Syllabus

UGA Ecology 4100/6100
Ecosystem Complexity in the Marine Environment
Seeking an Answer to the Question:
What is Biocomplexity?

Maymester 2003
Skidaway Institute of Oceanography
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Course Overview

Ecosystem Complexity in the Marine Environment – Seeking an Answer to the Question: What is Biocomplexity?
UGA Ecology 4100/6100 taught at Skidaway Institute of Oceanography

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Objectives

In this course students will
1. Build understanding of biocomplexity by constructing ecological models and making empirical measurements that are incorporated into a model framework;
2. Learn an approach and methodology for studying biocomplexity that integrates systems theory, empirical research, ecological modeling, and network environ analysis; and
3. Develop knowledge about salt marsh natural history and its ecosystem structure and function.

Grading

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
<th>Due</th>
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<tbody>
<tr>
<td>Participation</td>
<td>15%</td>
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</tr>
<tr>
<td>Informal System Description (Task 3.1)</td>
<td>5%</td>
<td>Due Day 3</td>
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<tr>
<td>Species Resume (Task 3.3)</td>
<td>5%</td>
<td>Due Day 6</td>
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<tr>
<td>Empirical Progress Report (Task 2.4)</td>
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<td>Due Day 9</td>
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<tr>
<td>Modeling Progress Report (Task 4.4)</td>
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<td>Due Day 10</td>
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<td>NEA Progress Report (Task 5.2)</td>
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<td>Due Day 14</td>
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<td>Final Written Report (Task 6.1)</td>
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<td>Due Day 15</td>
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<td>Final Oral Report (Task 6.2)</td>
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<td>Sunday</td>
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<td>Day 0</td>
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<td>Students Arrive</td>
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<td>18</td>
<td>19</td>
<td>Day 4</td>
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<td>Due: Task 3.2</td>
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<td>25</td>
<td>26</td>
<td>Day 9</td>
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<td>Due: Task 2.3</td>
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<td>1</td>
<td>2</td>
<td>Day 14</td>
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<td>Due: Task 5.2</td>
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<td>H: Tasks 6.1</td>
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**Legend**

- H = Homework
- R = Reading
Detailed Course Schedule

**Week 1**

**Day 0 — Tuesday, May 13**

**PM:**
1:00 pm – 5:00 pm. Residential students arrive
7:00 pm. Barbeque dinner

**Day 1 — Wednesday, May 14 (low tide 2:08 pm)**

**AM:** Orientation
9:00 am – 9:15 am. Introduction to SkIO. (Jim Sanders, Director)
9:15 am – 9:30 am. Ground rules & logistics. (Verity)
9:30 am – 10:00 am. Course elements and objectives — empirical: field & lab; computer lab; interim project report; final synthesis individual report; group oral report. (Whipple)
10:00 am – 12:00. Tour of SkIO: main lab, library, housing, waterfront, laboratory facilities. (Frischer & Verity)

**PM:** Orientation to Field & Labs (4 hrs)
1:00 pm – 5:00 pm. Field trip to principal habitats **Task 3.1 System Description** (all instructors)
   a) Prepare descriptions of major observable features taking account of structure & function, boundaries; similarities & differences; geology & soils; meteorology & hydrology; biology & ecology.
   b) Consider the question: What is Biocomplexity?
   c) Start empirical set-up & measurements.

**Homework:**
- Task 1.1 Initial Definition of Biocomplexity
- Task 3.1 Informal System Description

**Readings:**

**Day 2 — Thursday, May 15** (low tide 3:00 pm)
8:00 am, all day. Field Excursion: John Crawford (all instructors). The Georgia Coastal Zone – Habitats and Organisms. *Meet at MECA Dock.*

**Readings:**
Day 3 — Friday, May 16th (low tide 3:51 pm)

AM:
9:00 am – 10:30 am. Presentation & Discussion: Task 1.1 Initial Biocomplexity Definition (all instructors)

10:30 am – 12:00. Conceptual modeling: 3 C’s of model conceptualization — compartments, connections, and controls — and adjacency matrices, and hierarchical modeling. (Patten)

PM:
1:30 pm – 3:30 pm. Task 3.2 Formal System Description (all instructors)
   a) Students will organize into groups (3–4) to focus on a particular ecosystem sector.
   b) Each group should identify the ecosystem “boundary” and create a conceptual list of compartments, connections and controls (including boundary inputs and outputs of their ecosystem sector).
   c) Assign Task 3.3 Species Resume

4:00 pm – 5:30 pm. Guest Lecture: Structure and Function of Salt Marsh Ecosystems (Merryl Alber, UGA Marine Science)

Homework:
- Task 3.2 Conceptual Modeling
- Task 3.3 Species Resume

Readings:

Week 2

Day 4- Monday, May 19th (low tides 6:23 am, 6:25 pm)

AM:
9:00 am – 11:00 am. Presentation & Discussion: Task 3.2 Conceptual Models. (all instructors)

11:00 am – 12:00 m. Lecture: What is a system? Progressive definition I (Patten)

PM:
1:00 pm – 2:30 pm. Guest Lecture (1:30 pm – 2:30 pm): Geology: Formation of barrier islands and salt marshes. (Clark Alexander, SkIO)

5:00 pm – 7:00 pm. Lab & Field: Take it to the field: Conceptual models intersect empirical work. (all instructors)
   i. Identify data gaps and potential empirical investigations
   ii. Determine feasibility of obtaining data focusing on potential field observations
Homework:
- Task 2.1 Empirical Research Proposal

Day 5 – Tuesday, May 20th (low tide 7:05 am, 7:19 pm)

**AM:**
9:00 am – 11:00 am. Presentation & Discussion: Task 2.1 Empirical Research Proposal. (all instructors).
11:00 am – 12:00 m. Lecture: What is a system? Progressive definition II (Patten)

**PM:**
1:00 pm – 3:00 pm. Lecture: Simulation Modeling: Introduction to STELLA and model dynamics (Patten)
3:00 pm – 5:30 pm. Unstructured time available for group work, homework, etc.
5:30 pm – 8:00 pm. Task 2.2 Field observations and experiments. (all instructors).

Readings:

Day 6 – Wednesday, May 21st (low tide 8:09 am, 8:22 pm)

**AM:**
7:00 am – 10:00 am. Field & Lab. Continued field & laboratory work.
10:30 am – 12:00. Lecture: Dynamic modeling with STELLA (Whipple, Borrett)
a) Methods for constructing flow controls: constant rates, time-varying coefficients, functional responses
b) Describe and discuss donor and recipient control; linear vs non-linear formulations
c) Describe and demonstrate how to use STELLA graphical control functions

**PM:**
1:00 pm – 2:30 pm. Lecture: What is environment? I. Review of concepts (Patten)
3:00 pm – 5:00 pm. Computer Laboratory. Task 4.1 Simulation Modeling (all instructors)

Homework:
- Task 4.1: Model Quantification

Reading:
Day 7 – Thursday, May 22\textsuperscript{nd} (low tides 9:07 am, 9:20 pm)

\textbf{AM}:
8:00 am – 10:30 am. Field & Lab. Continued field & laboratory work.
11:00 am – 12:00. Lecture: What is a system? Progressive definition III. (Patten)

\textbf{PM}:
1:15 pm – 2:15 pm. Guest Lecture. Example Biocomplexity. Chemical Ecology
Title: TBA (Georg Pohnert)
2:30 pm – 3:45 pm. Lecture: Systems Analysis: Sensitivity Analysis and Model Evaluation. (Whipple, Patten)
   a) What can it tell you?
   b) Discuss the types of sensitivity analyses that can be done-changes in model structure, initial conditions, flow control parameters, etc.
   c) Give a Stella model demonstration of sensitivity analysis with example models. How does this relate to Biocomplexity?
4:00 pm – 5:00 pm. Guest Lecture. Example Biocomplexity. Complexity found at the individual-level: Mixotrophy and life stage transformations (Gabriela Smalley)

\textbf{Reading}:

Day 8 – Friday, May 23\textsuperscript{rd} (low tides 10:04 am, 10:26 pm)

\textbf{AM}:
8:00 am – 12:00. Field & Lab. Continued field & laboratory work.

\textbf{PM}:
1:00 pm – 2:30 pm. Model Demonstration: Patagonian Coastal Zone Management. (Patten)
3:00 pm – 4:30 pm. Lecture: Examples of Biocomplexity: Phaeocystis Biocomplexity Project. (Verity)

\textbf{Homework}:
- Task 4.2 Sensitivity Analysis
- Task 2.3 Empirical Progress Report

\textbf{Reading}:

\textbf{Week 3}

Day 9 – Monday, May 26\textsuperscript{th} (low tide 12:32 pm) MEMORIAL DAY

\textbf{AM}:
9:00 am – 11:00 am. Presentation & Discussion: Task 2.3 Empirical Progress Report. (all instructors)
11:00 am – 1:30 pm. Field, Lab, or Modeling Work. (as needed)

PM:
2:30 pm – 7:00 pm. Field Trip/Barbeque to be arranged

Homework:
- Task 4.3 Modeling Progress Report

Day 10 – Tuesday, May 27th (low tide 1:13 pm)

AM:
9:00 am – 11:00 am. Presentation & Discussion: Task 4.3 Modeling Progress Report (all instructors)
11:00 am – 12:00. Lecture. What is environment? II: Environ. (Patten)

PM:
12:30 pm – 3:00 pm. Field & Lab Continued field & laboratory work. (all instructors).
3:30 pm – 5:00 pm. Lecture. Examples of Biocomplexity. Microbial Ecology of the Salt Marsh. (Frischer)

Day 11 – Wednesday, May 28th (low tide 1:54 pm)

AM:
9:00 am – 9:45 am. Lecture. Introduction to Network Environ Analysis. (Patten, Borrett, Whipple)
9:45 am – 11:00 am. Lecture. Structural Network Environ Analysis I: Pathway extension and proliferation. (Patten)
11:00 am – 12:00. Lecture. Structural Network Environ Analysis II: Pathway generation. (Borrett)

PM:
1:00 pm – 3:00 pm. Field, Lab & Computer Work
3:30 pm – 5:00 pm. Guest Lecture. Chemical ecology and biocomplexity: indirect and cascading effects of prey chemical defenses. (Mark Hay)

Reading:

Day 12 – Thursday, May 29th (low tide 12:21 pm)

AM:
9:00 am – 9:50 am. Lecture. Throughflow Network Environ Analysis I: Network Nonlocality, Homogenization and Amplification. (Patten)
10:00 am – 10:50 am. Lecture. Throughflow Network Environ Analysis II: Network Unfolding and Enfolding. (Whipple)
11:00 am – 12:00. Lecture. Take it to the field: Connecting theory to the marsh ecosystem (Patten, all instructors present). (Lecture in the Marsh, bring sack lunch)
  a) Return to field to discuss how systems theory articulates with objects in the field
  b) dual (input/output) nature of environment
  c) hierarchical systems
  d) specifying system boundaries
  e) continue sampling, running experiments, collecting and analyzing data

PM:
1:00 – 3:00 pm. Continued Field, Lab, Computer Work.
3:30 pm – 5:00 pm. Computer Laboratory. Introduction to Matlab & NEA.m. (Borrett)

Homework:
• Task 5.1 Network environ analysis

Day 13 – Friday, May 30th (low tide 3:14 pm)
AM:
9:00 am – 10:30 am. Guest Lecture: Microbial Ecology of Acid Mine Drainage Systems. (Jenn Brofft, SkIO)
PM:
1:30 pm – 5:00 pm. Continued Field, Lab & Modeling Work.

Homework:
• Task 1.2 Revised Biocomplexity Definition
• Task 5.2 NEA Initial Results

Week 4
Day 14 – Monday, June 2nd (low tides 5:13 am, 5:12 pm)
AM:
9:00 am – 11:00 am. Presentation & Discussion: Task 5.2 NEA Initial Results. (15 minute presentations, all instructors)
11:00 am – 12:00. Lecture. Examples of Biocomplexity: Long-term environmental monitoring at SkIO (Verity)

PM:
1:00 pm – 4:00 pm. Modeling Workshop. Integrating the Models. (Borrett, all instructors present).
4:00 pm – 6:00 pm. Complete Field, Lab & Modeling Work.
Day 15 – Tuesday, June 3rd (low tides 5:52 am, 5:53 pm)
**AM:**
10:00 am – 12:00 am. **Task 6.2 Final Oral Reports** (groups 1 & 2)

**PM:**
1:00 pm – 3:00 pm. **Task 6.2 Final Oral Reports** (groups 3 & 4)
5:00 pm. **Task 6.1 Final Written Report Due.**
6:00 pm – cows come home. Oyster roast/party at SkIO

Day 16 – Wednesday, June 4th

**AM:**
9:00 am – 12:00. Discussion: What is our answer to the question: What is biocomplexity? (all instructors)

**PM:**
1:00 pm – 5:00 pm. Clean-up, packing, housing checkout, depart SkIO
Reading List


Task List

1. Biocomplexity Definitions
   1.1 Initial definition (individual). Due Day 3
   1.2 Revised definition (individual). Due Day 15

2. Empirical monitoring and experiments
   2.1 Construct empirical research proposal (group): Due Day 5
   2.2 Field observations and experiments by students (group).
   2.3 Empirical Progress Report: Oral (15 min) and written (2 pages + figures and tables, see example) report for group discussion (group): Due Day 9

3. Conceptual modeling and system description
   3.1 Informal system description: ≤ 1 page description of system, include hand-drawn map. (individual): Due: Day 3
   3.2 Formal system description of habitats: conceptual model in Stella (group): Due Day 4
   3.3 Species CV (individual): Due Day 6

4. Simulation modeling with Stella
   4.1 Quantification of ecosystem sector conceptual model (group). Due Day 15
   4.2 Sensitivity analysis with group models (group). Due Day 15
   4.3 Modeling Progress Report: Oral (15 min) and written (2 pages + figures and tables, see example) report for group discussion (group): Due Day 10

5. Network environ analysis (NEA)
   5.1 Implement NEA using Matlab (group): Due Day 15
   5.2 Oral presentation of initial NEA results (15 min) (group): Due Day 14

   6.1 Written synthesis reports (individual): Due Day 15
   6.2 Group oral reports (30-40 min.) (group): Due Day 15
Example Outline for Final Report (Task 6.1)

I. Introduction
   1. What is biocomplexity?
      a. initial biocomplexity definition
      b. final biocomplexity definition
   2. Overview of the Roebling Marsh Ecosystem

II. Empirical Project
   1. Introduction
   2. Materials & Methods
   3. Results
   4. Discussion & Conclusions

III. Modeling Project
   1. Introduction
   2. Background Information
   3. Overview of Model
   4. Model Description
      a. Conceptual model
      b. Simulation model
   5. Model Evaluation
      a. Comparison of simulated and observed (empirical & literature) system dynamics
      b. Sensitivity analysis
   6. Discussion & Conclusions

IV. Network environ analysis (static)
   1. Methods
   2. Results
   3. Discussion and Conclusions

V. Conclusions & Synthesis
   Questions to address
   1. How did the empirical work complement, intersect, and miss the modeling work?
   2. What is required to study and understand biocomplexity?
   3. Is the Roebling salt marsh a complex system? If so, how?
   4. What insights about biocomplexity come from the empirical work?
   5. What insights about biocomplexity come from environ theory and network environ analysis?
Tide Table

*(To be inserted)*
Map of Skidaway

Building Inventory
Skidaway Institute of Oceanography

1 - Dorothy Rohbock Laboratory and Administration Building
2 - Mechanical Shop A
3 - Skidaway Inst. Student Housing (Whitted Apartment)
4 - Barn Laboratory Complex
5 - Skidaway Institute Conference Center
6 - Salt Water Laboratory Facility
7 - Skidaway Inst. Student Housing (Buchner House)
9 - Bio-Renewable Laboratory & Field Complex
10 - Conference Annex
11 - Maintenance Shop B (Carpentry, Plumbing)
12 - Maintenance Shop C (Grounds, Mechanical)
13 - Post Doc Facility (Electronics, Postdoc Offices, Laboratory)
14 - Grey's Reef Marine Sanctuary (NOAA)
15 - Flume Test Laboratory Building
16 - Marine Emergency Spill Response Storage Building
17 - Georgia Southern University (Marine Program)
18 - Gas Bottle Storage Facility
22 - Marine Operations & Equipment Storage
23 - Solvent Storage Facility
24 - Pier Landing Laboratory Research Complex
27 - Library & Distance Learning Facility
35 - Skidaway Inst. Housing (Baggett Apartment)
36 - Skidaway Inst. Housing (Sears Cottage)
37 - Skidaway Inst. Housing (Martin & Thomas Apartments)
38 - Skidaway Inst. Student Housing (Quad Plex Apartment: Carpenter, Knight, Menzel & Zeliger)
39 - BERM Teaching laboratory
70 - Life Science Building