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Evaluating Oil Spill Risks through Stochastic and Deterministic Modeling

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Outline

- How modeling fits into an oil spill risk assessment
- Define ***stochastic*** and ***deterministic*** modeling
- Modeling considerations when assessing likelihood & consequence
- Comments on the common practice

Part of a bigger picture

Elements of the risk assessment

Hazard identification

HAZOP, PHA, What-If-Analysis

Likelihood analysis

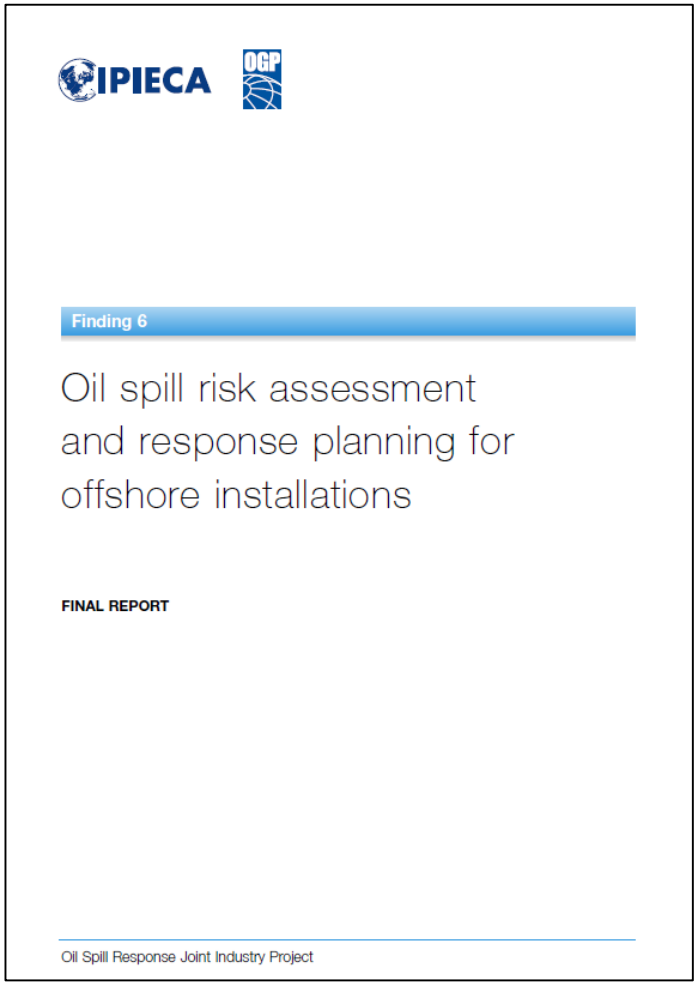
historical data and extreme value theory

Consequence analysis

Predicted exposure & receptor sensitivity

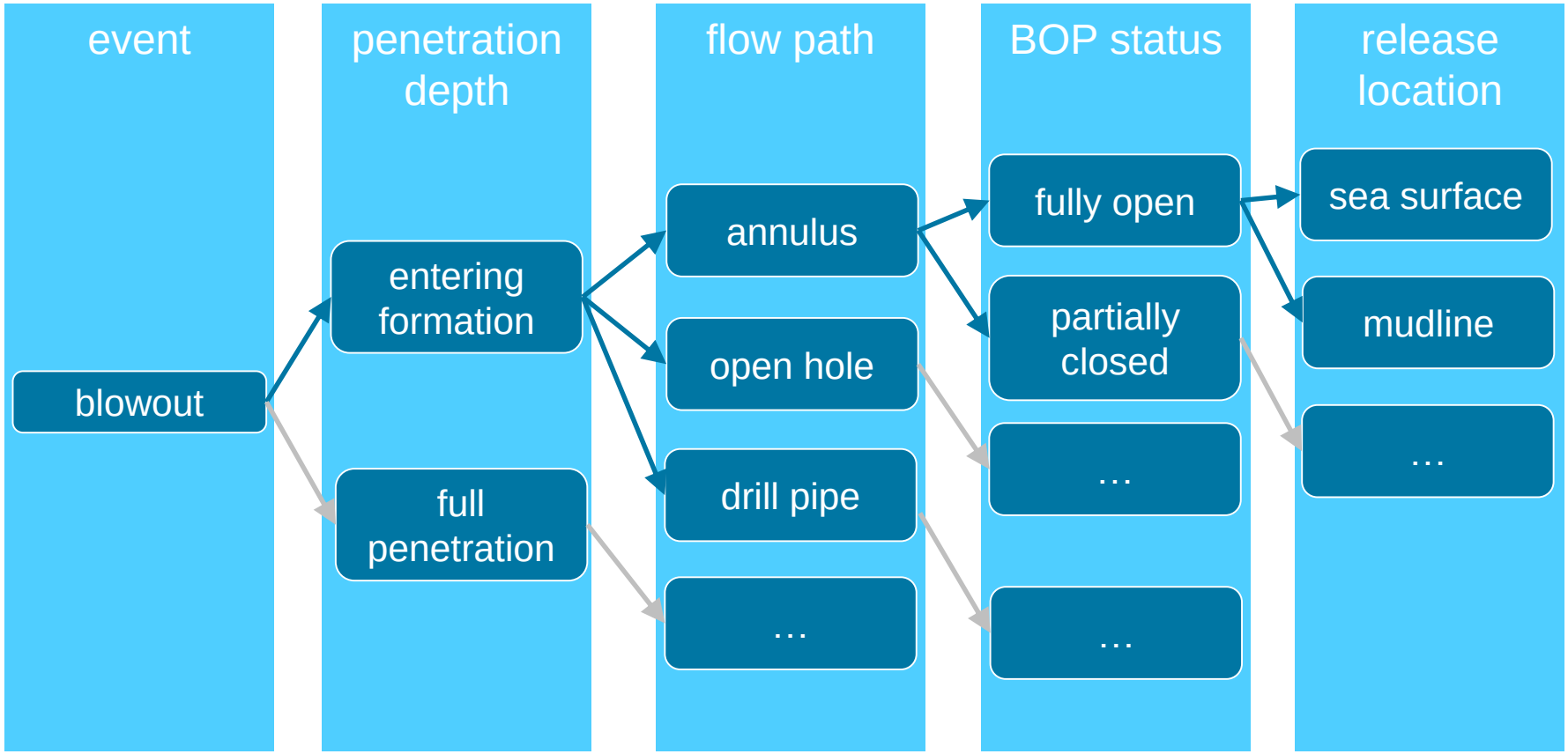
Evaluate risk

Compare severity/prob. to tolerance criteria



Hazard identification

Hypothetical Event Tree Analysis (ETA) for exploratory drilling

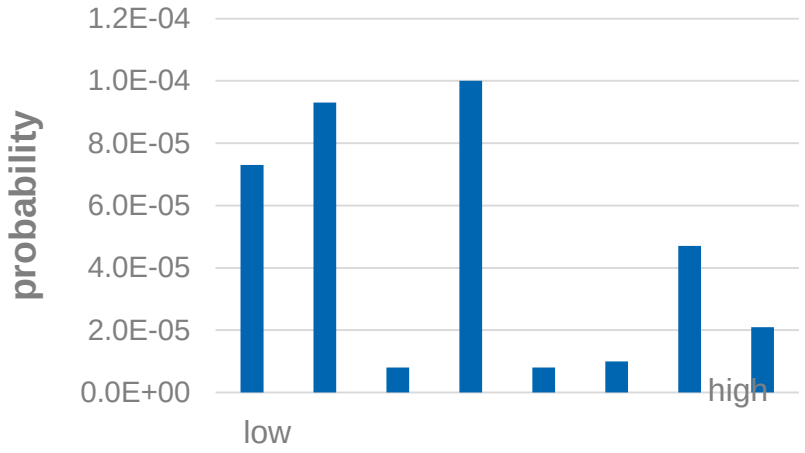


Likelihood analysis

Characterize volume & probability

For blowout example:

- Model flow for each ETA pathway
- Vol. based assumed intervention time
- Assign prob. based on historical data

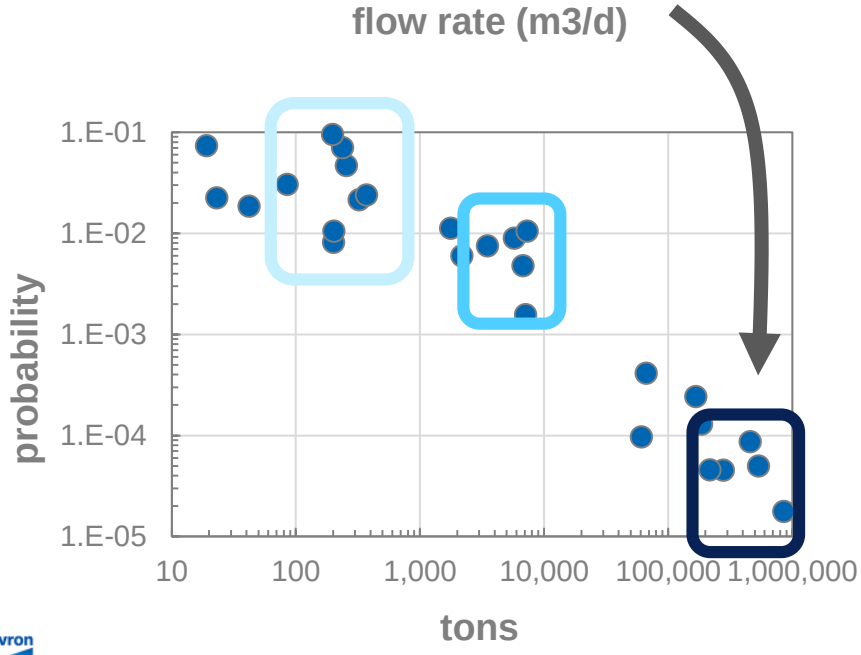


Consider complete risk profile

- Production & transportation risk

Representative spill scenarios

- Evaluating all hazards is intractable
- Select representative scenarios for consequence analysis



Consequence analysis

Severity of spill determined by:

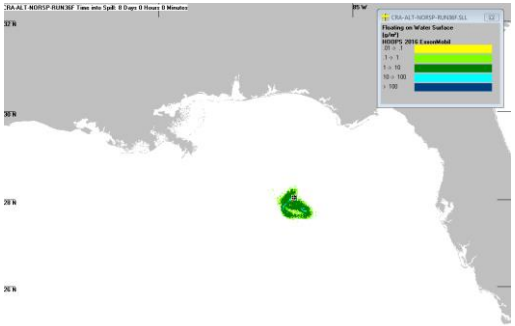
- Modeling fate & trajectory of spilled oil
- Comparing exposure to environmental sensitives

spill scenario
oil properties
volume, duration, location
metocean conditions

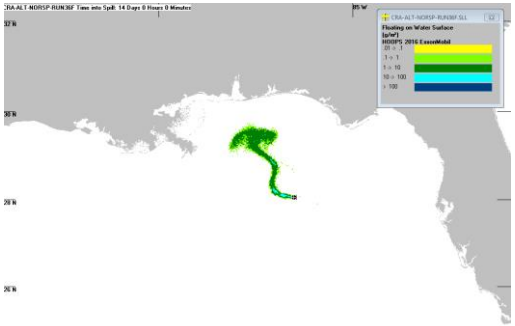
Importance of metocean inputs

- Drive trajectory…but also affect weathering
- Transient and seasonally variable

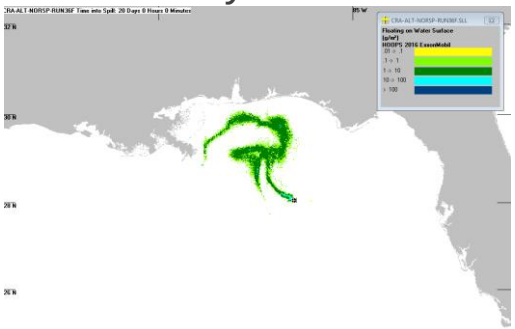
Day 8



Day 14



Day 20



Establish & evaluate risk

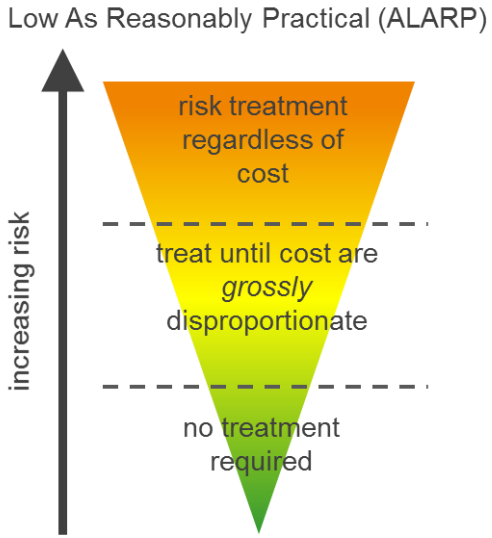
Establishing risk

- Combine likelihood and consequence
  - Establish risk level from one specific set of metocean parameters
  - Do different metocean inputs affect severity?

Evaluating risk

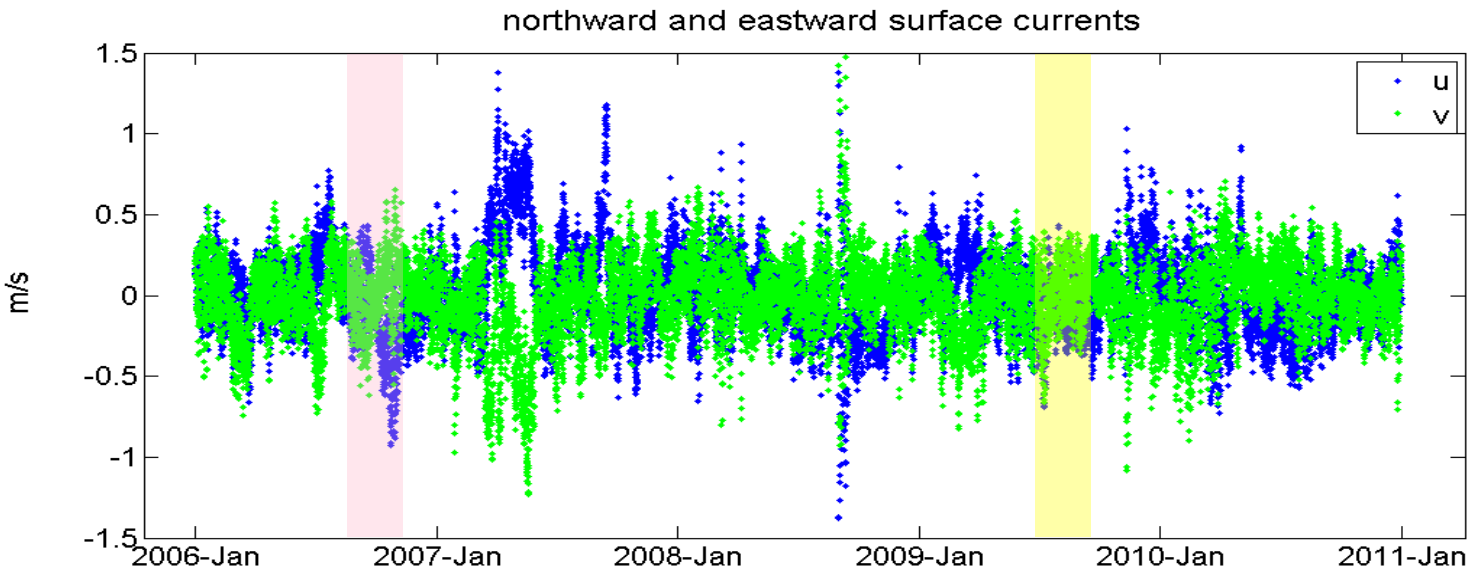
- Compare risk level to tolerance criteria
- Are safeguards needed?
- Are risks as low as responsibly practical (ALARP)?

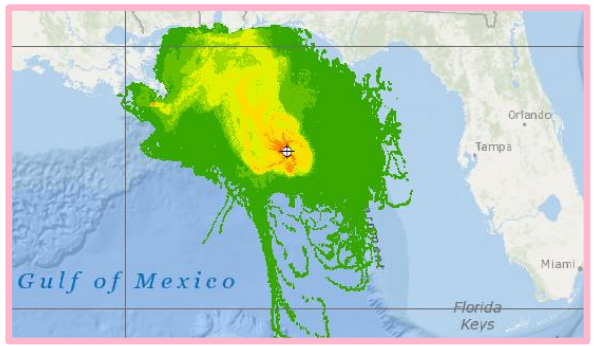
Consequence / Likelihood	Insignificant	Small	Moderate	Large	Very Large
≥≈10^{-1}					very high risk
≥≈10^{-2}					
≥≈10^{-3}					
≥≈10^{-4}					
≥≈10^{-5}	very low risk				

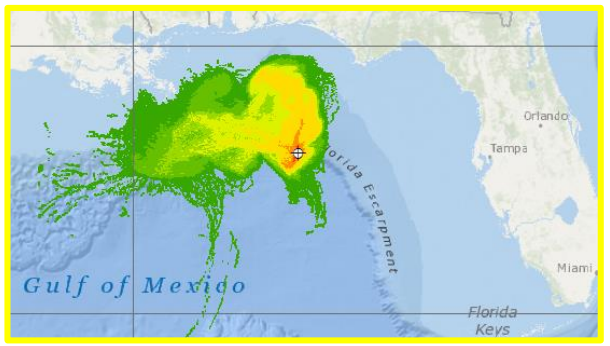


Deterministic modeling

Simulate fate & transport under **specific metocean forcing**



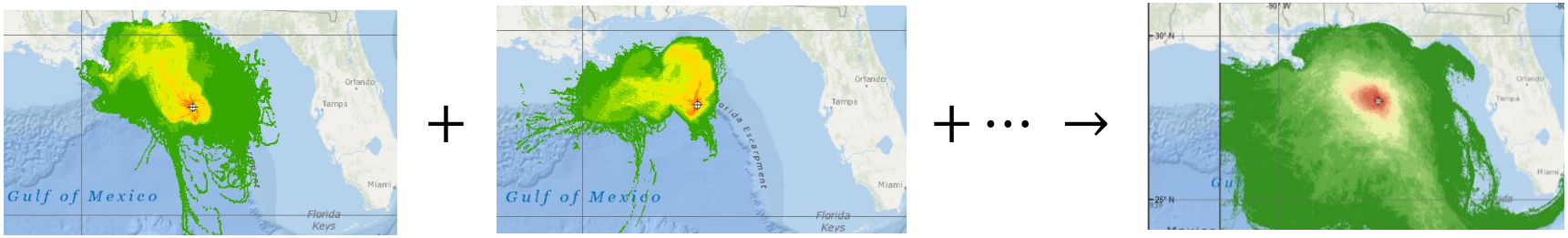




Stochastic modeling

Combine multiple runs under **various metocean forcing**

- Spatial variation of *conditional probability*
- Does *not* show extent of oiling



trajectory #1 trajectory #2 probability plot

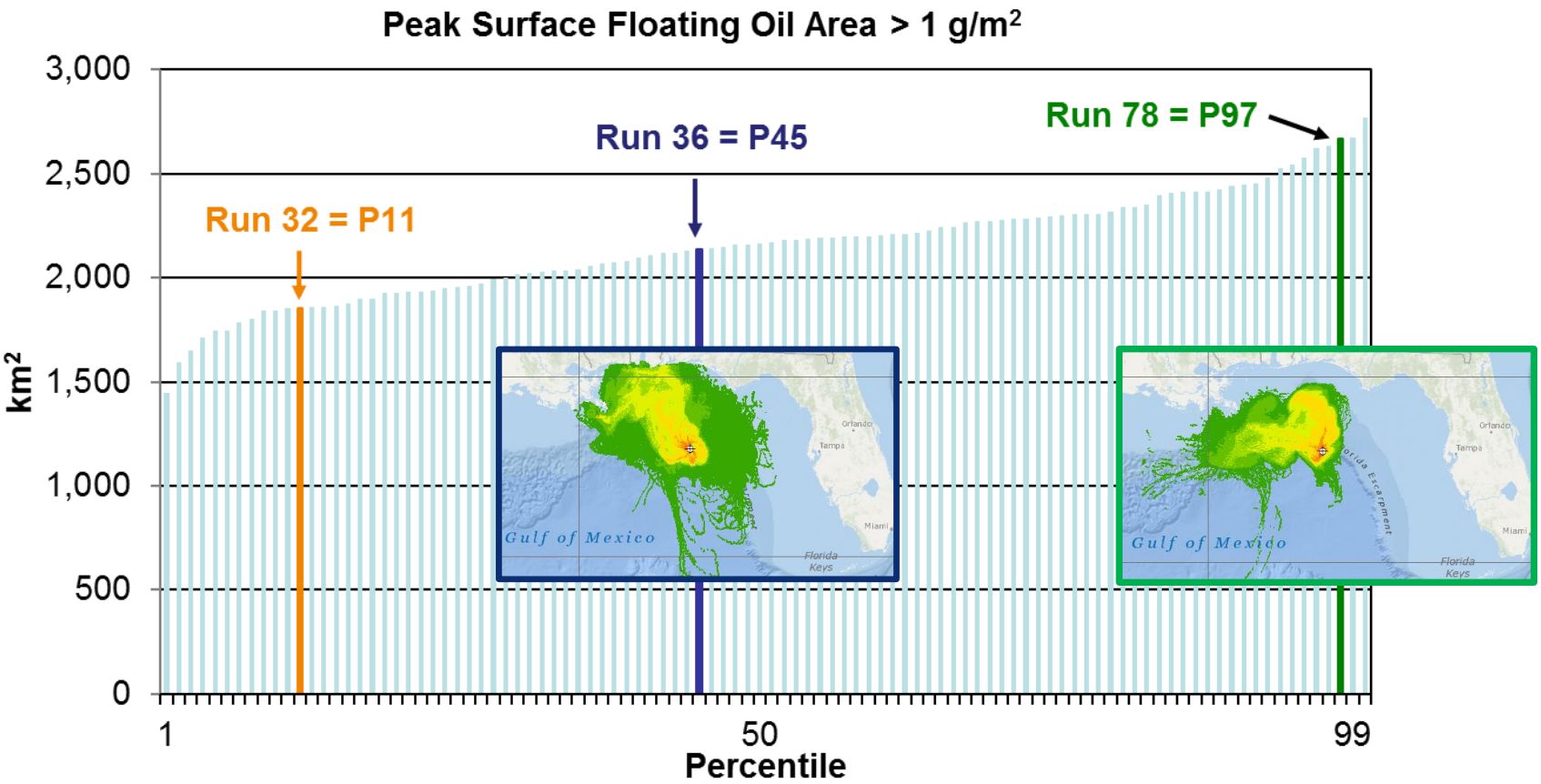
Histograms describe distribution of low/high exposure

- Rank runs by surface area oiled, shoreline oiled, …
- Shape of distribution indicates importance of metocean variabilty

A ‘representative’ or ‘worst-case’ run?

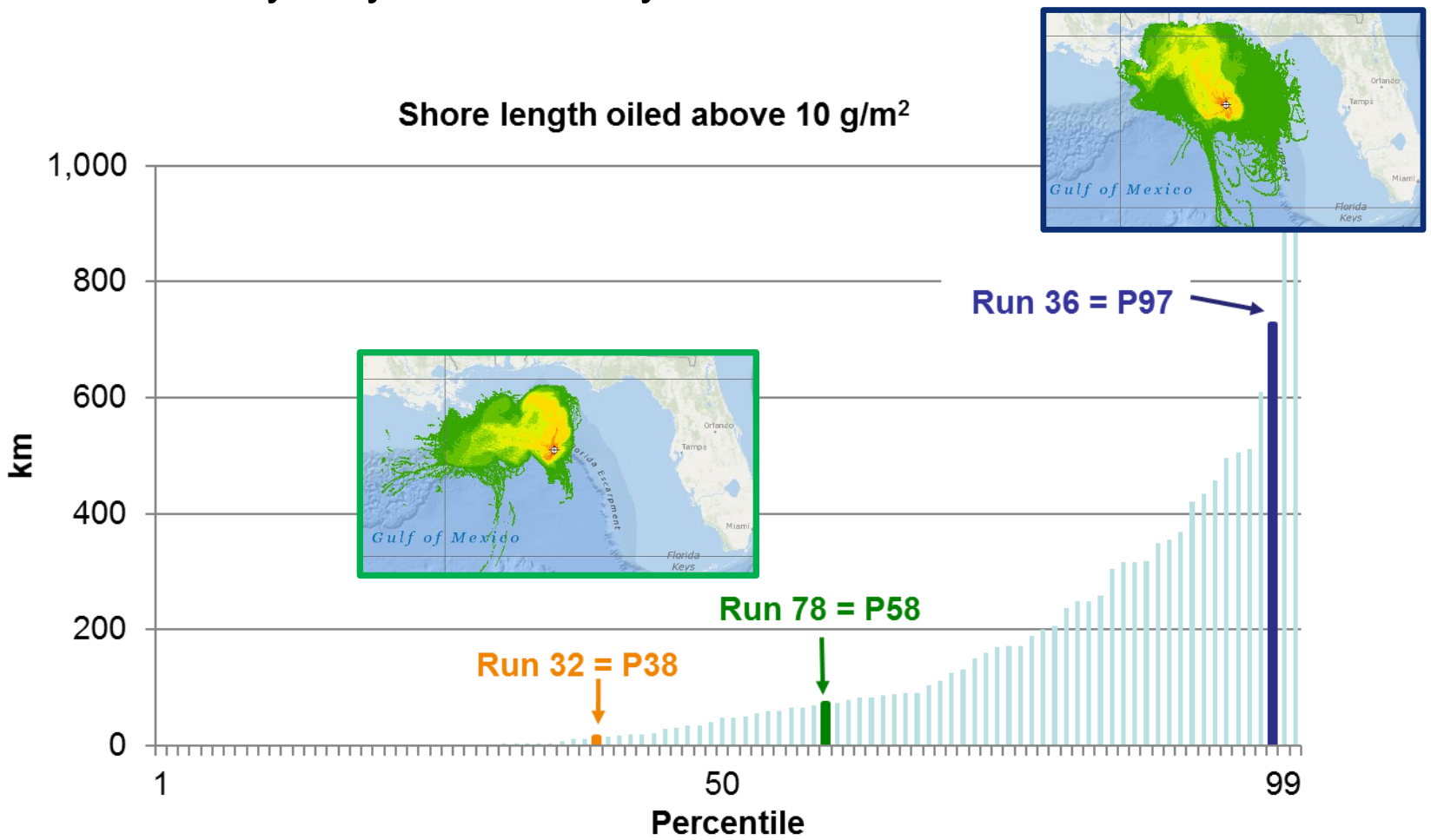
Some exposure metrics may not vary much….

but simplification may mask severity



A ‘representative’ or ‘worst-case’ run?

…but some may vary considerably



Conflicting guidance & practice

IPIECIA Good Practice Guide

*The stochastic analyses should be paired with a **most probable** deterministic case that can be utilized to support response planning*

Australian Maritime Safety Authority

*Stochastic modelling is the recommended method for determining the Zone of Potential Impact…assess the **likely effect** of the spill scenarios for each resource type identified within the ZPI .*

BOEM risk assessments

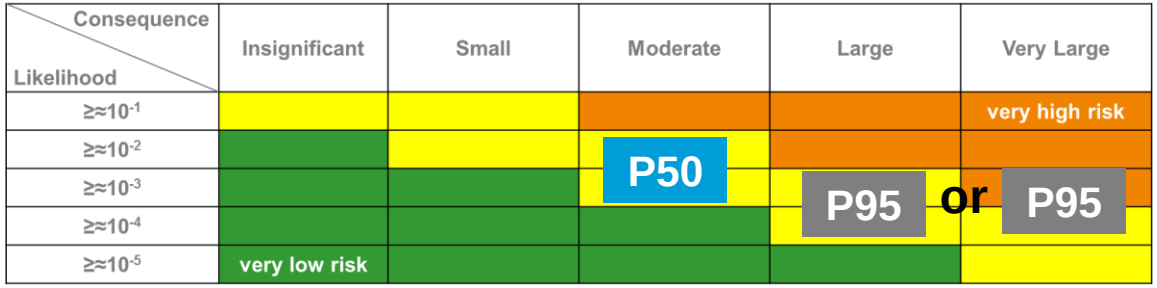
- Simplified consequence analysis (no weathering, 30-day trajectory, no ecology)
- Summation of prob. x extent of oiling over stochastic set

Typical practice

Use P100 run as a (overly?) conservative assumption

closing thoughts

- Don’t blindly adopt P100 run for consequence analysis
- Consider how severity varies with conditional probability
  - Is comparison to tolerance criteria robust?



- When practical, establish risk by weighting consequence by conditional probability
- If establishing risk only from central portion of stochastic set, confirm ability to scale-up response

Questions?