Addressing Resuspension Risks as a Decision Problem

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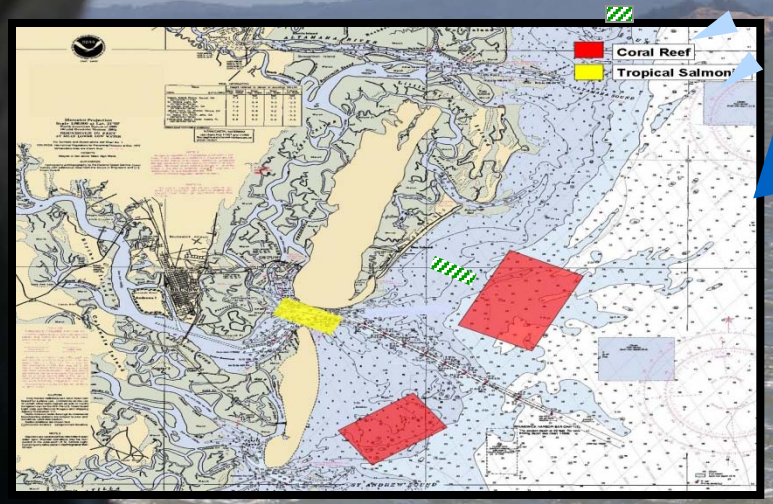
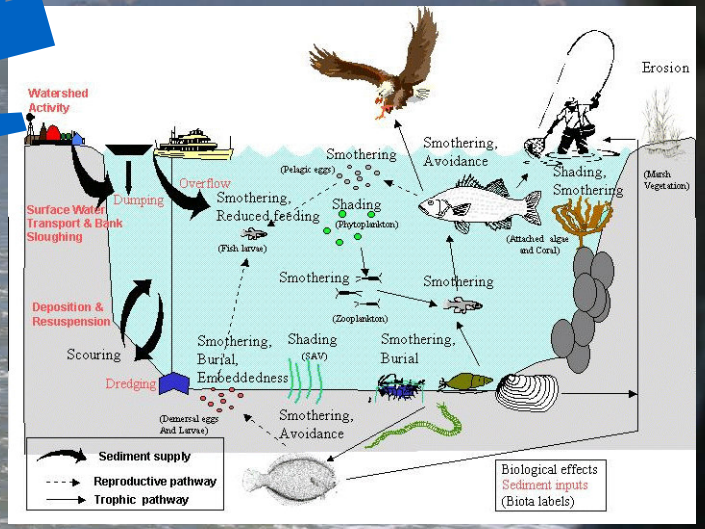
The Beginning…



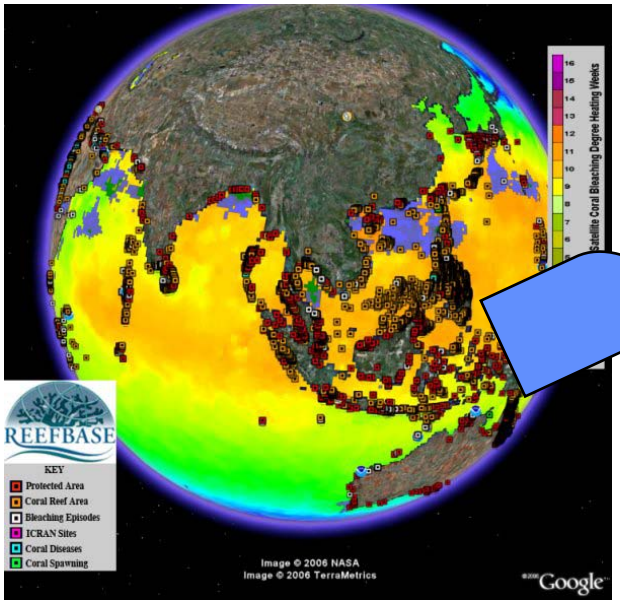


How could we balance engineering/societal needs with environmental protection goals?

Presentation -- Overview

- Case Study - Introduction
- Approaches to Selecting Dredging Alternatives
  - Gut Feeling
  - Some numbers
  - Multi-criteria Decision Analysis
- MCDA Framework and Case Study Illustration
  - Problem Formulation
  - Risk Assessment
  - Decision Analysis
- Conclusion
- References

Hypothetical Case Study - Introduction



- **Issue:** Toddistan is planning to deepen entrance channel to coastal port
- **Regulatory Environment**: Port borrowing money from World Bank, so required to:
  - Provide environmental protection
  - Decide whether or not to dredge

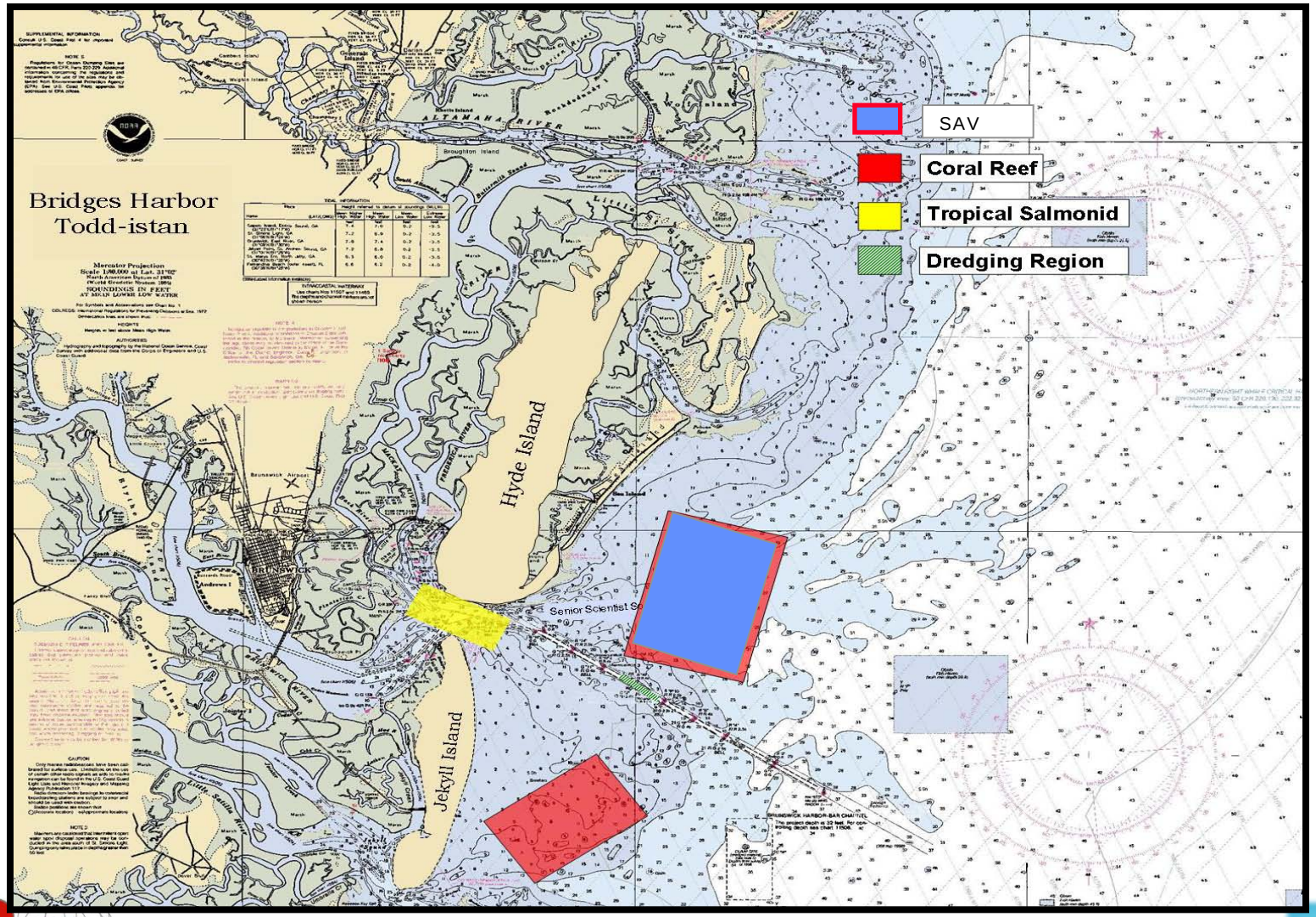
- Competing **Stakeholder Concerns:**
  - Maintaining navigation
  - Protection of resources from sediment resuspension
  - Minimizing duration of project and costs

Hypothetical Case Study - Introduction

Geo-physical Data:

- **Diurnal flow**
- **Predominately tidal-dominated currents**
- **Deepening means clean materials, not contaminated**
- **Sediments 30 percent fines, 70 percent sand**
- **Going to -55 ft depth from –45 ft**

Hypothetical Example – Map



Hypothetical Case Study - Introduction

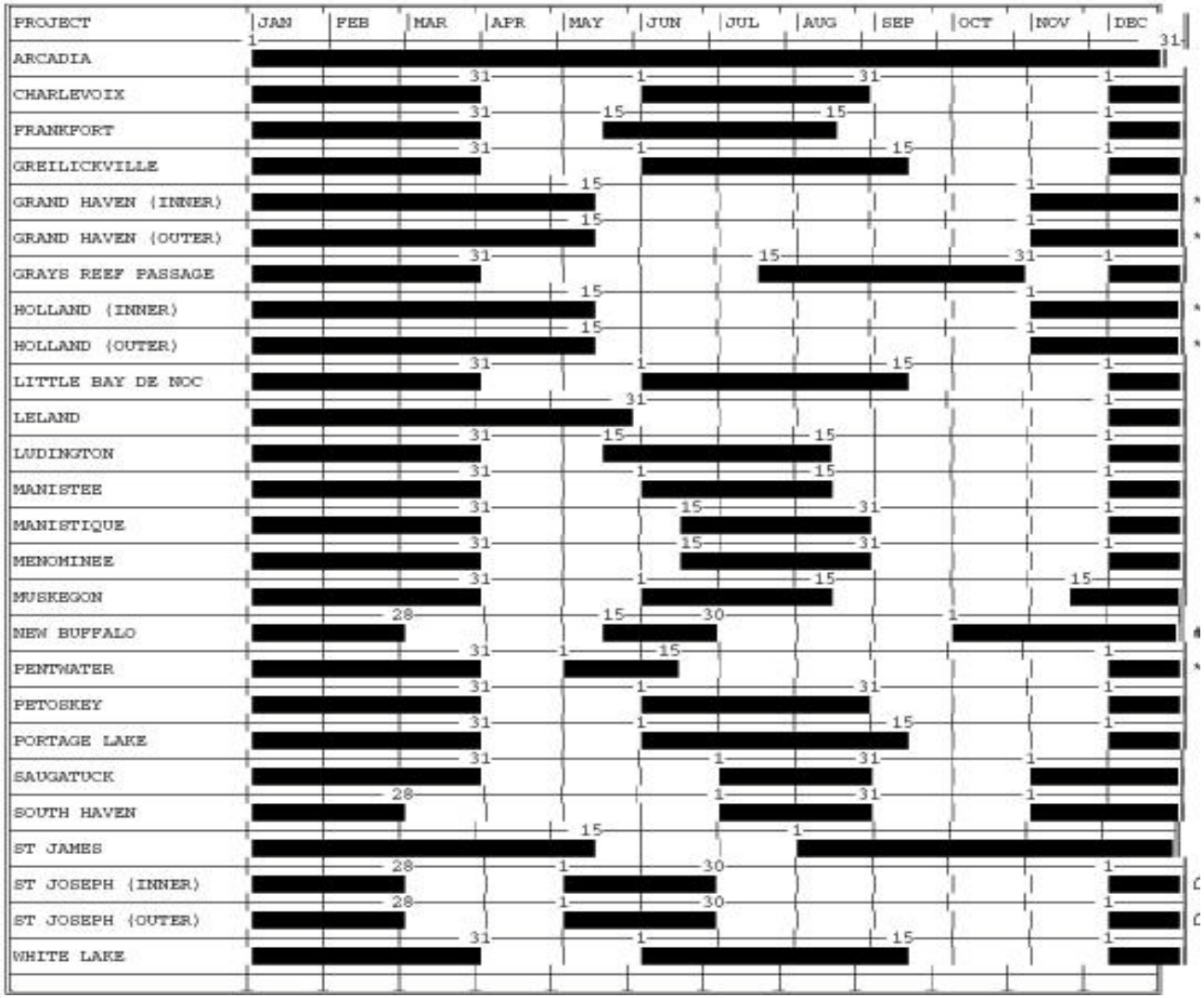
General Information

- **Dredging reach is 900 m long, 150 m wide**
- **Channel is 15,000 m long**

- **Distance from dredging area to:**
- **SAV = 1,200 m**
- **Fish = 4,000 m**
- **Coral = 4,200 m**

Alternatives: Hopper Dredge 0, 15 and 30 min Overflow

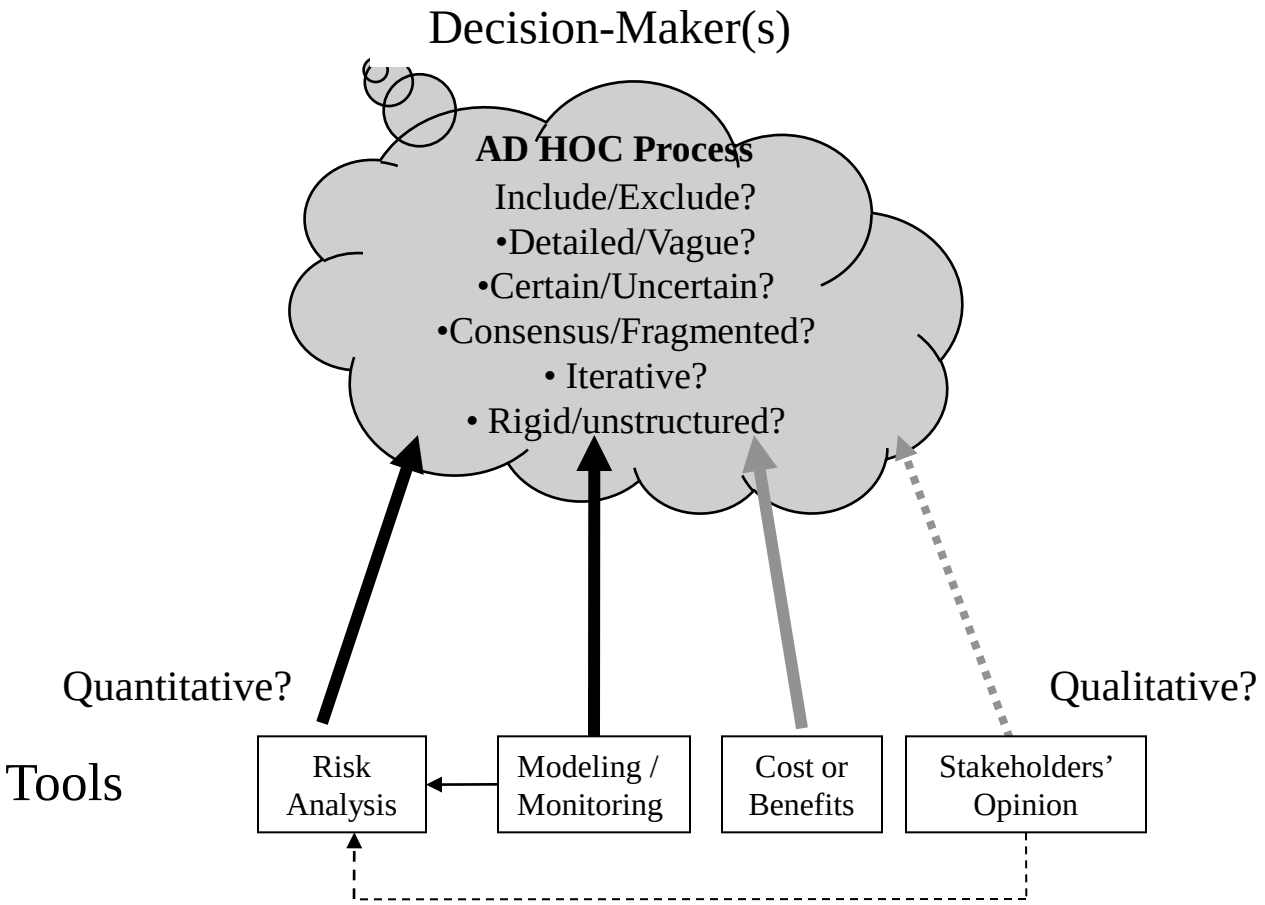
Alternative 4: Environmental Window



Approaches to Selecting Dredging Alternative

- Subjective (Gut Feeling)
  - Pros: easy to do
  - Cons: no rigor, potential mistakes, not transparent and not reliable
- Single Criterion (e.g., $$$) or Two Criteria (cost-benefit)
  - Pros: relative ease of implementing
  - Cons: requires monetizing or scaling to one unit, difficult to modify/adjust for specific criteria and values
- Multi-Criteria Decision Analysis
  - Pros: transparent, state-of-the-art tool, can be tailored/modified in real time, records and visualizes differences among alternative options and stakeholder groups
  - Cons: relatively intense, may require specialized expertise and knowledge

Ad-Hoc Decision-Making Processes



Challenge: Multiple & Uncertain Criteria

Risk Criteria

Alternative	Cost	Survivability of Juvenile Salmonids %	Survivability of SAV
Hopper - No Overflow	100	95	95
Hopper – 15 Min Overflow	40	80	70
Hopper – 30 Min Overflow	30	70	30
Env. Window	45	100	80

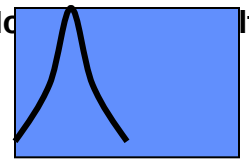
Real World

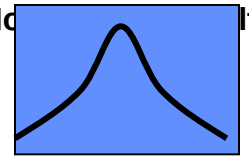
How to combine these criteria?

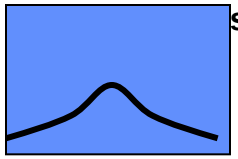
How to compare these alternatives?

How to interpret these results?

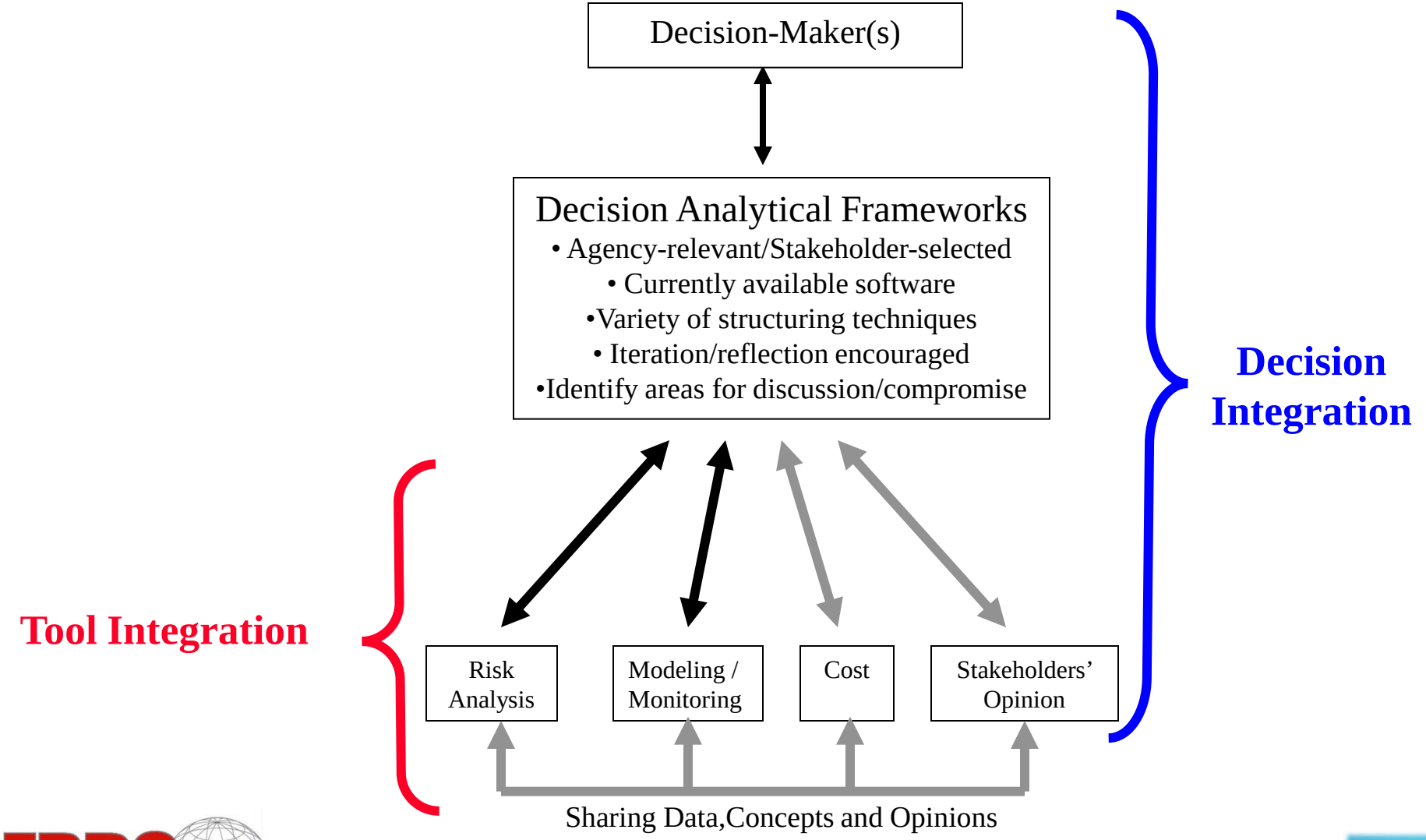
	Criteria 1	Criteria 2	Criteria 3	Criteria 4
Alt. 1	I			
Alt. 2	Monitoring Results	Stakeholder Preference	Economic Cost	Non-monetary benefit
Alt. 3	Mc lts	Stakeholder Preference	Economic Cost	Non-monetary benefit
Alt. 4	Mc lts	Stakeholder Preference	st	Non-monetary benefit



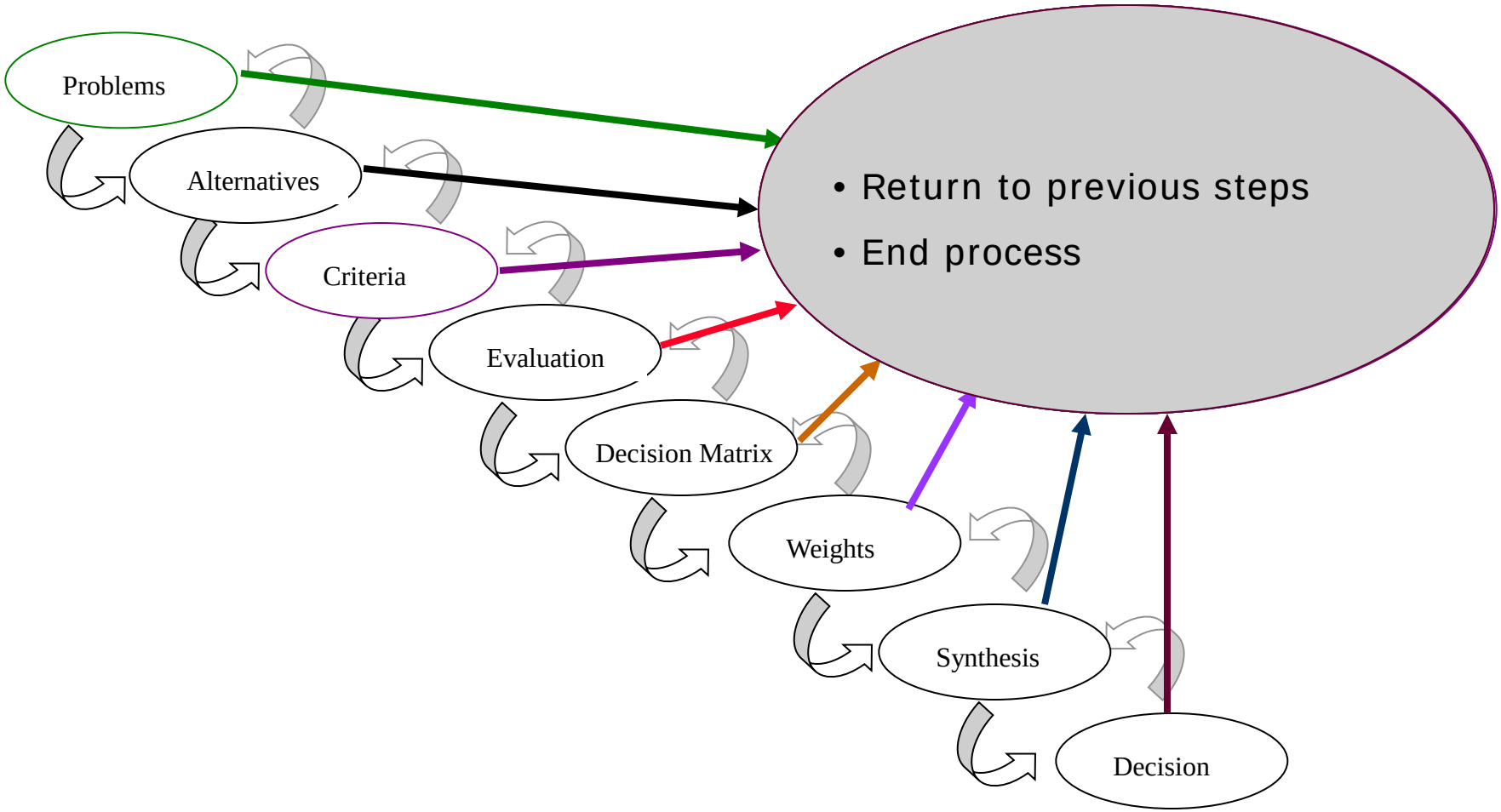


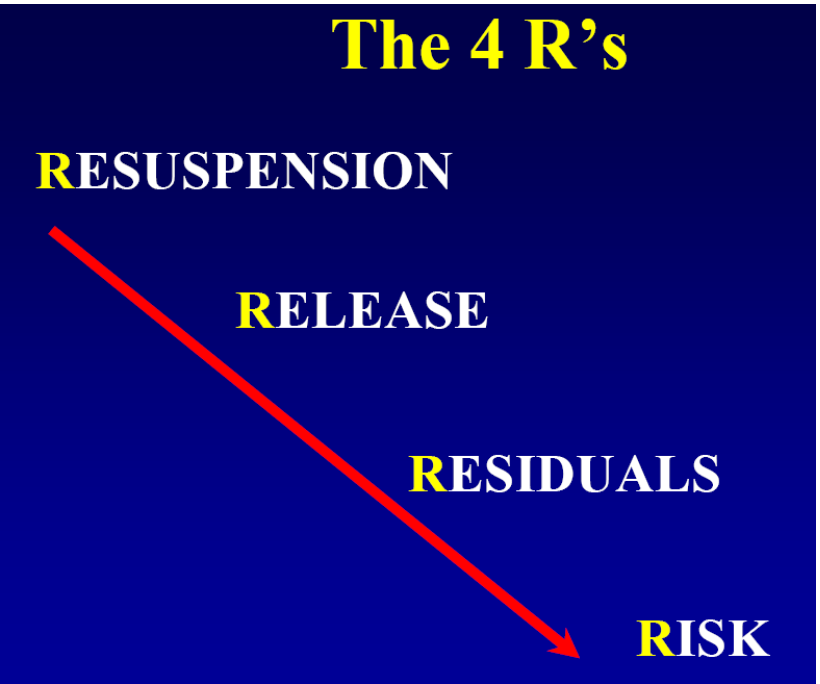


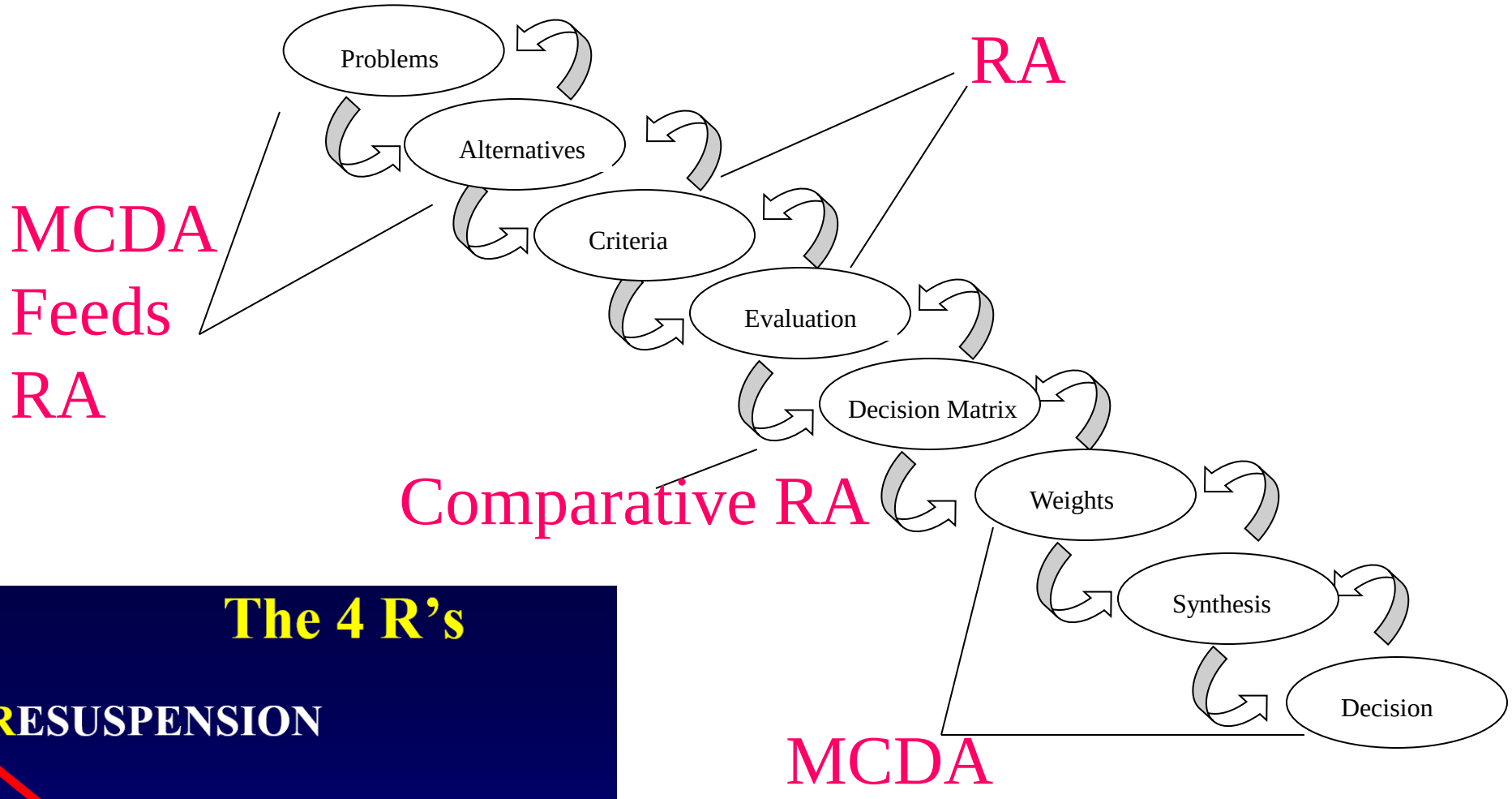
Evolving Decision-Making Processes



MCDA Framework







Resuspension as Decision Problem

Framing Decision

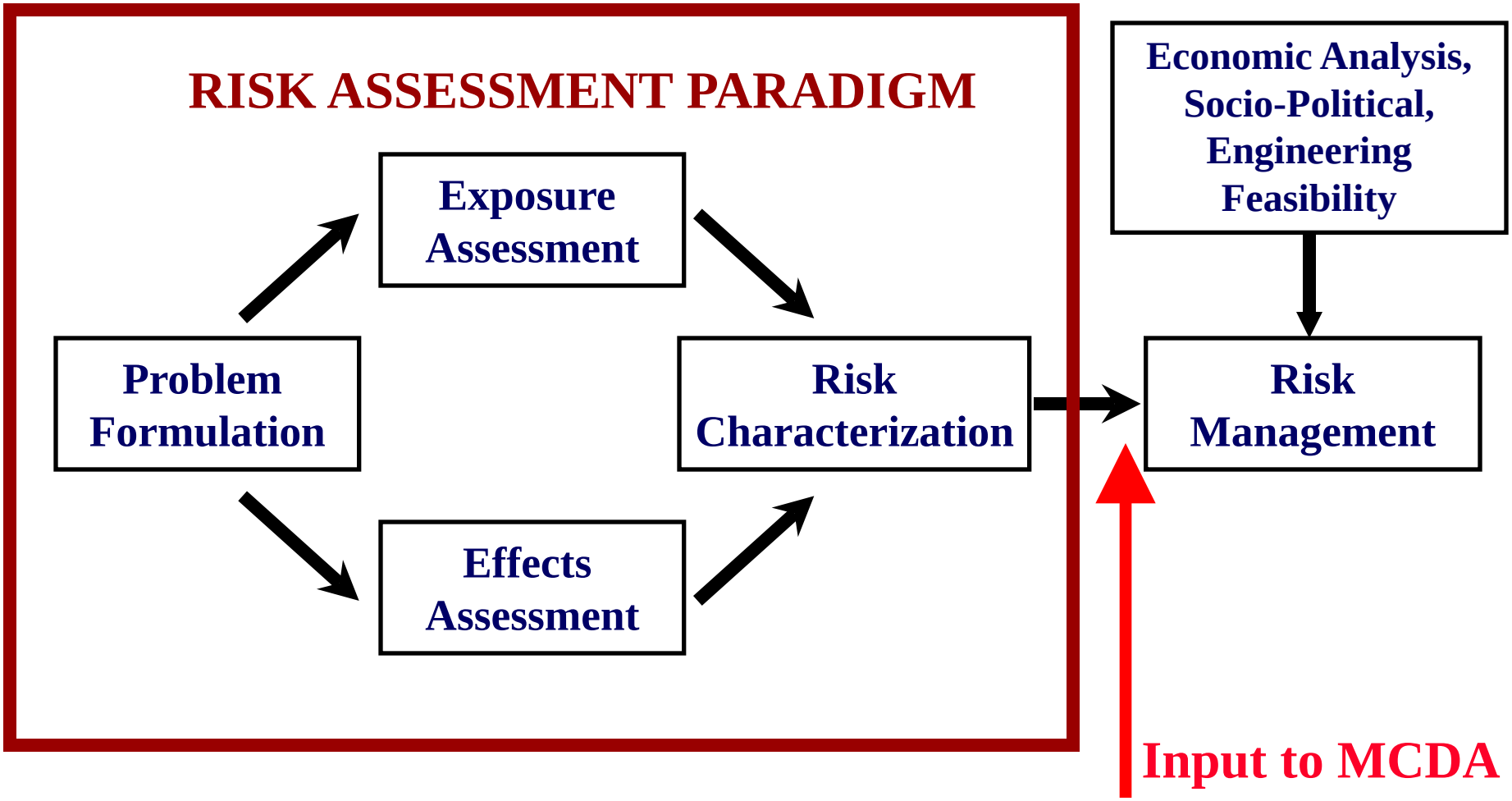
- **Problem statement**
  - **Select dredging alternative that maximizes benefits and minimizes risks**
- **Dredging Alternatives**
  - **Mechanical**
  - **Hopper**
  - **Others**
- **Constraints**
  - **Financial**
  - **Resources**
  - **Ecological (Protection of migrating salmonids and coral reefs)**
- **Stakeholders**
  - **Federal Agencies**
  - **State Agencies**
  - **Industry**
  - **General public**

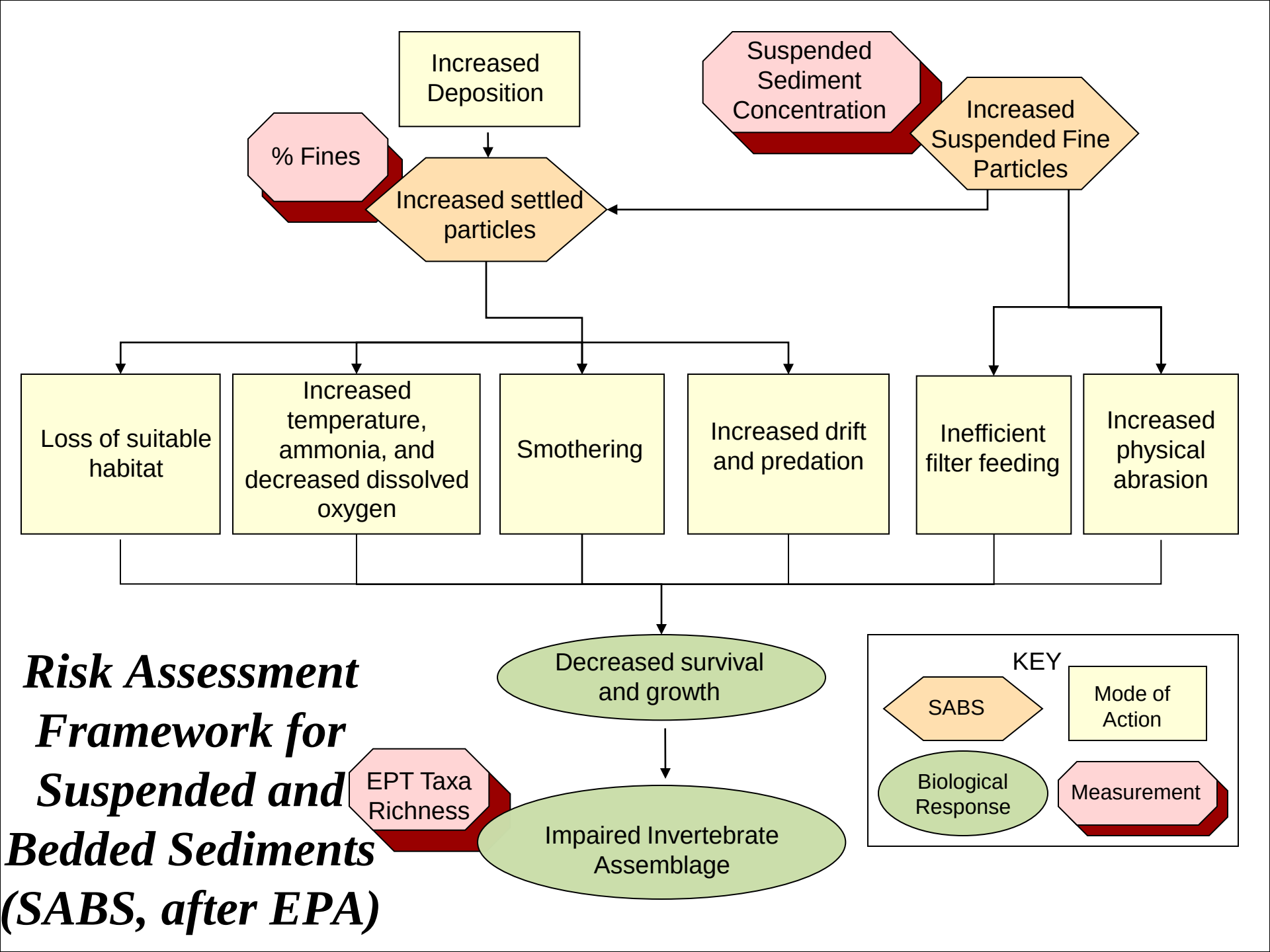
Requirements for Decision Criteria/Performance Measures

- **A coherent criteria set is: (Roy, 1985)**
  - **Exhaustive (nothing important left out)**
  - **Consistent (no secret preferences)**
  - **Non-redundant (no double counting)**
- **Effective criteria are: (Yoe, 2002)**
  - **Directional (maximum, minimum or optimum)**
  - **Concise (smallest number of measures)**
  - **Complete (no significant impact left out)**
  - **Clear (understandable to others)**
- **Criteria are often correlated but can still be acceptable**
- **Criteria should be tested throughout the decision process**

Dredging Impact

RISK FRAMEWORK





Risk Assessment Framework for Suspended and Bedded Sediments (SABS, after EPA)

Multi-Criteria Decision Analysis and Tools

- **Multi-Criteria Decision Analysis (MCDA) methods**
  - **Evolved as a response to the observed inability of people to effectively analyze multiple streams of dissimilar information**
  - **Many different MCDA approaches**

- **Based on different theoretical foundations (or combinations)**
  - **Optimization models**
  - **Goal aspiration**
  - **Outranking models**

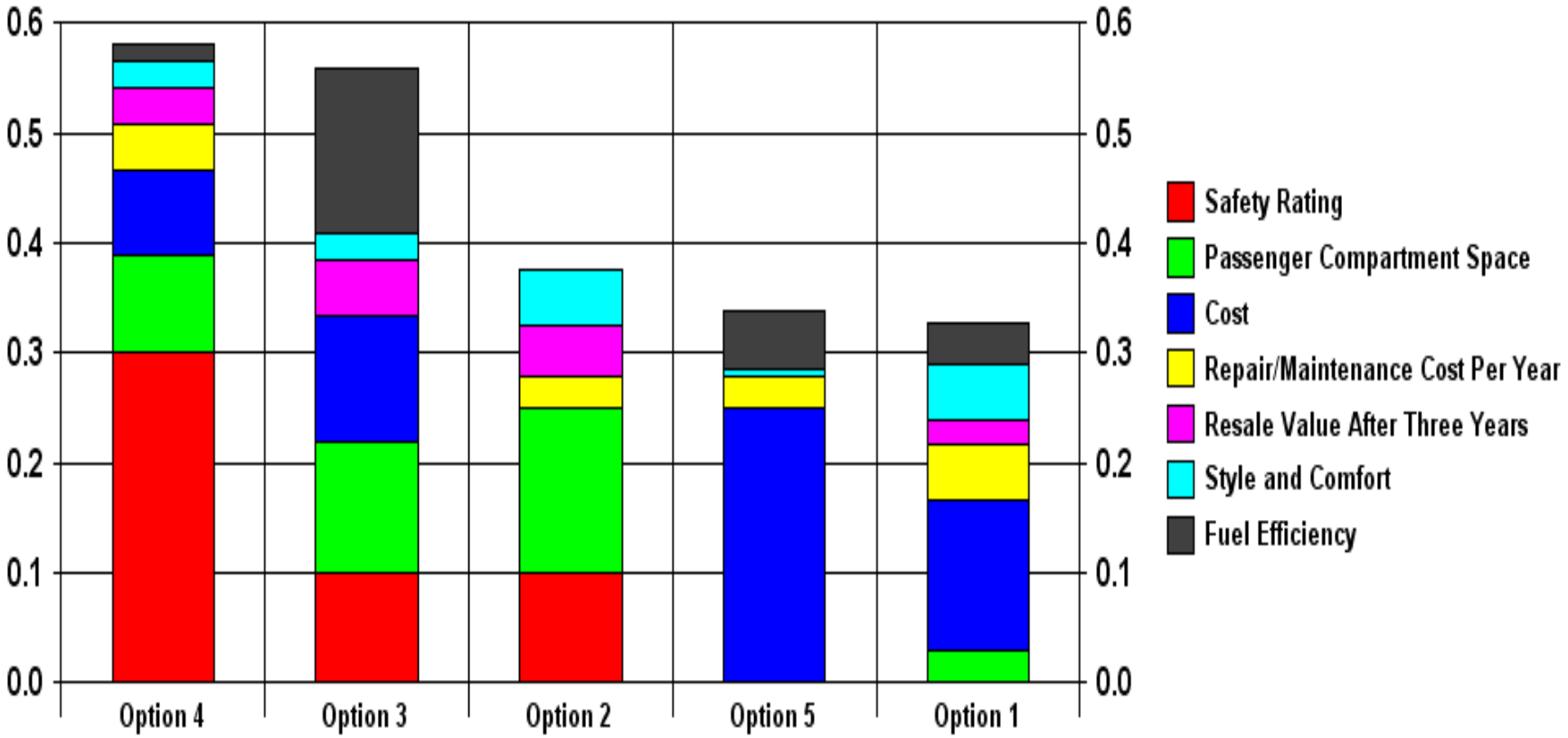
Multi-Criteria Decision Analysis and Tools

- **See Yoe 2002 (Web address in Reference Section)**
- **Simplified methods**
  - **"Pros and cons"**
  - **Maximin and Maximax**
  - **Decision tree**
  - **Influence diagrams**
- **Multi-attribute utility/value theory (MAUT)**
- **Analytical Hierarchy Process (AHP)**
- **Outranking**

A Familiar Decision: Buying a Car

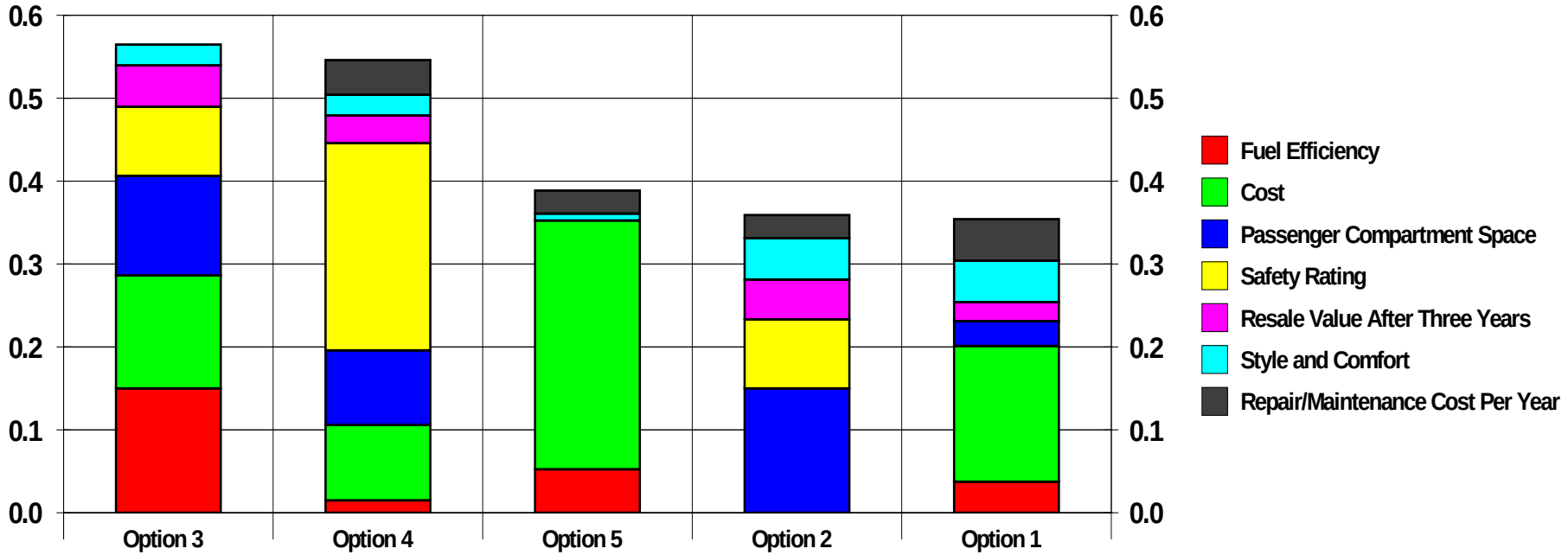
Metric (Weight)	Units	Cars				
		Option 1	Option 2	Option 3	Option 4	Option 5
Cost (25)	Dollars	27,000	45,000	30,000	35,000	12,000
Resale Value After Three Years (5)	% of Original Value	44	56	57	49	33
Repair/Maintenance Cost Per Year (5)	Dollars	100	500	1,000	250	500
Fuel Efficiency (15)	MPG	30	25	45	27	32
Passenger Compartment Space (15)	ft^3	150	170	165	160	145
Style and Comfort (5)	Qualitative	Finest	Finest	Average	Average	Poor
Safety Rating (30)	NHTSA Safety Rating	2	3	3	5	2

Ranking and Contributions by Metric



Ranking Sensitivity to Weight Allocation

Cost: 25 to 30 Safety: 30 to 25



Summary:
Why do We Need to Frame Resuspension as Decision Problem?

- Nature of the problem at hand
  - Goal: Select dredging alternative
  - Issues:
    - Limitation of dredging methods
    - Ecosystem Health
    - Regulatory Constraints
    - Stakeholder
  - Tradeoff are inevitable
  - Minimum Risk is not the goal, risk is just one of the assessment criteria

Main Points

- **Working through the resuspension problem using multi-criteria decision analysis:**
  - **Quantify risks and benefits associated with alternative resuspension management strategies**
  - **Integrate stakeholder values wrt objectives**
  - **Visualize technical data uncertainty and the implications of different values**
- **Risk assessment provides key inputs for quantifying defined decision criteria**