Interagency Coordinating Committee on Oil Pollution Research: FY 2020-2021 Activities

Report to Congress

July, 18, 2023

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Message from the U.S. Coast Guard Chief, Office of Marine Environmental Response Policy

July 18, 2023

The *Oil Pollution Act of 1990* requires the Chairman of the Interagency Coordinating Committee on Oil Pollution Research to submit biennial reports on the Interagency Committee's activities. The U.S. Coast Guard chairs the Interagency Committee and first reported to Congress in 1994. This report responds to the latest Congressional requirements.

The Interagency Committee member agencies addressed gaps in oil pollution research by leveraging the collective skills and resources of their research agendas as well as those of state and local governments, industry, and academia. This approach helped reduce duplication of efforts and advanced the state of oil pollution research.

The Interagency Committee's member agencies continued their high level of activity over the past two years. Collectively, they conducted and sponsored 125 oil pollution related research projects and published more than 192 reports and papers. The Interagency Committee, as a coordinating body, continued to promote coordinated and collaborative research through its outreach to industry, academia, research institutions, state governments, and other nations.

Pursuant to Congressional requirements, this report is provided to the following members of Congress:

The Honorable Maria Cantwell
Chair, Senate Committee on Commerce, Science, and Transportation

The Honorable Ted Cruz
Ranking Member, Senate Committee on Commerce, Science, and Transportation

The Honorable Sam Graves
Chairman, House Committee on Transportation and Infrastructure

The Honorable Rick Larsen
Ranking Member, House Committee on Transportation and Infrastructure.

I would be pleased to answer any questions you may have, or your staff may contact the Coast Guard's Senate Liaison Office at (202) 224-2913 or House Liaison Office at (202) 225-4775.

Sincerely,

Trey Wirth
Captain, U.S. Coast Guard
Chair, Interagency Coordinating Committee
on Oil Pollution Research

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I. Executive Summary

Title VII of the *Oil Pollution Act of 1990* (OPA 90) (Pub. L. No. 101-380) established the Interagency Coordinating Committee on Oil Pollution Research (referred to as the "Interagency Committee") to "coordinate a comprehensive program of oil pollution research, technology development, and demonstration among the federal agencies, in cooperation and coordination with industry, universities, research institutions, state governments, and other nations, as appropriate" and to "foster cost-effective research mechanisms, including the joint funding of research." This report discusses Interagency Committee activities carried out in fiscal years (FY) 2020 and 2021, as well as activities in progress and proposed for FY 2022 and 2023.

The Interagency Committee advanced the state of oil pollution research through its activities and member agencies' research agendas. The Interagency Committee identified research gaps and coordinated the collective skills and resources of the federal member agencies with those of state and local governments, industry, and academia. Over the current reporting period, this approach was effective in reducing duplication of efforts and capitalizing on individual agency strengths.

In FY 2020-2021, member agencies continued to oversee a large number of research projects related to the prevention of, preparedness for, and response to oil spills. Overall, there were 125 active member projects during the reporting period, and member agencies generated over 192 publications from their funded research.

In September 2015, the Interagency Committee released its FY 2015-2021 Oil Pollution Research and Technology Plan (OPRTP), which established a research framework grouped into four broad classes: Prevention, Preparedness, Response, and Injury Assessment and Restoration. The OPRTP further classified and prioritized research within the classes into 25 Standing Research Areas (SRA), representing the most common research themes encountered for oil spills. The Interagency Committee established 150 research priorities across the 25 SRA. In 2020-2021, the Interagency Committee focused their efforts on continuing to promote research and development in the four research classes.

During this reporting period, member agency research addressed 68 percent (17 out of 25) of SRA, and 30 percent of the 150 research priorities identified in the OPRTP.

In FY 2021, the Interagency Committee convened a steering group that assessed the status of priorities in the 2015-2021 OPRTP and evaluated newly identified research needs. The steering group drafted an updated OPRTP with an updated set of priorities. The full Interagency Committee approved and published a new 2022-2027 OPRTP in FY 2022.

The Interagency Committee encouraged member agency participation in key oil spill related workshops and conferences. Several member agencies sponsored and took leadership roles in planning and conducting major conferences including the International Oil Spill Conference, Clean Gulf and Clean Pacific Conferences, the Offshore Technology Conference, and the Gulf of Mexico (GOM) Oil Spill and Ecosystem Science Conferences. These conferences and workshops were a vital component of the Interagency Committee's abilities to stay abreast of the latest research initiatives.

The Interagency Committee's future initiatives include the continued increase of joint interagency research initiatives, tracking and monitoring efforts under the OPRTP, developing a formalized public communications outreach strategy, and exploring best practices of transition from research to operations for spill response. These initiatives were first introduced in the FY 2016-2017 report and the committee's member agencies have been actively incorporating these initiatives over the past two years. It is important to note that the continuation of the initiatives is essential to the Interagency Committee's success in the future.

II. Legislative Requirement

This report responds to the language set forth in Section 7001(e) of the *Oil Pollution Act of 1990* (Pub. L. No. 101-380), as per the following:

> **SEC. 7001. OIL POLLUTION RESEARCH AND DEVELOPMENT PROGRAM.**
>
> "(e) BIENNIAL REPORTS - The Chairman of the Interagency Committee shall submit to Congress every 2 years on October 30 a report on the activities carried out under this section in the preceding 2 fiscal years, and on activities proposed to be carried out under this section in the current 2 fiscal year period."

III. Background and Legacy Obligations

Purpose of the Interagency Committee

As prescribed by law, the purpose of the Interagency Committee is: (1) to coordinate a comprehensive program of oil pollution research, technology development, and demonstration among the federal agencies; and (2) to promote cooperation with industry, universities, research institutions, state governments, and other nations through information sharing, coordinated planning, and joint funding of projects.

Membership

The Interagency Committee expanded its membership in FY 2021 to 16 agencies with the addition of the U.S. Geological Survey. The 16 independent agencies, departments, and department components represented on the Interagency Committee are:

- Department of Commerce, represented by:
    - National Oceanic and Atmospheric Administration (NOAA)
    - National Institute of Standards and Technology

- Department of Energy (DOE)

- Department of the Interior (DOI), represented by:
    - Bureau of Safety and Environmental Enforcement (BSEE)
    - Bureau of Ocean Energy Management (BOEM)
    - U.S. Fish and Wildlife Service (USFWS)
    - U.S. Geological Survey (USGS)

- Department of Transportation, represented by:
    - Maritime Administration
    - Pipeline and Hazardous Materials Safety Administration (PHMSA)

- Department of Defense represented by:
    - U.S. Army Corps of Engineers (USACE)
    - U.S. Navy

- Environmental Protection Agency (EPA)

- National Aeronautics and Space Administration (NASA)

- Department of Homeland Security (DHS), represented by:
    - U.S. Coast Guard (USCG)
    - Federal Emergency Management Agency

- U.S. Arctic Research Commission (USARC)

Guided by Section 7001(c) of OPA 90, the Interagency Committee monitors, supports, and publicizes a variety of oil pollution research and development initiatives with industry, universities, research institutions, state governments, and other entities. Several ventures were completed in the first decade of the Interagency Committee's existence, while others continue to progress through the current reporting period. Listed below are key initiatives, identified in Section 7001(c)[1]:

Oil Pollution Technology Research: The cornerstone of the Interagency Committee's role and activities is the research that is funded, monitored, conducted, and coordinated by its members. Section IV of this report includes highlights of several member agency's research initiatives. The selected initiatives illustrate a small sample of the diverse research coordinated by the Interagency Committee. Appendix B includes a listing of specific projects overseen by member agencies, with further details on the Interagency Committee's website: http://www.dco.uscg.mil/iccopr.

Simulated Environmental Testing: Section 7001(c)(7) directed agencies of the Interagency Committee to ensure the long-term use and operation of Oil and Hazardous Materials Simulated Environmental Test Tank (Ohmsett) - the National Oil Spill Response Research & Renewable Energy Test Facility. BSEE continues to operate and maintain Ohmsett, which is located in Leonardo, New Jersey. Ohmsett provides independent and objective performance testing of full-scale oil spill response equipment and marine renewable energy systems (wave energy conversion devices). It is the largest outdoor saltwater wave/tow tank facility in North America and is the only facility where full-scale oil spill response equipment testing, research, and training can be conducted in a simulated marine environment using real oil under controlled environmental conditions. The Ohmsett facility can simulate varying wave conditions (such as breaking waves), drift ice conditions, and vessel movement up to six knots with the movable bridges. For more information on Ohmsett's capabilities and current projects, see http://www.ohmsett.com.

During FY 2021, BSEE temporarily closed the Ohmsett to perform periodic tank repairs and refurbish the facility. This action is conducted approximately every five years to mitigate the effects of deterioration and corrosion caused by the saline environment. The repairs and refurbishment of the Ohmsett facility will improve functionality of the facility for testing and ensure its long-term use and operation.

Regional Research Grant Program: Section 7001(c)(8) authorized a Regional Research Program. Funding. The program was not appropriated in FY 2020-2021.[2]

[1] Other key requirements under this section of OPA 90 were completed, including demonstrations under Section 7001(c)(6). Technical demonstrations were held during the triennial International Oil Spill Conference in 2017 and 2020.

[2] Last appropriation for this program was in 1995.

IV. Interagency Committee Activities

The Interagency Committee pursued a diverse set of activities during this reporting period. These activities addressed Government Accountability Office (GAO) recommendations[3,4] and emerging and continuing oil pollution research needs. The research activities of the member agencies, coordinated through the Interagency Committee, focused on research priorities, as identified in the OPRTP.

OPRTP Updates

Update the Oil Pollution Research and Technology Plan: The Interagency Committee continues to use its Oil Pollution Research Categorization Framework as a tool to track and measure research progress within the government, academia, and industry. The Interagency Committee approved and published a new 2022-2027 OPRTP in FY 2022. This new OPRTP was submitted to the National Academies of Sciences for a peer review. The Interagency Committee will continue to release revised versions of the OPRTP every six years to reflect timely conditions and needs.

Organizational Changes

Leadership Changes: BSEE served as the Vice Chair during the reporting period in accordance with the rotational assignments between NOAA, BSEE, and EPA under the 2013 revised Interagency Charter. However, the *Elijah J. Cummings Coast Guard Authorization Act of 2020* eliminated the rotational assignments by designating NOAA as the Vice Chair agency. NOAA assumed the permanent Vice Chair position in quarter three of FY 2021.

Interagency Committee Meetings

The Interagency Committee meetings are traditionally conducted in person with remote access available. The health risks of the COVID-19 pandemic and related safety precautions precluded in-person meetings during most of the reporting period. The Interagency Committee maintained its quarterly meeting schedule by changing to a fully virtual format. The Interagency Committee formally met nine times during FY 2020-2021. These meetings are outlined below and included quarterly and special meetings of the membership, and engagement with the Prince William Sound Regional Citizens' Advisory Council (PWSRCAC).

- December 11, 2019 – In Person: Quarterly Meeting
    - Main Themes: Gulf Research Program (GRP) Overview, USCG Unmanned Aerial Systems (UAS) Program, Remote Sensing, Norway Arctic Efforts.
- March 18, 2020 – Virtual: Quarterly Meeting
    - Maine Themes: Natural Resources Oil Spill Challenge, status of Report to Congress, and 2022-2027 Research and Technology (R&T) plan efforts.

[3] Government Accountability Office, Federal Oil and Gas: Interagency Needs to Better Coordinate Research on Oil Pollution Prevention and Response. GAO-11-319, March 2011

[4] Government Accountability Office, Oil Dispersants: Additional Research Needed, Particularly on Subsurface and Arctic Applications. GAO-12-585, May 2012

- June 24, 2020 – Virtual: Quarterly Meeting
    - Main Themes: Biennial Report to Congress, 2022-2027 R&T Plan efforts, International Oil Spill Conference (IOSC) 2020 report.
- September 16, 2020 – Virtual: Quarterly Meeting
    - Main Themes: Sponge technology, engineering of pipelines and lead causes to spills.
- November 09, 2020 – Virtual: PWSRCAC Meeting.
- December 09-10, 2020 – Virtual: Quarterly Meeting
    - Main Themes: International initiatives from Norwegian Coastal Administration, Deep Water Horizon short and long-term impacts on wetland microbial processes, Offshore platform integrity and lifespan.
- March 24-25, 2021 – Virtual: Quarterly Meeting
    - Main Themes: Wellhead burning in the arctic during blowouts, Shoreline Response Decision Making with international partners, National Academy of Sciences (NAS) report on Oil in the Sea IV.
- June 23, 2021 – Virtual: Quarterly Meeting
    - Main Themes: USGS Membership welcome, USGS inland research, Biennial Report to Congress efforts.
- September 21, 2021 – Virtual: Quarterly Meeting
    - Main Themes: Introduce NOAA as new Vice Chair, Coastal Response and Research Center (CRRC) R&T Plan close out meeting. Canada Multi-Partner Research Initiative (MPRI) update.

During the quarterly meetings, the Interagency Committee shared information on recent research projects, identified new research issues, hosted presenters from government agencies, industry, and academia, and developed strategies for future initiatives. At each meeting, the member agencies were provided an opportunity to share their research updates. These updates prompted increased collaboration within the membership by fostering new ideas and opportunities for joint agency projects or new initiatives.

The meeting with PWSRCAC provided an opportunity for Interagency Committee members to share information with this stakeholder organization and to hear their issues and perspectives on research needs. The Interagency Committee has conducted these annual information exchange meetings with PWSRCAC since FY 2013.

GAO Audit

During FY 2018, the GAO conducted an audit which was published in January 2019 as GAO 19-31. GAO 19-31 examined the status of federal oil spill research efforts by the Interagency Committee and how coordination has changed since the GAO last reported on it in March 2011. The GAO requested funding data and project information on oil spill research from all 15 member agencies[5] of the Interagency Committee. Additionally, GAO interviewed representatives at each of the member agencies and compared their coordination efforts to one of the federal leading practices for interagency collaboration to evaluate the Interagency Committee's efforts to coordinate oil spill research. Documents, including the 2013 Interagency Committee membership charter, Biennial Reports to Congress dating back to FY 2008, and the Interagency Committee's

[5] The GAO audit was conducted prior to USGS membership.

FY 2015-2021 Research and Technology Plan, were reviewed and several Interagency Committee quarterly meetings were attended by the GAO Audit team. The GAO Audit resulted in two recommendations for the Interagency Committee: (1) Develop a more systematic process to identify and consult with key non-federal stakeholders such as National Resource Damage Assessment (NRDA) trustee councils (specifically large restoration funds from Exxon Valdez and Deepwater Horizon oil spills), and (2) Review the Committee's membership to determine whether additional agencies would provide beneficial contributions.

The Interagency Committee is developing a systematic method for conducting membership evaluations as recommended by the GAO. The Interagency Committee Executive Director, under direction of the Chair, is working with members agencies to evaluate additional federal agencies that would be an asset to the Interagency Committee. Additionally, the Executive Director works with NRDA trustee councils to ensure that the executive action tasks from the GAO Audit are completed. It is imperative that Interagency Committee research is aligned with the NRDA trustee councils' missions. The two executive action tasks are an ongoing effort and will continue to be addressed and evaluated as the Interagency Committee moves forward.

Member Research and Technology Initiatives

Member agencies conducted research activities within the constraints imposed by COVID-19 health restrictions implemented throughout the world during most of the reporting period. Access to research facilities such as Ohmsett and Cold Regions Research and Engineering Laboratory (CRREL) was limited and two-week quarantine requirements in most locations made it impractical, or prohibitively expensive, to travel for research. Several research initiatives were postponed until they could be conducted safely. This affected the total number of research projects completed during this period.

An analysis was completed on the 125 projects carried out by member agencies during this reporting period[6] to assess the federal government's research relative to the OPRTP. During this reporting period, member agencies conducted research in 68 percent (17 out of 25) SRA, and addressed 30 percent of the 150 research priorities identified in the OPRTP. In many instances, research was conducted in the additional priority areas by other entities such as federal agencies not currently represented on the Interagency Committee, or by state, local, academic, and industry researchers.

Highlights of a small sampling of the research projects conducted or initiated by agencies of the Interagency Committee are presented below. These selected projects illustrate the value of the Interagency Committee's coordinated approach to conducting research, and the cross pollination of ideas, expertise, and resources. Appendix B includes a complete list of projects conducted by the Interagency Committee members in FY 2020-2021[7].

[6] Projects that have been initiated, on-going and/or completed during FY 2020-2021.
[7] More detail on these projects, as well as publications, can be found through the Interagency Committee website: http://www.dco.uscg.mil/iccopr

Prevention Research Class:

Oil Spill Occurrence Estimators for Onshore and Offshore Crude and Refined Oil Spills on the Alaska North Slope and Cook Inlet, Alaska**:** The primary objective of the BOEM funded project is to evaluate causal factors of actual and potential onshore and offshore oil spills in Alaska's North Slope and Cook Inlet. An additional objective of the project is to develop a likelihood spill occurrence estimator that is suitable for use both onshore and Alaska State offshore oil spills. The occurrence estimator will have the capability to provide a model for both small and large oil spills in and adjacent to Cook Inlet, which utilizes an appropriate exposure variable. Researchers are addressing issues associated with petroleum hydrocarbon spill data as it relates to the number, volume, and likelihood of occurrence of this spill type in accordance with supporting the National Environmental Policy Act impact potentials for the Beaufort and Chukchi Seas, as well as the Cook Inlet. This project is a collaboration between BOEM and BSEE, highlighting the Interagency Coordinating Committee on Oil Pollution Research's (ICCOPR) mission to coordinate interagency collaboration with research and development.

Assessing Current and Future Infrastructure Hazards – Aging Infrastructure: The history of drilling is associated with a complex network of infrastructure including pipelines, platforms, subsea installations, ports, and terminals. The present-day offshore infrastructure in the GOM was designed with a twenty to thirty year life span. This DOE funded project will utilize data, big data computing, and advanced analytics to evaluate the condition of the current infrastructure and drive analyses to assess potential infrastructure hazards and optimize the development and deployment of existing and new infrastructure technologies in the offshore environment.

Preparedness Research Class:

Population Connectivity of Deepwater Corals in the Northern Gulf of Mexico: In partnership with Lehigh University, Harvey Mudd University, and the Georgia Institute of Technology, this NOAA funded Resources and Ecosystems Sustainability Tourist Opportunities and Revived Economies (RESTORE) project is a collaboration between an Interagency Committee and academic research institutions. This project will determine where the corals in different mesophotic (15-150 meters) and deepwater (150-2400 meters) populations in the GOM originated from. Vital information on the origination of the corals will aid in the conservation and restoration of these important habitats that were damaged by the Deepwater Horizon oil spill. This collaborative effort will enhance the understanding of GOM coral ecosystems with concrete restoration and conservation initiatives to ensure recovery of degraded deepwater coral communities. The information gained from this project will aid in decision-making regarding establishment of Marine Protected Areas by the Gulf of Mexico Fishery Management Council.

Response Research Class:

Advancing UAS and Autonomous Underwater Vehicle (AUV) Capabilities to Characterize Water Column and Surface Oil in Ice Environments: This project is a joint collaborative effort between USCG and NOAA with significant support from CRREL to develop and test new remote sensing tools and technologies to better detect and characterize surface oil in icy waters (such as in the Arctic or Great Lakes). The project is building upon previous NOAA and BSEE work in ice-free water.

Freshwater In-Situ Oil Burn Research: This project is funded by the Great Lakes Restoration Initiative administered by the EPA. This project seeks to improve In-Situ Burn **(**ISB) knowledge for conducting ISB in freshwater (such as the Great Lakes) and is being led by USCG. The USCG has collaborated with EPA and CRREL on various tests under this project including leveraging EPA air monitoring sensors and analysis expertise, and providing EPA samples of fresh on-water burn residue to support separate EPA research.

Injury Assessment and Restoration Research Class:

Toxicity and Biodegradability of Crude Oil Exposed to Surface Washing Agents (SWA) and Chemical Herders: This EPA project is funded through the Canadian MPRI program. The research project expands the knowledge base of using National Contingency Plan (NCP) Product Schedule chemical treating agents on petroleum oils (weathered and fresh) via (1) determining the sensitivity of cold-water species to oils treated with chemical agents and ISB, (2) assessing the ecological relevance of laboratory toxicity tests, and (3) characterizing biodegradation of oil exposed to treating agents by high-latitude microbial cultures. This information is useful during oil spill response efforts, as well as for fate and transport models.

Chemistry and Toxicity of Polar Compounds in Oil: In collaboration with Bigelow Marine Lab and University of California (UC) Davis, this NOAA led project with EPA is conducting studies in relation to polar and non-polar oil compounds. These studies will quantify the relative mechanisms and potencies of polar and non-polar oil compounds utilizing weathered oil water-accommodated fractions and *Fundulus heteroclitus,* a small killfish that is found along the Atlantic Coast of the United States and Canada.

While there is a large body of research being conducted by the Interagency Committee member agencies, additional advancements, in oil pollution research being driven outside the federal government, are helping to bridge gaps in research. The Interagency Committee also monitors a variety of oil spill research projects funded by other non-Committee entities.

Member Collaboration and Ongoing Initiatives

In addition to the specific research projects, some member agencies prepared joint research strategies and initiatives and presented them to the Interagency Committee. These initiatives provide pathways for further research collaboration. They include:

Coordinating Recent Advances in Estimating and Measuring Oil Slick Thickness: In November 2019, NOAA's Office of Response and Restoration, the CRRC, and the BSEE hosted a workshop that brought together international experts working on advancing technology to better determine oil thickness and overall slick characterization. The Canadian Oceans Protection Plan's MPRI. The workshop was the first phase of a multi-year grant to NOAA from the Canadian Oceans Protection Plan's MPRI. Following the workshop, a series of vendors participated in experiments conducted by CRRC at the University of New Hampshire using an indoor test tank to measure and compare various remote sensing and destructive techniques used for characterizing oil thickness. The thicknesses were not disclosed to the participants, and the measurements were validated using a camera to determine the surface area which was used to estimate average slick thickness. Tank tests are scheduled in the Spring of 2022 for Ohmsett to determine field readiness levels and performance of the different technologies.

BSEE/USCG Quality Partnership: Through this partnership, the USCG and BSEE coordinated strategic policy and oil spill preparedness and response in the offshore environment. BSEE and the USCG coordinated their research and development priorities to align their on-going and future research and development project portfolios, allowing for greater synergies. BSEE included a USCG representative in the annual research project evaluation and selection process.
Arctic Domain Awareness Center (ADAC): ADAC, a DHS Science and Technology (S&T) Center of Excellence, was established to provide mission-focused support to USCG operations in the high latitudes. Its mission is to develop and transition technology solutions, innovative products, and educational programs to improve situational awareness and crisis response capabilities related to maritime challenges, including oil spill response, posed by the dynamic Arctic environment. Interagency Committee member agencies are integral advisors to and members/customers of the research conducted by ADAC and its network of academic researchers.

Oil in the Sea, IV: Inputs, Fates, and Effects: BOEM funded the National Academies of Sciences, Engineering, and Medicine (NASEM) on producing "Oil in the Sea, IV: Inputs, Fates, and Effects" report along with other federal, industry, non-profit, and international partners. The partnership includes American Petroleum Institute, BSEE, Fisheries and Oceans Canada, Gulf of Mexico Research Initiative (GoMRI), and NASEM's Presidents' Circle Fund. An ad hoc committee on *Oil in the Sea IV* will provide an update of the previous report's (Oil in the Sea III: Inputs, Fates, and Effects, 2003) inventory of the sources, composition, and quantity of hydrocarbon inputs to the marine environment, and provide assessment of the fate and effects of fossil fuel hydrocarbons in the marine environment. The focus will be on North American waters, but the committee will examine worldwide data to contextualize the North American waters against rest of the world. For more details, please visit: https://www.nationalacademies.org/our-work/oil-in-the-sea-iv-inputs-fates-and-effects.

BSEE/NOAA Partnership: This BSEE and NOAA partnership features a multidisciplinary team of scientists from agencies and academia such as BSEE, EPA, NOAA, USCG, NASA, Fisheries and Ocean Canada, Woods Hole Oceanographic Institute (WHOI), University of New Hampshire (UNH), University of South Florida (USF), as well as industry partners. Research partners collaborate on numerous projects in an effort to advance oil spill response, including surface oil and oil in the water column characterization. The research extends beyond the laboratory setting, including testing at BSEE's Ohmsett facility, as well as open water testing.

External Interagency Committee Collaborations

Coordination and cooperation with external stakeholders are critical to advancing oil pollution research in the United States. During the reporting period, the Interagency Committee pursued collaboration with numerous external oil spill related programs through direct engagement and participation in joint meetings, forums, and workgroups.

National Academy of Sciences' (NAS) Gulf Research Program (GRP): The Interagency Committee members met with NAS GRP Advisory board members and staff several times to help shape future NAS GRP grant opportunities, in alignment with OPRTP. These interactions satisfy the requirements of the British Petroleum and Transocean Settlement Agreements for the NAS GRP to annually seek the advice of the Interagency Committee on the program direction. Interagency members also participated in several NAS workshops across the spectrum of oil spill response.

Prince William Sound Regional Citizen's Advisory Council (PWSRCAC): The Interagency Committee and the PWSRCAC continued their annual meetings that began in 2013 to share current and future research initiatives, as well as results of studies of interest conducted by the members of both organizations. The Interagency Committee and PWSRCAC met once virtually over this reporting period.
Gulf of Mexico Research Initiative (GoMRI): GoMRI and Interagency Committee members collaborated on and shared research information throughout the program's 10-year life, which ended in 2021. The head of the GoMRI Sea Grant Oil Spill Outreach Team annually attended Interagency Committee quarterly meetings to present updates on their research. In addition, Interagency Committee members collaborated with GoMRI researchers on specific research projects as well as an initiative to document scientific achievements related to oil spill research.

During this biennium, GoMRI launched and completed its Synthesis and Legacy effort to "document and exploit scientific achievements and advances, with the idea that synthesis will lead to new understanding and improved practices. …" This effort, which involved several Interagency Committee member representatives, documents the results of the program, and provides important information for the research community and valuable input to the Interagency Committee work on the next Research and Technology Plan.

Member Agency Participation in Workshops and Conferences

Each year a variety of workshops and conferences are held that address various facets of the petroleum industry and oil pollution research. The Interagency Committee members use these platforms as an opportunity to share their research findings, and monitor them to stay abreast of the latest topics, and issues, that support on-going and future research initiatives. During the reporting period, the Interagency Committee's member organizations participated in or directly sponsored many of these workshops and conferences, including:

International Oil Spill Conference (IOSC): The IOSC is a triennial conference that attracts international and domestic attendees. It is the largest of three conferences conducted by five Interagency Committee member agencies are on the permanent conference committee for IOSC: USCG, BSEE, NOAA, EPA, and PHMSA. The IOSC was held again during this biennial report period in 2021. Regularly scheduled meetings have been held with the IOSC Executive Committee throughout this biennial report period.

Gulf of Mexico Oil Spill and Ecosystem Science (GoMOSES): Sponsored by GoMRI, the annual conference linked fundamental research on the GOM ecosystem with potential practical applications. During this reporting period, the Interagency Committee members served on the planning committee for the GoMOSES 2020 conference, participated as session and panel leaders, and presented numerous presentations on their oil spill related research during two conferences. A conference was not held in 2021.

Clean Gulf/Clean Pacific/Clean Waterways Series: These regional conferences focused on improving oil and hazardous materials spill prevention, preparedness, and response for inland, offshore, and coastal incidents.

Offshore Technology Conference (OTC): DOE representatives attended the OTC in Houston, TX. The OTC is the world's largest oil and gas sector trade show, where energy professionals meet to exchange ideas and opinions to advance scientific and technical knowledge for offshore resources and environmental matters.

Website and Other Outreach

The Interagency Committee continued to provide information through its website http://www.dco.uscg.mil/iccopr. The website provides data on research projects in accordance with the OPRTP. In addition, member agencies continued using their websites as tools to convey information on research initiatives to partners and the public. The Interagency Committee website contains links to each member's site.

Several member agencies published periodic newsletters that highlighted agency activities, including oil spill-related research. Examples include the BOEM Ocean Science quarterly newsletter, BSEE's semi-annual Ohmsett Gazette, USARC Arctic Daily Update by e-mail, the USFWS News, and several NOAA programmatic newsletters.

V. Future Activities

The Interagency Committee will continue to promote research and development in the four research classes: Preparedness, Prevention, Response, and Injury Assessment and Restoration. The Interagency Committee plans to conduct the following future actions:

Work with the National Academy of Sciences (NAS) Gulf Research Program (GRP): The Interagency Committee will continue to work closely with NAS as it executes the 30-year NAS GRP that is "focused on human health and environmental protection including issues relating to offshore oil and hydrocarbon production and transportation in the Gulf of Mexico and on the United States' outer continental shelf."

Continue Outreach to Non-Federal Stakeholders: The Interagency Committee will continue to engage non-federal stakeholders to gain insights into additional research needs, share research results and ideas, and promote advancements in the state of oil pollution research and technology. The upcoming year will include an increased focus on coordination with industry, and academic research programs.

Address Emerging Issues and Challenges: The Interagency Committee will continue to monitor technological advancements for oil spill prevention and response, as well as the conditions that increase the risk of oil spills.

Evaluate the Committee Membership: The Interagency Committee will continue its standing practice of evaluating other federal agencies for membership, as recommended by the GAO Audit. This practice led to the addition of the USGS as a member.

Coordinate With the Trustee Councils: The Interagency Committee will reach out to the Exxon Valdez and Deepwater Horizon NRDA Trustee Councils to determine if there are research areas of mutual interest and value to the parties. This may include periodic participation in meetings or other collaborative efforts.

Encourage Transition of Research to Operations: The Interagency Committee will examine the best practices of member agencies skilled at transitioning research to operations and will seek to accelerate this transition for promising Interagency Committee priority research areas.

Appendix A: List of Acronyms

ADAC	Arctic Domain Awareness Center
ADIOS	Automated Data Inquiry for Oil Spills
ASTM	American Society for Testing and Materials
AUV	Autonomous Underwater Vehicle
bbl	Barrels
BOE	Barrels of Oil Equivalent
BOEM	Bureau of Ocean Energy Management
BNR	Boron Nitride Nanoribbons
BSEE	Bureau of Safety and Environmental Enforcement
CFD	Computational Fluid Dynamics
CFR	Code of Federal Regulations
cLMS	climatological Lagrangian Coherent Structures
CSM-CHR	Colorado School of Mines Center for Hydrate Research
CRRC	Coastal Response Research Center
CRREL	Cold Regions Research and Engineering Laboratory
DCPT	Displacement Current Phase Tomography
DDO	Dispersants and Dispersed Oil
DESERT	Design, Simulate, Emulate and Realize Test-beds
DFO	Department of Fisheries and Oceans Canada
DHS	United States Department of Homeland Security
DOE	United States Department of Energy
DOI	United States Department of the Interior
ECT	Electrical Capacitance Tomography
ECVT	Electrical Capacitance Volume Tomography
EPA	United States Environmental Protection Agency
ERSP	Estimated Recovery System Potential
FECM	Fossil Energy and Carbon Management
fsw	Feet of Sea Water
FY	Fiscal Year
GAO	U.S. Government Accountability Office
GC-MS	Mass Spectrometry
GNOME	General NOAA Operational Modeling
GOM	Gulf of Mexico
GoMOSES	Gulf of Mexico Oil Spill and Ecosystem Science
GoMRI	Gulf of Mexico Research Initiative
GRP	Gulf Research Program

HDD	Horizontal Directional Drilling
HPHT	High Pressure High Temperature
ICCOPR	Interagency Coordinating Committee on Oil Pollution Research
IOSC	International Oil Spill Conference
ISB	In-Situ Burn
ITAC	Industry Technical Advisory Committee
JIP	Joint Industry Project
JMTF	Joint Maritime Training Facility
LiDAR	Light Detection and Ranging
LRAUV	Long Range Autonomous Underwater Vehicle
MARES	Marine Arctic Ecosystem Study
MOC	Memorandum of Cooperation
MPRI	Multi-Partner Research Initiative
MWS	Maxwell-Wagner-Sillars Polarization Effect
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NASEM	National Academies of Sciences, Engineering, and Medicine
NCP	National Contingency Plan
nm	Nanometers
NOAA	National Oceanic and Atmospheric Administration
NOPP	National Oceanographic Partnership Program
NRC	National Research Council
NRDA	National Resource Damage Assessment
NRT	National Response Team
OCS	Outer Continental Shelf
Ohmsett	Oil and Hazardous Materials Simulated Environmental Test Tank
OPA 90	Oil Pollution Act of 1990 (Public Law 101-380)
OPA	Oil Particle Aggregrate
ORFEUS	Optimized Radar to Find Every Utility in the Street
OPRTP	Oil Pollution Research and Technology Plan
OSRA	Oil Spill Risk Analysis
OTC	Offshore Technology Conference
PHMSA	Pipeline and Hazardous Materials Safety Administration
PINC	Potential Incident of Non-Compliance
PWSRCAC	Prince William Sound Regional Citizens' Advisory Council
QOS	Quality of Service
R&D	Research and Development
R&T	Research and Technology
REMUS	Remote Environmental Monitoring Unit

RESTORE	Resources and Ecosystems Sustainability Tourist Opportunities and Revived Economies
ROV	Remote Operated Vessels
RVI	Remote Visual Inspection
S&T	Science and Technology
SETAC	Society of Environmental Toxicology and Chemistry
SOM	Sunken Oil Mats
SORS	Spilled Oil Recovery System
SPME	Solid Phase Microextraction
SRA	Standing Research Areas
Sv	Sverdrup
SWA	Surface Washing Agents
UAS	Unmanned Aerial Systems
UC	University of California
ULTRA	Underwater Laser Telemetry and Remote Access
UNH	University of New Hampshire
USACE	United States Army Corps of Engineers
USARC	United States Arctic Research Commission
USCG	United States Coast Guard
USCG RDC	United States Coast Guard Research and Development Center
USF	University of South Florida
USFA	United States Fire Administration
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VAB	Vertical Adhesion Belt
VOSS	Vessel of Opportunity Skimming System
WHOI	Woods Hole Oceanographic Institute

Appendix B: Listing of FY 2020 and 2021 Research Projects and Papers[8]

I. PREVENTION

A. Human Error Factors – Research Projects

1. US Outer Continental Shelf Oil Spill Causal Factors Report (Lead agency: BOEM)
   This study evaluated causal factors of actual and potential oil spills in the GOM, Pacific, and Arctic OCS, extrapolating GOM and Pacific historical oil spill rates to the Arctic.
   GOVPUB-I-2730f07c31b5b7cd19f3f60cbf535ce8.pdf (govinfo.gov)

2. Oil Spill Occurrence Estimators for Onshore and Offshore Crude and Refined Oil Spills on the Alaska North Slope and Cook Inlet, Alaska (Lead agency: BOEM)
   This study evaluated causal factors of actual and potential onshore and offshore oil spills in Alaska's North Slope and Cook Inlet.
   https://marinecadastre.gov/espis/#/search/study/100240

3. Alternative Oil Spill Occurrence Estimators for Determining Rates for the Atlantic Outer Continental Shelf (Lead agency: BOEM)
   This study will examine the BOEM's Atlantic OCS planning areas to predict and validate the most applicable methodologies for determining oil spill occurrence rates.
   https://marinecadastre.gov/espis/#/search/study/100250

B. Human Error Factors – Research Papers: None

C. Offshore Facilities and Systems – Research Projects: None

D. Offshore Facilities and Systems – Research Papers:

1. Oil Spill Occurrence Rates from Alaska North Slope Oil and Gas Exploration, Development, and Production
   A dataset of 1,761 spills was compiled. The full dataset was characterized across oil fields and infrastructure types, as well as presenting the number and volume of spills over time.
   https://espis.boem.gov/final%20reports/BOEM_2020-050.pdf

2. Oil Spill Occurrence Rates for Cook Inlet, Alaska Oil and Gas Exploration, Development, and Production
   Past spills larger than one barrel associated with oil and gas exploration, development, and production were compiled. While 272 in-scope spills were identified between 1966-2019, only those between 1996-2019 were used to identify trends and develop occurrence estimators. Occurrence estimates were also sought for crude and refined spills separately.
   https://espis.boem.gov/final%20reports/BOEM_2020-051.pdf

[8] Further detail on the projects can be found at http://www.dco.uscg.mil/iccopr

3. The Use of Dispersants in Marine Oil Spill Response
   This report builds on two previous National Research Council (NRC) reports on dispersant use (NRC, 1989, 2005) to provide a current understanding of the state of science and to inform future marine oil spill response operations.
   https://marinecadastre.gov/espis/#/search/study/100211

4. Oil Spill Risk Analysis: Conditional Probabilities for the Beaufort Sea Planning Area
   The analysis in this report estimates the probability of contact to offshore and onshore coastal resources from accidental large oil spills occurring from potential OCS oil- and gas-related activities in the Beaufort Sea Planning Area.
   https://www.boem.gov/sites/default/files/documents/environment/BFT-Conditional-Probability.pdf

5. A Multifaceted Approach to Advance Oil Spill Modeling and Physical Oceanographic Research at the United States Bureau of Ocean Energy Management
   This study describes the findings of the BOEM funded oil spill modeling and physical oceanography projects since 2010. Additionally, this paper presents a path forward for BOEM's oil spill modeling and physical oceanographic research.
   https://www.mdpi.com/2077-1312/9/5/542

6. Progress of the Oil Spill Risk Analysis (OSRA) Model and Its Applications
   BOEM conducts OSRA prior to oil and gas lease sales. This paper summarizes some of the OSRA model progress and its applications in the past decade.
   https://www.mdpi.com/2077-1312/9/2/195

E. Onshore Facilities and Systems – Research Projects:

1. Arctic Facilities and Infrastructure Environmental Change Risk Index (Lead agency: DHS and USCG)
   The DHS Arctic Domain Awareness Center is studying environmental change on infrastructure and facilities built on permafrost and to determine the risks to USCG monitored facilities along select U.S. Arctic coastal regions. The term "facilities" is oriented to bulk oil/fuel facilities and/or piers, platforms, and pipelines.

2. Remote Unmanned Aircraft System (UAS) Inspection and Response Team Development in the Bering Strait Region (Lead agency: DHS and USCG)
   The DHS Arctic Domain Awareness Center is conducting experiments using multispectral sensors on a UAS to support infrastructure monitoring, and will co-produce a UAS-based monitoring program for conducting USCG regulated bulk oil facility inspections and emergency response with the Alaska Native Village of Unalakleet.

F. Onshore Facilities and Systems – Research Papers: None

G. Waterways Management – Research Projects: None

H. Waterways Management – Research Papers: None

I. Vessel Design – Research Projects: None

J. Vessel Design – Research Papers: None

K. Drilling – Research Projects:

1. Advanced Casing & Tubing Load and Stress Analysis, Joint Industry Project (JIP) (Lead Agency: BSEE)
   The purpose of the JIP is to provide BSEE with a solution to fully analyze well plan and casing design submitted by operators. It is BSEE's oversight responsibility to ensure a well's mechanical integrity by validating designs.
   https://www.bsee.gov/research-record/advanced-casing-tubing-load-and-stress-analysis-joint-industry-project-jip

2. Arctic 2020-21 Freeze-up / 2021 Break-up Study (Lead Agency: BSEE)
   The purpose of this research is to build upon the knowledge gained from freeze-up studies conducted since 2009 and to build upon the information acquired during the 2017 and 2020 break-up studies, which BSEE will make publicly available. This research will provide an understanding of the events which occur during freeze-up and break-up under present-day conditions and will provide the BSEE Alaska OCS Region with observation and analysis of the annual freeze-up and break-up of Arctic sea ice in the U.S. Beaufort and Chukchi Seas to help inform decision regarding the development of energy and mineral resources.
   https://www.bsee.gov/research-record/arctic-2020-21-freeze-up-2021-break-up-study

3. Offshore Research Portfolio (Lead agency: DOE)
   DOE's offshore research portfolio is a suite of projects supporting the Department of Fossil Energy and Carbon Management (FECM). It is focused on preventing spill prevention with innovative solutions to challenges associated with geohazard prediction, subsurface uncertainty reduction, addressing oil and gas infrastructure integrity, and optimization for new and existing infrastructure systems.

4. Hexagonal Boron Nitrate Reinforced Multifunctional Well Cement for Extreme Conditions (Lead agency: DOE)
   A proof-of-concept hexagonal boron-nitride/cement composite will be developed and tuned to offer optimum slurry formulation and rheological properties under High Pressure High Temperature (HPHT conditions.
   https://netl.doe.gov/project-information?p=FE0031574

5. In-Situ Applied Coatings for Mitigating Gas Hydrate Deposition in Deepwater Operations (Lead agency: DOE)
   Hydrate-phobic coatings in subsea pipelines will be developed to mitigate hydrate deposition in subsea pipelines. The project will include multiphase transient simulation and design of a full-scale field trial.
   https://netl.doe.gov/project-information?p=FE0031578

6. Project Ultra: Underwater Laser Telecommunications and Remote Access (Lead agency: DOE)
   The project is to address bandwidth and parallelism deficiencies in currently available undersea wireless optical communications technologies by using tight beam focused free space optical networks of 450 nanometer (nm) Laser nodes distributed along the sea floor for a highly scalable network backbone connecting a wide array of residency sensors as well as command and control devices.
   https://www.netl.doe.gov/project-information?p=FE0031857

7. Advanced Multi-Dimensional Capacitance Sensors Based Multiphase Mass Flow Meter to Measure and Monitor Offshore Enhanced Oil Recovery Systems (Lead agency: DOE)
   The objective is to demonstrate multi-dimensional extensions of Electrical Capacitance Volume Tomography sensors that involve Displacement Current Phase Tomography, Maxwell-Wagner-Sillars polarization effect, and velocimetry which exploit the variation of electric properties between the oil, water, and gas coming out of the well.
   https://www.netl.doe.gov/project-information?p=FE0031858

8. Enhancing Offshore Recovery by Enabling Longer, Safer, and Cheaper Subsea Well Tiebacks (Lead agency: DOE)
   The project goal is to engineer, build, permit, and deploy a deepwater chemical container for storage of exploration and production liquids in the offshore environment. This shuttle is intended to be a safe, effective, low-cost solution to assist with the monetization of economically stranded resources via subsea wells tied back to existing host facilities.
   https://www.netl.doe.gov/project-information?p=FE0031859

9. Arctic 2019-20 Freeze-up / 2020 Break-up Study of Arctic Sea Ice on the US Beaufort and Chukchi Seas. (Lead Agency: BSEE)
   The purpose of this research is to build upon the knowledge gained from freeze-up studies conducted since 2009 and to build upon the information acquired during the 2017 break-up study, which BSEE will make publicly available. This research will provide an understanding of the events which occur during freeze-up and break-up under present-day conditions and will provide the BSEE Alaska OCS Region with observations and analyses of the annual freeze-up and break-up of Arctic Sea ice in the U.S. Beaufort and Chukchi Seas to help inform decisions regarding the development of energy and mineral resources.
   https://www.bsee.gov/research-record/arctic-2019-20-freeze-up-2020-break-up-study-of-arctic-sea-ice-on-the-us-beaufort

L. *Drilling – Research Papers:*

1. Enabling Longer and Cheaper Subsea Tie-Backs Utilizing Local Subsea Chemical Storage and Injection
   This paper presents compelling economic findings from case study analysis that local, subsea chemical storage and injection can deliver significant savings compared to host platform storage and tube-based umbilical delivery. It then outlines a systematic approach developed for system qualification. Successful deployment of this new technology will greatly facilitate development of hundreds of smaller deep-water resources and billions of barrels (bbl) of oil equivalent (BOE) by enabling safe, cost-effective long distance tie-backs to existing infrastructure out of traditional reach of tube-based umbilicals.
   https://onepetro.org/OTCONF/proceedings-abstract/18OTC/4-18OTC/D041S052R002/179771

2. Qualification and Case Studies Subsea Chemical Storage and Injection Unit
   This paper summarizes results and lessons learned from qualification of a full scale subsea chemical storage and injection system. It also presents compelling findings from case studies that demonstrate the system can deliver significant savings compared to host platform chemical storage and umbilical delivery. Successful deployment of this new technology will initially provide, in brownfield applications, a very attractive alternative to

an umbilical replacement, particularly later in field life when production rates and percent oil tend to be much lower, where economics may all together preclude installing a new umbilical and result in pre-mature field abandonment.
https://onepetro.org/OTCONF/proceedings-abstract/19OTC/2-19OTC/D021S027R003/181105

3. Development and Qualification of a Subsea 3,000 Barrel Pressure Compensated Chemical Storage and Injection System
   This paper presents important findings while executing a detailed qualified design of a large (3,000+ bbls), subsea (to depths of 10,000 feet sea water (fsw)) production chemical storage and injection system. The design drivers for the system were safety first, extensive utilization of existing commercially available equipment/tools/methods, and a re-usable shuttle system that allows for delivery of production chemicals as a service versus the current approach where an operator/owner makes a capital investment. The system is designed to be compatible with existing production chemical formulations and features multiple barrier design between the chemicals and the environment.
   https://onepetro.org/OTCONF/proceedings-abstract/16OTC/3-16OTC/D031S033R007/85632

4. Subsea Broadband Communication Using Underwater Laser Telemetry and Remote Access
   This paper addresses the development of Underwater Laser Telemetry and Remote Access\ (ULTRA), an ultra-long range underwater laser communications system for use in critical points of the subsea communications architecture to increase reliability, operational flexibility, and reduce communication system maintenance associated with physical subsea connections. To demonstrate the data capacity and range of ULTRA, a subscale laboratory point-to-point wireless laser communication system was constructed with the flexibility to transmit through either air or water. The test system used power and modulation frequencies for air, fresh water, and different qualities of seawater.
   https://onepetro.org/OTCONF/proceedings-abstract/19OTC/1-19OTC/D011S002R005/181119

5. Wireless Remote Control for Underwater Vehicles
   New developments inspired many companies to start designing hybrid wireless-driven underwater vehicles specifically tailored for off-shore operations and that are able to behave either as remotely operated vehicles (ROVs) or as autonomous underwater vehicles (AUVs), depending on both the type of mission they are required to perform and the limitations imposed by underwater communication channels. This paper evaluates the actual quality of service (QoS) achievable with an underwater wireless-piloted vehicle, addressing the realistic aspects found in the underwater domain, first reviewing the current state-of-the-art of communication technologies and then proposing the list of application streams needed for control of the underwater vehicle, grouping them in different working modes according to the level of autonomy required by the off-shore mission. The proposed system is finally evaluated by employing the Design, Simulate, Emulate and Realize Test-beds (DESERT) for Underwater network protocol simulation framework by specifically analyzing the QoS that can be provided to each application stream when using a multimodal underwater communication system specifically designed to support different traffic-based QoSs.
   https://www.mdpi.com/2077-1312/8/10/736

6. Electrical Capacitance Volume Tomography (ECVT)
   A dynamic volume imaging based on the principle of electrical capacitance tomography (ECT), namely, ECVT, has been developed in this study. The technique generates, from the measured capacitance, a whole volumetric image of the region enclosed by the geometrically three-dimensional capacitance sensor. This development enables a real-time, 3-D imaging of a moving object or a real-time volume imaging (4-D) to be realized.
   https://ieeexplore.ieee.org/document/4118165

7. Advanced Multi-Dimensional Capacitance Sensors Based Multiphase Mass Flow Meter to Measure and Monitor Offshore Enhanced Oil Recovery Systems
   This innovation is based on advanced multi-dimensional extensions of ECVT sensors that involve Displacement Current Phase Tomography (DCPT), Maxwell-Wagner-Sillars Polarization Effect (MWS), and velocimetry which exploit the variation of electric properties between the oil, water, and gas coming out of the well. Capacitance sensors are embedded on the inside of a pipe spool and placed in line with the subsea oil line piping on the extraction end of the well. The difference in dielectric, dielectric loss, surface polarization, and velocity of each phase are used in the multi-dimensional algorithm to measure the volume fraction, distribution, velocity, mass flow rate, and flow regime of the mixture moving through the pipe.
   https://netl.doe.gov/node/9827

8. Deposition and Corrosion Mitigation using Surface Treatments
   A surface treatment was created with the potential to resist deposition from multiple species, while also protecting pipe surfaces from corrosion. Due to a combination of low surface energy, oleophobicity, and low surface roughness, this surface treatment has been shown to resist deposit formation for multiple flow assurance species. Data from static and flowing systems have been used to show the treatment's effectiveness.
   https://onepetro.org/NACECORR/proceedings-abstract/CORR21/4-CORR21/D041S020R003/463940

9. Evaluation of a Robust, In-Situ Surface Treatment for Pipeline Solids Deposition Mitigation in Flowing Systems
   The purpose of this study is to explore the feasibility of a particular surface treatment as part of a solids management strategy. This work utilizes an omniphobic surface treatment to probe its effects on gas hydrate, asphaltene, and wax deposition. Specifically, high pressure rocking cells are employed to study gas hydrate nucleation and deposition. A bench-scale flowloop filled with crude oil and heptane is used to quantify the deposition of crude oil and asphaltenes after a set time period. Lastly, a mechanical shear device measures the adhesion force of wax deposits on untreated/treated surfaces.
   https://onepetro.org/OTCONF/proceedings-abstract/20OTC/4-20OTC/D041S049R002/107503

10. Deposition Mitigation in Flowing Systems Using Coatings
    This study utilized two material formulations within several experimental setups to probe their interactions with water, gas hydrate, asphaltene, and crude oil. The results serve as part of an ongoing investigation into a surface treatment formulation that can be tested on larger-scale, fully flowing systems, which could be ultimately implemented into real-world production scenarios. The first surface treatment is a water-based polymeric surface that displays repellency to both oil and water phases (omniphobic). Testing of this material

consisted of water contact angle measurements and static asphaltene/crude oil deposition quantification at atmospheric conditions, as well as visual confirmation of hydrate deposition prevention at high pressures. Additionally, an experimental superomniphobic surface treatment, which displays elevated resiliency to both water and hydrocarbons, was also examined within the asphaltene/crude oil test as a comparison to the omniphobic surface treatment. https://onepetro.org/OTCONF/proceedings-abstract/19OTC/1-19OTC/D012S077R010/181227

11. Low-Adhesion Coatings as a Novel Gas Hydrate Mitigation Strategy
    In this study, two coatings were produced and evaluated to determine their effect on hydrate adhesion onto carbon steel surfaces. The coatings used in this study were a super-hydrophobic, anti-icing coating and an omniphobic and corrosion resistant coating. The coatings were applied to substrates in both pristine (no corrosion) and pre-corroded conditions, where the coupon was exposed to a 5. percent salt solution prior to coating. Hydrate/surface interactions were studied using micromechanical adhesion force measurements in both liquid and gas bulk phases. A model sII cyclopentane hydrate (forming the same hydrate structure that is typically formed in subsea flowlines) was utilized at atmospheric pressure for the liquid phase measurements, while the high-pressure measurements were performed using methane/ethane mixed gas hydrate (also sII). Rocking cell tests were also conducted to evaluate the coatings at high pressure under dynamic conditions using methane/ethane mixed gas hydrates and a liquid loading of 70 vol. percent (water + oil). https://onepetro.org/OTCONF/proceedings-abstract/17OTC/4-17OTC/D041S047R007/93771

12. Deposition Mitigation in Flowing Systems Using Coatings
    In pipelines, solid compounds including gas hydrates and asphaltenes may form/precipitate and accumulate on the pipe surface, leading to a gradual stenosis of the flowline. Typically, injected chemicals will either inhibit nucleation or dissolve already-formed deposits to restore original flow conditions back to the system; however, this can be a costly option. Coatings can provide a low surface energy layer on the pipe wall, which restricts liquid and solid accumulation, allowing for a stable slurry flow through a system.
    https://onepetro.org/OTCONF/proceedings-abstract/19OTC/1-19OTC/D012S077R010/181227

13. Flexoelectric Effects in Corrugated Boron Nitride Nanoribbons
    Hexagonal boron nitride monolayer is an isostructural analogue to graphene and promising dielectric. This report focuses on suspended and corrugated boron nitride nanoribbons (BNR) as model systems and report an intriguing flexoelectric polar effect using a series of ab initio-based density functional theory and tight binding calculations. Results decode various synergies of the complex flexoelectrical properties including the role of corrugation height, structural deformation, and orbital mixing in corrugated BNR.
    https://www.proquest.com/openview/f9f600a4f48a75299dac6818f6980d6d/1?pq-origsite=gscholar&cbl=48394

14. Deep Learning to Speed up the Development of Structure-Property Relations For Hexagonal Boron Nitride and Graphene
    Structure–property maps play a key role in accelerated materials discovery. The current norm for developing these maps includes computationally expensive physics-based simulations. The capabilities of deep learning agents are explored such as convolutional

neural networks and multilayer perceptrons to predict structure–property relations and reduce dependence on simulations.
https://onlinelibrary.wiley.com/doi/am-pdf/10.1002/smll.201900656

15. In-Situ Applied Coatings for Mitigating Gas Hydrate Deposition in Deepwater Operations – 2020
    The overall objectives of this research effort are to design, test, and validate robust pipeline coatings for commercial utilization that mitigate hydrate deposition in subsea pipelines. A novel coating developed during a previous DOE sponsored collaboration between the Colorado School of Mines Center for Hydrate Research (CSM-CHR) and Ocean showed promise for hydrate deposition prevention in small-scale apparatuses. The technology and methods to be used in this research will advance and scale-up this concept with second generation hydrate-phobic coatings in larger multiphase flowing systems. Particularly, the CSM-CHR deposition flowloop will be employed to assess the effectiveness of these advanced coatings during steady-state and transient (shut-in/restart) operations. Additionally, the strategy for in-situ application of the coatings to existing pipelines will be developed. The project will include the multiphase transient simulation and design of a full-scale field trial. The research will also evaluate the long-term survivability of the coating under high pressure, variable temperature, chemical exposure, and abrasive conditions.
    https://netl.doe.gov/sites/default/files/netl-file/20VPRONG_26_Koh.pdf

16. In-Situ Applied Coatings for Mitigating Gas Hydrate Deposition in Deepwater Operations – 2019
    The overall objectives of this research effort are to design, test, and validate robust pipeline coatings for commercial utilization that mitigate hydrate deposition in subsea pipelines. A novel coating developed during a previous DOE sponsored collaboration.
    https://netl.doe.gov/sites/default/files/netl-file/Koh-2019-DOE-NETL-Addressing-the-Nation-PPT-CSM-Oceanit-082319.pdf

17. Persistent meanders and eddies lead to quasi-steady Lagrangian transport patterns in a weak western boundary current
    The Brazil Current is a weak western boundary current flowing along the Southwestern Atlantic Ocean. It is frequently described as a flow with intense mesoscale activity and relatively low volume transport between 5.0 and 10.0 sverdrup (Sv). We use a 13-year eddy-resolving primitive-equation simulation to show that the presence of persistent meanders and eddies leads to characteristic quasi-steady Lagrangian transport patterns, aptly extracted through climatological Lagrangian Coherent Structures (cLCS). The cLCS position the surface expression of the Brazil Current core along the 2000-m isobath, in excellent visual agreement with high resolution satellite sea-surface temperature and the model Eulerian mean velocity.
    https://www.nature.com/articles/s41598-020-79386-9

18. Numerical Integrators for Lagrangian Oceanography
A common task in Lagrangian oceanography is to calculate a large number of drifter trajectories from a velocity field precalculated with an ocean model. We investigate trajectory calculation in modelled ocean currents with 800m, 4km, and 20km horizontal resolution, in combination with linear, cubic and quintic spline interpolation.
https://doi.org/10.5194/gmd-13-5935-2020

19. Horizontal Transport in Oil-Spill Modeling
Simulating oil transport in the ocean can be done successfully provided that accurate ocean currents and surface winds are available -- this is often too big of a challenge. Deficient ocean currents can sometimes be remediated by parameterizing missing physics -- this is often not enough. In this chapter, we focus on some of the main problems oil-spill modelers' face, which is determining accurate trajectories when the velocity may be missing important physics, or when the velocity has localized errors that result in large trajectory errors. A foundation of physical mechanisms driving motion in the ocean may help identify currents lacking certain types of physics, and the remedy.
https://arxiv.org/abs/2009.12954

20. Environmental Economics and Uncertainty Review and a Machine Learning Outlook
Economic assessment in environmental science concerns the measurement or valuation of environmental impacts, adaptation, and vulnerability. Integrated assessment modeling is a unifying framework of environmental economics, which attempts to combine key elements of physical, ecological, and socioeconomic systems. Uncertainty characterization in integrated assessment varies by component models: uncertainties associated with mechanistic physical models are often assessed with an ensemble of simulations or Monte Carlo sampling, while uncertainties associated with impact models are evaluated by conjecture or econometric analysis.
https://ssrn.com/abstract=3583911

21. Subsurface Trend Analysis Domains for the Northern Gulf of Mexico (GOM)
Geologic domains for the northern GOM derived using the Subsurface Trend Analysis method. The domains were postulated using geologic province, lithologic, and structural information and validated using statistical methods.
https://edx.netl.doe.gov/dataset/subsurface-trend-analysis-domains-for-the-northern-gulf-of-mexico

22. A Systematic, Science-Driven Approach for Predicting Subsurface Properties
As human exploration of the subsurface increases, there is a need for better data- and knowledge-driven methods to improve prediction of subsurface properties. Present subsurface predictions often rely upon disparate and limited a priori information. Even regions with concentrated subsurface exploration still face uncertainties that can obstruct safe and efficient exploration of the subsurface.
https://pubs.geoscienceworld.org/interpretation/article-abstract/8/1/T167/580834/A-systematic-science-driven-approach-for?redirectedFrom=fulltext

23. Building Regional Baselines and a Suite of Spatial Tools to Better Prepare for Oil Spills
Sensitivity Index data, infrastructure data from the Bureau of Ocean and Energy Management and the BSEE, and local information on tourism and recreation from state sources. These databases act as the foundation for understanding where future disasters

pose the greatest risks. Efforts to update and broaden baseline data into additional U.S. regions include the Atlantic coast, Pacific coast, and Alaska's North Slope.
https://agu.confex.com/agu/osm20/meetingapp.cgi/Paper/637186

24. A Review of Rheological Modeling of Cement Slurry in Oil Well Applications
The rheological behavior of cement slurries is important in trying to prevent and eliminate gas-migration related problems in oil well applications. In this paper, we review the constitutive modeling of cement slurries/pastes.
https://www.mdpi.com/1996-1073/13/3/570/pdf

25. What Technology is needed for Future Offshore Development?
Discussion focuses on key research findings from the DOE ultra-deepwater research portfolio of 2007-2013. Then the paper describes the current offshore research portfolio 2014 – 2019. Finally, the paper describes the outcomes and insights from key discussions with industry, academia, research and non-government and government stakeholders that could become a frame for a technology research roadmap for the entire OCS.
https://doi.org/10.4043/30469-MS

26. The Newly Published BSEE Guidance Documents for the Approval of HPHT Equipment, Wells, and Projects in the Gulf of Mexico
https://onepetro.org/OTCONF/proceedings-abstract/20OTC/2-20OTC/D021S023R001/107351

M. Rail and Truck Transportation – Research Projects: None

N. Rail and Truck Transportation – Research Papers: None

O. Pipeline Systems – Research Projects:

1. Improve Pipeline Leak Rate Estimation (Lead Agency: PHMSA)
The project will improve existing leak rate estimation models that can estimate the expected leak rates for pipelines with through wall cracks of various types and sizes. The model will support evaluating the consequence of a through wall crack, operational responses when incidents occur, and remedial action strategies and timelines. Additionally, the technology will serve as a linkage between inspection capability and leak detection technology specifications.
https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=919

2. Hydrostatic Retesting Optimization for Older Liquid Pipelines (Lead Agency: PHMSA)
The project will determine the minimum number of pressure cycles after a hydrotest liquid pipelines so that any surviving surface cracks will not rupture. The project will develop an approach to optimize hydrotest pressure of lower operating pressure (liquid) pipelines to avoid unnecessary repairs when using hydrotest guidelines for gas lines, to define a rupture-free fatigue life for liquid lines that experience pressure cycling.
https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=924

3. Forced Resonance Imaging for 3-D Mapping of Buried Gas Pipes (Lead Agency: PHMSA)
The project will field-test and fine-tune the technology and develop the software used to detect buried plastic gas pipelines, collect 3-D location information with increased

accuracy, and provide additional information on pipe diameter by 3-D mapping or volumetric image reconstructions.
https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=915

4. Fiber Optic Sensors for Direct Pipeline Monitoring Under Geohazard Conditions (Lead Agency: PHMSA)
   This Phase 1 Small Business Innovative Research project will demonstrate that distributed fiber optic sensing is a viable and cost-effective means to monitor ground movement threats to transmission pipelines.
   https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=889

5. Managing Geohazards Quantitative Risk Assessment for Pipelines (Lead Agency: PHMSA)
   This Phase 1 Small Business Innovative Research project will address risk from both isolated and cascading hazards (e.g., earthquake followed by landslide), support economic analysis of proposed mitigation to reduce risk at both the asset management level and project level, and outline the requirements for a data collection tool to close the gap on pipeline asset inventory and natural hazards.
   https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=888

6. Probabilistic Performance Evaluation of Cathodically Protected Pipeline Considering Alternating Current Corrosion (Lead Agency: PHMSA)
   The project will probabilistically evaluate the performance of cathodically protected pipelines under Alternating Current-induced corrosion.
   https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=900

7. Distributed Strain Sensing for Pipeline Safety Against Fault Moving and Landslide (Lead Agency: PHMSA)
   The project will develop a robust distributed fiber optic strain sensing system for long-term monitoring structural performance of pipeline subjected ground movements at fault crossing and landslide sites.
   https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=899

8. Technical Services for Pipeline Safety Research Projects at Transportation Technology Center (Lead Agency: PHMSA)
   The project will involve technical research services for various pipeline safety research projects that include applications involving railroads. The Research will occur at the Federal Railroad Administration's Transportation Technology Center located in Pueblo, Colorado and currently has three tasks: Fatigue Testing on Pipe Transported by Rail (Pipe by Rail), Technical Testing of Pipe Subjected to Railroad Loading (Pipe Under Rail), and Task 3 Project Management.
   https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=885

9. Feasibility of Using Alternative-Steel and Composite Material in Gas and Hazardous Liquid Pipeline Systems (Lead Agency: PHMSA)
   The project will establish design qualifications, requirements, inspection procedures, and a roadmap for using alternative steel and non-steel composite systems. As part of the scope, the project will review PHMSA's requirements under Title 49 Code of Federal Regulations (CFR) Parts 192 and 195 and the special permits issued under 49 CFR Part 190.341. This

regulatory and special permit review will assist PHMSA and the industry's ability to develop engineering-based integrity inspection requirements that mitigate risk and support safe operations.

10. Development and Validation of a Probabilistic Method for Estimating Accumulated Strain and Assessing Strain Demand and Capacity on Existing Pipelines (Lead Agency: PHMSA)
    The project will develop an estimate of the reserve strain capacity of a steel pipeline and a set of recommended interventions for mitigating situations where it is determined that there is insufficient strain reserve, lack of data, and/or inconsistency in the modeling process. The models will combine historic and new data with interacting threat models that address knowledge gaps in estimating compressive buckling and tensile overload risks that will be prioritized for intervention.

11. Pipeline Risk Management Using Artificial Intelligence-Enabled Modeling and Decision Making (Lead Agency: PHMSA)
    The project will develop Artificial Intelligence enabled tools to improve accuracy of probabilistic performance modeling. Furthermore, the tools will support decision-making of inspection and repair actions in pipeline risk management. The researcher will develop the Artificial Intelligence tools by identifying connections between pipeline safety datasets through machine learning approaches.

12. Easy Deployed Distributed Acoustic Sensing System for Remotely Assessing Potential and Existing Risks to Pipeline Integrity (Lead Agency: PHMSA)
    The project will investigate the feasibility of using Distributed Fiber-Optic Sensing cables, specifically, their Distributed Acoustic Sensing capabilities to detect and locate pipeline integrity risks based on vibration. Furthermore, the feasibility study will consider the effectiveness and robustness of using different cable deployment methods, especially easily deployed cables inside the pipeline. This research effort will focus on internal cables, rather than the cost prohibitive installation of externally mounted cables, which would require significant excavation.

13. Ensuring Oil and Gas Pipeline Safety Following a Geomagnetic Disturbance Event (Lead Agency: PHMSA)
    This Interagency Agreement with the DOE will evaluate the ability of oil and gas pipelines and associated infrastructure to maintain a safe state and, if needed, to safely shut down following a Geomagnetic Disturbance event.
    https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=927

14. Fiber Optic Sensors for Direct Pipeline Monitoring Under Geohazard Conditions (Lead Agency: PHMSA)
    This Phase 2 Small Business Innovative Research project will expand upon the Phase 1 project and conduct field demonstrations to validate distributed fiber optic sensing can perform under real conditions and collect the necessary data to monitor ground movement threats to transmission pipelines.

15. River Scour Monitoring System for Pipeline Threat Prevention (Lead Agency: PHMSA)
    The project will develop a river scour monitoring system capable of determining the degree of scour in a riverbed thereby alerting pipeline operators should the amount of cover of the pipeline become reduced.
    https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=740

16. Optimized Radar to Find Every Utility in the Street (ORFEUS) Obstacle Detection for Horizontal Directional Drilling (HDD) (Lead Agency: PHMSA)
    The project will produce a field proven, market ready, obstacle location technology for use in HDD applications. ORFEUS is an effort aimed at developing a safe, cost effective "look-ahead" obstacle detection system for HDD equipment.
    https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=736

17. Modernize the Assessment of River Crossings (Lead Agency: PHMSA)
    This project intends to supplement guidance from American Petroleum Institute, Recommended Practice 1133 "Guidance for Onshore Hydrocarbon Pipelines Affecting High Consequence Floodplains," and to expand and improve the capabilities of existing tools available to assess and monitor pipeline river crossings.
    https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=746

18. Engineered Composite Repair Joint Industry Project (Lead Agency: BSEE)
    The United Kingdom, Health and Safety Executive is conducting research in a JIP aimed at improving the collective knowledge and understanding of the long-term integrity of engineered composite repairs. BSEE set a goal in 2015 in the BSEE Annual report to obtain more information on the use of engineered composite repairs and their long-term use in the field. BSEE will obtain data that is currently limited to the JIP and will be able to ensure research is focused to obtain data critical to the field.
    https://www.bsee.gov/research-record/engineered-composite-repair-joint-industry-project

19. Remote Visual Inspection (RVI) Joint Industry Project (Lead Agency: BSEE)
    The United Kingdom, Health and Safety Executive is conducting research in a JIP aimed at providing a stronger understanding of both the benefits and limitations of RVIs and develop a set of best practices when conducting these types of inspections. The JIP will assess current technologies and practices, conduct RVI trials for probability and detection, determine the human factors and competence assessment, develop a good practice guide and methodology for demonstrating competence for RVI.
    https://www.bsee.gov/research-record/remote-visual-inspection-joint-industry-project

P. Pipeline Systems – Research Papers:

1. Status of Efforts on Hydrotest Optimization of Older Liquid Pipelines
   This is a PHMSA paper.
   No link to paper due to copyright restrictions.

2. Inspection and monitoring systems subsea pipelines: A review paper.
   The opportunity for research and engineering to overcome the challenge of subsea inspection and monitoring is tremendous and the progress in this area is continuously generating exciting new developments that may have far reaching benefits far outside of subsea pipeline inspection and monitoring. Thus, this review covers the most often used

subsea inspection and monitoring technologies as well as their most recent developments and future trends.
https://journals.sagepub.com/doi/pdf/10.1177/1475921719837718

II. PREPAREDNESS

A. *Pre-Spill Baseline Studies – Research Projects:*

1. Assessing the Impact of Oil Spills Using Three-dimensional Oil Spill Modeling (Lead agency: BOEM)
   Extend NOAA's oil spill Trajectory Analysis Planner tool by integrating NOAA's new web-based General NOAA Operational Modeling Environment (GNOME) tool in 3-D and apply the result to BOEM's oil-spill risk analysis in Southern California.
   https://marinecadastre.gov/espis/#/search/study/100114

2. Compendium on Oil Spill Science (Lead agency: BOEM)
   This project is compiling literature on the known impacts from a range of oil spill sizes and ecosystems. The goal is to then identify what information is unknown about the oil spills and the oil spill response impacts. https://marinecadastre.gov/espis/#/search/study/100255

3. Hydrocarbon Seeps in the Lower Cook Inlet, Gulf of Alaska, Chukchi Sea and Beaufort Sea OCS Planning Areas (Lead agency: BOEM)
   Researchers will identify and map any available information about the locations, volumes, and chemical and weathering characteristics of hydrocarbon seeps on the Alaska OCS, as well as information regarding hydrocarbon-consuming organisms in the area.
   https://marinecadastre.gov/espis/#/search/study/100239

4. Environmental Resource Areas: Developing Products to Support Oil-spill Risk Analysis and National Environmental Policy Act (Lead agency: BOEM)
   This study will establish a consistent foundation for developing and refining Environmental Resource Areas used for Oil-Spill Risk Analysis. This project will focus on evaluating the distribution and abundance of seabirds and forage fish in marine areas off Alaska.
   https://marinecadastre.gov/espis/#/search/study/100238

5. Synthesis of Contaminants Data for Cook Inlet: Evaluation of Existing Data as "Baseline Conditions" and Recommendations for Further Monitoring (Lead agency: BOEM)
   This study will compile existing information about a suite of contaminants to provide the foundation upon which to better evaluate any potential impacts to water and sediment quality from Federal OCS oil and gas related activities in Cook Inlet.

6. Oil in the Sea IV: Inputs, Fates, and Effects (Lead Agency BOEM)
   This study will provide an update of the Oil in the Sea III: Inputs, Fates, and Effects (2003) inventory of the sources, composition, and quantity of hydrocarbon inputs as well as an assessment of the state of the science on the fate and effects of fossil fuel hydrocarbons in the marine environment.

7. High Resolution Modeling of the Gulf of Mexico (Lead Agency BOEM)
   This study will provide BOEM with 20 years of hindcast of high-resolution oceanographic data for use in OSRA applications.

8. Update Of River Overflood on Sea Ice and Strudel Scour in the U.S. Beaufort Sea (Lead Agency BOEM)
   The overall goal of this study is to improve the knowledge of the spatial and temporal variability in overflooding and related pipeline and facility siting concerns. The results will be used for environmental assessment and hazard mitigation for present and future oil and gas facilities that may be located within or adjacent to the areas influenced by the overflood.

9. Ice-over Characterization on Rivers near Oil Transportation Infrastructure (Lead agency: USGS)
   Archived Sentinel-1 synthetic aperture radar data will be used to develop a machine learning model to characterize physical properties of ice on major rivers in the Great Lakes region. From these results, vulnerability maps will be developed where ice covered areas and oil transport areas intersect with ecological, hydrological, and cultural resources.

10. Assessing baseline contaminants in the 1002 Area of the Arctic National Wildlife Refuge in Alaska (Lead agency: USFWS)
    Project to assess baseline contaminant levels and types in biotic and abiotic matrices in the coastal plain of the Arctic National Wildlife Refuge prior to oil and gas exploration and development activities. Results to be used for the development of impact assessments, addressing subsistence concerns, and evaluating water quality.

B. Pre-Spill Baseline Studies – Research Papers:

1. Oil Spill Effects Literature Study of Spills of Greater than 20,000 Barrels of Crude Oil, Condensate, or Diesel https://espis.boem.gov/final%20reports/BOEM_2020-058.pdf

2. Biological Environment
   https://doi.org/10.1016/B978-0-12-818969-6.00026-1

3. Conditions and Prey Availability that Drive Arctic Nearshore Fish Community Structure in the Point Barrow, Alaska, Region
   https://doi.org/10.1139/cjfas-2019-0068

4. Implications of Trophic Discrimination Factor Selection for Stable Isotope Food Web Models of Low Trophic Levels in the Arctic Nearshore
   https://doi.org/10.3354/meps12893

5. Estimating Pacific Walrus Abundance and Demographic Rates from Genetic Mark-Recapture
   https://espis.boem.gov/final%20reports/BOEM_2019-059.pdf

6. Panmixia in a Sea Ice-Associated Marine Mammal: Evaluating Genetic Structure of the Pacific Walrus (Odobenus Rosmarus Divergens) At Multiple Spatial Scales
   https://doi.org/10.1093/jmammal/gyaa050

7. Behavior and Characteristics of Mating Polar Bears (Ursus Maritimus) in the Beaufort Sea, Canada
   https://doi.org/10.1007/s00300-019-02485-5

8. Beaufort Sea: Hypothetical Very Large Oil Spill and Gas Release
https://www.boem.gov/sites/default/files/documents//BOEM%202020-001%20Beaufort%20Sea%20Hypothetical%20Very%20Large%20Oil%20Spill%20and%20Gas%20Release.pdf

9. Variability in Polar Bear (Ursus Maritimus) Stable Isotopes in Relation to Environmental Change in the Canadian Beaufort Sea
https://doi.org/10.3354/meps13136

10. Space use Patterns Affect Stable Isotopes of Polar Bears (Ursus Maritimus) in the Beaufort Sea
https://doi.org/10.1007/s00300-019-02546-9

11. Spatial and Temporal Variability in Ringed Seal (Pusa Hispida) Stable Isotopes in the Beaufort Sea
https://doi.org/10.1002/ece3.6186

12. Pacific Salmon in the Rapidly Changing Arctic: Exploring Local Knowledge and Emerging Fisheries in Utqiavik and Nuiqsut, Alaska. Arctic
https://doi.org/10.14430/arctic68876

13. Distribution and Behavior of Bering-Chukchi-Beaufort Bowhead Whales as Inferred by Telemetry
https://doi.org/10.1016/B978-0-12-818969-6.00004-2

14. Pacific Walrus Diet Across 4000 Years of Changing Sea Ice Condition
https://doi.org/10.1017/qua.2018.140

15. Lipid Normalization and Stable Isotope Discrimination in Pacific Walrus Tissue
https://doi.org/10.1038/s41598-019-42095-z

16. Zinc Concentrations in Teeth of Female Walruses Reflect the Onset of Reproductive Maturity
https://doi.org/10.1093/conphys/coaa029

17. Distribution and Relative Abundance of Marine Mammals in the Eastern Chukchi Sea, Eastern and Western Beaufort Sea, and Amundsen Gulf, 2019
https://www.boem.gov/sites/default/files/documents/regions/alaska-ocs-region/environment/BOEM_2020-027.pdf

18. Distribution and Relative Abundance of Marine Mammals in the Eastern Chukchi and Western Beaufort Seas, 2018
https://www.boem.gov/sites/default/files/documents/regions/alaska-ocs-region/environment/BOEM_2019-021.pdf

19. Ontogenetic Patterns in Lipid and Fatty Acid Biomarkers of Juvenile Polar Cod (Boreogadus Saida) and Saffron Cod (Eleginus Gracilis) from Across the Alaska Arctic
https://doi.org/10.1007/s00300-020-02648-9

20. Song production by the North Pacific Right Whale (Eubalaena Japonica)
https://doi.org/10.1121/1.5111338

21. Ocean Circulation Model Forced Across the Coastal Interface by High-Resolution Terrestrial Hydrological Models
https://doi.org/10.1029/2019JC015724

22. Oceanic Routing of Wind-Sourced Energy along the Arctic Continental Shelves
https://doi.org/10.3389/fmars.2020.00509

23. New Estimates of Weight-at-Size, Maturity-at-Size, Fecundity, and Biomass of Snow Crab (Chionoecetes Opilio) in the Arctic Ocean off Alaska
https://doi.org/10.1016/j.fishres.2019.05.002

24. Toward a Coordinated Global Observing System for Marine Macrophytes
https://doi.org/10.3389/fmars.2019.00317

25. Animida III Boulder Patch and Other Kelp Communities in Development Area Final Report
https://www.boem.gov/sites/default/files/documents/regions/alaska-ocs-region/environment/BOEM%202019-053.pdf

26. Effects of Offshore Oil Exploration and Development in the Alaskan Beaufort Sea: Long term Patterns of Hydrocarbons in Sediments
https://doi.org/10.1002/ieam.4129

27. Diversity and Distribution of Meroplanktonic Larvae in the Pacific Arctic and Connectivity with Adult Benthic Invertebrate Communities
https://doi.org/10.3389/fmars.2019.00490

28. Circulation and Thermohaline Variability of the Hanna Shoal Region on the Northeastern Chukchi Sea Shelf
https://doi.org/10.1029/2019JC015639

29. Ecological Variation in the Western Beaufort Sea
https://doi.org/10.1016/B978-0-12-818969-6.00024-8

30. Documenting Growth Parameters and Age in Arctic Fish Species in the Chukchi and Beaufort Seas
https://doi.org/10.1016/j.dsr2.2020.104779

31. Spatial Patterns, Environmental Correlates, And Potential Seasonal Migration Triangle of Polar Cod (Boreogadus Saida) Distribution in the Chukchi and Beaufort Seas
https://doi.org/10.1007/s00300-020-02631-4

32. Acoustic Occurrence and Behavior of Ribbon Seals (Histriophoca Fasciata) in the Bering, Chukchi, and Beaufort Seas
https://doi.org/10.1007/s00300-019-02462-y

33. First Analysis of an Arctic Sea Ice Meiofauna Food Web Based on Abundance, Biomass and Stable Isotope Ratios
https://doi.org/10.3354/meps13170

34. The Distributed Biological Observatory: A Change Detection Array in the Pacific Arctic - an Introduction
https://doi.org/10.1016/j.dsr2.2019.05.005

35. Inferring Foraging Locations and Water Masses Preferred by Spotted Seals Phoca Largha and Bearded Seals Erignathus Barbatus
https://doi.org/10.3354/meps13145

36. CMI Graduate Student Projects Volume 3
https://espis.boem.gov/final%20reports/BOEM_2019-067.pdf

37. Coastal Community Vulnerability Index and Visualizations of Change in Cook Inlet, Alaska
https://espis.boem.gov/final%20reports/BOEM_2019-031

38. Indigenous Knowledge in Research and Management
https://doi.org/10.1016/B978-0-12-818969-6.00034-0

39. Evidence Suggests Potential Transformation of the Pacific Arctic Ecosystem is Underway
https://doi.org/10.1038/s41558-020-0695-2

40. Developing an Observational Design for Epibenthos and Fish Assemblages in the Chukchi Sea
https://doi.org/10.1016/j.dsr2.2018.11.005

41. Nearshore Food Web Structure on the OCS in Cook Inlet. OCS Study
https://espis.boem.gov/final%20reports/BOEM_2019-078.pdf

42. Variation in Habitat Use of Beaufort Sea Polar Bears
https://doi.org/10.1007/s00300-020-02705-3

43. Assessment of Nearshore Communities and Habitats: Lower Cook Inlet Nearshore Ecosystem 2015-2018
https://espis.boem.gov/final%20reports/BOEM_2019-075.pdf

44. Benthic Trophic Sensitivity to on-Going Changes in Pacific Arctic Seasonal Sea Ice Cover-Insights from the Nitrogen Isotopic Composition of Amino Acids
https://doi.org/10.1016/j.dsr2.2019.01.002

45. Seasonal and Latitudinal Variations in Sea Ice Algae Deposition in the Northern Bering and Chukchi Seas Determined by Algal Biomarkers
https://doi.org/10.1371/journal.pone.0231178

46. Representation of the Pacific Arctic Seabird Community within the Distributed Biological Observatory Array, 2007-2015
https://doi.org/10.1016/j.dsr2.2019.04.001

47. Annual Cycle of Export Fluxes of Biogenic Matter near Hanna Shoal in the Northeast Chukchi Sea
https://doi.org/10.1016/j.dsr2.2020.104730

48. Leads and Associated Sea Ice Drift in the Beaufort Sea in winter
https://doi.org/10.1029/2018JC014898

49. Weather Induced Subtidal Flows through Multiple Inlets of an Arctic Microtidal Lagoon
https://doi.org/10.1007/s13131-019-1361-2

50. Circulation of the Chukchi Sea Shelfbreak and Slope from Moored Timeseries
https://doi.org/10.1016/j.pocean.2019.01.002

51. Circulation in the vicinity of Mackenzie Canyon from a Year-Long Mooring Array
https://doi.org/10.1016/j.pocean.2020.102396

52. Assessment and Catalog of Benthic Marine Algae from the Alaska Peninsula
This is a BOEM paper.
No link to paper due to copyright restrictions.

53. The Effect of Oceanographic Variability on the Distribution of Larval Fishes of the Northern Bering and Chukchi Seas
https://doi.org/10.1016/j.dsr2.2020.104784

54. Predicting Sediment Organic Carbon and Related Food Web Types from a Physical Oceanographic Model on a Subarctic Shelf
https://doi.org/10.3354/meps13163

55. Assessing the Role of Oceanic Heat Fluxes on Ice Ablation of the Central Chukchi Sea Shelf
https://doi.org/10.1016/j.pocean.2020.102313

56. Influences of Temperature, Predators, and Competitors on Polar Cod (Boreogadus Saida) at the Southern Margin of their Distribution
https://doi.org/10.1007/s00300-019-02575-4

57. Environmental and Biological Influences on the Distribution and Population Dynamics of Polar Cod (Boreogadus Saida) in the US Chukchi Sea
https://doi.org/10.1007/s00300-019-02561-w

58. Population Trends of King and Common Eiders from Spring Migration Counts at Point Barrow, Alaska between 1994 and 2016
https://doi.org/10.1007/s00300-019-02581-6

59. Metaproteomics Reveal that Rapid Perturbations in Organic Matter Prioritize Functional Restructuring Over Taxonomy in Western Arctic Ocean Microbiomes
https://doi.org/10.1038/s41396-019-0503-z

60. Seasonal and Interannual Variability of Nitrate in the Eastern Chukchi Sea: Transport and Winter Replenishment
https://doi.org/10.1016/j.dsr2.2020.104807

61. The Encoding of Wind Forcing into the Pacific-Arctic Pressure Head, Chukchi Sea Ice Retreat and Late-Summer Barrow Canyon Water Masses
https://doi.org/10.1016/j.dsr2.2018.05.009

62. Krill Diel Vertical Migration: A Diagnostic for Variability of Wind Forcing Over the Beaufort and Chukchi Seas
https://doi.org/10.1016/j.pocean.2020.102265

63. Use of the Alaskan Beaufort Sea by Bowhead Whales (Balena mysticetus)
https://doi.org/10.1007/s00300-020-02710-6

64. Movement, diving, and haul-out behaviors of juvenile bearded seals in the Bering, Chukchi and Beaufort seas
https://doi.org/10.1007/s00300-020-02710-6

65. Satellite Tracking of Bowhead Whales: Habitat Use, Passive Acoustic and Environmental Monitoring. Anchorage, AK
https://espis.boem.gov/final%20reports/BOEM_2019-076.pdf

66. Ice Seal Movements and Foraging: Village-Based Satellite Tracking and Collection of Traditional Ecological Knowledge Regarding Ringed and Bearded Seals
https://espis.boem.gov/final%20reports/BOEM_2019-079.pdf

67. Spatial and Temporal Variation of Late Summer Ichthyoplankton Assemblage Structure in the Eastern Chukchi Sea: 2010-2015
https://doi.org/10.1007/s00300-019-02555-8

68. Biogeography of Epibenthic Assemblages in the Central Beaufort Sea
https://doi.org/10.1007/s12526-019-01036-9

69. Die-offs, Reproductive Failure, and Changing At-Sea Abundance ff Murres in the Bering and Chukchi Seas in 2018
https://doi.org/10.1016/j.dsr2.2020.104877

70. Sources of Primary Production to Arctic Bivalves Identified using Amino Acid Stable Carbon Isotope Fingerprinting
https://doi.org/10.1080/10256016.2019.1620742

71. Examination of Saffron Cod (Eleginus Gracilis) (Tilesius 1810) Population Genetic Structure
https://doi.org/10.1007/s00300-019-02601-5

72. An Assessment of Climate Change Vulnerability for Important Bird Areas in the Bering Sea and Aleutian Arc
https://doi.org/10.1371/journal.pone.0214573

73. Temporal Variation in Genetic Structure within the Threatened Spectacled Eider
https://doi.org/10.1007/s10592-019-01234-9

74. Physical and Biological Drivers of Zooplankton Communities in the Chukchi Sea
https://doi.org/10.1007/s00300-019-02498-0

75. Advection and In Situ Processes as Drivers of Change for the Abundance of Large Zooplankton Taxa in the Chukchi Sea
https://doi.org/10.1016/j.dsr2.2020.104805

76. Structure and Temporal Variability of Currents over the Chukchi Sea Continental Slope
https://doi.org/10.1016/j.dsr2.2020.104805

77. Seasonal Patterns of Near-Bottom Chlorophyll Fluorescence in the Eastern Chukchi Sea: 2010-2019.
https://doi.org/10.1016/j.dsr2.2020.104842

78. Distribution, Habitat Use, and Conservation of Albatrosses in Alaska
https://hmsc.oregonstate.edu/sites/hmsc.oregonstate.edu/files/seabird-oceanography-lab/suryan_and_kuletz_2018_iden_english.pdf

79. Comparison of Functional Diversity of Two Alaskan Arctic Shelf Epibenthic Communities
https://doi.org/10.3354/meps13478

80. Determining Sex of Adult Pacific Walruses from Mandible Measurements
https://doi.org/10.1093/jmammal/gyaa051

81. Effects of Offshore Oil Exploration and Development in the Alaskan Beaufort Sea: A three-decade Record for Sediment Metals
https://doi.org/10.1002/ieam.4069

82. Spatio-Temporal Distribution of Polar Cod (Boreogadus Saida) and Saffron Cod (Eleginus Gracilis) Early Life Stages in the Pacific Arctic
https://doi.org/10.1007/s00300-019-02494-4

83. Assessing the Sensitivity of Three Alaska Marine Food Webs to Perturbations: an Example of Ecosim Simulations Using Rpath
https://doi.org/10.1016/j.ecolmodel.2020.109074

84. Marine Arctic Ecosystem Study (MARES): Moorings on the Beaufort Sea Shelf, 2016-2017
https://espis.boem.gov/final%20reports/BOEM_2019-009.pdf

85. Marine Arctic Ecosystem Study: Moorings on the Beaufort Sea shelf (2016-2018) and Program Synthesis
https://www.boem.gov/sites/default/files/documents/regions/alaska-ocs-region/environment/BOEM_2020-029.pdf

86. Bowhead Whale (Balaena Mysticetus) and Killer Whale (Orcinus Orca) Co-Occurrence in the U.S. Pacific Arctic, 2009-2018: Evidence from Bowhead Whale Carcasses
https://doi.org/10.1007/s00300-020-02734-y

87. Mitochondrial Genome Diversity and Population Mitogenomics of Polar Cod (Boreogadus Saida) And Arctic Dwelling Gadoids
https://doi.org/10.1007/s00300-020-02703-5

88. Identifying Sources of Organic Matter to Benthic Organisms in the Beaufort and Chukchi Outer Continental Shelves
https://www.boem.gov/2019-030/

89. Acoustic Detection of the Critically Endangered North Pacific Right Whale in the Northern Bering Sea
https://doi.org/10.1111/mms.12521

90. Continuing and expanding a deep water biological observation system in the Northern Gulf of Mexico
https://espis.boem.gov/final%20reports/BOEM_2020-022.pdf

91. A real-time ocean observing station off Timbalier Bay, Louisiana.
https://espis.boem.gov/final reports/BOEM_2020-015.pdf

92. Atmospheric cold front induced exchange flows through a microtidal multi-inlet bay: analysis using multiple horizontal Acoustic Doppler Current Profilers and Finite-Volume Coastal Ocean Model simulations
https://doi.org/10.1175/JTECH-D-18-0143.1

93. A numerical study of sediment dynamics over Sandy Point dredge pit, west flank of the Mississippi River, during a cold front event.
https://doi.org/10.1016/j.csr.2019.06.009

C. *Response Management Systems – Research Projects:*

1. GOM Oil Spill Response Viability Analysis (Lead agency: BSEE)
Conduct an oil spill response viability for the U.S. OCS GOM exclusive economic zone to quantify the frequency and duration that a specific oil spill response strategy may not be feasible or 'unduly' impacted such that response effectiveness is judged to be degraded due to metocean conditions.
https://www.bsee.gov/research-record/gulf-of-mexico-oil-spill-response-viability-analysis

2. A Response Guide for Sunken Oil Mats (SOM): Formation, Behavior, Detection and Recovery (Lead Agency: NOAA)
   This operational guide includes: a summary of the literature on SOM; conditions necessary for SOM formation and persistence; effective survey methods to detect and remove SOM.
   https://response.restoration.noaa.gov/sites/default/files/SOM_Report_03-30-2020_508b.pdf

3. Trajectory Analysis Planner (Lead agency: NOAA)
   Trajectory Analysis Planner is a web-based tool for assessing the transport and impacts of potential oil spills in pre-defined regions. The user interface allows planners to view, in a stochastic framework, the potential impacts of a release of oil as a function of oil type and amount and location spilled.
   https://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/response-tools/trajectory-analysis-planner.html

4. Reach-scale surface velocity mapping using small UAS (Lead agency: USGS)
   Pilot project to establish best practices for creating reach-scale surface velocity maps, including sensor type (visible, thermal, and multi-spectral), data collection, ground control surveying, data processing, data delivery, and data publishing. Maps are designed to inform river dynamics and spill behavior. Model is being validated in the Green River Spill Exercise (October 2021).

5. Market Research of Spilled Oil Recovery System (SORS) and Vessel of Opportunity Skimming System (VOSS) Technologies (Lead agency: USCG)
   The objective of this project is to research the state-of-the-market for potential technologies that can replace current SORS and VOSS equipment. This research will aid the USCG in developing a procurement strategy for the replacement of the SORS and VOSS equipment in order to meet USCG's requirements as laid out in OPA 90.

6. Nearshore and Inland Evaluation of the Estimated Recovery System Potential (ERSP) Calculator (Lead agency: USCG)
   This project was initiated to assess the feasibility of, costs and benefits for, and potentially undertake the work to expand the BSEE Estimated Recovery System Calculator to the inland environments. The USCG is currently developing a conceptual model of the inland ERSP calculator.

D. Response Management Systems – Research Papers:

1. Inland ERSP Preliminary Factors, Requirements and Conceptual Model
   This USCG report is limited distribution due pre-decisional information for model effort.

2. Inland ERSP Operational Environment Calculator Design Document
   This USCG report is limited distribution due pre-decisional information for model effort.

3. VOSS Technologies Market Research
   This USCG report is For Official Use Only.

4. Development of the Inland ERSP Calculator
   This USCG report is limited distribution due pre-decisional information for model effort.

5. Preparedness, planning, and advances in operational response
   Summary of recent research that's applicable to improved preparedness and planning for oil spill response, with an emphasis on GoMRI research and advances that relate to operational activities, as well as limitations and opportunities for gap-filling future research.
   https://tos.org/oceanography/article/preparedness-planning-and-advances-in-operational-response

6. Responder Needs Addressed by Arctic Maritime Oil Spill Modeling
   There is a greater probability of more frequent and/or larger oil spills in the Arctic region due to increased maritime shipping and natural resource development. Accordingly, there is an increasing need for effective spilled-oil computer modeling to help emergency oil spill response decision makers, especially in waters where sea ice is present. A goal of this project is to prioritize new investments in model and tool development to improve response effectiveness in the Arctic. This project delineated Federal On Scene Coordinator needs during Arctic maritime spill response and provided a solution communicating sources of uncertainty in model outputs using a Confidence Estimates of Oil Model Inputs and Outputs table. The table shows the level of confidence (high, medium, low) in a model's trajectory prediction over scenario-specific time intervals and the contribution of different component inputs (e.g., temperature, wind, ice) to that result.
   https://doi.org/10.3390/jmse9020201

E. Other – Research Papers:

1. Evolution of Federal Oil Pollution Research Planning
   The paper discusses how the US went from ad hoc research planning to the current and future ICCOPR Research and Technology Planning approach.

III. RESPONSE

A. Structural Damage Assessment and Salvage Research Projects: None

B. Structural Damage Assessment and Salvage Research Papers: None

C. At Source Control and Containment - Research Projects: None

D. At Source Control and Containment - Research Papers: None

E. Chemical and Physical Behavior Modeling – Research Projects:

1. Automated Data Inquiry for Oil Spills (ADIOS) Oil Database Software (Lead agency: NOAA)
   The ADIOS Oil Database is a publicly available database of oil properties suitable for supporting oil spill preparedness and response. The data are maintained by NOAA and include data from other government agencies and industry. It has been made available via a user-friendly web interface and computer readable web application programming interface.

2. Behavior of Diluted Bitumen in Fresh Water (Lead agency: USCG)
   The goal of this project is to provide a more complete understanding of dilbit fate and transport and add to Federal On Scene Coordinator's knowledge base for further response considerations.

3. Subsurface oil pipeline model (Lead agency: NOAA)
   This is an ongoing project to develop uncertainty estimates for predicted volume released based on The Pocket Guide for Pipeline Oil Spill Volume Estimator, developed by the Department of Interior.

4. Oil Sands Products Spill Response (Lead agency: USCG)
   This project conducted research and developed enhanced decision making, recovery and mitigation tools for responding to spilled oil sands products.

5. Oil Spill Modeling for Improved Response to Arctic Maritime Spills: The Path Forward (Lead agency: DHS and USCG)
   The DHS Arctic Domain Awareness Center is creating a product to detail Arctic oil spill response models needs/gaps and outlining available Arctic spill and ice models. It will recommend new Arctic spill modeling components for developed and create the code necessary for data feeds to be ingested into spill models (e.g., GNOME.)

6. Development of Applications for Estimating Travel Times and Concentrations of Inland Oil Spills (Lead agency: USGS)
   Development of Web User Interface (USGS StreamStats) for Estimating Travel Times and Concentrations of Inland Oil Spills. Web application will allow for users to estimate reach velocities and travel times for any National Hydrography Dataset Plus river reach in the United States. The application is web enabled, mobile friendly, and designed to provide critical information to responders in the early response.
   https://www.usgs.gov/mission-areas/water-resources/science/streamstats-streamflow-statistics-and-spatial-analysis-tools?qt science_center_objects=0#qt-science_center_objects

7. Development of Oil Particle Transport Model and Training Modules Available for DOI (Lead agency: USGS)
   The deliverable is an analysis of the ease and benefits of applying the existing oil particle aggregate (OPA) transport modules (and potentially formation and breakdown modules) to these models, using the EPA's Kalamazoo River OPA transport models developed by the EPA, USGS, and USACE as a comparison. This project will improve inland river spill models by accounting for oil particle aggregates rather than all-solution models.

8. Integrating Hydraulic Models with Existing National Park Service Response Plans to Improve Response Times and Protect Natural and Cultural Resources (Lead agency: USGS)
   The project will provide a science-based tool to facilitate improved management and mitigation of oil spills. Objectives include: 1. Improve understanding of fate and transport of spilled bitumen in the lower St. Croix River by using hydraulic inputs from the existing FluEgg model to run FluOil simulations; 2. Develop and conduct a training session with the interagency St. Croix Spill Response team to demonstrate how FluOil models can be used to improve spill response activities; and, 3. Collect additional field data and develop hydraulic inputs for a FluOil model from Danbury, WI to St. Croix Falls, WI to improve understanding of fate and transport of spilled diluted bitumen in the upper St. Croix River.

9. The Web-based GNOME Anywhere (Lead agency: BSEE)
   The current NOAA's web-based GNOME platform displays the modeling bounds with available operational forecast models for selected areas. These areas are typically in shoreline areas. This project will expand the availability of forecast models to cover offshore areas where BSEE's regulated facilities reside. This added feature will enable the ability to run web-based GNOME more easily, using available operational forecast models. The focus will be on the following areas as priorities: GOM out to 200 miles, the Arctic, Cook Inlet, Southern California, and the Atlantic seaboard (for possibly renewable energy facilities).
   https://www.bsee.gov/research-record/the-web-based-general-noaa-oil-modeling-environment-webgnome-anywhere

10. Chemical characterization and toxicity of new Low Sulfur Fuel Oils (Lead agency: EPA)
    This project aims to develop a standardized and reproducible testing protocol to evaluate the shoreline cleaning efficiency of SWA. Oil removal efficiencies for SWA are being evaluated, as well as dispersibility, because an effective SWA should not disperse oil into water, as per U.S. policy.

F. Chemical and Physical Behavior Modeling – Research Papers:

1. Geochemical and geophysical indicators of oil and gas wastewater can trace potential exposure pathways following releases to surface waters
   https://doi.org/10.1016/j.scitotenv.2020.142909

2. Progress in Operational Modeling in Support of Oil Spill Response
   https://www.mdpi.com/2077-1312/8/9/668

3. Towards Integrated Modeling of the Long-term Impacts of Oil Spills
   This is a collaborative project with EPA, NOAA, BSEE, USCG, WHOI, and WaterMapping, Inc.

4. Crude Oil Migration in Sea-Ice: Laboratory Studies of Constraints on Oil Mobilization and Seasonal Evolution
   https://doi.org/10.1016/j.coldregions.2019.102924

5. Literature Review of Diluted Bitumen
   www.dtic.mil

6. Oil Spill Modeling For Improved Response to Arctic Maritime Spills The Path Forward
   https://arcticdomainawarenesscenter.org/P25_AMSM

G. Oil Spill Detection and Surveillance – Research Projects:

1. Slick Thickness Characterization Based on Low Noise, Polarized Synthetic Aperture Radar (Lead agency: BSEE)
   The project team will use radar technology instead of optical or infrared methods in order to enable 24-hour, weather independent operation that can be deployed in inclement or difficult to access environments and reduce dependence upon on-site personnel. The team will evaluate the capability of low noise L-band (1.26 GHz) synthetic aperture radar imagery acquired by the Uninhabited Aerial Vehicle Synthetic Aperture Radar sensor. The goal is to determine how accurately slick thickness can be determined from synthetic

aperture radar, including the extent to which weather conditions change the synthetic aperture radar backscatter and affect the parameters used to determine the oil thickness and fraction. The project will also determine whether and what calibration data are needed for the synthetic aperture radar thickness determination, including how changes in wind condition will alter the measurements and whether recalibration will be needed.
https://www.bsee.gov/research-record/slick-thickness-characterization-based-on-low-noise-polarized-synthetic-aperture

2. Oil Detection and Thickness Estimation Under/In Ice Based on ECT (Lead agency: BSEE)
This project will study and test the ECT sensor to detect oil in/under ice. For oil detection and thickness estimation under/in ice, where the access to the imaged region is limited to above its surface, a planar sensor design is proposed where the electrodes are mounted on a single plane and placed at a relatively close distance above the ice surface. The prototype remote sensor/algorithms will be delivered at the end of the project.
https://www.bsee.gov/what-we-do/oil-spill-preparedness/oil-spill-response-research/record-oil-spill-response-research-projects

3. Algorithm Development for (Near) Real Time Data Processing and Mapping for Remote Sensors (Lead agency: BSEE)
Real-time data processing is critical to decision making. Although various remote sensors to detect oil slicks have been developed, the advanced, processing/analyzing data and imagery requires significant time (at least several hours to days). The purpose of this project is to develop/advance algorithm for (Near) Real-Time Data Processing and Mapping for Commercially available Off the Shelf Remote Sensors to detect oil and measure slick thickness.
https://www.bsee.gov/research-record/algorithm-development-for-near-real-time-data-processing-and-mapping-for-remote

4. MARINE SCOUT Modification and Automation (Lead agency: BSEE)
MARINE SCOUT remote sensing technique provides the ability to map oil spill thickness in near real-time. The modified MARINE SCOUT payload can be mounted on UAVs and provide critical information to map oil spills and measure the varying slick thicknesses. This enhanced capability will provide responders with near real-time data to effectively respond to an oil spill.

5. Light Detection and Ranging (LiDAR) Oil Characterization and Automated Software Development (Lead agency: BSEE)
The U.S. Naval Research Laboratory performed preliminary experiments to assess pulsed laser light technology ability to detect oil and characterize oil thickness on water. Initial testing conducted at Ohmsett demonstrated the successful application of LiDAR remote sensing to detect and measure the presence of oil at the surface and underwater. This project will continue the development of the LiDAR system's ability to detect and characterize oil on the surface and varying subsurface layers thickness values and depth in the water.
https://www.bsee.gov/research-record/lidar-oil-characterization-and-automated-software-development

6. An Adaptable Frequency Modulated Continuous Wave Radar For Unmanned Aerial Systems To Detect Oil In Sea Ice (Lead agency: BSEE)
   As Arctic ice has receded, exploration and development of oil reserves have increased, thereby requiring an effective strategy to mitigate oil spills. The Pacific Northwest National Laboratory proposes demonstrating oil detection in and under sea ice via the frequency modulated continuous wave radar by leveraging recent advancements in commercial subcomponents and systems. Utilizing Commercial Off the Shelf hardware will address hardware reliability issues and focus work on implementation challenges.
   https://www.bsee.gov/research-record/an-adaptable-frequency-modulated-continuous-wave-fmcw-radar-for-unmanned-aerial

7. Three-dimensional mapping of dissolved hydrocarbons and oil droplets using a Remote Environmental Monitoring Unit (REMUS) AUV
   (Lead agency: BSEE)
   The goals of this project were to integrate a suite of sensors on a REMUS AUV to quantify, characterize and determine droplet size of spilled oil, demonstrate the utility of this technology for oil detection in the field, and develop a schema for real-time data transfer into existing spill response data management and visualization tools.
   https://www.bsee.gov/research-record/three-dimensional-mapping-of-dissolved-hydrocarbons-and-oil-droplets-using-a-remus

8. Canine Oil Detection – Using Odor Signatures to Improve Training Detection Proficiency on Land and Water (Lead agency: BSEE)
   The objectives of this research are first to determine the odor profile associated with spilled and obscured petroleum products used by the canine for detection and then use this knowledge to probe current canine detection limitations. The Naval Research Laboratory will develop and optimize methods of analysis for weathered crude oil using solid phase microextraction (SPME) with gas chromatography and mass spectrometry (GC-MS), and liquid injection with GC-MS for odor profile assessment. Chiron K9 will perform all canine training and testing. Oversight for both laboratory and canine testing will be provided by Owens Coastal Consultants to ensure operational work relevance.
   https://www.bsee.gov/research-record/canine-oil-detection-using-odor-signatures-to-improve-training-detection-proficiency

9. Development of Cellphone Application for Field-Screening Hydrocarbons Following Oil Spills (Lead agency: USGS)
   This projects aims to characterize and optimize the fluorescent properties of oil extracts to detect oil using a sensor using a cell phone camera. The resulting rapid screening tool will provide information on chemical classes and machine learning will be used to predict oil concentrations from the cell phone image.

10. Characterizing Dispersant Effectiveness of Crude Oils at High Salinities: Implications for Subsea Spill Preparedness (Lead agency: EPA)
    Potential oil exploration and production activities in close proximity to hypersaline water bodies (Arctic brine channels or GOM brine pool), necessitates characterization of dispersant effectiveness at high salinities. This project evaluates the performance and behavior of dispersants at high salinities.

11. Canadian MPRI Slick Thickness Asset Evaluation (Lead agency: NOAA)
    This collaborative project is funded by the Canadian government to evaluate current technologies that can provide estimates of slick thickness. Testing will be conducted in small-scale $1m^2$ totes for controlled slicks and also at Ohmsett tank for large-scale.

12. Comparing Advances in Estimating and Measuring Oil Slick Thickness (Lead agency: NOAA)
    This project is a joint collaborative effort between BSEE, NOAA, Fisheries and Oceans Canada, USCG, EPA, academia, and industry to advance the response community's ability to characterize and measure oil slick thickness through collaboration, knowledge sharing, and independent systematic technology assessment and testing. The project brings together an international team of experts who are working on technologies to characterize and measure the thickness of oil floating on water.

13. Advancing UAS and AUV Capabilities to Characterize Water Column and Surface Oil in Ice Environments (Lead agency: USCG)
    This project is a joint collaborative effort between USCG and NOAA to test a variety of UAS platforms and associated sensors for characterizing oil in ice environments. The project will build on previous NOAA (sensors) and the BSEE (facility) work in ice-free water.

14. Marine Induced Polarization Methods for the Detection and Mapping of Oil in an Arctic Marine Oil Spill; Including Investigation of Oil within and under Broken Ice Fields (Lead agency: DHS and USCG)
    The DHS Arctic Domain Awareness Center is conducting research to validate Marine Induced Polarization technology as a viable means to detect oil within ice and broken ice and is developing the hardware, firmware, software and testing to support creating a ruggedized deployable field kit.

15. Oil Sands Products Spill Response (Lead agency: USCG)
    Project is researching and developing enhanced decision-making tools and recovery and mitigation tools for responding to spilled oil sands products.

16. Propeller Driven Long Range Autonomous Underwater Vehicle (LRAUV) (Lead agency: DHS and USCG)
    The DHS Arctic Domain Awareness Center is creating a LRAUV that is helicopter portable with the ability to operate under ice for extended time with extended range to conduct environmental mapping and detect/characterize oil in and under ice.

17. Remote UAS Inspection and Response Team Development in the Bering Strait Region (Lead agency: DHS and USCG)
    The DHS Arctic Domain Awareness Center is conducting experiments using multispectral sensors on a UAS to support infrastructure monitoring and will co-produce a UAS-based monitoring program for conducting USCG regulated bulk oil facility inspections and emergency response with the Alaska Native Village of Unalakleet.

H. Oil Spill Detection and Surveillance – Research Papers:

1. Estimating Oil Slick Thickness with LiDAR Remote Sensing Technology
   This EPA report is a collaborative effort between the NRL and EPA. The study was funded by BSEE and was undertaken by NRL and EPA with testing conducted at Ohmsett.
   https://www.bsee.gov/sites/bsee.gov/files/research-reports//1091aa.pdf

2. Advances in underwater oil plume detection capabilities
   This is a collaborative project with EPA, NOAA, BSEE, USCG, WHOI, and WaterMapping Inc. 2021 International Oil Spill Conference Proceedings.

3. Classification of oil spill by thicknesses using multiple remote sensors
   https://doi.org/10.1016/j.rse.2019.111421

4. Measuring oil residence time with GPS-drifters, satellites, and UAS.
   https://doi.org/10.1016/j.marpolbul.2019.110644

5. Oil spill forecast assessment using Fractions Skill Score.
   https://www.sciencedirect.com/science/article/pii/S0025326X21000758

6. Multispectral UAS system for detecting, characterizing, and mapping oil spills on near shore environments. International Oil Spill Conference 2021.

7. Measuring oil residence time with GPS-drifters, satellites, and Unmanned Aerial Systems (UAS), Marine Pollution Bulletin, Volume 150, 2020.
   https://www.sciencedirect.com/science/article/abs/pii/S0025326X19307921?via%3Dihub

8. Classification of oil spill by thicknesses using multiple remote sensors, Remote Sensing of Environment, Volume 236, 2020.
   https://www.sciencedirect.com/science/article/abs/pii/S0034425719304407?via%3Dihub

9. Oil Spill Characterization with LiDAR. Ocean Sciences Meeting 2020.

10. Classification of Oil Spill Thicknesses Using Multispectral UAS And Satellite Remote Sensing for Oil Spill Response. 2019 Institute of Electrical and Electronics Engineers International Geoscience and Remote Sensing Symposium, 2019.

11. Engineering Design Report - Marine Induced Polarization Survey Arctic Ready Survey Kit
    https://arcticdomainawarenesscenter.org/P26_MIPM

I. In and On-Water Containment and Recovery – Research Projects:

1. Development of a Recovery Efficiency Sensor Phase II (Lead agency: BSEE)
   This project will continue development of a Recovery Efficiency sensor that can be used during oil response operations to accurately measure the percentage of oil and water in recovered fluid across the entire range of concentrations. Battelle will enhance functionality of the Phase I prototype including improved accuracy across the entire range of concentrations, ability to account for air in the recovered fluid, addition of wireless data transfer, and packaging of the system for easy deployment and use.
   https://www.bsee.gov/development-of-a-recovery-efficiency-sensor-phase-ii

2. Development of an Advancing Skimmer Test Protocol (Lead agency: BSEE)
   This project will develop a defined, repeatable test protocol for testing advancing skimmer systems. The contractor will convene a working group of experts in the field of oil spill response to develop a test protocol that is general enough to be suitable for use with a variety of advancing skimmers. The test protocol will be developed for use at the Ohmsett facility but will consider capabilities of other large-scale tank facilities during the development process to broaden the protocol's applicability. The resulting test protocol will produce skimmer test results that can be used as inputs to the recently developed ERSP calculator. Further, this test protocol will be introduced to the American Society for Testing and Materials (ASTM) F20 committee for their consideration and possible incorporation into a standard.
   https://www.bsee.gov/development-of-an-advancing-skimmer-test-protocol

3. Methods to Enhance Mechanical Recovery in Arctic Conditions (Lead agency: BSEE)
   This project focused on improving oil spill recovery methods in arctic conditions by developing and accessing techniques to herd oil under an ice sheet, increase recovery efficiencies of a vertical adhesion belt (VAB) skimmer, and increase the pumping efficiency of an oil/water mixture in sub-freezing temperatures.
   https://www.bsee.gov/research-record/osrr-1082-methods-to-enhance-mechanical-recovery-in-arctic-conditions

4. Assessment of Innovative Sorbents (Lead agency: BSEE)
   This project conducted a comprehensive assessment of sorbents for use in oil spill response. The assessment gathered information on sorbents currently used by Oil Spill Removal Organizations, and how and when they are used by these groups. The assessment compiled data on commercially available sorbents. The assessment also included a comprehensive review of recent research and development in sorbents for surface and subsurface use in oil spill response and identified multiple new and emerging sorbent technologies that could provide a potential benefit over current sorbent technologies. All typical sorbents were included in this assessment such as roll, film, sheet, pad, blanket, web, pom, loose, and enclosed sorbents including sock and pillow and sock boom sorbents. Sorbent material types included organic, inorganic, and synthetic sorbent materials.
   https://www.bsee.gov/research-record/assessment-of-innovative-sorbents

5. Development of a Field Scale Test Protocol for Testing Type I Sorbents (Lead agency: BSEE)
   This project will develop a Field Scale test protocol for testing Type I sorbents. Test activities will be used to answer questions and verify and validate the test protocol in a series of tests at Ohmsett. This test protocol will be socialized within the ASTM F20 committee with the goal of incorporation into an ASTM standard that can be used to provide repeatable and unbiased field scale test results to stakeholders including industry, oil spill removal organizations, manufacturers, and other users of Type I sorbent products.

6. Oil Spill Containment Boom Computational Fluid Dynamics (CFD) and Physical Modeling Study (Lead agency: BSEE)
   This project will investigate towed oil containment boom systems to assess how CFD modeling and physical scaled model testing results may predict full-scale boom performance. The contractor will conduct CFD modeling and physical testing of scaled

boom systems at multiple scales. Data obtained will be analyzed to determine their consistency when accounting for scale factors.

7. Research to Support Analysis of Oil Spill Response Plans for Spills on Snow and Solid Ice (Lead agency: BSEE)
   This project will develop a calculator tool to allow assessment of an operator's oil spill response plan for a well blowout, tank failure, pipeline leak, or other spill that occurs during winter months and results in recovery operations on snow and solid ice using "yellow gear" equipment as described in the Alaska Clean Seas Tactics Manual. Further, it will provide recommendations for further research and/or testing that should be conducted to reassess, verify, and potentially update the formulas incorporated into the calculator tool.

8. Enhancements to Ohmsett's Testing Capabilities in a Drift Ice Environment (Lead agency: BSEE)
   This project will enhance Ohmsett's capability to conduct testing in a drift ice environment. These enhancements have been identified through lessons learned from the past eight years of ice testing at Ohmsett. Successful execution of this project will lead to lower overall future test costs, better utilization of the available test time, more repeatable test conditions, and better analysis of the ice field. When completed, Ohmsett will be fully equipped to effectively and efficiently conduct ice testing to meet ASTM F3350-18 "Standard Guide for Collecting Skimmer Performance Data in Ice Conditions." In addition, Ohmsett will provide recommendations on how it can further expand its capabilities in providing frazil and slush ice for testing.

9. The Use of Additive Manufacturing to Investigate Novel Surface Geometries for Improved Oil Skimmer Recovery in Thin Oil Slicks (Lead agency: BSEE)
   This project will use additive manufacturing to investigate unique and innovative surface geometries that could improve an oleophilic skimmer's oil recovery rate and/or efficiency in thin oil slicks (1/2 inch and less.) Deep Analytics will develop and asses multiple 3-D printed surface geometries in a series of tiered tests at their facility. The most promising geometries will be implemented on a set of prototype drums and will be tested at the Ohmsett facility using a commercially available drum skimmer.
   https://www.bsee.gov/the-use-of-additive-manufacturing-to-investigate-novel-surface-geometries-for-improved-oil-skimmer

10. Development of an Active Ice Management System for Skimmers (Lead agency: BSEE)
    This project will design, build, and test an active ice management prototype to allow for improved mechanical recovery in broken ice with existing stationary skimmers.
    https://www.bsee.gov/research-record/development-of-an-active-ice-management-system-for-skimmers

11. Development of an Oil Thickness Sensor Phase II (Lead agency: BSEE)
    This project will continue development of an oil thickness sensor initially developed under BSEE project 1078. American University of Beirut will conduct design and test activities to enhance the Phase I prototype. They will then develop two unique prototypes for different uses. The first will be a handheld unit with a telescoping pole that can be extended up to 9 feet and measure oil thickness either from a vessel or from the side of a test tank. Oil thickness will be read directly by the user on the tool's handle. The second will mount

on a skimmer or in the apex of a boom and provide thickness information wirelessly to a user to a distance of up to 600 feet.
https://www.bsee.gov/development-of-an-oil-thickness-sensor-phase-ii

12. Market Research of SORS and VOSS Technologies (Lead agency: USCG)
Research state-of-the-market for potential technologies that can replace current SORS and VOSS equipment. Results will aid the USCG in developing a procurement strategy for replacing SORS and VOSS equipment to meet USCG's requirements as laid out in OPA 90.

13. Methods to Enhance Mechanical Recovery in Arctic Conditions (Lead agency: BSEE)
This project investigated several methods to enhance mechanical recovery in an arctic environment including using a remotely operated vehicle to recover oil under ice, developing methods to reduce icing of a vertical rope mop skimmer, and investigating the use of waste heat to improve pumping of recovered fluid.
https://www.bsee.gov/research-record/osrr-1082-methods-to-enhance-mechanical-recovery-in-arctic-conditions

14. Recovery of Oil Under Ice (Lead agency: BSEE)
This project will develop an ROV mounted tooling skid to detect, inspect, and recover pockets of oil under solid ice, and to scrape and remove oil-laden ice crystals formed on the underside of the ice. The tooling skid will consist of a pumping system, a manipulator arm with a collection nozzle and scraping tool, navigation, and lighting to allow differentiation of oil, water, and ice. It will have a standardized "plug and play" power and data protocol such that it can be used with any qualified ROV.
https://www.bsee.gov/development-of-an-oil-thickness-sensor-phase-ii

15. Ice Management for Vessel Oil Recovery Systems (Lead agency: BSEE)
This project designed, built, and tested an ice deflection system called BOWHEAD that can be used from the side of a vessel with an existing skimmer system. This project built upon previous work conducted under a Joint Industry Project that developed the MORICE system. The project enhanced the MORICE system based on recommendations made in the MORICE final report. The BOWHEAD focuses on simplicity, scalability, ease of operation, and deployability, and can be paired with multiple commercially available skimming systems.
https://www.bsee.gov/ice-management-for-vessel-oil-recovery-systems

J. In and On-water Containment Recovery – Research Papers:

1. Mitigation of Oil Moving Along the Waterway Bottom
The USCG report summarizes the results of testing of multiple prototype configurations developed to mitigate oil moving across the bottom of the waterway in inland and offshore environments. It also contains a summary of the effort and recommendations for responding to oils moving across the bottom.
AD1086872.pdf (dtic.mil)

2. Oil Sands Products Spill Response
www.dtic.mil

3. Recovery Technologies for Moving-Sunken Oil

This is a USCG report.

4. Vessel of Opportunity Skimming System Technologies Market Research
   This is a USCG report that is For Official Use Only.

K. Shore Containment and Recovery – Research Projects: None

L. Shore Containment and Recovery – Research Papers: None

M. Dispersants – Research Projects:

1. Update of the Ohmsett Dispersant Effectiveness Test Protocol (Lead agency: BSEE)
   This project will update the dispersant effectiveness test protocol that can be used by Ohmsett customers to conduct dispersant effectiveness experiments. Ohmsett is the largest facility of its kind and offers significant advantages for testing response technologies in controlled conditions. The original dispersant effectiveness test protocol was developed between 2000-2003. Since then, tank components have been replaced and testing procedures have been modified at Ohmsett. Additionally, engineering studies have been conducted on the tank to better characterize its performance and limitations. The data from these studies was not available when the original testing protocol was designed. The combination of these various factors support the need to update the dispersant testing protocol.
   https://www.bsee.gov/update-of-the-ohmsett-dispersant-effectiveness-test-protocol

2. Development of a Laboratory Protocol for Effectiveness of Commercial SWA in Cleaning Up Oil Spills on Shorelines (Lead agency: EPA)
   This project aims to develop a standardized and reproducible testing protocol to evaluate the shoreline cleaning efficiency of SWA. Oil removal efficiencies for SWA are being evaluated, as well as dispersibility, because an effective SWA should not disperse oil into water, as per U.S. policy.

3. Screening for NCP Product Schedule Potential New Reference Oils (Lead agency: EPA)
   Currently, there is a shortage of reference oils for NCP Product Schedule testing. The EPA has been screening oils to select the new reference oils to serve research needs for the next two decades. This is a high-priority project, as reference oils are critical to maintaining the NCP Product Schedule as mandated by OPA 90.

N. *Dispersants – Research Papers:*

1. The Interactive Effects of Crude Oil and Corexit 9500 on Their Biodegradation in Arctic Seawater
   This research was performed to determine the interactive effects of the copresence of crude oil and Corexit 9500 on the degradation of components from each mixture and the associated microbial community structure over time in Arctic seawater. These findings will help yield a better understanding of the biodegradability of dispersant components applied to an oil spill, the temporal microbial community response to dispersed oil, and the fundamental microbial ecology of organic contaminant biodegradation processes in the Arctic marine environment.
   https://doi.org/10.1128/AEM.01194-20

2. Long-Term Ecological Impacts from Oil Spills: Comparison of Exxon Valdez, Hebei Spirit, and Deepwater Horizon

This is an EPA research paper.

3. Microbial Biodegradation of Alaska North Slope Crude Oil and Corexit 9500 in the Arctic Marine Environment.
   https://www.boem.gov/sites/default/files/documents/regions/alaska-ocs-region/environment/BOEM_2020-033.pdf

4. Characterizing dispersion effectiveness at varying salinities
   This paper is a collaboration with EPA, BSEE, Canada. 2021 International Oil Spill Conference Proceedings.

O. *In-situ Burning – Research Projects:*

1. Characterization of Emissions and Residues from Simulations of Crude Oil Surface Oil Burns (Lead agency: EPA)
   Inefficiency during in situ burning results in the formation of burn residues that can sink through water and be buried within sediments. This project is dedicated to characterizing emissions and residues during burning to better understand the fate of hydrocarbons during burn operations.

2. In Situ Oil Burns: Analysis of Emissions and Residue from Methods to Improve Combustion Efficiency (Lead agency: BSEE)
   The EPA's Office of Research and Development will perform real-time air emissions and residue testing on two BSEE-sponsored, outdoor in situ burn tests at the Army Corp of Engineer's CRREL in New Hampshire. EPA will assess emission and residue to characterize the combustion efficiency. EPA will also assess emissions on an additional BSEE project at CRREL and a crude oil combustion study at the NRL's Chesapeake Beach Detachment.
   https://www.bsee.gov/research-record/analysis-of-emissions-and-residue-from-methods-to-improve-combustion-efficiency-of

3. Advancement of the Flame Refluxer Heat Feedback System (Lead agency: BSEE)
   The Flame Refluxer is technology that acts as a heat feedback system to enhance in situ burn operations. This new project will advance the technology readiness from a 6 to an 8 with the final integrated system tested in a real or relevant environment. Optimum materials and geometries will be studied for a bimetal heat collector intended for easy storage and deployment. The self-floating system will be tested at Ohmsett and the Army Corp of Engineers' CRREL to test burning and deployment efficiencies in waves.
   https://www.bsee.gov/research-record/advancing-the-maturity-of-the-flame-refluxer-technology

4. Accelerated, Clean, and Complete In Situ Burn of Crude Oil on Water Using Advanced Thermal, Air Flow, and Surface Catalysis Technologies (Lead agency: BSEE)
   The long-term objective of this proof-of-concept study is to accelerate and cleanly burn crude oil through a novel heat-feedback system. The research will study the use of heat pipe technology to enhance in situ burns of crude oil by transferring heat from the flames back into the oil slick. In addition to heat pipes, air-flow guide vanes will be studied to induce flame swirl and surface catalyst coatings to crude oil breakdown and combustion.
   https://www.bsee.gov/research-record/technology-for-accelerated-clean-and-complete-in-situ-burning-phase-i

5. Advancement of Low-Emission Spray Combustor for Commercialization (Lead agency: BSEE)
   The objective of this final phase of research is to transition the Technology Readiness Level of a low-emission, low-pressure atomization and combustor system for emulsified crude oil from 4 to 8 by developing and refining the performance of a half-scale or full-scale flow blurring atomizer spray burner so that the system design can be transferred to a manufacturer.
   https://www.bsee.gov/research-record/low-emission-combustor-system-for-emulsified-crude-oil

6. Advancement of Quantitative Measurements of ISB Volumes and Burn Rates in Open Water (Lead agency: BSEE)
   The objective of this project is to enhance an ISB quantification system. The system is designed to provide near real-time quantification of volumes of crude oil being burned thus yielding burn rate and efficiency. A series of small- and large-scale test burns will be conducted to acquire data for algorithms to accurately measure and quantify burning volumes and efficiencies to advance the state of maturity of the technology for commercialization.
   https://www.bsee.gov/research-record/advancement-of-quantitative-measurements-of-isb-volumes-and-burn-rates-in-open-water

7. Herder Burner Joint Industry Project (Lead agency: BSEE)
   BSEE will participate in a Joint Industry Project with the Prince William Sound Oil Spill Recovery Institute and ExxonMobil to design, develop, and test a spill response system for a single manned helicopter and/or several robotic helicopters. This spill response system can jointly apply chemical herders to a spill and ignite the oil once it has been corralled. This project will create a new rapid response tool that can address moderate-sized offshore spills that do not rely on vessel spill containment resources. Additionally, it will create a new aerial response tool that can address smaller localized spills close to a support vessel or platform without the risk of launching small boats into open seas or in ice, it will expand the suite of available response options that addresses spills in open water and ice-covered waters.
   https://www.bsee.gov/research-record/herder-burner-system-joint-industry-project

8. Autonomous Underwater Vehicle Deployable Oil Spill Igniter 'BSEE Igniter" – Phase II (Lead agency: BSEE)
   This project will focus on maturing the ignition system and developing the AUV launch module. The full-scale prototype of the technology will be tested and demonstrated with crude oil in the appropriate environment such as the USACE CRREL for ignition capabilities in extreme conditions including waves, ice, wind, and current. The system will be beta tested, and where appropriate, data analysis and/or interpretation will be automated.
   https://www.bsee.gov/research-record/efficient-remediation-of-oil-spills-using-fire-whirls-phase-ii

9. Efficient Remediation of Oil Spills using Fire Whirls – Phase II (Lead agency: BSEE)
   The objectives of this project are to characterize the ideal configurations and parameters of fire whirl formation, characterize the effects and burning/combustion efficiencies on emissions from different fire whirl configurations, fuels, and slick thicknesses, further understand the fundamental physics contributing to enhancement in the combustion

efficiency of fire whirls versus pool fires, and develop a scaled prototype fire whirl generator for use in a large-scale outdoor test facility.
https://www.bsee.gov/research-record/efficient-remediation-of-oil-spills-using-fire-whirls-phase-ii

10. Freshwater ISB Research (Lead agency: USCG)
    The objectives of this project is to develop and conduct a series of ISBs that evaluate crude oil/tar sands products and fuel oil burn behavior and impacts in fresh water. Efforts will provide science-based adaptive management approach information to response planners and Federal on Scene Coordinator about ISB efficacy and applicability to most likely spill scenarios in the Great Lakes. Work includes plume monitoring and measurement as precursor to protocol improvements.

P. In-situ Burning – Research Papers:

1. Freshwater ISB
   www.dtic.mil

2. Characterization of emissions and residues from measures to improve efficiency of ISB
   This is an EPA report published in The International Oil Spill Conference Proceedings: Vol. 2021, No. 1.

3. Experimental Approach for Measuring Burn Efficiency of a Reduced-Scale Wellhead Fire
   This is a BSEE report.

4. Method for Measuring Burn Efficiency of Spray Flames that Simulate Scaled-Down Petroleum Wellhead Fires
   This is a BSEE report.

5. Petroleum wellhead burning: a review of the basic science for burn efficiency prediction
   This is a BSEE report.

6. An Overview of Wellhead Burning: Fundamental Science to Burn Performance Prediction
   This is a BSEE report.

7. Comparison of particulate-matter emissions from liquid-fueled pool fires and fire whirls
   https://www.sciencedirect.com/science/article/abs/pii/S0010218020305824?via%3Dihub

8. Experimental Investigations and Scaling Analyses of Whirling Flames
   https://drum.lib.umd.edu/handle/1903/26614

9. Effects of Fire Whirl Generator Dimensions on Flame Length and Burning Rate
   This is a BSEE report.

10. Influence of enclosure dimensions on fire whirl geometry and burning rate
    This is a BSEE report.

11. Influence of natural and forced air entrainment on PM Emissions and burning behavior of diesel fire whirls
    This is a BSEE report.

12. Analysis of Emissions and Residue from Methods to Improve Combustion Efficiency of ISB
    This is a BSEE report.

13. The Influence of Turbulence on Subcooled Nucleate Pool Boiling
    This is a BSEE report.

Q. Alternative Chemical Countermeasures – Research Projects:

1. Development of a Laboratory Protocol for Effectiveness of Commercial SWA in Cleaning Up Oil Spills on Water (Lead agency: EPA)
   This project aims to develop a standardized and reproducible testing protocol to evaluate the shoreline cleaning efficiency of SWA. Oil removal efficiencies for SWA are being evaluated, as well as dispersibility, because an effective SWA should not disperse oil into water, as per U.S. policy.

R. Alternative Chemical Countermeasures – Research Papers:

1. Toxicity of Oil Spill Response Agents and Crude Oils to Five Aquatic Test Species
   This is an EPA manuscript published in Marine Pollution Bulletin.
   https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7425839/

2. Ecotoxicology of Deep Ocean Spills
   This is a book chapter within the Deep Oil Spills book by Murawski et al, published by Springer.
   https://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=350822&Lab=CEMM

S. Oily Waste and Oil Disposal – Research Projects: None

T. Oily Waste and Oil Disposal – Research Projects: None

U. Bioremediation and Biodegradation – Research Projects:

1. Microbial Biodegradation of Alaska North Slope Crude Oil in Arctic Marine Sediments (Lead agency: BOEM)
   Perform laboratory incubation studies investigating the biodegradation of fresh and weathered crude oil in arctic sediments under aerobic and anaerobic conditions to assess biodegradation rates and to identify oil-degrading microbes, which can help to formulate predictions regarding the fate of spilled oil in sediments.
   https://marinecadastre.gov/espis/#/search/study/100198

2. Dissolved hydrocarbon transformation products (Lead agency: USGS)
   This project aims to characterize the distribution, composition, and bio effects of dissolved partial hydrocarbon transformation products. These compounds are not routinely measured at spill sites but comprise the majority of dissolved organic carbon mass in the groundwater.
   https://mn.water.usgs.gov/projects/bemidji/

V. Bioremediation and Biodegradation – Research Papers:

1. Microbial Biodegradation of Alaska North Slope Crude oil and Corexit 9500 in the arctic Marine Environment
   https://espis.boem.gov/final%20reports/BOEM_2020-033.pdf

W. Other – Research Projects:

1. Chemical characterization and toxicity of new Low Sulfur Fuel Oils (Lead agency: EPA)
   EPA and NOAA are participating in the Emergency Prevention, Preparedness and Response-Protection of the Arctic Marine Environment project (Norway led) to evaluate new Low Sulfur Fuel Oils. There are emergency response cleanup concerns with Low Sulfur Fuel Oil, particularly in Arctic regions. EPA and NOAA are two of the participating laboratories to test three Low Sulfur Fuel Oil products.

X. Other – Research Papers: None

IV. INJURY ASSESSMENT AND RESTORATION

A. Environmental Impacts and Ecosystem Recovery – Research Projects:

1. A Review of distribution and quantity of lingering subsurface oil from the Exxon Valdez Oil Spill (Lead agency: NOAA)
   This study summarizes previous sampling and modeling efforts and refine previously presented models with additional data to characterize the present-day linear and areal spatial extent, and quantity of lingering subsurface oil.
   http://dx.doi.org/10.1016/j.dsr2.2017.07.009

2. Oil spill response-related injuries on sand beaches: When shoreline treatment extends impacts beyond the oil (Lead agency: USFWS)
   This study introduces the concept of 'Response Injury' categories that reflect both intensity and frequency of beach treatment methods. This study uses the literature on removal, beach nourishment) to describe the expected impacts.

3. Oil spills and their impacts on sand beaches: A literature review (Lead agency: USFWS)
   This review provides a synthesis of the scientific literature on major oil spills and their impacts on sand beaches, with emphasis on studies documenting effects and recoveries of intertidal invertebrate communities.
   https://doi.org/10.1016/j.envpol.2016.07.065

4. Heavily oiled salt marsh following the Deepwater Horizon oil spill, ecological comparisons of shoreline cleanup treatments and recovery (Lead agency: NOAA)
   Planting following treatment quickened vegetation recovery and reduced shoreline erosion. Faced with comparable marsh oiling in the future, this study would recommend manual treatment followed by planting.
   https://doi.org/10.1371/journal.pone.0132324

5. Meta-Analysis of Salt Marsh Vegetation Impacts and Recovery, Synthesis Following the Deepwater Horizon Oil Spill (Lead agency: NOAA)
   This study concludes that the Deepwater Horizon spill had multi-year impacts on salt marsh vegetation, with full recovery likely to exceed ten years, particularly in heavily oiled marshes, where erosion may preclude full recovery.

6. Bioenergetics-based migration model to assess migration effects and survival of oiled waterbirds (Lead agency: USGS)
   A temperature-based avian migration energetics model measures thermoregulatory costs of oiling on waterbirds. Sublethal oiling effects on springtime migration and reproduction, foraging requirements, and starvation susceptibility are quantified.

7. Enhance tribal capacity to prepare and respond to inland oil spills in the Pacific N.W.- Pre/post spill fish health and water quality assessments (Lead agency: USGS)
   This project will enhance tribal technical capacity to prepare for and respond to inland oil spills in the Pacific Northwest. This project provides updates on the development of training manual /standard operating procedures or pre-spill ecological baseline characterization and post-spill impact characterizations against which the baseline can be compared.

8. Using Biological Responses to Monitor Freshwater Post-Spill Conditions over 3 years in Blacktail Creek, North Dakota, USA (Lead agency: USGS)
   Project investigates biological responses to study the potential effects of an unconventional oil and gas wastewater spill. Estrogenicity, in-situ and site water toxicity experiments with fish, and microbial community structure characterizations were used to define biological responses post-spill at the individual, population, and community levels.

9. Environmental Effects of Illegal Oil and Gas Wastewater Dumping in the Permian Basin (Lead agency: USGS)
   This project with the Bureau of Land Management focuses on investigating the chemistry of Oil and Gas wastewaters from various formations, e.g., conventional gas vs. tight oil vs. conventional oil reservoirs, and evaluating the effects of oil and gas wastewater releases on soil biogeochemistry and vegetation.

10. Developing aquatic toxicity thresholds for major ions (potassium, chloride, sulfate) under natural conditions (Lead agency: USGS)
    This research aims to improve the aquatic toxicity thresholds used by regulatory agencies to make decisions regarding effects of major ions in by-product waters. This study aims to determine the acute and chronic toxicity of sulfate and chloride using a sensitive species under different hardness conditions.
    https://ww w.usgs.gov/centers/cerc/science/assessment-deep-fork-river-effluent-toxicity-unionid-mussel-fatmucket-lampsilis?qt-science_center_objects=0#qt-science_center_objects

11. Threatened and Endangered Species Fish Health Assessments for oil spill response (Lead agency: USGS)
    This project collects tissues and blood samples from fish, as a simpler method than estimating populations, to provide oil-related biomarker data. These data can then be used

to evaluate a species exposure to oil, efficacy of selected remedy, and can provide inferences to population level effects.

12. Determining carcass scavenging rates on major rivers for oil spill response and NRDA (Lead agency: USGS)
    This project addresses deficiencies in inland bird mortality models. The objective is to establish pre-disaster carcass scavenging rates that can serve as baselines for estimating the magnitude of avian injury following future oil spills along two major rivers.

13. Baseline Toxicity Testing of NCP Product Schedule Oil Spill Control Agents (Lead agency: EPA)
    Acute and chronic toxicity of commercially available products (chemical herder and surface washing agent) on the NCP Product Schedule using fresh and salt water species (fish and invertebrates) are being evaluated in this project.

14. Biodegradability of Crude Oil Exposed to SWA and Chemical Herders at Two Temperatures (Lead agency: EPA)
    Biodegradation rates of oil exposed to NCP Products that may remain in the environment after use are being evaluated. Such information is useful during oil spill response efforts and for fate and transport models.

15. Oil Spill Alternative Response Measures: Toxicity and Biodegradation of Treated Petroleum Oils (Lead agency: EPA)
    This project is funded through the Canadian MPRI for oil research. Toxicity testing of oil with and without treating agents (dispersants, herders, SWA) is currently underway.

16. Toxicity of Diluted Bitumens in Sediment to Benthic Invertebrates (Lead agency: EPA)
    The sub lethal toxicity of diluted bitumens in sediment to marine and freshwater benthic invertebrates will be determined.

17. Mitigating the Damage to Arctic Copepods from Surface Oil Spills: When to Apply Dispersants (Lead agency: DHS and USCG)
    The DHS Arctic Domain Awareness Center of Excellence at the University of Alaska Anchorage conducted research to determine "the impact of an oil spill, with and without dispersant, on copepods that are able to move vertically in the water column, thereby potentially avoiding the oil".

18. Photo-enhanced toxicity of dispersed and burned crude oil to Arctic mussels (Lead agency: DHS and USCG)
    The Arctic Domain Awareness Center is studying the effects of oil, dispersants, and in-situ burning, along with photo-enhanced effects, on physiological, biochemical, and metabolic aspects of a cold-water species of mussel (Mytilus trossulus).

B. Environmental Impacts and Ecosystem Recovery – Research Papers:

1. Biological Effects of Hydrocarbon Degradation Intermediates: Is the Total Petroleum Hydrocarbon Analytical Method Adequate for Risk Assessment? https://doi.org/10.1021/acs.est.0c02220

2. Hydrocarbons to carboxyl-rich alicyclic molecules: A continuum model to describe biodegradation of petroleum-derived dissolved organic matter in contaminated groundwater plumes
https://doi.org/10.1016/j.jhazmat.2020.123998

3. Assessment of the efficacy of six field cleaning protocols for hydrocarbon quantification
https://rdcu.be/cfJkt

4. Effect of Louisiana sweet crude oil on a Pacific coral (Pocillopora damicomis)
https://doi.org/10.1016/j.aquatox.2020.105454.

5. Tracking and Assessing Oil Spill Toxicity to Aquatic Organisms: A Novel Approach
https://doi.org/10.1002/etc.5000

6. Multi-stressor effects of ultraviolet light, temperature, and salinity on Louisiana Sweet Crude oil toxicity in larval estuarine organisms
https://doi.org/10.1007/s00244-021-00809-3

7. Developmental and reproductive effects in grass shrimp (Palaemon pugio) following acute larval exposure to a thin oil sheen and ultraviolet light
https://doi.org/10.1016/j.aquatox.2020.105651

8. Lionfish (Pterois volitans) as biomonitoring species for oil pollution effects in coral reef ecosystems
https://doi.org/10.1016/j.marenvres.2020.104915

9. Oil and Sea Turtles: Biology, Planning, and Response

10. Oil spills and sea turtles: documented effects and considerations for response and assessment efforts
https://doi.org/10.3354/esr01009

11. A multi-taxonomic framework for assessing relative petrochemical vulnerability of marine biodiversity in the Gulf of Mexico
https://doi.org/10.1016/j.scitotenv.2020.142986

12. Standardization of Dolphin Cardiac Auscultation and Characterization of Heart Murmurs in Managed and Free-Ranging Bottlenose Dolphins (Tursiops truncatus)
https://doi.org/10.3389/fvets.2020.570055

13. Project Knowledge Product: Mitigating the Damage to Arctic Copepods from Surface Oil Spills: When to Apply Dispersants
https://arcticdomainawarenesscenter.org/P24_Copepods

14. Towards Integrated Modeling of the Long-Term Impacts of Oil Spills.
https://myweb.fsu.edu/mstukel/Manuscripts/Solo-Gabriele_et_al_2021.pdf

15. Long-Term Ecological Impacts from Oil Spills: Comparison of Exxon Valdez, Hebei Spirit, and Deepwater Horizon
https://pubs.acs.org/doi/10.1021/acs.est.9b05020

C. Environmental Restoration Methods and Technologies – Research Projects: None

D. Environmental Restoration Methods and Technologies – Research Papers:

1. Effects of a Crude-Oil Recovery Remediation System Operated 1999–2003 on Groundwater Plumes and Unsaturated-Zone Vapor Concentrations at a Crude-Oil Spill Site Near Bemidji, Minnesota
https://doi.org/ 10.3133/ sir20205111

E. Human Safety and Health – Research Projects: None

F. Human Safety and Health – Research Papers:

1. Polyromantic hydrocarbons in pollution: a heart-breaking matter
https://doi.org/10.1113/JP278885

G. Sociological and Economic Impacts – Research Projects: None

H. *Sociological and Economic Impacts – Research Papers: None*

I. Other – Research Projects: None

J. Other – Research Papers: None