OIL SPILL RESEARCH and DEVELOPMENT for the ARTIC / SUBARCTIC

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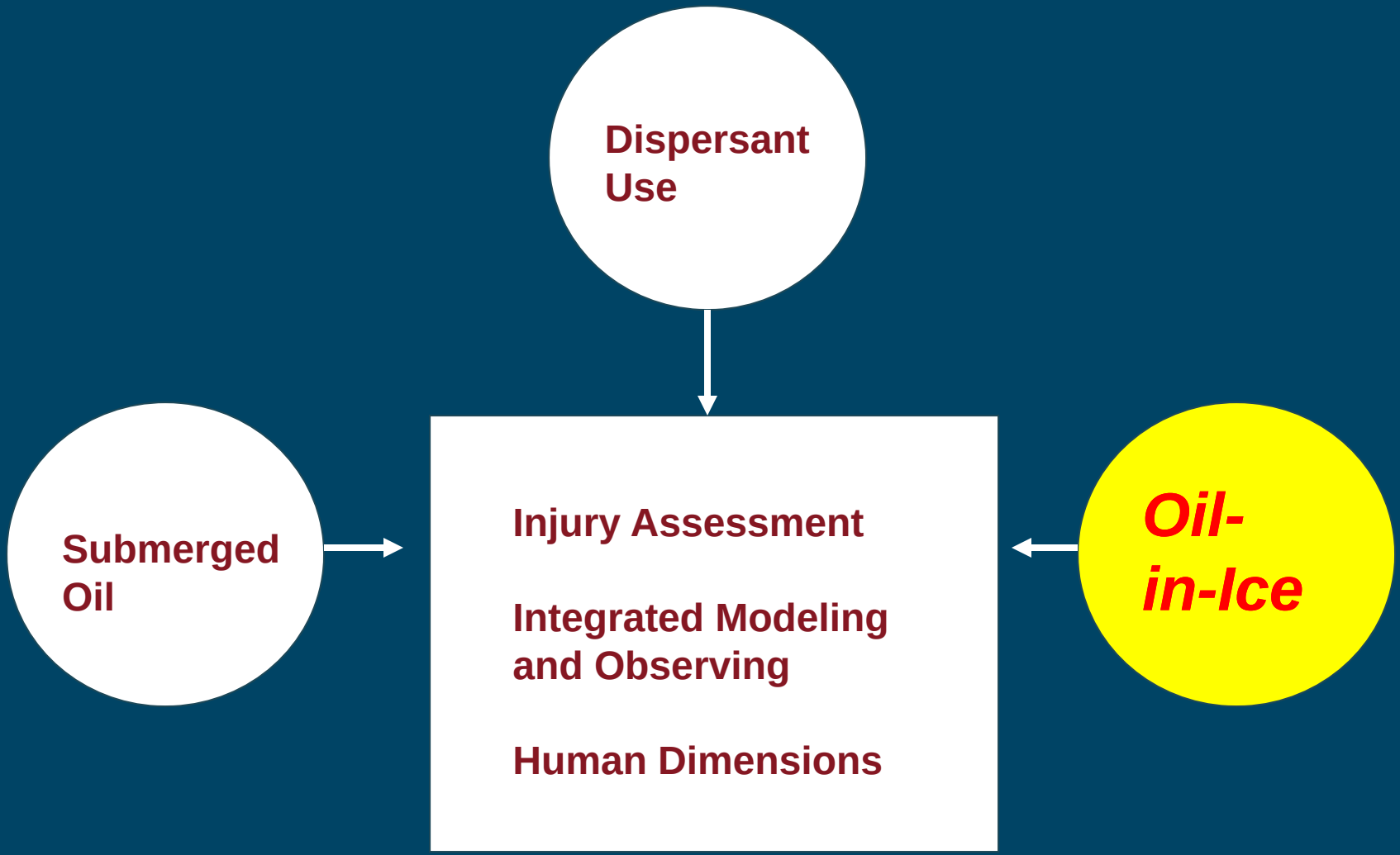
Presentation to ICCOPR and USARC
March 4, 2010

Coastal Response Research Center (CRRC)

- Partnership Between NOAA and the University of New Hampshire Since 2004
- CRRC Mission:
  - Conduct and oversee basic and applied research and outreach on spill response and restoration
  - Transform research results into practice
  - Serve as hub for oil spill community
  - Educate/train students to pursue careers in spill response and restoration

Focus Topics



Caveats

- My Views as CRRC Co-Director
- Response, Recovery, Restoration
  - CRRC focus
- Will Not Cover Prevention
  - Not CRRC focus; Coast Guard, IMO, MMS
- Only Spills Focus
  - No other impacts (e.g., drilling, noise, platform as attractants)

Research Since 2004 USARC Report

- Bibliography Being Compiled by CRRC on Spill Response, Recovery, Restoration in Arctic/SubArctic
  - Reports (e.g., MMS, SINTEF,COOGER, Environment Canada)
  - Peer reviewed literature
  - “Grey” literature

Sample Bibliography (2004-present):

- *MMS*:

  Powell, A.N., and Backensto. S. 2009. Common ravens (*Corvus corax*) nesting on Alaska's North Slope Oil Fields. OCS Study MMS. http://www.mms.gov/alaska/reports/2009rpts/2009_007.pdf

- *SINTEF*:

  Brandvik, P.J., and Faksness. L. 2009. Weathering processes in Arctic oil spills: Meso-scale experiments with different ice conditions. Cold Regions Science and Technology. 55: 160-166. http://md1.csa.com/partners/viewrecord.php?requester=gs&collection=ENV&recid=8770643

- *Environment Canada*:

  Wilhelm, S.I., Robertson, G.J., Ryan, P.C., Schneider, D.C. 2007. Comparing an estimate of seabirds at risk to a mortality estimate from the November 2004 Terra Nova FPSO oil spill. Marine Pollution Bulletin. 54(5): 537-544. http://www.ncbi.nlm.nih.gov/pubmed/17328926

Sample Bibliography (2004-present):

- *Prince William Sound Science Center (PWSSC):*

  Kumar, S.A., and Gray, D.L. 2007. Analysis of Meteorological and Oceanographic Data for Prince William Sound, Alaska, Prepared for Prince William Sound Science Center. http://www.pws-osri.org/publications/Met_ocn_2007.pdf

- *Prince William Sound Regional Citizen's Advisory Council*:

  Fingas, M. 2008. A Review of Literature Related to Oil Spill Solidifiers 1990-2008, for Prince William Sound Regional Citizens' Advisory Council (PWSRCAC) Anchorage, Alaska. http://www.pwsrcac.org/docs/d0054000.pdf

Focus on Uncontrolled Oil Releases

- Maritime Shipping Accidents
  - Single hulled vessels: freighters and cruise ships
  - Cargo (Selendang Ayu) = soybeans
  - Propulsion fuel and lubricants
- Oil and Gas Development and Production
  - Platform / Piping
  - Drilling
- Transport of Oil / Gas
  - Piping networks
  - Double hulled tankers / barges

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CRRC Arctic Disasters Workshop

- March 2008
- Issues of Navigation, Communication, Search & Rescue, Inter-Governmental Agreements
- These Not Directly Addressed in My Presentation - But Have Implications with Respect to Spill Prevention and Human Health & Safety

Port of Refuge

- Pre-Established Locations to Host Ships in Distress
  - With marine salvage & logistical support
- More Possibilities in Eastern Arctic (e.g., Barents Sea)
- T/V Prestige Example in 2002 Off Spanish Coast
  - 2.5 million gallon oil spill
  - No Port of Refuge

Oil Spill Prevention & Response

- How Much of Existing Non-Arctic Knowledge Can Be Used in Arctic / SubArctic?
- What Factors Make Arctic / SubArctic Response Unique / More Complex?

Unique Factors and Issues on Arctic / SubArctic Spill Response

- Cold Temperature
  - Harsh working conditions
  - $k_{0^\circ C} = k_{10^\circ C}\ \theta^{(0^oC - 10^oC)}$

    so $k_{0^\circ C} < k_{10^\circ C}$

    k= reaction rate constant

    Applies to all chemical/biological reactions
- Can Biota Adapt so That $k_{0^\circ C}$ Is Not Significantly Reduced?

Unique Factors / Issues on Arctic / SubArctic Spill Response

- Darkness
- Bathymetry Poorly Known and Some Coastal Regions Relatively Shallow
  - Important to 3D models / mixing / impact of surface waves with depth
  - Sediment / benthic interactions

Unique Factors / Issues on Arctic / SubArctic Spill Response

- Climate Change Impacts
  - Sea level rise – inundation
  - Baseline is changing
    - Biota
    - Chemistry
  - Storm intensity / frequency increasing
  - Coastal erosion – sediment transport
    - Sediment oil interaction

Unique Factors / Issues on Arctic / SubArctic Spill Response

- Ice Extent, Thickness
- First Year vs. Multi-Year Ice
- NOAA, NSIDC, NIC

Unique Factors / Issues on Arctic / SubArctic Spill Response

- Ice Melting – Macro Scale
  - Leads
  - Broken ice
- Ice Formation – Oil Encapsulated in Ice
- Ice Microscale
  - Flow in brine channels
- Oil Under Ice
  - Non-linear surfaces
  - Pooling
  - Adhesion

Unique Factors / Issues on Arctic / SubArctic Spill Response

- Coastal Erosion:
  - Issue for Beaufort, Chukchi and Bering Seas and Cook Inlet
  - Sediment + Oil = Submerged Oil
  - Associated Problems
    - Risk to infrastructure
    - Sedimentation in channels/waterways

Coastal Erosion

- Lack of Data Limits Quantitative Model Development
  - Cold, harsh, remote location, so few comprehensive nearshore observational programs
- Need Dynamic 3D Models of Coastal Behavior
- Need Permanent Circumpolar Arctic-Layer Monitoring (CALM) Sites & Alaskan Ocean Observing System (AOOS) Buoys
  - On beach and close to bluff edge
  - Issue with uncertain erosion rates
- Need Studies to Predict Coastal Profile Evaluation for Forecasted Climate Change Scenarios
- Need Understanding of Coupling Between Thermal Properties & Temperature of Beaches, Bluffs & Coastlines and Wave & Current Driven Sediment Transport

Fate & Behavior of Oil Spills

- Weathering Processes
  - Evaporation rates in low temperatures = slower
  - Emulsification – f(wave energy)
  - Sinking due to sedimentation + oil mixtures
  - Density differences $(\rho)_{oil}$ vs. $(\rho)_{water}$
    - f (salinity, temperature)

Fate & Behavior of Oil Spills

- Dissolution (dissolved into water)
- Solubility Naphthalene in Water

Temp (Freshwater)	Salinity (Temp = 1˚C)
1˚C = 2.7 mg/L	1 ppt = 2.5mg/L
25˚C = 31.7 mg/L	35 ppt = 2 mg/L

- Biodegradation
- Adsorption / Absorption / Ingestion / Inhalation
- Stranded on Shorelines (Fate on Sandy vs. Rocky Beaches)

Weathering Rates

- Governed in Part by Rate Constants
  - f(Temp air, Temp water, Turbulence, Suspended Sediment Load)
- Oil Mixture of 100's MAHs and PAHs
- All with Unique Rate Constants (e.g., biodegradation, dissolution, evaporation)
- Affected by Mixture (Co-Solvent Effect)

DETECTION TECHNIQUES IN and UNDER ICE SOMEWHAT SUCCESSFUL, STILL NEEDS WORK

(USCG, MMS)

Response Measurements

- This Is Area Where Much of Research Has Been Conducted
  - Detection in and under ice needs more work
    - In, under ice
    - In water / on bottom
    - In leads or broken ice
    - USCG & MMS R&D emphasis
      - SINTEF
      - Industry

Response Measurements

- Herders - collect oil to facilitate collection or treatment
  - Efficacy / toxicity
- Mechanical Devices
  - Skimmers and booms with ice present
- Dispersants
  - Cold temperatures
  - Mixing energy - prop wash
  - Toxicity
- In Situ Burning
  - Ignition
  - Efficiency of burn
  - Smoke impacts - toxicity
  - Residue Impacts - toxicity

Response Technologies Efficacy Research

- R&D = MMS, EPA, Industry and SINTEF
- Herders, Solidifiers, Dispersants (Chemicals, OMA), Skimmers, Booms
- Tank Tests
  - OHMSETT tank
  - DFO Canada / USEPA tank
  - S.L. Ross
  - SINTEF
- At Sea Tests
  - DFO Canada / SINTEF / U.S. Proposal (USARC white paper)

RESPONSE TECHNOLOGIES = SUCCESS STORY

Research Still Needed But Well Along Since USARC, 2004

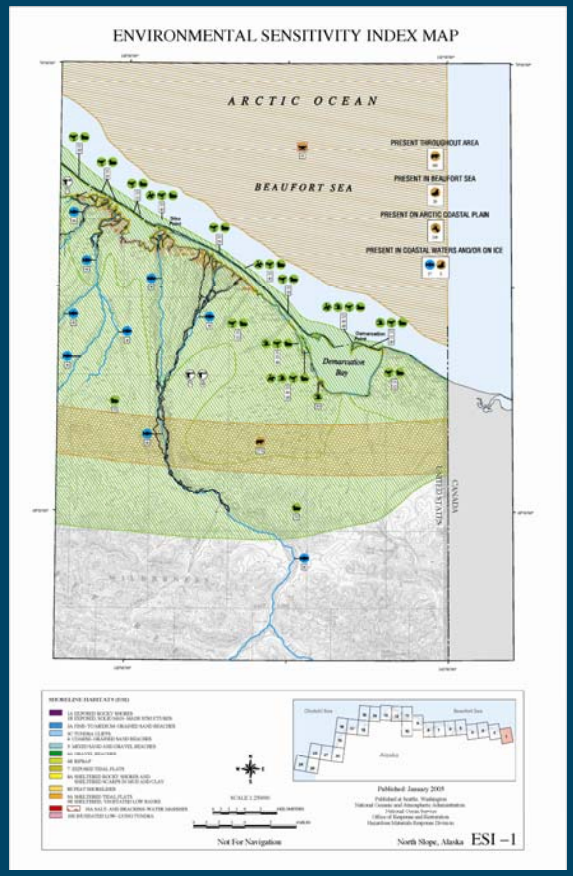
Biodegradation and Natural Attenuation R&D Still Controversial and Unresolved

Current Spill Response

- Limited Equipment & Facilities Available in Alaska Arctic
  - Oil Spill Response Organizations (OSROs) hired by industry
    - Example: Alaska Clean Seas (ACS)
- Evaluating Environmental Tradeoffs

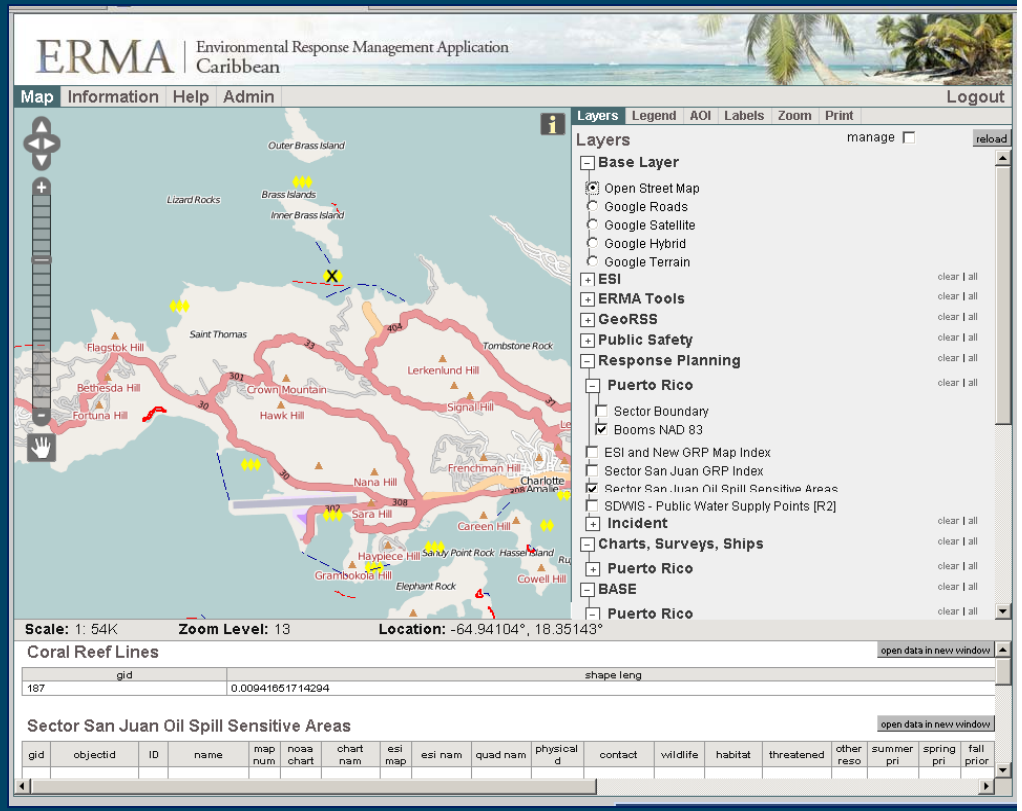
Current Spill Response: Information Management

- Key is Rapid, Informed Decisions
  - Protect human health/safety
  - Consider human dimension issues (e.g., socioeconomic, cultural considerations, subsistence)
- Incident Command Needs Relevant Information in Easily Understandable Format
- Environmental Response Management Application (ERMA®)
  - Dr. Amy Merten, NOAA ORR, CRRC NOAA Co-Director



ERMA

- NOAA/CRRC GIS-Based Platform with Layered Data
  - Real-Time Information & Prediction
    - e.g., Weather, IOOS, Tides
  - Area Databases
    - Species Sensitivity, Sensitive Infrastructure
- Spill Trajectory Models
- Responders' Field Observations



Current Spill Response: Fate & Behavior of Oil - Modeling

- Models of Oil in Cold and Ice-Infested Waters, In Ice and Under Ice are Rudimentary
- Hampered by Lack of Peer-Reviewed Cold Water and Ice/Oil Behavior Studies
- Need to Link Current 2D Spill Models to Brine Channel Models in Ice, 3D Mixed Layer
- Mass Transfer Models of Dissolution, Food Web Models for Fate

Toxicity Rates

- Adsorption / Absorption / Ingestion / Inhalation
- Lethal / Sublethal Effects
- Compound Specific
  - Mixtures complicate actions
- Species Specific
- CRRC/NOAA PAH Toxicity (Lethal) Field Guide

Toxicity Rates

- Few Arctic / SubArctic Studies
  - Nominal concentrations issues
  - Complicated by dispersant issues
  - Current Alaskan JIP study
    - Barrow Lab Perkins et al.

Importance of Species

- Key Natural Resources
  - Role in food web
  - Threatened and endangered species
  - Economic importance
  - Cultural importance
- Arctic Species Are "Living on the Edge" and Changes Are Happening Quickly
  - Confounded by protracted exposure to oil
- Much of This Information is Poorly Known or Controversial for Arctic/SubArctic
  - Lethal / sublethal / food web role (in, on, under ice, water column, sediments, shoreline)
  - Assigning $ values
  - Addressing cultural values

Assessment and Restoration

- Reality #1 = When (NOT IF) Oil Spill Occurs in Arctic
- Reality #2 = Substantial Amount of Oil Will Remain in Environment After Response
  - In spite of technological/equipment advances in response
- Reality #3 = Natural Resource Damage Assessment (NRDA) Will Be Initiated as a Result of Spill

NRDA

- Assess Types and Magnitudes of Injuries to Natural Resources or Services Provided by Resources
- Identify Appropriate Restoration to Fully Compensate Public for Resource Injuries

Assessment and Restoration

- Reality #4 = NRDA Requires Much Better/ More Complete Knowledge of Arctic Marine Ecosystem Than We Have
- Reality #5 = Must Be Quick Injury Assessment and Rapid Implementation of Restoration in Arctic
  - Little room for delay because Arctic is ecosystem on the edge
- Reality #6 = Baseline Is Rapidly Shifting in Arctic Due to Climate Change
  - What is baseline?

Goal of Arctic NRDA Workshop

- NOAA ORR ARD Wants to Be Proactive
- Initiate the Dialogue on Arctic NRDA
  - Among NRDA practitioners / Arctic scientists
- Identify Data Gaps in Understanding of Resources/Ecology at Risk from Spills
  - Temporal and spatial
- Develop Rapport Among Stakeholders
  - Bring everyone to the table
  - Better to initiate dialogue **BEFORE** spills occur

Workshop Logistics

- CRRC Partnering with OSRI to Host Workshop
- Organizing Committee (OC) = Technical and Scientific Personnel Representing Diverse Stakeholders
  - Cheryl Rosa – USARC
  - e.g., NOAA, DOI, ADEC, NGOs, Industry, Alaska Natives
- April 20-22, 2010 in Anchorage
- Format = Plenary Sessions and Breakout Groups

Breakout Groups

- Birds
- Marine Mammals
- Fish and Invertebrates
- Habitat: Ice and Under Ice
- Habitat: Lagoon/Nearshore Shallow
- Habitat: Freshwater/Coastal Tundra

Workshop Questions

- What is the list of key species, ecological services and human uses associated with or dependent upon the habitat that may be most affected by an oil spill?
- How might the key species, ecological services, and human uses of this habitat be affected by an oil spill?
- What are characteristics of key food webs in these habitats? What are key components of the food webs? How might food webs in this habitat be affected by an oil spill?

Workshop Questions

Workshop Outcomes

- Report on Workshop Including Recommendations on R&D and Way Forward
- Working Group = Arctic Assessment
  - Continues dialogue
  - Coordinates efforts
- Likely to Be First in Series of Workshops
  - Restoration will be discussed in subsequent workshop

Human Dimensions of Spills

- Selendang Ayu – Subsistence and Cultural Issues Major Driver in Response, Seafood contamination, Risk Communication, and Damage Assessment
- Human Dimension Issues
  - Communication
  - Valuing natural resources
  - Social impacts
  - Subsistence
  - Environmental ethics
  - Organizational (institutional) behavior

Current Spill Response: Human Dimension

- Indigenous Communities Have Strong Cultural Ties to Subsistence Fishing and Hunting
  - e.g., whales, seals, polar bears, pelagic fish
- Spiritual Oneness with Natural World
- Wealth of Local Knowledge about Coastal Environment
- Some Human Dimensions Research, Especially on Exxon Valdez, But More Needed
  - Tools

Guiding Concepts I = Complexity

- Arctic Coastal Ecosystem = Complex & Dynamic
  - Action/reaction links
  - Interacting components = Water, Ice, Sediment, Shore, Air, Biota

Guiding Concept II = Great Variability

- Sea Ice Retreat/Absence = High Temporal & Spatial Variability in Coastal Processes & Human Activities
  - Daily, Monthly, Annually
- Variability in Tides, Wind, Weather, Anthropogenic Activity

Guiding Concept III = Great Uncertainty

- Poor Baseline Understanding of Arctic Coastal Processes
- Lack of Data with QC
- Exacerbated by Uncertainty about Rate/Scope of Climate Change

Temporal/Spatial

Complexity + Variability + Uncertainty = Resilient Response, Assessment and Restoration

Moving Forward: Arctic / SubArctic R&D

- Step 1: Identify Needs
- Step 2: Secure funding
- Step 3: Fund Research Through Traditional Peer Review RFP Process
  - Without peer review fraught with issues
    - Lack of trust
    - Controversy about experimental design and methods, results and conclusions
- Step 4: Monitor Research Once Team Selected

Arctic / Subarctic R&D

- Step 5: Liaisons – Practitioners Working with Researchers
  - Goal: Results into practice
- Step 6: Open Data, Peer Reviewed Reports / Publications
  - Be sure results are reported to ALL stakeholders in clear, understandable terms

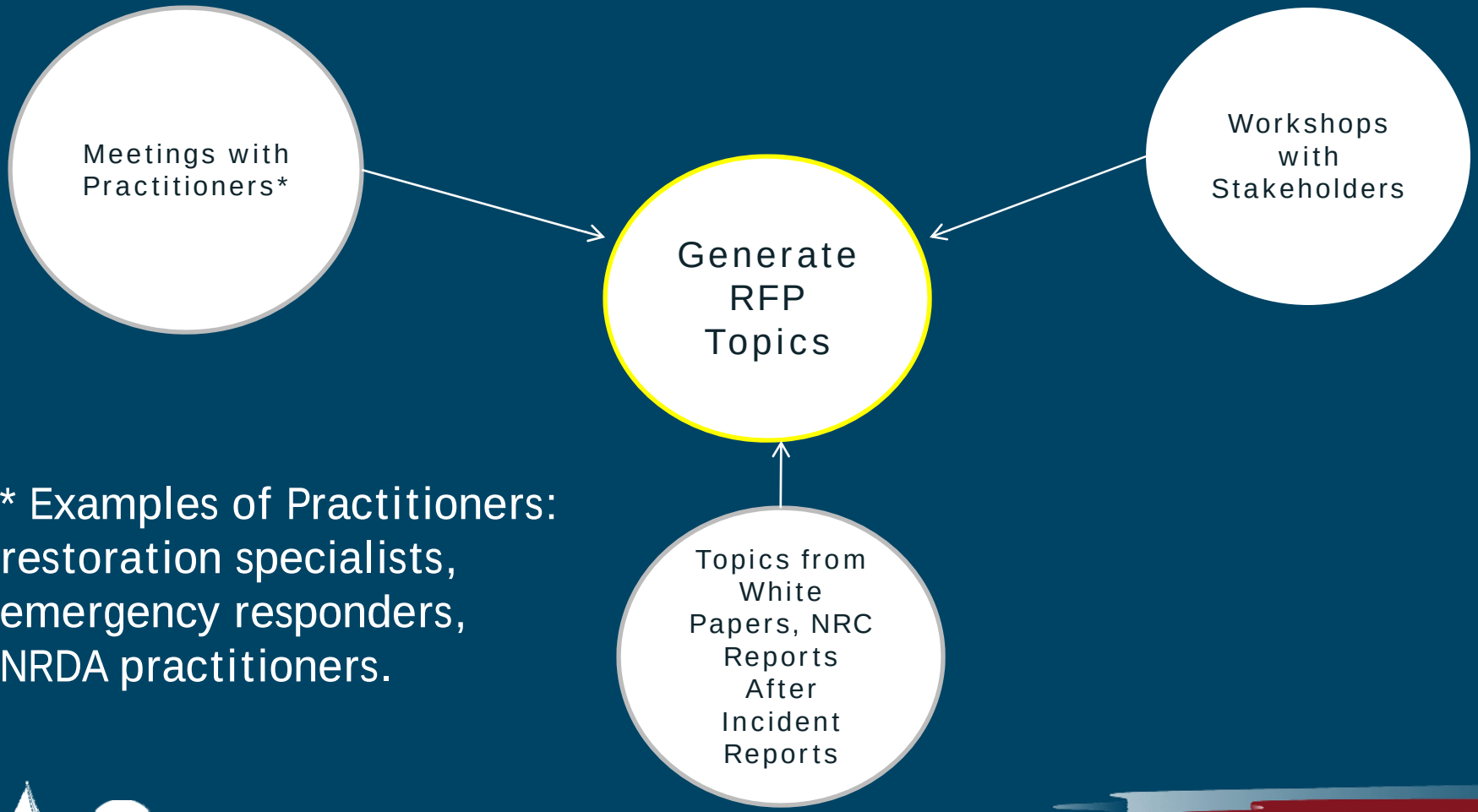
R&D Needs Peer Reviewed RFP: Traditional Unrestricted Solicitation vs. Highly Directed Stakeholder Solicitation (e.g., AWWA, WEF Model)

Directed Stakeholder R&D

- Step 1: Stakeholders* Identity Problem
- Step 2: Experimental Design Prepared by Stakeholder Technical Team
  - Discussion mediated by facilitator
  - Becomes part of RFP
- Step 3: Proposals Submitted in Response to Directed RFP Are Peer-Reviewed
- Steps 4, 5 and 6: Same as Traditional RFP

*Stakeholders = Representation of All Parties (e.g., Government, Industry, NGOs, Indigenous, Academia)

Generating RFP Topics



* Examples of Practitioners: restoration specialists, emergency responders, NRDA practitioners.

Typical Information Supplied with RFP Topics*

- Objectives of Research
- Guidelines for Conducting Research on Topic
- Issues/Problems Potentially Associated with this Type of Research
- Application of Research to Practice

*Gathered from meetings with practitioners and workshops with stakeholders

Overall Conclusion: Enormity of Nescience*

Most Knowledge

- Response Methods and Situational Awareness
- Biological Effects, Modeling, Human Dimensions
- NRDA
- Restoration

Less Knowledge

*Lack of Knowledge, Ignorance

Coastal Response Research Center Website

www.crrc.unh.edu