Complex Coastal and Marine Socio-Ecological Systems

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Learning objective and outline

1. Understand key concepts of complex coastal and marine social-ecological systems
   - Complex adaptive systems
   - Social-ecological systems
   - Ecosystem services
   - Scale
   - Resilience

- Social-ecological systems frameworks

- Defining your SES

- Examples of SES
Social-Ecological systems are Complex System

- Complex systems exhibit characteristics that stem from the interactions and patterns within the system
  - Non deterministic, unpredictable
  - Process dependent
  - Multiple-scale feedbacks
  - Self-organization
When they have the capacity to self-organize, learn and adapt they are complex adaptive systems (CAS)

Properties: aggregation, non-linearity, diversity, uncertainty, self-organization, resilience
Complex adaptive behaviour

- Informal pedestrian path formation
- Slow traffic jams
- Stadium waves
- Standing ovations
- Stock markets
- Human societies

- Immune systems
- Human and other animal brains
- Ants and termites
- Birds flocking
- Fish schooling
- Ecosystems
Why Social-Ecological Systems approach for Oceans research governance?
Social ecological system (SES)

- Human society shapes nature
- Nature shapes human society
- Humans and nature coevolving
- Social and ecological systems are inevitably linked and integrated ... the delineation between the two systems is artificial and arbitrary (Berkes and Folke 1998)
Figure 3. Conceptual diagram showing the key features and processes of the coastal zone.
Coastal Ecosystem Services
Scales and Levels
(Cash et al. 2006)
Holling et al. (1995) observed that:

- Ecological change are not gradual and continuous, they are epsotic

- Spatial attributes are not uniform or unvariable at different scales

- Ecosystem has no singular equilibrium state, but may have alternating stable states and multiple equilibria

- Ecosystem are hierarchically structured (panarchy)
Holling’s Adaptive Renewal Cycle (1986)
Scale: processes and variables on different size and temporal cycles

Gunderson, Lance and C. S. Holding.

Scale and cycle mis-matches can challenge governance
- Geological, climate etc. cycles
- Project versus political cycles
- Policy and management cycles
- Legal and institutional cycles
Resilience
(Holling 2001)

- the extent to which ecosystems can absorb recurrent natural and human perturbations and continue to regenerate without slowly degrading or unexpectedly flipping into alternate states

- the capacity of a system to absorb disturbance, undergo change and still retain essentially the same function, structure, identity, and feedbacks
Valleys represent stability domains, balls represent the system, and arrows represent disturbances. Engineering resilience is determined by the slopes. Ecological resilience is described as the width. Adaptive capacity refers to the ability of the system to remain in a stability domain, as its shape changes.

(http://mysite.verizon.net/vzesz4a6/current/id610.html)
Losing resilience - Shifting domains
**Transform-ability**

<table>
<thead>
<tr>
<th>Preparing for transformation</th>
<th>Navigating the transition</th>
<th>Building resilience of the new direction</th>
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**Window of opportunity**

*In the preparation phase, institutional entrepreneurs and their networks may work simultaneously at different scales of the social-ecological system. By intervening at broader institutional levels, they can open up new trajectories of development.*

*In the navigation phase, cross-scale brokers can provide bridging functions that connect different actors operating at different scales and launch new initiatives and scale up innovations.*

*In the building resilience phase bridging organizations can create incentives and foster values for stewardship in the new context.*

*Source: Olson et al. 2004, Folke et al. 2009*
"Resilience" as applied to ecosystems, or to integrated systems of people and the natural environment, has three defining characteristics:

1. The amount of change the system can undergo and still retain the same controls on function and structure
2. The degree to which the system is capable of self-organization
3. The ability to build and increase the capacity for learning and adaptation

http://www.resalliance.org
Examples of Frameworks Linking Social and Ecological System

Analysis oriented
Action oriented
The Resource system approach for fisheries mng’t (Charles 2001)

Figure 2. The resource systems approach (Charles 2001).
Social-Ecological Systems in traditional management systems (Berkes et al. 2003)
Another version of Ostrom’s framework
Social-Ecological Systems for Community Conservation (Berkes et al 2015)
DPSIR
(European Environmental Agency)
Millennium Ecosystem Assessment Framework (MA 2005)
IPBES Conceptual Framework (Diaz et al. 2015)
Defining your SES

- What is your question?
- What is the problem you wish to address?
- Who are the stakeholders? Their interests? Their values? Their knowledge?
- In what biophysical (ecosystem) scale the problem can be addressed?
- In what social (institutional scale) scale the problem can be addressed?
- What time scale is needed to answer your question?
Multiple stakeholders

- Oil & Gas
- Urban Sewage disposal
- Mariculture
- Different fisher groups
- Navy
- Nuclear power plant
- Harbor
- Researchers
- Protected areas
- Beach tourism
- Sight seeing tourism
- Fish traders
- diving
Example from The Caribbean

Spatial (geographical area)
- Gulf & Carib.
- Sub-region
- Country
- Watershed
- Settlement

Jurisdictional (administration)
- International
- Regional
- National
- District
- Community

Network (links and ties)
- Regional
- Industry
- Organization
- Household
- Individual

(Links and ties)
The Caribbean

social-ecological system

"social"

"ecological"
Nested institutions of governance

Community managed area local level plan
Multi-scale policy-cycles are based on regional governance framework.
Key indirect drivers leading to direct drivers of ecosystem change in the Brazilian coast zone (Marone et al. 2011)

<table>
<thead>
<tr>
<th>Key Indirect Drivers</th>
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<tbody>
<tr>
<td>Increase of the population and urbanization in the coastal area</td>
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<tr>
<td>Growth of the tourism and leisure industry</td>
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<tr>
<td>Increase in industrialization and in public and private services</td>
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<td>Increase on the demand for non-renewable energy</td>
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<td>Intensification of sea and terrestrial transportation</td>
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<tr>
<td>Intensification of aquaculture</td>
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<tr>
<td>Intensification of conservationist view and policies (governmental agencies and NGOs)</td>
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<tr>
<td>Expansion of new Pentecostal evangelical movements</td>
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<tr>
<td>Increase in number of environmental and developmental NGOs</td>
</tr>
<tr>
<td>Cultural homogenization (consumerism, lack of criticism, individualism and immediacy in the context of the globalization)</td>
</tr>
</tbody>
</table>
DPSIR analysis of marine pollution
Ibiraquera Lagoon, South Brazil
Figure 3.3: Different periods of Lagoon and fishery management in Ibaquaera, as represented by successive iterations of the adaptive renewal cycle (Holling 1986, Gunderson et al. 1995).

Memory (remember): renewal of shrimp larvae and fish from ocean to lagoon
Return (revolt): return of adult shrimp and fish from lagoon to ocean
Aventureiro, Ilha Grande, Rio de Janeiro, Brazil

Por
D. Prado
C. S. Seixas
Pathway of social-ecological change - focus on livelihoods (Prado et al. 2015)
Self-organization of SES in integrated conservation and development initiatives (Seixas & Davy 2008)
Pred Nai community, Thailand Mangrove forest restoration and management (Senyk 2005)
Q: Shall one foster resilience in SES?
Building resilience in local social-ecological lagoon systems (Berkes & Seixas 2005)

<table>
<thead>
<tr>
<th>Learning to live with change and uncertainty</th>
<th>Promote diversity for re-organisation and renewal</th>
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<tr>
<td>Learning from crises</td>
<td>Maintain diversity of institutions</td>
</tr>
<tr>
<td>Building capacity to respond to change</td>
<td>Maintain diversity of functional groups –</td>
</tr>
<tr>
<td>Developing coping strategies</td>
<td>ecological memory.</td>
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<tr>
<td></td>
<td>Use social memory.</td>
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<td></td>
<td>Support experimentation</td>
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<tr>
<td><strong>Combine different kinds of knowledge</strong></td>
<td><strong>Promote self-organisation</strong></td>
</tr>
<tr>
<td>Building capacity to monitor the environment</td>
<td>Building capacity for resource-users to self-</td>
</tr>
<tr>
<td>Combining local and scientific knowledge</td>
<td>organise</td>
</tr>
<tr>
<td>Building capacity for participatory</td>
<td>Self-organising for equal access to fisheries</td>
</tr>
<tr>
<td>management</td>
<td>and distribution of benefits</td>
</tr>
<tr>
<td>Creating cross-scale mechanisms to share</td>
<td>Build conflict management mechanisms</td>
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<tr>
<td>knowledge</td>
<td>Matching the scale of ecosystem and governance</td>
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<td>Creating multi-level governance</td>
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7 Principles for Building Resilience in Social-Ecological Systems
(Simonsen et al. 2015)

- Maintain diversity and redundancy
- Manage connectivity
- Manage slow variables and feedbacks
- Foster complex adaptive systems thinking
- Encourage learning
- Broaden participation
- Promote polycentric governance systems
Thank you!