The Science of Coastal and Marine Spatial Planning: Social Science and Legal Expertise Integration

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Stanford University
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Outline

• Addressing (mundane but) Fundamental Institutional Capacity Issues
• Putting Ecological Principles to Work
• Tackling Cumulative Impacts
• Learning from Public Lands Planning and Management
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Fundamentals

Marine spatial planning entails the strategic use of information to change behavior and achieve specified objectives.

- Gathering relevant information
- Re-packaging information in ways that are easy to understand
- Making information products easy to obtain, use, share
Working Definition: Spatial Data Infrastructure

“... the underlying infrastructure ... that allows data to be shared between and within organizations, states or countries ...”

August, 2009 Workshop

- Leadership
- Improved communication among agencies, ocean users, and citizens
- Common points of access to relevant information
- Searchable and discoverable data holdings
- Tools for sharing data easily and using it collaboratively
Mandate for Modernizing CA’s Information Infrastructure

• AB 2125 (Ruskin, 2010)
  • “The protection and enhancement of California’s ocean resources depends on comprehensive and coordinated ocean management.”
  • Need for improved management, sharing, and analysis of geospatial information.

• OPC and state agencies:
  • Assess agency needs, capacity re: geospatial information.
  • Increase availability of baseline information.
  • Support collaborative management and use of geospatial information.
2009-2010: Understanding Institutional Constraints

NOW, THEREFORE, the California Coastal Marine Geospatial Work Group hereby:

RESOLVES to urge the state of California to expediently fund a stakeholder-requirements study for the development of data-sharing resources to support the efficient access, management, viewing, and downloading of coastal and marine geospatial information to the benefit of natural resource management, agency staff, decision-makers, and the general public; and

1 The CCMG-WG is composed of state and federal agency representatives, as well as private, non-profit, and academic members. For a full list of members, visit http://www.cio.ca.gov/wiki/CGCOceans.ashx and view the CCMG-WG charter under the list of attachments.
2011: Institutional Capacity

New mandate

Lack of resources

Awareness of data & tools

More connected & informed management

Increased ability to cooperate and share?

Needed information and tools identified.

Infrastructure foundations under construction. MSP?
2011: Improving Institutional Capacity

Literature review: GIS studies

Various studies show that GIS yield positive benefits / costs ratios

Benefits / costs analysis for 18 GIS projects from around the world show benefits of up to 7:1

- Average B:C ratio from a shared system is 4:1

- System used only for computer aided mapping and updating

- Used also for planning and engineering purposes

- 1 & 2 plus all commonly used datasets are automated

- Used for automating conventional maps

- Common system is created such that all info can be shared among different organizations

- Transitioning from manual map production to an automated system

North Carolina’s GIS is projected to have benefits that far outweigh costs

North Carolina’s GIS is projected to have benefits that far outweigh costs

- Benefits
- Recurring cost
- Non recurring cost

This study specifically focused on the benefits to the interagency leadership Team’s utilization of data for orthophotography, parcel boundaries, roads, rivers, and streams.

Note that both of these studies were focused on the implementation of GIS systems, not on the implementation of a shared platform.
2011: Improving Institutional Capacity

**Important IMS Institutional Design Features**
An effective and sustainable geospatial IMS depends as much on institutional structures and relationships as on specific technologies and tools. IMS institutional design consists of an array of complex and inter-related factors. Without particular design features such as broad institutional support, effective governance, and strong collaboration, an IMS may have little participation and limited perceived utility and its technological system may become obsolete quickly. In the text box, we present the design features that provide the foundations for effective IMS structures and relationships in the case studies.

**Evaluation Criteria**
Based on an assessment of these design features and the best practices related to the design features, Blue Earth Consultants identified six evaluation criteria of exemplary IMS institutional designs. Below we present an evaluation framework, including definitions of these criteria and explanations of their importance to an effective and sustainable IMS (see Table 1). Our research suggests that “tier one” evaluation criteria—authority, durability, and usability—are most important for evaluating potential institutional designs. “Tier two” criteria—accountability, adaptability, and efficiency—while not essential, are nevertheless important for the OPC to consider.
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Cumulative Impacts of Climate Change

Ecological Principles (Foley, et al. 2010)

- Vulnerability
- Cumulative Impacts
- Climate Change
- Resilience

Species Diversity

- Habitat Diversity/Heterogeneity
- Connectivity
- Key Species

UNCERTAINTY

CONTEXT
Ecosystem Considerations

- **Vulnerability**
  - likelihood that a species or habitat will sustain losses due to a disturbance, natural or human-induced

- **Cumulative Impacts**
  - the overall impact on ecosystems caused by the effects of multiple human activities that co-occur in space and/or time

- **Climate Change**
  - impacts from sea level rise, temperature increase, ocean acidification, and inundation

- **Resilience**
  - measure of the persistence of ecosystems and their ability to resist change or recover to a similar state following a disturbance
Ecological principles for CMSP

1. Maintain native species diversity
   - abundance, richness, genetic, functional redundancy
     * productivity, vulnerability, stability, resilience

2. Maintain habitat diversity & heterogeneity
   - representation, arrangement, dynamic habitats
     * diversity, productivity, connectivity, shelter

3. Maintain populations of key species
   - keystone, foundation, top predators, basal prey
     * diversity, stability, resilience, ecosystem engineering

4. Maintain connectivity between populations
   - population persistence, flow of subsidies
     * diversity, resilience, recovery

Foley et al. 2010, Marine Policy (34)
Ecological Principles in Practice

- Map attributes of ecosystems and ecosystem services
- Identify use-ecosystem conflicts and compatibilities
- Set impact thresholds based on vulnerability and cumulative impact loads
- Develop objective-based planning principles
- Monitor effect of management decisions
- Inform adaptive management efforts
Ecological principles in practice

- Map attributes of ecosystems and ecosystem services
- Identify use-ecosystem conflicts and compatibilities
- Set impact thresholds based on vulnerability and cumulative impact loads
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In a Perfect World
Putting the Ecological Principles to Work: California State-Level Agency Decision-making

Step 1: Identify Treatment of Ecological Principles within Enabling Authorities

- Marine Life Management Act
- Coastal Act
- The Public Trust Doctrine

The California Environmental Quality Act: (Compliance or Equivalent)

Inter-Agency Communication

Step 2: Draft Guidance Incorporating Ecological Principles into Agency Management Decisions

- Fishery Management Plan: White Seabass
- CDP: Dredging Humboldt Bay
- General Lease for Right of Way Use: AT&T Fiber Optic Cable
<table>
<thead>
<tr>
<th>Ecological Principle</th>
<th>Features/data sets</th>
<th>California Laws</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native species diversity</td>
<td>• Migratory hotspots</td>
<td>• Coastal Act &amp; PTD</td>
</tr>
<tr>
<td></td>
<td>• ADDITIONAL DATA NEEDED</td>
<td>• MLPA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• CEQA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Fish &amp; Game Code</td>
</tr>
<tr>
<td>Habitat diversity &amp;</td>
<td>• Eelgrass</td>
<td>• Coastal Act &amp; PTD</td>
</tr>
<tr>
<td>heterogeneity</td>
<td>• Persistent kelp forests</td>
<td>• MLPA</td>
</tr>
<tr>
<td></td>
<td>• Estuaries</td>
<td>• CEQA</td>
</tr>
<tr>
<td></td>
<td>• Nearshore habitats</td>
<td>• Fish &amp; Game Code</td>
</tr>
<tr>
<td></td>
<td>• Hard substrate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Upwelling centers</td>
<td></td>
</tr>
<tr>
<td>Key species</td>
<td>• Seabird density &amp; colonies</td>
<td>• Coastal Act &amp; PTD</td>
</tr>
<tr>
<td></td>
<td>• Eelgrass</td>
<td>• MLPA</td>
</tr>
<tr>
<td></td>
<td>• Persistent kelp forests</td>
<td>• CEQA</td>
</tr>
<tr>
<td></td>
<td>• Leatherback sea turtles</td>
<td>• CESA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Fish &amp; Game Code</td>
</tr>
<tr>
<td>Connectivity</td>
<td>• Upwelling centers</td>
<td>• Coastal Act &amp; PTD</td>
</tr>
<tr>
<td></td>
<td>• River plumes</td>
<td>• MLPA</td>
</tr>
<tr>
<td></td>
<td>• Storm water run-off</td>
<td>• CEQA</td>
</tr>
<tr>
<td></td>
<td>• Agricultural run-off</td>
<td>• State Water Quality Act</td>
</tr>
</tbody>
</table>
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• **Tackling Cumulative Impacts**
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Cumulative Impacts

• Total impact to ecosystems that results from the impact of individual actions overlapping in time and/or space

• Assessment of cumulative impact required for national and many state-level environmental review processes
  - no standardized method for assessing impact
  - assessments are often incomplete and ineffective
Applying Cumulative Impact Scores

- Necessary to ground truth cumulative impact score with actual ecosystem condition
- Still needs to be done for the California Current
  - Use existing survey data and impact model to determine what the “scores” mean
  - Start with a case study in the Monterey Bay with coastal managers
- Learn to apply together (scientists and managers)
### Mitigating Cumulative Impacts

<table>
<thead>
<tr>
<th>Activity</th>
<th>Current Score</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean engineering</td>
<td>0.0</td>
<td>+0.5</td>
</tr>
<tr>
<td>Fishing: Demersal Destructive</td>
<td>0.07</td>
<td>— 0.07</td>
</tr>
<tr>
<td>Fishing: Demersal Non-Destructive High-Bycatch</td>
<td>0.08</td>
<td>— 0.08</td>
</tr>
<tr>
<td>Fishing: Demersal Non-Destructive Low-Bycatch</td>
<td>0.1</td>
<td>— 0.1</td>
</tr>
<tr>
<td>Fishing: Pelagic High-Bycatch</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Fishing: Pelagic Low-Bycatch</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Fishing: Recreational</td>
<td>0.2</td>
<td>— 0.2</td>
</tr>
<tr>
<td>Inorganic pollution</td>
<td>0.2</td>
<td>— 0.03</td>
</tr>
<tr>
<td>Organic pollution</td>
<td>0.7</td>
<td>— 0.02</td>
</tr>
<tr>
<td>Nutrient runoff</td>
<td>0.1</td>
<td>— 0.02</td>
</tr>
</tbody>
</table>

**Initial cumulative impact score** 4.6  
**New cumulative impact score** 4.6
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U.S. Ocean, Coasts, & Great Lakes

Significant regional diversity
Many values and uses
National policies + local interests
National Forest System

Significant regional diversity
Many values and uses
National policies + local interests
The Forest Service uses integrated spatial plans...
<table>
<thead>
<tr>
<th>Forest Planning Process (in conjunction with NEPA)</th>
<th>Essential elements of the CMSP Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify purpose and need</td>
<td>Identify regional objectives</td>
</tr>
<tr>
<td></td>
<td>Identify existing efforts</td>
</tr>
<tr>
<td>Identify planning criteria</td>
<td>Engage stakeholders and the public</td>
</tr>
<tr>
<td></td>
<td>Consult scientists and experts</td>
</tr>
<tr>
<td>Collect and organize information</td>
<td></td>
</tr>
<tr>
<td>Analyze the management situation</td>
<td>Identify existing efforts</td>
</tr>
<tr>
<td></td>
<td>Analyze data, uses, services, impacts</td>
</tr>
<tr>
<td>Formulate alternatives</td>
<td>Analyze data, uses, services, impacts</td>
</tr>
<tr>
<td>Predict effects of alternatives</td>
<td>Engage stakeholders and the public</td>
</tr>
<tr>
<td></td>
<td>Consult scientists and experts</td>
</tr>
<tr>
<td>Evaluate alternatives</td>
<td>Develop and evaluate scenarios</td>
</tr>
<tr>
<td>Select a preferred alternative</td>
<td>Create a final plan and submit for NOC review</td>
</tr>
<tr>
<td>Approve the plan and EIS</td>
<td>Implement, monitor, evaluate</td>
</tr>
<tr>
<td>Monitor and evaluate performance</td>
<td></td>
</tr>
</tbody>
</table>
# National forest diversity protection rules

<table>
<thead>
<tr>
<th>Approach</th>
<th>Term of art</th>
<th>Legal Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Species Richness</strong></td>
<td>“Vertebrate viability”</td>
<td>Substantive (“maintain, support”)</td>
</tr>
<tr>
<td>“All species are important”</td>
<td></td>
<td>Procedural (“identify, evaluate”)</td>
</tr>
<tr>
<td>Pay attention to numbers and distribution</td>
<td></td>
<td>Monitoring (“inventory, monitor”)</td>
</tr>
<tr>
<td><strong>Featured Species</strong></td>
<td>“Management Indicator Species”</td>
<td></td>
</tr>
<tr>
<td>“Some species are special for certain reasons”</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Theory: Good Indicators…

State explicitly the research study goals and the purposes for which the indicator is being used.

State explicitly the criteria used to select the indicator species from the panoply of candidates.

Cite the data used to establish a link between indicator and the indicated environmental or biological variable.

Use an ecologically and evolutionarily diverse set of species for each indicator set.
Clearly establish a baseline or reference condition against which to measure change or state.

Assess the statistical power, variability, precision, and accuracy of the indicator set to determine whether conclusions may be drawn from the data.

Ensure the practical, financial, and social feasibility of the indicator set.
Theory: Good Indicators…

Create assessment thresholds connecting indicator response with environmental inference.

Link indicator outcomes to management actions.

Use the indicators to measure or predict the effects of management, not as primary drivers of management. Set explicit standards for monitoring the indicators.

Evaluate all sources of error, including sampling error and intra-annual, inter-annual, and spatial variability in the indicator.
Lessons From Indicators in National Forests

Agencies will seek to maximize flexibility, especially given scientific uncertainty and/or lack of funds

Clear statements of standards and requirements = greater accountability

Scientists can play active roles in establishing and implementing policy (and defending it)
1. Science for ecosystem-based management (EBM)
   - Principles for maintaining ecosystem services
   - Better analysis of cumulative impacts
   - Improved tradeoff analysis

2. Institutions for coordination

3. Information infrastructure
Let’s Discuss!
Extra Slides
2009-10 Root Causes of Institutional Hang-Ups in CA

- Initial workshop (August 2009)
- OPC Resolution (September 2009)
- Initial GIO support (late 2009)
- Interagency working group (early 2010)
- AB 2125 (September 2010)
- Planning tools workshop (Feb. 2011)
- “Proof of concept” using existing data (March 2011)
- Needs assessment for interagency IMS (2011)
Focus on Improving Information Use

Can **existing data and tools** empower agencies to make more efficient decisions and engage in more proactive management?

Can states incorporate better information management and analysis practices into planning **for emerging uses** while respecting existing spatial management?
Social-Ecological Systems and MSP

- Coastal ecosystems are linked “social-ecological” systems with complex interactions between people and oceans
- Understanding the “peopled seascapes” of coastal oceans is critical for developing effective marine spatial plans
- We are building a generalizable framework to assess human dimensions for MSP

Reciprocal relationships exist between coastal communities & ecosystems
Characterizing Ocean Use Patterns

A framework can help to characterize the diverse spatial patterns of human use and their attributes.

Key considerations: spatial distribution patterns; seasonality, intensity, conflicts with other uses, thresholds, etc.

*Trawl fleet fishing grounds, Gulf of Maine*
Calculating Cumulative Impact Scores

- Halpern et al. developed a cumulative impact model that provides an opportunity for advancement by:
  - calculating the combined effect of multiple uses using a common metric
  - combining vulnerability, number of activities in an area, and the expected impact of each activity
  - using a method of analysis that is quantitative, reproducible, and multi-scale