Response Strategies: Dispersant Issues and Realities

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Spill Response Options
The Toolbox

Monitor & Evaluate **Mechanical Recovery** **In-Situ Burning**

Dispersants

Aerial **Vessel** **Subsea**

The goal is to design a response strategy based on Net Environmental Benefit Analysis (NEBA)/Spill Impact Mitigation Assessment (SIMA)

Optimum Response Strategy

- **Use appropriate combination of response tools to minimize impacts**
  - If possible, deploy mechanical in thick oil to maximize recovery
  - Consider dispersant use early in a response
  - Responder and public safety is critical
- **Environmental protection priorities**
  - Minimize wildlife exposure
  - Minimize habitat contamination
  - Minimize oil stranding on sensitive shorelines
- **Human resource protection priorities**
  - Tourist beaches
  - Marinas, commercial activities
  - Shoreline property values

NEBA

- **A risk comparison process to improve decision-making**
- **A planning and response tool**
  - Rank response options by least negative environmental consequences and effectiveness in treating/removing spilled oil
  - Speed the selection of response options for various locations, weather conditions and spill circumstances
- **Can be an intensive and detailed process to arrive at a consensus with respect to the response decision**
  - Have the necessary discussions in advance of a spill

NEBA is being to changed to SIMA: Spill Impact Mitigation Assessment to reflect broader socioeconomic considerations.

Primary Goal of Oil Spill Response

Maximize Encounter Rates and Effectiveness…

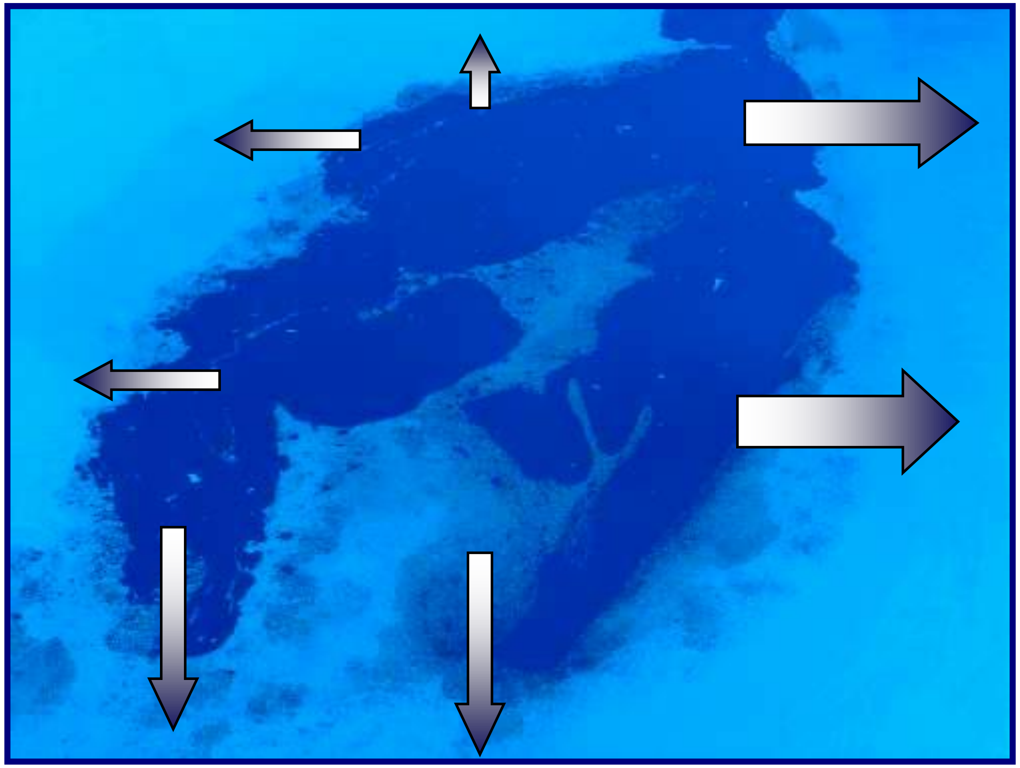
…to Minimize Impact

Rapid Response is Key

Slick Continuously Expands as Oil Thins

Direction of Wind/Currents

The size of the problem increases with time

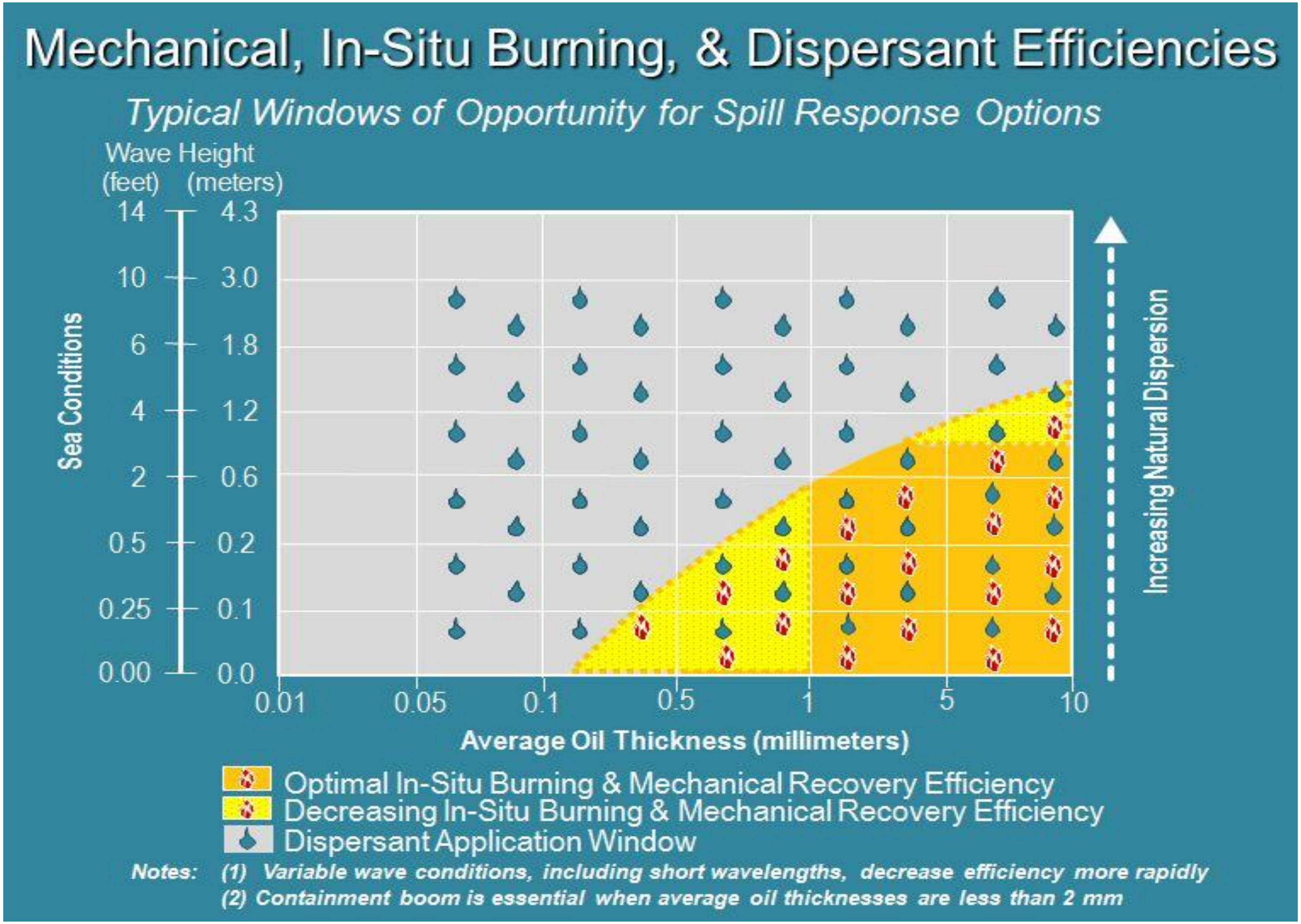


Response is less efficient with time

Challenges to Oil Spill Response

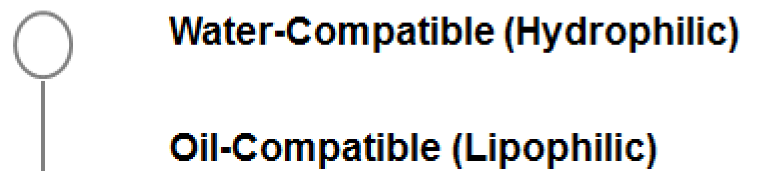
- Weather
  - Recovery Impossible In Rough Seas (>2 M) or High Winds (>25 kts)
  - Safety concerns In high seas and inclement weather
- Thousands of different oils with a wide range of properties
  - Weathering Effect
- Remote locations may not have immediate logistical support
- Wide Range of Impacted Habitats
  - Rock Beaches to Sensitive Marshes
- May have limited access to impacted areas

Spill Conditions May Limit Response Options



Dispersants – What are they?

- Dispersants are solutions of surfactants dissolved in a solvent
- Surfactants reduce oil-water interfacial tension – allows slicks to disperse into very small droplets with minimal wave energy

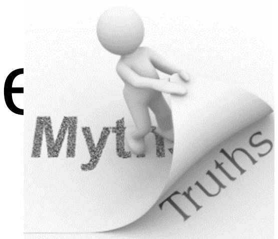


- Dispersed oil rapidly dilutes to concentrations <10 ppm within minutes, <1 ppm within hours, ppb range within a day

Common Misunderstandings…

"Dispersants are used to simply hide the oil from sight"

- This is not the intention, it is an inevitable result of successful dispersant application
- Successful dispersant application remove oil from sea surface into the water column
- Enhance the natural biodegradation process



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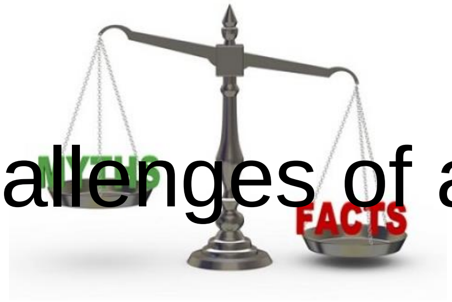
- Successful dispersant application remove oil from sea surface into the water column

FACT : Dispersants reduce the potential impact on sensitive coastlines by moving the oil into water column where it is diluted by wave and current actions and biodegraded by naturally occurring bacteria.

- Enhance the natural biodegradation process

"Dispersant use is just a cheap alternative to other proper response techniques"

- There is a common misunderstanding that containment & recovery is the best response option
- C&R also has its limitations
- Slow process, low efficiency rate, logistical and weather constraints
- May not be able to meet the challenges of a large offshore spill



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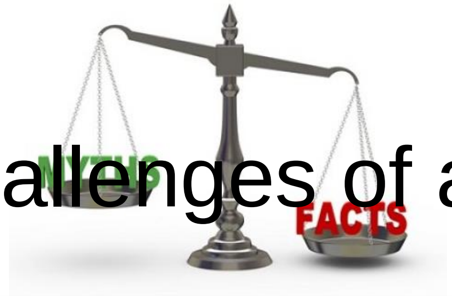


FACT : Dispersants are an effective response tool in many cases compared to other response techniques. With proper NEBA considerations, dispersants often provides the best option to reduce the overall environmental impact

"Using dispersants is adding a toxic chemical to an already polluted sea"

- Dispersants increase the amount of oil entering the water column

- They do not make oil more toxic to marine species

- Modern dispersants are formulated to avoid problems encountered during Torrey Canyon

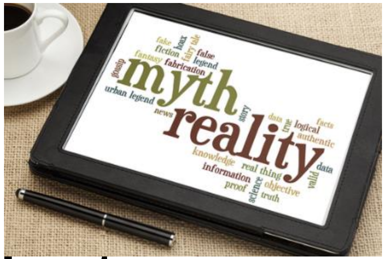
"Using dispersants is adding a toxic chemical to an already polluted sea"

- Dispersants increase the amount of oil entering the water column
- They do not make oil more toxic to marine species

- Canyon

FACT: Modern dispersants are formulated to have low toxicity and high biodegradability. Dispersants does not increase the toxicity of the oil.

"Dispersant Use sinks oil into the seabed"



- Based on the common assumption that anything introduced to water will either float or sink
- Small droplets formed by dispersant application remain suspended in the water column
- These suspended oil droplets are biodegraded by oil eating microbes

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FACT: Successful dispersant application break oil slicks into small droplets tens of microns in diameter that remain suspended in the water column. These oil droplets are biodegraded by naturally occurring microbes.

"We don't have enough information. Dispersant use is just a big experiment"

- National Research Council (2005) publication was quoted without proper understanding of the report context
- Effect of dispersant use were extensively studied following the Sea Empress Spill (UK, 1996)
- Effects of naturally dispersed oil were studied after the Braer incident in the UK in 1993

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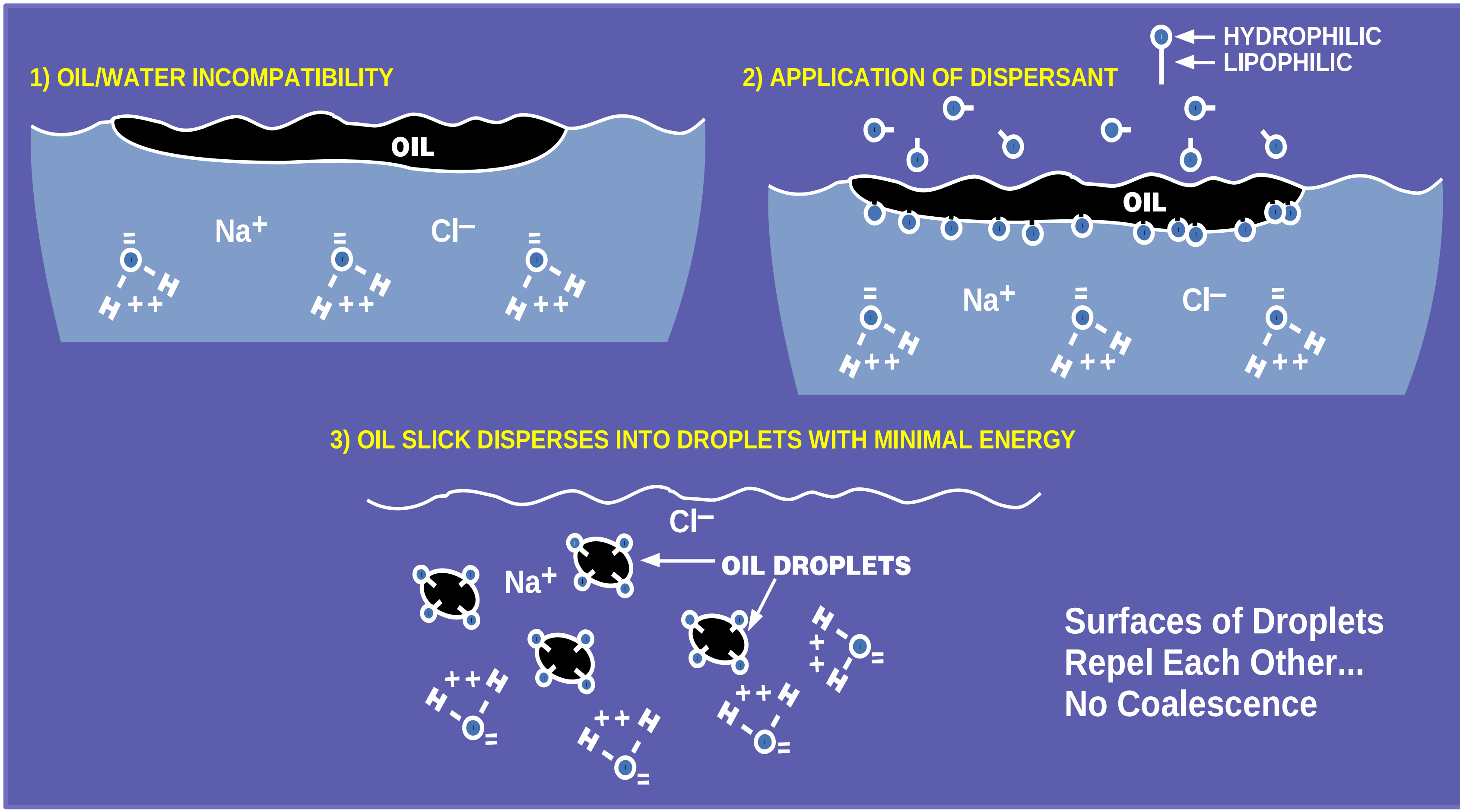
FACT: While there are uncertainties surrounding the environmental fate and effects of dispersed oil in some habitats, environmental monitoring during and after the spill events in many parts of the world as wells as extensive field and laboratory studies have enabled scientists to anticipate the likely impacts of dispersed oil. Credible NEBA efforts have consistently provided a reliable basis for determining when dispersant use is appropriate.

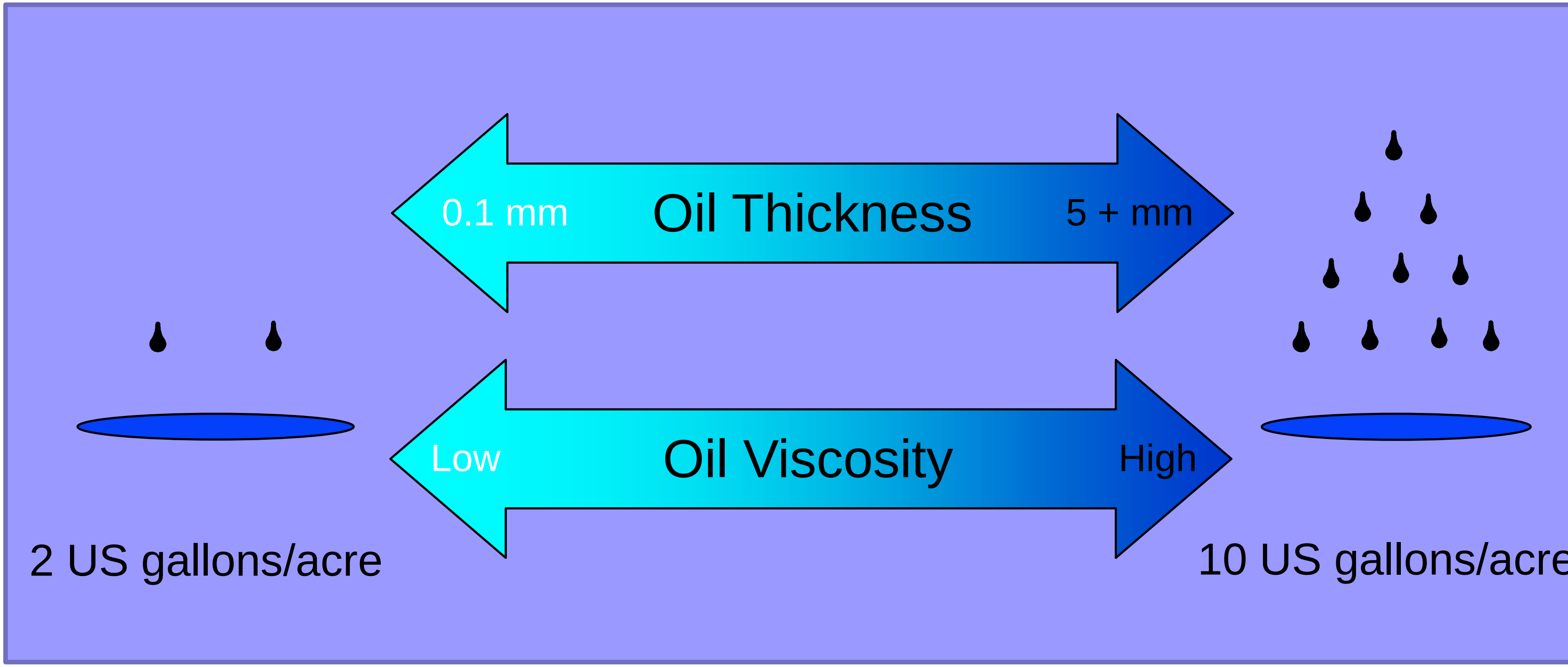
How Dispersants Work

The Goal: Rapidly Reduce Oil Concentration to Below Impact Levels Rapidly



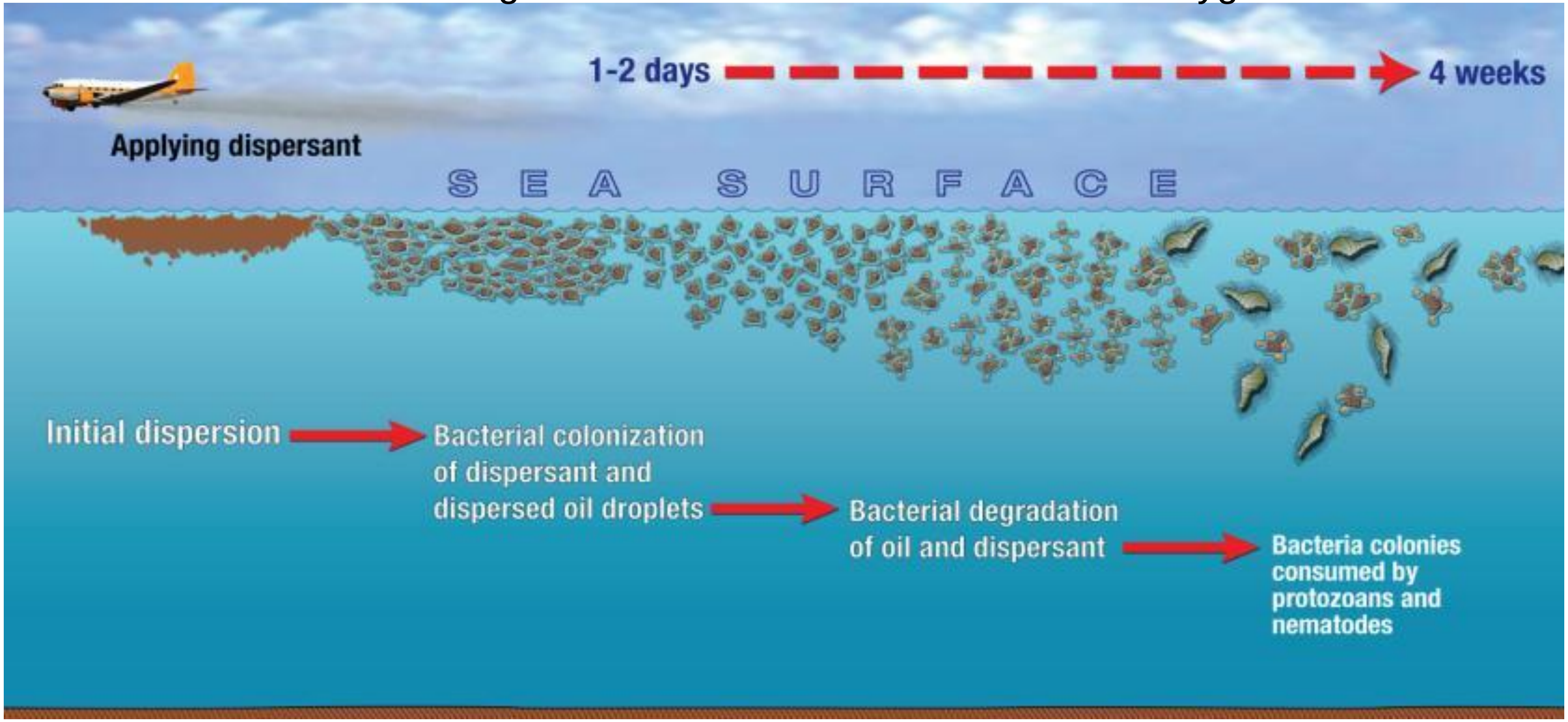
Dispersant Dosages

Typically 5 gallons per acre



Dispersants – What do they do?

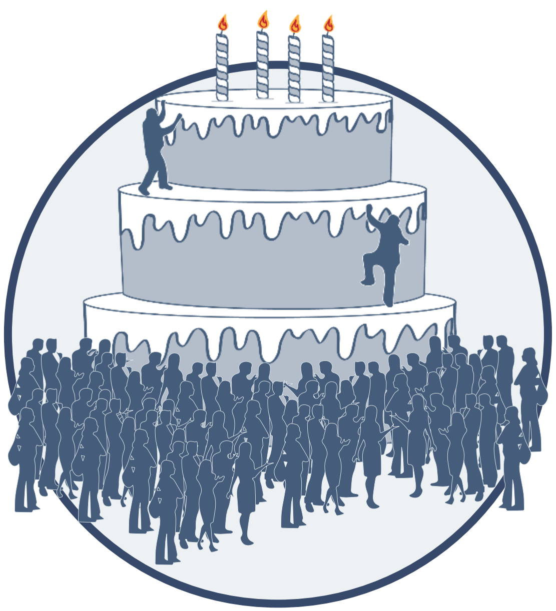
- Dispersants Enhance Removal of Oil from the Environment Through Biodegradation
  - Each dispersed oil droplet is a concentrated food source that is rapidly colonized and degraded by marine bacteria
  - Dilution allows biodegradation to occur without nutrient or oxygen limits



Graphic consistent with Venosa & Holder, EPA 2007

Dispersants Break Down Oil in the Environment

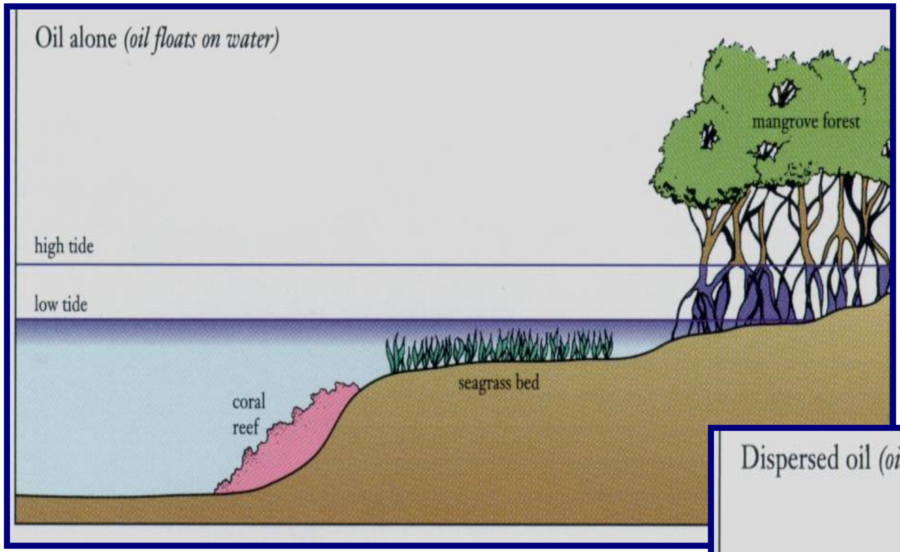
"Dispersants don't remove oil from the sea, but they are designed to help nature do so…Imagine a cake the size of a house, and a hundred thousand people trying to wolf it down at once; then imagine that cake cut into slices and passed around to the same crowd."
-The New Yorker, March 2011



Versus

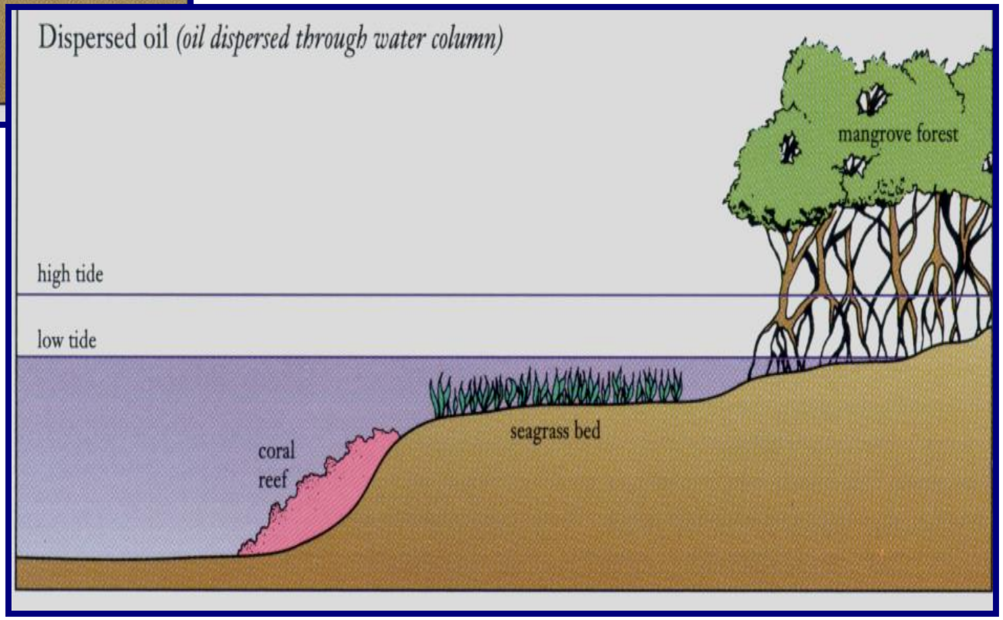
Dispersants work in a similar fashion to the cake analogy above: oil is broken into tiny droplets that are more easily consumed by microorganisms.

Dispersants – NEBA perspective



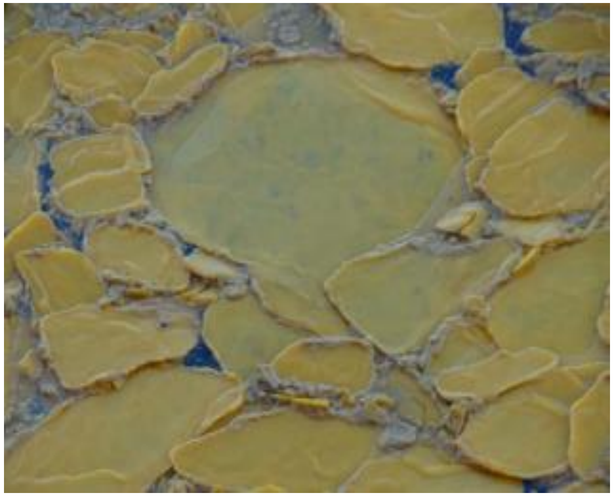
Without Dispersant: Limit Water Column Organism Exposure

With Dispersant: Limit Surface Organism Exposure



Factors Influencing Effectiveness

- **Oil Type/Properties**
  - Viscosity
  - API Gravity
  - Wax Content/Pour Point
  - Emulsifiers



- **Environmental Conditions**
  - Water Temperature
  - Sea State (Mixing Energy)
  - Extent of Weathering (How Long on the Sea)
  - Water Salinity

Environmental Impacts

- Toxicity of oil > toxicity of the dispersant
- Modern dispersants use ingredients found in household products
  - NALCO website*
  - Centers for Disease Control assessment supports low health risk
  - NOAA & FDA test results for dispersants in Gulf seafood, "There is no question Gulf seafood coming to market is safe from oil or dispersant residue."

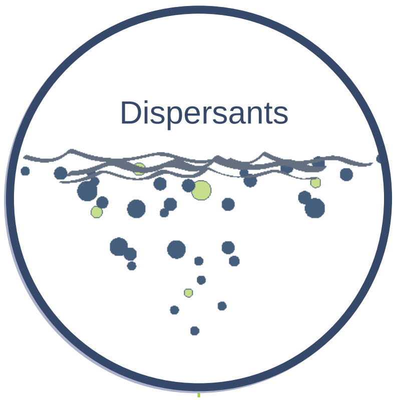
(*http://www.noaanews.noaa.gov/stories2010/20101029_seafood.html*)

Other Uses of Corexit® 9500 Ingredients (from Nalco website)

Corexit® 9500 Ingredients	Common Day-to-Day Use Examples
Span™ 80 (surfactant)	Skin cream, body shampoo, emulsifier in juice
Tween® 80 (surfactant)	Baby bath, mouth wash, face lotion, emulsifier in food
Tween® 85 (surfactant)	Body/Face lotion, tanning lotions
Aerosol® OT (surfactant)	Wetting agent in cosmetic products, gelatin, beverages
Glycol butyl ether (solvent)	Household cleaning products
Isopar™ M (solvent)	Air freshener, cleaner

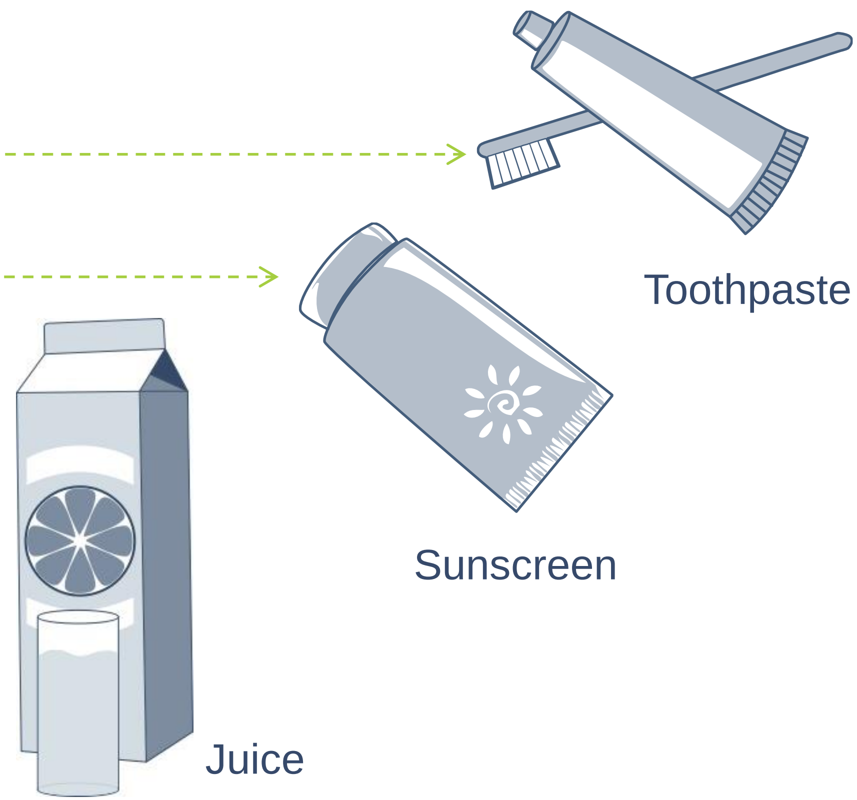
***http://www.nalco.com/applications/corexit-technology.htm**

Understanding the Composition of Dispersants



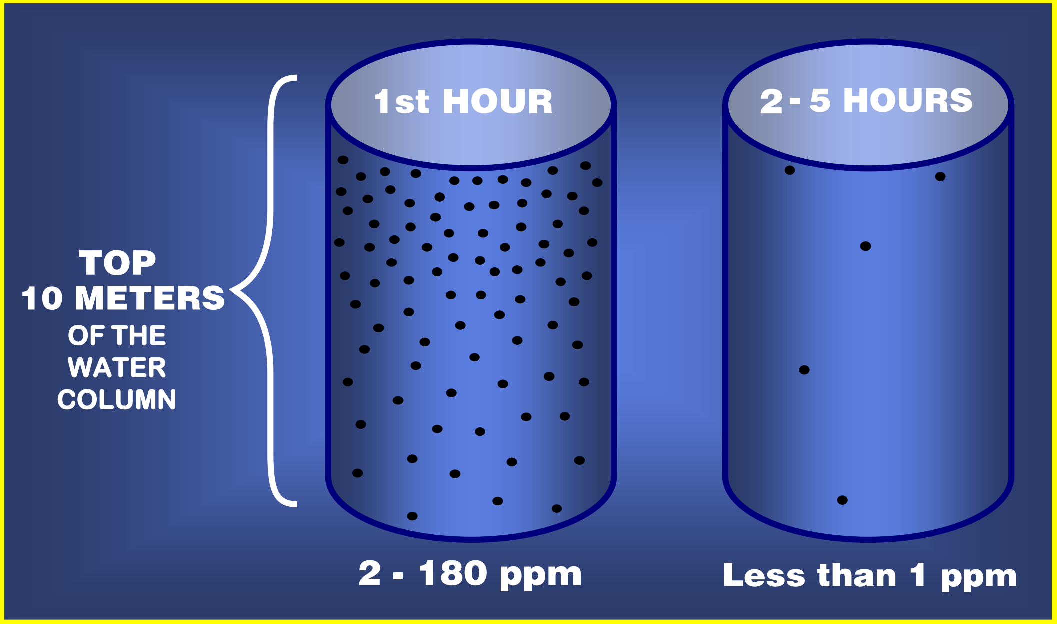
Dispersants work just like soaps and shampoos. They clean up spills by breaking oil slicks into tiny droplets – smaller than the diameter of a human hair. Dispersants are designed to work in the marine environment and prevent oil from re-coalescing.

The same ingredients in dispersants are also found in:



Environmental Impacts

- Toxicity
  - Rapid dilution limits ecosystem impacts of both dispersant and dispersed oil
  - Concentrations start low and rapidly dilute (National Academy of Sciences, 1989)



Lessard, R.R. and DeMarco, G. (2000) The significance of oil spill dispersants. *Spill Science & Technology Bulletin, 6*, 59-68

  - Lab toxicity tests expose organisms to constant concentrations for multiple days
  - Organisms only see elevated concentrations for a few hours during a real spill
  - Dispersants are only applied in areas with high potential for dilution

Relative Toxicity

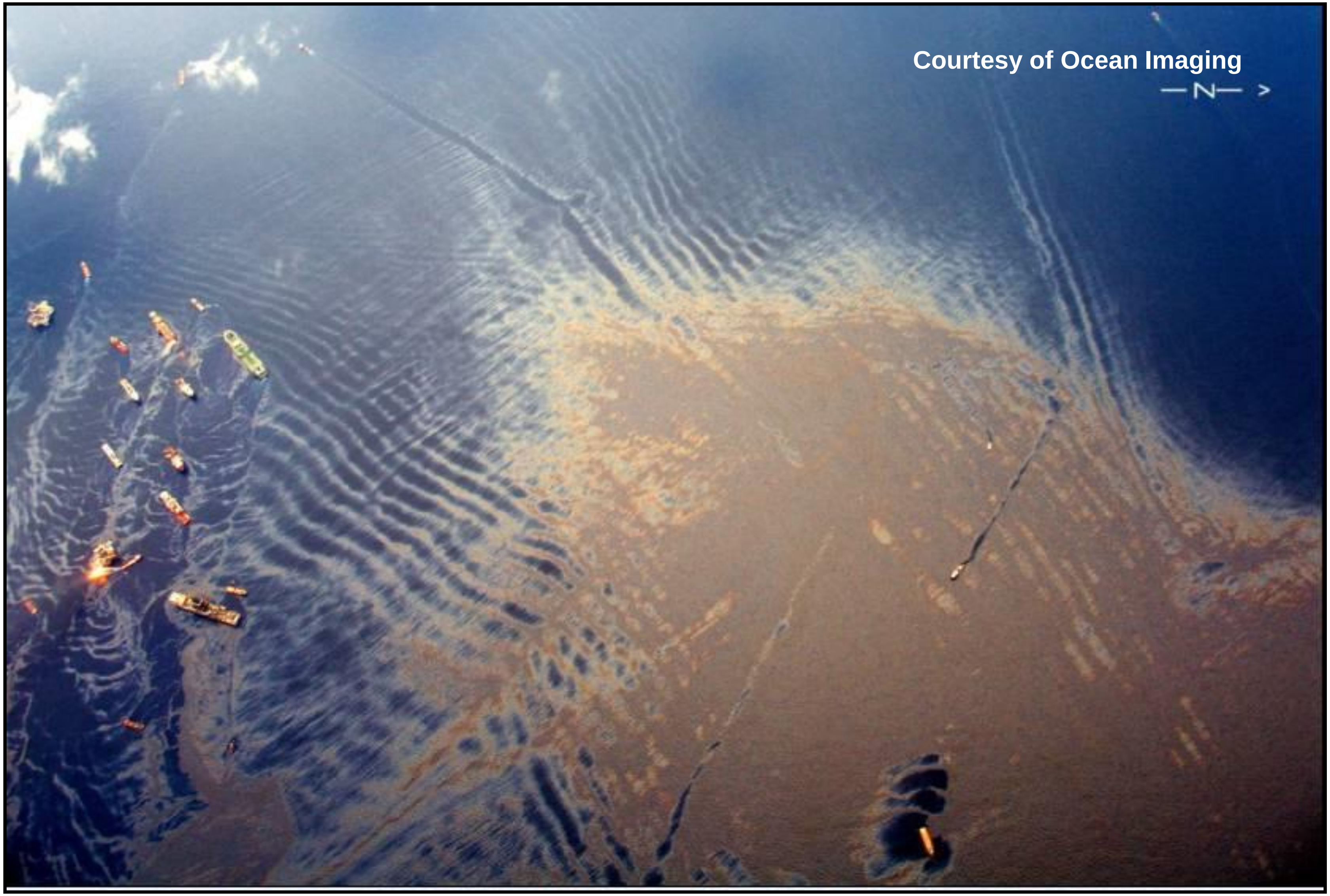
Environment Canada Study

Product	Toxicity (ppm)
Palmolive Dish Soap	13
Sunlight Dish Soap	13
Mr. Clean	30
Corexit 9527	108
Corexit 9500	350

(96 HR Rainbow Trout LC50)

Less toxic

Encounter Rate is Key to Offshore Response



Vessel Application

- Small spills near land
- Slow transit times
- Low coverage rate
- Low cost, easily procured
- Flat, uniform spray
- Mixing action enhanced by vessel wake
- Fire monitors deliver wider swaths faster but less uniformly

Small Fixed-Wing Aircraft

- Single engine planes modified for temporary use or converted from pest control spraying
- Higher capacity pumps, meters, aft spraying nozzles
- Agricultural sprayers may produce too fine a droplet
- Payload often < 100 gal (380 L)
- Newer aircraft carry 400 - 600 gal (1,500 - 2,300 L)
- Can be used for spotting

Medium Size Twin-Engine Aircraft

- Vary in size: piper Aztec to Canadair CL-215
- Converted for dispersant spraying
- Carry 800 - 1,200 gal (3,000 - 4,500 L)
- Have greater range than small aircraft
- Can operate safely on offshore spills
- Can be used for spotting

Large Multi-Engine Transport Aircraft

- Longer range aircraft
- Carry 1,500 - 3,000 gal (5,700 - 11,000 gal)
- C-130 Hercules may use an Aerial Dispersant Delivery System (ADDS)

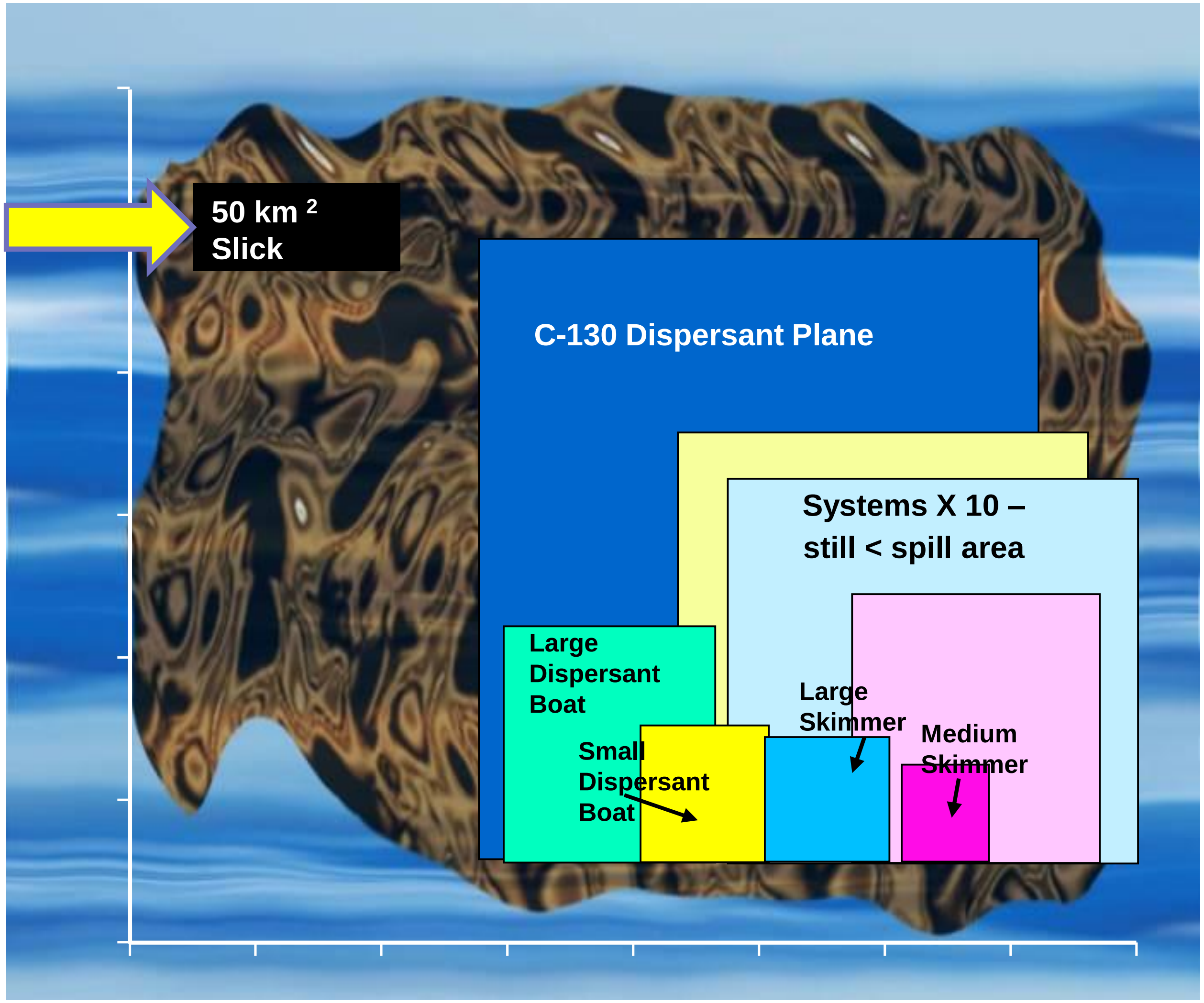
Large Multi-Engine Transport Aircraft

Safe Seas demonstration off coast of San Francisco, 2006

- Key tool in long range response
  - Fast with large payload

Dispersant Application Platform Comparison

- **5,000 MT spill (37K bbl)**
- **Slick 0.1 mm thick**
- **100 MT/km²**
- **8 hrs of operation**
- **Continuous encounter with slick**



For reference:

9300 American Football fields
6500 Football (soccer) fields
2900 Australian rules Football fields

Jet Platform

The Issue: The Hercules

- The world fleet is small and diminishing
- To date, no replacement for the civilian Lockheed Hercules L-100 aircraft is either available or planned
- Replacement or development cost is high

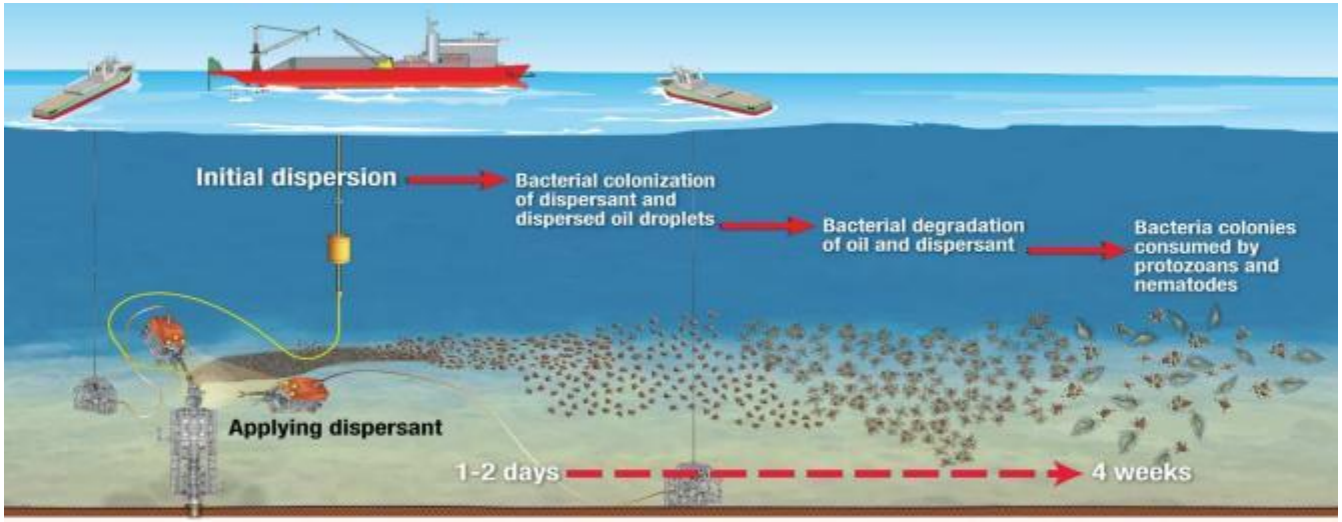
Key criteria for 727:

- Readily available
- High transit speed: 478 nautical mph (885 kph)
- Payload: 55,000 lb (25,000 kg)
- Range (with full payload): 2,140 nm (3,960 km)
- Three-engine operation, providing the following advantages:
  - High power-to-weight ratio
  - Improved long-range operations over water
  - High reliability
- High T-tail avoids disruption of spray by turbulence associated with control surfaces
- Strong structure around spray arm attachment

Certified for Use 2016

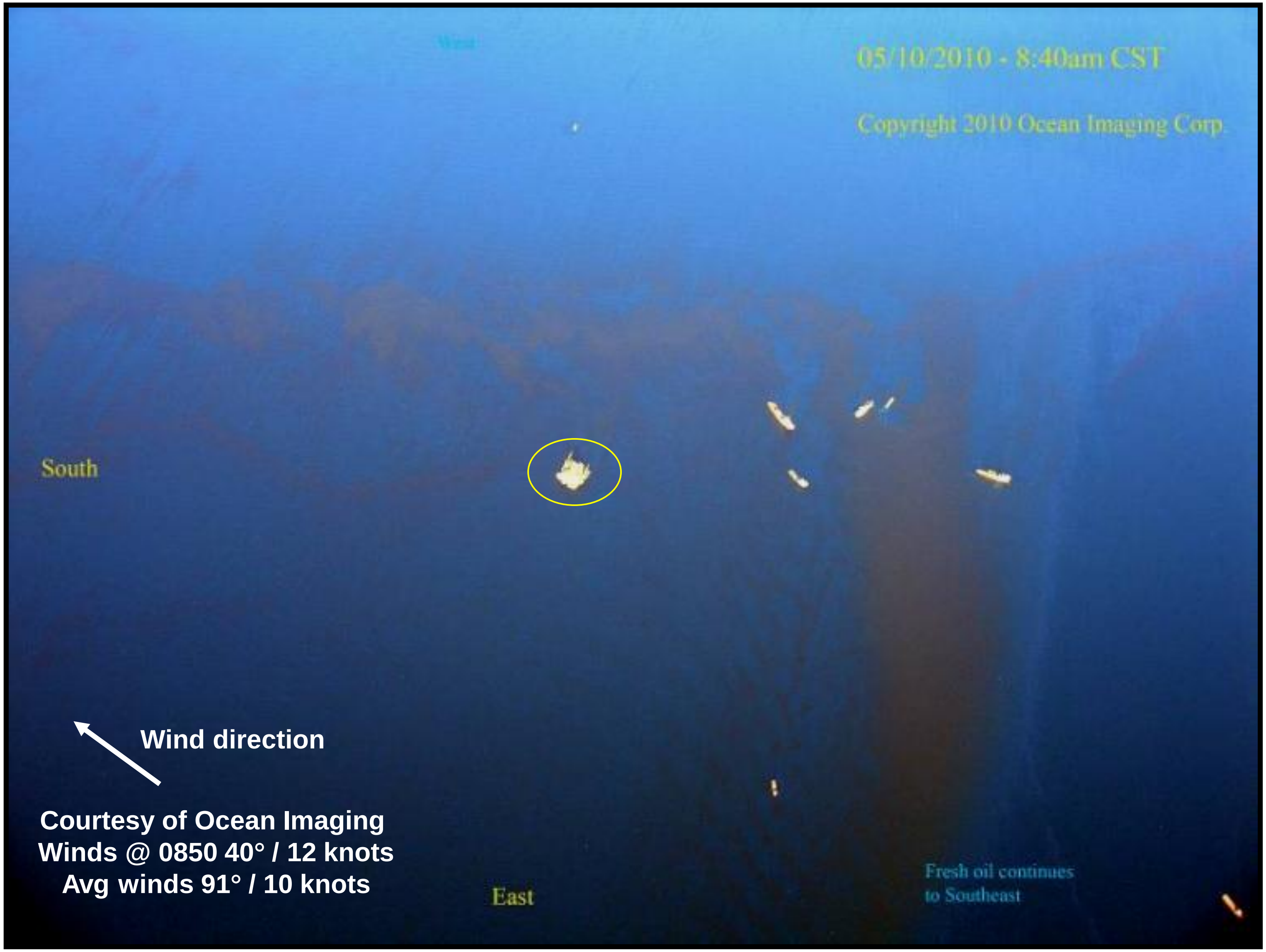
Subsea Injection of Dispersants

- Preliminary observations of DWH experience
- Benefits of subsea injection
- Long-term fate and effects



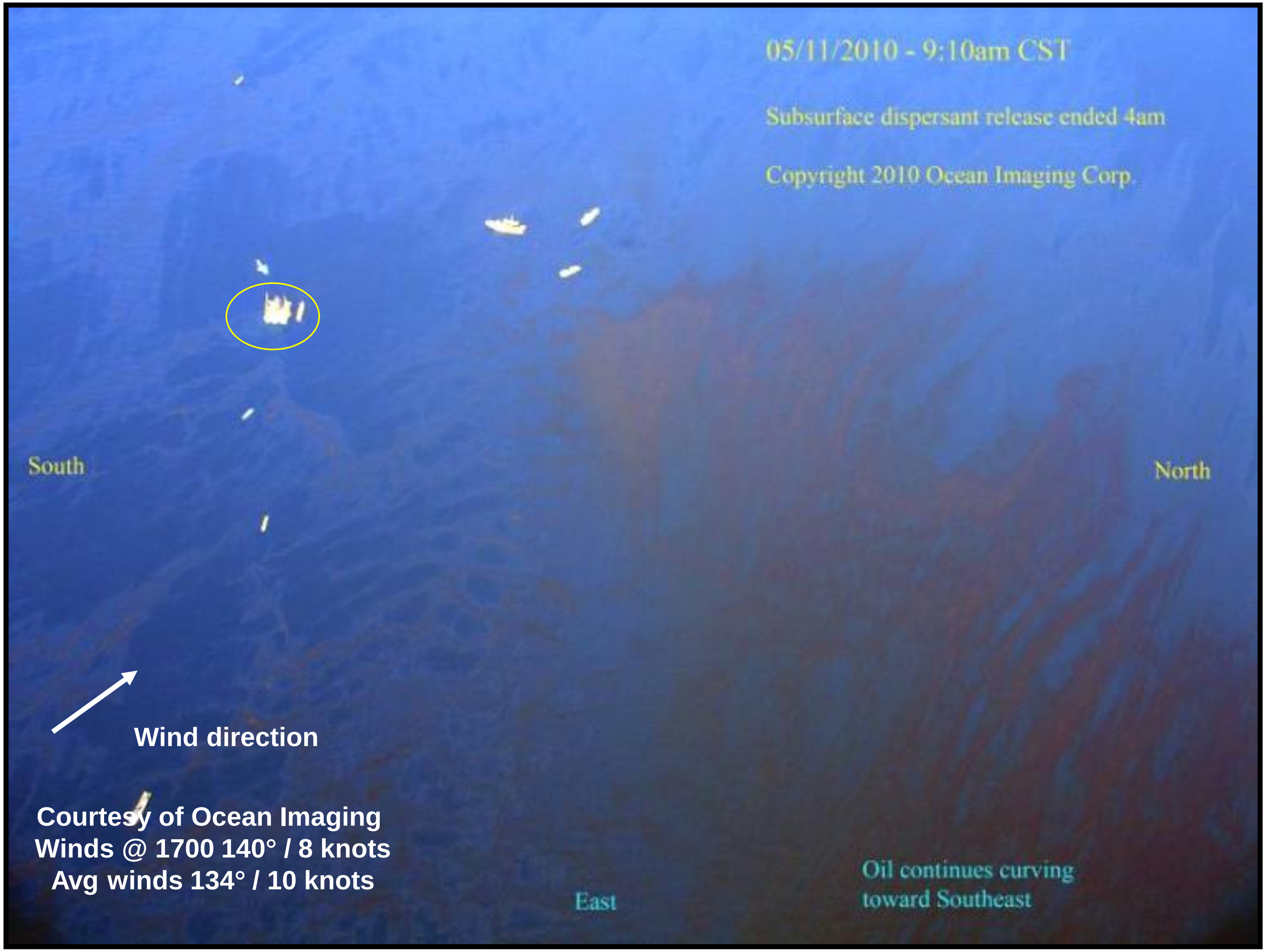
Release Site May 9: Prior to Injection

Release Site May 10: 3 hrs of Injection

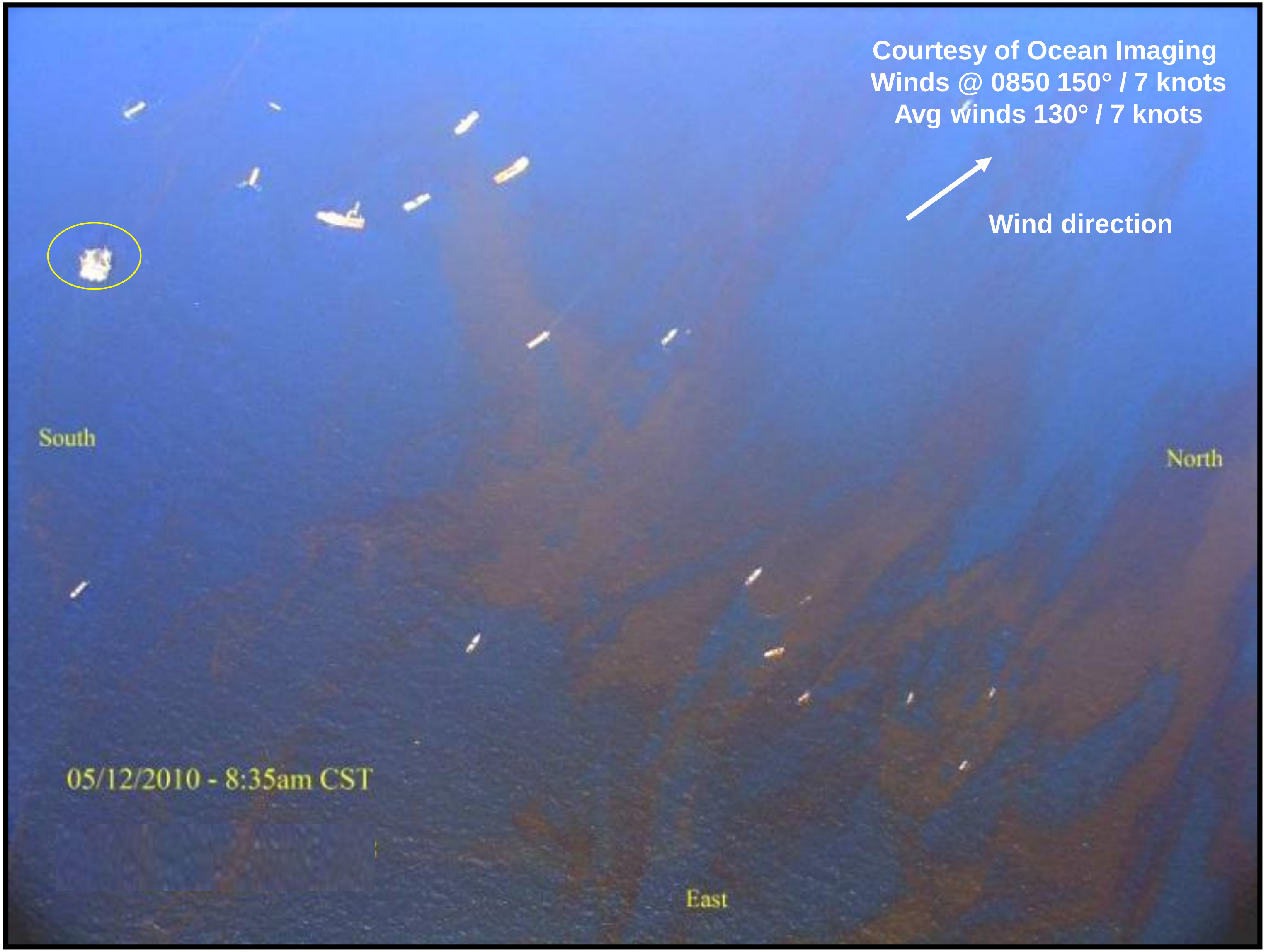


Release Site May 10: 11 hrs of Injection

Release Site May 11: 5 hrs after Injection Ended



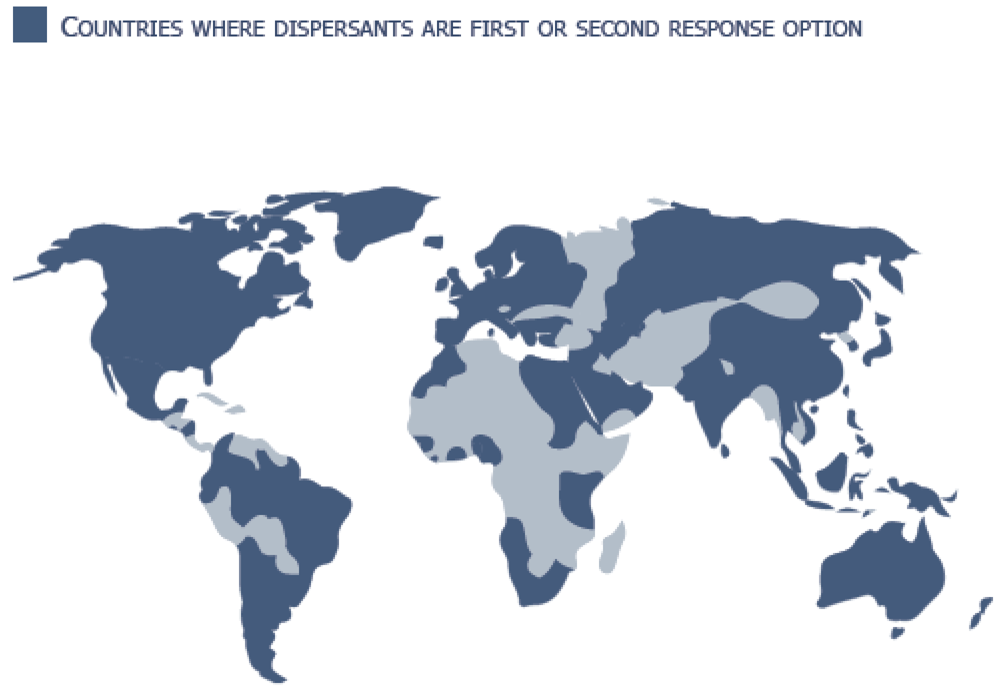
Release Site May 12: 28 hrs After Injection Ended



Dispersant Use Across the Globe

- Dispersants are a first or second response option in many countries today

- Angola
- Argentina
- Australia
- Belgium
- Brazil
- Brunei
- Cameroon
- Canada
- Chile
- China
- Columbia
- Côte d'Ivoire
- Croatia
- Cyprus
- Denmark
- Djibouti
- Ecuador
- Egypt
- El Salvador
- Eritrea
- France
- French Guiana
- Gabon
- Georgia
- Germany
- Ghana
- Greece
- Greenland
- Iceland
- India
- Indonesia
- Ireland
- Israel
- Italy
- Japan
- Kenya
- Kuwait
- Lebanon
- Libya
- Malaysia
- Malta
- Mexico
- Montenegro
- Morocco
- Namibia
- Nicaragua
- Netherlands
- New Zealand
- Nigeria
- Norway
- Oman
- Pakistan
- Papua New Guinea
- Philippines
- Poland
- Portugal
- Qatar
- Russia
- Saudi Arabia
- Senegal
- Sierra Leone
- Singapore
- South Africa
- South Korea
- Spain
- Sri Lanka
- Sudan
- Syria
- Tanzania
- Thailand
- UAE
- UK
- Uruguay
- US
- Vietnam



Many countries consider dispersants an important tool in oil spill response. However, there is global inconsistency in the types of approved dispersants and how and when to use them.

Source: International Tanker Owners Pollution Federation (ITOPF)

energy API Used with permission of the API

Summary

- **Along with prevention, robust oil spill response (OSR) is critical**
- **Highest priority in emergency response is human health and safety**
- **Basic strategy for addressing oil spilled from an offshore well**
  - Respond as close to the source as possible
  - Utilize all appropriate tools to keep oil from reaching shorelines
- **Dispersant use presents significant advantages over the limitations of mechanical recovery and should be considered as a primary response option**
- **Subsea injection is a step-change advance that may reduce spill impacts by an order of magnitude**
- **More research would enhance the optimization of subsea injection and allow better understanding of the long term effects of dispersed oil in deep waters**

Spill Impact Mitigation Assessment for Dispersant Use

Overview

- SIMA
- SIMA in 4 Stages
- Response Strategy Development using SIMA
- SIMA for Subsea Dispersant Injection

Net Environmental Benefit Analysis **(NEBA)**
to
Spill Impact Mitigation Assessment **(SIMA)**?

- Better reflects the process, its objectives, and the suite of shared values which shape the decision-making framework, including ecological, socio-economic and cultural aspects
- More accurately describes this long-standing practice and its objectives

Principles of SIMA

- International publication aligned with the Good Practice Guidelines
- Integrating ecological, socio-economic and cultural considerations
- Promoting the full response ‘toolkit’
- A qualitative methodology to assess response options’ relative mitigation, not measuring spill damage
- Primarily applicable to larger or higher consequence oil spill incidents
- Can be used during either planning or incident response

Spill Impact Mitigation Assessment (SIMA)

"Structured approach used by the response community and stakeholders during oil spill preparedness planning and response, to compare the environmental benefits of potential response tools, and develop a response strategy that will reduce the impact of an oil spill on the environment"

Helps decision-makers use the response tools to achieve the most beneficial outcome overall i.e. keep damage ALARP

Spill Impac
Assessm

“Structured approach used
and stakeholders during oi
and response, to compare
of potential response tools,
strategy that will reduce the
environment”

Helps decision-makers use the
beneficial outcome over

IPIECA

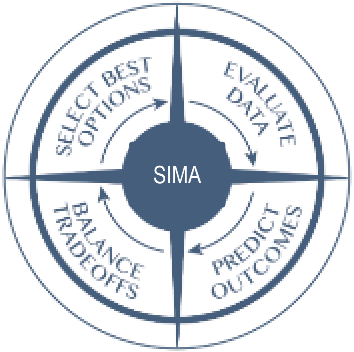
To Be Updated

Response strategy development using net environmental benefit analysis (NEBA)

Good practice guidelines for incident management and emergency response personnel

New IPIECA-IOGP
Good Practice Guidance

SIMA in 4 stages



1. **Compile and evaluate data** to identify exposure scenario and potential response options, and to understand the potential impacts of that scenario
2. **Predict outcomes** for the given scenario to determine which techniques are effective and feasible
3. **Balance trade-offs** by weighing a range of benefits and drawbacks resulting from each feasible response option
4. **Select the best options** for a given scenario, based on which combination of tools and techniques will minimize impacts

Response strategy development using SIMA

	Compile and evaluate data	Predict outcomes	Balance trade-offs	Select best option(s)
Before a spill	A wide range of data is compiled and evaluated to understand the area potentially affected, and to identify and prioritize environmental and community assets within it, based on environmental sensitivities and social values.	Planning scenarios are used to assess the potential effects on the environment. For specific locations, feasible response options are identified from the 'response toolbox'.	The advantages and disadvantages of the potential response options are evaluated and weighed against the environmental and social effects of each to understand and balance trade-offs.	Data, information and viewpoints are taken into account to select the combination of response options that will create the greatest net environmental benefit. This allows a full response strategy to be developed encompassing detailed plans, capability development and approvals.
During a spill	Based on the specifics of the spill, a range of data is evaluated to assess anticipated effects.	Response options identified in the pre-spill planning stage are reviewed against the actual spill conditions and anticipated effects, and the list of feasible response options considered.	The balancing of trade-offs carried out in the pre-spill planning stage is adjusted and confirmed against the actual conditions of the spill. Continued re-evaluation and re-balancing of trade-offs takes place to address evolving conditions.	The response strategy is developed based on the optimum response options for the conditions. The strategy is implemented and continually monitored and adjusted based on ongoing evaluations. Pre-spill planning work facilitates rapid decision making during a response, minimizing delays.

If no pre-spill planning work has been undertaken, or if analogue planning scenarios cannot be adjusted to correlate with the specifics of a spill, response strategy development using NEBA follows an expedited version of the process above. In this instance, it is possible that the data which forms the basis of the analysis may be incomplete or limited, thus necessitating a greater reliance on professional judgement to correctly balance the trade-offs and select the best options, especially given the time-pressured nature of a response.

The ongoing application of the NEBA process throughout a response allows clean-up end points to be determined and agreed to by stakeholders early and in a systematic manner. This helps to avoid unnecessary clean-up activities which could result in additional detrimental effects on the environment.

Response strategy development using SIMA

Before a spill ≈ "Strategic" SIMA

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During a spill ≈ "Operational" SIMA

	Compile and evaluate data	Predict outcomes	Balance trade-offs	Select best option(s)
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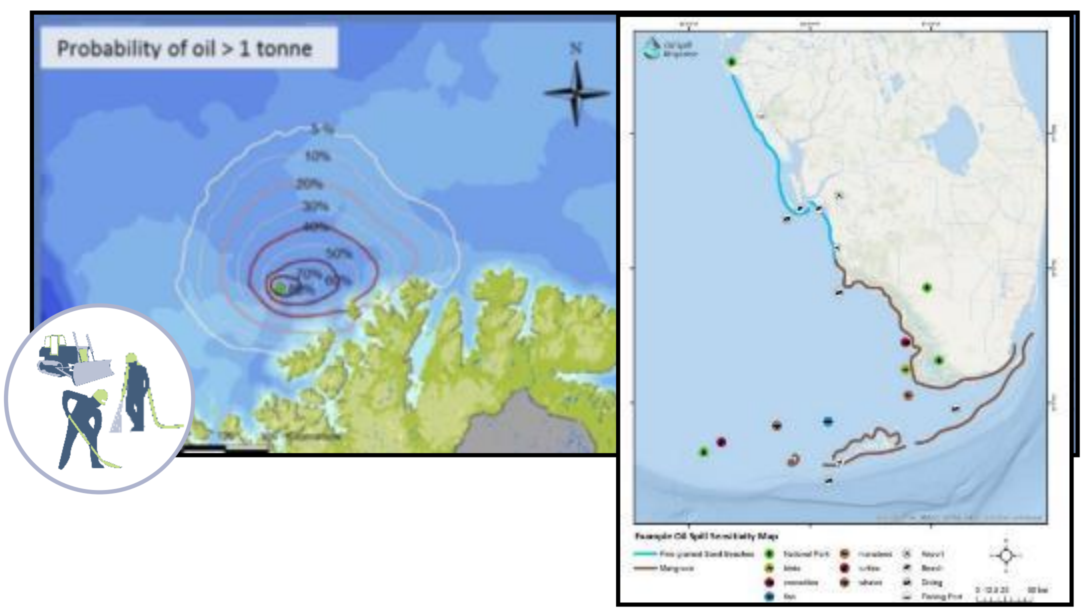
Compile and evaluate data ▶ Predict outcomes ▶ Balance trade-offs ▶ Select best option(s)

- Know your oil
- Model fate and trajectory
- Consider sensitivity data
- Identify potential response options:
  - effectiveness
  - feasibility
  - regulation



Factors Influencing Feasibility

Climate and sea state

Oil properties and weathering characteristics

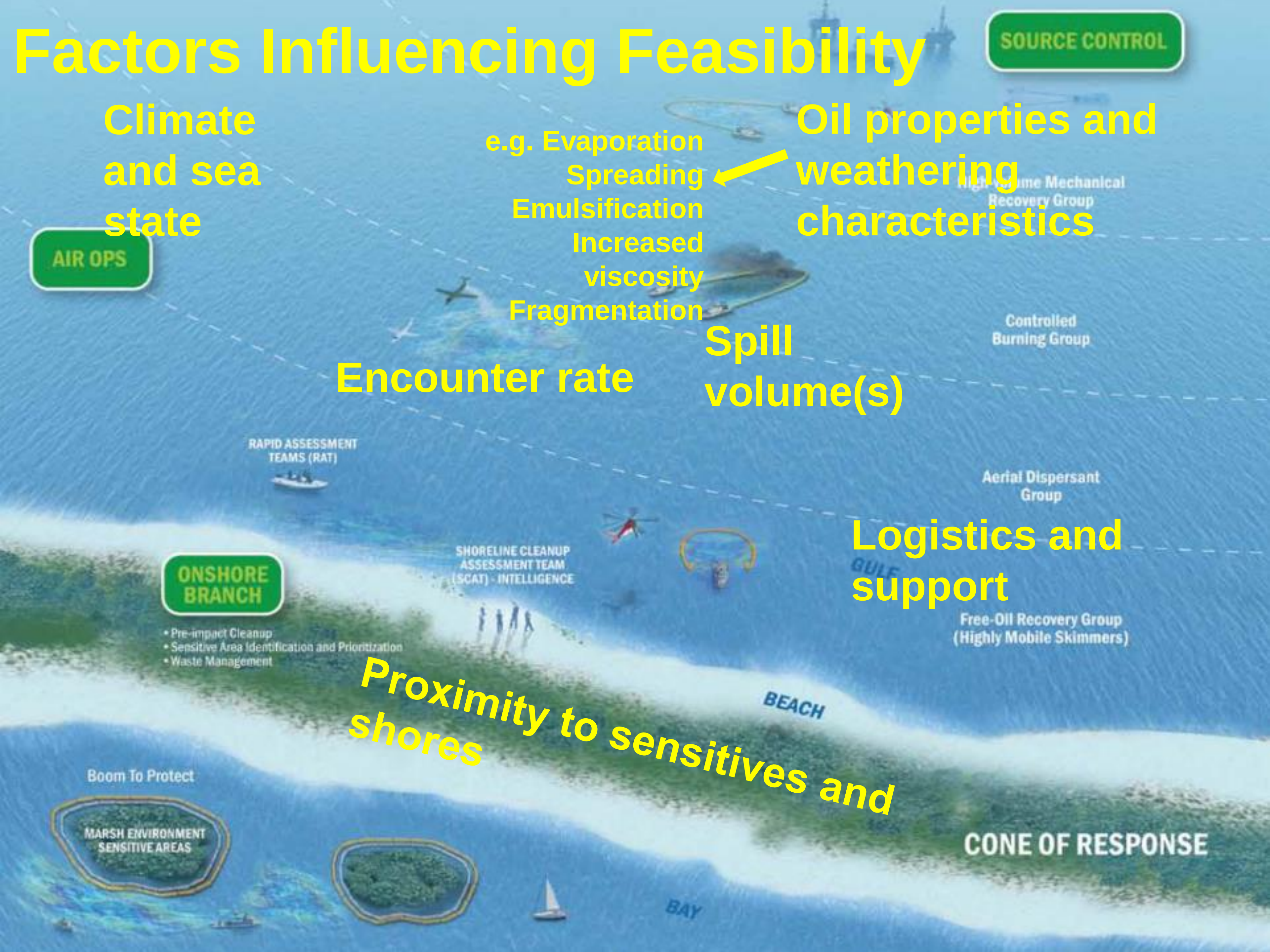
e.g. Evaporation
Spreading
Emulsification
Increased viscosity
Fragmentation

Encounter rate

Spill volume(s)

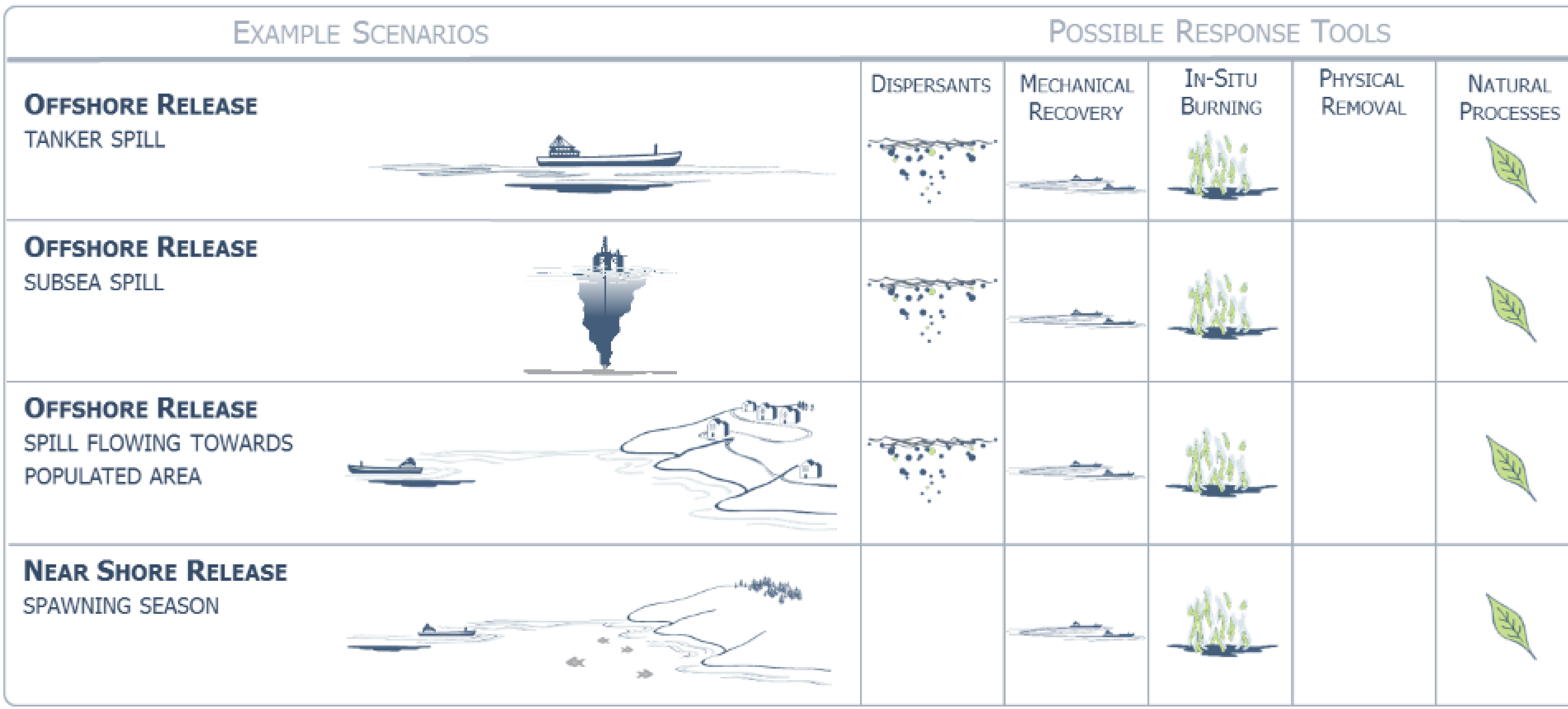
Logistics and support

Proximity to sensitives and shores



Compile and evaluate data ▶ **Predict outcomes** ▶ Balance trade-offs ▶ Select best option(s)

- For chosen scenarios, review consequences of “no response” activities
- Consider how different combinations of response options may change these impacts in order to characterize trade-offs



How to predict outcomes?

- ‘No response’ scenario covers the timescale needed for the oil to weather and naturally attenuate
- Identifies potential environmental effects at a general level
- With the number of variables involved, it is impractical to quantify potential damage to any environmental resource in the SIMA process

How to predict outcomes?

- ‘No response’ scenario covers the timescale needed for the oil to weather and naturally attenuate
- Identifies potential environmental effects at a general level
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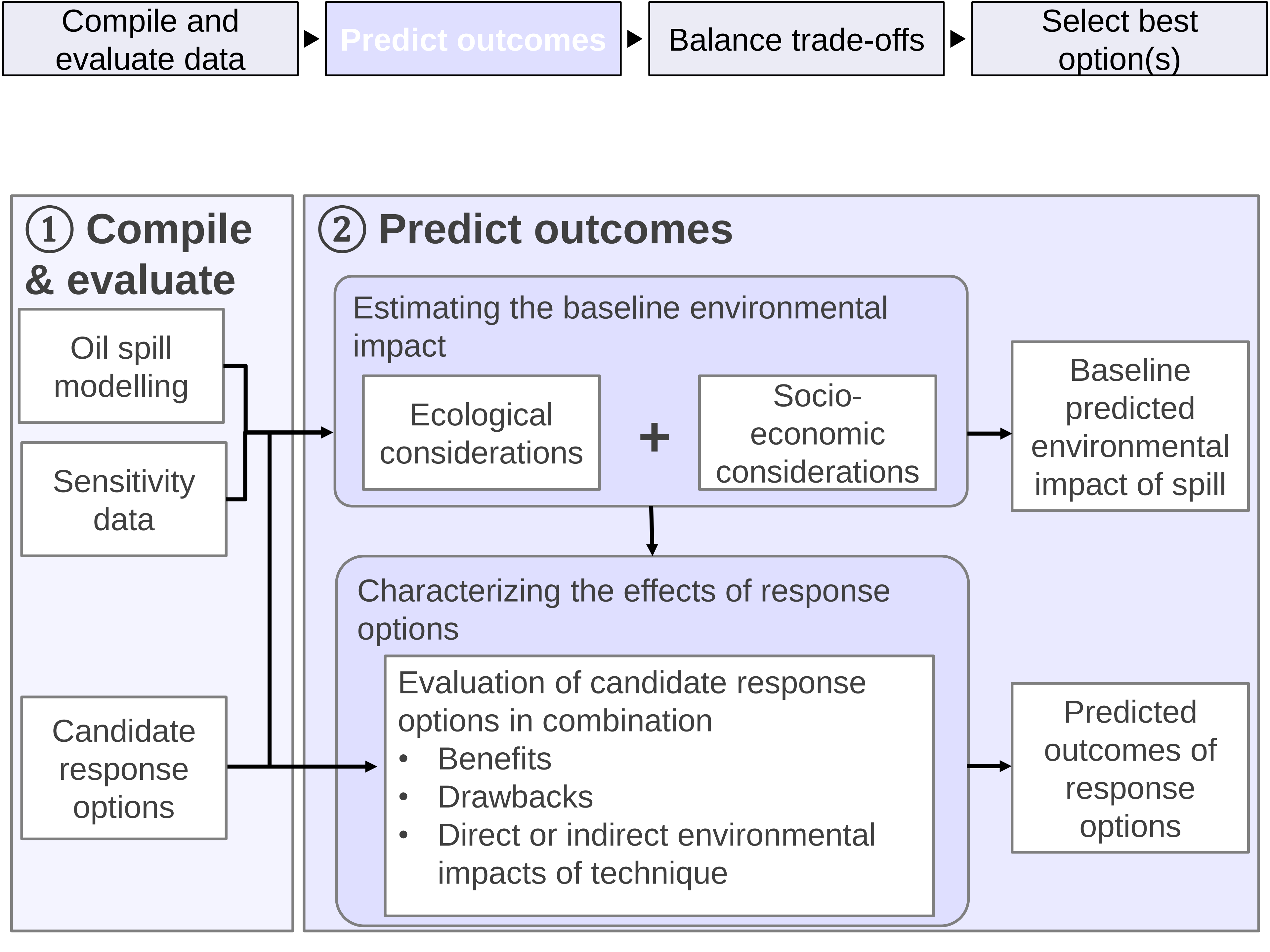
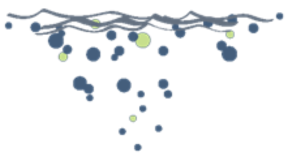
Overall, the SIMA process provides an estimate of potential environmental effects which is sufficient to allow the parties to compare and select preferred combinations of response options



Compile and evaluate data
Predict outcomes
Balance trade-offs
Select best option(s)
1 Compile & evaluate
Oil spill modelling
Sensitivity data
Candidate response options
2 Predict outcomes
Estimating the baseline environmental impact
Ecological considerations
+
Socio-economic considerations
Baseline predicted environmental impact of spill
Characterizing the effects of response options
Evaluation of candidate response options in combination
• Benefits
• Drawbacks
• Direct or indirect environmental impacts of technique
Predicted outcomes of response options

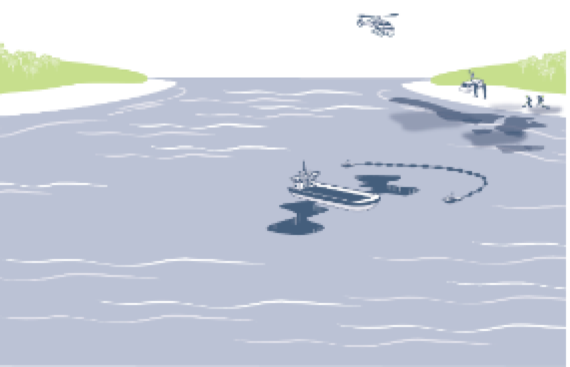
- May be differing priorities relating to perceptions of the importance of sensitive resources
- No universally accepted way to assign value or importance to different environmental and socioeconomic sensitivities
- Essentially a qualitative process
  - Seeks consensus
  - A risk-based decision making approach may allow comparison of disparate resources in order to facilitate consensus on relative values of resources

Compile and evaluate data ► Predict outcomes ► Balance trade-offs ► Select best option(s)

Response Toolbox	Benefits	Drawbacks
Dispersants  Dispersants allow small oil droplets to form which speed up natural breakdown in the water column.	• High aerial coverage rate possible at the water surface • High treatment efficiency possible subsea • Large volumes of oil can be treated • Potentially high oil elimination rate • Reduced vapors at the water surface; improves safety • No recovered oil storage requirements • Lower manpower requirements • Potentially the quickest response option • Prevents oil from spreading to shoreline • Useful in higher wind and sea conditions • Effective over wide range of oil types and conditions	• Special approvals required • Less known about long term effects of subsea use • Perceived to be unsuitable for calm seas • Short-term, localized reduction in water quality • Potential impact on water column ecology • Specialized equipment and expertise required • Usage near shore in shallow water could result in greater water column impacts • Will not work on high viscosity fuel oils in calm, cold seas • Has a limited "window of opportunity" for use
Mechanical Recovery  Mechanical recovery uses booms and skimmers to contain and remove oil from the water surface.	• Well-accepted, no special approvals needed • Effective for recovery over wide range of spilled products • Large "window of opportunity" • Minimal side effects • Greatest availability of equipment and expertise • Recovered product may be reprocessed	• Inefficient and impractical on thin slicks • Ineffective in inclement weather or high seas • Requires storage capability • Typically recovers no more than 10-20 percent of the oil spilled • Labor- and equipment-intensive
In-Situ Burning  In-situ burning involves igniting contained oil slicks.	• High oil elimination rate possible • No recovered oil storage requirements (except possibly for burn residue) • Effective over wide range of oil types and conditions • Specialized equipment (boom) is air transportable • Minimal environmental impact	• Special approvals required • Ineffective in inclement weather or high seas • Black smoke perceived as significant impact on people and the atmosphere • Localized reduction of air quality • Specialized equipment and expertise required • Potential for secondary fires during inland use • Burn residue can be difficult to recover
Physical Removal  Physical removal consists of the physical removal of surface oil by crews with tools and machinery.	• Non-aggressive methods can have minimal impact on shore structure and shore organisms • Useful for detailed cleaning of near shore environment in specific or sensitive areas	• Aggressive removal methods may impact shoreline and shore organisms (e.g., sand removal and cleaning) • Potential for heavy equipment and high foot traffic (trampling) can cause additional environmental damage • Removal occurs after oil has already impacted shore • Labor-intensive
Natural Processes  Natural removal allows for more effective recovery in environments where intervention would be detrimental.	• No intrusive removal or cleanup techniques that further damage the environment • Complements other response techniques • May be best option if there is little to no threat to human or environmental well-being • When selected for certain areas and conditions, the environment can recover from the spill more effectively than it might when using other response tools	• Winds and currents can change, sending the oil spill toward sensitive areas • Residual oil can impact shoreline ecology, wildlife, and economically relevant resources • Public perception that responders are doing nothing

Compile and evaluate data ▶ Predict outcomes ▶ Balance trade-offs ▶ Select best option(s)

- Target an optimum response strategy for planning scenarios and incident specific conditions
  - Before a spill, response strategies are defined for each of the planning scenarios, and response capabilities are designed and developed accordingly
  - During a spill, SIMA supports
    - the deployment and adjustment of response resources as conditions change
    - decisions about when response end-points have been reached



Dispersant Use

COMPARE

amount of severe and long-lasting damage to oil-sensitive coastal habitats and socio-economic resources that can likely be prevented by dispersant use…

versus

…the highly localized and short-lived effects that might be caused to the marine environment by dispersant use

→All feasible response options should be compared, and their advantages and disadvantages weight against each other and compared with the option of no intervention and allowing natural recovery

Summary

A systematic SIMA process can:

- establish an understanding of the potential effects of a spill on environmental and other resources
- help to evaluate various response options
- address potential trade-offs that may result for different response strategies

SIMA has a role once a response is under way:

- safety at the forefront
- SIMA should regularly be considered as a scenario evolves
- response strategies are optimized for a balance of response techniques
- government and industry working together cooperatively
- effective, timely and transparent communication