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# ***Risk-Informed Decision Framework for Setting Environmental Windows for Dredging Projects***



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**Dredged Material Assessment and Management Seminar  
15-17 April 2008, Sacramento, CA**



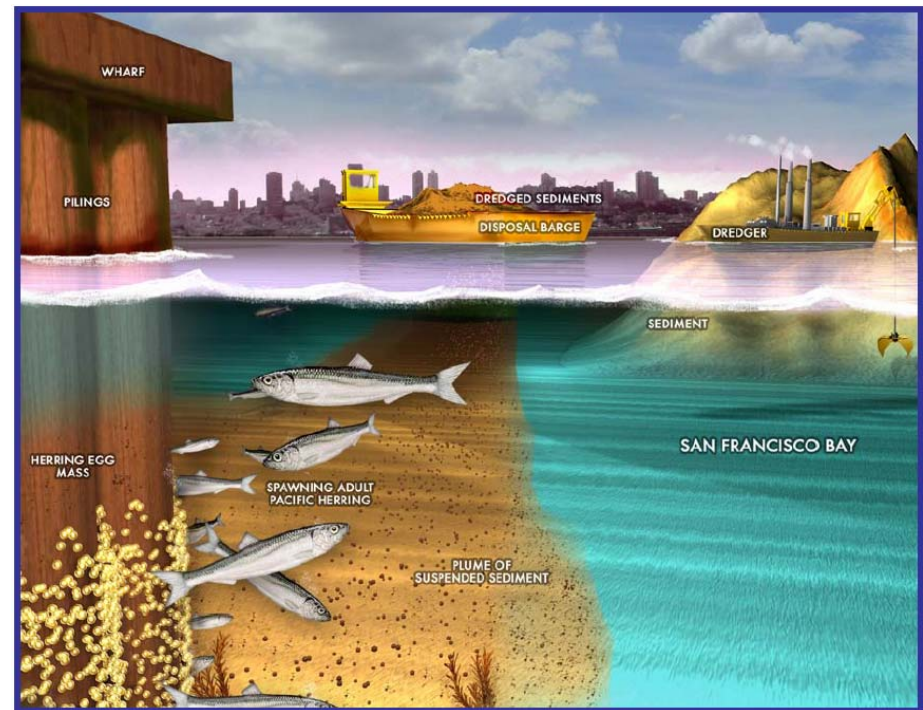
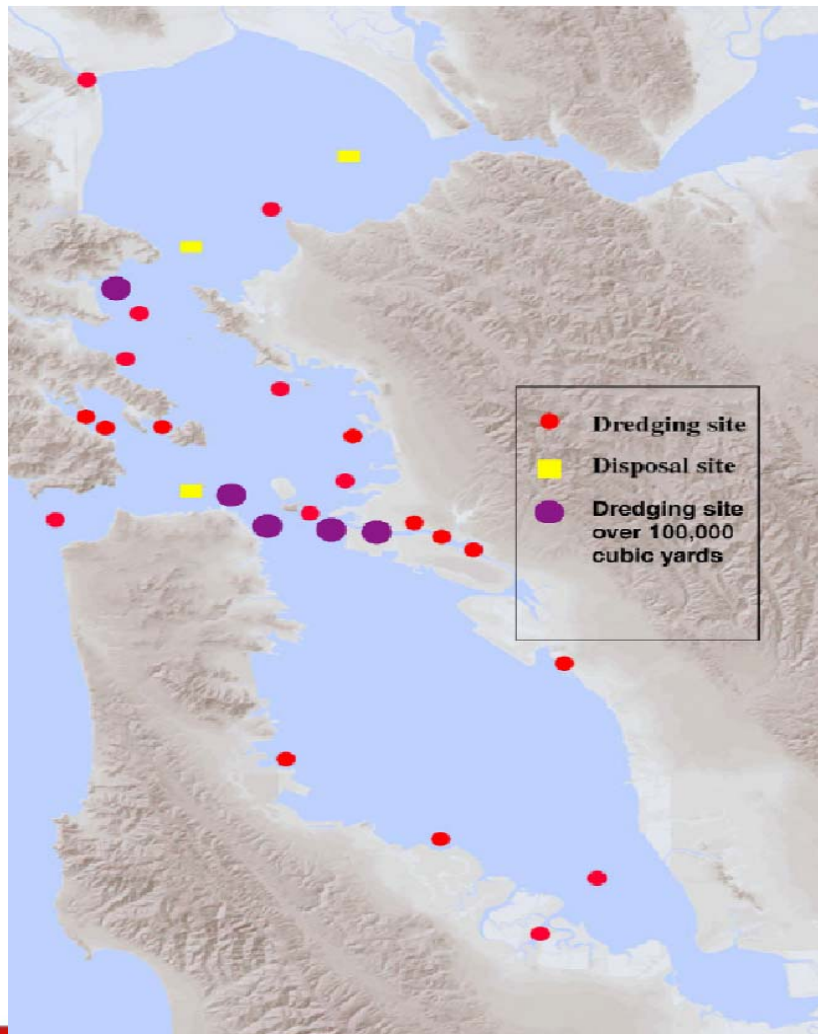
# Presentation -- Overview

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- **Why do We Need to Frame Environmental Windows as Decision Problem?**
  - Nature of problem
  - Limitation of RA
  - Regulatory and Stakeholder Drivers
- **RIDF for Environmental Windows**
  - Problem Formulation
  - Risk Assessment
  - DA
- **Conclusion**
- **References**



# Dredging: Environmental Impacts



# Environmental Windows: Management Alternative to Minimize Impact

Site	Species	Jan	Jan	Feb	Feb	Mar	Mar	Apr	Apr	May	May	Jun	Jun	Jul	Jul	Aug	Aug	Sep	Sep	Oct	Oct	Nov	Nov	Dec	Dec
		1-15	16-31	1-15	16-28	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31
SF Bay Bridge to Sherman Island	Steelhead Trout	[Pattern]										[Pattern]													
	Chinook Salmon Juveniles	[Pattern]										[Pattern]													
Carquinez Bridge to Collinsville	Sacramento Splittail	[Pattern]																							
	Delta Smelt	[Pattern]																							
	Longfin Smelt	[Pattern]																		[Pattern]					
Pinole Shoal Suisun Bay Channel	Chinook Salmon (Adults)	[Pattern]										[Pattern]													
San Pablo Bay	Longfin Smelt	[Pattern]		[Pattern]												[Pattern]									
North San Pablo Bay, Napa & Petaluma Rivers	Sacramento Splittail (Juveniles)	[Pattern]		[Pattern]												[Pattern]									
Napa & Petaluma Rivers, Sonoma Creek	Steelhead Trout	[Pattern]																		[Pattern]					
San Pablo Bay & South SF Bay	Western Snowy Plover	[Pattern]																							
North SF Bay & San Pablo Bay shallow berthing areas	Dungeness Crab	[Pattern]						[Pattern]						[Pattern]											
Richardson Bay, North & South Bay	Pacific Herring	[Pattern]						[Pattern]																	
Waters of Marin County from the Golden Gate Bridge to Richmond-San Rafael Bridge	Coho Salmon	[Pattern]										[Pattern]													
Central SF Bay	Steelhead Trout	[Pattern]										[Pattern]													
	Pacific Herring	[Pattern]						[Pattern]																	
Berkeley Marina to San Lorenzo Creek within 1 mile of coastline	California Least Tern	[Pattern]						[Pattern]												[Pattern]					
South of Highway 92 Bridge (San Mateo-Hayward)	California Least Tern	[Pattern]						[Pattern]												[Pattern]					
In Areas with Eelgrass Beds	California Least Tern	[Pattern]																							
Baywide in Areas of Salt Marsh Habitat	California Clapper Rail	[Pattern]																							
Baywide within 250 feet of Salt Marsh Habitat	California Clapper Rail	[Pattern]						[Pattern]																	
In and Adjacent to Salt Marsh Habitat	Salt Marsh Harvest Mouse	[Pattern]																							
Within 300' of known roost site	California Brown Pelican	[Pattern]												[Pattern]											

For more detailed information, see Appendix F of the LTMS Management Plan or the LTMS EIR/EIS

WORK WINDOW

CONSULTATION REQUIRED



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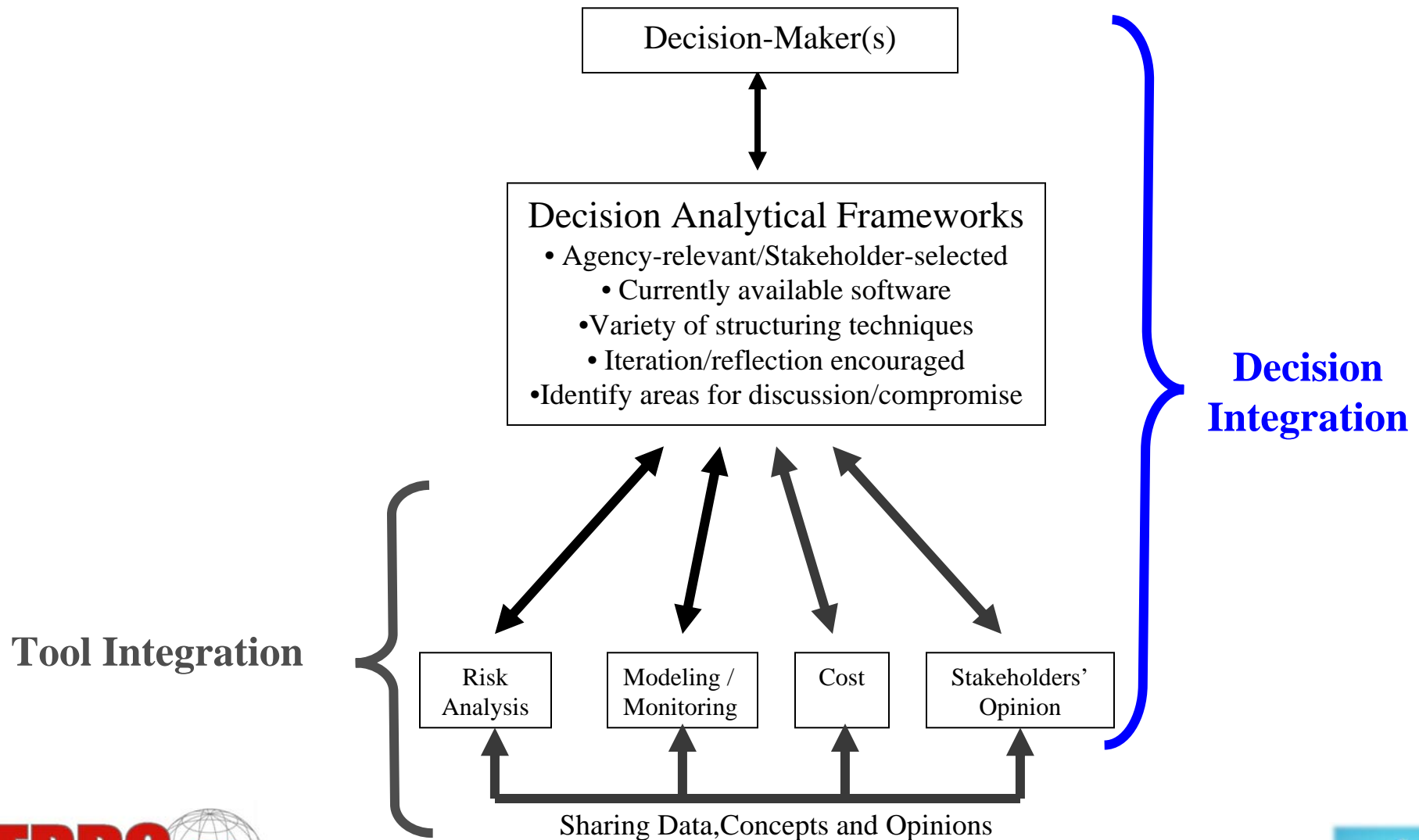
# Problems with Setting Environmental Windows

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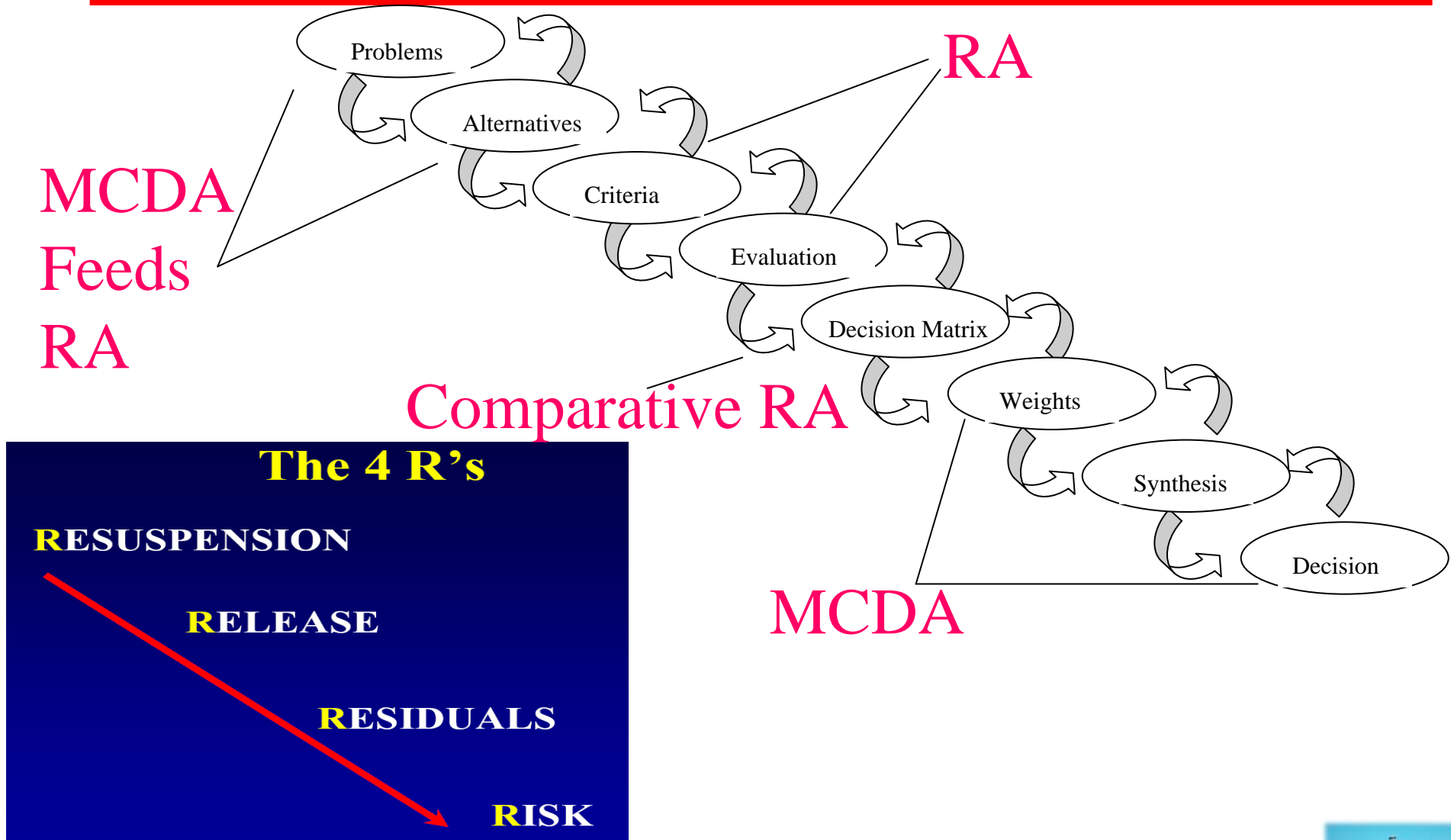
- No consistent, broadly accepted methodology for objectively setting EWs
- Some case, EWs are set without scientific basis (NRC 2001) and established by negotiations emphasizing conservative professional judgments
- Decisions have seldom sought to factor in all sources of risk, including consequences of contractual delays
  - impacts of exhaust emissions caused by protracted operations during severe weather conditions
  - risks to dredge crew (e.g., safety during cold weather periods)
  - Higher incremental dredging costs for Federal projects



# Evolving Decision-Making Processes



# Environmental Windows as Decision Problem



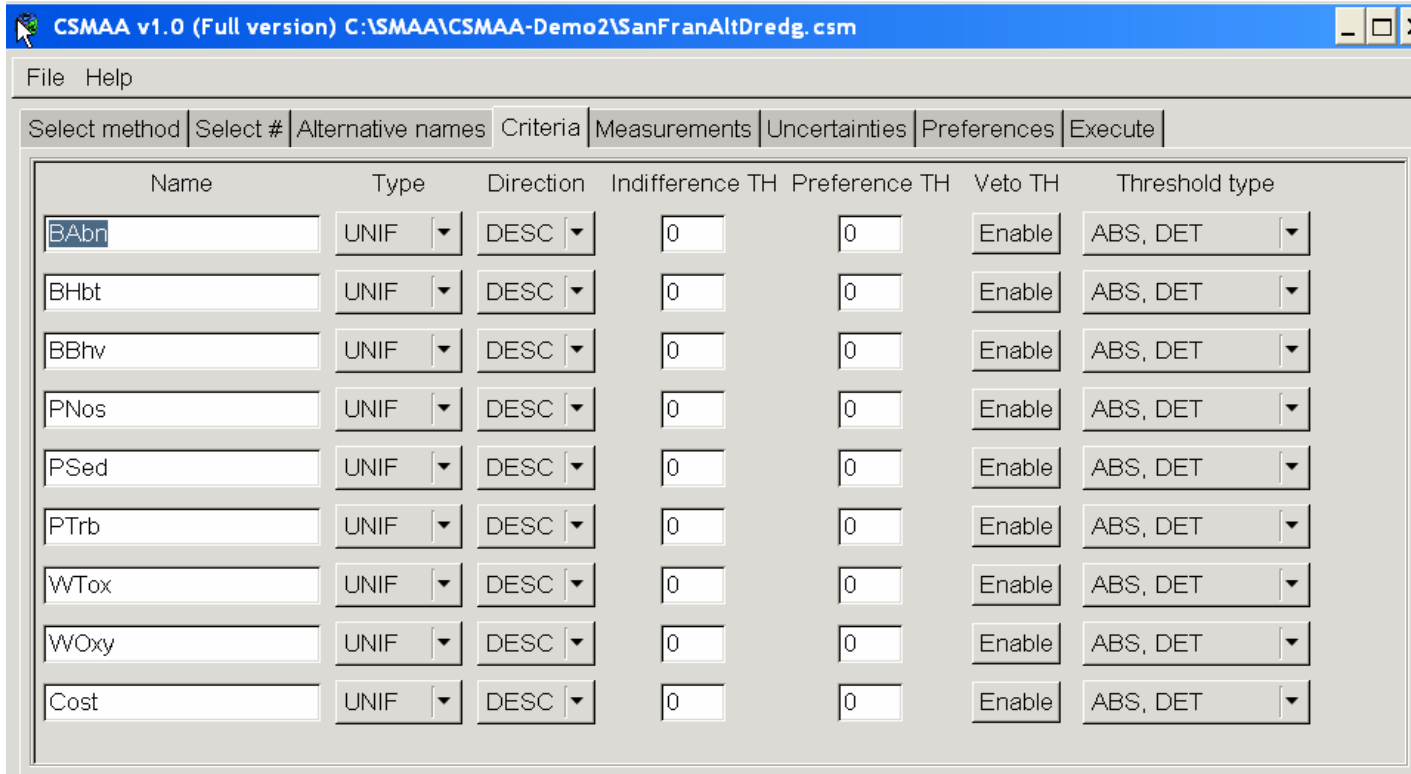
# Alternatives

- Hydraulic and mechanical dredging in November, December and January (HNov, MNov, HDec, MDec, HJan, MJan)





# Assessment Criteria



The screenshot shows the CSMAA v1.0 software interface. The title bar reads "CSMAA v1.0 (Full version) C:\SMAA\CSMAA-Demo2\SanFranAltDredg.csm". The menu bar includes "File" and "Help". Below the menu bar is a tabbed interface with tabs for "Select method", "Select #", "Alternative names", "Criteria", "Measurements", "Uncertainties", "Preferences", and "Execute". The "Criteria" tab is active, displaying a table of assessment criteria.

Name	Type	Direction	Indifference TH	Preference TH	Veto TH	Threshold type
BAbn	UNIF	DESC	0	0	Enable	ABS, DET
BHbt	UNIF	DESC	0	0	Enable	ABS, DET
BBhv	UNIF	DESC	0	0	Enable	ABS, DET
PNos	UNIF	DESC	0	0	Enable	ABS, DET
PSed	UNIF	DESC	0	0	Enable	ABS, DET
PTrb	UNIF	DESC	0	0	Enable	ABS, DET
WTox	UNIF	DESC	0	0	Enable	ABS, DET
WOxy	UNIF	DESC	0	0	Enable	ABS, DET
Cost	UNIF	DESC	0	0	Enable	ABS, DET

**Biological:** Abundance (BAbn), Impact on Habitat (BHbt), and Impact on spawning behavior (BBhv)

**Physical:** Suspended Sediments (PSed) and Noise (PNos)

**Water Quality:** Contamination, (WTox) and Oxygen Reduction (WOxy)

**Economic - Cost**



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# Metric Assessment by Criteria

CSMAA v1.0 (Full version) C:\SMAA\CSMAA-Demo2\SanFranAltDredg.csm

File Help

Select method | Select # | Alternative names | Criteria | Measurements | Uncertainties | Preferences | Execute

Input measurements for the alternatives.  
For ordinal criteria: the rank.  
For uniform distributed cardinal: mean of the interval.  
For Gaussian distributed: the mean.

	BAbn	BHbt	BBhv	PNos	PSed	PTrb	WTox	WOxy	Cost
HNov	2	1	1	2	15	1	15	1	1
MNov	2	1	1	1	66	2	66	1	3
HDec	22	1	1	2	15	1	15	1	1
MDec	22	1	1	1	66	2	66	1	3
HJan	50	1	1	2	15	1	15	1	1
MJan	50	1	1	1	66	2	66	1	3



# Criteria Weight

CSMAA v1.0 (Full version) C:\SMAA\CSMAA-Demo2\SanFranAltDredg.csm \*

File Help

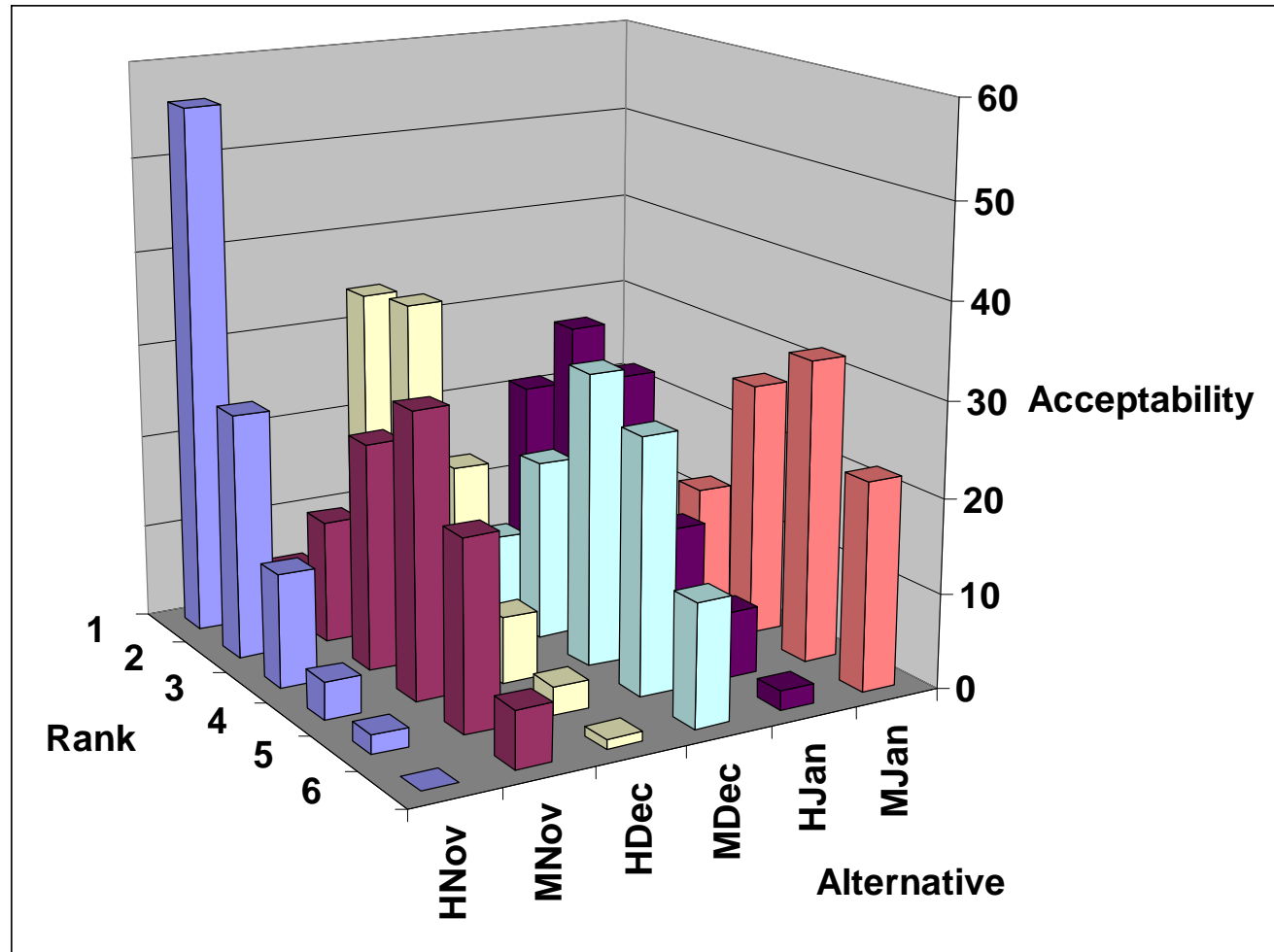
Select method | Select # | Alternative names | Criteria | Measurements | Uncertainties | Preferences | Execute

Add exact preferences | Remove cardinal preferences | Add ordinal (ranking) preferences

BAbn	<input type="text" value="0.05"/>	<input type="button" value="Remove lowerbound"/>	<input type="text" value="0.49"/>	<input type="button" value="Remove upperbound"/>
BHbt	<input type="text" value="0.05"/>	<input type="button" value="Remove lowerbound"/>	<input type="text" value="0.49"/>	<input type="button" value="Remove upperbound"/>
BBhv	<input type="text" value="0.05"/>	<input type="button" value="Remove lowerbound"/>	<input type="text" value="0.49"/>	<input type="button" value="Remove upperbound"/>
PNos	<input type="text" value="0.05"/>	<input type="button" value="Remove lowerbound"/>	<input type="text" value="0.49"/>	<input type="button" value="Remove upperbound"/>
PSed	<input type="text" value="0.05"/>	<input type="button" value="Remove lowerbound"/>	<input type="text" value="0.49"/>	<input type="button" value="Remove upperbound"/>
PTrb	<input type="text" value="0.05"/>	<input type="button" value="Remove lowerbound"/>	<input type="text" value="0.49"/>	<input type="button" value="Remove upperbound"/>
WTox	<input type="text" value="0.05"/>	<input type="button" value="Remove lowerbound"/>	<input type="text" value="0.49"/>	<input type="button" value="Remove upperbound"/>
WOxy	<input type="text" value="0.05"/>	<input type="button" value="Remove lowerbound"/>	<input type="text" value="0.49"/>	<input type="button" value="Remove upperbound"/>
Cost	<input type="text" value="0.05"/>	<input type="button" value="Remove lowerbound"/>	<input type="text" value="0.49"/>	<input type="button" value="Remove upperbound"/>



# Rank Acceptability Analysis



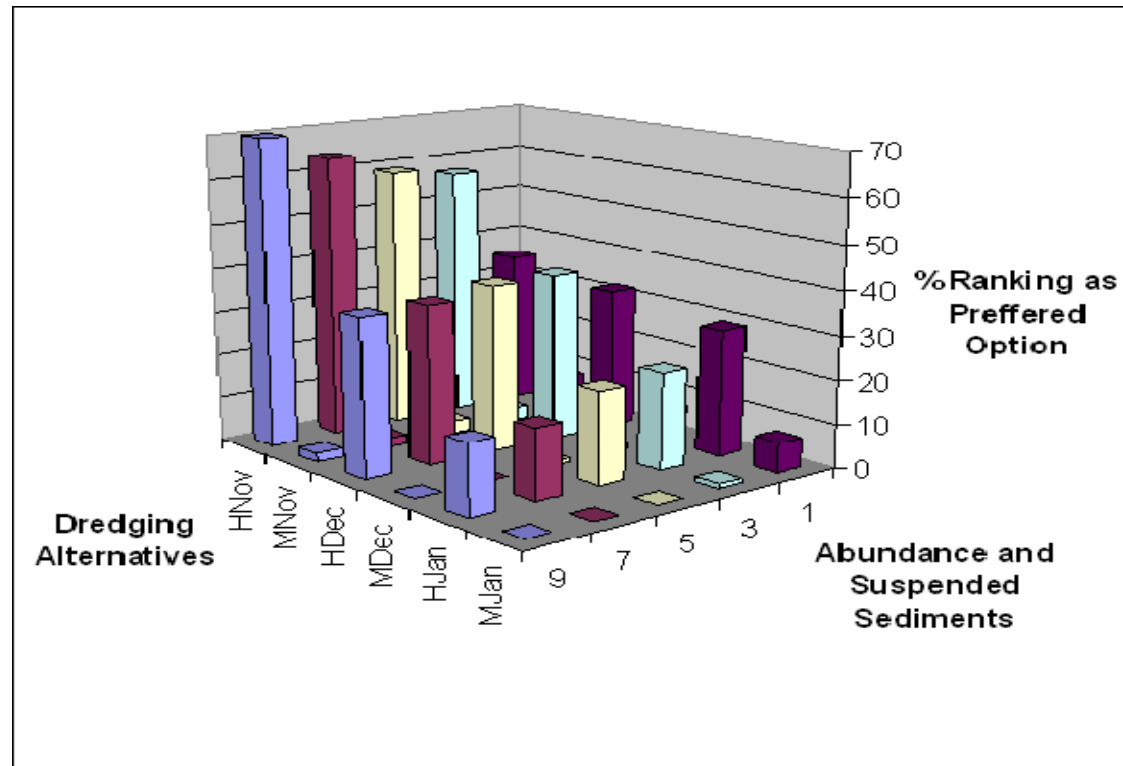
# Pairwise Metrics Domination

⏏	HNov	MNov	HDec	MDec	HJan	MJan
HNov	0	86	78	98	96	100
MNov	9	0	30	77	68	95
HDec	13	63	0	87	83	98
MDec	1	18	9	0	37	77
HJan	3	26	11	53	0	84
MJan	0	4	1	13	11	0

- **Dark green: 50-100%**
- **Light green is 25-49%**
- **Red is less than 25% of cases outranked by other alternatives.**



# Sensitivity Analysis



- With varying weights for one biological (BAbn) and one physical criterion (PSed) while all other criteria were equally ranked.



# Main Points

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- **Risks and benefits associated with alternative resuspension management can be quantified using Risk Informed Decision Framework (RIDF)**
- **Model, Parameters and Scenario uncertainty and variability associated with predicting efficiency of dredging alternatives as well as stakeholder value judgment are important to consider**
- **Challenges of risk assessment and planning for situations with a limited knowledge base and high uncertainty and variability require coupling traditional risk assessment and planning with multi-criteria decision analysis (MCDA) to support dredging decisions**



# Technology Transfer

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Publication:

Suedel, B.C., Clarke, D.G., Kim, J. and Linkov, I. (2008, in press). A Risk-Informed Decision Framework for Setting Environmental Windows for Dredging Projects. Submitted to Science of the Total Environment.



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