# Integrating Structured Decision Making with Scenario Planning

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## Introduction

- The case study I was going to present…
- Athabasca River water management framework

# Athabasca Water Mngt Framework

## Government / Regulators

- Alberta Environment (Water)
- Alberta Sustainable Resource Development (Fish & Wildlife)
- Energy Resources Conservation Board
- Fisheries and Oceans Canada
- Parks Canada – Wood Buffalo National Park

## Oil Sands Companies

- Canadian Natural Resources Limited
- Imperial Oil Resources
- Shell Canada Energy
- Suncor Energy
- Syncrude Canada
- Total E&P Canada

## Non-Governmental Organizations

- World Wildlife Fund Canada
- Alberta Wilderness Association
- South Peace Environmental Assoc.

## Aboriginal Organizations

- Fort McKay First Nation
- Fort Chipewyan Métis
- Fort McMurray Métis 2020

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# Introduction

- Integrated SDM & Scenario Planning
  - Wide range of future possibilities (scenarios)
  - Unknown probabilities of scenarios coming true
  - But consequences of scenarios can be estimated to a plausible degree

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# Core steps of SDM


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# Core steps


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# Decision Context

- You are a manager of Dry Tortugas National Park tasked with managing cultural resources.
- Changes in hurricane frequency are unknown but frequency of major hurricanes (Category 3) are predicted to increase proportional to increased SLR
- Fort maintained by masons

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# Decision Context

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## Decision Context

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## Decision Context

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# Decision Context

- **Decision is sensitive to climate scenarios:**
  - **Scenario A:** low SLR – storm surge Cat 3+ hurricane severely crumbles Fort Walls, fort floods
  - **Scenario B:** medium SLR – walls seriously damaged with Cat 1-2 hurricane, sand around fort moves extensively, fort floods on high tides (6x/year)
  - **Scenario C:** high SLR – Fort flooded, walls crumble extensively on ongoing basis, winter storms -> large chunk of wall fall

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# Some features we recognize…

- Need to balance multiple objectives
- Multiple stakeholders and roles
- High stakes
- Complexity and uncertainty
- Intense government and public scrutiny
- High expectations: quality and transparency
- Limited resources: time, money, personnel

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# Decision Context

- What makes decisions hard?
  - "People"
  - "Living with the consequences of decisions"
    - Woulda
    - Coulda
    - Shoulda

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# Decision Context

- Multi-stakeholder SDM
  - Gets people truly engaged in today's decisions
  - Helps them understand the pros and cons of management actions, with uncertainty
  - Helps them share the DM's burden of responsibility
  - If there is an unwanted outcome, the DM can say, "we explored that but people thought the pros outweighed the cons"

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# Decision Context

- Stakeholders
  - Heritage lovers
    - Today
    - Future generations
  - Government → Taxpayers
  - Campers / tourism industry
  - Building industry
  - Environmentalists??

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# Decision Context

- Other decision context
  - Planning horizon – 100 years? More?
  - Who is the decision maker?
  - Isolated project or one project among many?
  - Resources for the decision making process?
  - Timeline for meetings?

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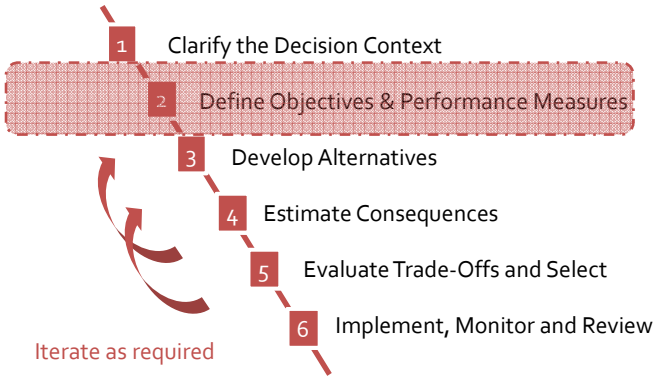
# Core steps

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# Introduction

- What do stakeholders think are important?
- Ask 'em!

Protect the fort!

Stop climate change!

Protect part of the fort

Reduce my taxes!

Generate revenues from tourism

Move the artifacts to a museum

Increase maintenance

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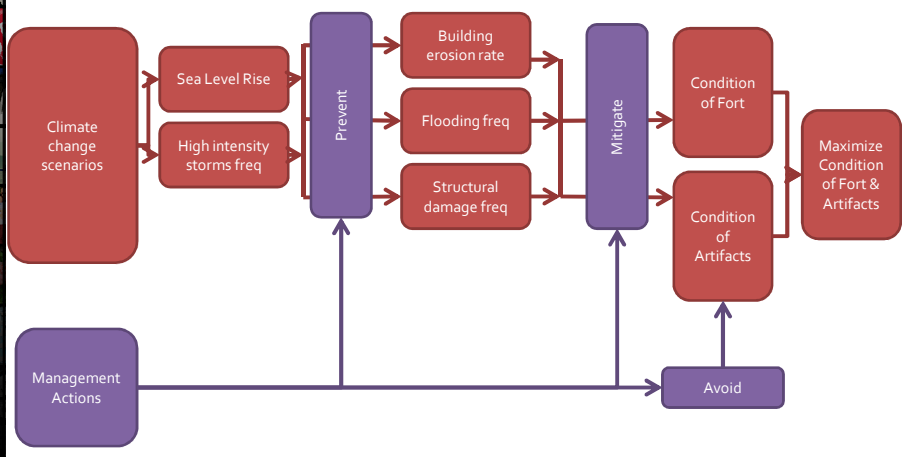
# Dry Tortugas National Park

- Clarify objectives using influence diagrams…
  - May need technical subcommittees of stakeholders for this one



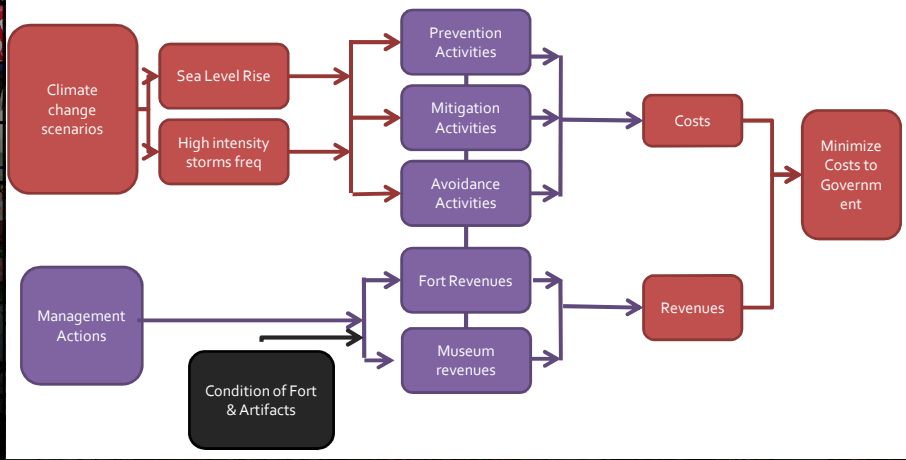
# Dry Tortugas National Park

- Possible influence diagram for Heritage



# Dry Tortugas National Park

- Possible influence diagram for Cost




# Dry Tortugas National Park

- Let's assume these objectives
  - Maximize condition of fort
  - Maximize condition of artifacts
  - Minimize net costs to government
- In this case there are other objectives…we'll neglect for now

# Dry Tortugas National Park

- Performance measures for 'condition of fort'?
  - Natural units….no (simulated photos?)
  - Proxies…e.g. quality weighted % intact areas(?)
  - Constructed scales e.g.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| "Ruin…" | ..elaborate… | ..elaborate… | ..elaborate… | "As good as today or better" |



# Dry Tortugas National Park

- Performance measures for 'condition of artifacts'?
  - Natural units….no (simulated photos?)
  - Proxies…e.g. quality weighted % intact artifacts(?)
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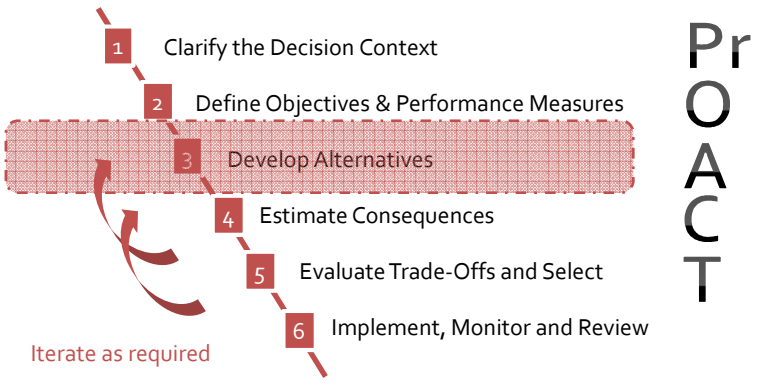
| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| "Ruin…" | ..elaborate… | ..elaborate… | ..elaborate… | "As good as today or better" |

# Dry Tortugas National Park

- Performance measures for 'cost'?
  - Natural units….
    - sure, just use expected $ per year?
  - BUT: Do we care about cost risk tolerance?



# Core steps



# Dry Tortugas National Park

- In this case, might help to make use of a strategy table…
- In this case, it seems to make sense to:
  - Define a trigger point
  - Things to do up to a trigger point
  - Things to do after a trigger point



# Dry Tortugas National Park

| Before trigger point | | | | Trigger | After trigger point | | | |
|---|---|---|---|---|---|---|---|---|
| Avoid | Prevent | Mitigate - Maintenance | Mitigate - Repair | | Avoid | Prevent | Mitigate - Maintenance | Mitigate - Repair |
| Do Nothing | Do Nothing | Do Nothing | Do Nothing | None | Do Nothing | Do Nothing | Do Nothing | Do Nothing |
| Move artifacts | Build sea wall | Maintain up to $1m yr | Repair damage up to $10m | Maintenance > $5m/yr | Move artifacts | Build sea wall | Maintain up to $1m yr | Repair damage up to $10m |
| | Build floating island | Maintain up to $5m yr | Repair damage up to $50m yr | Repair > $ 20m | | Build floating island | Maintain up to $5m yr | Repair damage up to $50m yr |
| | Jack-up | Maintain all | Repair Full | | | Jack-up | Maintain all | Repair Full |

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| | Jack-up | Maintain all | Repair Full | | | | | Repair Full |

**ALTERNATIVE 1**
"Abandon ship"

# Dry Tortugas National Park

| Before trigger point | | | | Trigger | After trigger point | | | |
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| | Build floating island | Maintain up to $5m yr | Repair damage up to $50m yr | Repair > $ 20m | | | | |
| | Jack-up | Maintain all | Repair Full | | | | | |

**ALTERNATIVE 2:**
"Whatever it takes"

# Dry Tortugas National Park

| Before trigger point | | | | Trigger | After trigger point | | | |
|---|---|---|---|---|---|---|---|---|
| Avoid | Prevent | Mitigate - Maintenance | Mitigate - Repair | | Avoid | Prevent | Mitigate - Maintenance | Mitigate - Repair |
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| | Build floating island | Maintain up to $5m yr | Repair damage up to $50m yr | Repair > $ 20m | | Build floating island | | |
| | Jack-up | Maintain all | Repair Full | | | Jack-up | | |

**ALTERNATIVE 3:**
"When the going gets tough, the tough ...er, take their stuff and get going"

# Dry Tortugas National Park

| Before trigger point | | | | Trigger | After trigger point | | | |
|---|---|---|---|---|---|---|---|---|
| Avoid | Prevent | Mitigate - Maintenance | Mitigate - Repair | | Avoid | Prevent | Mitigate - Maintenance | Mitigate - Repair |
| Do Nothing | Do Nothing | Do Nothing | Do Nothing | None | Do Nothing | Do Nothing | Do Nothing | Do Nothing |
| Move artifacts | Build sea wall | Maintain up to $1m yr | Repair damage up to $10m | Maintenance > $5m/yr | Move artifacts | Build sea wall | Maintain up to $1m yr | Repair damage up to $10m |
| | Build floating island | Maintain up to $5m yr | Repair damage up to $50m yr | Repair > $ 20m | | | | Repair amage p to 50m yr |
| | Jack-up | Maintain all | Repair Full | | | | | epair ull |

**ALTERNATIVE 4:**
"Solid commitment – but There comes a point..."

# Dry Tortugas National Park

| Before trigger point | | | | Trigger | After trigger point | | | |
|---|---|---|---|---|---|---|---|---|
| Avoid | Prevent | Mitigate - Maintenance | Mitigate - Repair | | Avoid | Prevent | Mitigate - Maintenance | Mitigate - Repair |
| Do Nothing | Do Nothing | Do Nothing | Do Nothing | None | Do Nothing | Do Nothing | Do Nothing | Do Nothing |
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| | Jack-up | Maintain all | Repair Full | | | Jack-up | Maintain all | Repair Full |

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# Dry Tortugas National Park

- So we'll move forward with 4 management alternatives for now – iterate later:
  - 1: Abandon ship
  - 2: Whatever it takes
  - 3: When the going gets tough
  - 4: Solid to a point

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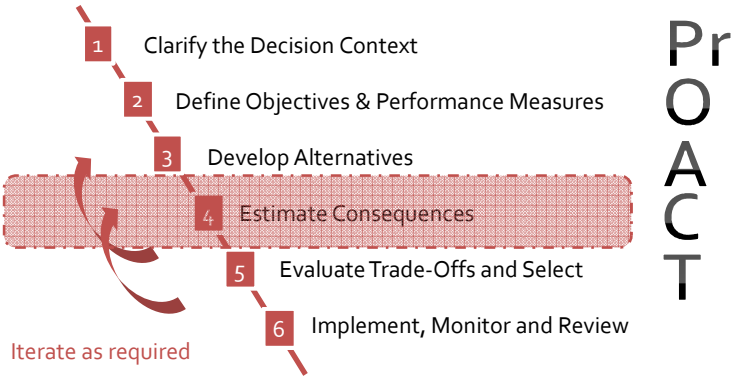
# Core steps

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# Dry Tortugas National Park

- If we weren't considering climate change
- Could simply use various tools to estimate consequences of alternatives on objectives:
  - E.g. storm damage stochastic modelling
    - Expert judgment panels on damage assessment ranges?
  - Cost estimations for management options
  - Multiply consequences by probability of storms etc over, say 100 years to get expected values

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# Dry Tortugas National Park

- But…this is a **scenario planning workshop**
- We don't know the probabilities of those scenarios…remember the scenarios?

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# Scenarios – a reminder

- **Decision is sensitive to climate scenarios:**
  - **Scenario A:** low SLR – storm surge Cat 3+ hurricane severely crumbles Fort Walls, fort floods
  - **Scenario B:** medium SLR – walls seriously damaged with Cat 1-2 hurricane, sand around fort moves extensively, fort floods on high tides (6x/year)
  - **Scenario C:** high SLR – Fort flooded, walls crumble extensively on ongoing basis, winter storms -> large chunk of wall fall

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## Dry Tortugas National Park

- We don't know how likely each scenario is
- But we can make reasonable assumptions about their effects if we characterize them specifically enough
- We know climate change
  - increases frequency of high intensity storms
  - Increases sea level

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## Dry Tortugas National Park

- So for each of our scenarios, we need to define
  - Precisely what change in frequency of storms of each intensity category
  - Precisely what change in sea level rise
- So let's ask a climatologist to do that…

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# Dry Tortugas National Park

Climatologist looks into it and says…

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# Dry Tortugas National Park

| | Frequency of Cat 1 Storms | Frequency of Cat 2 Storms | Frequency of Cat 3 Storms | Average Sea Level Rise over 50 yrs |
|---|---|---|---|---|
| Scenario A | 1 in 20 | 1 in 30 | 1 in 50 | 50 cm |
| Scenario B | 1 in 12 | 1 in 18 | 1 in 30 | 100 cm |
| Scenario C | 1 in 8 | 1 in 12 | 1 in 16 | 150 cm |

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## Dry Tortugas National Park

- Remember the beauty of scenarios is that they don't need to be 'correct'
- They don't need to be collectively exhaustive
- They're just scenarios…

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## Dry Tortugas National Park

- More about where those numbers in the consequence table are coming from…
- Could be some modelling, expert judgment panels or you might need to…

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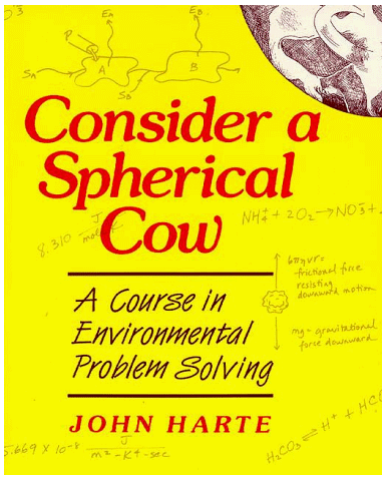
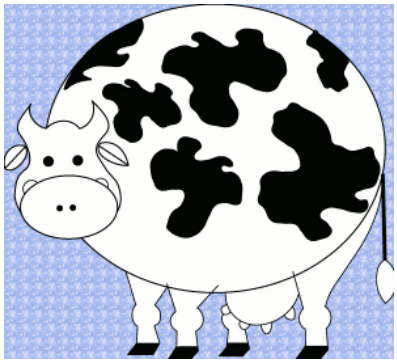
# Dry Tortugas National Park



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## 1. Counting Cobblers

How many cobblers are there in the United States?[1]

. . . . . .

One excuse for including this problem in a book about the environment is that getting your shoes repaired consumes less resources than buying a new pair. It is here mainly, however, to illustrate the ease with which a few plausible guesses can be combined to answer a question that at first glance seems resistant to guesswork. Can you estimate the order of magnitude[2] of the answer?

To do so, you could find out if there are cobbler licensing boards and, if so, write to them for their statistics. Or you could walk to the library and check the yellow pages of telephone directories for representative U. S. cities. However, why not be lazy and let your mind do the walking? Start by assuming that cobblers are generally busy most of the work week. As a rough estimate, they spend about 10 minutes on a heel job and perhaps 30 minutes on full heels and soles. More complicated repairs are rare, so ignore them. If time out for cleaning shop and dealing with customers is included, an average of 30 minutes per job is a reasonable guess. (Remember, the answer is an order of magnitude.)

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# Dry Tortugas National Park

By this reasoning, a cobbler can finish perhaps 15 jobs in a workday, or about 4000 a year. All you need to know now is how many repair jobs are done each year in the United States. I get a pair of shoes or boots repaired about every four years. Assuming I am typical, the $2.3 \times 10^8$ people in the United States (1983) have about $2.3 \times 10^8/4$ or $5.75 \times 10^7$ repair jobs carried out each year. Since one cobbler can repair 4000 shoes in a year, we need $5.75 \times 10^7/4000$ or 14,375 cobblers to do all the repair work in the United States.

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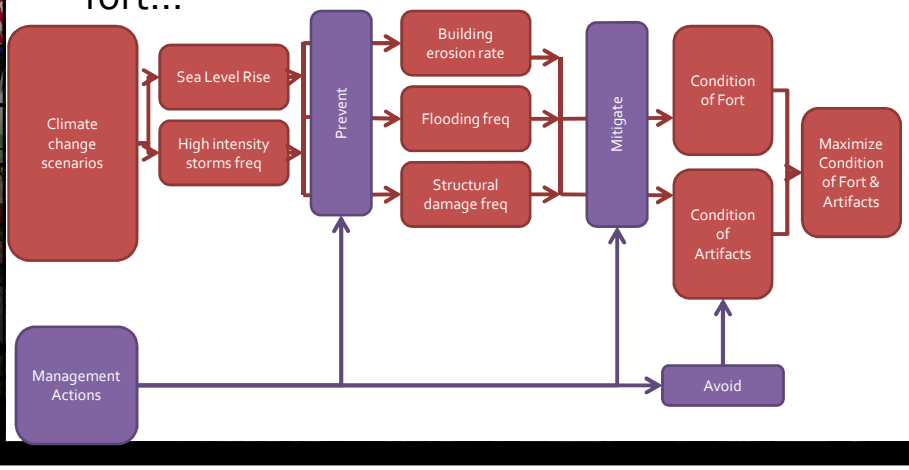
# Dry Tortugas National Park

- For the damage to the condition of the fort…

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# Dry Tortugas National Park

- In our case, we would work with a technical panel through each step
  - E.g. how much damage would the fort suffer during a Category 1 storm if a solidly constructed seawall of *x dimensions* existed…etc
- The more specific we are in terms of defining our objectives, performance measures, alternatives and scenarios, the more plausible the numbers generated are
- Remember it's more important to get the relative difference across alternatives right

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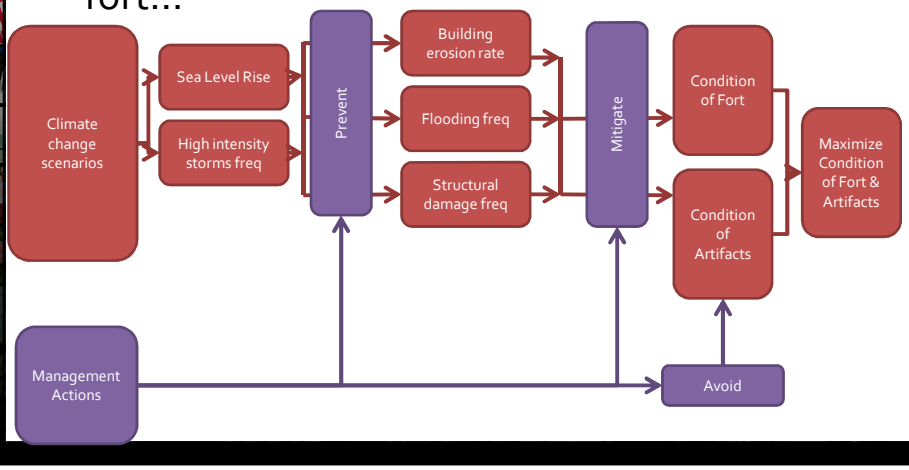
# Dry Tortugas National Park

- For the damage to the condition of the fort…

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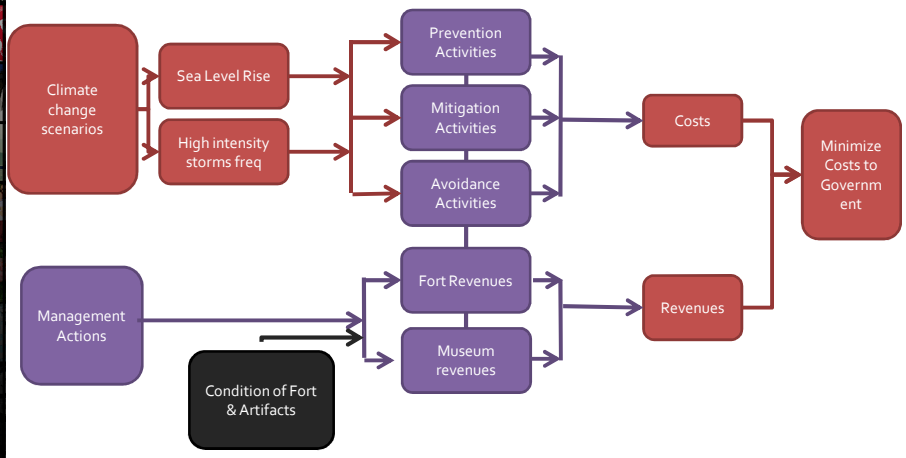
# Dry Tortugas National Park

- For costs…

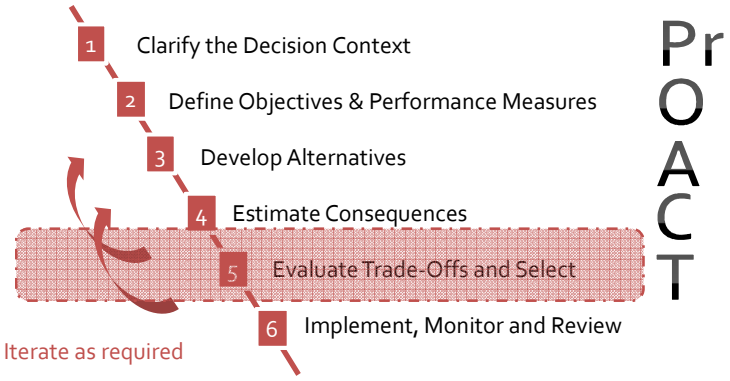



# Dry Tortugas National Park

- For consequences, let's assume we have:

| Objective | Units | Dir | Alt 1 | Alt 2 | Alt 3 | Alt 4 |
|---|---|---|---|---|---|---|
| **Scenario A** | | | | | | |
| Maximize condition of fort (a) | % | H | 30 | 98 | 55 | 91 |
| Maximize condition of artifacts (a) | % | H | 25 | 95 | 85 | 89 |
| Minimize costs (a) | $m / yr | L | 0.2 | 15.0 | 3.0 | 8.0 |
| **Scenario B** | | | | | | |
| Maximize condition of fort (b) | % | H | 15 | 72 | 30 | 65 |
| Maximize condition of artifacts (b) | % | H | 8 | 65 | 98 | 50 |
| Minimize costs (b) | $m / yr | L | 0.2 | 18.0 | 5.0 | 10.0 |
| **Scenario C** | | | | | | |
| Maximize condition of fort (c) | % | H | 10 | 65 | 20 | 55 |
| Maximize condition of artifacts (c) | % | H | 5 | 55 | 20 | 35 |
| Minimize costs (c) | $m / yr | L | 0.2 | 25.0 | 7.0 | 15.0 |

# Core steps

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# Dry Tortugas National Park

- For trade-offs, we'll explore two methods:
  - Non-weighted dominance
  - Multi-method weighting

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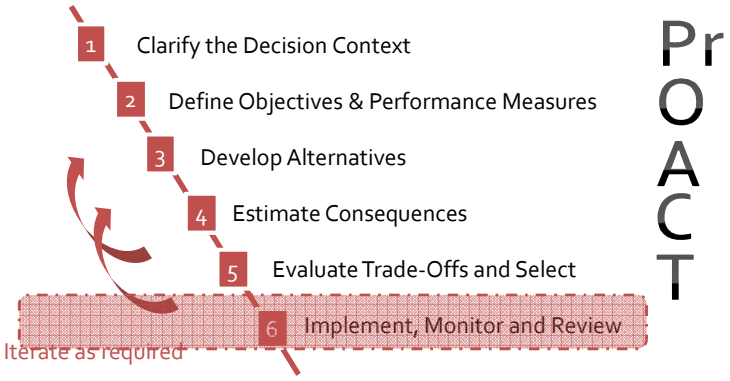
# Core steps

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# Summary

- Final decisions made by the DM of course
- But rationale is well documented
- If a 'trigger event' occurs, plan is already agreed.
- Shared responsibility
- No woulda, coulda, shoulda

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# Summary

- Integrated SDM & Scenario Planning
- Works where…
  - Wide range of future possibilities (scenarios)
  - Unknown probabilities of scenarios coming true
  - But consequences of scenarios can be estimated to a plausible degree

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# THANKS!

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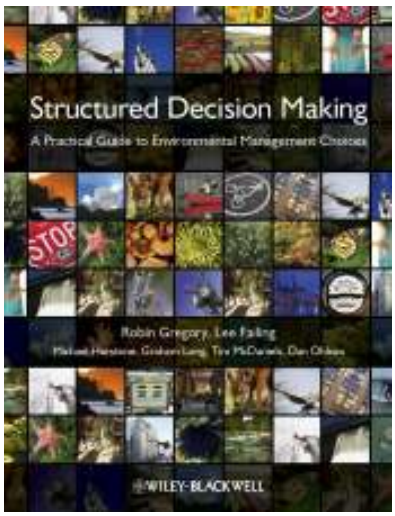


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