Oil Spill Response Options for the Flower Garden Banks National Marine Sanctuary

Photo Credit: Flower Garden Banks National Marine Sanctuary

May 25 – 26, 2016
Flower Garden Banks National Marine Sanctuary
Galveston, Texas

A WORKSHOP REPORT

COASTAL RESPONSE RESEARCH CENTER

Coastal Response Research Center

Acronyms

ACP	Area Contingency Plan
API	American Petroleum Institute
ARD	Assessment and Restoration Division (ORR)
ASTM	American Society for Testing and Materials
BOA	Basic Ordering Agreement
BOEM	Bureau of Ocean Energy Management (DOI)
BSEE	Bureau of Safety and Environmental Enforcement (DOI)
CERA	Consensus Ecological Risk Assessment
CFR	Code of Federal Regulations
CRRC	Coastal Response Research Center
CTCAC	Central Texas Coastal Area Committee
CTEH	Center for Toxicology & Environmental Health, LLC
CWA	Clean Water Act
DARRP	Damage Assessment, Remediation and Restoration Program
DDO	Dispersants and Dispersed Oil
DOI	Department of Interior
DPnB	Dipropylene Glycol n-Butyl Ether
DRC	Gulf of Mexico Disaster Response Center (ORR)
DROPPS	Dispersion Research on Oil Physics and Plankton Studies
DWH	Deepwater Horizon Oil Spill (also known as MC-252 and Macondo)
EFH	Essential Fish Habitat
ERD	Emergency Response Division (ORR)
ESA	Endangered Species Act of 1973
ETA	Environmental Tradeoff Analysis
FGB	Flower Garden Bank
FGBNMS	Flower Garden Banks National Marine Sanctuary
FOSC	Federal On-Scene Coordinator
FRV	Fast Response Vessel
FSU	Florida State University
GOM	Gulf of Mexico
GoMRI	Gulf of Mexico Research Initiative
HOSS	High Volume Offshore Skimming System
ICS	Incident Commend System
IPIECA	International Petroleum Industry Environmental Conservation Association
ISB	*In-Situ* Burning
MMPA	Marine Mammal Protection Act of 1972
MOSCA	Miscellaneous Oil Spill Control Agent
MSRC	Marine Spill Response Corporation
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEBA	Net Environmental Benefit Analysis
NGO	Non-Governmental Organization
NIMS	National Incident Management System
NOAA	National Oceanic and Atmospheric Administration
NPFC	National Pollution Funds Center (USCG)
NRC	National Response Center (USCG)

NRDA	Natural Resource Damage Assessment
NRPT	NOAA Regional Preparedness Training
OPA 90	Oil Spill Pollution Act of 1990
ORR	Office of Response and Restoration (NOAA)
OSAT	Operational Science Advisory Team
OSC	On-Scene Coordinator
OSLTF	Oil Spill Liability Trust Fund
OSRO	Oil Spill Removal Organization
PAH	Polycyclic Aromatic Hydrocarbons
POC	Point of Contact
RCP	Regional Contingency Plan
ROV	Remotely Operated Vehicle
RP	Responsible Party
RRT	Regional Response Team
SIMA	Spill Impact Mitigation Analysis
SMART	Special Monitoring of Applied Response Technologies
SOSC	State On-Scene Coordinator
SPMD	Semi-Permeable Membrane Device
SSC	Scientific Support Coordinator
SSDI	Subsea Dispersant Injection
TPAH	Total Polycyclic Aromatic Hydrocarbons
TGLO	Texas General Land Office
USCG	United States Coast Guard
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
UT Austin	University of Texas at Austin

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The workshop was facilitated by Dr. Nancy Kinner from the Coastal Response Research Center (CRRC; www.crrc.unh.edu) and was held at the Flower Garden Banks National Marine Sanctuary (FGBNMS) in Galveston, TX. CRRC has extensive experience with issues related to oil spills. The Center is known for its independence and excellence in the areas of environmental engineering, marine science, and ocean engineering as they relate to spills. CRRC has conducted numerous workshops bringing together researchers, practitioners, and scientists of diverse backgrounds (including from government, academia, industry, and non-governmental organizations) to address issues in spill response, restoration and recovery.

We wish to thank all the presenters for their participation in the training and workshop:

- Arden Ahnell, Exponent
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- Dr. Edward Buskey, UT Austin
- Dr. Jeff Chanton, FSU
- Dr. Lisa DiPinto, NOAA ARD
- Dr. Paige Doelling,
- Dr. Nancy Kinner,
- Dr. Tim Nedwed, ExxonMobil Upstream Research Company
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- Doug Helton, NOAA ERD
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Introduction

On May 25-26, 2016, the Coastal Response Research Center (CRRC)[1] and Disaster Response Center (DRC) co-sponsored a NOAA Regional Preparedness Training (NRPT) Workshop at the Flower Garden Banks National Marine Sanctuary (FGBNMS). The workshop focused on preparedness, planning and improvement of response to a potential oil spill that threatened the FGBNMS. The workshop examined response options such as dispersant use and *in-situ* burning (ISB) while developing the framework for an Environmental Tradeoff Analysis (ETA) to evaluate response options. The workshop also provided the opportunity for the spill response community to build relationships, understand the role each group plays in a response, and create a common understanding of the issues at the regional level.

Preceding the workshop, the CRRC and DRC conducted a one-day training on May 24, 2016 at the FGBNMS titled, "State-of Science of Dispersants and Dispersed Oil" which was open to all 43 workshop participants.

The participants (Appendix A) represented federal and state agencies, industry, response organizations, academia, and non-governmental organizations (NGOs).

The workshop was the first of three in the NRPT series to provide a focused training activity to enhance Gulf of Mexico (GOM) regional preparedness across NOAA line offices and among key state, federal, and other stakeholder partners. The overall goal of the NRPT workshops was to better understand the human and natural resources at risk, the roles and responsibilities of the different response agencies, and the science that drives decision-making during a coastal emergency.

The second workshop, held in Mobile, AL on June 8-9, 2016, focused on preparedness, planning and improving response to an oil spill during a natural disaster (*e.g.,* flooding from a tropical storm). Additionally, the workshop explored the roles and responsibilities under the *Robert T. Stafford Disaster Relief and Emergency Assistance Act* and the *Oil Pollution Act of 1990* (OPA 90).

The third workshop, held in St. Petersburg, FL on June 28-30, 2016, focused on risk communications during major oil spills.

[1] A list of acronyms is provided on Page 1 of this report.

Training:
State-of Science of Dispersants and Dispersed Oil

The purpose of the training was to educate and better prepare the response community regarding the current state-of-science of dispersants and dispersed oil (DDO), as well as to build relationships among the response community including federal and state agencies, academia, industry, and local community and other stakeholder groups. There is diversity of opinion regarding DDO and the training provided a forum to identify and discuss areas of controversy and examine the current state of research.

The agenda for the training can be found in Appendix B.

Presentations

The training included five topics on DDO, each covered in a 30-minute formal presentation followed by a 30-minute discussion. Below is a list of the presentation titles, speakers and their affiliations.

- Dispersant Efficacy and Effectiveness, Tim Nedwed, ExxonMobil Upstream Research Company
- Physical Transport and Chemical Behavior, Chris Barker, NOAA ORR Emergency Response Division (ERD)(remote presentation)
- Degradation and Fate, Nancy Kinner
- Eco-toxicity and Sublethal Effects of Oil in the Environment, Lisa DiPinto, NOAA ORR Assessment and Restoration Division (ARD)
- Public Health and Food Safety, Doug Helton, NOAA ORR ERD (remote presentation)

The training presentations slides are located in Appendix C.

Workshop: Environmental Tradeoff Analysis for an Oil Spill Response Impacting the Flower Garden Banks National Marine Sanctuary

Introduction

Nancy Kinner, G.P. Schmahl (Sanctuary Superintendent) from the FGBNMS, and Charlie Henry (Director) from the DRC provided the welcome and introductions for the workshop. Charlie Henry provided background information about the NRPT workshops and their goals. This workshop focused on preparedness, planning and improvement in response to oil spills that could impact the FGBNMS. Response options (*e.g.,* dispersant use, mechanical recovery, ISB) were examined and discussions centered on the use of ETAs in making response decisions.

The workshop consisted of plenary presentations and breakout sessions. Presentation topics included: an overview of the FGBNMS, oil spill response options, Natural Resource Damage Assessments (NRDAs), regional planning and preparedness, regulatory considerations and ETAs. The breakout sessions included discussions of: resources at risks, spill response options applicable to the FGBNMS, and determination of the best spill response options for a given spill scenario, along with its associated environmental tradeoffs.

The workshop agenda can be found in Appendix D.

Plenary Presentations

A summary of each plenary presentation from the workshop is provided in this section. Slides for the presentations are located in Appendix E. Most summaries were written by the presenters.

Flower Garden Banks National Marine Sanctuary

G.P. Schmahl provided an overview of the Flower Garden Banks (FGBs) with respect to the physical, chemical, and biological conditions, as well as regulatory considerations.

The FGBNMS consist of three of the dozens of reefs and banks scattered across the outer- and mid-continental shelf in the GOM (Figure 1).

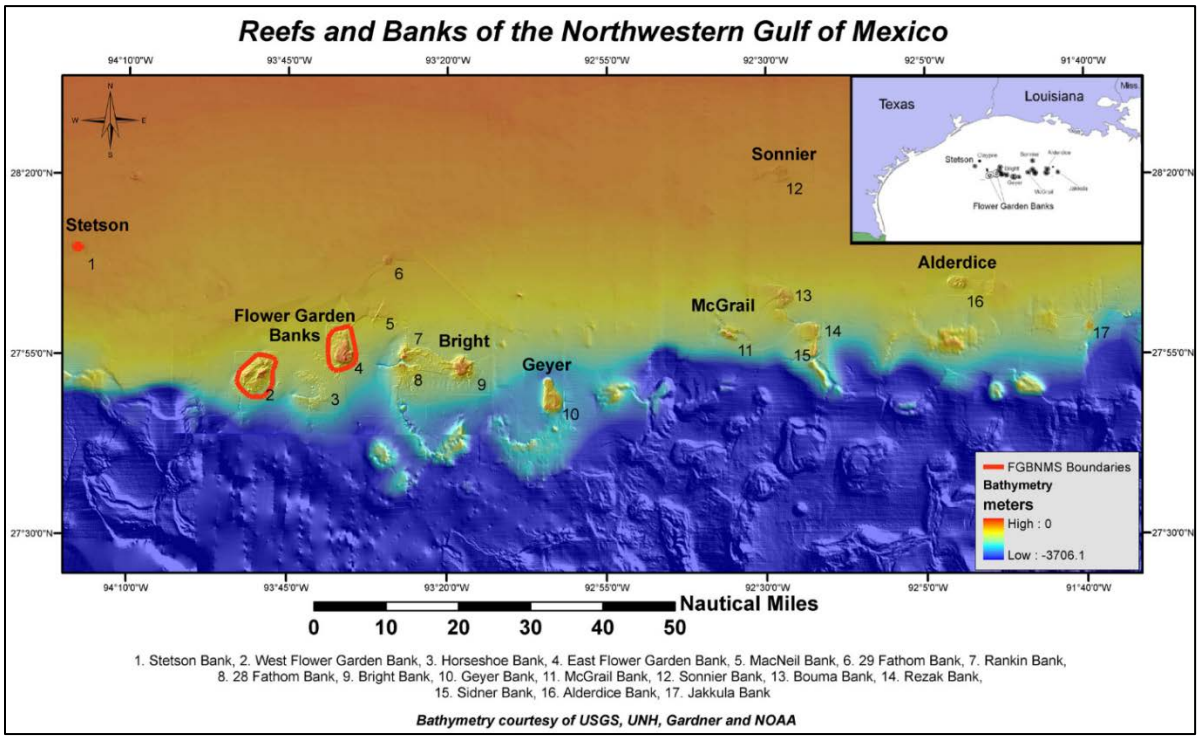

Figure 1. Map of the Reefs and Banks of the Northwestern Gulf of Mexico; East and West Flower Garden Banks and Stetson Banks are the sanctuary boundaries.

Two-thirds of the United States drains into the GOM through various waterways, including the Mississippi River. The nutrient content of this runoff is directly responsible for the hypoxic zone which has spread across the western coastal shelf in the GOM. The FGBNMS can also be influenced by the loop current if spin-off eddies peel off the current and cross the Gulf bringing warm or cold core eddies. The general movement of water is easterly within the area, however mesoscale dynamics of currents measured by the Naval Research Laboratory (Teague *et al.*, 2013) at the East FGB have revealed interesting details on the influence of the bathymetry on the movement of water. A two-layer current system is in play at the vicinity of the bank. A southerly flow of water at the southern edge of the bank can cause an area of convergence for deep offshore flow. Tidal currents are weak at the banks. Hurricanes can and have had serious impacts on the reefs. For example, Hurricanes Katrina and Rita were documented to have resulted in mechanical and water quality impacts. A combination of storm events and current can bring coastal waters out to the offshore banks.

The northern GOM is home to one the busiest oil and gas industries in the world. Conversely, the FGBs harbor some of the heathiest coral reefs in the Caribbean. They were first suggested as coral locations in charts dated 1910. In the mid-1900s fisherman named the location the FGBs. Reports, as recent as the

1950s, stated that massive coral reefs were unlikely to be prevalent in this area of the Gulf due to the lack of necessary environmental conditions required by corals (*e.g.,* warmer temperature, lower turbidity). Confirmation and first documentation of the astounding reefs and associated biology were first obtained by divers in the 1960s. FGB's habitats include the coral reefs, brine seeps, mud volcanos, and mesophotic coral habitats.

Wildlife abound with fish, sea turtles, sharks and rays, and invertebrates. Tagging studies have revealed movement and habitat use by loggerhead sea turtles, whale sharks, and manta rays. Over 70 individual manta rays have been identified (using the spot patterns on their underbellies). A variety of research is conducted using the sanctuary's research vessel, RV MANTA, primarily for scuba and remotely operated vehicles (ROVs). Extensive surveys and sampling conducted by ROVs have resulted in the development of habitat maps. Long-term monitoring has been conducted at all three banks of the sanctuary for over 20 years. The Bureau of Ocean Energy Management (BOEM) and the Bureau of Safety and Environmental Enforcement (BSEE) are partners in the long-term monitoring efforts.

Monitoring has recorded consistently high coral cover (over 50% cover) on the FGB's coral caps for the duration of the surveys – first collected in the last 1970s. The deep stations (*i.e.,* 30.5-40 m (100-130 ft)) have over 70 % coral cover. This is astounding considering the global decline of corals, including a long-term region-wide decline in Caribbean corals. The dominant species are represented by the *Orbicella* complex – three species which have been recently designated as threatened through the *Endangered Species Act of 1973* (ESA). The corals of the FGBs have not been affected by coral disease and have been minimally impacted by coral bleaching. Long-term images of permanent stations have illustrated the growth and robust nature of the corals. Fish monitoring has revealed healthy populations of large predators (*e.g.,* grouper, snapper). While fishing is a concern, the FGBs have higher numbers of large predators than many other Caribbean reefs. Various parameters of water quality are measured, including temperature and salinity. Invasive species are monitored and addressed. For example, lionfish are a recent serious threat. Removals are conducted, but it is evident that an intense local effort is needed to have an impact locally as control on a large scale is not possible.

Management zones and infrastructure that must be considered during spill response in and around the FGBs include: sanctuary boundaries, Habitat Areas of Particular Concern, BOEM No-Activity Zones, shunting zones, lease blocks and oil and gas platforms and pipelines. In 2012, the FGBNMS published an updated Sanctuary Management Plan that included a proposal to expand its boundaries. Mapping, exploration, and characterization within the region in preparation for this expansion have revealed additional hard bottom habitats, and levels of connectivity/interactions between the banks previously unknown. The Sanctuary Advisory Council and the FGBNMS have considered information available since the original designation of the sanctuary in 1992 (*N.B.*, Stetson Bank added in 1996). In 2015, a Notice of Intent to expand the boundaries of the sanctuary was published. The Draft Environmental Impact Statement for Sanctuary Expansion was announced during Capitol Hill Oceans Week and published in the Federal Register on June 10, 2016.

Oil Spill Response 101

State and federal Scientific Support Coordinators (SSCs), Steve Buschang from the Texas General Land Office (TGLO) Oil Spill Program and Paige Doelling from NOAA ORR ERD, presented a general overview of spill response history, regulatory authorities, responsible party (RP) requirements, and spill response techniques.

The primary purpose of the session was to prepare those participants who do not have a spill response background for plenary presentations and breakout sessions.

The following basic spill response options were discussed:

- Natural recovery,
- Berms and barriers,
- Physical herding,
- Manual removal,
- Skimming,
- Mechanical removal,
- Sorbents,
- Vacuuming,
- Debris removal,
- Sediment re-working/tilling/sifting,
- Vegetative cutting,
- Flooding,
- Flushing,
- Surface washing agents,
- ISB,
- Dispersant use

Natural Resource Damage Assessment

Lisa DiPinto (NOAA ORR ARD) provided an overview of NRDAs. NRDA is a legal process where injuries to the public's natural resources associated with oil and other hazardous substance releases and the appropriate amount and type of restoration are determined. Damages are assessed to make the public whole for their loss of resources from the time of the incident until full recovery to 'baseline'. Federal, state, and tribal "Trustees" representing the public and acting under various state and federal authorities are required to demonstrate causality between release and resource injury and lost use, including documentation of release, pathway, exposure and quantification of associated injuries. Examples of injury include adverse effects on:

- Survival, growth, and reproduction,
- Health, physiology and biological condition,
- Behavior,
- Community composition,
- Ecological processes and services,
- Physical and chemical habitat quality or structure,
- Public services, such as recreation.

Trustees often work in coordination with RPs as part of an overall cooperative assessment process. Ephemeral data collection and information coordination in the earliest hours and days of an incident is important, as it shapes plans for longer term injury studies. Ephemeral data considerations include:

- Documentation of wildlife animals present and/or oiled (e.g., fish, turtles, birds),
- Documentation of extent of oiling,

- Beach closures, advisories, boat access restrictions,
- Environmental sampling,
- Baseline (areas where oil predicted to impact, reference areas), and
- Water column data for fingerprinting and support of water column modeling (e.g., fate, transport, toxicity).

After initial ephemeral data is collected, there is a coordinated effort to transition to focus sampling and design to conduct studies for longer term impacts and recovery trajectory. Response data may be considered to help in determining areas for further study. A timeline for data collection is determined and may be based on a window of opportunity, a one-time event, or a collection over time.

The overall objective of NRDAs is to restore the injured resources, where injuries are balanced against and scaled to restoration projects.

State-of-Science as Applied to Flower Garden Banks National Marine Sanctuary

Mechanical Recovery

James Hanzalik from Clean Gulf Associates (CGA; New Orleans, LA) provided an overview of offshore mechanical oil recovery systems.

There are several types of mechanical oil recovery devices in the current inventory of oil spill cooperatives, including Oil Spill Removal Organizations (OSROs), in the Gulf of Mexico. Since the Deepwater Horizon oil spill (DWH), the OSROs CGA and the Marine Spill Response Corporation (MSRC) have invested millions of dollars in increasing the numbers and capabilities of these systems. CGA, for example, has increased its skimming capability eight-fold. This equipment is usually employed in different response areas including the offshore, near shore and inshore response.

Offshore and near shore mechanical recovery systems typically are vessel systems that would respond to a spill near the FGBs. Offshore vessels include the MSRC Responder Class vessels and oil spill response barges, CGA's Fast Response Vessels (FRVs), High Volume Open Sea Skimming System (HOSS) and various "vessels of opportunity skimming systems." Vessel based systems are limited by their forward speed and encounter rate is an issue with mechanical recovery systems because the skimming system must come in contact with the spilled oil. In addition, these recovery systems are limited by sea state or weather depending on the individual systems or vessels where they are employed. Most mechanical systems are limited to 2-4 ft seas with the exception of Koseq Arm system that can recover oil in seas up to 9 ft.

In addition, new infrared technologies and various aerial surveillance systems including drones, balloon systems and aircraft sensor systems have become a part of oil spill response strategies and tactics. For example, since DWH, the CGA FRVs and HOSS have the capability to skim oil 24/7 using infrared cameras and X-band radar equipment that allows tracking of spills in low or no light. This has made a "first light response" a phrase of the past.

In-Situ Burning

Charlie Henry provided an overview of ISB which is a controlled ignition at the location of the corralled or pooled oil.

The benefit of ISB is that it can be 90-98 % efficient of removing surface oil, with no significant increase in dissolved hydrocarbons in the water column. Oil is removed quickly, > 2,000 bbl/hr (318 m^3/hr), which is faster than a skimming system. Additionally, there are no storage capacity issues. ISB in open ocean environments often has a relatively limited window of opportunity (often only a few days) as a response option. The window of opportunity is limited because the oil must be first collected in a fire-resistant boom and contain less than 50% water-in-oil emulsion to burn effectively. Emulsification, not the evaporative loss of the more volatile organic constituents, is normally a limiting factor. ISB was used extensively during DWH as compared to the Exxon Valdez spill (1989) where only a test burn was conducted.

Usually, an oily tar residue remains at the completion of the burn and may sink.

ISB in federal waters may require Special Monitoring of Applied Response Technologies (SMART) air monitoring and likely wildlife monitoring to ensure safety and environmental compliance with respect to established best management practices. While the primary products of oil combustion are carbon dioxide and water, ~ 5 % of the oil removed from the surface is converted into incomplete combustion by-products including particulates (*e.g.,* smoke, soot) and polycyclic aromatic hydrocarbons (PAHs).

ISB may require authorization from the Regional Response Team (RRT). RRT-6 (*i.e.,* Region 6 states: Arkansas, Louisiana, New Mexico, Oklahoma, Texas) has a preauthorization in place for the offshore GOM which includes pre-identified exclusion zones because of potential of sinking residues.

Vessels, equipment, and logistics are required including specialized fire boom systems in order for the slick to be collected and thick enough to support continuous combustion (*i.e.,* several millimeters thick at a minimum). Similar to skimming operations, there is an issue with encounter rate. In addition, the oil is not destroyed or removed from the environment, but instead is transferred from the water into the air.

Dispersant Overview (Surface and Subsea Application)

Arden Ahnell from Exponent (Maynard, MA) provided an overview of dispersants, focusing on the options for their use during an oil spill scenario exposing the FGBNMS.

Deciding on oil spill response method alternatives often requires choosing methods with differing success rates and environmental effects. For an oil spill in an offshore environment, the options beyond stopping the release are usually monitoring, skimming, surface dispersant application and ISB. In the case of a deepwater oil well blowout, subsea dispersant injection (SSDI) is also possible.

The choice of response methods is often driven by what effect oil could have on the various resources at risk. Dispersants are a response tool that can be quickly deployed which aids in protecting resources on the ocean surface and, ultimately, shoreline resources, if applied away from shore. The tradeoff is the introduction of additional DDO into the water column.

Dispersants can be applied on the sea surface or in the subsea near the source of a deepwater well blowout (e.g., DWH). Surface application methods available include aerial (planes, helicopters) and floating vessels. Surface methods are well understood and responders can readily deploy these response systems. Aerial dispersant applications are often chosen due to the advantage of being able to be quickly deployed and its ability to treat a large surface oil slick rapidly (high encounter rate).

An important question for dispersant use in the area of FGBs is the potential DDO fate and transport given the location and at ~ 17 m (55 ft) depth. Studies from the DWH provided new information from the very extensive and detailed studies of the water. Data from 11,500 samples indicated the water from 0-10 m (0-33 ft) had mean concentrations of near 0.01 ppb (µg/L) Total Polycyclic Aromatic Hydrocarbons (TPAH) (Boehm et al, 2016). Data collected of a dispersant indicator, dipropylene glycol n-butyl ether (DPnB), during the response, indicated dispersants concentrations were always less than 300 ppb in the water column and seldom above 10 ppb at all depths (Operational Science Advisory Team (OSAT), 2010). Studies conducted immediately after dispersant use on DWH oil showed maximum concentrations of 78 ppb TPAH and 100 ppb DPnB in the water 1 m (3 ft) below the treated area with ~ 0.2 ppb TPAH observed at 10 m (33 ft) (Berjarano *et al.*, 2013). Additional studies of surface water mixing during DWH indicated oil mixes to ~ 5 m (16 ft) depth (Morrison *et al.*, 2016), indicating that oil from natural dispersion and dispersant use would occur at depths above the ~ 17 m (55 ft) reef depth where the FGBs exist.

SSDI was useful during DWH. Subsequent research at SINTEF (Trondheim, Norway) has better defined SSDI performance and shown it to be robust at deepwater depth (1500 m) and in the presence of gas (Brandvik *et al.*, 2016). The expected reduction in oil droplet size when using SSDI is ~ a factor of 10 vs. conditions where chemical dispersants are not added. This would suggest oil treated by SSDI will create droplets that still rise to the surface in a full scale blowout, albeit more slowly. The slower droplet rise means SSDI droplets would contribute to surface oil over a wide area. Since SSDI will create slowly rising droplets, the dissolved oil may rise to above the FGB reef depth if SSDI is applied beyond 10 km from the reef.

Marine Snow/Oil Flocculation

Jeffrey Chanton from Florida State University provided an overview on marine snow and oil flocculation.

Rapid sedimentation of petroleum (petrocarbon) following the DWH event was caused by the interaction of hydrocarbons with marine snow, and oil interaction with microbes and clay minerals (Daly *et al.*, 2016; Passow *et al.*, 2012; Ziervogel *et al.*, 2012). Microbial processes are important in controlling the deposition and composition of the organic materials transported to the seafloor to a similar degree as temporal changes in the delivery of materials derived from allochthonous sources (*e.g.,* river inputs). Hydrocarbons released from the DWH well were transformed by abiotic and biotic processes. Two approaches can be used to follow transformed hydrocarbons: high resolution mass spectrometry and isotopic analysis. The presentation focused on the latter.

Evidence from a variety of methods indicated that a centimeter of DWH-affected sediment was deposited on the seafloor in the northern Gulf (Brooks *et al.*, 2015; Chanton *et al.*, 2015; Valentine *et al.*, 2014). A substantial enrichment in gene sequences from phytoplankton chloroplasts in the top 2 cm (0.8

in) of deep sea sediment cores was consistent surface input (Brooks *et al.*, 2015). Estimates range from 0.5-14 % of the total hydrocarbons released in the DWH were deposited to the deepwater seafloor. This estimate does not include material deposited on beaches or in shallow waters.

Air Quality

Edward Buskey from the University of Texas at Austin provided an overview on oily aerosols and potential human health effects from the Dispersion Research on Oil Physics and Plankton Studies (DROPPS) Gulf of Mexico Research Initiative (GoMRI) Consortium.

The overarching research goals of DROPPS include studies of the effects of physical and chemical processes on the dispersion and distribution of oil in the sea. Studies have been made of the breakup of surface oil slicks by surface waves and by raindrops. The research uses a specialized laboratory flume at Johns Hopkins University that can generate waves of various heights and speeds. Detailed observations using high-speed video and digital holography have revealed that tiny droplets of oil are released into the water column and the atmosphere above the seawater surface by both of these physical processes. These dispersed droplets of oil become more numerous and smaller when chemical dispersants are applied to the surface oil slick. The laboratory system can detect oil droplets down to a few microns in diameter. These observations indicate that even smaller oily aerosol droplets may be created. Using a scanning mobility particle sizer, sub-micron oily aerosol particles in the 10-420 nm size range can be quantified. Addition of dispersants in a 1:25 dispersant to oil ratio led to a significant increase in oily aerosols in the 10-250 nm size range. A larger wave tank that can generate waves over 1 m (3.3 ft) in height has been recently converted to add a wind tunnel above the tank to disperse and sample the oily aerosols generated by breaking waves.

Researchers at the Johns Hopkins University School of Public Health are investigating the effects of these oily aerosols on human lung epithelial tissue cultures. All observations to date have been made under laboratory conditions. Field measurements of oily aerosols during a marine oil spill are needed to accurately assess the potential threat to human health.

Current Regional Response Team Area Contingency Planning for the FGBNMS

Michael Sams, RRT-6 co-chair, from the U.S. Coast Guard (USCG), provided an overview of the contingency planning and preparedness for the FGBNMS.

The Central Texas Coastal Area Committee (CTCAC), under the leadership of the Captain of the Port Houston-Galveston, is responsible for oil spill planning, preparedness, and response activities within the FGBNMS. OPA 90 and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) in the Code of Federal Regulations (CFR) Title 40, Part 300, provide the requirements for oil pollution contingency planning. The FGBNMS also falls within the RRT-6 area of responsibility.

The Central Texas Coastal Area Contingency Plan lists FGBNMS Point of Contact (POC) information. Likewise, the Southeast Texas and Southwestern Louisiana Area Contingency Plan, overseen by the Captain of the Port in Port Arthur, TX, also lists FGBNMS POC information.

Appendix C in the *RRT-6 Federal On-Scene Coordinator (FOSC) Dispersant Pre-Approval Guidelines and Checklist*[2] within the Region 6 Regional Contingency Plan (RCP), describes dispersant use policy within the FGBNMS. Although the FGBNMS is not identified as an exclusion area, the FOSC will engage the FGBNMS Superintendent early-on to discuss the viability of dispersant use.

The RRT-6 In-Situ Burn Pre-Approval lists the FGBNMS as an exclusion zone and ISB is not a viable response action.

RRT-6 identified the FGBNMS as a planning priority in 2015 and placed it on their executive committee priority list. This CRRC NOAA NRPT workshop is a significant step in advancing planning and preparedness in the vicinity of the FGBNMS.

The USCG, as the FOSC for oil spill response within the coastal zone, is committed to improved preparedness, ensuring a quick and efficient response, making the right response action choices for the right reasons. Persons not already involved in the Area Contingency Plan (ACP) process (with the Central Texas Coastal Area Committee) are highly encouraged to participate.

Regulatory Considerations: Subpart J – Use of Dispersants and Other Chemicals

Gregory Wilson from the U.S. Environmental Protection Agency (USEPA) Office of Emergency Management provided an overview of the NCP Subpart J – Use of Dispersants and Other Chemicals, as summarized by CRRC below.

The NCP is the federal government's blueprint for responding to both oil spills and hazardous substance releases. It establishes the:

- National Response Team and its roles and responsibilities in the National Response system. This includes planning and coordinating responses, providing guidance to Regional Response Teams, coordinating a national program of preparedness planning and response, and facilitating research to improve response activities,
- RRTs and their roles and responsibilities in the National Response System, including coordinating preparedness, planning, and response at the regional level,
- General responsibilities of FOSCs.

The Fish and Wildlife and Sensitive Environments Plan, incorporated in each ACP as an annex, is to be consistent with the RCP and NCP, and is to be prepared in consultation with the U.S. Fish and Wildlife Service (USFWS), NOAA and other interested natural resource management agencies or organizations. Among other requirements, the annex is to:

- Identify and establish priorities for fish and wildlife resources and their habitats and other important sensitive areas requiring protection from any direct or indirect effects from discharges,

[2] http://www.glo.texas.gov/ost/spill-response-resources/rrtvi/rrt6.pdf

- Provide a mechanism to be used during a spill response for timely identification of protection priorities of those fish and wildlife resources and habitats and sensitive environmental areas that may be threatened or injured by a discharge,
- Identify potential environmental effects on fish and wildlife, their habitat, and other sensitive environments resulting from removal actions or countermeasures, including the option of no removal.

Based on the evaluation of potential environmental effects, the annex establishes priorities for application of countermeasure and removal actions to habitats within the geographic region of the ACP.

The *Clean Water Act* (CWA) authorizes USEPA to prepare a schedule, in cooperation with the States, identifying:

- Dispersants, other chemicals, and other spill mitigating devices and substances, if any, that may be used in carrying out the Plan,
- The waters in which such dispersants, other chemicals, and other spill mitigating devices and substances may be used,
- The quantities of such dispersant, other chemicals, or other spill mitigating device or substance which can be used safely in such waters.

Authorization of use is governed by CFR Title 40 Part 300 Section 910 of the NCP. For preauthorization plans, RRTs and ACPs address the desirability of using appropriate dispersants, other products listed on the NCP Product Schedule, and burning agents. Preauthorization plans require approval of the USEPA RRT representative, the States with jurisdiction over the waters of the area to which a preauthorization plan applies, and the Department of Commerce (DOC) and the Department of Interior (DOI) Natural Resource Trustees.

Authorization of use for spill situations that are not addressed by the preauthorization plans requires concurrence of the USEPA representative to the RRT, and as appropriate, concurrence of the RRT representatives from the states with jurisdiction over the navigable waters threatened by the release or discharge and consultation with DOC and DOI Natural Resource Trustees. The exception is only to prevent or substantially reduce threat to human life when there is insufficient time to obtain the needed concurrences/consultations. The OSC must inform the USEPA RRT representative and, as appropriate, the RRT representatives from the affected states and, when practicable the DOC/DOI natural resources trustees as soon as possible. The exception is not intended to circumvent preauthorization or case-by-case use authorizations. The use of burning agents is authorized on a case-by-case basis, and sinking agents are <u>not</u> authorized for application on oil spills.

While a product listed in the NCP Schedule has met the minimum requirements for listing, it does not mean the USEPA approves, recommends, licenses, certifies, or authorizes its use on an oil discharge. There are 117 products listed (April 2016) with data and information requirements for dispersants, surface washing agents, surface collecting agents, bioremediation agents, and Miscellaneous Oil Spill Control Agents (MOSCAs). For dispersants, additional information includes:

- Components and their percentages (may be claimed confidential business information),

- Effectiveness and acute toxicity testing, and
- Recommended application procedures, concentrations, and conditions for use depending upon salinity, water temperature and other application restrictions.

More information on the NCP Subpart J can be found on the USEPA website[3].

Decisions for the use of dispersants or any other chemical agent are governed by provisions in the CWA and implemented through the NCP, including Subpart J. In the event any material presented by CRRC in this summary conflicts with the statute or regulations, the statute or regulations control. [*N.B.*, USEPA participation in this workshop should not be interpreted to mean endorsement or agreement with its outcomes or recommendations, nor with specific planning, preparedness and response determinations.]

Net Environmental Benefit Analysis

Jim Staves, an independent environmental consultant, provided an overview of Net Environmental Benefit Analysis (NEBA). [*N.B.* NEBA is a term used by the private sector. For this NRPT workshop the comparable term is ETA.] NEBA is a structured approach that can be used by the response community and stakeholders during oil spill preparedness, planning and response, to compare the environmental tradeoffs of potential response tools and develop a response strategy that will reduce impacts of a spill on the environment. The NEBA process involves four steps:

1. Compile and evaluate data to identify an exposure scenario and potential response options, and to understand the potential impacts of that spill scenario;
2. Predict the outcomes for the given scenario, to determine which techniques are effective and feasible;
3. Balance tradeoffs by weighing a range of ecological benefits and drawbacks resulting from each feasible response options. This may also include an evaluation of socio- economic benefits and costs resulting from each feasible response option; and,
4. Select the best response options for the given scenario, based on which combination of tools and techniques will minimize impacts.

Conducting a NEBA for oil spill response is not required by regulations in the United States, but a similar process, known as a Consensus Ecological Risk Assessment (CERA) has been used as an oil spill planning tool for many years. An expedited form of NEBA, involving fewer stakeholder representatives and compressed timeframes has recently been used by RRT-6 to support tabletop exercises which included seeking authorization for SSDI. Additional NEBA guidance documents are currently under development by the American Petroleum Institute (API), and a name change to “Spill Impact Mitigation Analysis” or SIMA is likely to be proposed. Regardless of the name selected, it is clear that use of the NEBA process can assist stakeholders in developing response strategies for the FGBNMS.

There are two example guidance documents for NEBA for spill response:

- “Choosing Spill Response Options to Minimize Damage: Net Environmental Benefit Analysis” (Volume 10) from the International Petroleum Industry Environmental Conservation Association (IPIECA), and

[3] https://www.epa.gov/emergency-response/national-contingency-plan-subpart-j

- "Standard Guide for Determining Net Environmental Benefit of Dispersant Use" (F2532-13) from American Society for Testing and Materials (ASTM) International.

Breakout Sessions and Oil Spill Scenario

The workshop participants were divided into four groups for parallel breakout sessions. [*N.B.*, Each group discussed the same topic. Hence, the feedback on each topic reflected the input of four different teams] An effort was made by CRRC to have a distribution of participant expertise in all groups. A list of the breakout groups is located in Appendix F. Each group had a leader to help facilitate discussion among all participants and a note taker equipped with a laptop computer and projector to capture the discussion. Each group completed workshop template (Appendix G).

The summary and distillation of key points from the breakout sessions are presented below. Breakout session notes from Groups A, B, C, and D can be found in Appendix H, I, J, and K, respectively.

Breakout Session I

The first breakout session was in the afternoon on the first day of the workshop. It was a preplanning activity to develop a basic understanding of the types of resources at risk, spill threats (*e.g.,* pipelines, oil rigs, shipping fairways), and resource protection priorities for the FGBNMS. This session was not incident-specific; participants were asked to focus on the East and West FGBs and to:

- Identify the resources at risk,
- Establish initial response objectives and actions,
- List current pre-authorization and exclusion zones as they apply to the FGBNMS, and
- Identify NRDA activities occurring during response.

Resources at Risk

The FGBNMS offers a complex and diverse habitat for ~ 250 fish, 23 coral, and 80 algae species. The sanctuary has 15 threatened or endangered species of whales, sea turtles, and coral listed under the ESA. The corals include: the lobed (*Orbicella annularis*), mountainous (Orbicella faveolata), and boulder (*Orbicella franksi*) star coral, as well as the elkhorn coral (*Acropora palmata*).

Resources at risk can be characterized by habitat type, including the air, surface layer, water column, and benthic layer. A species list of sanctuary animals found within the coral cap (0-40 m, 0-130 ft) can be found at the FGBNMS website[4]. Additionally, human-use resources at risk are also identified.

[4] http://flowergarden.noaa.gov/about/specieslist.html

Air

The FGBs is in the path of migratory flyways over the GOM. There have been a variety of birds sighted at the FGBNMS:

- Boobies,
- Cardinals/ grosbeaks,
- Cuckoos,
- Doves,
- Falcons,
- Flycatchers,
- Frigate Birds,
- Gallinules,
- Gannets,
- Gulls,
- Herons,
- Hummingbirds,
- Mockingbirds/ thrashers,
- Nightjars,
- Orioles,
- Pelicans,
- Petrels,
- Sparrows,
- Swallows,
- Swifts,
- Tanagers,
- Teals,
- Terns,
- Thrushes,
- Vireos ,
- Warblers,
- Woodpeckers.

Surface layer

Several resources at risk were identified for the surface water layer.

- *Sargassum*, a large brown seaweed, is designated as Essential Fish Habitat (EFH) under the *Magnuson-Stevens Fishery Conservation and Management Act* as it provides a floating habitat to an array of wildlife including fish, sea turtles, and marine birds.
- The surface layer is also important for air-breathing animals such as whales, dolphins and sea turtles.
- Once a year, 7-10 days after a full moon in August, and sometimes in September, there is a mass coral spawning event where floating coral gametes and gamete bundles create a sheen on the surface of the water. Other species spawning at this time include sponges, brittle stars, and Christmas tree worms.
- Early life stages of many species (*i.e.,* eggs and larvae) are at the surface.

Water Column

Marine mammals, sea turtles, boney fish, cartilaginous fish (*e.g.,* rays, sharks), jellies, and plankton are examples of resources found in the water column. The following section lists species found in the FGBNMS.

Marine mammals:

- Beaked whale sp. (*Mesoplodon* sp.)
- Pantropical spotted dolphin (*Stenella attenuate*)
- Atlantic spotted dolphin (*Stenella frontalis*)
- Bottlenose dolphin (*Tursiops truncates*)

Marine mammals are protected under the *Marine Mammal Protection Act of 1972* (MMPA).

Sea turtles:

- Loggerhead turtle (*Caretta caretta*); listed as threatened under ESA
- Hawksbill sea turtle (*Eretmochelys imbricata*); listed as endangered under ESA

Cartilaginous fish:

Rays:

- Spotted eagle ray (*Aetobatus narinari*)
- Southern stingray (*Dasyatis americana*)
- Roughtail stingray (*Dasyatis centroura*)
- Manta ray (*Manta birostris*)
- Lesser devil ray (*Mobula hypostoma*)
- Sicklefin devil ray (*Mobula tarapacana*)

Sharks:

- Spinner shark (*Carcharhinus cf. brevipinna*)
- Silky shark (*Carcharhinus falciformis*)
- Blacktip shark (*Carcharhinus cf. limbatus*)
- Bull shark (*Carcharhinus leucas*)
- Dusky shark (*Carcharhinus obscurus*)
- Caribbean reef shark (*Carcharhinus perezii*)
- Sandbar shark (*Carcharhinus plumbeus*)
- Tiger shark (*Galeocerdo cuvier*)
- Nurse shark (*Ginglymostoma cirratum*)
- Angel shark (*Squatina dumeril*)
- Smooth dogfish (*Mustelus canis*)
- Gulf smoothhound (*Mustelus sinusmexicanus*)
- Whale shark (*Rhincodon typus*)
- Atlantic sharpnose shar (*Rhizoprionodon terraenovae*)
- Scalloped hammerhead shark (*Sphyrna lewini*)
- Great hammerhead shark (*Sphyrna c.f. mokarran*)
- Atlantic angel shark (*Squatina dumeril*)

Cartilaginous fish:

- Angelfish
- Barracuda
- Batfish
- Bigeye
- Blenny
- Bonnetmouth
- Boxfish
- Butterflyfish
- Cardinalfish
- Chub
- Cobia
- Conger Eel
- Cornetfish
- Damselfish
- Dolphin
- Dragonet
- Driftfishes
- Drum
- False Moray Eel
- Filefish
- Flyingfish
- Frogfish
- Goatfish
- Goby
- Grunt
- Halfbeak
- Hawkfish
- Jack
- Jawfish
- Lefteyed flounder
- Lionfish
- Lizardfish
- Mackerel
- Mooray eel
- Mullet
- Needlefish
- Ocean sunfish
- Parrotfish
- Pipefish
- Porgy
- Puffer
- Remora
- Sea bass (grouper)
- Sea robins
- Scorpionfish

- Snake eel
- Snapper
- Soapfish
- Spadefish
- Spaghetti eel
- Spiny puffer
- Squirrelfish
- Surgeonfish
- Shreadfin
- Tilefish
- Triggerfish
- Trumpetfish
- Tripletail
- Wrasse

Jellies:

- Moon jelly (*Aurelia aurita*)
- Warty sea wasp (*Carybdaea marsupialis*)
- Sea nettle (*Chrysaora quinquicirrha*)

Plankton:

- Eggs and larvae of larger animals
- Coral gametes
- Other invertebrate gametes

Benthic layer

Table 1 includes a summary of the habitat characterization and description of the FGBNMS which include the coral reefs, coral community, coralline algae, deep coral, and the soft bottom community. An interactive GIS-based mapping tool which includes the habitat characterization within the FGBNMS is available from NOAA[5].

[5] http://www.ncddc.noaa.gov/website/google_maps/FGB/mapsFGB.htm

Table 1. Summary of the biological zones, major habitats, and biology in and around the FGBNMS from the FGBNMS Habitat Classification web page (FGBNMS, 2016)

Biological Zone	**Major Habitats**	**Biology**	**Description**
Coral reef	Coral reef community, *Montastraea*, *Orbicella*, *Madracis*, Stephanocoenia, carbonate sand (reef-derived sediments)	*Montastraea*, *Orbicella*, *Stephanocoenia*, *Madracis*, *Agaricia*, sponge, mixed coral, leafy algae, hardbottom community, sand community	• Shallowest zone, ~ 18-45 m (59-148 ft) • Characterized by a high cover of coral assemblages dominated by *Montastraea* and *Orbicella* species, brain coral (*Pseudodiploria strigosa)*, mustard hill coral (*Porites astreoides)*, boulder brain coral (*Colpophyllia natans)* and blushing star coral (*Stephanocoenia intersepta*). • Coralline algae, filamentous and leafy algae also occur on reef substrates, but are not dominant members of the benthic assemblage • Yellow pencil coral (*Madracis auretenra*) forms large monotypic stands in deeper portions of the coral reef community • Sponges and *Agaricia* species are common in crevices and cavities of the reef • Sand patches and channels

Coral community	Coral community, *Millepora*-sponge, sponge, leafy algae/sponge, low density coral	*Millepora*-sponge, sponge, leafy algae/sponge, low density coral, mixed coral, leafy algae, sand community, hardbottom community	• 40-55 m (131-180 ft) depths • Characterized by the blushing star coral, the large star coral (*Montastraea cavernosa*), fire coral (*Millepora alcicornis*), and the boulder brain coral • Lettuce corals (*Agaricia* species) and brain coral are important part of community • Crustose coralline algae dominant encrusting form on dead coral rock, along with leafy algae and numerous sponges • Dominance of hard corals declines with depth; few coral colonies occur between 45-50 m (147-180 ft)
Coralline algae	Algal nodules	Sand community, *Madracis*, leafy algae/sponge, octocoral, black corals, mixed coral, sponge, algal pavement, leafy algae, rhodolith assemblage, tilefish mound	• Dominated by crustose coralline algae, forming individual algal nodules or rhodoliths, or forming large plates and ridges that develop into massive reef structures • Variety of sponge species are abundant, numerous black corals and octocorals • Few reef-building corals occur at these depths, mostly limited to small isolated colonies • Variety of leafy algae fields resent
	Coralline algal reefs	Sand community, leafy algae/sponge, octocoral, black corals, mixed coral, algal pavements, sponge	

Deep coral	Deep reef	Octocoral, black corals, stony corals, sponge/coral, mixed coral, sponge	• Occurs below water depths that support active photosynthesis • Characterized by a diverse assemblage of black corals and gorgonian corals, crinoids, bryozoans, sponges, azooxanthellate branching corals, and small, solitary hard corals • Rock surfaces often highly eroded and lack coralline algal growth • Reef outcrops may be covered with thin layer of silt
Soft Bottom Community	Soft bottom community	Bacterial mats, black coral fields, stony corals, octocorals	• Deeper areas characterized by a soft, level bottom community composed of both terrigenous sediments originating from coastal rivers and carbonate sediments resulting from erosion of rocky outcrops and coral reef communities • Few conspicuous fishes and invertebrates occur on soft bottom communities when compared to coral reef or rocky zones • Characterized by sand waves, burrows and mounds • Transitional zones between soft bottom communities and hard bottom features are characterized by exposed rubble, isolated patch reefs or exposed hardbottom; areas with buried or exposed rubble are often colonized by black corals, octocorals or solitary hard corals

Human Use

Human-use resources at risk from an oil spill affecting the FGBNMS include:

- Ecosystem services (*e.g.,* tourism, diving, sailing),
- Recreational and commercial fishing,
- Oil and gas (note: oil rigs also provide artificial reefs for wildlife)
- Shipping and transportation, and
- Historical value of the FGBs.

Initial Response Objectives and Actions

The initial response objectives are to:

1. Protect the health and safety of the public and spill responders,
2. Control the source,
3. Containment and cleanup of the oil spill,
4. Minimize and mitigate environmental impact to the resources at risk,
5. Keep the public and stakeholders informed.

In prioritizing the resources at risk in the sanctuary, protection of the coral habitat was determined to be the most important. Avoiding contact between air-breathing organisms and surface oil was also deemed important.

Initial response actions include notifying the National Response Center (NRC) and establishing the Incident Command System (ICS) which is a part of the National Interagency Incident Management System (NIMS). The Incident Commander is responsible for the response to the incident and all related activities. In cases where several organizations have shared authority to respond to an oil spill, a Unified Command allows for the Incident Commander's responsibility to be shared with agencies and organizations that have jurisdiction. For example, the Unified Command for oil spills in the coastal zone typically consists of the FOSC, State On-Scene Coordinator (SOSC), and the RP.

With an established Incident Command, the following actions occur:

- Coordinating with FGBNMS and other Trustees,
- Identifying the RP,
- Gathering information on the oil spill, including taking oil samples, and:
    - Determination of specifics of the event (*e.g.,* type of release, time, scale, location),
    - Analysis of oil characteristics from samples (*e.g.,* oil type, properties, weathering), and
    - Initiation of aerial surveillance and monitoring
- If applicable, securing the source,
- Modeling the oil spill trajectory with weather and oceanographic models and understanding currents,
- Identifying the resources at risk that are present,
- Assessing and mobilizing appropriate response resources (*e.g.,* mechanical recovery, ISB, dispersant application), and mitigation of effects of the oil spill, beginning as far away from the FGBNMS as possible,

- Establishing and implementing an environmental data management plan for collection and storage,
- Establishing a joint information center, and
- Communicating and engaging with stakeholders.

Each RRT is a planning, policy and coordinating body and it maintains an RCP. In the event of a spill, the RRT does not respond directly, but it provides assistance as requested by the OSC.

Pre-Authorization and Exclusion Zones in the FGBNMS

The FGBNMS Superintendent would be contacted early by the FOSC to discuss the viability of the use of surface dispersants as the sanctuary is not listed as an exclusion zone. Appendix C in the *RRT-6 Federal On-Scene Coordinator (FOSC) Dispersant Pre-Approval Guidelines and Checklist*[6] describes the dispersant use policy within the FGBNMS, stating, "all efforts must be made to apply [dispersants] in water as deep as possible and as far from the Sanctuary as possible, in order to promote dilution of dispersed oil and minimize the effects on shallow-water organisms". Further, it is noted that the FGBNMS Superintendent may be able to provide information to the RRT and FOSC on the resources as risk that could affect the decision to apply dispersants.

The *RRT VI In-Situ Burn Plan Part I (Operations Section)*[7] includes exclusion zones "because of concerns about the possibility of sinking residue or atmospheric emissions, certain sensitive areas 'have been set aside for exclusion from the pre-approved *in-situ* burn area of 3 mi or farther off the Louisiana and Texas coasts". The Stetson Bank, as well as the East and West FGBS, are listed as an exclusion area in the plan under Appendix E: Exclusion Zones.

NRDA Activities during Response

The use of the Oil Spill Liability Trust Fund (OSLTF), with the primary source of revenue of the per-barrel tax on the oil industry, was authorized when OPA 90 was signed into law. Under OPA 90, the RP is liable for costs and damages. The National Pollution Funds Center (NPFC) has a billing and collection program to recover costs expended by the OSLTF. Included in the use of the funds is the removal costs incurred by the USCG and USEPA, as well as the payments to federal, state and Indian Tribe Trustees to conduct NRDAs and restorations.

NRDAs are conducted by NOAA's Damage Assessment, Remediation and Restoration Program (DARRP), which includes ARD and the National Marine Fisheries Service Restoration Center. The NRDA team, often in coordination with the RP (responsible party) goes to the site with the RP representative in coordination with the other Trustees. There is often a cooperative agreement with the RP and NRDA team to facilitate data collection and data sharing.

As discussed in the NRDA plenary session, documentation of ephemeral data is important. The NRDA team starts contacting experts on the resources at risk (*e.g.,* species, habitats) to determine what data exist, what data are needed, and what methods should be used to conduct surveys. The scale of the spill

[6] http://www.glo.texas.gov/ost/spill-response-resources/rrtvi/rrt6.pdf
[7] http://www.rrt6.org/Uploads/Files/Appendix%2013%20--%20In-Situ%20Pre-Authorization%20Plan%20--%201994.pdf

has an impact on the NRDA process; smaller scale spills are more manageable with respect to coordination. The NRDA process includes an assessment of the impact of the spill response. It is important to apply best management practices during the response to minimize damage to the resources at risk.

Example initial NRDA activities include:

- Sampling source oil, water, air, sediment and biota,
- Surveying recreational and other human use activities,
- Wildlife (*e.g.,* mammals, birds, fish) observations.

Sampling occasionally is split between agencies. With respect to a NRDA for the FGBNMS, long-term monitoring studies will provide data regarding the health of the sanctuary (i.e. baseline) prior to a spill.

NRDA establishes a monitoring and long-term recovery program. Semi-Permeable Membrane Devices (SPMDs) can be deployed and attached to a buoyed line to characterize dissolved hydrocarbon fractions in the water column.

Breakout Sessions II

The second breakout session was in the morning on the second day of the workshop and was another preplanning activity to develop a basic understanding of response options that could be used in or near the FGBNMS. Similar to the first session, it was not incident-specific; participants were focused on the East and West FGBs and identified:

- Response options,
- Response tradeoffs,
- “External pressures” affecting response decision-making,
- Key elements driving the decision-making process.

Each group evaluated the following response options: mechanical recovery, ISB, surface dispersant application, sub-surface dispersant application and no response.

Tables 2, 3, and 4 identify the tradeoffs, “external pressures” affecting decision-making, and key elements driving the response selection process, respectively, for each response option.

Table 2. Tradeoffs for oil spill response options that could occur in or near the FGBNMS

Mechanical removal	ISB	Surface dispersant application	SSDI	No response
Pro: • No chemicals added to environment • Fraction (ranging up to 10-15 %) of oil encountered is removed (but still need to manage the waste disposal) **Con:** • Low encounter rate and less efficient offshore (~ <10%) • Skimming is limited by sea state conditions • Timely process to mobilize (*e.g.,* 5-6 h at 24 kt vessel speed); difficult logistics with getting vessels and equipment to site • Depending on spill size, limitation of response fleet size • Responder health and safety potentially at risk • Weather dependent • Surface-dependent natural resources (*i.e.,* turtles, mammals, Sargassum habitats) at risk from vessel encounters and related response activity	**Pro:** • Removes large fraction of oil encountered from surface (~ 90 %) • Removes oil faster than skimming • No storage needed for waste disposal **Con:** • Time constraint (it must be done early before oil emulsifies) • Health and safety issues • Risk to wildlife and recovery • May have limitation with the availability of equipment: mechanical collection (*i.e.,* herding) and/or chemical herding agents, specialized fire boom (fire boom with vessel would take 10-12 h at 12 kt (6 m/s) vessel speed from dock to spill) • Containment is limited by sea state • Long-term persistence from sunken/smothering residue, impacting natural benthic resources (*e.g.,* coral) • Transfer pollution to air; adverse air quality • Adverse impact on surface natural resources (*e.g.,* mammals, birds, turtles) • Interrupt maritime traffic • Offshore ISB is unlikely (due to oil weathering by the time equipment reaches the area)	**Pro:** • High speed of deployment (1.5 h to get to spill by plane) • High encounter rate • Effective dispersion of oil into water column • Responder risk for contact with contaminants is reduced • Increased biodegradation due to smaller oil droplets • No storage needed for waste disposal **Con:** • Transfer pollution into the mixed layer upper 10 m; adverse impact to natural resources with increased toxicity (*e.g.,* manta and eagle rays, sharks, fish) • Weather dependent, sea state dependent • Detailed monitoring plans required (*e.g.,* Tier 1, Tier 2) • Potential increase in aerosol droplet formation (*e.g.,* air exposure pathway) • Interaction with marine snow • Increased risk of exposure to natural benthic resources (with sinking of oil associated with sediment and marine snow)	(Only applicable for subsea deepwater well blowout) **Pro:** • Responder risk for contact with contaminants is reduced • More efficient because dispersant is applied to fresh oil • Operation is 24 h/day (3 days to deploy) • Less dispersant is added to the environment (100:1 instead of 20:1 at surface) • No storage needed for waste disposal **Con:** • More difficult to monitor (*i.e.,* subsurface requirements for monitoring are more complex) • Likely to "sacrifice" benthic habitat organisms in the near field	• Any other response option would cause more harm **Pro:** • May be best option for very light oils (*i.e.,* high volatilization potential) • Potentially less physical encounters with natural resources • Responder risk for contact with contaminants is reduced **Con:** • Impact to surface and upper 10 m of water column • Increased risk of oil coming to shoreline • Increased risk of: surface animal encounters, impacts to human health, impacts to human use (*e.g.,* shipping, boating, recreational and commercial activities) • Disruption of shipping fairway • Allows oil to weather/emulsify and may become persistence in environment

Table 3. "External pressures" affecting decision-making for response options that could occur in or near the FGBNMS

Mechanical removal	**ISB**	**Surface dispersant application**	**SSDI**	**No response**
• Public perception: mechanical recovery is preferred option • Public and political pressure: urgency to remove oil as quickly as possible • Maintains on-scene presence (despite limited vessel capability) and there is visible response action • Compliance with contingency plan; preferred option • Regulatory requirements	• Public concern if burn is near-shore • Air quality: concern for wildlife and human health populations downwind • Concern that sunken residue will smother benthos • Political pressure: less expensive response option than mechanical recovery • Human community scale impacts • Regulatory requirements	• Public perception: dispersants are toxic causing harm to humans and marine resources • Public and political pressure to remove oil as quickly as possible • Stakeholder concerns • Concern of adding chemicals to environment • Loss of consumer confidence (*e.g.,* seafood safety) • Perceived damage of spraying dispersant on charismatic megafauna • Need to search for damage and handle claims • Requirement to restrict dispersant application if turtles are present (even if the oil slick could be more damaging) • Human community scale impacts • Regulatory requirements	• Negative public perception • Less is known about fate and impact; lack of independent/academic research • Political issue: politicians pushing own agenda • Economic impact • Stakeholder concerns • Concern of adding chemicals to environment • Loss of consumer confidence (*e.g.,* seafood safety) • Human community scale impacts • Regulatory requirements	• Public and political pressure to do something for a significant spill • Organizationally, federal and state agencies have pressure to respond • Negative media • Interfere with maritime traffic • Bias to manage shoreline impact vs FGBNMS is offshore • Regulatory requirements

Table 4. Key elements driving the decision-making process for response options that could occur in or near the FGBNMS

Mechanical removal	**ISB**	**Surface dispersant application**	**SSDI**	**No response**
• Spill scenario (*e.g.,* size/nature of spill, type of oil, time of year, location, oceanographic conditions, natural resources/ biological priorities such as spawning) • Weather, sea state, cloud cover (may limit response) • Fate and trajectory modeling • Longer window of opportunity • Availability of assets • Safety of response personnel • Expected persistence • Waste disposal options • Response time vs. spill size	• Spill scenario (*e.g.,* size/nature of spill, type of oil, time of year, location, oceanographic conditions, natural resources/ biological priorities such as spawning) • Weather, sea state, cloud cover • Fate and trajectory modeling • Moving pollution to atmosphere • Effect of burn residue smothering; need high confidence that any sunken residue would be far from FGBNMS • Narrow window of opportunity • Exposure to smoke plume, public health and economic impact (*e.g.,* shipping lanes) • Speed of response • High removal rate; expected efficiency • Additional option when capability mechanical recovery resources are exceeded • Availability of assets • Safety of response personnel	• Spill scenario (*e.g.,* size/nature of spill, type of oil, time of year, location, oceanographic conditions, natural resources/biological priorities such as spawning) • Weather • Fate and trajectory modeling (including of dispersed oil) • Availability of assets • Public perception and political response • Expected dispersant mixing in water column	• Spill scenario (*e.g.,* size/nature of spill, type of oil, time of year, location, oceanographic conditions, natural resources/ biological priorities such as spawning) • Fate and trajectory modeling (including of dispersed oil) • Weather is less of an issue • Well head depth is considered for safety issues regarding the surface gas release • Oil spill distance to shore • Public perception and political response • Expected dispersant mixing in water column • Persistence in the environment	• Spill scenario (*e.g.,* size/nature of spill, type of oil, time of year, location, oceanographic conditions, natural resource/ biological priorities such as spawning) • Fate and trajectory modeling • No response due to conditions (*e.g.,* weather environment) • Seasonality, species sensitivity, and vulnerability • Safety of response personnel • Availability of assets • Expected persistence • Presence of natural resources

There was a discussion in multiple groups regarding the evolving science of SSDI. Knowledge gaps include: the depth at which SSDI is effective, the fate and transport of DDO, and the proficiency of 3-D trajectory modeling to predict DDO behavior and fate. Of concern was the potential significant impact to benthos where dispersant is applied in the subsurface (based on the DWH NRDA).

As discussed in the "Eco-toxicity and Sublethal Effects of Oil in the Environment" presentation by Lisa DiPinto during the training, adverse effects for fish occurred where concentrations of 1 ppb of the 50 individually measured PAHs (TPAH 50) occurred. Participants discussed that without the use of dispersants, the water column would likely have a concentration of 1 ppb TPAH 50 due to mixing and natural dispersion. While there has been a great deal learned from the DWH NRDA and its Toxicity Program, there still remain knowledge gaps on DDO toxicology (*i.e.,* exposure, duration, dosage). For example, the effect of DDO on adult species, including corals and deepwater habitat, at low levels and speed of recovery is still not well understood.

There was also a discussion on how a pre-use dispersant trial would occur at a spill, and the time needed to communicate results to the FOSC. A trial run would determine whether the oil is dispersible. Currently, there is no standardized dispersant "shake test" that is conducted on board a vessel to determine the effectiveness of a given dispersant on the oil spilled. It was acknowledged that there are two buoys within the FGBNMS which may not give enough information regarding the mixing layer in and around the area that would be crucial in understanding the potential benefit of using dispersants.

Multiple groups discussed the knowledge gap regarding the amount and trajectory of sunken residue after ISB.

Oil Spill Scenario: FGBNMS Mystery Spill

For the final (afternoon) breakout session, Charlie Henry provided participants with a drill scenario as a basis for discussion (Appendix L). The information from the given scenario is summarized below.

Spill Scenario

Just before noon on 26 May 26 2016, two BSEE employees en-route via helicopter to an offshore platform observe a slick ~ 10 km (6 mi) long by 0.8 km (0.5) mi wide that is greater than 60% dark oil coverage.

The mystery spill was observed in the Flower Garden Banks Lease Area. The source of the spill could not be determined by the observers. The leading edge was located at 27°45'N and 93°20'W. Once the helicopter landed at the Shell Auger Platform, an NRC notification was made. The BSEE employees notified their headquarter office in New Orleans, LA and the USCG Sector Houston-Galveston. The Shell Auger platform was not suspected as the source of the spilled oil.

The observers estimated that the volume of oil was 1000 bbl (42,000 gal, 159 m^3). The true volume could be 500 bbl (79 m^3)or as much as 2000 bbl (318 m^3)because it is difficult to estimate true oil thickness. The NOAA SSC was notified and coordinated an initial trajectory analysis and spot weather forecast. Given the threat to the FGBNMS, the waters of the GOM, and Texas Coastal Zone, the USCG Marine Safety Unit Galveston FOSC initiated a response.

Spill Trajectory

At noon on 26 May 2016, the leading edge of the reported slick was located roughly 32 km (20 mi) east-southeast of the East FGB of the FGBNMS. Winds were 5.1-7.7 m/s (10-15 kt) out of the east-southeast and ocean currents along the shelf were running west at just under 0.3 m/s (0.5 kt). The slick was expected to pass over the East FGB overnight.

The trajectory forecast predicted that the slick would develop a more northeasterly track once it moved over the shelf and toward the Texas coast (Figure 2).

Landfall of any remnants of the slick was possible on Memorial Day on beaches in the Bolivar - Galveston area and potentially even further to the south depending on the longshore current speed. Beach oiling would likely be sporadic tarballs and streamers of emulsified weathered oil.

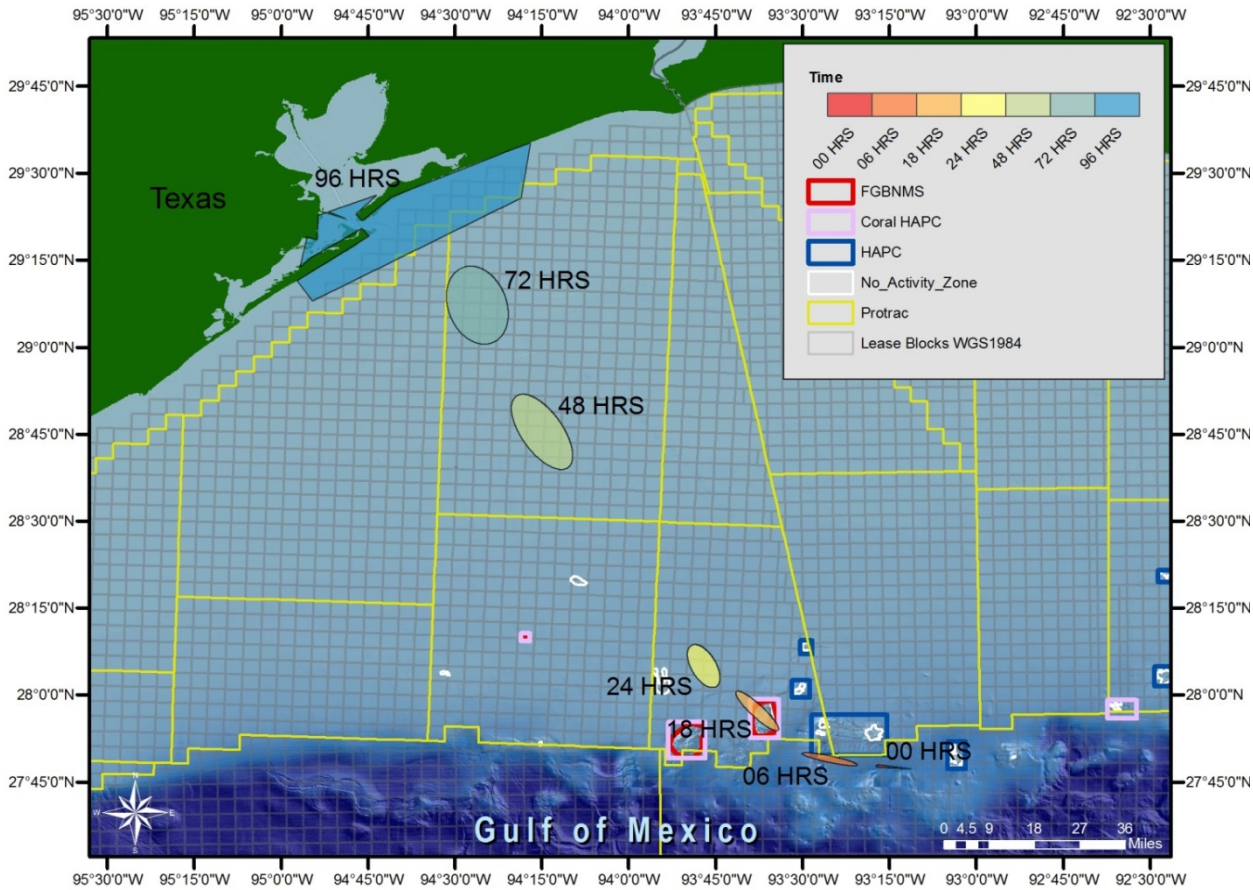

Figure 2. Oil spill trajectory forecast for the NRPT FGB mystery spill drill

Weather Forecast

The weather forecast (Table 5) for the spill scenario began with 0.6-1.2 m (2-4 ft) seas on the day of the spill with increasing winds and wave heights through the weekend, culminating with 10.3-12.9 m/s (20-25 kt) winds from the southeast and 1.5-2.1 m (5-7 ft) waves on Sunday. By Memorial Day, the winds are predicted to calm down to 5.1-7.7 m/s (10-15 kt) with 0.9-1.5 m (3-5 ft) waves with sunny conditions. The on- and off-shelf currents are northwesterly and westerly, respectively. [*N.B.*, Storms were not an issue during the response.]

Table 5. Wind and wave forecast for the spill scenario.

Date	Wind	Wave Height
Thursday, 26 May 2016 (Day 0)	ESE at 5.1-7.7 m/s (10-15 kt)	0.6-1.2 m (2-4 ft)
Friday, 27 May 2016 (Day 1)	SE at 7.7-10.3 m/s (15-20 kt)	0.9-1.5 m (3-5 ft)
Saturday, 28 May 2016 (Day 2)	SE at 7.7-10.3 m/s (15-20 kt)	1.2-1.8 m (4-6 ft); frequent breaking waves and white caps
Sunday, 29 May 2016 (Day 3)	SE at 10.3-12.9 m/s (20-25 kt)	1.5-2.1 m (5-7 ft)
Monday, 30 May 2016 (Memorial Day)	SSE at 5.1-7.7 m/s (10-15 kt)	0.9-1.5 m (3-5 ft)

Oil Characteristics

The oil was an unknown crude with an estimated API gravity of 32-34. It was estimated that 30-35 % of the oil would evaporate in the first 48 h and 10-15 % would naturally disperse. The water-in-oil emulsification was less than 50 % within the first 24 hr and within 36-48 hr the oil viscosity was 4,000-5,000 centipoise (cp).

Breakout Session III

During the final breakout session, in the afternoon on the second day of the workshop, the participants were charged to address the following in light of the FGBNMS Mystery Spill Scenario:

- Determine the response options that are applicable in this scenario,
- Discuss the tradeoffs that are applicable in this scenario,
- Capture key elements that drove the group's decision-making process,
- Based on these tradeoffs, recommend to the FOSC which response option(s) should be used for the scenario,
- List key elements not considered in the Breakout Session II discussions.

Assumptions: The USCG could mobilize any spill response equipment and that the equipment was available. The spill response, including the work conducted by OSROs, would be paid through the OSLTF under a Basic Ordering Agreement (BOA) contract.

All groups considered mechanical recovery and the use of surface dispersants applicable to the spill scenario. While the estimated time for a vessel with mechanical recovery equipment and for a plane with dispersants to arrive on scene varied, all groups considered aerial dispersants before sunset on Day 0 whereas the soonest mechanical recovery would begin at nighttime on Day 0. Table 6 summarizes the groups' discussion tradeoffs and key elements in the decision-making process for each response option. One group included mobilizing shoreline cleanup as a response option in the event that oil reaches the beach. This information is not included in Table 6, but is located in Appendix K. [*N.B.*, SSDI would not be a response option in this scenario. ISB is not allowed in the FGBNMS. The "No Response" option was also not considered.]

Table 6. Tradeoffs and key elements for mechanical recovery and surface dispersant application for FGB mystery spill scenario

Response option	Tradeoffs	Key elements that drove the decision-making process	Key elements not considered in Breakout Session II
Mechanical recovery	• Higher risk to responders with nighttime operations • Optimal time to skim is nighttime of Day 0 and Day 1 before breaking waves on Day 2; less effective skimming as weather worsens • 10-15% estimated recovery; oil may reach shoreline by Day 4	• Prioritize mature wildlife with a low survival rate (*e.g.,* turtles, marine mammal) over mass spawning species (*e.g.,* fish, coral) • Surface-feeding animals need to be considered (*e.g.,* manta rays, whale sharks) • Amount of oil evaporation by the time slick reaches the FGBs • Weather; high potential for slick to break • Response visibility is high for public • No approvals needed by RRT, etc.	• Availability of pre-determined response rescue team specifically for spotting and capturing turtles and possibly marine mammals
Surface dispersant application (includes applying aerial dispersants on Day 0 or waiting until after the slick had passed the FGBNMS on Day 1)	• Natural dispersal vs. chemically dispersed oil • Concern for air-breathers vs. benthic species (*e.g.,* coral) • Avoid oil coming to shore: Nesting season for Kemp ridley sea turtle (*Lepidochelys kempii*), listed as endangered under ESA; colonial bird nesting on rookery islands and beaches; socio-economic impacts (*e.g.,*	• Plane access for aerial dispersal • Prioritize mature wildlife with a low survival rate (*e.g.,* turtles, marine mammal) over mass spawning species (*e.g.,* fish, coral) • Surface-feeding animals need to be considered (*e.g.,* manta rays, whale sharks) • Amount of oil evaporation that has occurred prior to dispersant	• Respect policy to use dispersants as far away from FGBNMS as possible • Availability of competent Tier 1 observers • Lag time for dispersal consultations for trial runs and shake tests on Day 0 before decision can be made (impact on window of opportunity for Day 0)

	recreational impacts) • If dispersants are applied on Day 1, reduce surface oil before the slick reaches the FGBNMS • If wait until Day 2 after slick passes over FGBNMS, no DDO plume in area of sanctuary, but surfacing air-breathers may be impacted prior to dispersion of the slick	application • Surface currents, mixing zone are key to predicting effectiveness of dispersion • Uncertainty to whether there would be impact to the coral • Need a competent Tier 1 observer • Higher encounter rate with dispersants vs. mechanical recovery • Weather is more suitable for dispersants (*i.e.,* wind/waves promote mixing and reduce droplet size) • Input from FGBNMS Superintendent will be important • More time required for mechanical recovery equipment vs. aerial dispersant application equipment to the spill area	

Each group recommended a response option to the FOSC for the FGBNMS Mystery Spill Scenario. Three of the four groups recommended the following:

- Deploy mechanical recovery as soon as possible and begin mechanical recovery during the nighttime of Day 0 into Day 1,
- On Day 1, after the slick has passed the FGBNMS, apply dispersants to the surface using planes,
- Continue mechanical recovery to collect any remaining oil,
- Activate safety restriction zones (*e.g.,* fishing area closures),
- Mobilize shoreline protection and oil recovery resources (*e.g.,* booming sensitive areas, near-shore skimming assets) in case oil reaches the shoreline on Day 4.

The key elements that drove this recommendation were the value of the coral versus the air-breathing megafauna (*e.g.,* sea turtles), the cost of impact to either, including whether a reef or turtle population can be restored. This response approach (*i.e.,* a combination of mechanical recovery and surface dispersant application) protects onshore resources at risk: nesting sea turtles, heavy recreational beach use, and critical near/on-shore habitats (*e.g.,* estuaries, mangroves). Offshore, wildlife at the surface is at risk, including sea turtles, mammals, and sargassum patches. The recommendation reduces the risk of oil exposure to the coral reef habitat which is important in the long-term (*i.e.,* corals are hundreds to thousands of years old). Multiple groups acknowledged that the West FGB may be more affected than the East FGB with dispersant concentrations because of westward drift following a dispersant application.

One group recommended, in consultation with the FGBNMS Superintendent, applying surface dispersants on Day 0 assuming the slick is 16-19 km (10-12 mi) away before reaching the sanctuary. If, during the consultation, the Superintendent did not concur with the recommendation, the group then recommended the same option as the other three groups. The key elements that drove this recommendation were to reduce the risk to sanctuary resources including marine mammals, turtles, and birds impacted by an oil slick on the surface.

Conclusions

Throughout the workshop, there was a theme that the response options considered and selected should be based on a “minimal regret” approach with respect to sensitive natural resources such as the FGBNMS. Participants were reminded that the alternative response technologies should mitigate the harm that would already been caused by the spill and should “do no more harm than good”.

It was recognized by all groups that access to local real-time oceanographic data is necessary to respond successfully.

The threat to unique natural resources such as the FGBNMS in the GOM is a real one. The workshop could not have been timelier as two weeks prior on May 12, 2016, NOAA was contacted by the USCG Marine Safety Unit from Morgan City, LA, regarding a discharge of ~ 2,100 bbl (88,200 gal, 334 m^3) of crude oil in the Green Canyon block in the GOM, from a Shell subsea well-head flow line. The release was ~ 145 km (90 mi) south of Timbalier Island, LA, (and ~ 298 km (185 mi) east of the East FGB) moving in a westerly direction. An oil sheen ~ 3.2 km (2 mi) by 20.9 km (13 mi) was reported. NOAA supported

the USCG with an oil spill trajectory analysis, overflight reports, as well as information on natural resources at risk, including consulting with Natural Resource Trustees such as the FGBNMS. The oil spill trajectory predicted no shoreline impact and potential impact to the East FGB. The response operation selected was mechanical recovery with vessels conducting skimming operations and by May 15, 2015 ~ 1,214 bbl (51,000 gal, 193 m^3) of oily-water mixture was removed.

Another major conclusion from the workshop participants was to not use DWH as baseline case in spill response training. For example, SSDI was a novel response option used in DWH. While there remain knowledge gaps regarding SSDI, it is a response option that is limited to deepwater well blowouts. Most marine spills are not well blowouts. However, it is also important to take the information and lessons learned from DWH and apply them. For example, with respect to response operations, there is now a capability, developed as a result of DWH, to mechanically remove oil with vessels operating skimmers 24/7 using infrared cameras and X-band radar equipment. DWH also increased the overall investment in response equipment (numbers and capabilities of response systems) in the GOM.

Further, the DWH NRDA has increased our understanding of the impacts and effects of oil on organisms with over 30 peer-reviewed publications and more planned for the near future. The DWH Toxicity Program tested 40 species including fish, invertebrates, plankton, turtles, and birds. Findings indicated adverse effects for fish and invertebrates at water concentrations of 1 ppb and 13 ppb of TPAH50, respectively. This type of information can now be incorporated into the decision-making process when considering the use of dispersants as a response option and for NRDAs.

The workshop was an example of the importance of continual regional training to improve preparedness, planning and response for potential oil spills that impacts natural and human resources. There can be a tendency for emergency responders to take aggressive action early-on in a spill, however during this workshop with input from staff and scientists, including those from the FGBNMS, the response decisions shifted to minimal regret with a primary focus to preserve the FGBs habitat (*e.g.,* corals) by applying dispersants after the oil slick had passed over the East FGB. Likewise, it was an opportunity for Natural Resource Trustees and other organizations to participate in preparedness training to understand the process and the science that drives the decision-making to determine the best spill response option for a given spill scenario. These discussions among all of the potential stakeholders prior to a spill improve the “climate” for response when an actual spill occurs.

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