

Economic tools for ecosystem-based management in coastal waters: Some preliminary thoughts

Presentation to MOPF on May 17, 2007

Dan Holland, GMRI
Rob Johnston, UCONN
James Sanchirico, RFF



Outline of talk

- Introduction (Jim)
 - Economic perspective of EBM
 - Deconstruct EBM definition from consensus statement
 - Integral part of scenario analysis tool in MOPF
- Selected topics
 - Market and non-market valuation (Rob)
 - Decision making under uncertainty (Rob)
 - Behavioral (predictive) modeling (Dan)
- Discussion

EBM as defined in consensus statement

“EBM is an integrated approach to management that considers the entire ecosystem, including humans. The goal of EBM is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need. EBM differs from current approaches that usually focus on a single species, sector, activity or concern; it considers the cumulative impacts of different sectors.”

Specifically, ecosystem-based management:

- emphasizes the protection of ecosystem structure, functioning, and key processes;
- is place-based in focusing on a specific ecosystem and the range of activities affecting it;
- explicitly accounts for the interconnectedness within systems, recognizing the importance of interactions between many target species or key services and other non-target species;
- acknowledges interconnectedness among systems, such as between air, land and sea; and
- integrates ecological, social, economic, and institutional perspectives, recognizing their strong interdependences.”

1. Externalities

“EBM is an integrated approach to management that considers the entire ecosystem, including humans. The goal of EBM is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need. EBM differs from current approaches that usually focus on a single species, sector, activity or concern; it considers the **cumulative impacts of different sectors.”**

Specifically, ecosystem-based management:

- emphasizes the protection of ecosystem structure, functioning, and key processes;
- is place-based in **focusing on a specific ecosystem and the range of activities affecting it;**
- explicitly accounts for the **interconnectedness within systems, recognizing the importance of interactions between many target species or key services and other non-target species;**
- acknowledges **interconnectedness among systems, such as between air, land and sea;** and
- integrates ecological, social, economic, and institutional perspectives, recognizing their strong interdependences.”

1. Externalities

- “cumulative impacts of different sectors”,
“interconnectedness among (e.g., air, land and sea), and
within systems (e.g., species interactions)”

Externalities—Actions of one agent (sector) affect the welfare of another agent (sector)

- Positive and negative externalities
- Measurement requires linking ecological-economic models
 - Impact of one use → ecological and biophysical relationships → changes in ecosystem service provision → changes in welfare of other users

E.g. of externalities in coastal waters

- Clearing of mangroves for **tourism development** results in less nursery ground for commercial and recreationally important species and biodiversity
- Borrowing sites in **sand and gravel mining** can affect the erosion rates of nearby beaches and demersal habitat for important species
- **Commercial fishing** for a suite of species might reduce the resiliency of the ecosystem, increasing the ability of invasive species to take hold and change the suite of ecosystem goods and services
- **Agents affected in each case include consumptive and non-consumptive users (not necessarily the same group in each example)**

Tools to address externalities

- Private ordering
- Judicial (Liability)
- Legislative/regulation
 - Command and control
 - Technology, input, and output restrictions, including zoning
 - Incentive-based approaches
 - Cap and trade markets, charges or fees based on damages

2. Goods and Services

“EBM is an integrated approach to management that considers the entire ecosystem, including humans. The goal of EBM is to maintain an ecosystem in a healthy, productive and resilient condition so that it can **provide the services humans want and need. EBM differs from current approaches that usually focus on a single species, sector, activity or concern; it considers the **cumulative impacts of different sectors.**”**

Specifically, ecosystem-based management:

- emphasizes the protection of ecosystem structure, functioning, and key processes;
- is place-based in focusing on a specific ecosystem and the range of activities affecting it;
- explicitly accounts for the interconnectedness within systems, recognizing the importance of interactions between many target species or key services and other non-target species;
- acknowledges interconnectedness among systems, such as between air, land and sea; and
- integrates ecological, social, economic, and institutional perspectives, recognizing their strong interdependences.”

2. Goods and Services

- “...provide the services humans want and need”

Analysis of individual and societal demands and the relative values of ecosystem goods and services, including private AND public goods and services

Missing: phrase “today and in the future”

3. Model Scope

“EBM is an **integrated** approach to management that considers the **entire ecosystem, including humans**. The goal of EBM is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need. EBM differs from current approaches that usually focus on a single species, sector, activity or concern; it considers the **cumulative impacts of different sectors.**”

Specifically, ecosystem-based management:

- emphasizes the protection of ecosystem structure, functioning, and key processes;
- is place-based in focusing on a specific ecosystem and the range of activities affecting it;
- explicitly accounts for the **interconnectedness** within systems, recognizing the importance of interactions between many target species or key services and other non-target species;
- **acknowledges interconnectedness among systems, such as between air, land and sea; and**
- **integrates ecological, social, economic, and institutional perspectives, recognizing their strong interdependences.**”

3. Model Scope

- “Integrated, interconnectedness, entire ecosystem...”

Partial Equilibrium: Analysis of a single sector (e.g., producers)

E.g., Effect of a regulation to limit wetland development only focusing on residential development

General Equilibrium: Analysis of an economy (consumers, producers, government sectors)

E.g., Same as above but now include the effects and feedbacks from bird watching, agricultural sector, recreational and commercial fishing, local labor markets, etc....

4. Model Scale

“EBM is an integrated approach to management that considers the entire ecosystem, including humans. The goal of EBM is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need. EBM differs from current approaches that usually focus on a single species, sector, activity or concern; it considers the cumulative impacts of different sectors.”

Specifically, ecosystem-based management:

- emphasizes the protection of ecosystem structure, functioning, and key processes;
- is **place-based in focusing on a specific ecosystem and the range of activities affecting it;**
- explicitly accounts for the interconnectedness within systems, recognizing the importance of interactions between many target species or key services and other non-target species;
- acknowledges interconnectedness among systems, such as between air, land and sea; and
- integrates ecological, social, economic, and institutional perspectives, recognizing their strong interdependences.”

4. Model Scale

- “place-based” or “area specific”
 - Scale of analysis and policies typically thought of coming from ecosystem and ecology
- Economics can shed light on the benefits and costs of
 - different scales/sizes of zones given the socioeconomic and ecological system
 - exclusive vs. non-exclusive uses of zones, means of allocation
 - various spatially explicit policies
 - E.g., hotspot effects vs. lower costs in cap and trade systems

5. Framing of the problem

- Benefit–cost analysis
 - Maximize the net benefits from a project that is inclusive of private and social benefits and costs
 - EBM as multi-objective function
 - Maximize the net benefits of wind electricity **plus** commercial fishing **plus** beach recreation **plus** ecosystem conservation
 - Weights are the relative values to society from these activities

5. Framing (2)

- Cost-effectiveness analysis
 - Minimize the economic cost on the agricultural sector or electricity sector of meeting a target level
 - E.g., Air or water pollution regulation
 - EBM as a set of constraints (Swallow 1996)
 - Minimize the economic costs to all sectors of meeting constraints to
 - “Maintain an ecosystem in a healthy, productive, and resilient condition”
 - Key ecological question is how to measure the targets

Economics and scenario analysis

- Measure the relative benefits and costs
 - Market and non-market values for goods and services
 - Quantifying damages/social costs/social benefits
- Incorporate uncertainty formally into the decision making
 - Ecological uncertainty and economic uncertainty, e.g., future demand, costs and prices
 - Risks, risk-aversion, precautionary approaches

 An economic framework makes trade-offs explicit, measures changes in social well-being, and can help prioritize policy choices

Economics and scenario analysis(2)

- Rigorous policy design and analysis includes predicting responses to regulations (scenario analysis)
- What happens when you don't include behavioral responses in scenario analysis?
 - You make predictions like:
 - “if the trend continues all fish and seafood species will collapse (meaning their catch will have declined by 90 percent) by 2048.” Worm et al. *Science* 2006.

Economic Values and Ecosystem Based Management

Robert J. Johnston

University of Connecticut



Economic Values and Ecological Systems

- Ecosystem based management affects components and processes of natural systems.
- Natural systems provide ecological goods and services with direct or indirect value to the public.
- Changes in goods and services affect human well-being; measurement of these effects is economic valuation.
- Economic valuation estimates the effect on human well-being of changes in ecological systems.

Marginal Values and Clear Baselines

- Appropriate economic welfare analysis assesses marginal changes from identifiable baselines.
- Economic value is about tradeoffs and as such requires well-defined alternatives.
- To an economist, it is nonsensical to discuss “the economic value of ecosystems as if the choice were between having them as they are or not having them at all.” (Bockstael et al. 2000).

Economic Valuation Complements Ecological Science

- Economic valuation, appropriately framed, does not replace or compete with ecological perspectives.
- Rather, it quantifies the human effects of ecological change, providing a complementary tool to assist policymakers.
- Can help prioritize actions when resources are scarce (as they always are!).
- Economic information complements ecology!

Economic Values, Tradeoffs and Priorities

- Appropriate assessment of economic values can help policymakers:
 - Identify the true social benefits generated by ecological stewardship, management and restoration.
 - Prioritize environmental policy proposals or actions.
 - Assess whether the social benefits of particular policies outweigh the social costs (this is Benefit-Cost Analysis).
- As noted earlier, this is not about money—it is about long-term social well-being.

Total Economic Value

- Total economic values comprise both Market and Non-Market Values; these are equally important.
- Market values are related to observable transactions in organized markets.
 - Benefits to consumers.
 - Benefits to producers.
- Market values are not jobs and income!!! This is economic impact analysis and is entirely different.
- Market values often depend on ecological systems and their management; this provides link to EBM.

Non-Market Values

- A large proportion of the economic value of environmental protection or restoration is made up of non-market values.
- Non-market values are effects on individuals' well-being that are not measurable in markets.
- Ignoring non-market values can result in significant underestimation of social benefits.
- These can include use and non-use values.
 - Use Values: Values related to observable behavior (e.g., recreational, consumptive, etc.).
 - Non-use Values: Values not related to observable behavior (e.g., bequest, existence values).

Measuring Non-Market Values

- Market values are easily measurable in most cases.
- Non-market values are harder, but economists have developed a variety of methods to measure different aspects of non-market value.
 - Revealed Preference methods based on observable behavior (hedonic; travel cost).
 - Stated Preference methods based on carefully designed surveys (stated preference; contingent valuation).
 - Others (productivity methods, etc.)
- It is important to distinguish benefits from costs (e.g., replacement cost is not a measure of value).



Example #1: Wind Farms

- Provide a wide range of measurable benefits & costs—optimal policy must balance all of these.
 - Market benefits related to electricity production (producer/consumer).
 - Non-market benefits related to reduced reliance on alternative, more polluting energy sources.
 - Non-market benefits or costs related to impacts on coastal aesthetics and property values.
 - Market benefits or costs related to fishery impacts.
 - Market and/or Non-Market benefits or costs related to other impacts on ecosystem services, short and long term (e.g., recreation).
- Economic benefits/costs depend not only on project existence, but also on scale and attributes.



Example #2: Salt Marsh Restoration

- Insufficient resources to restore all sites, so how do you prioritize? Ecology is only part of the solution.
- Model coordinates economic and ecological information to prioritize salt marsh restoration projects in Rhode Island.
- Links restoration impacts on salt marsh features to functions to non-market values.
- Alternative models (e.g., developed for Peconic estuary) can also predict productivity effects on market values.

What About Risk and Uncertainty?

- Environmental outcomes often involve risk or uncertainty—these are different.
 - Risk: You can at least approximate possible outcomes and probabilities. We have some range of knowledge about future possibilities.
 - Uncertainty: Outcomes and probabilities are entirely unknown.
 - Under true uncertainty (e.g., we don't know anything), it is difficult to apply economic models.
- Under risk, there are well-defined methods to adjust economic values (expected values; option prices, quasi-option values).

Linking Economics and Ecology Under Uncertainty

- To the extent that we can reduce uncertainty to risk, economic tools can provide significant insight regarding tradeoffs and policy choices.
- What are the best plans of action? What will benefit society most in the long run?
- Economic forecasts depend in part on knowledge of ecological systems.
 - Economic model certainty is limited, in many cases, by knowledge of underlying ecological systems. Where ecological systems are involved, we can be no more certain than the underlying ecological models.

EBM Approaches to Threatened Coastal Resources

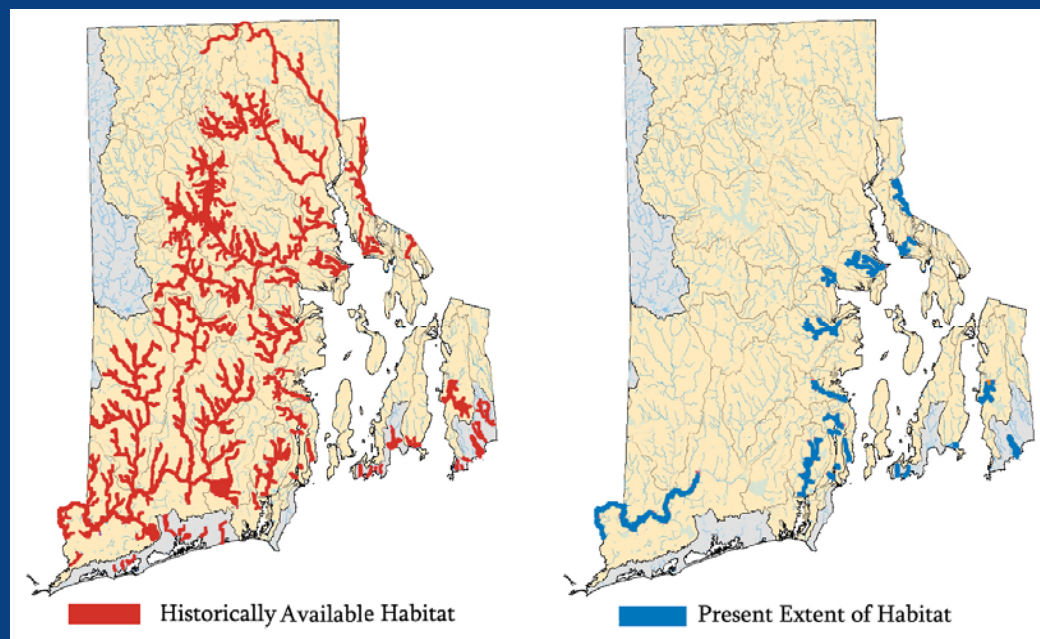
- There is no free lunch—there are always “opportunity costs.”
 - Option #1: Protect or Conserve (but you can’t preserve everything!)
 - Option #2: Mitigate, Offset or Replace (but you can’t replace everything, and mitigation may be only partially effective.)
 - Option #3: Triage (preserve or replace the most valuable).
- Economics and economic values can help inform these choices.
- A tool for decision making under uncertainty.

Example #3: New England Diadromous Fish Restoration

- Diadromous fish restoration is a major policy initiative in most New England states.
- Example: **Red** shows RI rivers where migratory fish used to live before humans arrived. **Blue** shows rivers where these fish live today.



River Herring (alewife)

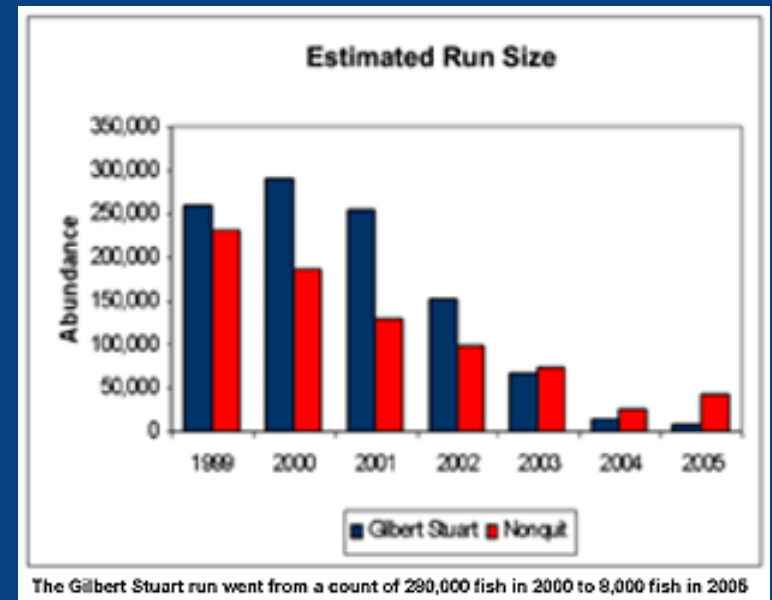


New England Diadromous Fish Restoration

- Fish passage efforts such as the provision of fish ladders and dam removal have been ongoing for decades. Efforts were costly but at least moderately effective.
- Diadromous fish populations appeared stable or growing in most areas until very recently (2000-01).
- Recent precipitous declines appear to be unrelated to fish passage concerns.

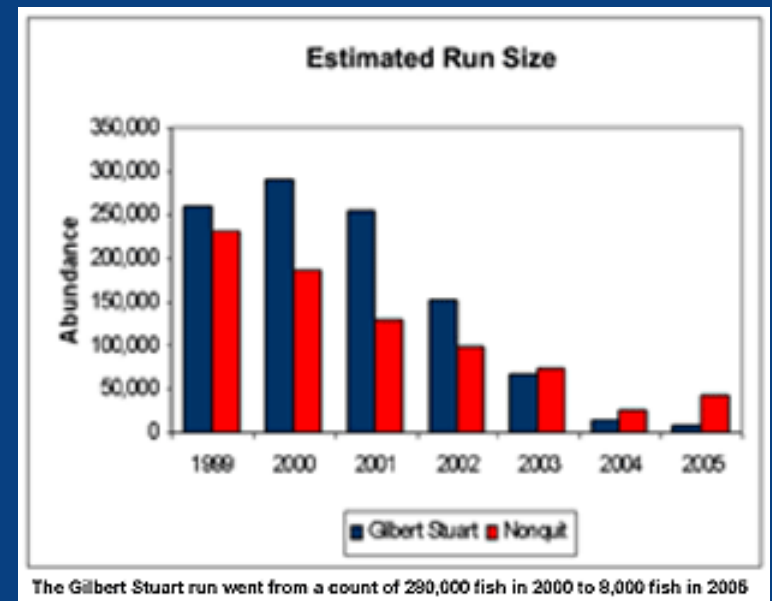
Decline of Southern New England River Herring

- Between 95-99% decline in many Southern New England fish runs; river herring fishery closed in MA, CT, RI.
- Fish passing over Holyoke Dam in MA dropped from over 630,000 in 1985 to 21 last year (yes, that's twenty-one fish).



The Cause of Decline is Unknown

- Consensus is that decline has nothing to do with fish passage—it's something happening at estuarine interface or in the open ocean.
- Possibilities include:
 - By-catch in sea herring fishery.
 - Resurgence of predators.
 - Climate change.



What is Going On?

- "It's clear striped bass are having an impact," he said. "But I'm not convinced it's the main thing. Something is happening in the Atlantic Ocean and Long Island Sound, too. We are just not sure exactly what." (R. Gephard, CT DEP, quoted in Hartford Courant 4/17/2007).
- So how do you manage this valued but threatened resource?

What is the Optimal Response?

- Place additional resources to try and offset or reverse the decline?
 - But restoration activities are costly, and restoration expenditures may be ineffective at halting the decline.
- Abandon new restoration efforts?
 - But restoration efforts might help to slow the decline or even prevent extinction in some rivers.
- What about striped bass or the sea herring fishery?
- From an economic perspective, answer depends on both probabilities and relative values.

The Structure of Probability is Critical

- Assume that the probability that fish run i will persist (P_i) is a function of resources allocated to fish passage in river i (X_i) and exogenous events beyond the control of managers (Q_i).



$$P_i(X_i, Q_i)$$



The more important is X_i , the more resources should be expended.

The more important is Q_i , the less resources should be expended.

- What is the probability that you will win if you stay in the game?

Social Value is Also Critical

- Expected surplus (or value), ES_i , is a function of the probability that fish run i will persist (P_i) and the attributes of the fish run (Y_i).



$$ES_i(P_i(X_i, Q_i), Y_i)$$



The larger is social value compared to that of other resources, the more resources should be expended.



- What is the size of the pot? How much is at stake?

And What if You Can Control Other Factors?

- But EBM explicitly focuses on multiple resources simultaneously...
- What if you can (partially) control striped bass populations (S_i) and/or fishing bycatch (B_i)?
- Now $P_i(X_i, Q_i) = P_i(X_i, S_i, B_i, Q_i)$, and tradeoffs become more complex, but not intractable.
- Each policy tool has estimable benefits and costs.
- Economics provides a consistent framework for analysis and policy guidance under uncertainty (or more specifically, risk).

What Information Is Needed?

- In some cases, estimates of market and non-market values are available.
 - For example, we are currently conducting a study of non-market values associated with the restoration of river herring passage and populations.
 - Benefit Transfer is also an option, where approximations are acceptable.
- Estimating probabilities can be more difficult, but natural scientists are trying to solve the puzzle.
- Key: link appropriate economic and ecological information to guide more optimal policy responses.

Choices, Tradeoffs and Coastal Resources

- Economics can assist managers in conceptualizing and facing tradeoffs related Ecosystem Based Management
- Resources are not infinite—how should we prioritize our actions?
- Given empirical estimates or approximations of probabilities and values, economics can provide guidance.
- Even without specific empirical estimates, economics can contribute structural clarity to policy dialogs.
- This is not the only tool available to managers—but can help to ensure that policy serves the long-term interests of society.

Moving From Valuation to Prediction

Dan Holland

Gulf of Maine Research Institute

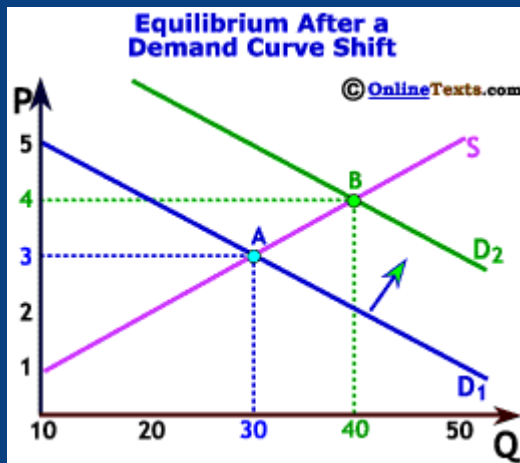


Understanding and Modeling Human Behavior

- Changes in net benefits resulting from changes in ecosystem services are the result of human preferences and are moderated by human behavior
- Valuation techniques that evaluate peoples' preferences for various goods and services provide the means for quantifying the net benefits of changes in the provision of those goods and services
- They can also be used to understand and predict how people will react to changes in availability and prices of those goods and services
- This is necessary to evaluate beforehand the consequences of different policy choices

Modeling Economic Behavior

- Standard models of aggregate supply and demand



$$P(k) = P[V_k(q_k, s_n) + \varepsilon(q_k, s_n) \geq V_{k'}(q_{k'}, s_n) + \varepsilon(q_{k'}, s_n) \forall k \in C_i, k \neq k']$$

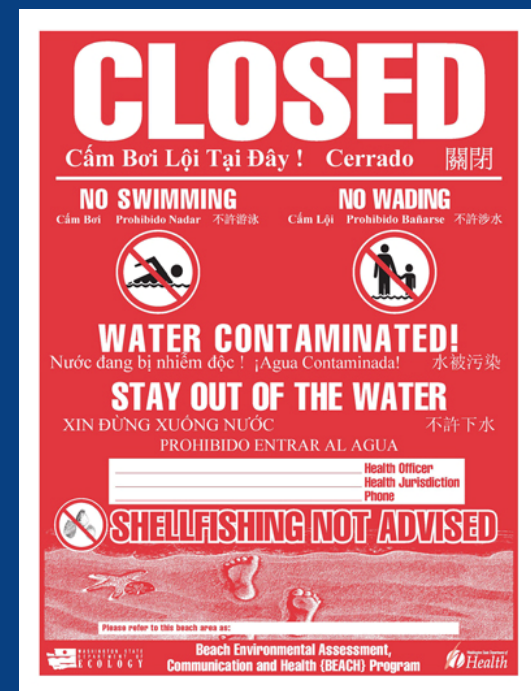
- Individual level model based on observed choices or stated preferences

Static Valuation of Ecosystem Services

- Evaluate the change in producer and consumer surplus measures of any corresponding changes in the one-period market equilibrium for the ecological service (Barbier 2000).
- This should include modeling of or assumptions about changes in behavior.
- When a preferred choice is restricted, people will substitute something else.
- The loss in value is the difference in value between the first choice and the alternative.

Valuing a Beach Closure

- What is the lost value to would be users of the beach while it is closed
- Value of that experienced minus value of what is substituted
- If the individual simply goes to an equally desirable beach but it's a little further away, lost value may be the cost of additional time and money getting to the other beach.
- Market value losses to businesses (e.g. hotels and restaurants) may also be offset by gains elsewhere



Dynamic Valuation of Ecological Services

- Static valuation generally neglects longer run changes that may occur as physical, ecological and human components of the system adapt to the initial changes
- **Dynamic Valuation:** “the ecological service is considered to affect an intertemporal, or “bioeconomic,” production relationship. For example, a coastal wetland that serves as breeding and nursery habitat for fisheries could be modeled as part of the growth function of the fish stock, and any welfare impacts of a change in this habitat support function can be determined in terms of changes in the long-run equilibrium conditions of the fishery or in the harvesting path to this equilibrium.” (Barbier 2000)

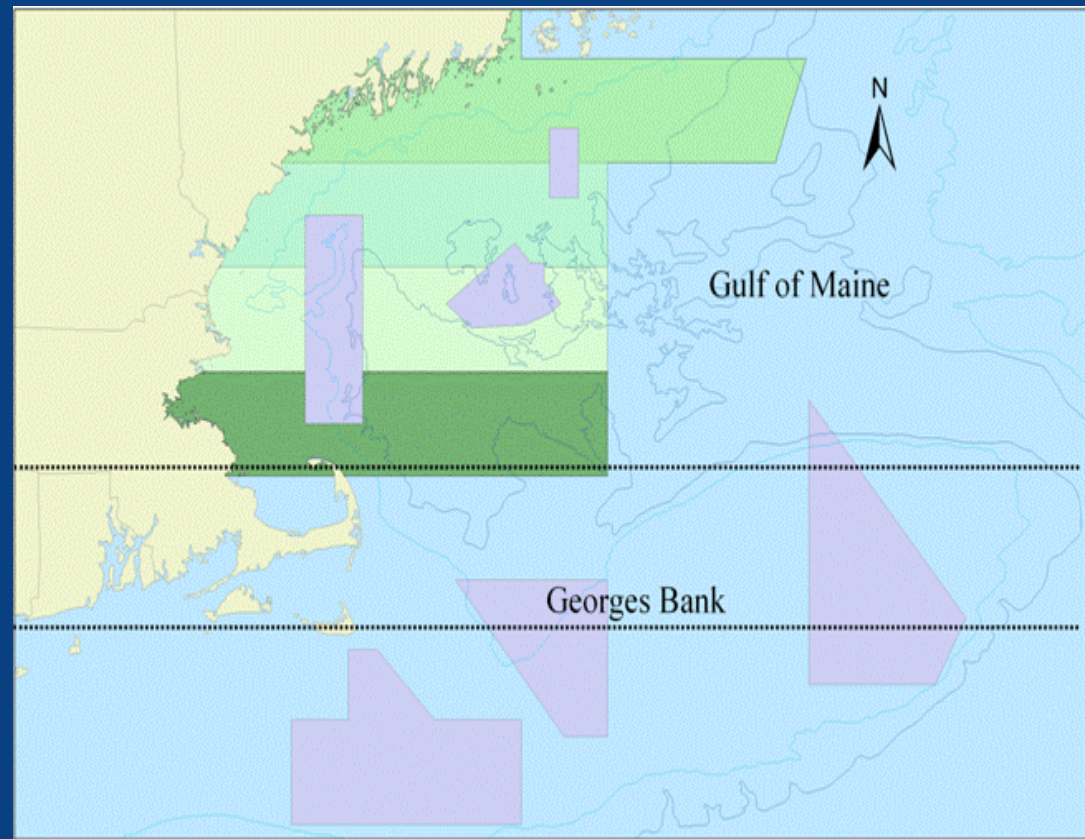
Valuing Changes in Habitat Quality

- Valuation may utilize ecological or physical models to predict and value changes in production of ecosystem services that are expected to occur
- Study of Peconic Estuary Salt Marsh Productivity (Johnston et al. 2002) links ecological and economic models to assess ecological productivity values.
 - Estimate primary (plant) and bottom (amphipods, worms, etc.) production rates from ecological models.
 - Estimate fraction of the additional production passed up through food web
 - Translate into commercial fish and shellfish production and landings using average estuarine values
 - Estimate values using species-specific fishery information for PES landings

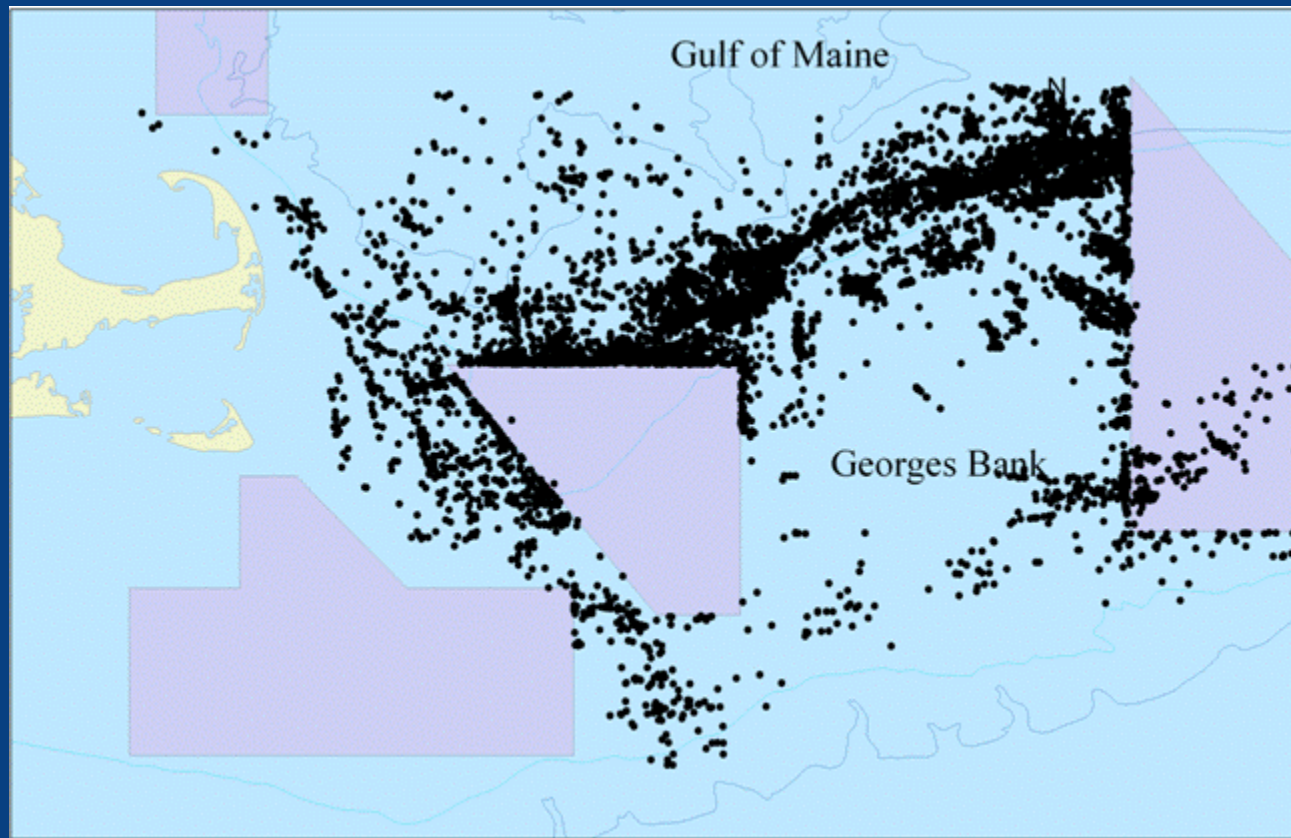


Example: Understanding the Effects of Year-round and rolling closures in groundfish fishery

- Permanent and rolling closures for groundfish not only displace groundfish effort they affect distribution of lobster traps and recreational fishing effort



Do Area Closures Affect Behavior Outside Them?



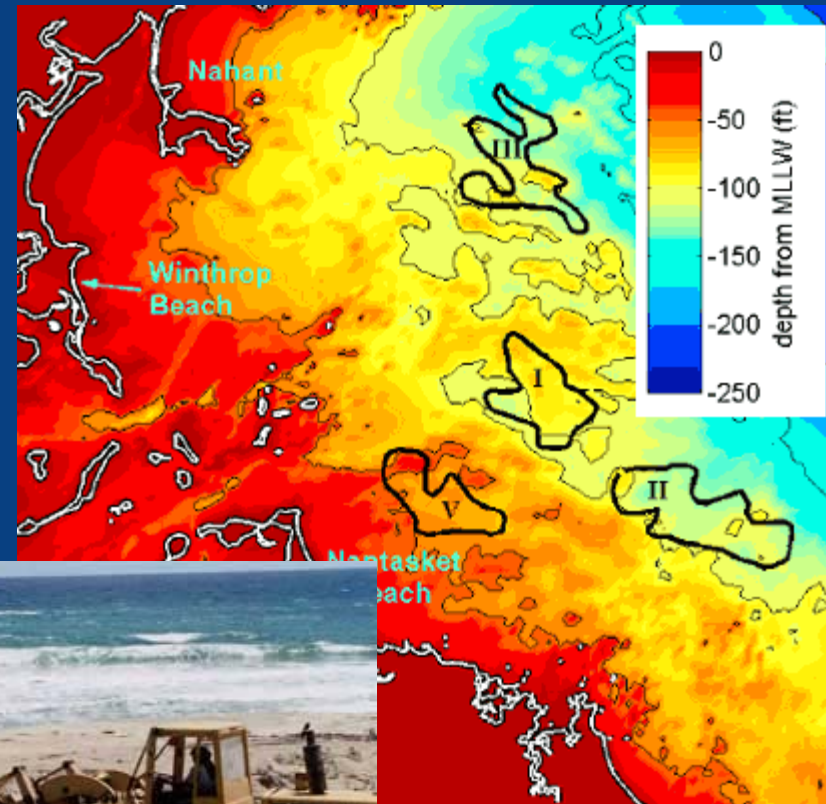
Starting points of individual tows by a group of trawlers from New Bedford
(data collected by SMAST)

Short Run and Long Run Effects of a Spatial Fishery Closure

- Effort is displaced (presumably to next best option)
- Loss in value to fishers (difference between fishing in the closed area and the next best option)
- The value of the next best option may change even in short run as more effort is added in open areas
- Non prohibited users may move in to closure and benefit (e.g., recreational fishers, lobstermen)
- Closure may have impacts in medium term (leakage and recruitment) as well as longer term effects from displaced effort

Sand mining for beach nourishment

1. Nourish Beach
2. Increased benefits from beach use and increased local property values
3. End of story?



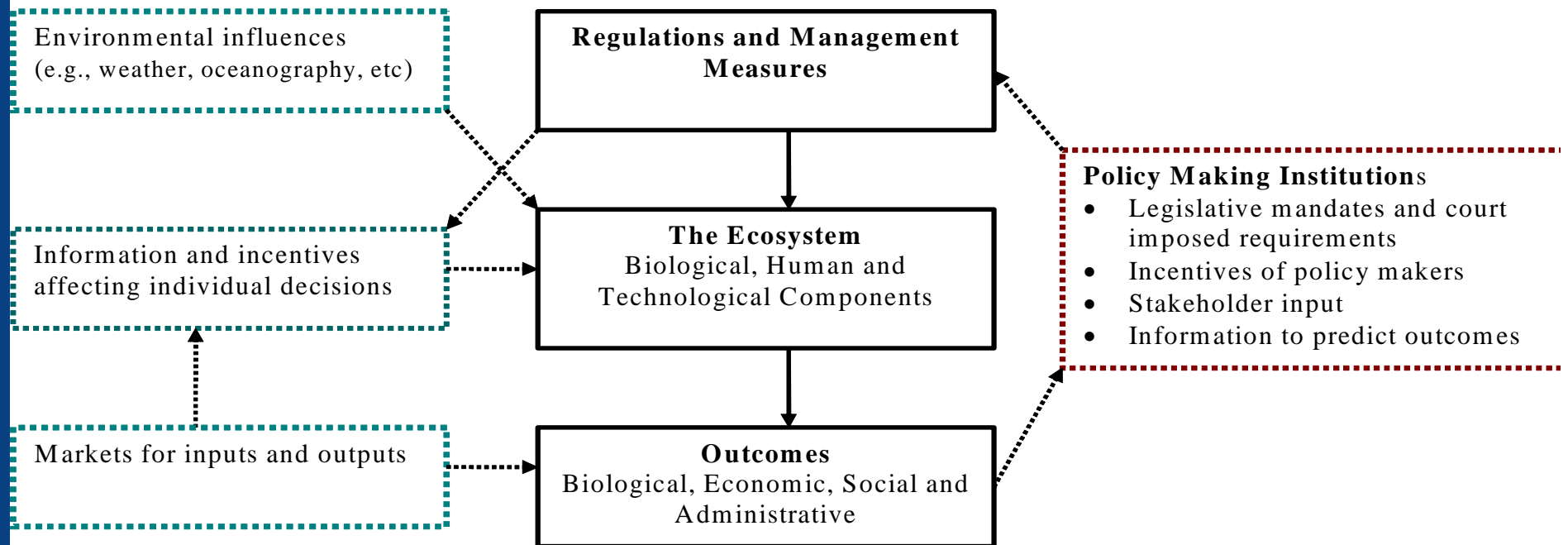
Coupling Human and Natural Influences on Coastline Evolution as Climate Changes (NSF CNH Grant)

- “ Human efforts to stabilize the shoreline position -- especially through artificial sand placement or "beach nourishment" -- are becoming increasingly prevalent, and these localized manipulations likely affect how entire coastlines evolve through their long-range as well as regional effects.”
 - This research project will incorporate human manipulations into an enhanced computer model of large-scale, long-term coastline change caused by wave-driven sediment transport. Addressing the behaviors of the fully coupled human-natural system will require developing a model that represents how humans respond to coastline changes, especially local shoreline erosion.

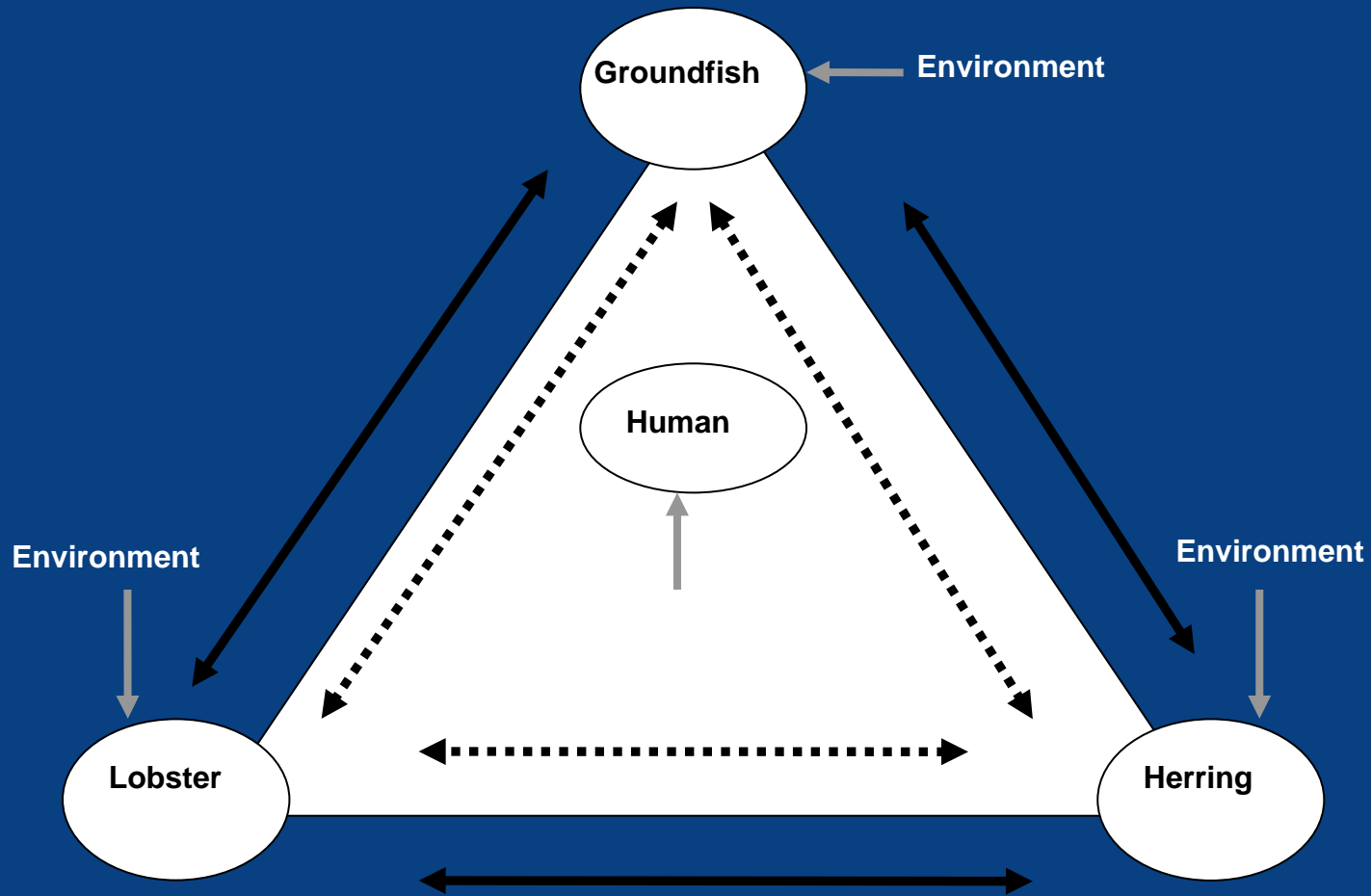
A systems approach

- Ideally we seek to understand how economic incentives that influence human behavior are changed by policies and exogenous factors and how expected changes in behavior influences outcomes (economic and ecological) both in the short run and in the long run as changes in the ecosystem feed back to change incentives.
- In many cases to fully understand impacts, we must consider linkages between natural and human systems that have traditionally been managed separately

Understanding and modeling humans as part of the marine ecosystem



Direct and Indirect coupling of fisheries through economic, regulatory, environmental and ecological linkages



Conclusions

- Economists have a variety of statistical techniques to model how changes in ecosystem services impact human welfare
- Economic models can be coupled with biological or physical models that relate policies and actions to ecological services people value
- Predictive models can quantify not only short-term changes in benefits but behavioral responses
 - E.g., increases or decreases of demand for a particular good or service and substitution
- Ideally we should evaluate impacts and policies in the context of the larger coupled natural-human systems in which they are nested which may require complex dynamic models
 - Information constraints will often limit our ability to do this quantitatively, but qualitative analysis may still be valuable
- In some cases, we may not be able to predict the net benefits of a particular policy action and may have to be satisfied with trying to determine the least costly way of achieving a specified objective

Outline of Economic Study

Role of economics in EBM and Coastal Zone Management

- Literature review on the economics of ocean zoning & EBM
- Economic frameworks (BCA, cost-effectiveness, regional impact analysis)
- Methods for estimating value of ecosystem services and resource uses (non-market valuation)
- Economic principles in making decisions with uncertainty
- Understanding and modeling human behavior
- Economics of explicit spatial and temporal management
- Governance and choice of regulatory methods
- Illustrative examples used throughout
 - **nutrient impacts in the coastal zone**
 - **sand and gravel mining**
 - **explicit spatial and temporal management of fishing activities**

Further Reading (1)

Johnston, R.J., T.A. Grigalunas, J.J. Opaluch, J. Diamantedes, and M. Mazzotta. 2002. Valuing Estuarine Resource Services Using Economic and Ecological Models: The Peconic Estuary System Study. *Coastal Management* 30(1): 47-66.

Johnston, R.J., G. Magnusson, M. Mazzotta and J.J. Opaluch. 2002. Combining Economic and Ecological Indicators to Prioritize Salt Marsh Restoration Actions. *American Journal of Agricultural Economics* 84(5): 1362-1370.

Mazzotta, M.J., J. J. Opaluch, G. Magnuson, and R.J. Johnston. 2002. Setting Priorities for Coastal Wetland Restoration: A GIS-Based Tool That Combines Expert Assessments And Public Values. *Earth System Monitor* 12(3): 1-6.

Bockstael, N.E., A.M. Freeman, III, R.J. Kopp, P.R. Portney, and V.K. Smith. 2000. On Measuring Economic Values for Nature. *Environ. Sci. Technol.* 34 (8), 1384 -1389.

Further reading (2)

Barbier, E.B. 2000. Valuing the environment as input: Applications to mangrove-fishery linkages. *Ecological Economics* 35:47-61.

National Research Council 2005. *Valuing Ecosystem Services: Toward Better Environmental Decision-Making*. National Academies Press. 290 pages, Washington D.C.

Holland, D.S. 2007. Managing Environmental Impacts of Fishing: Input Controls versus Outcome Oriented Approaches. *International Journal of Global Environmental Issues*. Forthcoming 7(2,3):255-272.

Holland, Daniel S. 2005. Economic Analysis of Protection of Essential Fish Habitat in Alaskan Fisheries: An Analysis of Research Needs. NOAA Technical Memorandum NMFS-AFSC-154. August.

Holland, Daniel S. 2004. Spatial Fishery Rights and Marine Zoning: A Discussion with Reference to Management of Marine Resources in New England. *Marine Resource Economics*. 19(1):21-40.

Sanchirico, J. N and S. Hanna. Navigating U.S. Fishery Policy Into the 21st Century, *Marine Resource Economics*, 19(3): 2004.

Sanchirico, J. N. *Zoning the Oceans*. In *New Approaches on Energy and the Environment: Policy Advice for the President* (Richard Morgenstern and Paul R. Portney, eds.). RFF Press, Washington, DC (Nov. 2004).

Sanchirico, J.N., J. Eagle, S. Palumbi, B. Thompson. Beyond ocean zoning. RFF Discussion paper. Available at www.rff.org.