Title: Integrated Gulf of Mexico Bird Monitoring Strategy

A Case Study from the Structured Decision Making Workshop
February 3-7, 2014
National Conservation Training Center, Shepherdstown, WV

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DECISION PROBLEM

Over the years, the conservation community comprised of dedicated scientists and conservationists ranging from on the ground habitat managers and researchers to those making programmatic, region-wide funding allocations have done an admirable job of monitoring the "species/topic du jour"; usually in the form of a research project. However, the conservation community continues to struggle to design and implement a large-scale, coordinated monitoring program due to the complexity of the Gulf of Mexico System (e.g., multiple priority bird species using different habitats during different times of the year [breeding season vs. migration]). This issue is further complicated by the need for both surveillance-based (e.g., baselines, trends) and outcome-based (e.g., response to management) monitoring. To address the reoccurring question of what and where to monitor, the conservation community needs to engage in a structured process to identify information needs and priorities of a coordinated bird monitoring strategy that addresses multiple objectives, species, and habitats along the Gulf of Mexico, such that operational and financial decisions can be made in a proactive and adaptive manner. To that extent, we developed the following problem statement: *"how do we develop a cost-effective monitoring strategy for the Gulf Coast avian community/Gulf Coast ecosystem that evaluates on-going, chronic, and acute threats and conservation activities, maximizes learning, and is flexible and holistic enough to detect novel ecological threats with respect to management triggers and to evaluate new and emerging conservation activities?"* To address this problem statement, a group of conservation partners (representing a variety of agencies and organizations) with interest in the Gulf of Mexico participated in a Structured Decision Making Workshop at NCTC with the objective of utilizing the principals of decision analysis to identify a structured process for developing and implementing a bird monitoring strategy across the Gulf of Mexico to better inform conservation actions.

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BACKGROUND

Legal, regulatory, and political context

At this point, there are no legal, regulatory or political underpinnings to the implementation of a bird monitoring strategy in the Gulf of Mexico, per se. However, several Federal and State Wildlife Agencies have legal mandates to protect and conserve wildlife resources and their habitats for the continuing benefit of the American people. Hence, the success of designing and implementing a coordinated and collaborative monitoring strategy for the Gulf of Mexico requires the commitment and dedication of a wide array of conservation partners (e.g., Federal Agencies, State Wildlife Agencies, NGOs, Joint Venture Partnerships and Landscape Conservation Cooperatives), all operating under different mandates and missions.

Ecological context

Birds are a conspicuous and remarkable natural resource of the Gulf of Mexico. Hundreds of species and millions of individual birds are supported by barrier islands, beaches, marshes, and coastal forests across the Gulf ecosystem. Collectively, these species are an unparalleled indicator of system health and the natural resources on which humans rely for their health, economy, and quality of life. Today, the conservation of coastal habitats for birds is often at odds with human population growth, creating tension between the importance of coastal areas for human needs and their value for birdlife. Anthropogenic stressors (e.g., oil spills, urban development) along with more natural disturbances (e.g., hurricanes, sea level rise) can result in loss, fragmentation, and reduced quality of habitats in sensitive coastal ecosystems. Quantifying the magnitude of these impacts, as well as assessing bird/habitat response to mitigation and restoration activities is critical, if the conservation community is to work in a collaborative, proactive-manner to protect and conserve valuable natural resources along the Gulf Coast.

DECISION STRUCTURE

The core of Structured Decision Making (SDM) is a set of well-defined objectives and evaluation criteria. Together they define "what matters" about the decision, drives the search for creative alternatives, and becomes the framework for comparing alternatives (Gregory et al. 2012). To initiate discussions per identification of monitoring objectives, a group of scientist met at the Grand Bay National Estuarine Research Reserve, Grand Bay, MS (November 12-13, 2013) and participated in a 2-day SDM prototyping exercise. During the Grand Bay workshop, participants identified the following goal and objectives:

Goal: Develop a Gulf-wide avian monitoring plan that efficiently

1. ***Maximizes our ability to evaluate the state of the system (in terms of predefined conservation objectives);***
2. ***Maximizes our ability to evaluate the effect of chronic and acute threats;***
3. ***Maximizes our ability to evaluate the effects of positive and negative anthropogenic activities;***
4. ***Maximizes understanding of natural processes; and***

5. ***Maximizes the probability of detecting and responding to unknown and emerging threats.***

At the NCTC Workshop, initial discussions suggested that there were overlap in the objectives previously identified at Grand Bay, thereby prompting the group to restructure the objectives resulting in four fundamental objectives (see below). Additionally, the group's thinking per the overarching goal of a monitoring program evolved to consider a more explicit linkage to conservation, as opposed to simply designing a monitoring program as stated in previous discussions.

Goal: Maximize understanding of birds & habitat to facilitate / inform conservation

1. ***Maximize understanding of management actions***
2. ***Maximize understanding of anthropogenic threats***
3. ***Maximize understanding of ecological processes / variation***
4. ***Maximize understanding of baseline conditions***

To clearly examine and refine our fundamental objectives, the group undertook a "stakeholder brainstorming session" where each person was asked to list the core values and/or needs they deemed necessary for underpinning a bird monitoring effort in the Gulf of Mexico. From this exercise, several key concepts repeatedly emerged – scientific rigor; relevancy; state of the system; response to management; integration; and partnerships. From here we developed an influence diagram that linked monitoring to the larger fundamental objective of restoring the Gulf of Mexico and providing direct linkages to ongoing conservation planning efforts (Figure 1) which permitted us to think about fundamental objectives in a new light (i.e., do our fundamental objectives serve as means objectives for achieving the overarching vision of integrated restoration and management?). Additionally, the influence diagram identified the "process objectives" which will need to be addressed in the development of bird monitoring strategy including several embedded components such as data management and communication. The recognition of these process objectives provided additional structure to our thinking allowing us to separate the key components, while at the same time realizing necessary linkages where appropriate. By constructing the influence diagram, the group was able to redirect its thinking to better articulate core values and a new set of fundamental objectives that represent these values in a hierarchical format (see below).

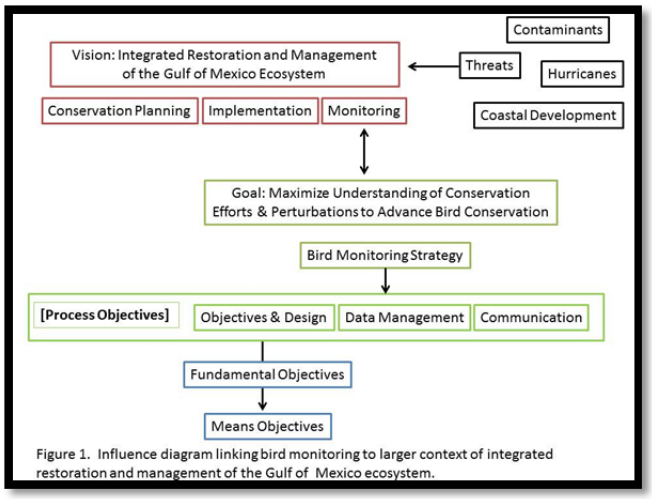


Figure 1. Influence diagram linking bird monitoring to larger context of integrated restoration and management of the Gulf of Mexico ecosystem.

Specifically, the new fundamental objectives are:

- **Objective**: *Maximize Relevance of Monitoring Projects (ensure monitoring projects are addressing contemporary data needs, management issues and/or threats outlined in conservation business plans [FWS, Joint Ventures, State Wildlife Action Plans, etc.] and are integrated across multiple partners).*

    - **Sub-objective**: *Maximize Understanding of the State of the System (baseline information related to the status and trends of priority bird species in the Gulf of Mexico)*

    - **Sub-objective**: *Maximize Understanding of Perturbations (increased understanding of cause and effect relationships of contemporary management actions and/or threats impacting bird populations in the Gulf of Mexico)*

    - **Sub-objective**: *Maximize Integration of Monitoring Projects (increased integration and explicit linkages to monitoring efforts and data needs outlined in Conservation Business Plans)*

- **Objective:** *Maximize Rigor of Monitoring Projects (increase emphasis on scientific rigor [study designs, sampling frameworks, power analysis, etc.] underpinning monitoring projects in the Gulf of Mexico)*

PERFORMANCE METRICS

For each of the fundamental objectives, we articulated a set of performance metrics or evaluation criteria, as they are often referred, to facilitate the evaluation of monitoring objectives and the development of alternatives. For this prototype, value functions for all performance metrics were designed as constructed scales using a linear value function (e.g., 1+1+1=3). All values scores were normalized across objectives, such that the "value" scores were comparable across objectives and alternatives.

Objective: Maximize Relevance of Monitoring Projects

Sub-objective: Maximize Understanding of the State of the System

Performance metrics: (1) Number of priority bird species surveyed;
(2) Average percentage of Gulf-wide range.

Sub-objective: Maximize Understanding of Perturbations

Performance metrics: (1) Scope, severity and uncertainty of perturbation;
(2) Number of priority bird species impacted

Sub-objective: Maximize Integration of Monitoring Projects

Performance metrics: (1) Number of partners with funding;
(2) Number of partners contributing in-kind;

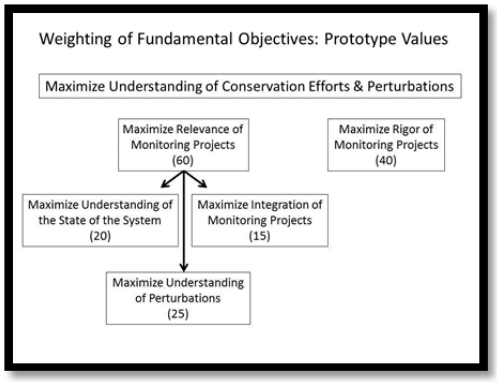
(3) Percentage of the budget comprised of in-kind;
(4) Number of conservation plans addressed.

Objective: Maximize Rigor of Monitoring Projects

Performance metrics: (1) Technical merit;
(2) Clearly articulated hypotheses /objectives

WEIGHTING OF OBJECTIVES

During the development of the objectives, the group spent considerable time discussing the question…who is the decision maker, with respect to development and implementation of a Gulf of Mexico bird monitoring strategy? After much discussion, the group decided for the sake of this exercise, that we, the local bird experts representing a myriad of agencies and organizations were the decision makers. However, the group also realized that in terms of implementation, the decision maker could and will likely vary somewhere between the local on-the-ground manager and a State/Regional Director. To account for potential differences in decision makers and their respective core values of a monitoring strategy, the group discussed the use of objective weighting. By weighting the objectives, different stakeholder core values can be represented and a transparent and equitable process can be developed to ensure these core values are incorporated within the analysis and selection of alternatives.



As a trial run and means to evaluate the process, each group member was asked to weigh each of the objectives based upon his/her personal, core values of a monitoring strategy. A quick analysis was conducted with the group agreeing to accept the average weights as a starting point for this prototype.

ALTERNATIVE ACTIONS

At the end of the first prototype, the group realized that the solution to developing a Gulf-wide bird monitoring strategy would require the development and implementation of several bird surveys (e.g., alternatives) functioning as a portfolio of surveys. In that, our challenge was to generate and discriminate among a suite of survey portfolios. Based on the previously identified set of hierarchical objectives and performance metrics, the group developed a suite of hypothetical surveys for use in trade-off analysis. We developed a set of eleven hypothetical surveys to represent the different types of activities that might be considered for gathering critical information on one or more specific threat or management issue (see below).

PREDICTIVE MODEL

We used a consequences table to capture the predicted outcomes for each of the eleven hypothetical surveys included in the prototype. Group members serving as the expert panel, scored each of the surveys with respect to our objectives and performance measures. For illustration purposes, the table below shows raw scores (prior to normalization) for 6 of our 10 performance measures.

SCORES	1	2	3	4	5	6
	Monitoring Rigor		State of the Gulf		Perturbations	
Monitoring project	Technical Merit	Hypoth/Obj	# priority sp. w/ trend	Avg. gulf-wide range	Scope, Severity, Uncert.	# priority sp. Affected
Salinization BACI (1 site, 6 yr, 5 sp)	4	5	0	0.0	7	30
Stewardship/predator control	3	5	4	0.5	12	4
Oil contamination	2	5	0	0.0	6	5
Marshbird productivity	4	5	1	0.8	13	1
Omnibus monitoring	5	3	30	0.9	22	90
Dredge on Barrier Islands, replicated	5	4	7	0.4	8	7
Coastal devel. on least terns	3	3	1	0.1	14	1
Drought on mottled ducks	5	5	1	0.6	13	1
Hurricane impacts	4	5	0	0.0	7	75
Marsh creation	5	5	0	0.0	8	30
Human disturbance on beaches	4	5	0	0.0	5	8

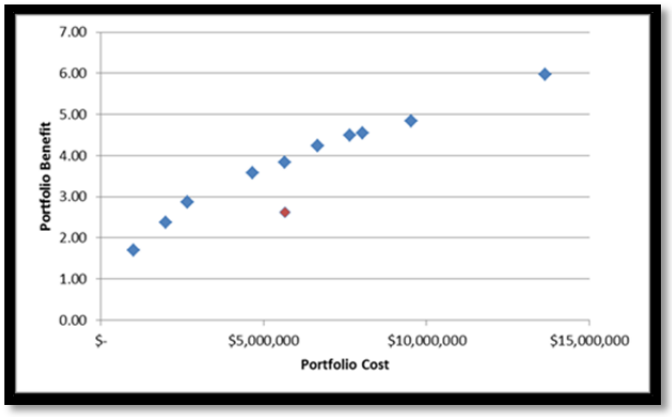
DECISION ANALYSIS

Using linear programming and the "Solver" extension within Microsoft Excel, different portfolios of survey projects were optimized based on the survey value (as determined from the performance metrics) and constrained by cost (e.g., total amount of funding available). In our prototype, we ran this constrained optimization across a wide range of budget scenarios. We compared the budget-conditional optimal portfolios to several randomly selected monitoring portfolios. This analysis allowed the group to evaluate several different portfolios of surveys based upon their combined survey values

PORTFOLIO ANALYSIS			
Monitoring project	Include?	Monitoring Benefit	Cost
Salinization BACI (1 site, 6 yr, 5 sp)	1	0.71	750,000
Stewardship/predator control	0	0.72	2,000,000
Oil contamination	1	0.26	1,000,000
Marshbird productivity	0	0.68	1,000,000
Dredge on Barrier Islands	1	0.68	125,000
Dredge on Barrier Islands, replicated	0	0.73	500,000
Coastal devel. on least terns	1	0.32	125,000
Drought on mottled ducks	0	0.55	2,500,000
Hurricane impacts	1	0.19	3,000,000
Marsh creation	0	0.66	2,000,000
Human disturbance on beaches	1	0.48	650,000
	Total:	2.62	5,650,000
	Cost Constraint:		10,000,000

relative to the total amount of funding available and determine the increased benefit of an optimal portfolio relative to a non-structured selection of monitoring activities at the same cost.

Each of the selected portfolios along with a randomly selected portfolio were plotted and examined for cost/benefit tradeoffs using a Pareto Efficiency Frontier analysis. This exercise was informative in that it provided a means to realistically evaluate each portfolio against funding. That is, if the conservation community has limited dollars (e.g., $1,000,000), which portfolio of survey projects yields the biggest conservation return on the dollar? Alternatively, for an unspecified budget, this analytic approach permits the identification of changes in the rate of benefit accumulation per monitoring dollar spent (i.e., the slope of the efficiency frontier).



Additionally, the group discussed the need for other portfolio constraints (e.g., portfolio objectives) to ensure the portfolio of surveys include a comprehensive set of spatial, taxonomic, and/or objective-specific surveys. However, due to time and programming constraints, the group was not able to evaluate the use of other portfolio constraints at NCTC, but intends to incorporate into future prototypes.

DISCUSSION

The Structured Decision Making process provided the necessary structure to focus, weigh, and constrain a large number of surveys to produce maximum efficiency, focus on multiple conservation objectives, and fulfill multiple partners' interests (core values). As a result of applying the SDM process, the group has developed a prototype structure that: (1) identified a set of hierarchical fundamental objectives; and (2) yielded a decision support tool for selecting and optimizing among competing surveys (i.e., alternatives). The value-added input of the SDM process in this effort is reflected in the identification of, and agreement regarding fundamental objectives which will permit the group to work with additional conservation partners to develop a suit of surveys that address these objectives, thereby focusing surveys at the most critical conservation needs. Furthermore, the development of optimization and trade-off strategies has resulted in a decision support tool whereby decision makers can make transparent and defensible decisions that result in the greatest contributions to bird conservation.

As the group worked through the SDM process the group either learned and/or was reminded of a number of key lessons via the prototyping process:

- It is easy to first jump to alternatives thus by-passing consideration of objectives and value focused thinking. In this case, not anchor on a specific monitoring project without consideration of what monitoring information is really needed.

- The identification of multiple objectives and associated performance metrics provided a means for each partner to articulate their core values. A high level of respect and trust was generated with the understanding that our agencies missions are different therefor each stake holder will have slightly different needs but each are considered.

- Rapid prototyping allows for the generation and testing of ideas, a process for creative thinking; however in our case as we moved through multiple prototypes there was more consideration and discussion of needing to refine the technical details.

- Prototypes need to result in decisions or tools but sometimes need structure and commitment to become operational. We acknowledge the need to develop a process objective hierarchy to address what is needed for the deliverables to be workable (e.g., communication plan, data management schema).

- It is critical to have individuals who represent a diversity of views, values and expertise present regarding the problem. It is equally important to acknowledge that we did not have everyone we needed and are currently working on rolling this process out to a broader group of constituents.

The implementation of a coordinated bird monitoring strategy in the Gulf of Mexico will ultimately require the design and develop of a myriad of bird surveys; it is this group's hope and expectation, that the lessons learned and products generated from this SDM effort will facilitate and provide structure to that effort.

To that extent, workshop participants are currently working to refine technical elements of the prototype in preparation for briefing a larger group of bird conservation constituents in the spring of 2014. The goal of this in-person meeting is to brief the larger group on the process used and tools developed, gather input to ensure the objectives and values of all partners are reflected, and develop and design a broader suite of potential, alternative monitoring programs. The next step will be engagement of the broader bird conservation community to further refine and evaluate the suite of potential, alternative monitoring programs that as a portfolio represent an "optimal" strategy for Gulf bird monitoring. At the same time, on-going communications with stakeholder decision makers is occurring to inform them of the steps being taken, gather input, and resulting deliverables.

Specifically the group is working to:

- Add details to performance metrics (e.g., identify and rank threats and conservation actions, develop priority bird list, and develop list of conservation plans)

- Develop performance metric value functions

- Refine weights for each objective

- Develop a template to guide development of projects

- Develop suite of projects that address state of the system and perturbations objectives
- Sensitivity analysis of portfolio constraints
- Develop a process objectives hierarchy

RECOMMENDATIONS

A small group of researchers, managers, coordinators, and administrators representing a subset of state and federal agencies, NGOs, universities, and partnerships across the Gulf met February 3-7, 2014 at NCTC to refine a vision and process for developing the role of bird monitoring in achieving integrated, efficient, and effective Gulf of Mexico management and recovery. Three deliverables resulted from the SDM workshop:

1. The group used a structured decision making process to develop an objectives hierarchy that reflects the values, goals, objectives, and information needs of the workshop participants for an integrated Gulf of Mexico bird monitoring strategy.

2. The group developed a prototype prioritization tool to evaluate how well alternative monitoring strategies could meet our objectives as a portfolio of projects.

3. The group realized that identification and development of survey projects must be undertaken by wider-array of individuals and/or entities than those represented at the NCTC workshop. Next steps include adding additional participants to reflect a broader array of stakeholders and decision makers.

LITERATURE CITED

Gregory et al 2012 – Structured Decision Making: A practical guide to environmental choices.

Hammond JS, Keeney RL, Raiffa H. 1999. Smart Choices: A Practical Guide to Making Better Life Decisions. Broadway Books, New York.