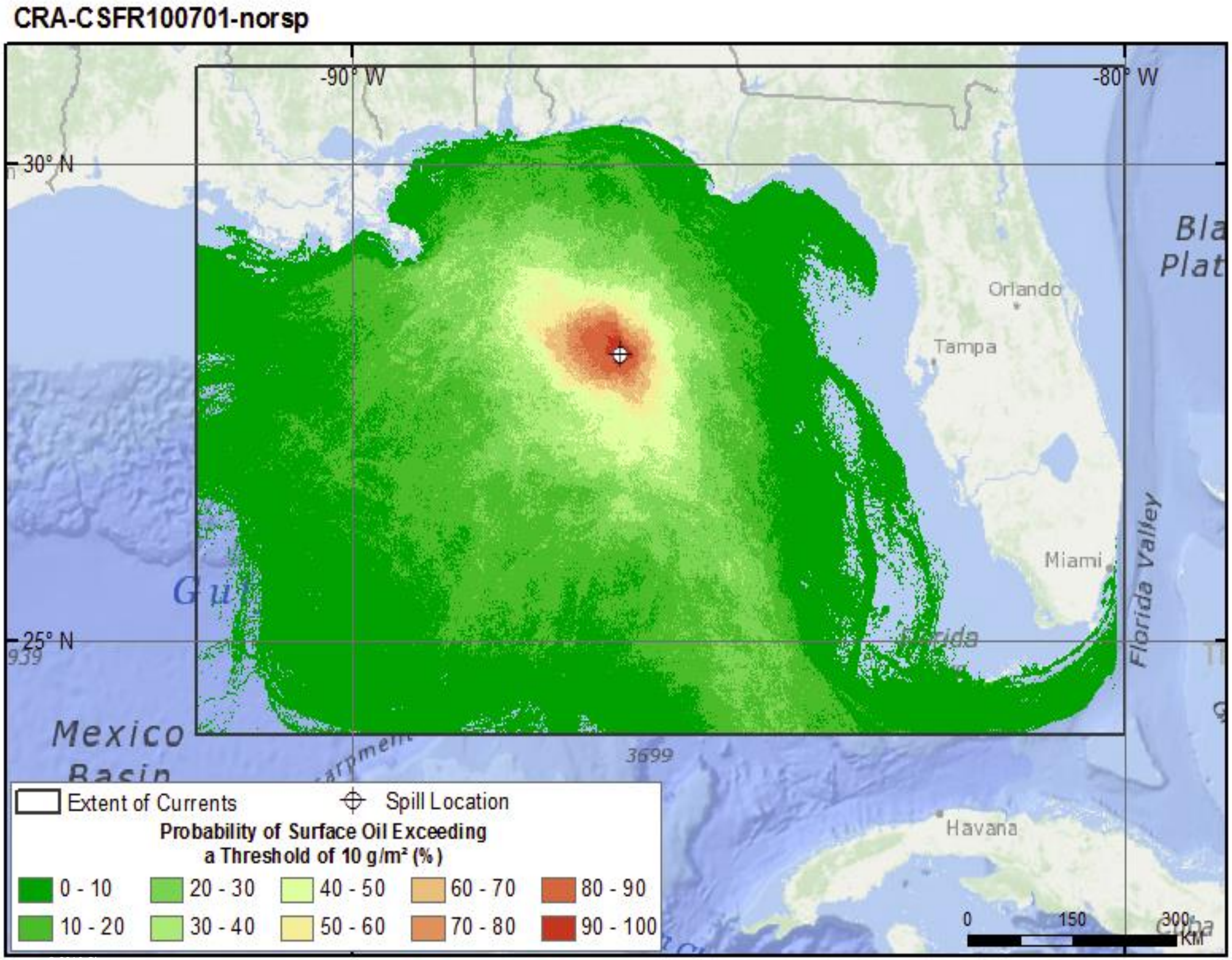

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Improving Oil Spill Risk Assessment

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Oil spill risk assessment guidance

	Question	Step	Guidance
OSRA	What can happen?	Identify Potential Release Scenarios	IOGP guidance
OSRA	Know your oil.	Oil Characterization	IOGP + CVX guidance
OSRA	Where can it go?	Fate and Trajectory Modeling	CVX guidance, API CRA
OSRA	What is in its way?	Resources at Risk	IOGP + CVX guidance
OSRA	Potential consequences (without safeguards)	Risk Evaluation	IOGP guidance, API CRA
OSCP	What should we plan for?	Business Unit develops & implements response plans to increase preparedness	

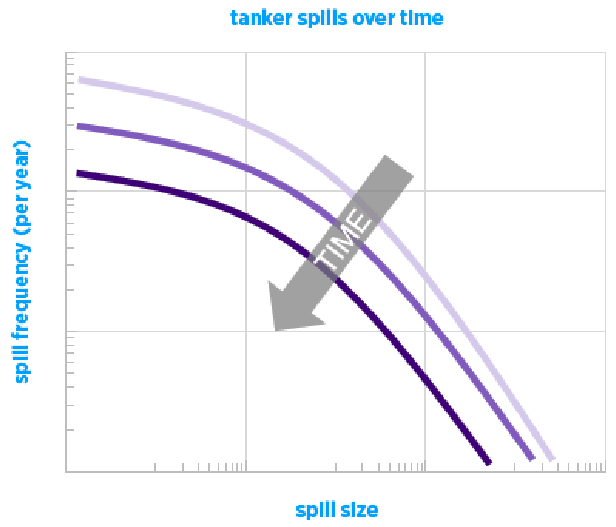
Identify potential release scenarios

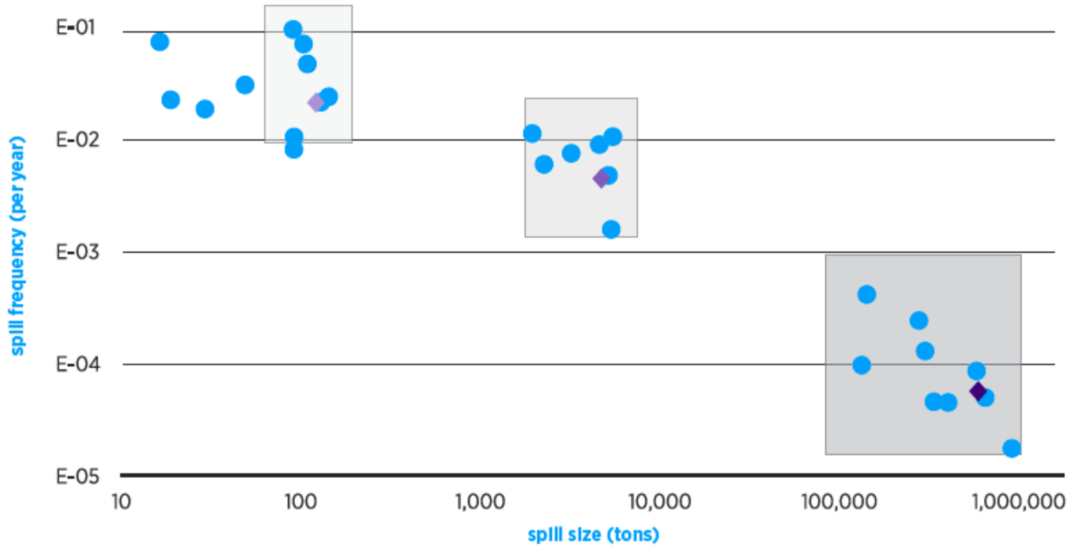
- Recognized sources of likelihood data should be used
  - SINTEF Offshore Blowout database (mostly based on North Sea and GOM data)
  - BSEE eWell system (since 2010) (Well Activity Reports - WARs)
  - ITOPF Oil Tanker Spill Database

- May need to adjust likelihood based on historical trends or site-specific data

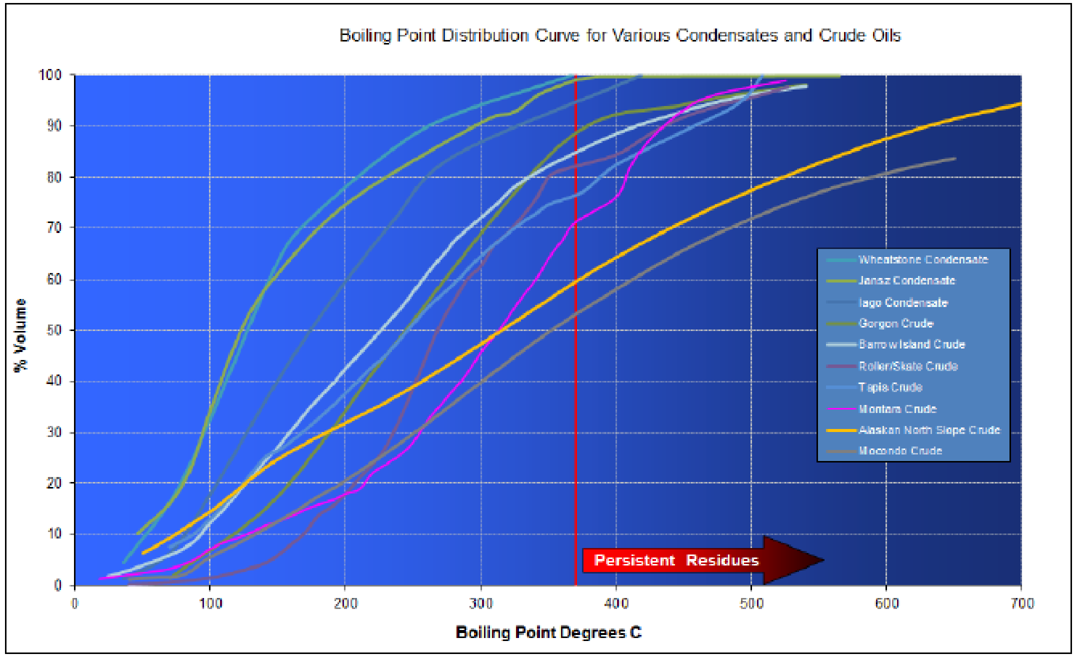
- Will historical data capture very rare events?
  - Extreme value analysis

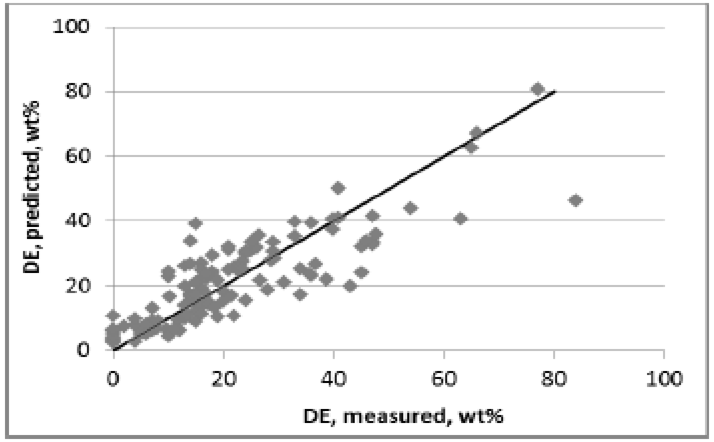
- Select representative spill scenarios for consequence analysis





Oil characterization

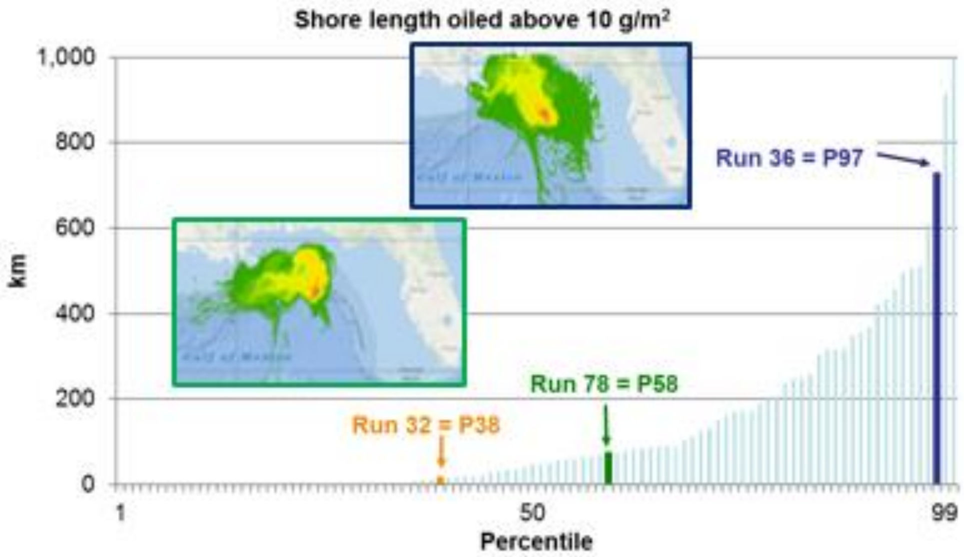


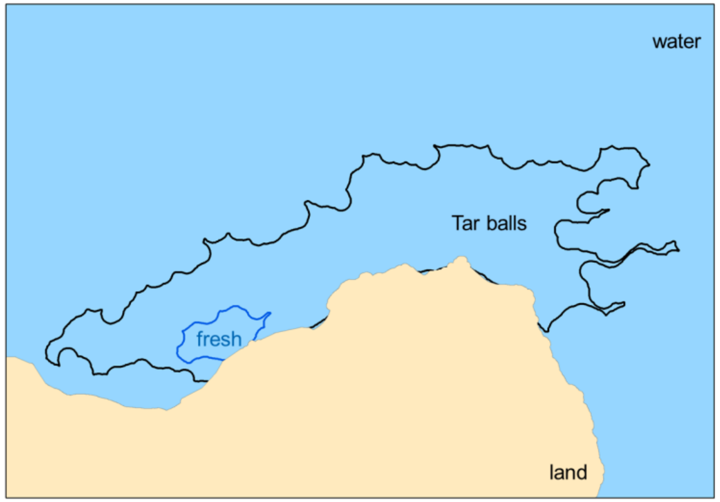


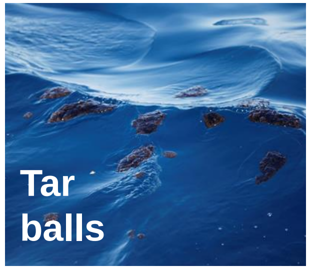
- Laboratory data on fresh and weathered crude oil
  - Distillation curves
  - Viscosity
  - Density
  - Pour Point
  - Interfacial Tension
  - Flash Point
  - SARA
  - Waxes
  - Sulfur compounds (e.g., light mercaptans)
  - VOCs
- Dispersant efficacy tests
- Aquatic Toxicity tests
  - PETROTOX

Fate and trajectory modeling

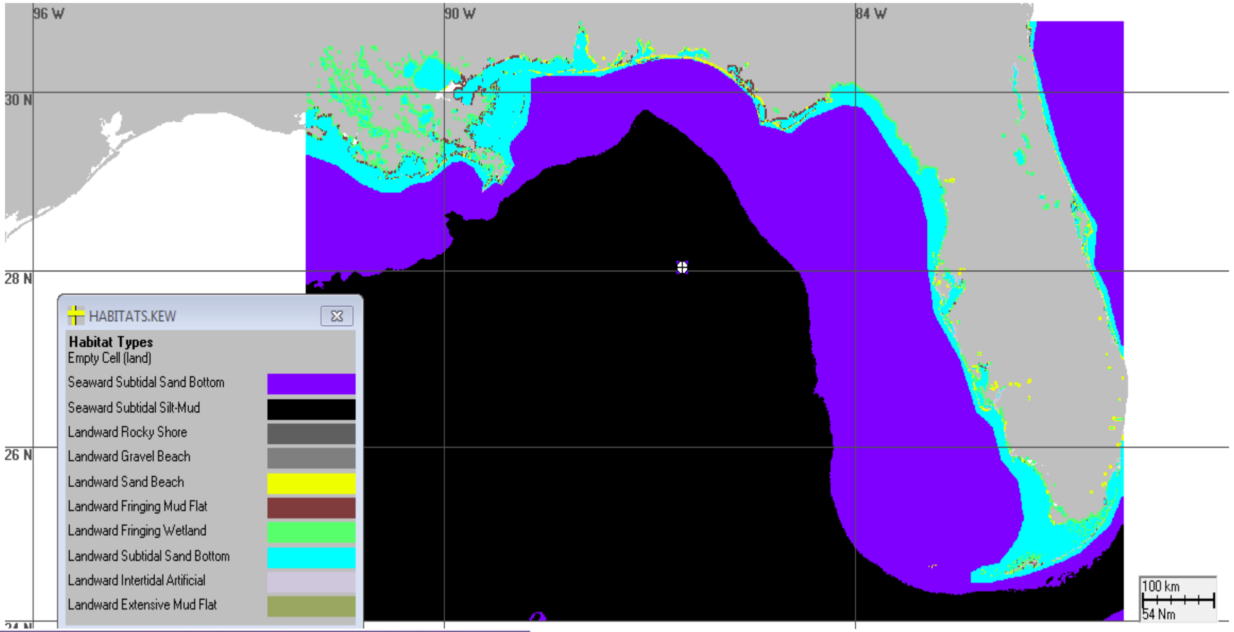
- Stochastic modeling used to quantify extent and probability of oiling
- Conflicting guidance on how to select "representative" spill
  - Don't blindly adopt P100 run for consequence analysis
  - Select moderately conservative (Run 78) run to represent "expected value"
  - Remember to adjust likelihood if utilizing rare worst-case deterministic runs (Run 36)
- Discriminate between "fresh oil" and "tar balls" (≤1% VOC/SVOC)

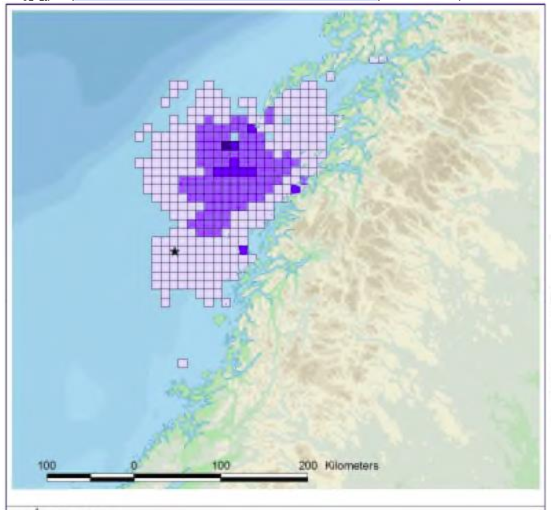






Resources at risk





★ Spill site

Surface blowout 5000 Sm3 /day, 15 days

Atlantic Puffin

Average expected impacted population fraction in a 10x10 km grid cell

- Resources at risk includes:
  - shoreline habitat and socio-economic resources (often found on ESI maps)
  - but also coastal, pelagic and deep-water resources (rarely included on ESI maps)
- Resources at risk may be highly seasonally dependent in temperate and arctic waters
- Predicted oiling less than thresholds equal low likelihood of unacceptable impacts

VEC Type	Exposure Measure	Lower Threshold	Higher Threshold
Birds, Mammals, & Reptiles; Sargassum	Surface floating oil mass per unit area	10 g/m^2 (10 µm)	100 g/m^2 (100 µm)
Plankton in Upper 20m	PAH concentration in water	1 µg/L (ppb)	10 µg/L (ppb)
Other Water Column	PAH concentration in water	10 µg/L (ppb)	100 µg/L (ppb)
Vegetation & Habitats	Shoreline oil mass per unit area	100 g/m^2 (100 µm)	1 kg/m^2 (1 mm)
Intertidal Invertebrates	Shoreline oil mass per unit area	10 g/m^2 (10 µm)	100 g/m^2 (100 µm)

Source: API CRA (RPS ASA 2016)

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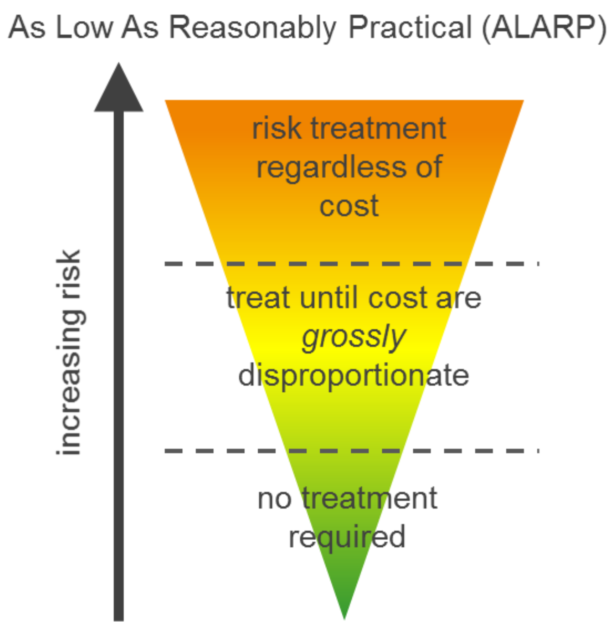
Risk evaluation

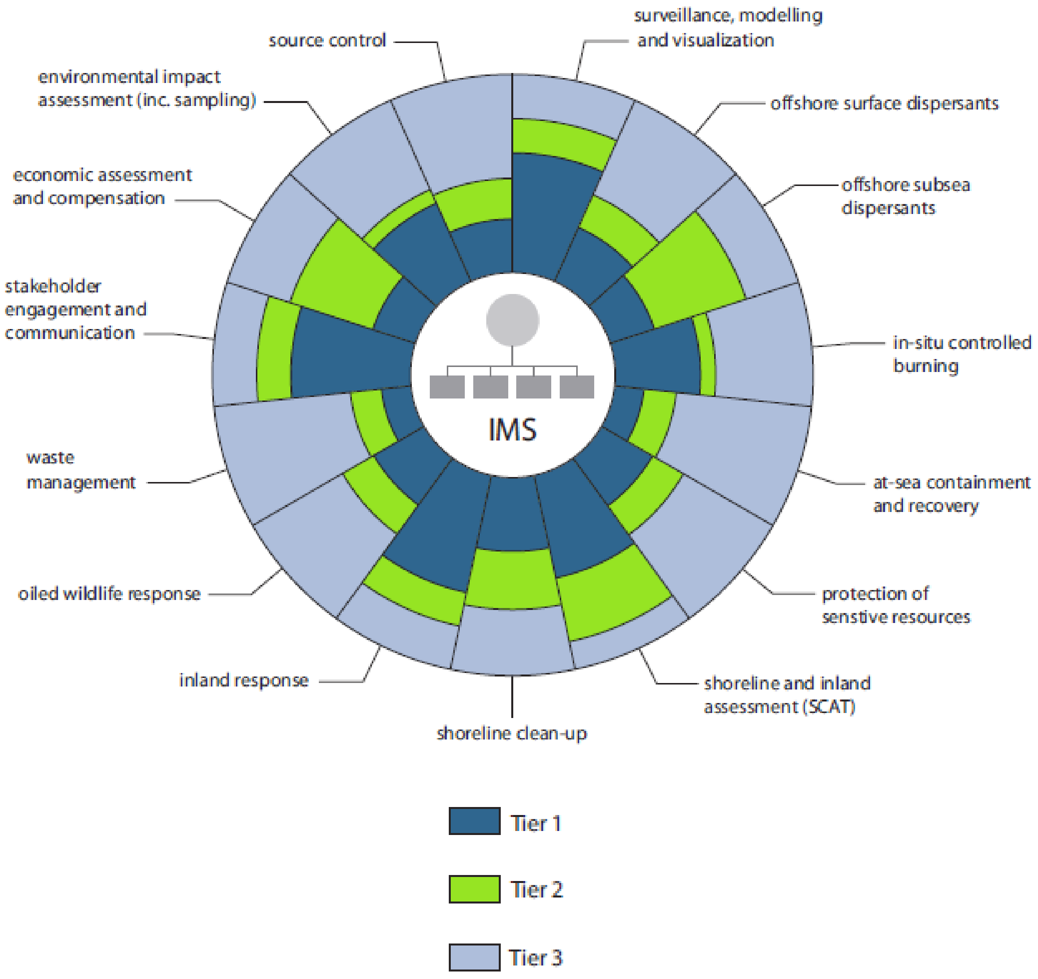
- Severity of spill determined by:
  - Modeling fate & trajectory of spilled oil
  - Comparing exposure to environmental sensitives

- Evaluating risk
  - Compare risk level to tolerance criteria
  - Account for the conditional probability (from stochastic modeling)
  - 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				

Oil spill contingency planning

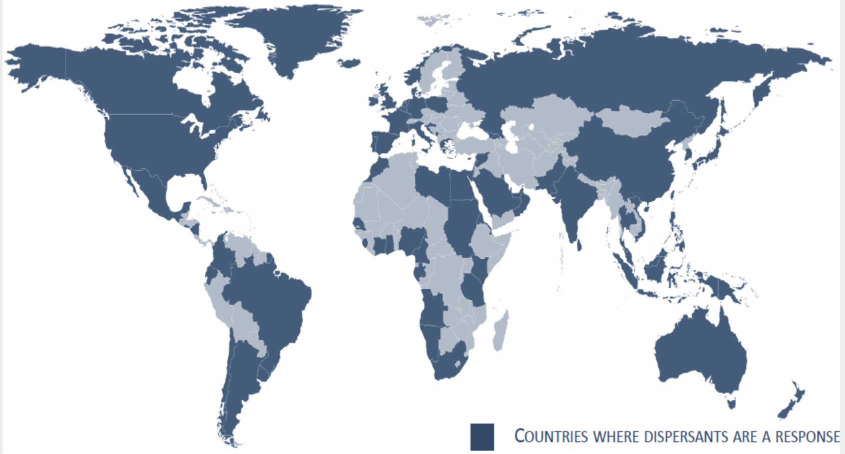


- Select release scenarios for contingency planning
- Develop response strategies based on capabilities and regulations
- Use Spill Impact Mitigation Analysis (previously NEBA) to select preferred response strategies
- Develop tactical response plans for high priority locations
- Local (Tier 1) and Regional/National (Tier 2) response resources
  - Location
  - Type
  - Amount
- Plan for cascading of Tier 2 and Tier 3 resources and sustaining long responses

Aquatic Toxicity of the Global Dispersant Stockpile pre-planning to support approval

Approval to Use GDS

- GDS is essential to subsea response preparedness
- Dispersant pre-approval varies by country
  - Slickgone NS not listed on US NCP Product Schedule
  - Corexit 9500 “transitionally accepted” by AMSA (use national stockpiles only)
- Operator must demonstrate that non-approved dispersant is low in aquatic toxicity
- Two options:
  - Conduct testing consistent with regulatory requirements
  - Use existing toxicity data



Type	Quantity (m3)*	Location
Dasic Slickgone NS	500	OSRL Base UK Southampton
	350	OSRL Base Singapore
Finasol OSR 52	500	OSRL Base UK Southampton
	350	OSRL Base Singapore
	1500	France
	800	OSRL Base South Africa
Corexit EC9500A	500	Florida USA
	500	Brazil

*Quantities at each location are provisional figures only and may be subject to change

Aquatic Toxicity of the Global Dispersant Stockpile pre-planning to support approval

Study Objective

Compare the aquatic toxicity of dispersants in the GDS to support approval for use in response plan

Methods

- Generate species sensitivity distributions* using existing data (LC/EC50s)
- Data for marine crustaceans, fish, mollusks, cnidarians, and algae
- Compared distributions and calculate 5th percentile concentrations (HC5) of species potentially affected

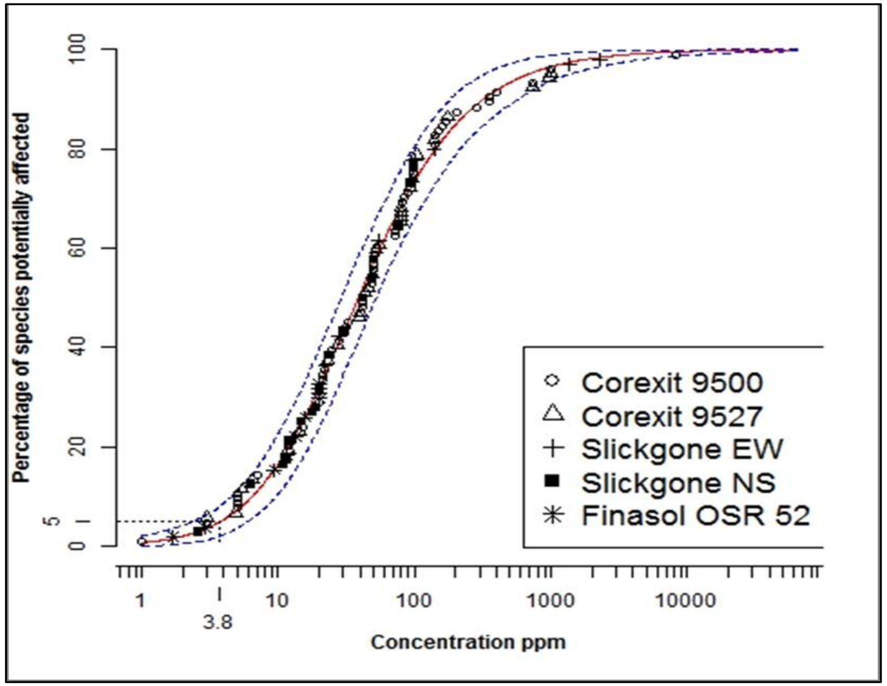
Conclusion

GDS dispersants have similar across a range of taxonomic groups

– Overlapping SSDs

– HC5s within a factor of 2

*Based on Burr Type III (Burrlioz 2.0, v.1.1, CSIRO) distribution if data included eight or more taxonomic species



Dispersant	HC5 (ppm)	95% CI
Corexit 9500	3.4	1.3 – 7.8
Finasol OSR 52	3.0	0.33 – 11
Slickgone NS	4.0	0.99 – 11
Slickgone EW	6.3	3.2 – 39
Corexit 9527	4.8	2.1 – 14