FISH 670: Quantitative Analysis for Marine Policy Decisions (3 credits)

Instructor: **Dr. Keith R. Criddle**
Contact Information: kcriddle@sfos.uaf.edu 796-5449 LP 203
Office hours: TR 10-12 or by appointment

Time/Location: TR 3:40-5:10 Juneau (LP 103) and by video conference as demand warrants.

Course Description: An introduction to the practical application of mathematical programming, operations research, simulation, cost-benefit analysis, cost effectiveness analysis, regional impact assessment, economic valuation, risk analysis, adaptive management, and other decision theoretic tools in preparation of regulatory documents required for the management of living marine resources and for assessment of environmental damages. *Prerequisites: STAT F401 and MATH F200, MATH F262, or MATH F272; graduate standing or permission of instructor.* (3+0)

Course Goals and Learning Objectives: Upon completion of this course, students will have a working background and an understanding of pitfalls associated with the use and abuse of quantitative methods as they are applied to the evaluation of alternatives and options for the management of living marine resources. Armed with this working background, students will be prepared to participate on analytic teams that are engaged in preparing economic analyses for inclusion in regulatory documents such as Environmental Assessments and Regulatory Impact Reviews, or to review and comment on draft regulatory documents on behalf of their employer. Students who successfully complete this course will:

- Be familiar with the federal laws and regulations that must be addressed when actions that could affect marine resources are being contemplated.
- Be able to structure and solve decision trees for unitary and multiple criteria.
- Understand how Benefit-Cost analyses are structured and potential misuses of Benefit-Cost analysis.
- Understand how present value is determined and how the choice of discount rate affects estimated benefits and costs.
- Be familiar with methods used to estimate the value of environmental goods and services the strengths and shortcomings of alternative estimation methodologies.
- Be familiar with methods used to estimate regional impacts aware of common abuses of regional impact analysis.
- Understand how mathematical programing models are structured and how they can be used to solve optimization problems.
- Be familiar with the principles of risk analysis, risk assessment, and risk management.

Course Readings: J. Loomis and G. Helfand. (2001) Environmental Policy Analysis for Decision Making. Kluwer Academic Publishers. Selected readings from academic articles and federal and state agency reports

Instructional Method: A combination of lectures, facilitated discussions, and work sessions. UAF's Electronic Blackboard will be used to post readings, data sets, examples, and exercises.

Evaluation: Evaluation will be based on 8 homework assignments (10% each) designed to reinforce topics covered in lectures and to allow you to demonstrate your ability to work with the analytic methods introduced in class. In addition, there will be a final exam (20%) designed to assess your ability to retain and integrate material covered in the lectures and homework assignments. Each homework assignment is worth 100 points and will require several hours of effort. The final is worth 100 points. Course grades will be assigned based on a weighted sum of scores on the exercises and exam: $\geq$90 = A; $\geq$80 but <90 = B; $\geq$70 but <80 =C; $\geq$60 but <70 =D; and < 60 = F.

Course policies: Academic dishonesty cannot be excused; at best it represents indolence, at worst it is a willful and unconscionable act of intellectual theft. Students enrolled in this class are expected to conform with the UAF Student Code of Conduct (www.uaf.edu/catalog/current/academics/regs3.html). Plagiarism and cheating are particularly heinous forms of academic dishonesty and will not be tolerated. If you plagiarize you will receive an F in this course and you may face additional disciplinary actions initiated by UAF. Plagiarism includes representing another person's work as one's own by paraphrase or direct quotation. It also includes the unacknowledged use of materials prepared by anyone engaged in the selling of term papers or other academic materials. You are welcome to discuss the homework assignments with one another but you are expected to do your own work. You are expected to do your own statistical analysis to obtain estimates of parameter values and you are expected to write your own computer code (in Excel, R, or another modeling platform) to solve the computer modeling exercises. If you cheat on the final exam you will receive an F in

this course and you may face additional disciplinary actions initiated by UAF. The computer modeling exercises are due at the start of class on the assigned day. Unless prior permission has been granted by the instructor, late assignments will be docked 10 points for each day after the due date. That is, an assignment turned in within 24hrs of the deadline is worth, at most, 90 points; an assignment turned in more than 24 hours late but less than 48 hours late is worth, at most, 80 points; etc. The final exam is due at the end of the scheduled examination period. Late exams will not be accepted.

Disabilities Services: The office of Disability Services implements the Americans with Disabilities Act (ADA), and insures that UAF students have equal access to the campus and course materials. I will work with the Office of Disabilities Services (208 WHIT 474-5665) to provide reasonable accommodation to students with disabilities.

Other Support Services: The Writing Center (www.alaska.edu/english/writing-center/) offers tutorial and fax-tutorial assistance with grammar, composition, and style. Students connected to the UAF network (Ethernet or wireless on-campus or through VPN off-campus) have access to UAF Library catalogs, electronic journal holdings, and interlibrary loan resources. Miscellaneous support services (e.g., tutorial services, instruction in mathematics skills, academic advising, mentoring and personal support, cultural and social engagement, use of laptop computers, labs, and other technology resources, and direct financial assistance to qualified low-income participants) are available through UAF Student Support Services (www.uaf.edu/sssp/index.html).

Registration: Registration can be completed at: uaonline.alaska.edu.

COURSE OUTLINE & READING ASSIGNMENTS:

Course Outline and Tentative Schedule

1. **Introduction:** **weeks 1& 2**

   National Environmental Protection Act (NEPA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Endangered Species Act (ESA), Magnuson-Stevens Fisheries Conservation and Management Act (MSFCMA), Resource Conservation and Recovery Act (RCRA), Marine Mammal Protection Act (MMPA), Clean Water Act (CWA), Coastal Zone Management Act (CZMA), Executive Order 12866 (Regulatory Impact Review—RIR), Regulatory Flexibility Act (RFA), Administrative Procedures Act (APA), etc.

   Homework 1 is due at end of this module.

2. **Decision Criteria and Decision Methods for Policy Analysis:** **weeks 3 & 4**

   Decision Criteria: efficiency, equity, political/social acceptability, legality/operational feasibility. Decision Methods: dominance (payoff tables, decision trees, Minimax, Maximax, Minimum Regret, Expected Value, Value of Information, game theory), criteria ranking, benefit-cost analysis, multiattribute analysis.

   Homework 2 is due at end of this module.

3. **Principles of Benefit-Cost Analysis:** **weeks 5 & 6**

   Effect of alternate specifications of the status quo. Effect of accounting stance. Gross benefits, net benefits, marginal net benefits. Consumer surplus, producer surplus, social welfare, willingness-to-pay vs. willingness-to-accept.

   Homework 3 is due at end of this module.

4. **Discounting Benefits and Costs Over Time:** **weeks 7 & 8**

   Time preferences for benefits and costs. Net present value. Benefit-cost ratio. Internal rate of return.

   Homework 4 is due at end of this module.

5. **Valuation of Environmental Resources and Quality:** **weeks 9 & 10**

   Stated preferences vs. revealed preferences. Hedonic pricing. Travel cost method. Contingent valuation. Contingent behavior. Conjoint analysis. Benefit transfer.

   Homework 5 is due at end of this module.

6. **Regional Economic Analysis, Input-Output Models and Multipliers:** **weeks 11 & 12**

   Economic linkages and leakages, multiplier effects. Effect of accounting stance. Input-output models. Social accounting matrix. Economic base models. General equilibrium models. RIMS. IMPLAN.

   Homework 6 is due at end of this module.

7. **Optimization and Linear Programming:** **weeks 13 & 14**

   Specification of objectives and constraints. Sensitivity analysis. Duality. Shadow values.

   Homework 7 is due at end of this module.

8. **Risk Analysis:** **week 15**

   Risk assessment. Risk management.

   Homework 8 is due at end of this module.

Final Exam.

Supplementary Readings:

Regulatory Framework

- Criddle KR. 2008. The legal context of US fisheries management and the evolution of rights-based management in Alaska. Pages 369-382 in R Townsend, R Shotton, & H Uchida (editors). *Case Studies in Fisheries Self-Governance*. FAO Fisheries Technical Paper. No. 504. Rome, FAO.
- EO 12866-Regulatory Planning and Review.
- MSFCMA 2007 as amended.
- NMFS 2000 Guidelines for economic analysis of fishery management actions.

Decision Criteria/Decision Methods

Analytic Hierarchy Process

- DiNardo G, D Levy, B Golden. 1989. Using decision analysis to manage Maryland's river herring fishery: an application of AHP. *Journal of Environmental Management* 29:193-213.
- McDaniels TL. 1995. Using judgment in resource management: a multiple objective analysis of a fisheries management decision. *Operations Research* 43:415-426.
- Merritt MA, KR Criddle. 1993. Multiple criterion decision theory for judging management strategies and resolving conflict: a case study of the Kenai River recreational fisheries. Pages 683-704 *in* G Kruse, DM Eggers, RJ Marasco, C Pautzke, TJ Quinn II (Editors). *Proceedings of the International Symposium on Management Strategies for Exploited Fish Populations*, Alaska Sea Grant, Fairbanks, AK.

Bayesian Decision Analysis

- Charles AT. 1988. In-season fishery management: a Bayesian model. *Natural Resource Modeling* 2:599-629.
- Fried SM, R Hilborn. 1988. Inseason Forecasting of Bristol Bay, Alaska, sockeye salmon *(Onchorhynchus nerka*) abundance using Bayesian probability theory. *Canadian Journal of Fisheries and Aquatic Science* 45:850-855.
- Robb CA, RM Peterman. 1998. Application of Bayesian decision analysis to management of a sockeye salmon fishery. *Canadian Journal of Fisheries and Aquatic Science* 55: 86–98.
- Schnute JT, A Cass, LJ Richards. 2000. A Bayesian decision analysis to set escapement goals for Fraser River sockeye salmon. *Canadian Journal of Fisheries and Aquatic Science* 57: 962–979.

Game Theory

- Dockner E, G Feichtinger, A Mehlmann. 1989. Noncooperative solutions for a differential game model of fishery. *Journal of Economic Dynamics and Control* 13:1-20.
- Kaitala V, M Pohjola (1988) Optimal recovery of a shared resource stock-a differential game with efficient memory equilibria. *Natural Resource Modeling* 3: 91-119.
- Lee DJ, SL Larkin, CM Adams. 2000. Bioeconomic analysis of alternative swordfish management policies. *Marine Resource Economics* 15: 77-96.
- Levhari D, LJ Mirman. 1980. The great fish war: an example using a dynamic Cournot-Nash solution. *Bell Journal of Economics* 11:322-334.
- Russell, CS. 1990. Game models for structuring monitoring and enforcement systems. *Natural Resource Modeling* 4:143-173.

Multiple Criterion Decision Analysis

- Boutilier J, D Noakes, D Heritage, J Fulton. 1988. Use of multiattribute utility theory for designing invertebrate fisheries sampling programs. *North American Journal of Fisheries Management* 8:84-90
- Healey M. 1984. Multiattribute analysis and the concept of optimum yield. *Canadian Journal of Fisheries and Aquatic Science* 41:1393-1406.
- Hilborn R, CJ Walters. 1977. Differing goals of salmon management on the Skeena River. *Journal of the Fisheries Research Board of Canada* 34:64-72.
- Mardle S, S Pascoe. 1999. A review of applications of multiple-criteria decision-making techniques to fisheries. *Marine Resource Economics* 14: 41–63.

- Pan M, P-S Leung, SG Pooley. 2001. A decision support model for fisheries management in Hawaii: a multilevel and multiobjective. Programming approach. *North American Journal of Fisheries Management* 21:293–309.
- Sylvia G. 1994. Market information and fisheries management-a multiple-objective analysis. *North American Journal of Fisheries Management* 14:278-290.
- Sylvia G, RR Enriquez. 1994. Multiobjective bioeconomic analysis: an application to the Pacific whiting fishery. *Marine Resource Economics* 9:311-318.
- Walker KD, RB Rettig, R Hilborn. 1983. Analysis of multiple objectives in Oregon coho salmon policy. *Canadian Journal of Fisheries and Aquatic Science* 40: 580-587.

Structured Decision Making

- Bain MB. 1987. Structured decision making in fisheries management: trout fishing regulations on the Au Sable River, Michigan. *North American Journal of Fisheries Management* 7:475-481.
- MacGregor, BW, RM Peterman, BJ Pyper. 2002. A decision analysis framework for comparing experimental designs of projects to enhance Pacific salmon. *North American Journal of Fisheries Management* 22:509–527
- Mendelssohn R. 1980. Using Markov decision models and related techniques for purposes other than simple optimization: analyzing the consequences of policy alternatives on the management of salmon runs. *Fishery Bulletin* 78: 35-50.
- Peters CN, DR Marmorek, RB Deriso. 2001. Application of decision analysis to evaluate recovery actions for threatened Snake River fall chinook salmon (*Oncorhynchus tshawytscha*). *Canadian Journal of Fisheries and Aquatic Science* 58: 2447–2458
- Peters CN, DR Marmorek. 2001. Application of decision analysis to evaluate recovery actions for threatened Snake River spring and summer chinook salmon (*Oncorhynchus tshawytscha*). *Canadian Journal of Fisheries and Aquatic Science* 58: 2431–2446
- Tomlinson JWC, PS Brown. 1979. Decision analysis in fish hatchery management. *Transactions of the American Fisheries Society* 108: 121-129.

Cost-Benefit Analysis

- Herrick Jr. SF, I Strand, D Squires, M Miller, D Lipton, J Walden, and S Freese. 1994. Application of cost-benefit analysis to fisheries allocation decisions: the case of Alaska walleye pollock and Pacific cod. *North American Journal of Fisheries Management* 14:726-741.
- Huppert DD, D Squires. 1987. Potential economic benefits and optimum fleet size in the Pacific coast trawl fleet. *Marine Resource Economics* 3:297-319.
- Johnson DM, RJ Behnke, DA Harpman, RG Walsh. 1995. Economic benefits and costs of stocking catchable rainbow trout: a synthesis of economic analysis in Colorado. *North American Journal of Fisheries Management* 15: 26-32
- NOAA 1991. BSAI 18 GOA 23 Inshore-Offshore I SEIS-EA.
- NOAA BSAI 38 GOA 40 Inshore-Offshore II EA-RIR-IRFA
- NOAA BSAI 51 GOA 51 Inshore-Offshore III
- OMB. 2000. Guidelines to standardize measures of costs and benefits and the format of accounting statements.
- OMB. 2003. Circular A-4—Guidance to Federal agencies on the development of regulatory analysis as required under Section 6(a)(3)(c) of Executive Order12866
- Smith VK. 1987. Nonuse values in benefit cost analysis. *Southern Economic Journal* 54:19-26
- Somerton DA, J June. 1984. Cost-benefit method for determining optimum closed fishing areas to reduce trawl catch of prohibited species. *Canadian Journal of Fisheries and Aquatic Science* 41: 93-98.

Discounting Benefits and Costs

- Mendelssohn R. 1982. Discount factors and risk aversion in managing random fish populations. *Canadian Journal of Fisheries and Aquatic Science* 39:1252-1257.
- NOAA. 1999. Discounting and the treatment of uncertainty in natural resource damage assessment.

Valuation of Environmental Resources

- Arrow K, R Solow, PR Portney, EE Leamer, R Radner, H Schuman. 1993. Report of the NOAA Panel on Contingent Valuation

- Henderson MM, KR Criddle and ST Lee. 2000. The economic value of Alaska's Copper River personal-use and subsistence fisheries. *Alaska Fishery Research Bulletin* 6: 63-69.
- Layman CS, JR Boyce, KR Criddle. 1996. The economic value of the recreational king salmon fisheries on the Gulkana and Klutina Rivers, Alaska. *Land Economics* 72: 113-128.
- Lipton DW, K Wellman, IC Sheifer, RF Weiher. 1995. Economic valuation of natural resources—a handbook for coastal resource policymakers, NOAA Coastal Ocean Program Decision Analysis Series No. 5, NOAA Coastal Ocean Office, Silver Spring, MD.

Regional Economic Impacts

- Hamel C, M Herrmann, ST Lee, KR Criddle, HT Geier. 2002. Linking sportfishing trip attributes, participation decisions, and regional economic impacts in Lower and Central Cook Inlet, Alaska. *Annals of Regional Science* 36: 247-264.
- Huppert DD. 1995. Fisheries and the economy: measuring economic contribution and economic impact. School of Marine Affairs, University of Washington.
- Seung CK, EC Waters. 2005. A review of economic models for Alaska fisheries. AFSC processed report. 2005-01
- Steinback SR. 1999. Regional economic impact assessments of recreational fisheries: an application of the IMPLAN modeling system to marine party and charter boat fishing in Maine. *North American Journal of Fisheries Management* 19: 724–736,

Optimization and Linear Programming

- Rothschild BJ, JW Balsiger. 1971. Linear-programming solution to salmon management. *Fishery Bulletin* 69: 117-139.

Risk Analysis

- Brown BE, GP Patil 1986. Risk analysis in the Georges Bank haddock fishery—a pragmatic example of dealing with uncertainty. *North American Journal of Fisheries Management* 6: 183-191.
- Criddle KR and AY Streletski. 2000. Multiple criterion management of a sequential fishery. *Annals of Operations Research* 94: 259-273.
- Criddle KR. 1996. Predicting the consequences of alternative harvest regulations in a sequential fishery. *North American Journal of Fisheries Management* 16:30-40.
- Criddle KR, M Herrmann, JA Greenberg, and EM Feller. 1998. Climate fluctuations and revenue maximization in the eastern Bering Sea fishery for walleye pollock. *North American Journal of Fisheries Management* 18: 1-10.
- Ferson S, L Ginzburg and A Silvers. 1989. Extreme event risk analysis for age-structured populations. *Ecological Modelling* 47:175-187.
- Jones DD and C J Walters. 1976 Catastrophe theory and fisheries regulation. *Journal of the Fisheries Research Board of Canada* 33:2829-2833.
- Mendelssohn R. 1979 Determining the best trade-off between expected economic return and the risk of undesirable events when managing a randomly varying population. *Journal of the Fisheries Research Board of Canada* 36:939-947.
- Mendelssohn R. 1980. Using Markov decision models and related techniques for purposes other than simple optimization: analyzing the consequences of policy alternatives on the management of salmon runs. *Fishery Bulletin* 78:35-50.
- NRC. 1983. *Risk Assessment in the Federal Government: Managing The Process*. National Academy Press, Washington, D.C., 191p.
- NRC. 1993. *Issues in Risk Assessment*. National Academy Press, Washington, D.C., 356p.
- NRC. 1996. *Understanding Risk: Informing Decisions in a Democratic Society*. National Academy Press, Washington, D.C., 249p.
- NRC. 2004. *Non-native Oysters in the Chesapeake Bay*. National Research Council, National Academy Press. Washington DC 325p.
- Silvert W. 1978. The price of knowledge: fisheries management as a research tool. *Journal of the Fisheries Research Board of Canada* 35(1978):208-212.
- Walters CJ, D Ludwig. 1987. Adaptive management of harvest rates in the presence of a risk averse utility function. *Natural Resource Modeling* 1: 321-337.
- Walters CJ, R Hilborn. 1978. Ecological optimization and adaptive management. *Annual Review of Ecological Systems* 9: 157-188.