Adaptive Resource Management; A Special Case of Structured Decision Making

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If AM is a special form of SDM

What is structured decision making?

"A formal application of common sense for situations too complex for the informal use of common sense."

R. Keeney

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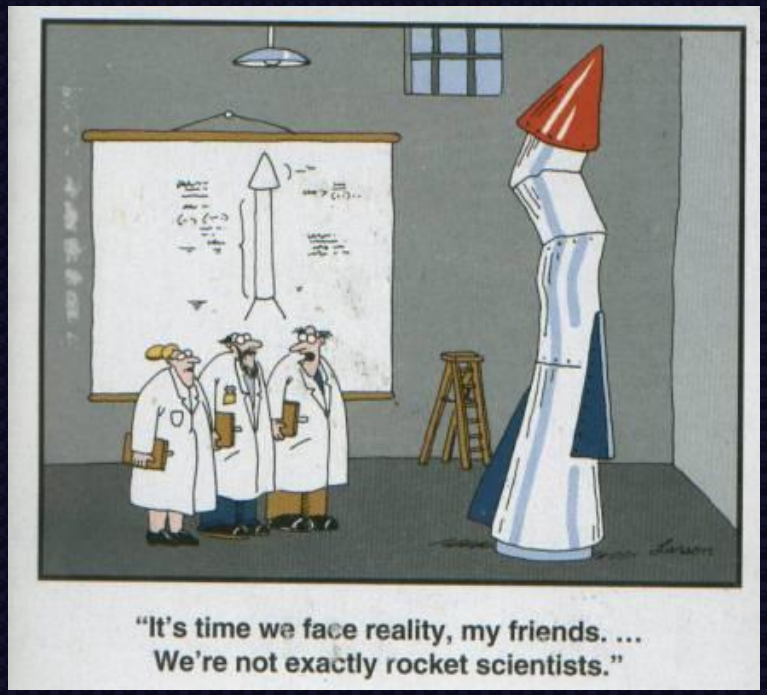
It isn't rocket science….

$$\ddot{x} = \frac{1}{M-mt}\{mc_e + F_n(p - p_{atm_e}e^{-(k/H)(\sqrt{(x^2+y^2+z^2)}-R)})\}\cos\alpha(t) - g_0R^2\frac{x}{(x^2+y^2+z^2)^{3/2}} +$$
$$- \frac{c_n(\sqrt{(\dot{x}^2+\dot{y}^2+\dot{z}^2)}, \chi)}{M-mt}\rho_0 e^{-(1/H)(\sqrt{(x^2+y^2+z^2)}-R)} F\dot{x}\sqrt{(\dot{x}^2+\dot{y}^2+\dot{z})} +$$
$$+ \frac{c_a(\sqrt{(\dot{x}^2+\dot{y}^2+\dot{z}^2)}, \chi)}{M-mt}\rho_0 e^{-(1/H)(\sqrt{(x^2+y^2+z^2)}-R)} F \times$$
$$\times \frac{\dot{z}\{\dot{z}\cos\alpha(t) - \dot{x}\cos\gamma(t)\} - \dot{y}\{\dot{x}\cos\beta(t) - \dot{y}\cos\alpha(t)\}\sqrt{(\dot{x}^2+\dot{y}^2+\dot{z}^2)}}{\sqrt{[\{\dot{y}\cos\gamma(t) - \dot{z}\cos\beta(t)\}^2 + \{\dot{z}\cos\alpha(t) - \dot{x}\cos\gamma(t)\}^2 + \{\dot{x}\cos\beta(t) - \dot{y}\cos\alpha(t)\}^2]}} + 2\dot{y}\omega + \omega^2 x$$

$$\ddot{y} = \frac{1}{M-mt}\{mc_e + F_n(p - p_{atm_e}e^{-(k/H)(\sqrt{(x^2+y^2+z^2)}-R)})\}\cos\beta(t) - g_0R^2\frac{y}{(x^2+y^2+z^2)^{3/2}} +$$
$$- \frac{c_n(\sqrt{(\dot{x}^2+\dot{y}^2+\dot{z}^2)}, \chi)}{M-mt}\rho_0 e^{-(1/H)(\sqrt{(x^2+y^2+z^2)}-R)} F\dot{y}\sqrt{(\dot{x}^2+\dot{y}^2+\dot{z}^2)} +$$
$$+ \frac{c_a(\sqrt{(\dot{x}^2+\dot{y}^2+\dot{z}^2)}, \chi)}{M-mt}\rho_0 e^{-(1/H)(\sqrt{(x^2+y^2+z^2)}-R)} F \times$$
$$\times \frac{\dot{x}\{\dot{x}\cos\beta(t) - \dot{y}\cos\alpha(t)\} - \dot{z}\{\dot{y}\cos\gamma(t) - \dot{z}\cos\beta(t)\}\sqrt{(\dot{x}^2+\dot{y}^2+\dot{z}^2)}}{\sqrt{[\{\dot{y}\cos\gamma(t) - \dot{z}\cos\beta(t)\}^2 + \{\dot{z}\cos\alpha(t) - \dot{x}\cos\gamma(t)\}^2 + \{\dot{x}\cos\beta(t) - \dot{y}\cos\alpha(t)\}^2]}} - 2\dot{x}\omega + \omega^2 y$$

$$\ddot{z} = \frac{1}{M-mt}\{mc_e + F_n(p - p_{atm_e}e^{-(k/H)(\sqrt{(x^2+y^2+z^2)}-R)})\}\cos\gamma(t) - g_0R^2\frac{z}{(x^2+y^2+z^2)^{3/2}} +$$
$$- \frac{c_n(\sqrt{(\dot{x}^2+\dot{y}^2+\dot{z}^2)}, \chi)}{M-mt}\rho_0 e^{-(1/H)(\sqrt{(x^2+y^2+z^2)}-R)} F\dot{z}\sqrt{(\dot{x}^2+\dot{y}^2+\dot{z}^2)} + \frac{c_a(\sqrt{(\dot{x}^2+\dot{y}^2+\dot{z}^2)}, \chi)}{M-mt}\rho_0 \times$$
$$\times e^{-(1/H)(\sqrt{(x^2+y^2+z^2)}-R)} F \frac{\dot{y}\{\dot{y}\cos\gamma(t) - \dot{z}\cos\beta(t)\} - \dot{x}\{\dot{z}\cos\alpha(t) - \dot{x}\cos\gamma(t)\}\sqrt{(\dot{x}^2+\dot{y}^2+\dot{z}^2)}}{\sqrt{[\{\dot{y}\cos\gamma(t) - \dot{z}\cos\beta(t)\}^2 + \{\dot{z}\cos\alpha(t) - \dot{x}\cos\gamma(t)\}^2 + \{\dot{x}\cos\beta(t) - \dot{y}\cos\alpha(t)\}^2]}}$$

in which: $\chi = \arccos\dfrac{\dot{x}\cos\alpha(t) + \dot{y}\cos\beta(t) + \dot{z}\cos\gamma(t)}{\sqrt{(\dot{x}^2+\dot{y}^2+\dot{z}^2)}}$



"powered flight of rocket through terrestrial atmosphere with prescribed thrust direction as a function of time, considered as a system of reference rotating with the earth"

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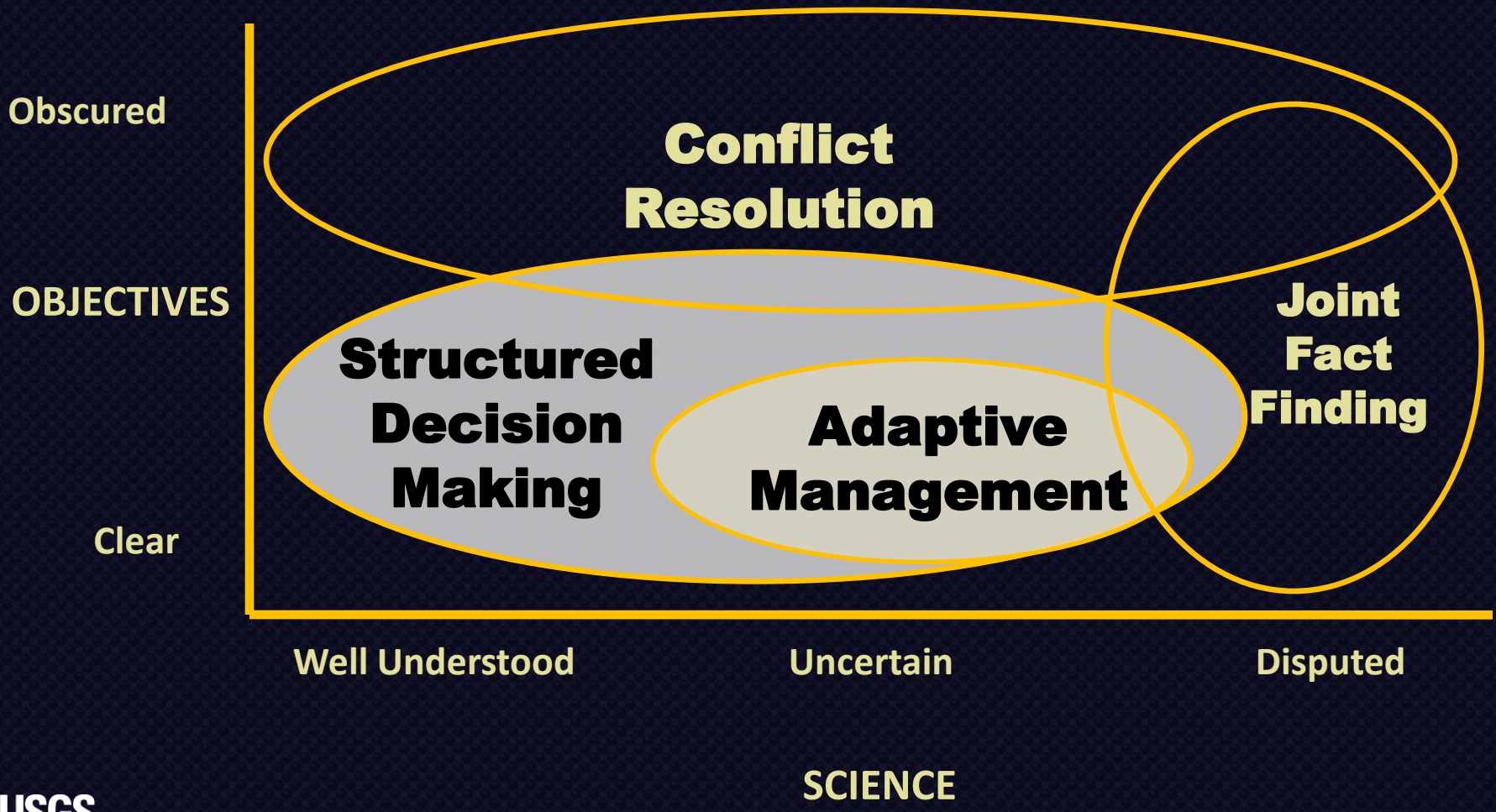
When is SDM appropriate?



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Who can use structured decision making?

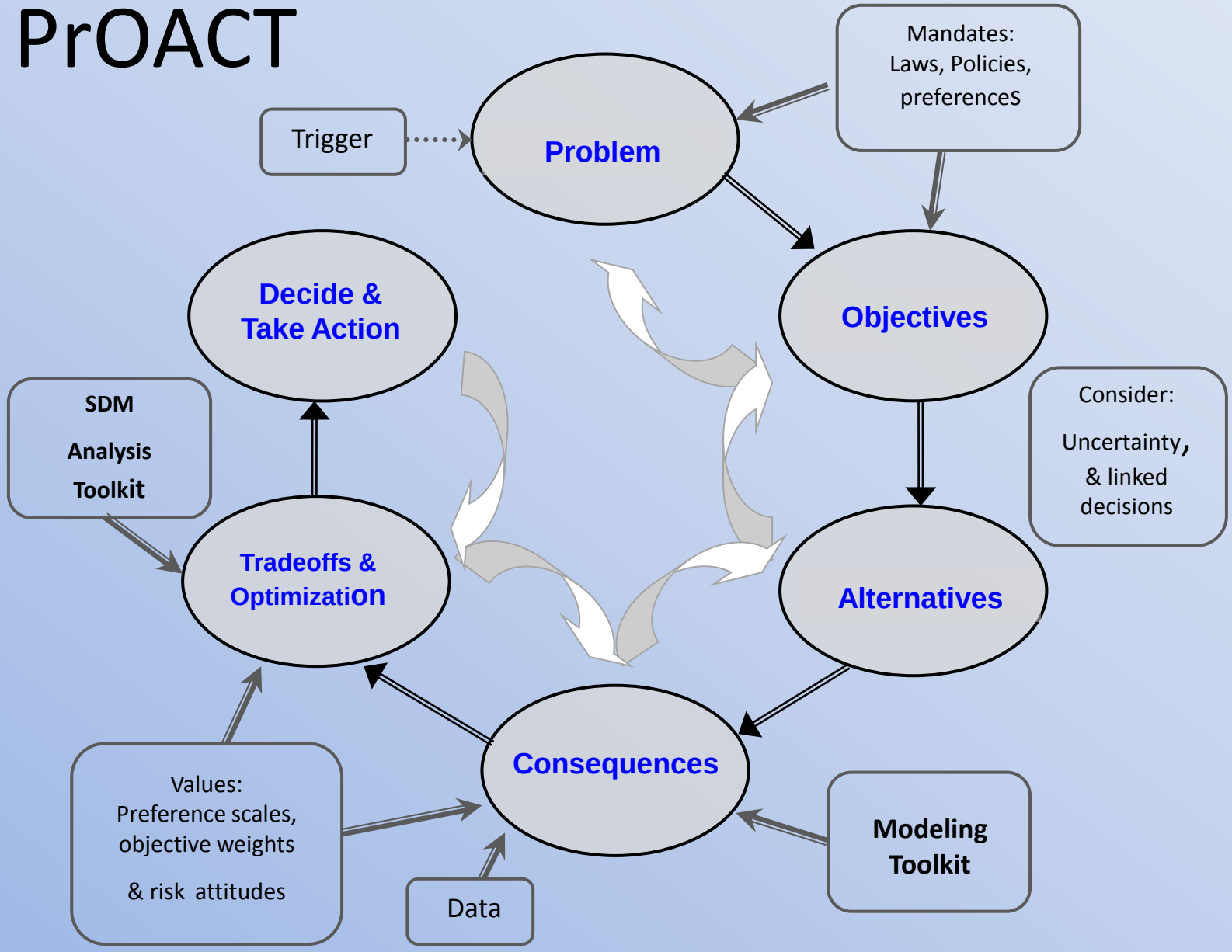
- Anyone for any sized problem

- Tiny ones
  - 1 person at their desk, an hour
  - Fine-tuning an impoundment drawdown schedule
- Little ones
  - Field office, days to weeks
  - Bull trout Section 7 workload allocation
- Middle-sized ones
  - Regional problems, months of analysis
  - R4/R5 coordinated monitoring of migratory birds
- Big ones
  - National scope, years
  - Waterfowl harvest regulations, Major listing decisions

How? PrOACT

- A guide for defensible decision-making
  - Problem decomposition
  - Values-focused thinking
- Steps
  - Problem
  - Objectives
  - Actions
  - Consequences
  - Trade-offs
  - Additional steps

PrOACT


Mandates:
Laws, Policies,
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Trigger
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Objectives
Consider:
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objective weights
& risk attitudes
Tradeoffs &
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Analysis
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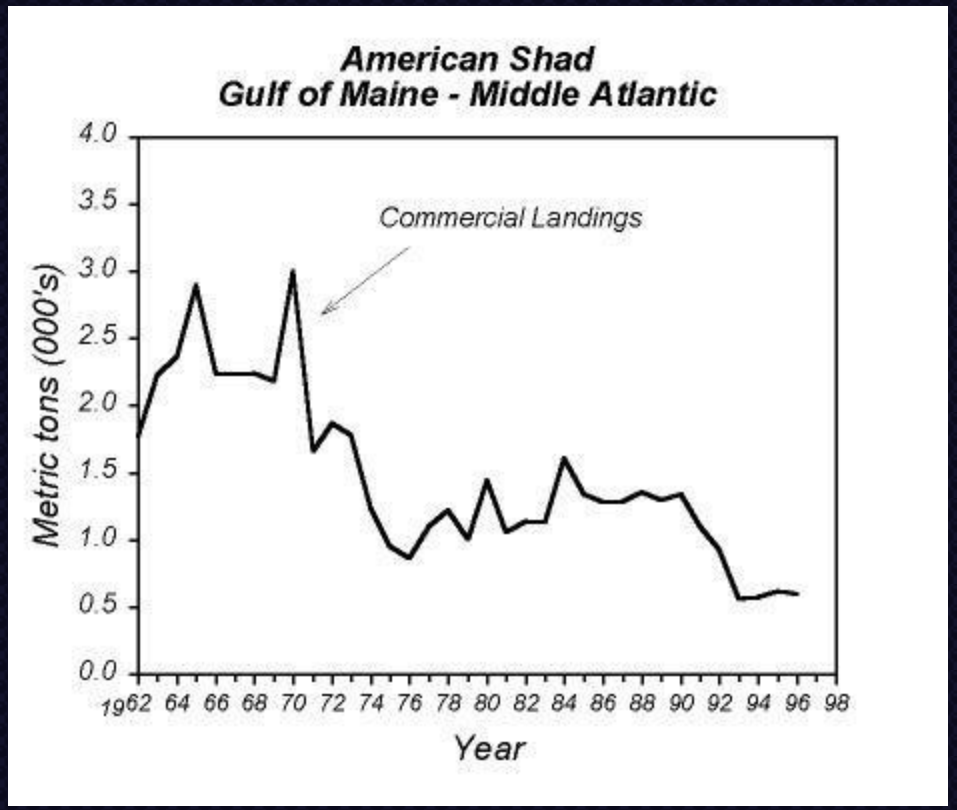
Decide &
Take Action

Problem Framing

- Who is the decision maker?
- What are the legal and regulatory contexts?
- Identify the decision's essential elements
  - Scope and scale
  - Timing and frequency
- Understand what other decisions are linked to this one. Iterative?



Massachusetts Division of Marine Fisheries

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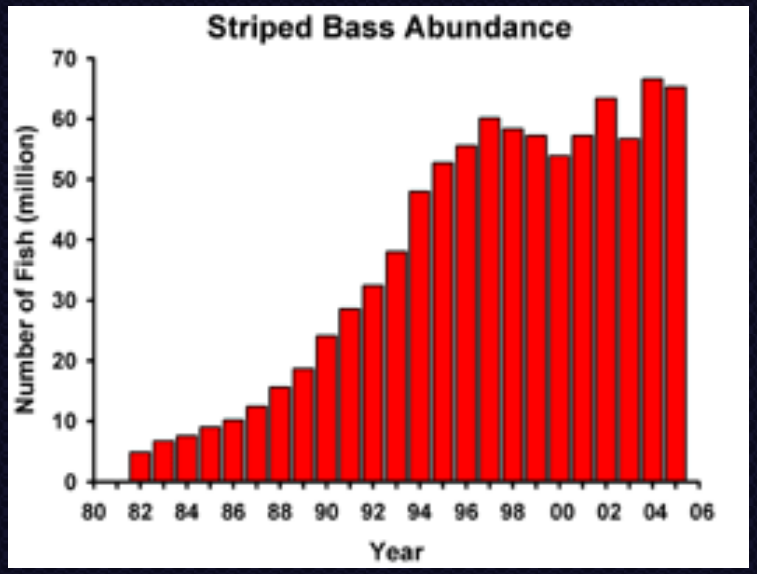
Objectives

- Values…what we really care about
- Stated clearly (versus ambiguous)
- Attainable
- Consider cultural and spiritual aspects
- Cost constraints
- Fundamental and means objectives



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Alternatives

- Are the things that we do to manage toward achieving our objectives.
- Paralysis can occur here…
  - Get out of the box…
  - Alternatives that worked other places in similar systems can't work "here"
  - Management options for imperiled species are too severe or risky (or expensive)
  - Experimental designs are problematic despite theoretical basis
    - Spatial and temporal replication

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Consequences

- Evaluation of how alternative management affects our resource objectives.
  - Prediction is critical
  - Data constraints are real but expert opinion is valuable
- Other issues include
  - Scale (spatial and temporal)
  - Knowledge from other systems?
  - Detectability issues
  - Cost of long-term experimental approaches

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Consequences

"decision making is a forward-looking process….And if decision making is the attempt to achieve a desired future, then any such attempt must include, implicitly or explicitly, a vision of what that future will look like."

- Sarewitz et al. (2000). Prediction: Science, Decision Making, and the Future of Nature. Island Press.

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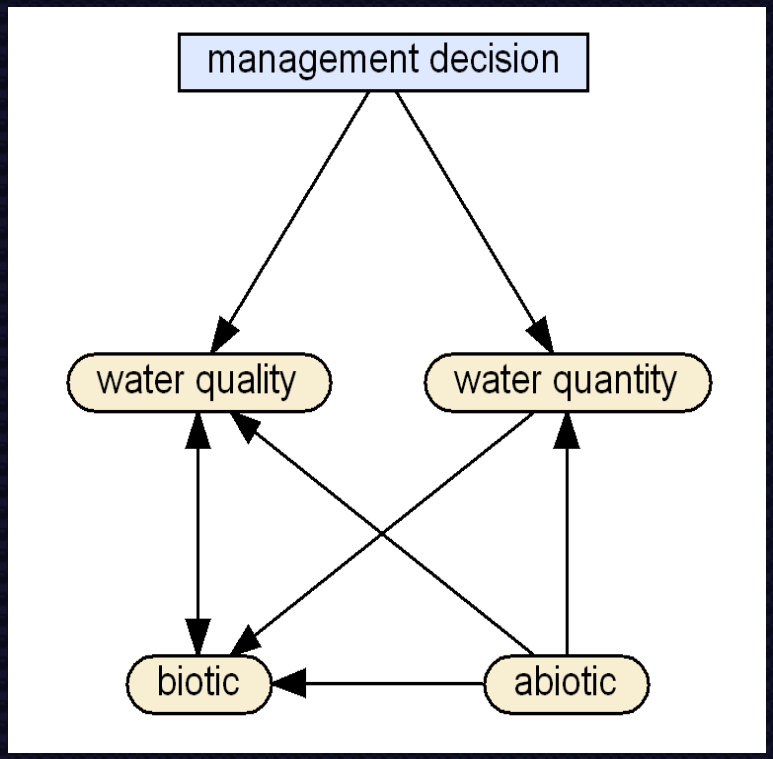
Influence diagram



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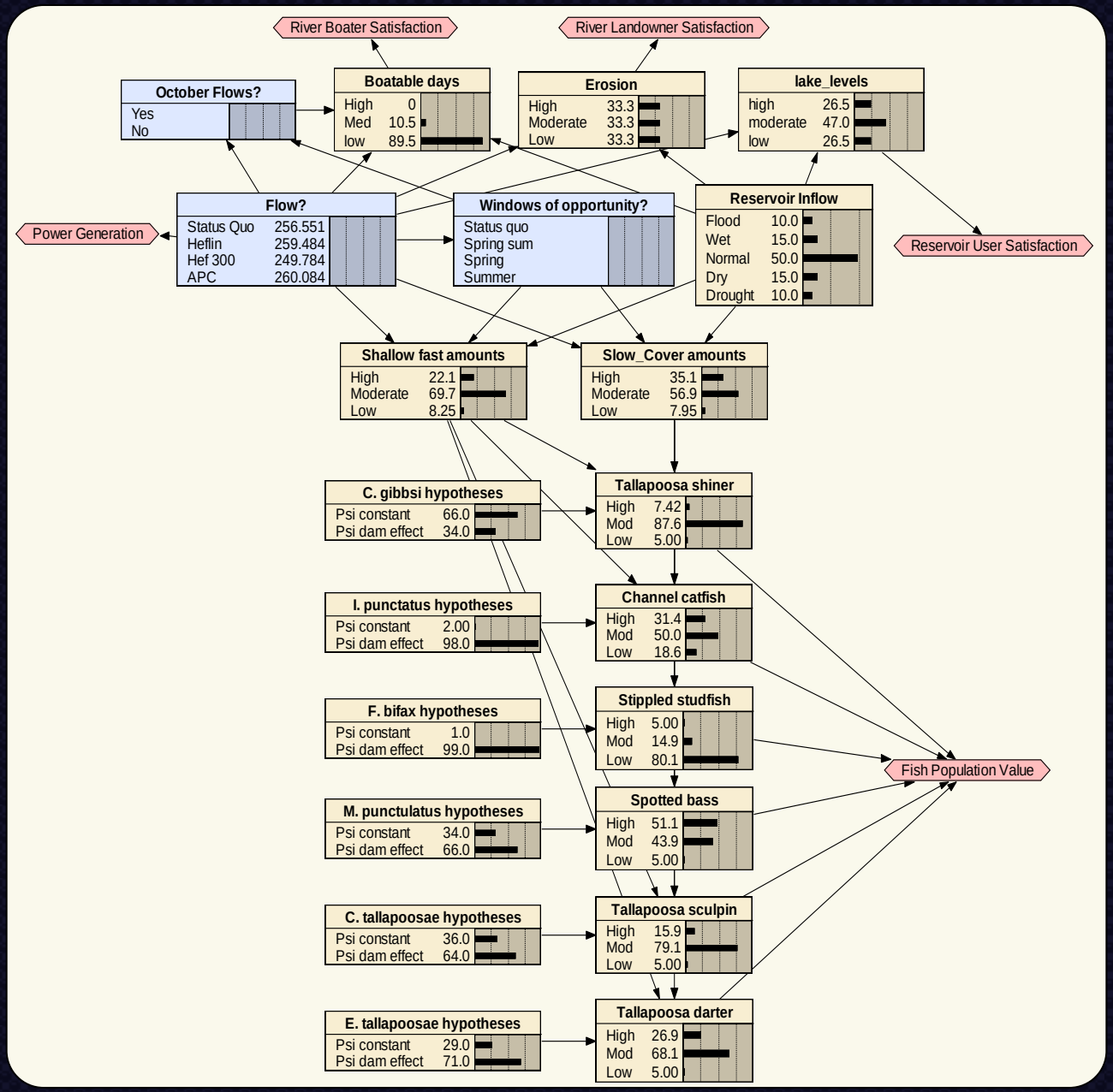
- Multiple species-one locale
- GCN species & sportfishes
- Many stakeholders
- Initial management prescription decided with BBN



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Trade-offs

- Consumption versus conservation of species
- Imposing limits to point-source pollution ($) versus biodiversity.
- We can't remove large dams…..??? $$$$$
- Trout are more important than darters ($$) therefore…..

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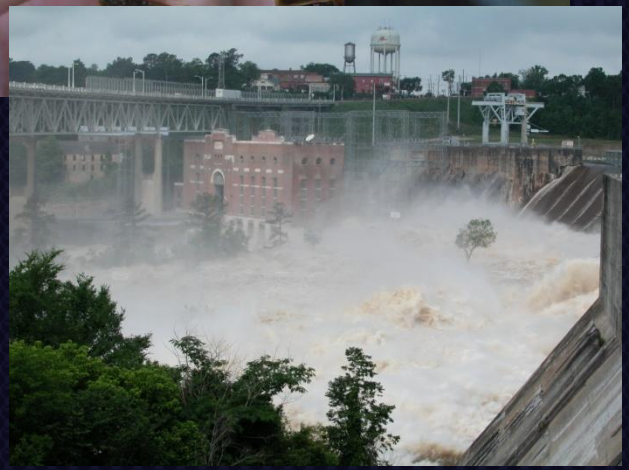
Why use SDM?

- Decision processes that are
  - Transparent
  - Explicit
  - Deliberative
  - Able to be documented
  - Replicable

Problems are opportunities-to learn



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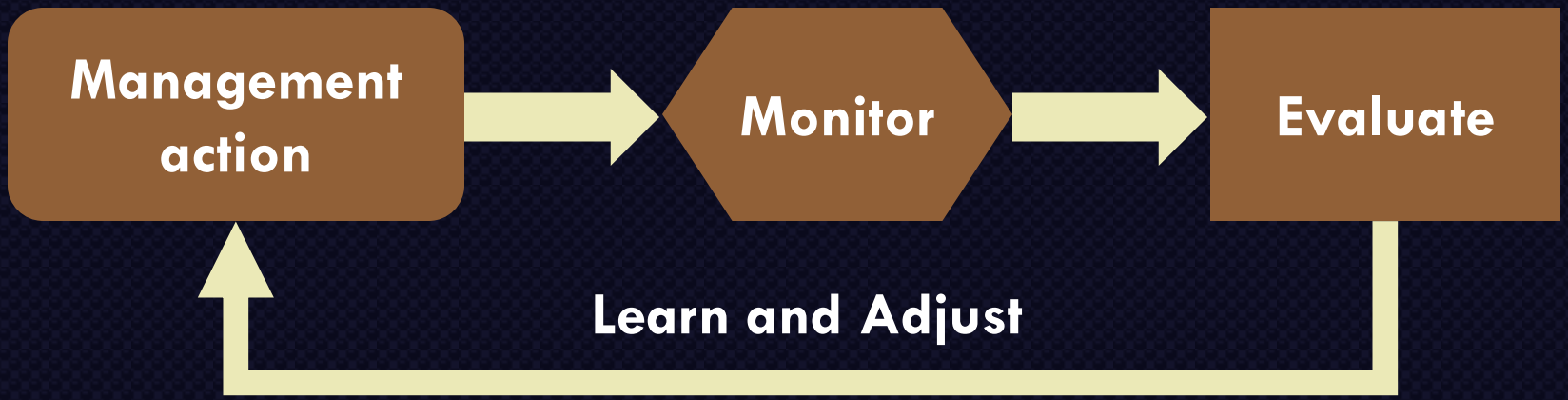
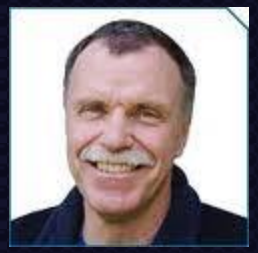
Theory





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(Walters 1986; Williams and Johnson 1995; Irwin and Freeman 2002)

Challenges

- Cross-scale links
- Evaluating mechanisms
  - Specific causes may be linked with proxy but needs evaluation
- Land and management legacy
- Institutional change
- Innovation
- Lag-time in effects of management
  - Ontogenetic shifts in species needs
  - Long-lived species
  - Cryptic fauna

- Stakeholder management

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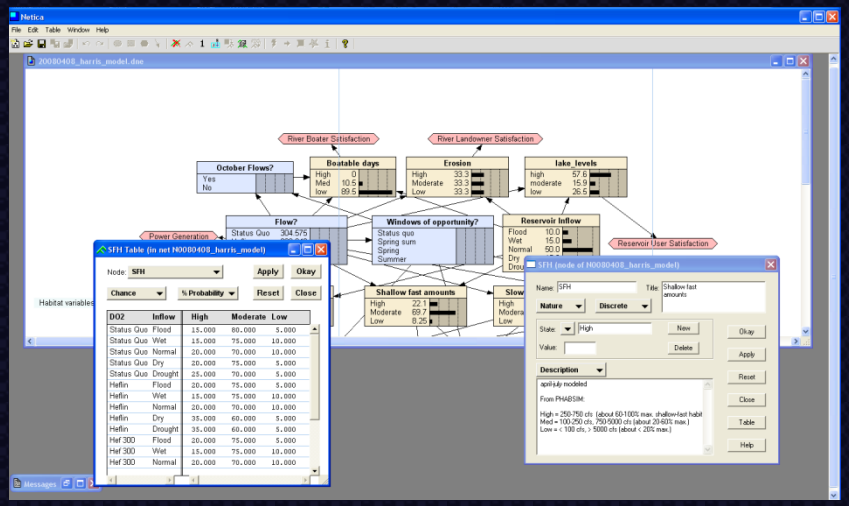
Challenges

- Setting population goals
- Fear of models at grass roots level
- Paradigms and loss of institutional memory
- Focus on structural objectives
  - Agency goals versus population, society and economic goals
  - And these differ
- Focus on interesting questions not related to objectives
- Preferences not well defined
- Decision makers not engaged



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It's the stakeholders…..

- Inclusivity
  - To *try* to get objectives right
- Governance structure and management
  - Maintain communication

"Never confuse motion with action."

Benjamin Franklin

"Giving money and power to government is like giving whiskey and car keys to teenage boys."

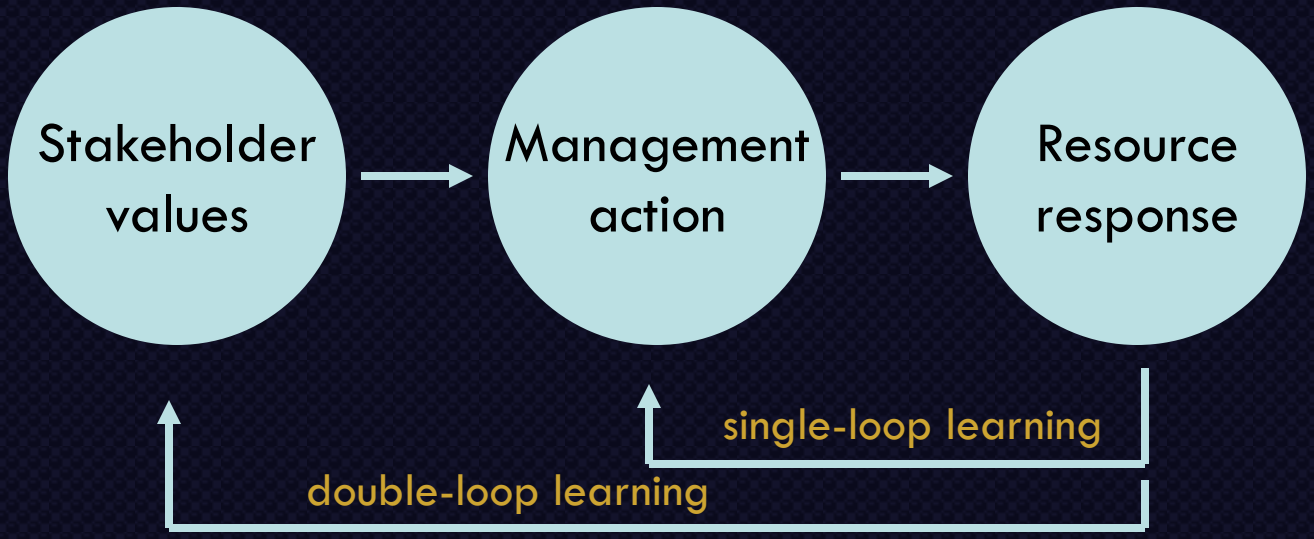
P. J. O'Rourke

"Government was designed to be slow so that no one has to make any decisions"

Robin Kelley

The daydreams of cat herders

Double-loop Learning



- Single-loop focuses on incremental change
- Double-loop focuses on transformational change that uses information from past actions (single-loop) to question assumptions and values about system structure.

Modified from Argyris and Schön (1978)

Implementation

- Commitment = long term
- Process is usually a stable "structure"
- Process and a very deep toolkit

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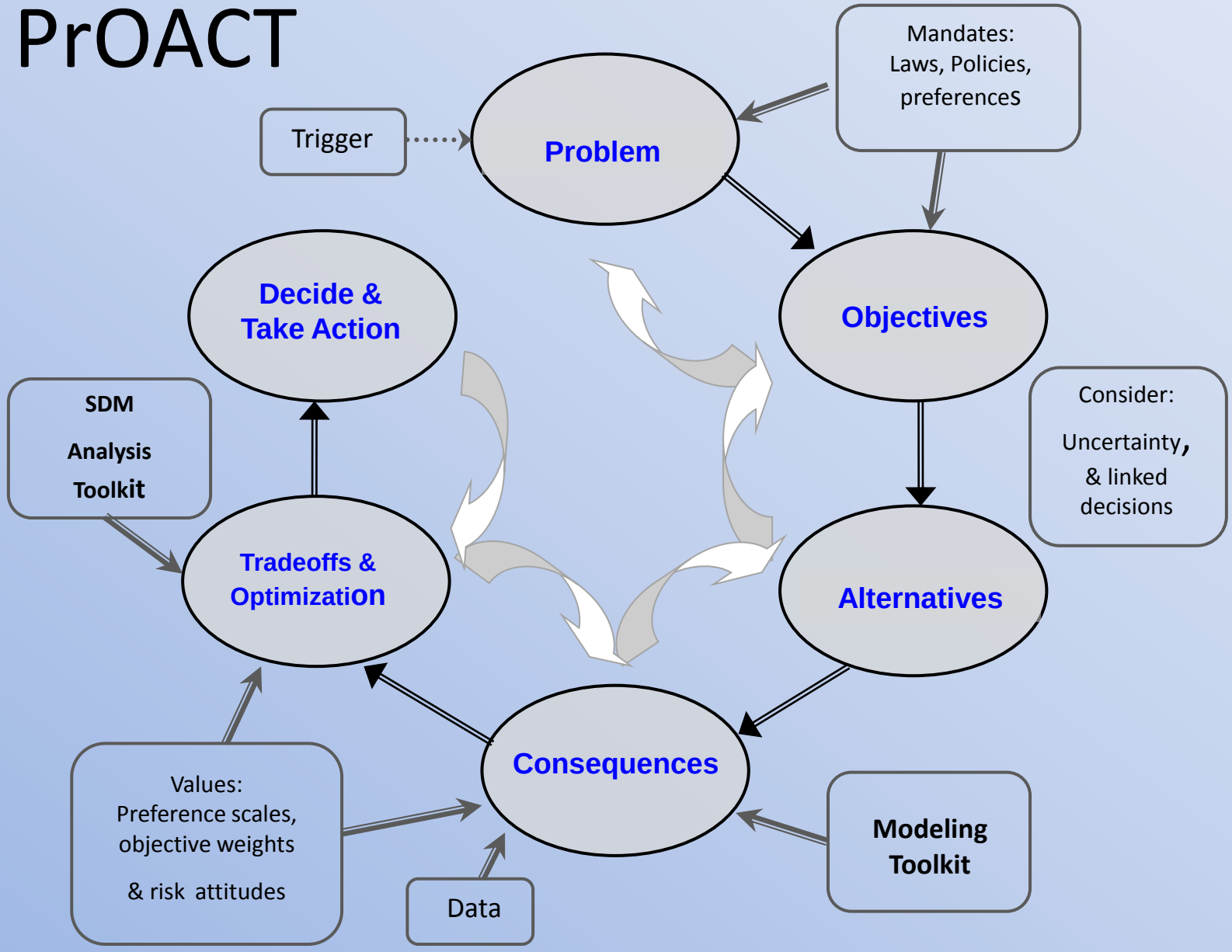
PrOACT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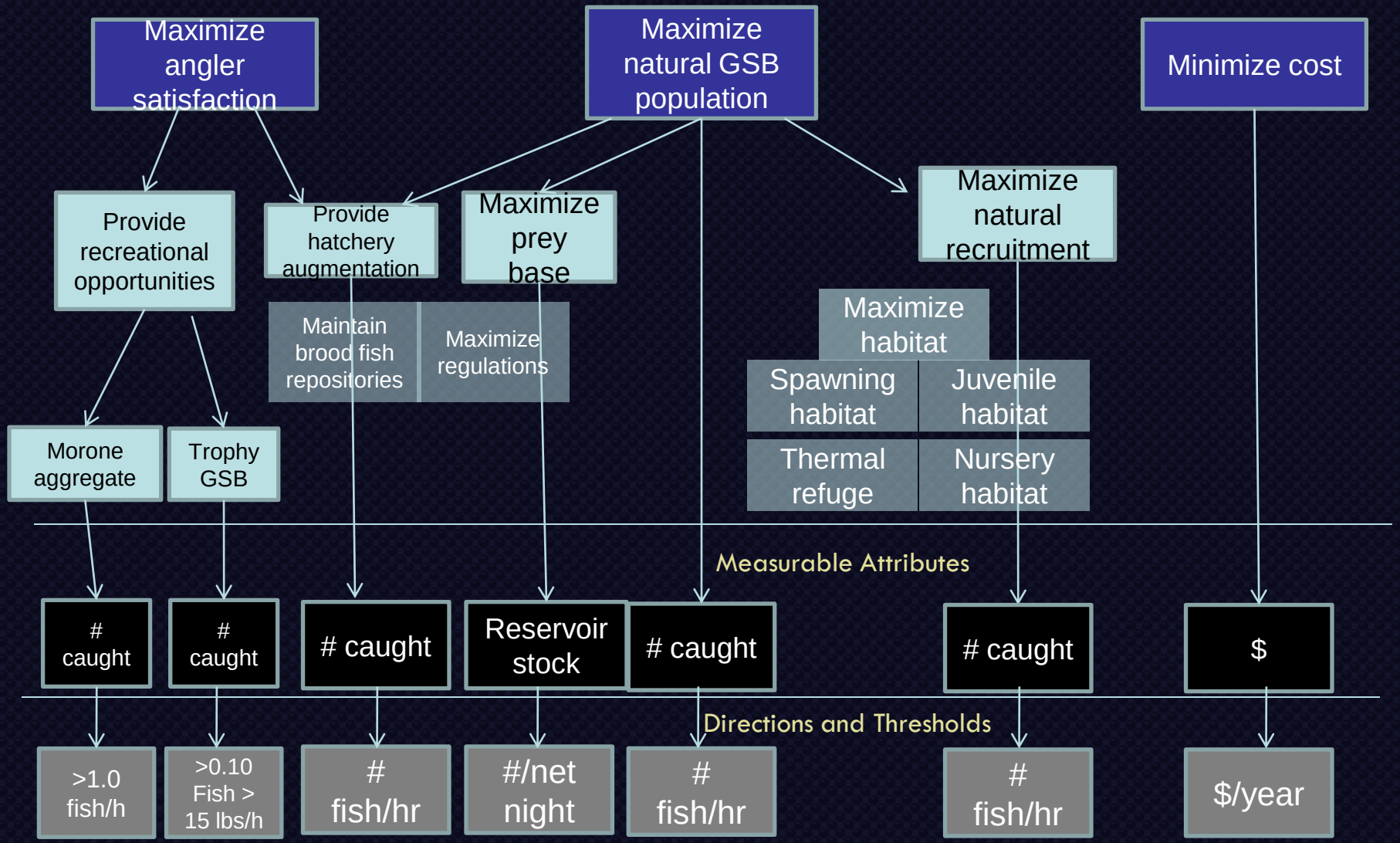
Gulf striped bass-objectives hierarchy



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Alternatives with habitat theme		Other alternatives
status quo		status quo
modify flows		increase stocking
create new spring habitat		stock hybrids/white bass
control hydrilla for juvenile habitat		stock forage
increase passage		increase access
reduce erosion		engage anglers to collect data
manage/limit irrigation systems		install educational kiosks
rehabilitate spring habitat		provide attractant flows
increase landowner involvement		implement moratorium
improve spring water quality		implement seasonal no-take
other hydrilla control		no stocking of other Morones
minimize point source pollution		increase # brood fish for gen div
no action		provide no-take zones
		increase stocking upper reservoirs
		no action

Consequences-Habitat

Habitat	*Fundamental*	Population	Population	Population	Angler Satisfaction	Angler Satisfaction	Population and Anglers	Cost
Gulf Striped Bass	*Means*	Population persistence	Natural recruitment	Prey base	Morone aggregate	Trophy striper fishery	Hatchery augmentation	Cost
	Direction:	Max	Max	Max	Max	Max	Max	Min
	Attribute:	relative abundance	relative abundance	reservoir stock	# caught	# caught	number stocked	$
Alternative	*Scale:*	#/hour	#/hour	#/net night	fish/hour	fish/hour	# a/year	0-5
weights		0.35	0.15	0.125	0.1	0.075	0.15	0.05
status quo		7	6	45	0.75	0.01	15	3
modify flows		10	12	100	1	0.015	10	2
create new spring habitat		15	12	45	0.85	0.02	10	3
control hydrilla for juv habitat		8.5	8.5	60	0.8	0.01	14	3
increase passage		8	7	125	0.75	0.01	14	3
reduce erosion		8	6	45	0.76	0.015	15	3
manage/limit irrigation systems		8	6.5	45	0.75	0.015	14	4
rehabilitate spring habitat		8	6.5	45	0.75	0.015	14	3
increase landowner involvement		7	6	45	0.75	0.01	15	3
improve spring water quality		8	6.5	45	0.75	0.013	14	3
other hydrilla control		10	12	150	1	0.02	13	3
minimize point source pollution		7	6	45	0.75	0.01	15	3
increase stocking		15	30	37	2	0.02	30	3
stock hybrids/white bass		7	5	38	2.25	0.01	15	3
stock forage		9	7.75	44	0.85	0.015	15	3
increase access		6.5	5.5	45	0.9	0.015	15	3
engage anglers to collect data		7	6	45	0.75	0.01	15	3
install educational kiosks		7	6	45	0.75	0.01	15	3
provide attractant flows		6.5	5.5	45	0.9	0.015	15	3
implement moratorium		9	7.75	44	0.85	0.015	15	3
implement seasonal no-take		9	7.75	44	0.85	0.015	15	3
no stocking of other Morones		7	6	45	0.15	0.01	15	3
increase # brood fish for gen div		7	6	45	0.75	0.01	15	3
provide no-take zones		8	6.5	44.5	0.25	0.0001	15	3
increase stocking upper reservoirs		17	30	45	1.5	0.015	30	3
no action		0.5	1	55	0.75	0.0001	0	1

Consequences-Tradeoffs