# Decision Making under Deep Uncertainty (DMDU) What is it and how might NOAA use it? Report to the Science Advisory Board

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### What is Deep Uncertainty?

- Likelihood of future events & outcomes cannot be wellcharacterized with existing data and models
- Uncertainty cannot be reduced by gathering additional information
- Stakeholders disagree on consequences of actions



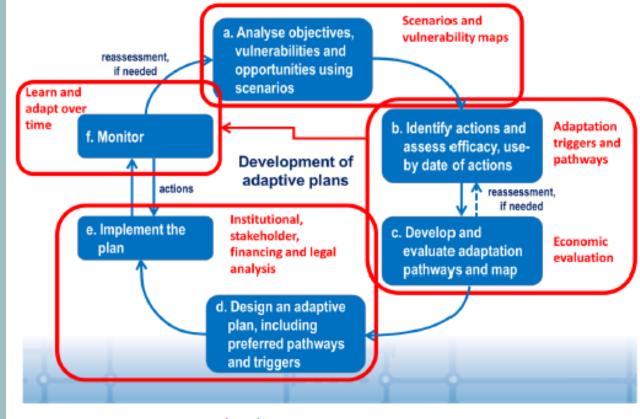
### DMDU Techniques to Manage Deep Uncertainty

Common goal - Identify decisions that succeed under a wide range of plausible, but not necessarily likely, outcomes

- Robust Decision Making
- Probability-Bounds Analysis
- Info-Gap Theory
- Resilience Analytics
- Dynamic Adaptive Policy Pathways or Dynamic Adaptive Planning

## Elements of DMDU Techniques

- 1. Stakeholder engagement from beginning to end
- 2. Structured (parsimonious) scenario development
- Optimization modeling OR Modeling of pre-selected options
- 4. Stress-testing recommended actions to characterize <u>regret</u>
- 5. Dynamic adaptive planning



Source: Adapted from Haasnoot et al (2013)

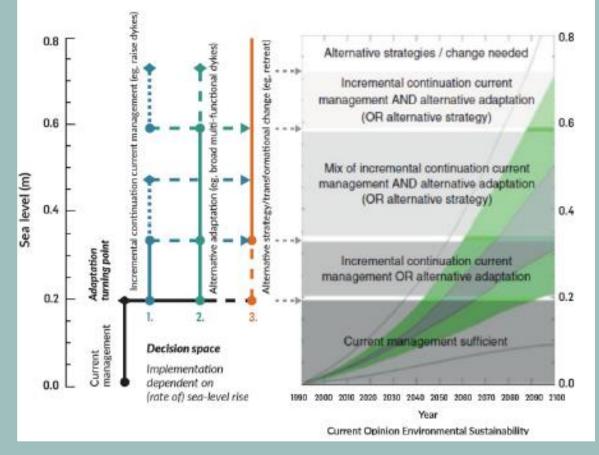
#### When to use DMDU

Short-term analysis	Scenario Planning	Probabilistic risk assessment	DMDU approaches
Capital expenses low Decisions few System response is well characterized Certainty	<ul> <li>improved concertainty</li> <li>Probabilistic (PRA) seeks given quanties</li> <li>Decision M</li> </ul>	sion stakes increase, haracterization of v is desirable c Risk Assessment s a best guess solution, tifiable variability aking under Deep	Capital expenses high Decisions numerous Many unknowns or choices sensitive to known unknowns Deep uncertainty
	regret" solution regret r	y (DMDU) seeks "low- utions across diverse utcomes, where cannot be quantified	

# Potential Benefits of Applying DMDU

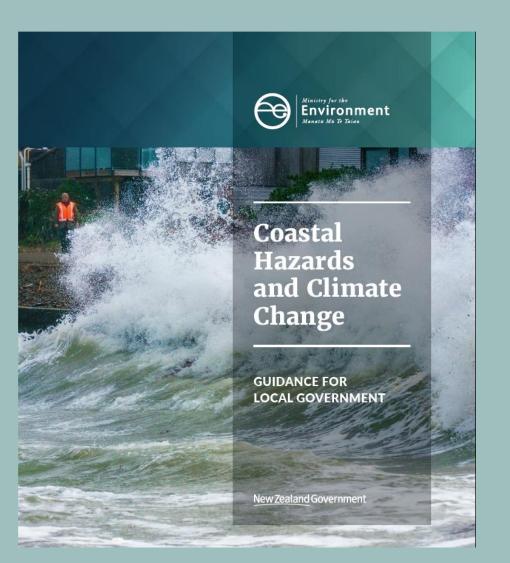
- Avoid unanticipated or unintended consequences with low-regret solutions
  - Systematic and deliberate exploration of potential decision outcomes
- Decrease risk mitigation costs by using risk triggers to determine timing/sizing of actions
  - Most beneficial when decision stakes justify the substantial investment in data and models

Adaptation route map showing how different adaptation options combine into adaptation pathways: current management (black): raise dykes or stopbanks (blue), broaden dykes (green) and retreat (red)



### Recommendations

- Include elements of DMDU where riskbased planning is already used (e.g., Marine Strategy Evaluation)
- Explore potential applications of DMDU to inform coastal planning
- Apply DMDU to design monitoring programs
- Develop guidelines and data to enable systematic scenario development
- Consider whether there are other promising areas of DMDU application within NOAA



### Potential next steps

- Initiate a broader discussion within NOAA to identify potential application
- Identify research needed to develop guidance on application within NOAA



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