Decision Support Framework for Restoring Connectivity and Enhancing Resilience as Part of Gulf Coast Restoration

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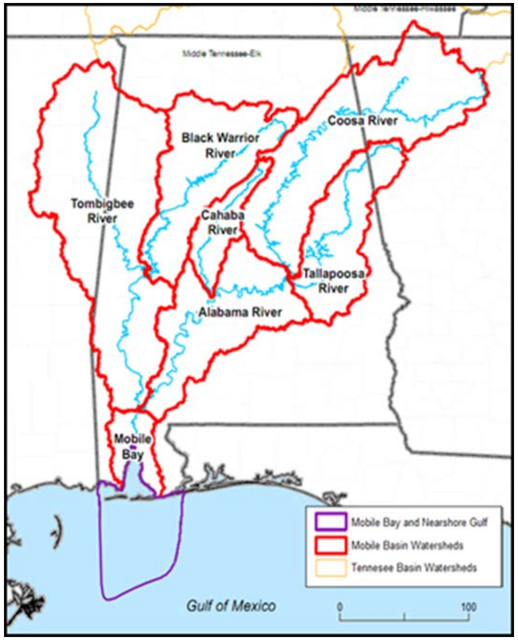
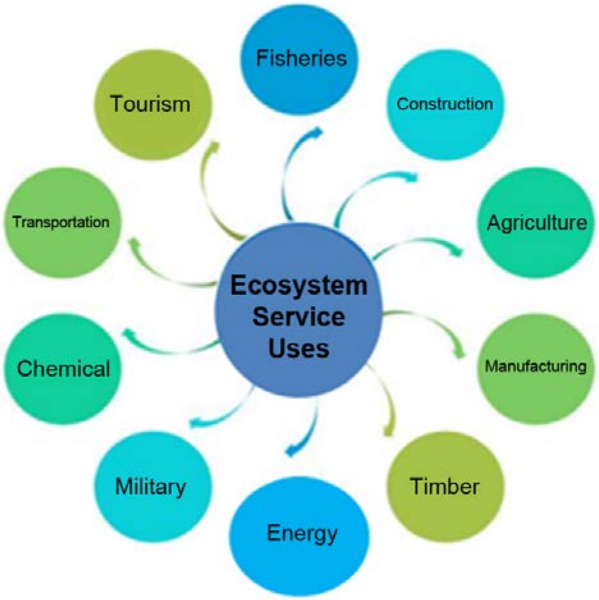
Role of Connectivity in Building Gulf Resilience: Based on Lessons from Previous Studies

- Incorporating landscape connectivity and uncertainty into ecosystem restoration scaling of environmental damages
  - Hanson et al (in press; June 2016) WIT Transactions on Ecology and the Environment. xxxx
- Restoration scaling of environmental damages in the face of a changing environment and uncertainty
  - Hanson et al (2014). WIT Transactions on Ecology and Environment Vol. 181 (2014): 491-502 (ISSN 1743-3451)
- Gulf of Mexico Ecosystem Restoration: A risk-based integrated environmental, economic, and social resource management decision framework
  - Hanson et al (2014) WIT Transactions on Ecology and Environment Vol. 181 (2014): 531-541 (ISSN 1743-3451)
- Fisheries Infrastructure Investigation & Assessment: Sustaining the Alabama Gulf Coast Fishery Resources Final Report.
  - David P. Hale, David Hanson and five others. The University of Alabama. NOAA Research Grant NA08NMF4520546. Jan. 2012. 176 pp.

Encouraging Desired Change While Protecting and Restoring What's Valued





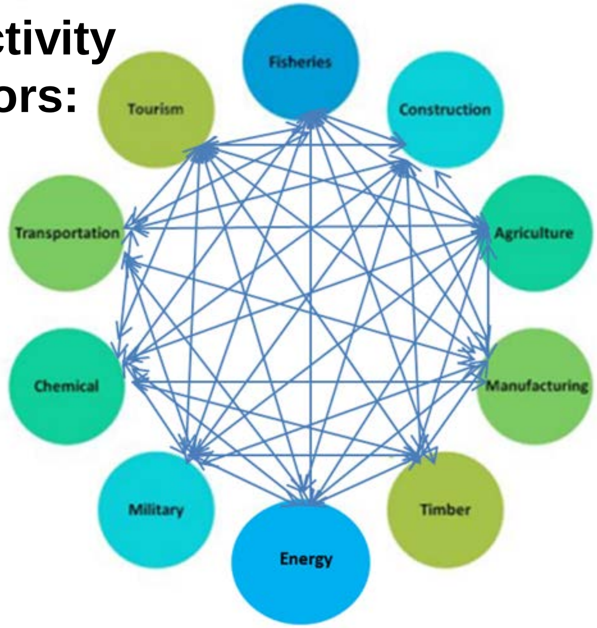
- Alabama transitioning from maritime, agriculture, forestry, and mining economy to expand manufacturing and tourism
- Declining marine and recreational fisheries; loss of habitat and water quality; destruction of habitat and infrastructure from tropical storms
- **Congressional leaders concerned how to encourage further economic development while preserving maritime culture and natural resources**

Sustaining Alabama Gulf Coast Fisheries Resources
(NOAA funded, The Univ. of Alabama AISCE Project)

Desired Project Outcome:

- **Provide** decision support system framework (DSS) for stewardship of coastal/marine resources
- **Evaluate and model** the social, economic, constructed, and natural factors that impact management of sustainable fisheries
- **Provide** a common platform for disparate constituents to express their goals, concerns, constraints, and processes
- **Support** policy and regulatory decisions balancing trade-offs among user groups

Connectivity of Sectors:



Connectivity of Goals:

- Economic
- Cultural
- Environmental
- Supporting Infrastructure

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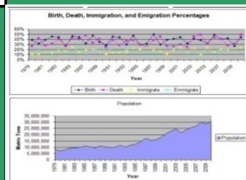
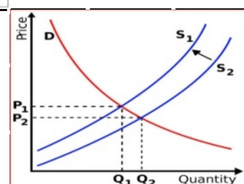
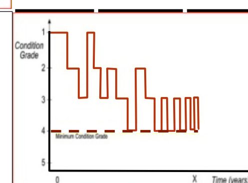
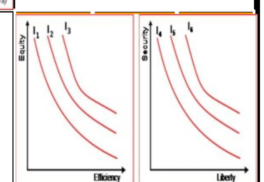
Connectivity of Social Goals

Constraints

System Integration Framework	Environment (ENV)	Economic (ECON)	Infrastructure (INFRA)	Social (SOCIAL)
Goals: Environment (ENV)		**Will ECON growth degrade ENV?**	**Will aging INFRA degrade ENV?**	**Do we understand and value ENV issues?**
Goals: Economic (ECON)	**Will ENV restrictions limit ECON growth?**		**Have INFRA to support ECON growth?**	**Are ECON benefits and impacts shared?**
Goals: Infrastructure (INFRA)	**Will ENV impacts prevent new INFRA?**	**Can ECON afford desired INFRA?**		**No INFRA in my backyard!**
Goals: Social (SOCIAL)	**Is there ENV justice?**	**Who should pay for your SOC benefits?**	**Is needed INFRA appropriately distributed?**	

- Fragmented governance, stove-piped goals,& sector specific tools
- Although people want four healthy capitals, individual focus on one capital creates opposition

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Supplemented Historical Information with Diverse Stakeholder Workshops

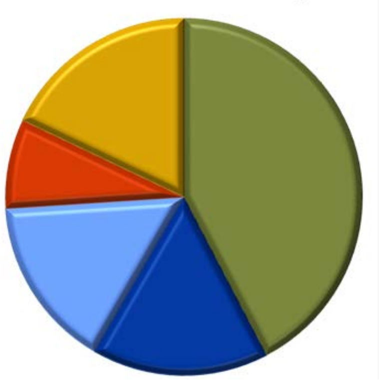
- Held Coastal and Watershed Workshops (Mobile and Montgomery – spring and summer 2009
- Broad diversity of user groups represented
- Issues identified and evaluated
  - Major uses of watershed/bay and needs to meet those uses
  - System health and attributes
  - Limitations and threats to a sustainable system
  - Management needs
- Stakeholders prioritized issues

Understanding Connectivity of Goals was Biggest Threat to Sustainable System in Workshops

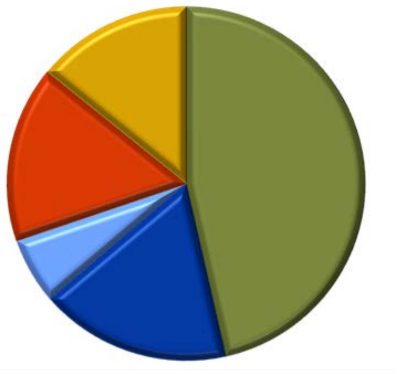
Summary of Perceived Threats to Sustainable System:

- **Economic** - Unfettered development and population growth
- **Infrastructure** - Aging infrastructure, climate resiliency, and displacement
- **Environmental** - Non-point source water quality and sediment issues
- **Social** - Lack of understanding or apathy
- **Governance** - ***Lack of understanding and ability to balance of trade-offs in environmental, economic, and social goals;*** stove-piped agencies, regulations and programs;

Coastal Workshop



Watershed Workshop



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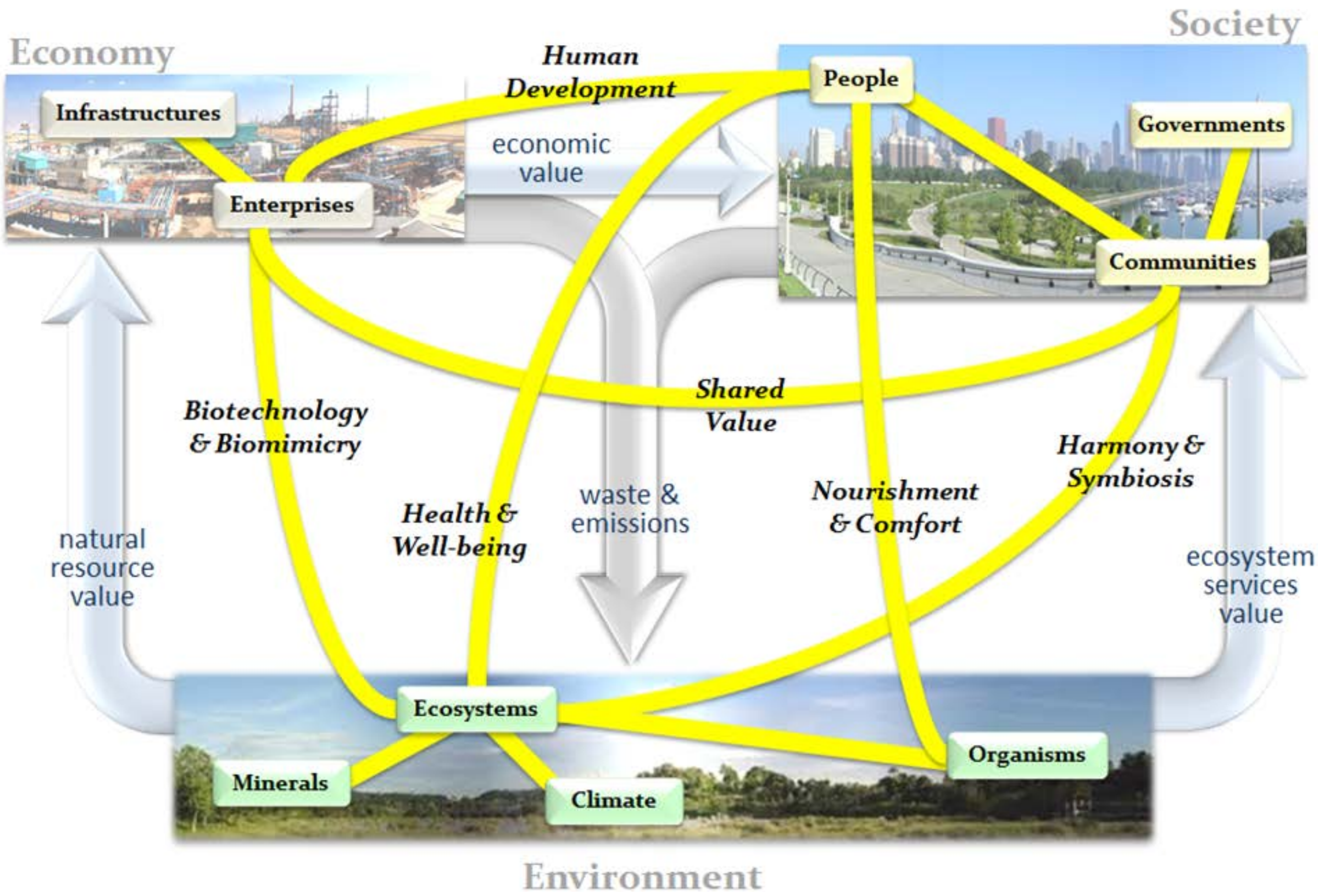
The Biggest Threat to Sustainable System – Not Understanding the Big Picture Connections



Interdependencies among resilient systems (Fiskel et al., 2014)

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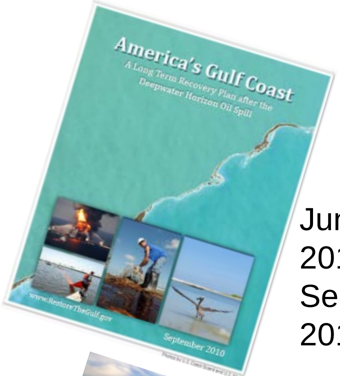
Alignment of DSS Framework to Post Deepwater Horizon Spill Response and Actions

- Long-term Recovery Plan (Maybus Report)
  - Balanced recovery of the environment, economy, and culture
  - Presidential Task Force to develop ecosystem restoration strategy
  - Restore Act to fund & Gulf Council to guide restoration
- Task Force for Long-term Ecosystem Recovery Strategy
  - Restoration Goals & Recommended Priority Actions
  - Adaptive Management
  - Comprehensive “Watershed to Gulf” program
  - Provide integrated decision-support
  - Ecosystem services & benefits analysis tools
  - Policy & procedural barriers
- Task Force senior leaders requested we align our draft study with long-term restoration strategy



June 2010 - Sept. 2010

Nov. 2010 - Dec. 2011

Nov. 2008- Jan. 2012

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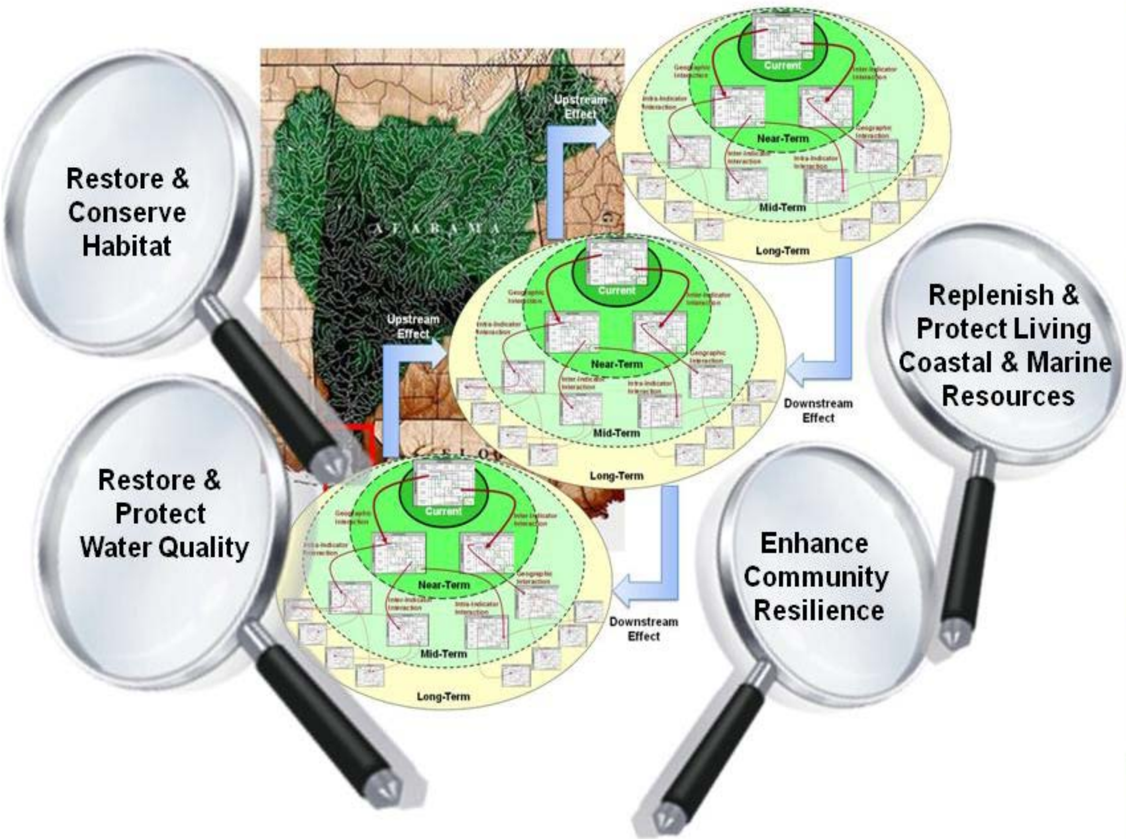
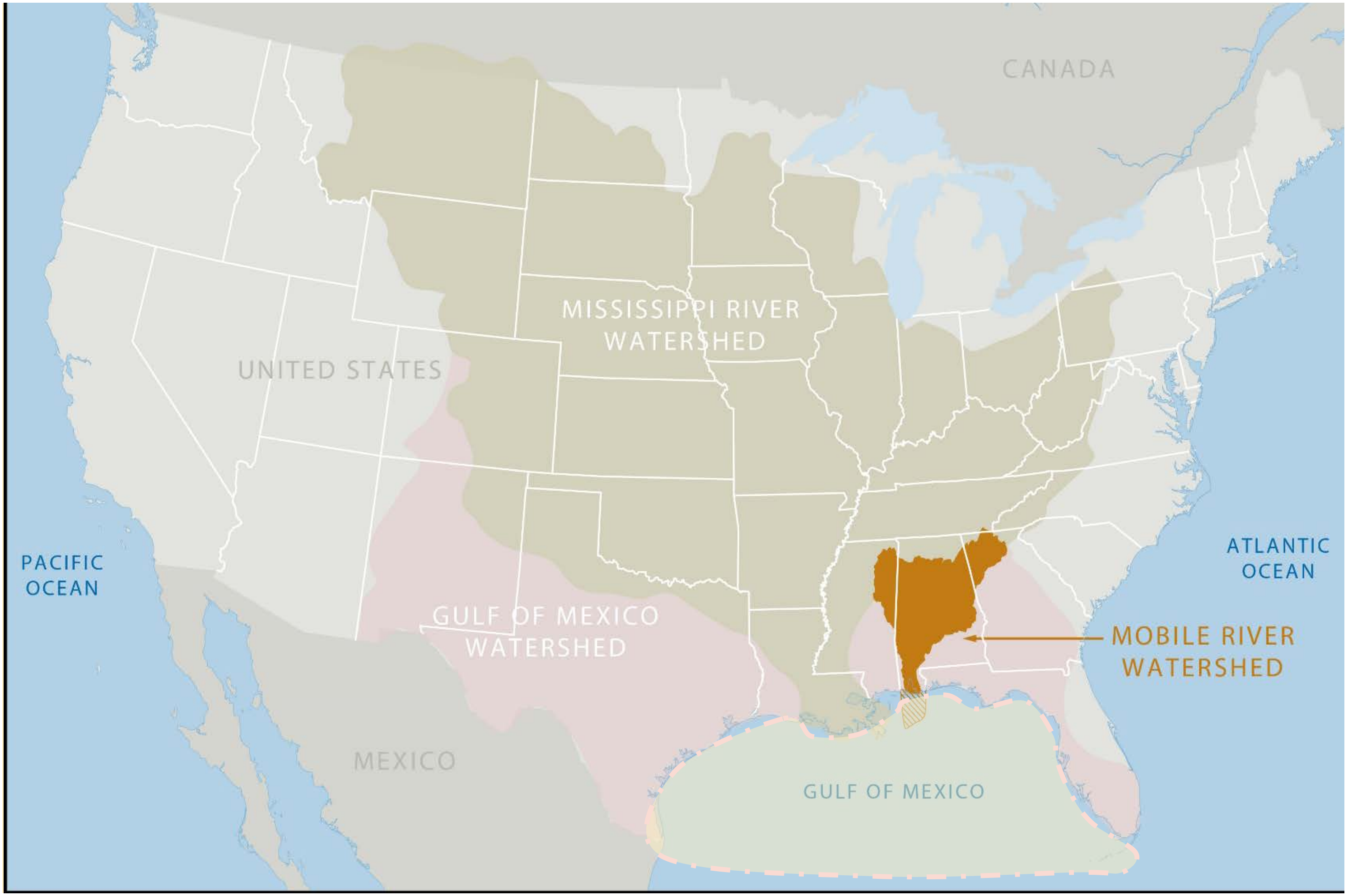
Design Workshop to Align DSS Framework Based on Strategy Goals and Priority Actions



- **Stakeholders**
  - Stakeholders Define Needs and Policy Makers Set Goals
- **Goals**
  - Goals Requiring Strategic Actions
- **Actions**
  - Implementing Strategic Actions Requires Understanding Systems Interactions
- **Key Decisions**
  - Evaluating Interactions Requires Key Tactical Decisions, Which Generate Critical Questions
- **Critical Questions**
  - Critical Questions Drive DSS Needs and Features
- **DSS Features**
  - DSS Features and Outputs Inform Decision Makers
- **Decision Makers**
  - Decision Makers Select Among Alternatives and Implement Policy and Actions

This Resulted in Significant Change in Geographic Scope of Project



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Goal 1 – Restore & Conserve Habitat
Task Force Priority Actions & Proposed DSS Features

Actions

1. Prioritize ecosystem restoration by ensuring that social, environmental, and economic outcomes are fully considered in all river management decisions
2. Improve sediment management using a "strategic use" approach
3. Restore natural river processes of sediment and freshwater distribution
4. Expand the network of conservation areas to ensure healthy landscapes
5. Restore and conserve coastal and nearshore habitats

Features

- River operations model to evaluate human and environmental interactions (e.g., Missouri River operations model for EIS covered systems interactions from Canadian border to Gulf of Mexico)
- Habitat prioritization models (e.g., EDT, LA Coast Strategic Plan)
- Geospatial land-use and habitat interaction model (OPTIONS Model)

Connectivity

- The above are all integrated resource management models that are both geospatially explicit and incorporate landscape connectivity

Goal 2 – Restore Water Quality
Task Force Priority Actions & Proposed DSS Features

Actions

1. Decrease nutrients in the Gulf through state nutrient reduction frameworks
2. Focus restoration on priority watersheds to reduce hypoxic conditions
3. Reduce pollutants and pathogens from stormwater flows and other sources
4. Improve the quality and quantity of freshwater flow into priority estuaries

Features

- Linking land-use and water quality models would provide information to both land owners, local economies, and environmental community
- Geospatially-based loadings for environmental management
- NPV of land costs and benefits for land operations
- Multiple perspective basis for valuing BMPs and conservation programs

Connectivity

- EPA Administrator Lisa Jackson, May 6, 2011 Gulf Task Force Mtg: What's missing in our current approach (to managing nutrients)? …. the benefits to farmers
- Findings of Hypoxia in the Northern Gulf of Mexico – An Update by the EPA Science Advisory Board: Develop integrated economic and watershed models to fully access costs and benefits, including co-benefits, of management options

Goal 3 – Replenish & Protect Living Coastal Resources Task Force Priority Actions & Proposed DSS Features

Actions

1. Restore depleted populations of living coastal and marine resources
2. Conserve and protect offshore environments
3. Restore and protect oyster and coral reefs, and other coastal environments
4. Coordinate/expand Gulf monitoring to track sentinel species and sites
5. Minimize invasive species that impact on the Gulf

Features

- Develop and implement ecosystem-based management (EMB)
- Input vs output linkages to habitat, hydrology, and water quality models
- Geospatial planning land-use and habitat models that include functional linkages, scenario land uses, economics, and habitat models

Connectivity

- Incorporates connectivity both within and among biological, physical, socioeconomic, and management capitals and actions

Goal 4 – Enhance Community Resilience
Task Force Priority Actions & Proposed DSS Features

Actions

1. Develop and implement comprehensive, scientifically based, and stakeholder-informed coastal improvement programs
2. Provide analytical support tools to enhance community planning, risk assessment, and smart growth implementation
3. Enhance environmental education and outreach

Features

- Apply critical non-transportation and natural infrastructure to Mobile DOT infrastructure risk and adaptation study methodologies
- Incorporate physical processes that sustain barrier islands & coastal wetlands

Connectivity

- Planning and preparedness efforts connecting non-stationarity threats with vulnerability of critical resources and potential to reduce severity of impacts and enhance recovery rate and levels achieved

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How Incorporating Connectivity Changes Results – NDRA Restoration Scaling w HEA

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
R1	4	8	4	8	6	6	7	7	4	4
R2	8	8	8	8	6	6	7	7	4	4
R3	2	1	1	3	6	6	6	7	6	7
R4	2	1	1	3	4	4	5	7	6	6
R5	4	1	1	3	6	6	5	6	6	4
R6	5	7	4	4	1	1	1	4	5	4
R7	5	7	4	4	3	5	5	4	5	4
R8	6	6	2	1	1	5	5	6	6	4
R9	6	6	1	1	1	5	8	8	2	7
R10	6	3	1	1	1	5	8	8	2	7
R11	6	3	2	1	1	2	6	2	2	4
R12	6	3	2	6	4	4	6	2	2	4
R13	6	3	3	6	4	4	6	2	2	4
R14	8	3	3	6	6	5	5	6	2	4
R15	8	2	2	5	5	5	5	6	4	4
R16	8	2	2	4	6	5	5	4	6	6
R17	4	2	2	5	6	2	2	1	2	1
R18	2	1	1	1	1	2	2	1	2	1
R19	2	1	1	1	1	2	2	1	6	6
R20	2	4	6	6	6	6	8	8	1	2
R21	1	4	6	6	6	6	8	8	1	2
R22	1	4	6	6	6	6	8	8	8	2
R23	1	4	6	6	4	4	4	8	4	2
R24	1	2	2	6	4	7	7	8	4	2
	KEY									

Degraded habitat with 240 equal size parcels

Existing Conditions (quality, risk)

1	HQ, NR
2	HQ, LR
3	SD, LR
4	MD, LR
5	MD, MR
6	MD, HR
7	SD, ER
8	NH, ZR

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Settlement Negotiations between Resource Managers (RMs) and Responsible Parties (PRPs)

- Present 3 simple scenarios of each party's preferences change when choosing between 4 restoration alternatives
  - Influenced by what factors are included in restoration planning

Initial Assumptions:

- Required restoration: restore four parcel 4s & two parcel 7s
- No partial parcel restoration or exchange of categories
- Temporal considerations ignored
- Rational decisions based on perspectives of each party
- Costs and credits are function of individual parcel condition with all parcels within a category equal
- Landscape connectivity between parcels for both benefits and risks is not included in restoration scaling metrics

Scenario 1 – Choosing Between Scenarios Given Initial Assumptions

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
R1	4	8	4	8	6	6	7	7	4	4
R2	8	8	8	8	6	6	7	7	4	4
R3	2	1	1	3	6	6	6	7	6	7
R4	2	1	1	3	4	4	5	7	6	6
R5	4	1	1	3	6	6	5	6	6	4
R6	5	7	4	4	1	1	1	4	5	4
R7	5	7	4	4	3	5	5	4	5	4
R8	6	6	2	1	1	5	5	6	6	4
R9	6	6	1	1	1	5	8	8	2	7
R10	6	3	1	1	1	5	8	8	2	7
R11	6	3	2	1	1	2	6	2	2	4
R12	6	3	2	6	4	4	6	2	2	4
R13	6	3	3	6	4	4	6	2	2	4
R14	8	3	3	6	6	5	5	6	2	4
R15	8	2	2	5	5	5	5	6	4	4
R16	8	2	2	4	6	5	5	4	6	6
R17	4	2	2	5	6	2	2	1	2	1
R18	2	1	1	1	1	2	2	1	2	1
R19	2	1	1	1	1	2	2	1	6	6
R20	2	4	6	6	6	6	8	8	1	2
R21	1	4	6	6	6	6	8	8	1	2
R22	1	4	6	6	6	6	8	8	8	2
R23	1	4	6	6	4	4	4	8	4	2
R24	1	2	2	6	4	7	7	8	4	2
	KEY									

- PRPs are indifferent on alternatives (credit and costs are equal for each scenario)
- Based on BPJ, RMs prefer S4 based benefits of connecting high quality habitats
- Agreement on S4 likely

Scenario 2 – Relative Costs Vary
(R1, R2, R23, R4 = 1; C9 and C10 = 1.5; All others = 4.0)

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
R1	4	8	4	8	6	6	7	7	4	4
R2	8	8	8	8	6	6	7	7	4	4
R3	2	1	1	3	6	6	6	7	6	7
R4	2	1	1	3	4	4	5	7	6	6
R5	4	1	1	3	6	6	5	6	6	4
R6	5	7	4	4	1	1	1	4	5	4
R7	5	7	4	4	3	5	5	4	5	4
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R17	4	2	2	5	6	2	2	1	2	1
R18	2	1	1	1	1	2	2	1	2	1
R19	2	1	1	1	1	2	2	1	6	6
R20	2	4	6	6	6	6	8	8	1	2
R21	1	4	6	6	6	6	8	8	1	2
R22	1	4	6	6	6	6	8	8	8	2
R23	1	4	6	6	4	4	4	8	4	2
R24	1	2	2	6	4	7	7	8	4	2
KEY										

- PRPs want S1 or S3; no incentive to compromise until settlement costs high relative total costs
- RMs still don’t like S1 or S4; still prefer S4 based on BPJ of connected benefits; seek S2 settlement based on costs

Scenario 3 – Costs Vary, Risks Are Function of Both On-site and Adjacient Parcel Conditions (Risks)

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
R1	4	8	4	8	6	6	7	7	4	4
R2	8	8	8	8	6	6	7	7	4	4
R3	2	1	1	3	6	6	6	7	6	7
R4	2	1	1	3	4	4	5	7	6	6
R5	4	1	1	3	6	6	5	6	6	4
R6	5	7	4	4	1	1	1	4	5	4
R7	5	7	4	4	3	5	5	4	5	4
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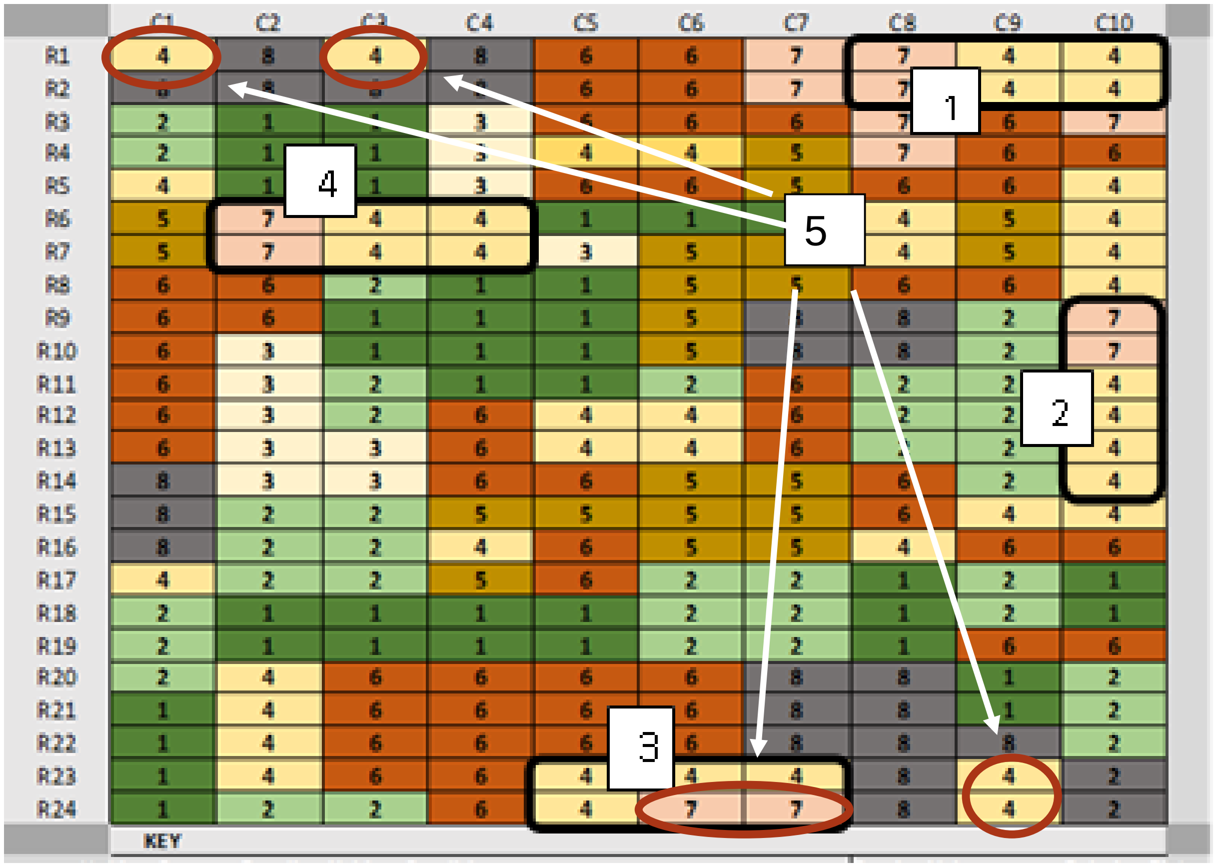
R21	1	4	6	6	6	6	8	8	1	2
R22	1	4	6	6	6	6	8	8	8	2
R23	1	4	6	6	4	4	4	8	4	2
R24	1	2	2	6	4	7	7	8	4	2

KEY

- PRPs don’t want S1 or S3; S2 looks better based on EV

Scenario 3 – Costs Vary, Risks Are Function of Both On-site and Adjacient Parcel Conditions (Risks)



	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
R1	4	8	4	8	6	6	7	7	4	4
R2	8	8	8	8	6	6	7	7	4	4
R3	2	1	1	3	6	6	6	7	6	7
R4	2	1	1	3	4	4	5	7	6	6
R5	4	1	1	3	6	6	5	6	6	4
R6	5	7	4	4	1	1	[illegible]	4	5	4
R7	5	7	4	4	3	5	[illegible]	4	5	4
R8	6	6	2	1	1	5	5	6	6	4
R9	6	6	1	1	1	5	8	8	2	7
R10	6	3	1	1	1	5	8	8	2	7
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R21	1	4	6	6	6	6	8	8	1	2
R22	1	4	6	6	6	6	8	8	8	2
R23	1	4	6	6	4	4	4	8	4	2
R24	1	2	2	6	4	7	7	8	4	2

More scenarios w benefits of connectivity available

- PRPs don't want S1 or S3; S2 looks better based on EV; new S5 even better
- RMs don't want S1, S3; want S5 even less; S2 as good, maybe better than S4
- Agreement depends on overall cost of liabilities

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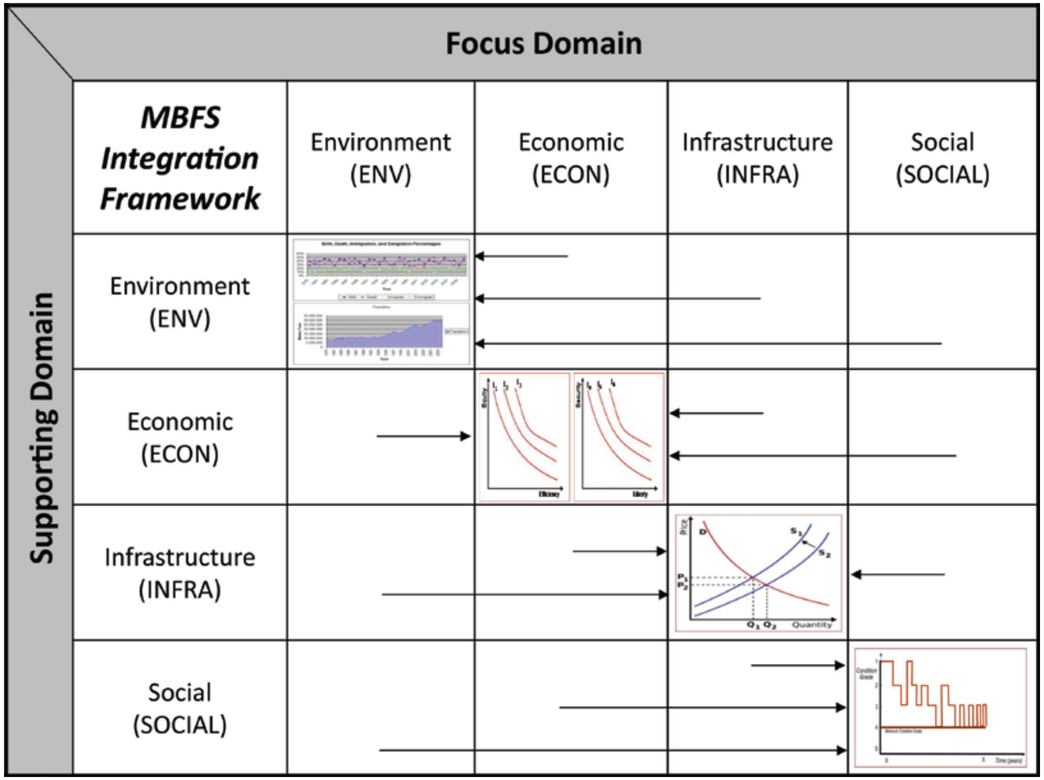
Incorporating Connectivity in Restoration Planning Becomes Increasing Important as ____ Increases

- Size of area and restoration requirements
- Complexity of geology, hydrology, and geography
- The number, type, and stages of habitat stands
- Risks and uncertainty of non-stationary conditions due to climate change, disease, invasive species, or severe wildfire
- Number of endangered or highly valued species which utilize different habitat categories
- Extent and severity of residual contamination
- Presence of significant cultural resource areas
- Differences society preferences and opportunity costs among parcels
- Overall cost of restoration increases, and
- Temporal implications and both parcel and inter-parcel settlements are incorporated in the analysis

Understanding System Interaction: Evolution of New Tools and Approaches

Current tools: allow cross-capital inputs and constraints



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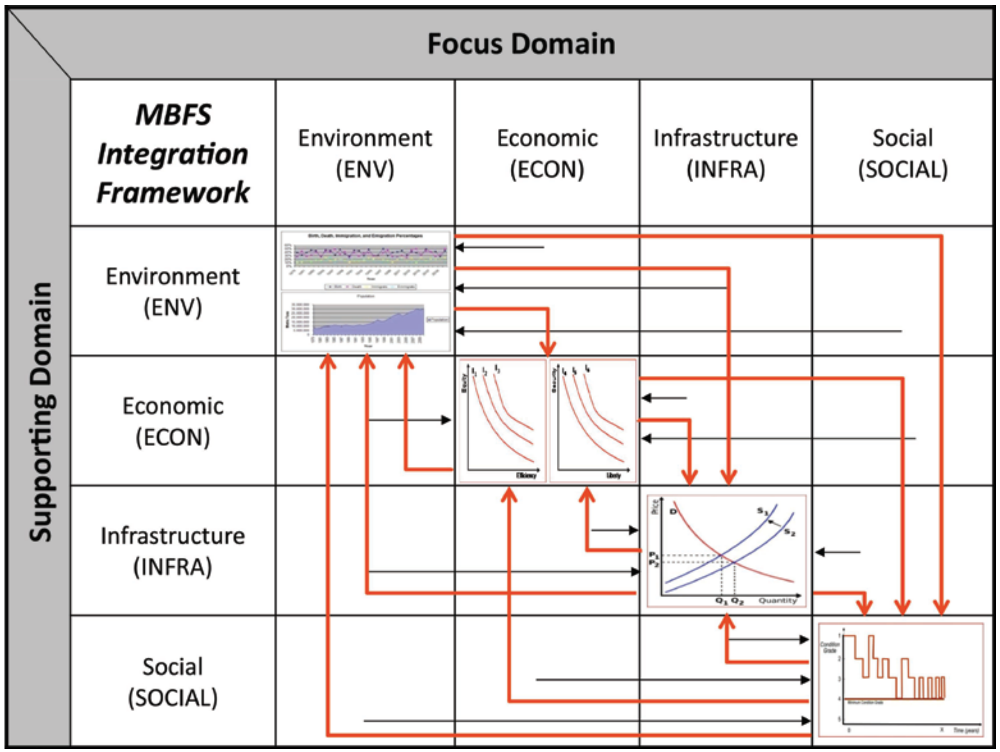
Understanding System Interaction: Evolution of New Tools and Approaches

Next generation <u>decision science</u> tools: need to understand and consider interactions and trade-offs across capitals more effectively



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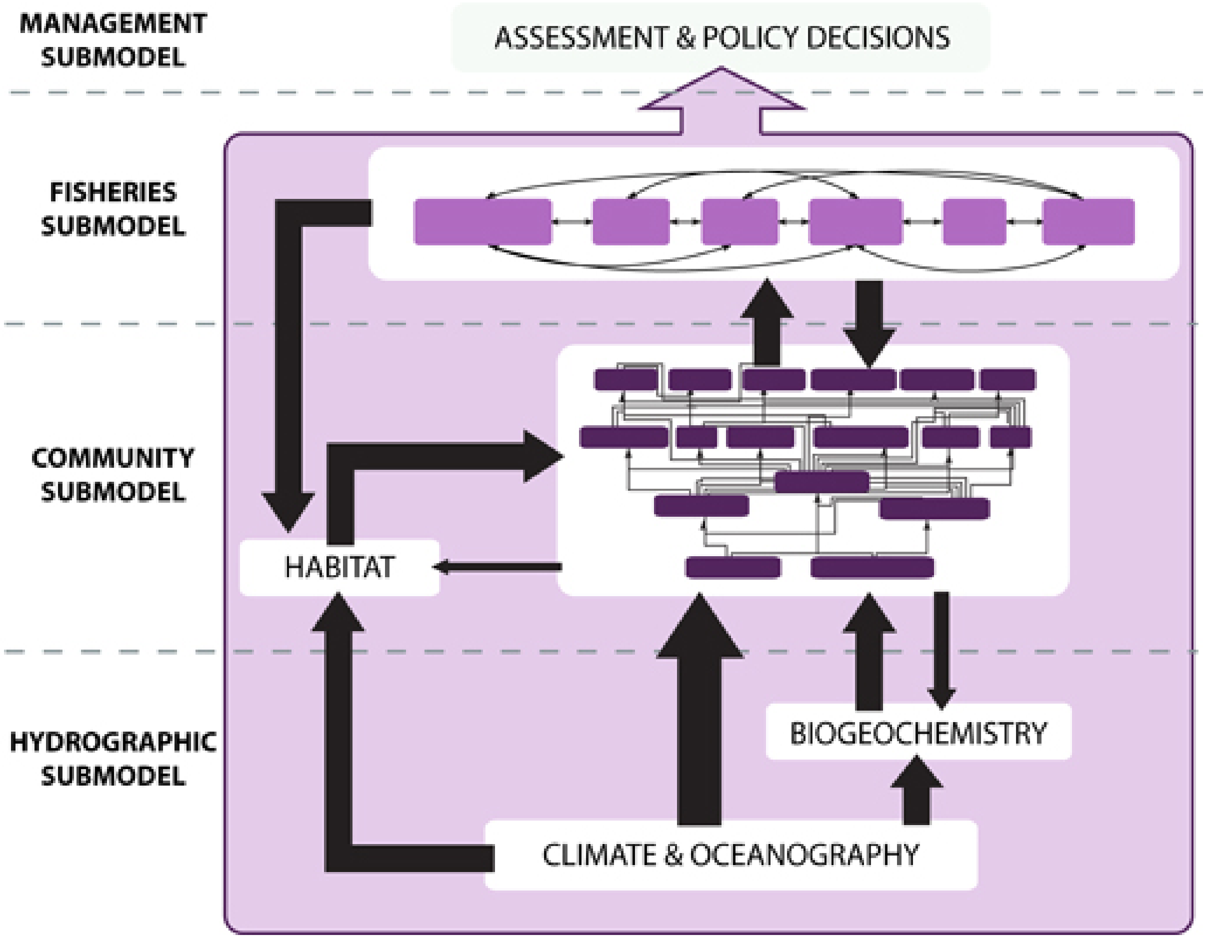
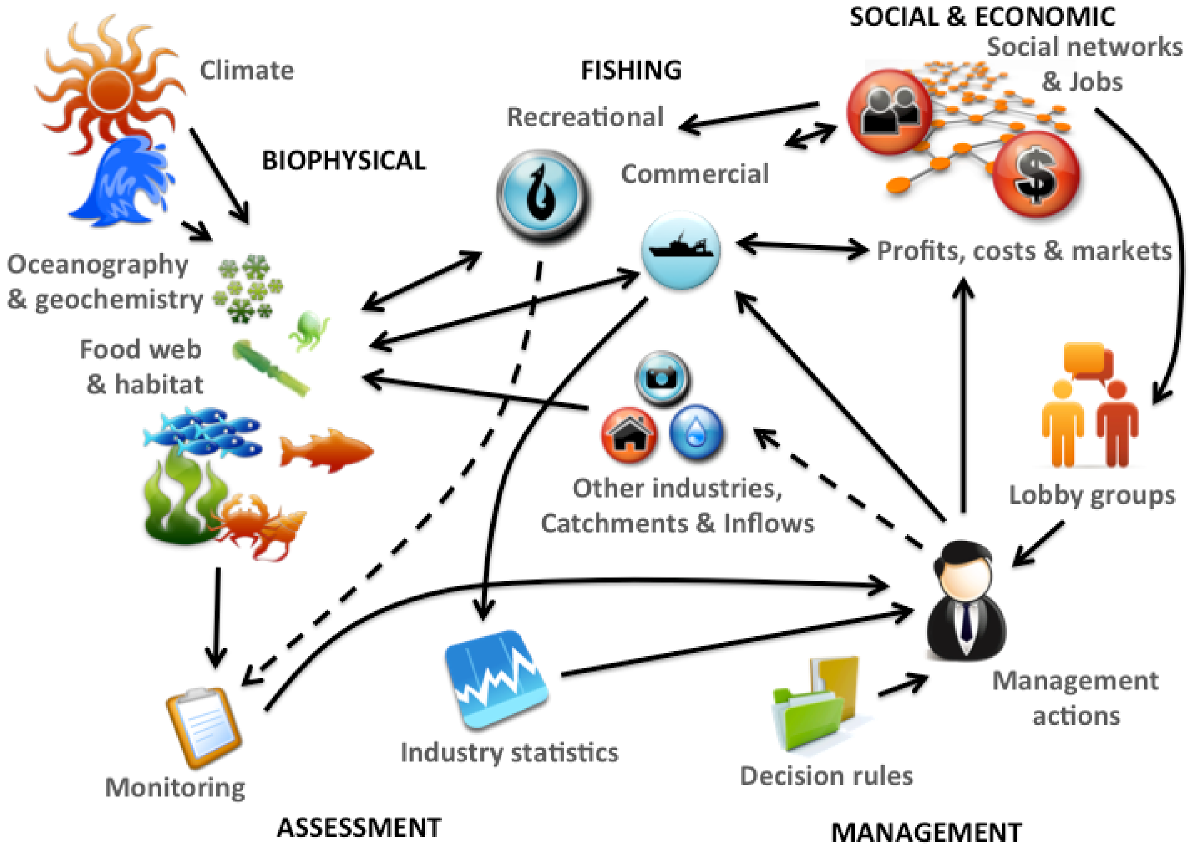
The Fisheries Management Version of Conceptual Framework of Atlantis Model



Organizational structure and focus appeals well to its narrow audience

Schematic Connectivity of Chesapeake Bay EBM Modeling



Model elements are all there but doesn't place one user group's objectives above others

(from CSIRO and NOAA Chesapeake Bay Office)

Gulf Coast Ecosystem & Community Resilience, the Short Story

- We could be satisfied with unprecedented opportunity of financial and technical resources to apply to long-term Gulf coastal degradation, but
  - no basis to expect the amount of resources aligned with overall needs
  - better achieve measurable advancement towards strategy goals if we hope for future funding to finish job of creating a resilient and sustainable Gulf ecosystem
  - explicitly addressing landscape and human connectivity essential to achieving long-term ecosystem and community resilience and restoration strategy goals
- We can improve decision science even in the absence of perfect science
  - decision science utilizes higher level conceptual relationships
  - use stochastic models of expected value to deal with uncertainty of non-stationarity and building resilience
- Need effective communications with others who have different perspectives to turn zero-sum perspectives into win/win opportunities

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