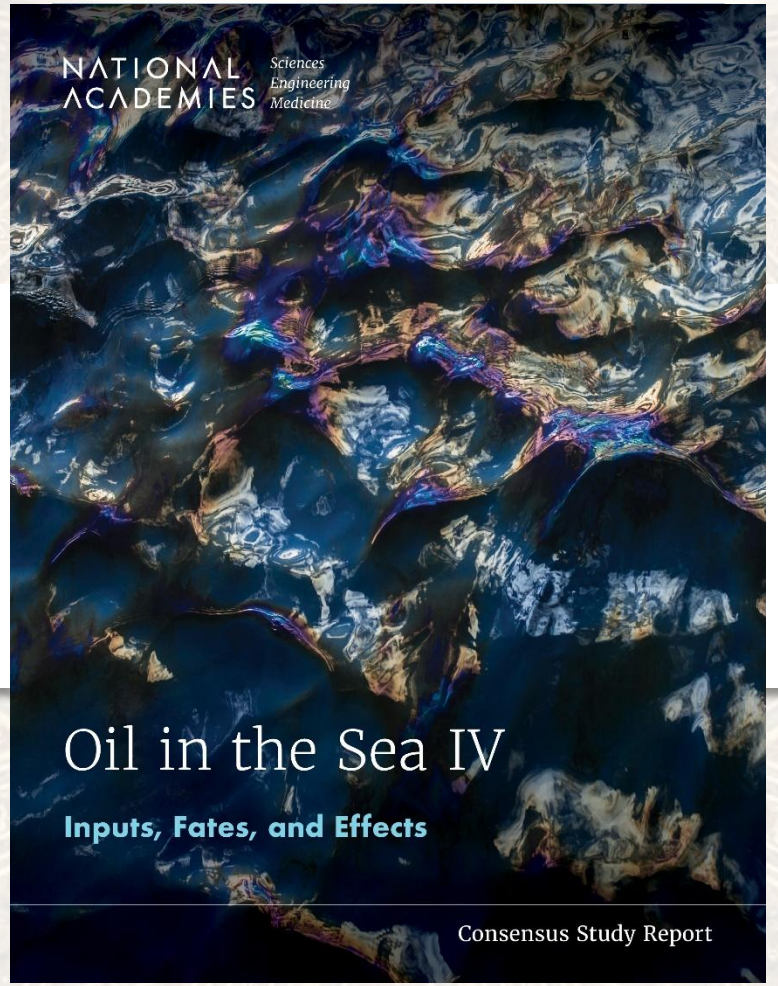
Public Briefing



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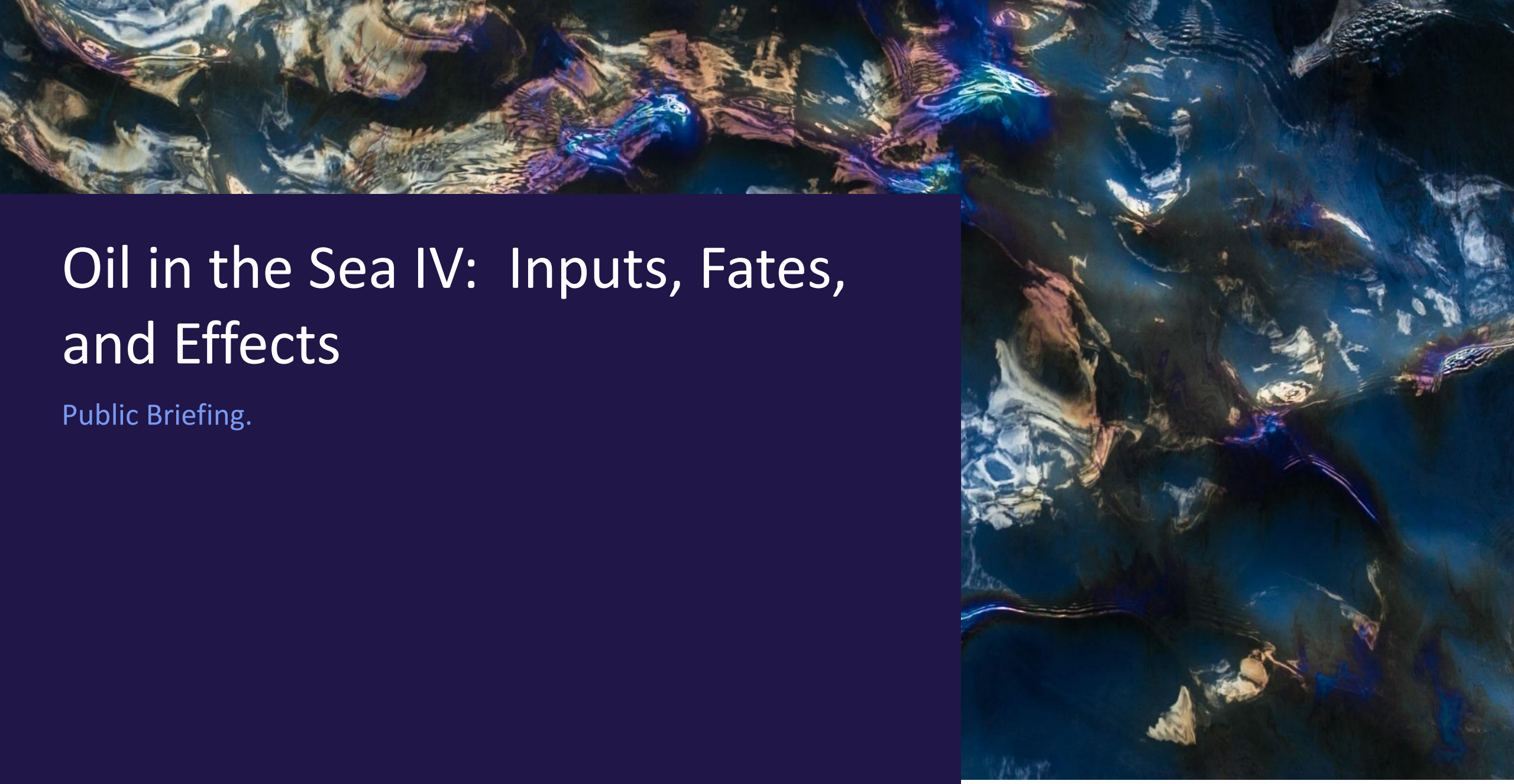


Oil in the Sea IV: Inputs, Fates, and Effects

Public Briefing.

SEPTEMBER 28, 2022

Agenda

1. Project context and overview
2. What is oil?
3. Inputs of oil into the sea
4. Minimizing inputs through source control and response
5. Fate of oil in the sea
6. Effects of oil in the sea
7. Overarching themes to advance oil spill science
8. Key takeaways
9. Q&A

Study Overview

- 2-year consensus study (100% virtual).
- Sponsored by:
  - American Petroleum Institute,
  - Bureau of Ocean Energy Management,
  - Bureau of Safety and Environmental Enforcement,
  - Gulf of Mexico Research Initiative,
  - NASEM President's Circle Fund, and
  - Oceans and Fisheries Canada
- 17-member committee.
- Monthly meetings - input from: committee expertise, scientific literature, 58 invited speakers, and 3 consultant teams.
- Resulting report was peer-reviewed by an additional 13 experts.

Committee

Kirsi Tikka (Chair)
Ed Levine (Vice-chair)
Akua Asa-Awuku
C.J. Beegle-Krause
Victoria Broje
Steve Buschang (through August, 2021)
Dagmar Schmidt Etkin
John Farrington
Julia Foght
Bernie Goldstein
Carys Mitchelmore
Nancy Rabalais
Jeffrey Short
Scott Socolofsky
Berrin Tansel
Helen White
Michael Ziccardi

Statement of Task – Inputs

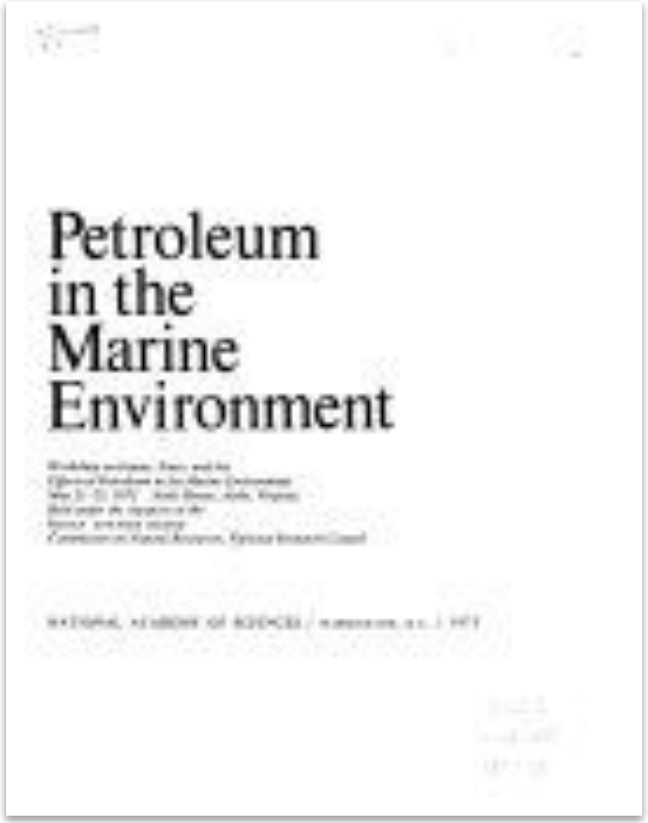
With an emphasis on North American waters:

1. Identify and quantify natural and anthropogenic sources of hydrocarbons entering the marine environment.
2. Review progress in implementing the recommendations from the 2003 report and identify priority recommendations that have yet to be implemented.
3. Provide recommendations to improve estimates of inputs and identify focus areas for reducing hydrocarbon inputs from human activities.

Statement of Task – Fates and Effects

1. Assess and discuss the physical and chemical characteristics and behavior of these hydrocarbons, the transport and fate of various hydrocarbon mixtures in the marine environment, and the effects of these mixtures on marine life and ecosystems.
2. Characterize, to the degree possible, the risk posed to the marine environment by fossil fuel hydrocarbon components or type of input, given the range of organisms or ecosystems likely to be affected.
3. Review progress in implementing the recommendations from the 2003 report and identify priority recommendations that have yet to be implemented.
4. Provide recommendations to improve understanding of the fates and effects of hydrocarbon inputs from human activities and strategies for reducing the more harmful effects.

Study Context



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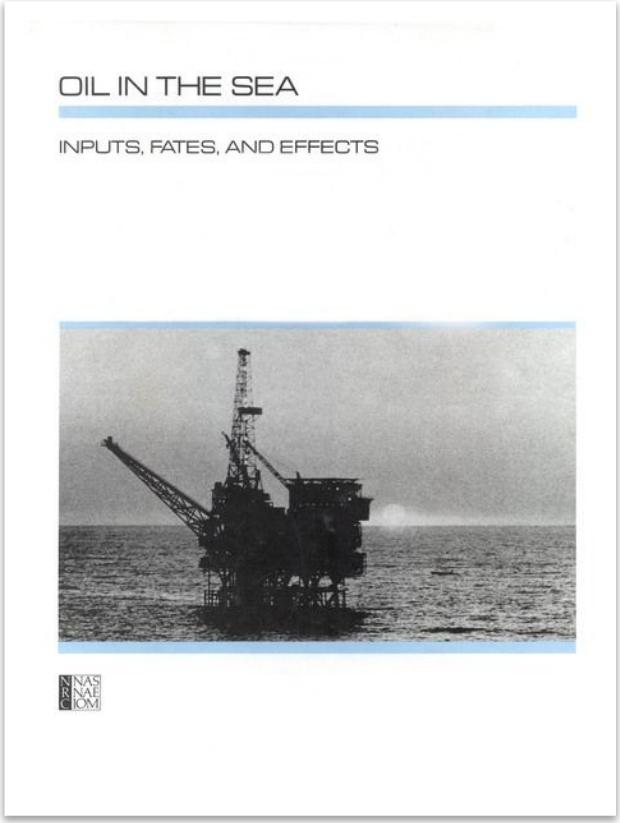

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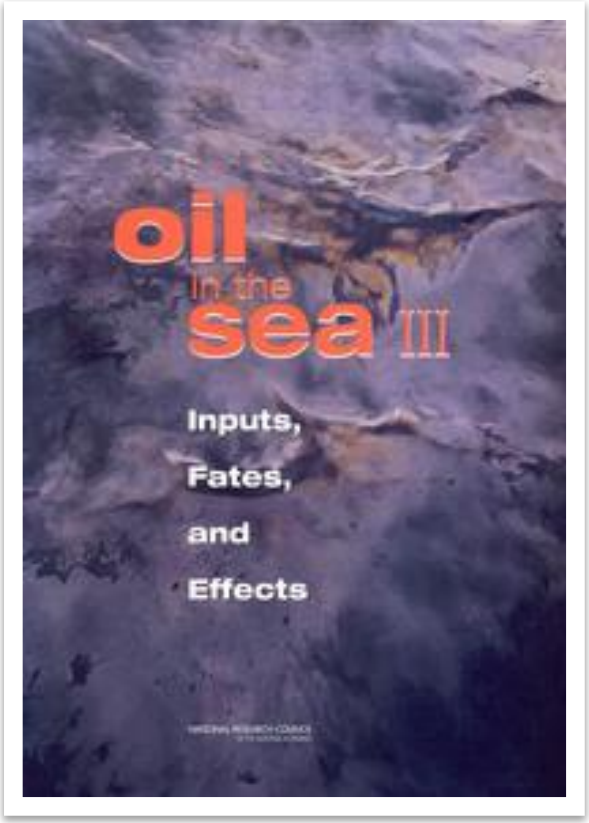

2003

2022

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What is different about this update?

1. Extensive discussion of fates and effects includes many advances in understanding over the last 20 years.
2. Highlights and synthesizes the extensive amount of post-DWH research following 10-years of dedicated funding for oil spill science.
3. Inclusion of details on complexity of oil mixtures.
4. Inclusion of oil spill response; its importance to minimizing both the amount of oil spilled and effects on the environment and people.
5. Inclusion of human health and seafood safety.
6. Detailed discussion and identification of gaps in understanding and suggestions for future research.
7. Overarching recommendations that cross-cut multiple chapters.

How will this report be helpful?

1. Report summary for the casual reader and conclusions at the end of each chapter for a quick overview.
2. Textbook-style explanations of the current definitions and state of knowledge of oil spill science (chemistry, fate, effects, and response) with a detailed table of contents to guide the reader.
3. Synthesis of over 1,300 references.
4. Current estimations of volumes of oil entering the sea and projections for the future.
5. Each chapter includes tables identifying critical research needs for:
   - advancing analytical chemistry,
   - increasing response capabilities,
   - better understanding fate of oil in the sea (thus better modeling and predicting), and
   - better understanding effects of oil in the sea (including to humans).
6. Recommendations for better estimating important inputs, decreasing inputs, decreasing effects, and preparing for future spill scenarios.

Report Structure

What is Oil? (Chapter 2)

Where does oil in the sea come from? (Chapter 3)

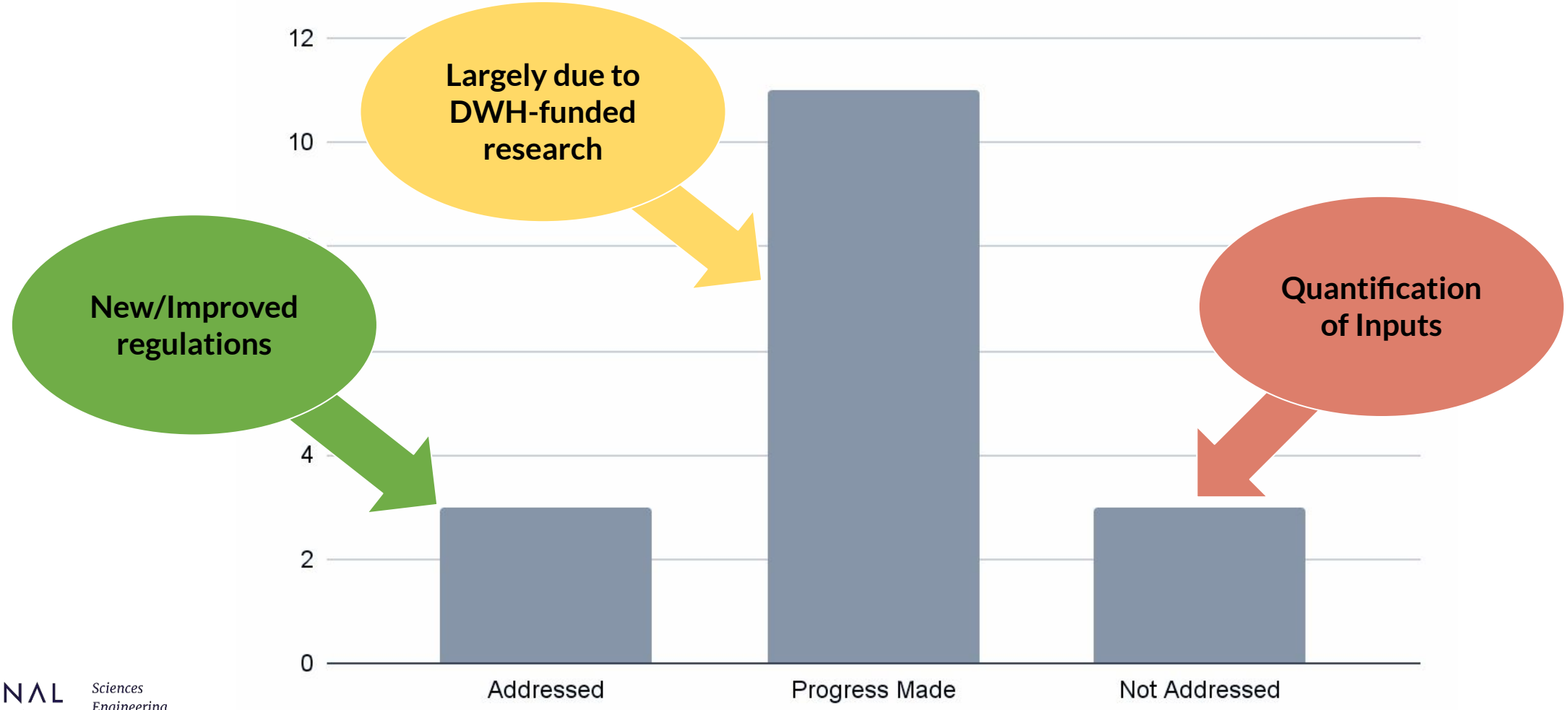
What can be done? (Chapters 3 & 4)

Where does the oil go? (Chapter 5)

What harm could the oil do? (Chapter 6)

Image Credits (left to right): NOAA, Alan Mearns, NOAA, NOAA, NOAA

Progress Made on *Oil in the Sea III* Recommendations



Ch. 2 Oil as a Complex Mixture

- "Oil" is a three letter word that is helpful in describing petroleum in everyday general public discussions.

- Important to understand that petroleum ("oil") is a complex mixture of hundreds to thousands of individual chemicals.

Ch. 2 Oil as a Complex Mixture

- The chemical mixtures differ for various types of inputs of oil to the sea, and for each oil - sometimes markedly so.
- These differences allow for forensic analyses to distinguish one oil from another e.g. determining the source of a specific oil spill.
- These compositional differences are important considerations when responding to oil spills and the regulation and control of various types of inputs.
- Each chemical has its own set of important characteristics (e.g. volatility, solubility in sea water) that contribute to the fates and effects of the complex mixtures once released to the environment.

Ch. 2 Oil as a Complex Mixture

Chapter Content:

- Definitions and classifications.
- Chemical compositions.
- Sampling and analysis.
- In situ measurements/chemical analyses.
- Thermodynamics of oil mixtures.
- Phases and states of oil in the sea.

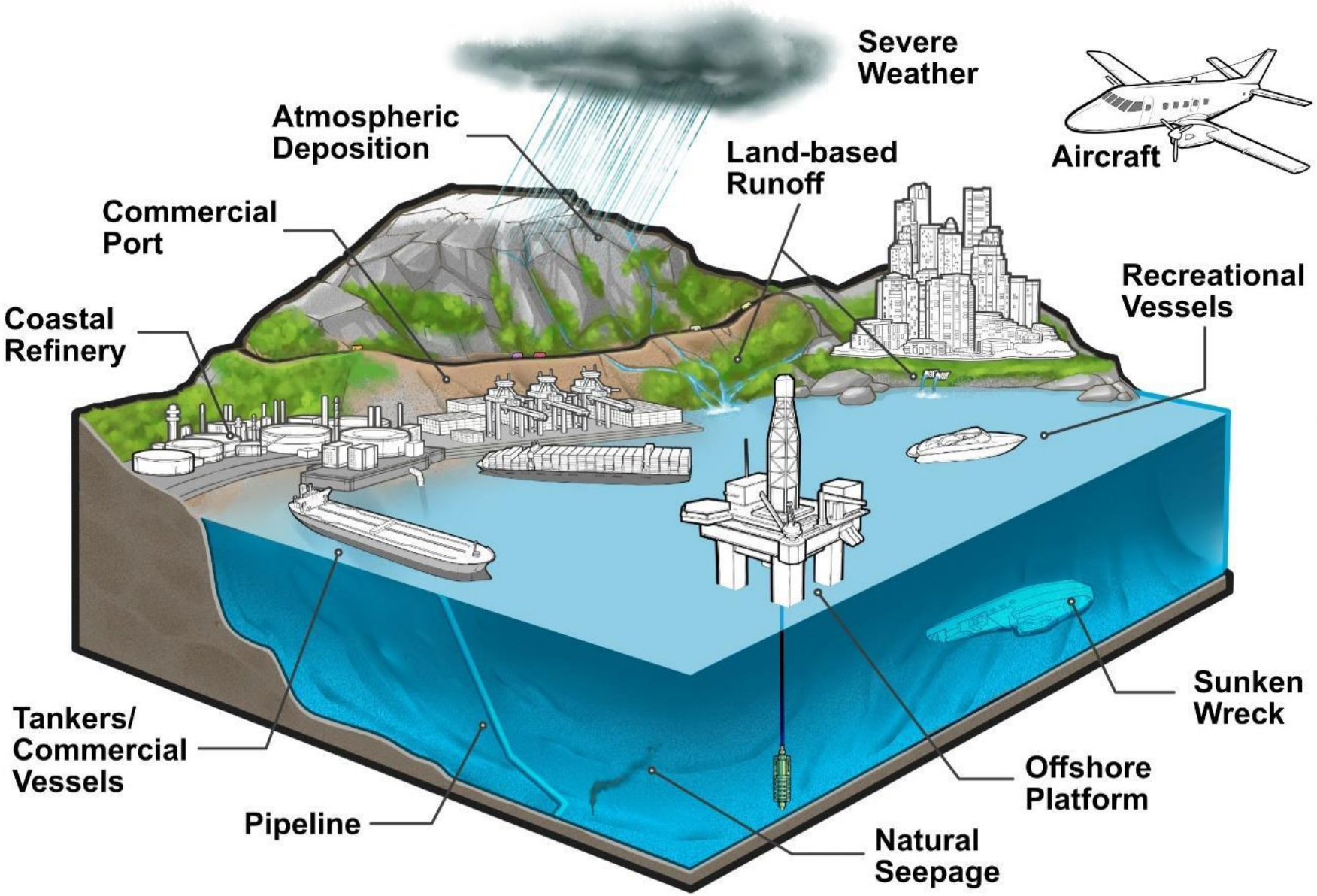
Conclusions and Recommendations:

- Analytical chemistry methodology.
- Reporting of chemical composition.
- Utilization of large databases.
- Modeling.
- New fuels.

Oil in the Sea IV: Inputs, Fates, and Effects

Ch. 3 Inputs

2010 – 2019



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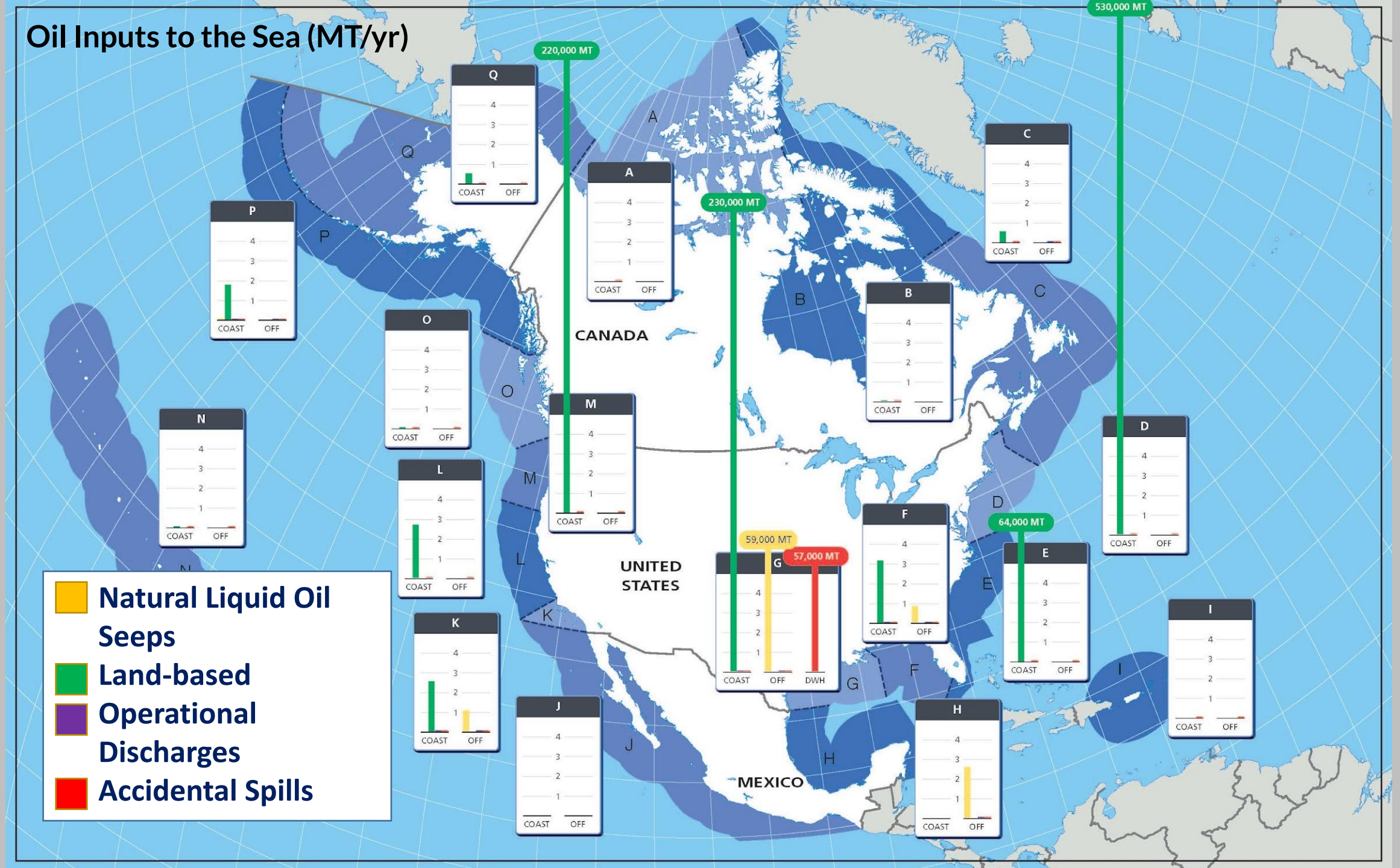

Oil Inputs to the Sea (MT/yr)
220,000 MT
230,000 MT
530,000 MT
64,000 MT
59,000 MT
57,000 MT
CANADA
UNITED STATES
MEXICO
COAST
OFF
DWH
Natural Liquid Oil Seeps
Land-based
Operational Discharges
Accidental Spills

Ch. 3 Annual Inputs – Comparison between Decades

			Oil in the Sea IV (2010 – 2019) (MT/yr)	Oil in the Sea III (1990 – 1999) (MT/yr)
Natural Oil Seeps			100,000	160,000
Extraction	Including DWH Excluding DWH		67,000 10,000	3,000
Transportation			800	9,200
Consumption			1,200,000	84,000
Total (Rounding to 2 significant digits) **Total (excluding consumption)** **Total (excluding consumption, DWH)**			**1,400,000** **170,000** **110,000**	**260,000** **170,000** **170,000**

Ch. 3 Inputs – Future Challenges

- Aging offshore infrastructure risks (pipelines, platforms, sunken wrecks).
- Damage to offshore and coastal infrastructure caused by increases in extreme weather and sea-level rise.
- More challenging and remote drilling environments, such as deeper waters and Arctic conditions.
- Changes in shipping routes.
- New fuels with unknown fate and effects.
- Additional sources of oil hydrocarbons, i.e., plastics.

Ch. 4 Reduction of Inputs – Accidental Spill Mitigation

Image Credit: Oil Spill Response, Ltd.

Image Credit: NOAA

Image Credit: NOAA

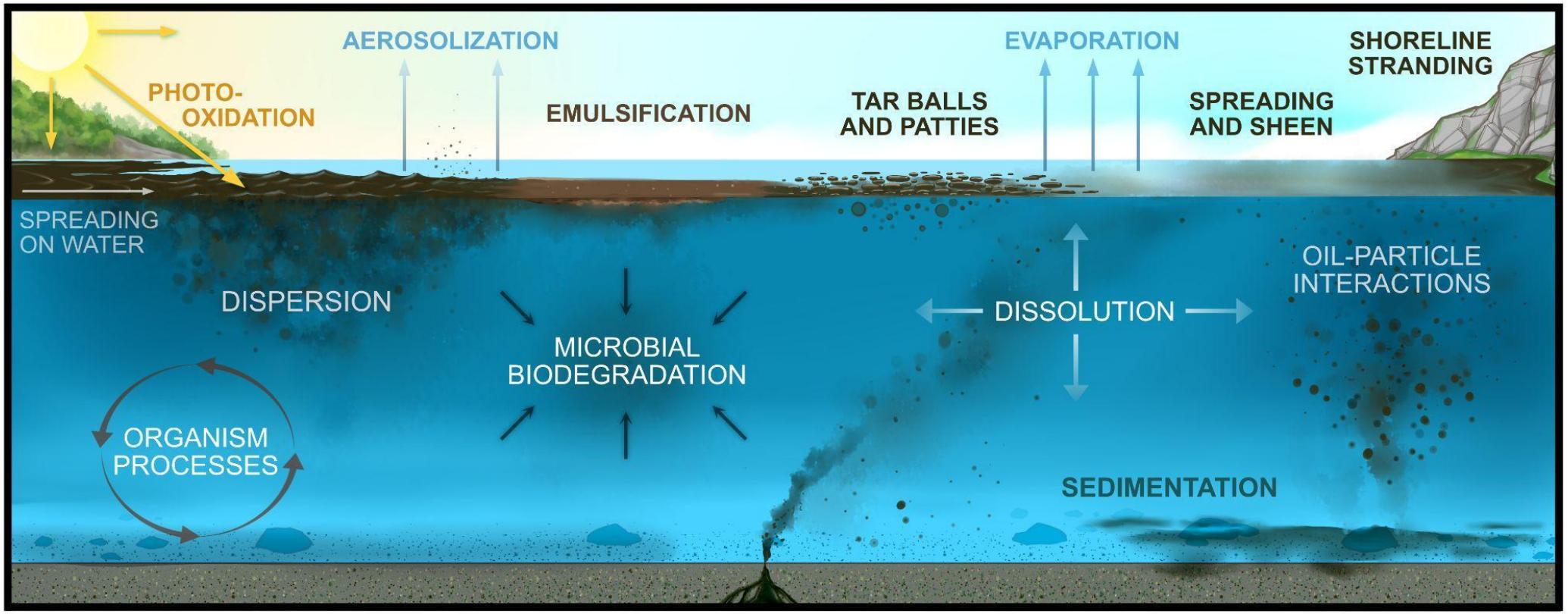
Ch. 4 Accidental Spill Mitigation – What is New?

- Advances in blowout prevention, well control techniques, and equipment.
- Salvage operations as an important mitigation step.
- Advances in pipeline integrity monitoring and leak detection.
- Incident Command System as the standard for emergency management.
- Response toolbox concept to optimize response efficiency and environmental protection.
- New risk assessment tools.
- Advances in oil spill modeling, monitoring, sampling, analytical methods, and data management.
- Integration of oiled wildlife response with oil spill response efforts.

Ch. 4 Source Control & Response – Future Research Needs

- Field experiments with real oil to test and improve response techniques under realistic conditions.
- Understanding effectiveness of response techniques on new fuel types.
- Life-cycle analysis of oil spills for different response scenarios.
- Understanding health and psychological risks to response professionals.
- Further improvements of response tools: mechanical recovery, in situ burning, chemical dispersants, and shoreline response for various environments.
- Research on long-term impacts to animals to inform oiled wildlife management strategies.

Ch. 5 Fates of Oil in the Sea



Ch. 5 Fates – What is New?

- Dynamic interaction of complex oil and gas mixtures with the ocean water column.
- Fluid dynamic behavior of oil spills through profound advances in computational fluid dynamics models.
- Prediction of the formation of gas bubbles and oil droplets from different sources and at the sea surface.
- Effects of chemical dispersants on oil droplet sizes, including a new phenomenon of "tip streaming."
- Methods to reduce oil droplet size for subsea spills, including subsea dispersant injection.
- Importance of dissolution and models for predicting spills and natural seeps, including the effects of natural gas hydrates.

Ch. 5 Fates – What is New?

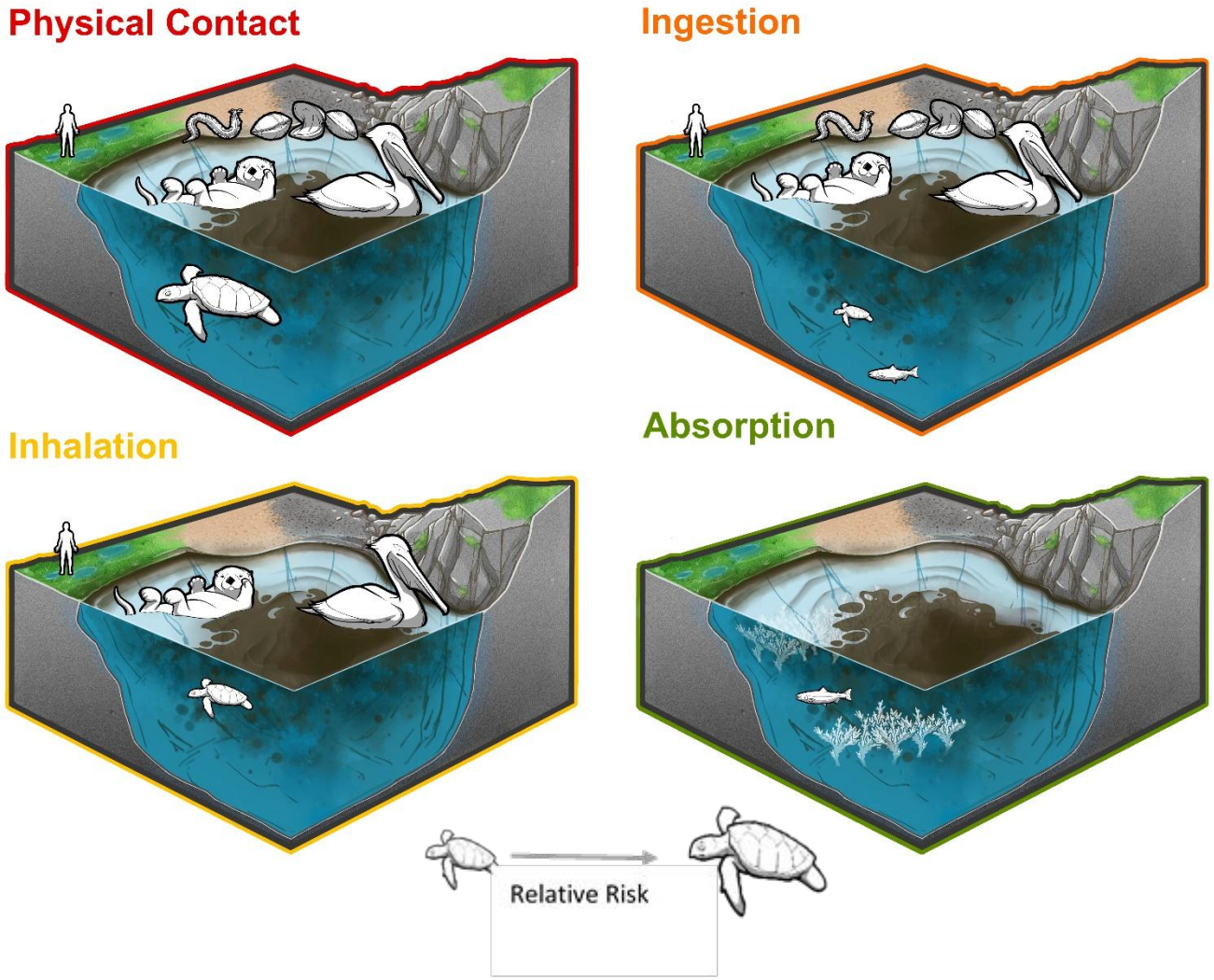
- Importance of photo-oxidation in oil degradation.
- Aggregation of oil with suspended material and stranded on shore, including a new process of Marine Oil Snow Sedimentation and Flocculant Accumulation, MOSSFA.
- Microbial communities through revolutionary advances in high-throughput DNA sequencing, bioinformatics, and sequence databases.
- Microbial communities involved in oil degradation and the complex factors controlling their growth and interaction with oil.
- Processes in cold water affecting oil fates, including new recognition that biodegradation can be fast.
- Through multi-disciplinary teams involving many physical, chemical, and biological processes.

Ch. 5 Fates – Future Research Needs

- Further understanding of the fundamental processes controlling:
  - Field-scale behavior of oil droplets and droplet formation,
  - Photo-chemical reactions affecting the fates of oil and the effect of dispersant addition on these reactions, and
  - Biological modification and degradation of oil, including understanding the kinetics and range of anaerobic biodegradation of oil in the sea.
- Behavior and fate of new or unconventional oils, such as very low sulfur fuel oils and diluted bitumen (dilbit).
- Refining of modeling algorithms to predict oil behavior and fate, including new databases of oil properties.

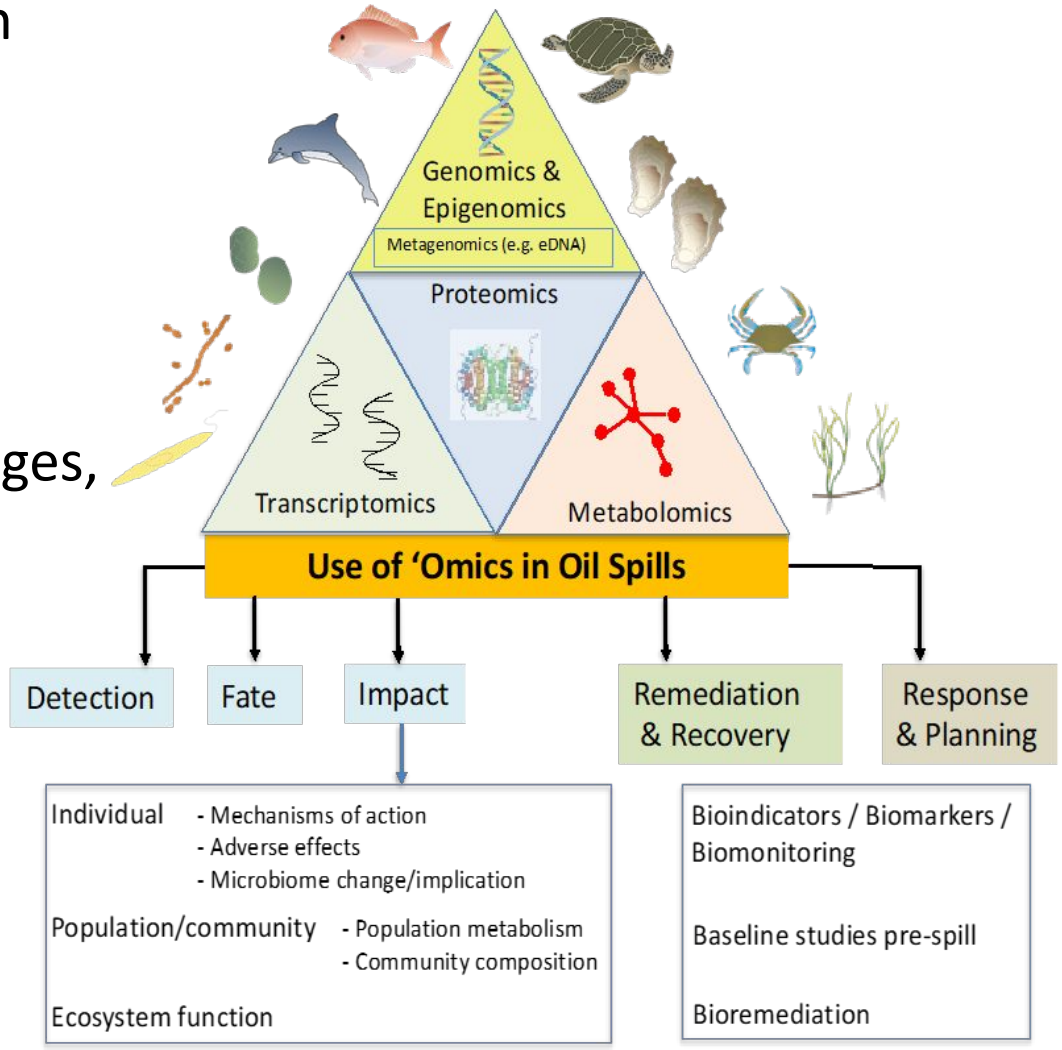
Ch. 6 Effects of Oil in the Sea

- Modes of Exposure
- Mechanisms of Toxicity
- Effects on Populations, Communities, and Ecosystems
- Effects in the Arctic
- Effects on Humans
- Effects Modeling
- Limitations and Challenges



Ch. 6 Effects – What is New?

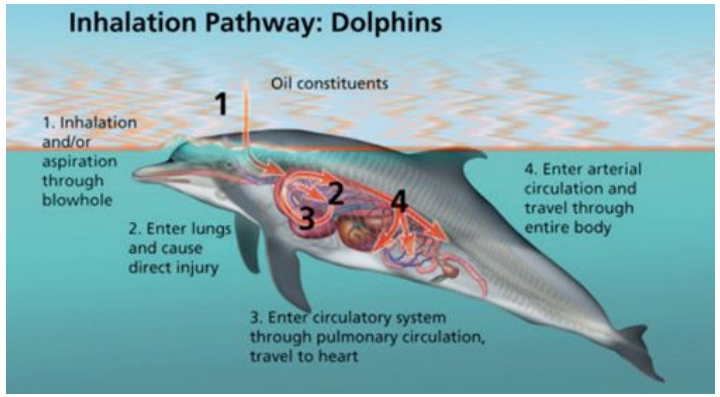
- Greater understanding of chronic, longer-term effects on population and community levels (including food webs).
- Identifying new mechanisms of action and effects of oil through omics and other advanced technologies.
- Predicting effects within a changing ecosystem and the influence of multiple co-stressors.
- Enhanced understanding of exposure routes and challenges, such as appropriate conduct/interpretation of toxicity tests.
- Identification of new affected habitats and species.
- Advances in modeling to predict oil effects.
- Effects of oil release on humans, includes socioeconomic, mental and behavioral health.



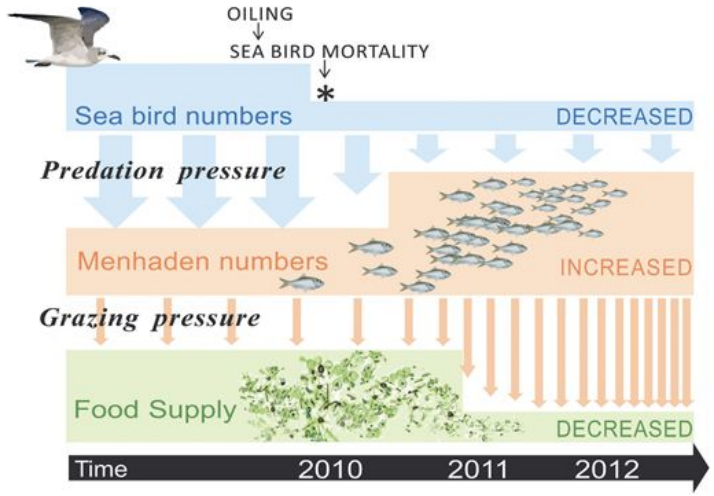
Ch. 6 Effects – Future Research Needs

Continued efforts to further our understanding on the following:

- Real-time, in situ assessment techniques,
- New oil types (diluted bitumen, low sulfur fuel oils), habitats and species (Arctic, natural seeps, deep sea),
- Focus on understudied exposure routes (air-sea interface) and mechanisms of action,
- Understudied effects (behavioral, trophic interactions, food webs),
- Influence of co-stressors on bioaccumulation and toxicity (photo-oxidation, marine oil snow),
- Enhanced guidelines and developments in toxicity studies and models,
- Improvements to seafood safety guidelines, and
- Expanded efforts for human health and community resilience.



SOURCE: NOAA



SOURCE: Short et al., 2017

Ch. 7 – Common Themes to Advance Oil Spill Science

1. Long-term Funding
2. Human Health
3. Open Water Experimentation
4. Oil in the Arctic
5. New Fuels
6. Baseline Knowledge and Data
7. Big Data and Interdisciplinary Research

Ch. 7 – Common Themes: Long-term Funding

Long-term, sustained funding to:

- Support multidisciplinary research,
- Improve response capabilities, and
- Apply new data and technologies to advance knowledge.

Image Credit: NOAA

Ch. 7 – Common Themes: Human Health

A more holistic approach in the Incident Command System decision-making and response process regarding human and ecosystem health, including:

- Individual and community mental and behavioral health effects, and
- Community socioeconomic disruptions.

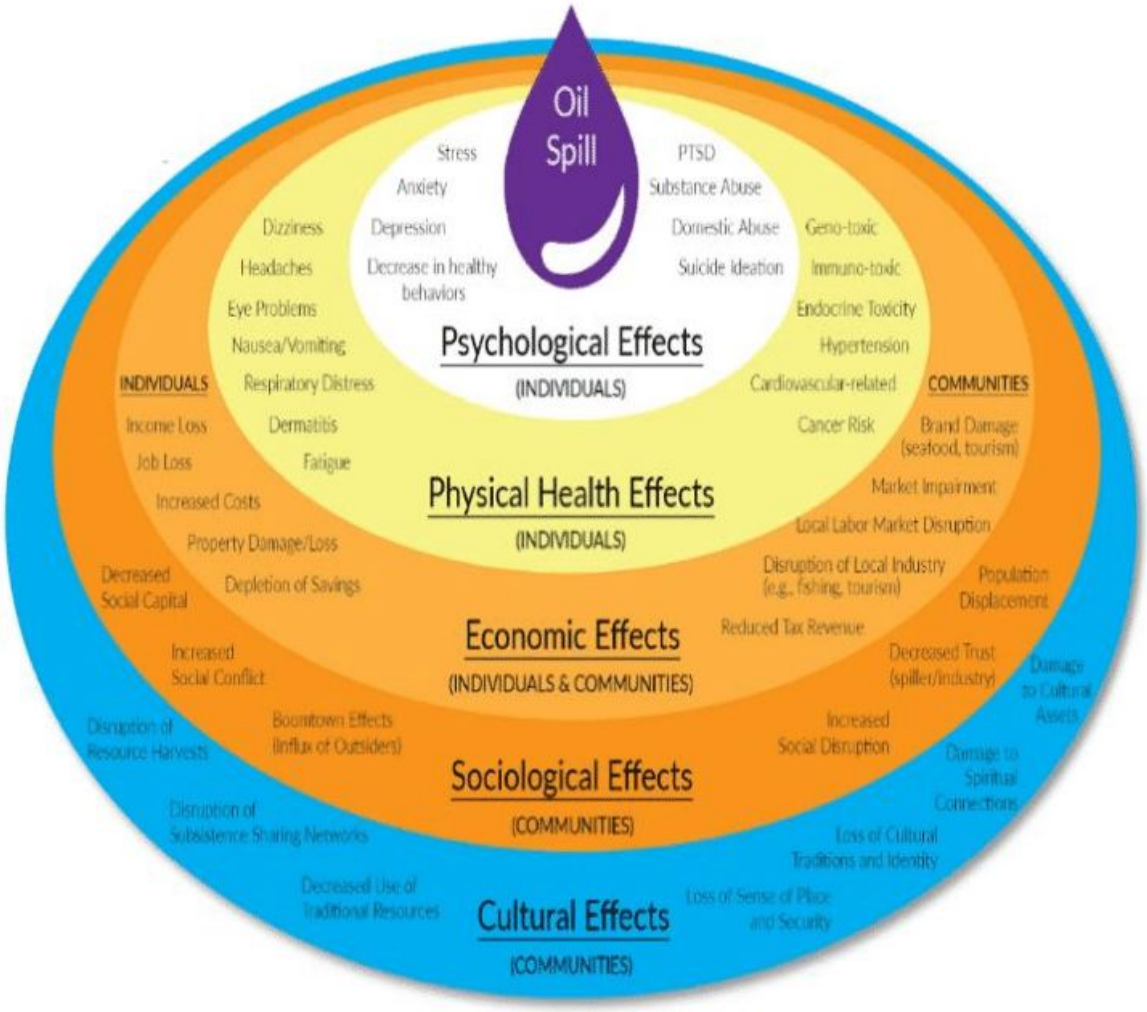


Image Credit: Sandifer, 2021

Ch. 7 – Common Themes: Open Water Experimentation

- Controlled in situ field trials using real oils.
- Use of spills of opportunity as appropriate.

Image Credit: NOAA

Ch. 7 – Common Themes: Oil in the Arctic

Fate and effects of oil in the Arctic marine ecosystem:

- Baseline surveys,
- Response and mitigation options,
- Remediation strategies, and
- Ecosystem effects in Arctic waters and shorelines.

Image Credit: NOAA

Ch. 7 – Common Themes: New Fuels

- Composition, toxicity, and behavior of new types of fuels, such as diluted bitumen and low sulfur fuel oils.
- Understand their fates and effects to inform effective response.

Image Credit: EPA

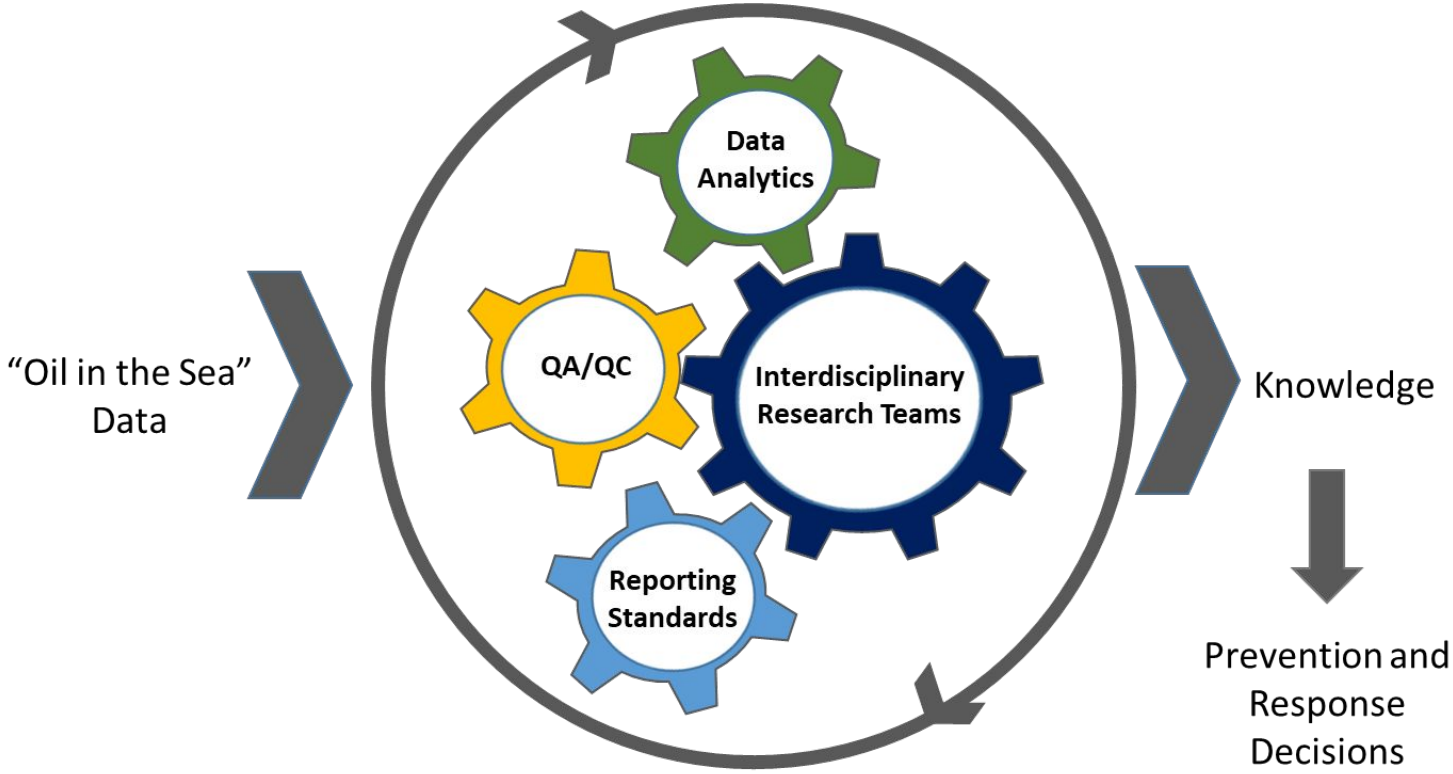
Ch. 7 – Common Themes: Baseline Data and Knowledge

- A review to determine what is needed for baseline knowledge.
- Established funding for collecting data in high-risk areas.
- Process for rapid data collection in event of a spill – control areas.

Image Credit: NOAA

Ch. 7 – Common Themes: Interdisciplinary Research

- Free and accessible repository for pertinent "oil in the sea" data from:
  - Chemical analyses,
  - Omics techniques,
  - Geoscience surveys, and
  - Field and laboratory studies.
- Data analytics, QA/QC, reporting standards.
- Integration and interpretation by interdisciplinary teams.

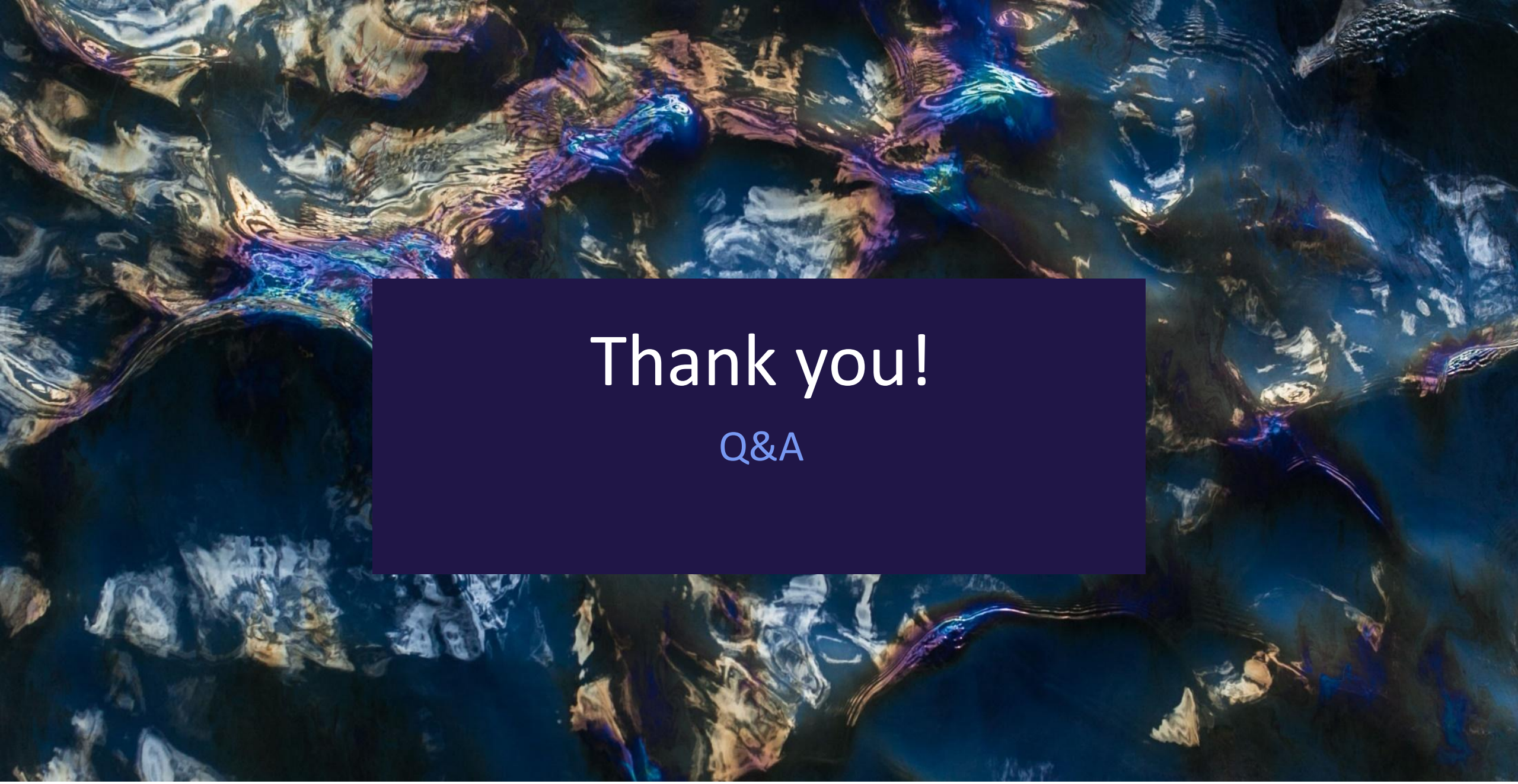


Defining Roles and Responsibilities

Recommendation—Defining Roles and Responsibilities: In light of the complexity of agency responsibilities for oil in the sea and recent reorganizations of many of these agencies, the Committee recommends the roles and responsibilities of various authorities involved in overseeing the oil and gas industry and marine environmental protection should be clarified in order to make specific recommendations to these authorities. Specific to the U.S., the committee recommends that the Interagency Coordinating Committee on Oil Pollution Research examine the recommendations, assign responsibility, and form a working group to further explore potential funding mechanisms such as the Oil Spill Liability Trust Fund.

Key Takeaways

- Available data are inadequate for accurate quantification of most inputs.
- Estimates of land-based inputs, by far, outweigh all other sources.
- Future sources of oil in the sea may look different due to, e.g., intense weather, sea level rise, aging infrastructure, new shipping routes, and new fuels. The broad oil spill community should be prepared for these new challenges.
- Unprecedented progress has been made in understanding oil spill science in the last two decades.
- Sustained funding is needed to continue progress and adapt to changing parameters.
- Human health effects of oil include adverse individual and community harm.
- Many research gaps remain in understanding fates and effects of oil in the sea that, if filled, could inform more effective and efficient response in a changing environment (baseline and co-stressors).



Thank you!

Q&A

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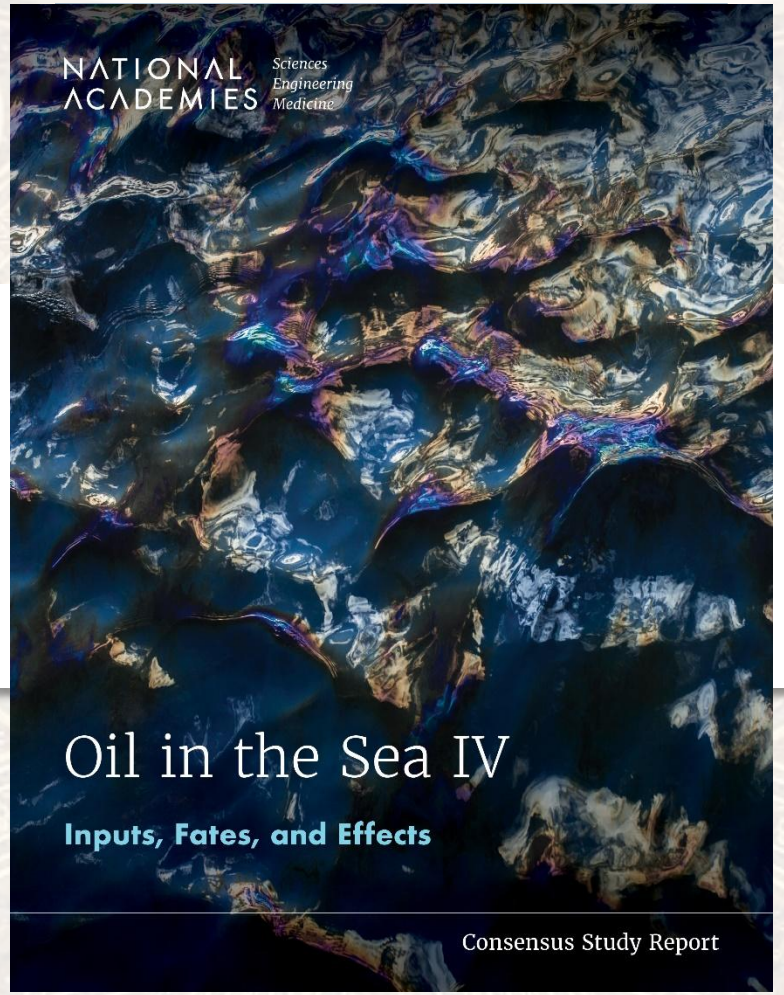

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