

**Course Number:** MAR XXX  
**Course Title:** Bayesian Statistics & Hierarchical Modeling for Ecology  
**Instructors:** Gavin Fay, Assistant Professor  
School for Marine Science & Technology  
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**Class Location:** SMAST East Room 103  
**Class Time:** Wednesdays 10:00-12:00  
**Office Hours:** By appointment

**Course Description:** Independent study in Bayesian statistics and hierarchical modeling with an emphasis on a mathematical statistics. Bayesian modeling has become an indispensable tool for ecological research. This course will provide an overview of the principles of Bayesian statistics and concepts. Students will work through the recent textbook by Hobbs & Hooten (2015) with additional supplementary reading from the literature. A set of problems in the textbook will be worked through using multiple methods, including writing out properly factored statistical expressions representing the Bayesian models, as well as implementation of models using current state-of-the art algorithms and software. Advanced topics in Bayesian methods will also be covered. Weekly meetings will be used to review chapter readings, discuss additional key papers on weekly topics, and work through problems as a group.

**Course Objectives:**

1. Obtain understanding of principles of Bayesian statistics, and the relationship of Bayesian methods to other statistical concepts and estimation methods.
2. Be able to use basic statistical distributions to write joint and conditional posterior distributions for Bayesian models.
3. Practical experience implementing Markov chain Monte Carlo (MCMC) methods to estimate the posterior distributions of parameters. Conduct worked examples using problems from textbook to create sets of computer code in R, JAGS, ADMB, and STAN.
4. Apply Bayesian methods to own research.

**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 instructor.

**Principal Text**

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

**Credits:** 3

**Evaluation procedures:**

1. Attendance and participation in discussion at weekly meetings to review chapter readings (30%).
2. Compilation of key papers on assigned advanced topics, most pertinent to student thesis research (10%).

3. Contribution to online repository of worked-through solutions to textbook problems, including computer code to run examples in R, JAGs, and STAN (10%).
4. Project detailing implementation of code for a Bayesian analysis applied to student's dataset of choice (50%).
5. Late submissions 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.
6. 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.
7. University policy on academic dishonesty, including plagiarism, applies (see: <http://www.umassd.edu/studenthandbook/academicregs/ethicalstandards.cfm>).

**Required Hardware:** laptop computer

**Required Software:**

1. R (free download at <http://r-project.org>, students may also wish to install Rstudio, an integrated development environment for R, free download at <http://www.rstudio.com>)
2. JAGS
3. STAN
4. AD Model Builder (free download at <http://admb-project.org>)

**Schedule and tentative list of topics (subject to change)**

Week	Topic	Reading
9/7	Review: Probability, Likelihood, Bayes Theorem	Chaps 1-4
9/14	Simple Bayesian models	Chap 5
9/21	Hierarchical Bayesian models 1	Chap 6
9/28	Hierarchical Bayesian models 2	Chap 6
10/5	Bayesian computation, Markov Chain Monte Carlo 1	Chap 7
10/12	Markov Chain Monte Carlo 2, Model checking	Chap 8
10/19	Sampling-Importance-Resampling, other methods	McAllister et al. 2001
10/26	Model selection, Model averaging	Chap 9
11/2	Empirical Bayes	Ch 5 of Carlin & Louis 2009
11/9	ADMB & hierarchical models using INLA	Skaug & Fournier 2006
11/16	Hamiltonian Monte Carlo & Stan	Hoffman & Gelman 2014
11/30	Hybrid Bayesian networks	Ch 3 of Scutari & Denis 2015
12/7	Project presentations, Finalize code/example repository	

**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/>