct high-quality scientific research in stock assessment, fishery population dynamics and related fields" (U.S. Dept. Commerce and U.S. Dept. Education 2008 NOAA Tech. Mem. NMFS-F/SPO-91).

Course Objectives:
1. Ability to apply principles underlying process based model building
2. Familiarity with advanced stock assessment models and their implementation
3. Experience in model building and parameter estimation
4. Understanding of quantitative theories, model diagnostics and results

Number of Credits: 4

Prerequisites:
Students should have taken coursework in applied statistics (e.g. MAR 536) and population dynamics (e.g. MAR 544), or seek permission from the instructors. *The Ecological Detective*, by Hilborn & Mangel, will serve as a good preparation and perspective on the course topics.

Students should also be familiar with the statistical programming software R. The following free resources are excellent refreshers or introductory training material for R:

- R for data science: https://r4ds.had.co.nz/
- Software carpentry R lessons: https://software-carpentry.org/lessons/
- Swirlstats (learn R in R): https://swirlstats.com/

Evaluation procedures:

1. Five homework assignments (80%) on advanced population models will be evaluated based on analytical approach, correct solution, and appropriate interpretation. Analytical components of assignments should include submission of complete analytical results (e.g., model scripts and input and output files). Assignments will integrate over course material and expand on the in-class computer exercises. Assignments should be accompanied by a written report (e.g. Rmarkdown or Word document) that provides answers to the assignment questions. Assignments are due before class on the due date. Assignments will be distributed and administered through github classroom.
2. Weekly in-class lab exercises (10%) will develop methods and applications of course material. Lab exercises should be submitted for pass/fail evaluation, with students able to resubmit revised solutions for full credit.
3. Participation (10%) during lectures and labs, including engagement in discussions on class readings, and reflection on learning. Attendance at the weekly lectures and labs is the best way to understand topics and assignments. Absence from class and labs can be requested in advance.
4. Late submission of homework assignments will be penalized 10 points (out of a 100) for each day that an assignment is late – assignments submitted later than three days after the deadline will not be graded.
5. Failure to complete any of these requirements for evaluation will result in a score of zero for missing components. A final grade of 'incomplete' may be recorded at the request of the student and the discretion of the professor.
6. If you have read this far, please use google search to find a picture of a pallas cat that best reflects your response to coding error messages, and send it to Gavin Fay attached to an email with the subject line "Here is a response to an error message", worth an extra 5 points on one homework assignment.
7. University policy on academic dishonesty, including plagiarism, applies (see: http://www.umassd.edu/studenthandbook/academicregs/ethicalstandards.cfm).

A full description of Academic Policies associated with this and other UMass Dartmouth courses can be found at:
https://www.umassd.edu/media/umassdartmouth/provost/omnibus_language_for_syllabi_-jan_11_2019.pdf

Required Hardware: Class will take place in the SMAST-East computer teaching lab. Students are able to make use of the workstations in this lab outside of classroom. However, students may find that completing coursework and lab exercises on individual laptop computers useful.

Required Software:

1. R (free download at http://r-project.org, students should also install Rstudio, an integrated development environment for R, free download at http://www.rstudio.com). It is recommended to update your version of R for the course.
2. Template Model Builder (see https://github.com/kaskr/adcomp/wiki/Download for installation instructions, and troubleshooting).

Course Materials: Materials will be distributed through a Google Drive folder for the course and via github classroom.

TMB Workshop: Additional sessions focused on Template Model Builder to take place week of September 23. 9/23: 1-5; 9/24: 9-12, 2-4; 9/26 9-12, 2-4. These sessions will be held in SMAST-E room 102.

Primary & Suggested Reading (weekly readings in schedule to be distributed by professor):

Bolker, B. M. 2008. Ecological models and data in R. Princeton University Press. . (draft pdf at https://ms.mcmaster.ca/~bolker/emdbook/book.pdf)

Brooks, M.E., Kristensen, K., van Benthem, K.J., Magnusson, A., Berg, C.W., Nielsen, A., Skaug, H.J., Machler, M. and Bolker, B.M., 2017. glmmTMB balances speed and flexibility among packages for zero-inflated generalized linear mixed modeling. The R journal, 9(2), pp.378-400.

Bunnefeld, N., Hoshino, E., & Milner-Gulland, E. J. 2011. Management strategy evaluation: a powerful tool for conservation?. Trends in Ecology & Evolution, 26: 441-447.

Caddy, J.F., 1999. Fisheries management in the twenty-first century: will new paradigms apply?. Reviews in Fish biology and Fisheries, 9(1), pp.1-43.

Cadrin, S.X. 2014 Do Not Believe Your Model Results. In Future of Fisheries: Perspectives for the Next Generation of Professionals, A. Lynch, N. Leonard & W. Taylor, eds. American Fisheries Society Press.

Cooch E & G White, eds. 2009. Program MARK: a gentle introduction. 7th edition.

Deroba J.J. and 30 co-authors. 2015. Simulation testing the robustness of stock assessment models to error: some results from the ICES Strategic Initiative on Stock Assessment Methods. ICES JMS 72: 19-30.

Dorn M. 2002. Advice on west coast rockfish harvest rates from Bayesian meta-analysis of stock- recruit relationships. North American Journal of Fisheries Management, 22: 280–300.

Fournier DA. 2008. An Introduction to AD Model Builder Version 9.0.0 For Use in Nonlinear Modeling and Statistics. http://admb-project.org.

Fournier DA, HJ Skaug, J Ancheta, J Ianelli, A Magnusson, MN Maunder, A Nielsen & J Sibert. 2011. AD Model Builder: using automatic differentiation for statistical inference of highly parameterized complex nonlinear models. Optimization Methods and Software 2011: 1-17.

Haddon, M. 2001. Modelling and Quantitative Methods in Fisheries. CRC Press.

Hilborn, R. 1990. Estimating the parameters of full age structured models from catch and abundance data. Int. North Pac. Fish. Comm. Bull. 50:207-213.

Hilborn, R. and Mangel, M., 1997. The ecological detective: confronting models with data. Princeton University Press.

Hilborn, R. and C.J. Walters. 1992. Quantitative Fisheries Stock Assessment: Choice, Dynamics, and Uncertainty. Chapman and Hall.

Hobbs, N.T. and Hooten, M.B., 2015. Bayesian models: a statistical primer for ecologists. Princeton University Press.

Kristensen, K., Nielsen, A., Berg, C.W., Skaug, H. and Bell, B., 2015. TMB: automatic differentiation and Laplace approximation. arXiv preprint arXiv:1509.00660.

Legault, C.M. and V.R. Restrepo. 1998. A flexible forward age-structured assessment program. ICCAT Working Doc. SCRS/98/58.

Mace, P.M. 1994. Relationships between Common Biological Reference Points Used as Thresholds and Targets of Fisheries Management Strategies. Canadian Journal of Fisheries and Aquatic Sciences, 1994, 51: 110-122, https://doi.org/10.1139/f94-013.

Maunder MN & AE Punt. 2013. A review of integrated analysis in fisheries stock assessment. Fisheries Research 142: 61-74.

Newman, K. B., Buckland, S. T., Morgan, B. J., King, R., Borchers, D. L., Cole, D. J., Besbeas, P., Gimenez, O., & Thomas, L. (2014). Modelling Population Dynamics. Model formulation, fitting and assessment using state-space methods. Springer.

Punt, A. E., & Hilborn, R. 1997. Fisheries stock assessment and decision analysis: the Bayesian approach. Reviews in Fish Biology and Fisheries, 7(1), 35-63.

Punt, A. E., Butterworth, D. S., Moor, C. L., De Oliveira, J. A., & Haddon, M. (2014). Management strategy evaluation: best practices. Fish and Fisheries.

Quinn, T.J., 2003. Ruminations on the development and future of population dynamics models in fisheries. Natural Resource Modeling, 16(4), pp.341-392.

Restrepo. V.R. & Legault, C.M. 1998. A Stochastic Implementation of an Age-Structured Production Model. In Fishery Stock Assessment Models Alaska Sea Grant College Program AK-SG-98-01, 1998.

Thorson, J. T., & Minto, C. 2014. Mixed effects: a unifying framework for statistical modelling in fisheries biology. ICES Journal of Marine Science. doi: 10.1093/icesjms/fsu213

Title IX statement: The purpose of a university is to disseminate information, as well as to explore a universe of ideas, to encourage diverse perspectives and robust expression, and to foster the development of critical and analytical thinking skills. In many classes, including this one, students and faculty examine and analyze challenging and controversial topics.

If a topic covered in this class triggers post-traumatic stress or other emotional distress, please discuss the matter with the professor or seek out confidential resources available from the Counseling Center, http://www.umassd.edu/counselling/, 508-999-8648 or -8650, or the Victim Advocate in the Center for Women, Gender and Sexuality, http://www.umassd.edu/sexualviolence/, 508-910-4584. In an emergency contact the Department of Public Safety at 508-999-9191 24 hrs./day.

UMass Dartmouth, following national guidance from the Office of Civil Rights, requires that faculty follow UMass Dartmouth policy as a "mandated reporter" of any disclosure of sexual harassment, abuse, and/or violence shared with the faculty member in person and/or via email. These disclosures include but are not limited to reports of sexual assault, relational abuse, relational/domestic violence, and stalking. While faculty are often able to help students locate appropriate channels of assistance on campus, disclosure by the student to the faculty member requires that the faculty member inform the University's Title IX Coordinator in the Office of Diversity, Equity and Inclusion at 508-999-8008 to help ensure that the student's safety and welfare is being addressed, even if the student requests that the disclosure not be shared.

For confidential counseling support and assistance, please go to http://www.umassd.edu/sexualviolence/

Course topics outline (subject to change):

Date	Day	Topic	Reading	Assignment
9/5	Th	probability & likelihood review	Bolker et al. 2008, Chaps 4, 6	HW 1 assigned
9/10	Tu	NO CLASS - ICES/GROUNDFISH UPDATES	Quinn 2003, Caddy 1999	
9/12	Th	NO CLASS - ICES/GROUNDFISH UPDATES	Cadrin 2014	
9/17	Tu	process-based model building, matrix pop dy models	Newman et al. 2014, Chap 2	
9/19	Th	Numerical methods review, model fitting in R	Cooch & White 2009, Thorson & Minto 2014	
9/23	M	TMB workshop: Session 1	Kristensen et al. 2015, Brooks et al. 2017, TMB book	HW 1 due
9/24	Tu	TMB workshop: Session 2		HW 2 assigned
9/24	Tu	TMB workshop: Session 3		
9/26	Th	TMB workshop: Session 4		
9/26	Th	TMB workshop: Session 5		
10/1	Tu	surplus production models	Hilborn & Walters 1992, Chap 8; Polacheck et al. 1993	
10/3	Th	simulation testing, bootstrapping	Deroba et al. 2015	
10/8	Tu	state-space models	Newman et al. 2014, Chap 3-4	HW 2 assigned
10/10	Th	state-space production models	Punt 2003	
10/15	Tu	Guest lecture: multispecies production models		
10/17	Th	age structured models	Hilborn 1990	
10/22	Tu	statistical catch at age models	Restrepo & Legault 1998	HW2 due
10/24	Th	integrated population modeling	Maunder & Punt 2013	HW4 assigned
10/29	Tu	Reference point estimation	Mace 1994	
10/31	Th	Diagnostics and data-weighting	Francis 2011	
11/5	Tu	Projections, decision tables		
11/7	Th			
11/12	Tu	State-space age-structured models	Miller et al.	
11/14	Th	Bayesian estimation, MCMC		HW 4 due, HW 5 assigned
11/19	Tu	multi-state & tag recovery models	Cooch & white 2009	
11/21	Th	Covariates, time-varying parameters		
11/26	Tu	Size-based models		
11/28	Th	NO CLASS-THANKSGIVING		
12/3	Tu	Stock assessment software packages	Methot and Wetzel 2013	HW 5 due
12/5	Th	Management Strategy Evaluation	Edwards & Dankel Chaps 1-2.	
12/10	Tu	Course Review		