ABSTRACT

Biodegradation of Finasol OSR 52 and Dispersed Alaska North Slope Crude Oil at 5 C and 25 C

Yu Zhang, Pablo Campo, Ruta Deshpande, Mobing Zhuang, and Robyn Conmy

2016 Gulf of Mexico Oil Spill & Ecosystem Science Conference

A study was conducted with Finasol OSR 52 dispersant and Alaska North Slope (ANS) crude oil in sterile GP2 artificial seawater to explain the biodegradability of the dispersant as well as dispersed ANS. Two oil degrading cultures, isolated from the surface (meso) and deep sea (cryo) of the Gulf of Mexico, were enriched on ANS crude oil at 25 °C (meso) and 5 °C (cryo) were used as inocula. Time series concentrations for oil components (alkanes and aromatics) and an anionic surfactant in Finasol were determined. Results indicated that almost all the surfactant was biodegraded by meso culture, while remained at the lower temperature. Over 90% of the total alkane fraction was biodegraded for the oil with and without dispersant at both the temperatures. For the aromatic fraction, the cryo culture metabolized 76% of the aromatics in ANS alone and 64% in ANS dispersed with Finasol, whereas aromatics persisted in both oil alone and dispersed oil samples at 25 °C. The obtained results figured the effect of dispersant on the fate of spilled oil and rates of oil and dispersant biodegradation, which will be essential for dispersant usage.

To: Conmy, Robyn[Conmy.Robyn@epa.gov]
From: Holder, Edith
Sent: Fri 9/18/2015 1:58:02 PM
Subject: RE: Dorado results

Robyn,

California and Arizona.

I will talk with you either Monday or Tuesday, September 28 or 29.

I spoke with Keith today, and he would like to work on the Oil Spill Project. So we shall see what happens in the new fiscal year.

Edie

Edith Holder

Pegasus Technical Services, Inc.

On-Site Contractor to the U.S. EPA

ORD/NRMRL/LRPCD

26 W. Martin Luther King Dr.

Cincinnati, OH 45268

Phone: 513-569-7178

Email: holder.edith@epa.gov

From: Conmy, Robyn
Sent: Friday, September 18, 2015 8:33 AM
To: Holder, Edith

Subject: RE: Dorado results

Thank you for the update on the BFT. As you suspected, the Dorado is more dispersible. I will talk with OEM and let them know the preliminary results and start looking for a heavier oil option.

As for the SWA, I handed the mark up and the revised draft to the Division Director for ORD clearance. I will be sending to OEM after that. Guess manuscript writing of that will begin in October.

The last week of September let's plan to meet on that Monday or Tuesday after you return. Want to make sure that we get a chance to meet before the fiscal year change over.

Have a good week off. Can't remember where you were going???

Cheers,

Robyn

<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>

Robyn N. Conmy, Ph.D.

Research Ecologist

USEPA/NRMRL/LRPCD

26 West MLK Drive

Cincinnati, Ohio 45268

513-569-7090 (office)

513-431-1970 (EPA mobile)

727-692-5333 (Personal mobile)

conmy.robyn@epa.gov

From: Holder, Edith
Sent: Thursday, September 17, 2015 9:44 PM
To: Conmy, Robyn
Subject: Dorado results

Robyn,

Here are the results that I have so far. I measured the density of both Endicott and Dorado at 20C and used those numbers for the calculations. So the Endicott numbers changed a bit.

Basically Dorado is more dispersible than Endicott. I started with the less effective dispersants, so the results for Corexit 9500, Dispersit, and presumably Finasol will be better.

I will be out of town next week. Then when I come back, I have WAFs and cultures to extract. So I won't have time to do any more BFT before the end of September. I will finish in October.

I hope that you have successfully completed the SWA report to your satisfaction.

Cheers,

Edie

Edith Holder

Pegasus Technical Services, Inc.

On-Site Contractor to the U.S. EPA

ORD/NRMRL/LRPCD

26 W. Martin Luther King Dr.

Cincinnati, OH 45268

Phone: 513-569-7178

Email: holder.edith@epa.gov

To: Conmy, Robyn[Conmy.Robyn@epa.gov]
From: Holder, Edith
Sent: Fri 9/18/2015 1:43:42 AM
Subject: Dorado results
Ref_oils_BFT.xlsx

Robyn,

Here are the results that I have so far. I measured the density of both Endicott and Dorado at 20C and used those numbers for the calculations. So the Endicott numbers changed a bit.

Basically Dorado is more dispersible than Endicott. I started with the less effective dispersants, so the results for Corexit 9500, Dispersit, and presumably Finasol will be better.

I will be out of town next week. Then when I come back, I have WAFs and cultures to extract. So I won't have time to do any more BFT before the end of September. I will finish in October.

I hope that you have successfully completed the SWA report to your satisfaction.

Cheers,

Edie

Edith Holder

Pegasus Technical Services, Inc.

On-Site Contractor to the U.S. EPA

ORD/NRMRL/LRPCD

26 W. Martin Luther King Dr.

Cincinnati, OH 45268

Phone: 513-569-7178

Email: holder.edith@epa.gov

To: McClellan, Kim[Mcclellan.Kim@epa.gov]
Cc: Herrmann, Ronald[Herrmann.Ronald@epa.gov]; Conmy, Robyn[Conmy.Robyn@epa.gov]
From: Dyson, Brian
Sent: Fri 9/18/2015 12:10:35 AM
Subject: RE: STICS Entries

I can't help you with that. I entered those as a favor and was not given that information.

I think Ron Herrmann or Robyn Conmy might know.

From: McClellan, Kim
Sent: Tuesday, September 15, 2015 1:01 PM
To: Dyson, Brian
Subject: STICS Entries

Hi Brian,

All of your STICS entries are not complete. I need this additional information before these abstracts can be submitted to clearance.

You need one internal technical review (reviewer can be from inside or outside of the clearing author's Division) using EPA Form 363 + Reviewer comments for each of these abstracts.

You also need to include the Meeting Name, the Start and End Dates, the Country, State, and City of this conference.

The abstracts are listed below:

TIM Approval	Brian Dyson	Devi Sundaravadivelu	ORD-[illegible]021	Evaluation of Sorbent and Solidifier Properties and their Impact on Oil Removal Efficiency	Abstract 9/11/2015 4:43 PM
TIM Approval	Brian Dyson	Mobing Zhuang	ORD-013917	Biodegradability of Dispersed Heavy Fuel Oil at 5 and 25 C	Abstract 9/11/2015 4:28 PM
TIM	Brian	Yu Zhang	ORD-	Biodegradation of Finasol OSR 52 and Dispersed Alaska	Abstract 9/11/2015

ApprovalDyson			013915	North Slope Crude Oil at 5 C and 25 C	3:34 PM
TIM ApprovalDyson	Brian	Ruta Deshpande	ORD-013912	Biodegradability Of Diluted Bitumen Oil By Kalamazoo River Abstract Cultures In Freshwater	9/11/2015 2:57 PM

Thanks,

Kim

To: Conmy, Robyn[Conmy.Robyn@epa.gov]
From: Mandsager, Kathy
Sent: Mon 3/21/2016 1:47:06 PM
Subject: FW: State-of-Science for Dispersants Use in Arctic Water: Degradation & Fate Group
2016.02.25_Degradation and Fate with appendices for panel final review.docx

Robyn,

Is there any chance you could review and sign off on this document soon? I need to prepare it for the public input period soon.

Thanks.

From: Mandsager, Kathy
Sent: Wednesday, March 16, 2016 8:17 AM
To: Mandsager, Kathy <kathy.mandsager@unh.edu>
Subject: FW: State-of-Science for Dispersants Use in Arctic Water: Degradation & Fate Group
Importance: High

Sorry for the confusion on the due date. March 17 is actually tomorrow – Thursday. We would greatly appreciate your approval of this document.

From: Mandsager, Kathy
Sent: Thursday, March 10, 2016 1:38 PM
To: Mandsager, Kathy <kathy.mandsager@unh.edu>
Subject: FW: State-of-Science for Dispersants Use in Arctic Water: Degradation & Fate Group
Importance: High

Reminder…. Due on Thursday.

From: Mandsager, Kathy
Sent: Thursday, February 25, 2016 5:50 PM
Subject: State-of-Science for Dispersants Use in Arctic Water: Degradation & Fate Group

Dear Panel:

We would very much appreciate your review of this final version of the *Degradation and Fate* document. This document incorporates the edits and suggestions made via email and final discussion.

If you could reply by email with your approval of this document by **Monday, March 17** (2 weeks for this review) that would be greatly appreciated. I will need each of you that participated in this discussion to reply in the affirmative that you approve this document.

Please also confirm that your name and affiliation are listed correctly at the end of this document.

You deserve kudos for this great accomplishment! Thank you very much!

Kathy Mandsager

Program Coordinator

Coastal Response Research Center

Center for Spills and Environmental Hazards

234 Gregg Hall, Colovos Rd

University of New Hampshire

Durham, NH 03824

603.862.1545

To: Mandsager, Kathy[kathy.mandsager@unh.edu]
From: Mandsager, Kathy
Sent: Wed 3/16/2016 12:16:39 PM
Subject: FW: State-of-Science for Dispersants Use in Arctic Water: Degradation & Fate Group
2016.02.25_Degradation and Fate with appendices for panel final review.docx

Sorry for the confusion on the due date. March 17 is actually tomorrow – Thursday. We would greatly appreciate your approval of this document.

From: Mandsager, Kathy
Sent: Thursday, March 10, 2016 1:38 PM
To: Mandsager, Kathy <kathy.mandsager@unh.edu>
Subject: FW: State-of-Science for Dispersants Use in Arctic Water: Degradation & Fate Group
Importance: High

Reminder…. Due on Thursday.

From: Mandsager, Kathy
Sent: Thursday, February 25, 2016 5:50 PM
Subject: State-of-Science for Dispersants Use in Arctic Water: Degradation & Fate Group

Dear Panel:

We would very much appreciate your review of this final version of the *Degradation and Fate* document. This document incorporates the edits and suggestions made via email and final discussion.

If you could reply by email with your approval of this document by **Monday, March 17** (2 weeks for this review) that would be greatly appreciated. I will need each of you that participated in this discussion to reply in the affirmative that you approve this document.

Please also confirm that your name and affiliation are listed correctly at the end of this document.

You deserve kudos for this great accomplishment! Thank you very much!

Kathy Mandsager

Program Coordinator

Coastal Response Research Center

Center for Spills and Environmental Hazards

234 Gregg Hall, Colovos Rd

University of New Hampshire

Durham, NH 03824

603.862.1545

To: Robinson, Brian[Brian.Robinson@dfo-mpo.gc.ca]
Cc: Conmy, Robyn[Conmy.Robyn@epa.gov]; Ken.Lee@csiro.au[Ken.Lee@csiro.au]; King, Thomas L[Tom.King@dfo-mpo.gc.ca]; Ryan, Scott A[Scott.Ryan@dfo-mpo.gc.ca]
From: Michel Boufadel
Sent: Thur 9/17/2015 5:18:45 PM
Subject: Re: GoMRI 2016 Abstracts
GOMRI Abstract #1BIO september 17 2015.docx
GOMRI Abstract #2BIOv3 September 17 2015.docx

Hi Brian,
Please find attached. I made minor changes, but please feel free to decline them as you see fit. I do not need to see the document again.

Cheers,

Michel

On Wed, Sep 16, 2015 at 12:56 PM, Robinson, Brian <Brian.Robinson@dfo-mpo.gc.ca> wrote:

Dear Colleagues,

Attached please find two abstracts that we intend to submit for the GoMRI conference next February. We will likely submit both (one as a presentation and one as a poster) in the Session 12 - Determination of the Oil Droplet Size Distribution and Its

Impact on the Fate and Transport of Oil: Consequences on Public Health and Ecology. Abstracts are due September 18th if you have any feedback.

There may be an opportunity for a series of joint presentations (i.e. Droplet Size Data – Fluorometer Results – Jet Modelling) depending on your own plans.

Regards,

Brian

--
Michel C. Boufadel, PhD, PE, BCEE, F. ASCE, D.WRE, P.Hydro.
Director, Center for Natural Resources Development and Protection (NRDP)
Professor, John A. Reif, Jr. Dept. Civil and Environmental Engineering
The New Jersey Institute of Technology
Room 435 Colton Hall
323 MLK Blvd, Newark, NJ 07102-1824
Ph: 973-596-6079
email: boufadel@gmail.com
http://civil.njit.edu/people/Boufadel.php
http://nrdp.njit.edu

Surface VOC Emissions from Subsurface Oil Release without and with Dispersant Application: Flume Tank Tests

Brian Robinson[1], Thomas King[1], Patrick Toole[1], Claire McIntyre[1], Scott Ryan[1], Robyn Conmy[2], Michel Boufadel[3], and Kenneth Lee[4]

[1] Centre for Offshore Oil, Gas and Energy Research (COOGER), Fisheries and Oceans Canada, Dartmouth, Nova Scotia, Canada

[2] US Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio, USA

[3] Center for Natural Resources Development and Protection, Department of Civil and Environmental Engineering, New Jersey Institute of Technology, Newark, New Jersey, USA

[4] Wealth from Oceans National Research Flagship, CSIRO, Australian Resources Research Centre, Kensington, WA, Australia

The use of chemical dispersants during the response to a well blowout is often promoted as a means of protecting onsite workers from exposure to Volatile Organic Compounds (VOCs), yet very little information is available to demonstrate the effect that subsurface dispersant use has on surface VOC emissions. To evaluate this hypothesis, a series of experiments were conducted in a 32 m long flume tank located at the Bedford Institute of Oceanography. Four different hydrocarbon products (ANS, SLC, IFO-120, gas condensate) were tested to represent a range of different physical and chemical properties. Two dispersant products were used in four dispersant-to-oil treatments. The tank was equipped with a subsurface oil injection system used to release oil or oil/dispersant premix through a small diameter (2.4 mm) nozzle under high pressure, forming a plume of oil droplets, which was transported horizontally by water currents. Different droplet size distributions were formed, depending on the treatment, which affected the transport of the oil in the tank. Increased DOR resulted in decreased surface VOC concentrations for all four products. Compared to the non-treated oils, a DOR of 1:20 resulted in a 5 to 25 folds decrease, depending on the oil type, in surface VOC concentrations. This study demonstrated that the use of chemical dispersants on a subsurface oil release reduces surface VOC emissions.

To: Conmy, Robyn[Conmy.Robyn@epa.gov]
From: King, Thomas L
Sent: Mon 11/9/2015 3:27:51 PM
Subject: RE: checking in
Dilbit toxicity Madison 2015.pdf

FYI- here is paper on dilbit toxicity to fish. The work was funded by DFO's National Contaminants Advisory Committee (NCAG).

Tom

From: Conmy, Robyn [mailto:Conmy.Robyn@epa.gov]
Sent: November-09-15 9:46 AM
To: Robinson, Brian; King, Thomas L
Subject: RE: checking in

OK – just give me a call when you are done with Michel. Effects of heating on dispersant performance?? Interesting. Please recap when I talk with you.

<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>

Robyn N. Conmy, Ph.D.

Research Ecologist

USEPA/NRMRL/LRPCD

26 West MLK Drive

Cincinnati, Ohio 45268

513-569-7090 (office)

513-431-1970 (EPA mobile)

727-692-5333 (Personal mobile)

conmy.robyn@epa.gov

From: Robinson, Brian [mailto:Brian.Robinson@dfo-mpo.gc.ca]
Sent: Monday, November 09, 2015 8:43 AM
To: Conmy, Robyn <Conmy.Robyn@epa.gov>; King, Thomas L <Tom.King@dfo-mpo.gc.ca>
Subject: RE: checking in

Hi Robyn,

We have a conference call with Michel in 20mins. Perhaps we could call you right after that call? I don't expect it to go very long…perhaps we can call about between 9:30-10:00 EST? Or if you wanted to join in on the conference call with Michel, I'm sure he wouldn't mind…he has some questions regarding the effect of heating dispersants on their effectiveness. The call in info for Michel is 1-712-432-3900 and enter the conference access code 545577

Brian

From: Conmy, Robyn [mailto:Conmy.Robyn@epa.gov]
Sent: November-09-15 9:36 AM
To: Robinson, Brian; King, Thomas L
Subject: RE: checking in

Hi Brian and Tom,

Are you in the office this morning? I wanted to discuss with you some QA questions from the subsurface injection experiments.

Thanks,

Robyn

<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>

Robyn N. Conmy, Ph.D.

Research Ecologist

USEPA/NRMRL/LRPCD

26 West MLK Drive

Cincinnati, Ohio 45268

513-569-7090 (office)

513-431-1970 (EPA mobile)

727-692-5333 (Personal mobile)

conmy.robyn@epa.gov

From: Robinson, Brian [mailto:Brian.Robinson@dfo-mpo.gc.ca]
Sent: Tuesday, October 27, 2015 3:09 PM
To: Conmy, Robyn <Conmy.Robyn@epa.gov>; King, Thomas L <Tom.King@dfo-mpo.gc.ca>
Cc: Doane, Rod <Roderick.Doane@dfo-mpo.gc.ca>
Subject: RE: checking in

Hi Robyn,

Good to hear from you. The crisp fall air has moved in, but we're still hoping we have a good month left to complete a series of tank experiments. To answer your questions:

1) I was a little delayed in sending the Horiba back due to an illness. It was sent back last Thursday and is in transit.
http://www.dayross.ca/Forms/TrackShipmentResult.aspx?shipmentnumber=DAR3091181++++++++++&multi

2) I believe all insitu fluorometers are coming back to us. We were hoping to do a few dilbit runs with them in November, but I can send them back to you if they are needed.

3) Wonderful news!! A call to discuss timelines would be helpful.

4) That's a tough one. Would Zhengkai Li be appropriate? I think he would have the interest, and he has the experience on the droplet size and modelling aspects. We have also recently worked with a scientist from CSIRO (Dr. Xiubin Qi) who is developing a dispersed oil rapid response monitoring protocol. She has experience with both fluorometry and droplet size data. I would be happy to ask either individual if you think they are a good fit.

5) I was recently discussing the plan for manuscripts with Haibo. We were thinking that it would be good if the first paper we published covered the general operation of the tank, and perhaps included droplet size/chem data and maybe the in-situ fluorometry. Then further manuscripts could reference this paper? Just a thought. Have the comments from the BSEE review come in yet? I'm curious to see what they said.

Thanks,

Brian

From: Conmy, Robyn [mailto:Conmy.Robyn@epa.gov]
Sent: October-27-15 10:48 AM
To: Robinson, Brian; King, Thomas L
Subject: checking in

Hey Guys!

Hope this message finds you well. I wanted to touch base with you about a few things:

1. I have yet to receive the Horiba EEMS fluorometer and wanted to get the tracking information for the shipment.

2. Was Michel instructed to send all the in situ fluorometers back to DFO or sending the EPA ones to Cincinnati?

3. BSEE has officially awarded us the Hypersaline project. I am working on the contract and once all of that is through, we will have a call to discuss the project timeline for the year. Fun to keep this collaboration going!

4. EPA is looking to conduct its internal review of the BSEE wave tank DE draft report that we submitted to BSEE last month. I am having a hard time finding the one external reviewer, in part b/c it is such a huge report. Does DFO have any suggestions on a person that is well suited to review it?

5. Now that the DE report is together, we need to discuss manuscripts. I know that Brian intends to lead a VOC paper? But we need to figure out who (Tom, Michel, Haibo, Mary, Robyn, others?) will be leading which manuscripts. Thinking early November would be a good time for mapping this out.

Cheers,

Robyn

<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>

Robyn N. Conmy, Ph.D.

Research Ecologist

USEPA/NRMRL/LRPCD

26 West MLK Drive

Cincinnati, Ohio 45268

513-569-7090 (office)

513-431-1970 (EPA mobile)

727-692-5333 (Personal mobile)

conmy.robyn@epa.gov

To: Conmy, Robyn[Conmy.Robyn@epa.gov]
From: Clark, Patrick
Sent: Wed 4/27/2016 11:34:41 AM
Subject: RE: Invoice for Finasol sample

Will get it in to Dennis today!!

From: Conmy, Robyn
Sent: Wednesday, April 27, 2016 7:34 AM
To: Clark, Patrick <Clark.Patrick@epa.gov>
Subject: FW: Invoice for Finasol sample

Attached is the invoice to purchase dispersants for the oils program. Please charge to oil.

Thanks!

Robyn

<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>

Robyn N. Conmy, Ph.D.

Research Ecologist

USEPA/NRMRL/LRPCD

26 West MLK Drive

Cincinnati, Ohio 45268

513-569-7090 (office)

513-431-1970 (EPA mobile)

727-692-5333 (Personal mobile)

conmy.robyn@epa.gov

From: Admin Clearcoast [mailto:admin@clearcoastllc.com]
Sent: Tuesday, April 26, 2016 6:15 PM
To: Conmy, Robyn <Conmy.Robyn@epa.gov>

Cc: Malcolm Gore <malcolm.gore@clearcoastllc.com>
Subject: Invoice for Finasol sample

Robyn,

Please fid attached an invoice for sample of Finasol ORS 52 as requested.

Please be advised payment should be made on receipt of product.

Please do not hesitate to contact us if you need any further information

Many thanks for your order

Admin

CLEAR COAST

www.clearcoastllc.com

To: Conmy, Robyn[Conmy.Robyn@epa.gov]
Cc: Malcolm Gore[malcolm.gore@clearcoastllc.com]
From: Admin Clearcoast
Sent: Tue 4/26/2016 10:14:32 PM
Subject: Invoice for Finasol sample
Clearcoast inv 150212.pdf

Robyn,
Please fid attached an invoice for sample of Finasol ORS 52 as requested.
Please be advised payment should be made on receipt of product.
Please do not hesitate to contact us if you need any further information
Many thanks for your order

Admin

CLEAR COAST

www.clearcoastllc.com

CLEAR COAST LLC

24044 Cinco Village Center Blvd, Suite 100
Katy, TX 77494
(832) 244-1533
admin@clearcoastllc.com
www.clearcoastllc.com

INVOICE 150212

DATE 04/26/2016 TERMS Payment due on receipt of product

DUE DATE 04/29/2016

BILL TO

Robyn N. Conmy, Ph.D.
Research Ecologist
USEPA/NRMRL/LRPCD
26 West MLK Drive
Cincinnati, Ohio 45268

SHIP TO

Robyn N. Conmy, Ph.D.
Research Ecologist
USEPA/NRMRL/LRPCD
26 West MLK Drive
Cincinnati, Ohio 45268

TRACKING NO.
Sample

ACTIVITY	QTY	RATE	AMOUNT
Finasol OSR 52 DAP 2 US GALLONS		788.00	788.00

Electronic payment:-
Amegy Bank N.A.
ABA number 113011258
Clear Coast LLC
Account : 5791940660
Swift number SWBKUS44
Remiit checks to
Clear Coast LLC
24044 Cinco Village Center Blvd, Suite 100,
Katy TX 77494 USA

TOTAL DUE $788.00

To: Conmy, Robyn[Conmy.Robyn@epa.gov]
From: Malcolm Gore
Sent: Mon 4/25/2016 9:45:07 PM
Subject: Re: Finasol OSR 52 Sample Request

Apologies for the delay Robyn
Awaiting some shipping information. Should have this to you in the morning.
Malcolm

Malcolm Gore
President

CLEAR COAST

+1 832 244 1533
malcolm.gore@clearcoastllc.com
www.clearcoastllc.com

From: "Conmy, Robyn" <Conmy.Robyn@epa.gov>
Date: Monday, April 25, 2016 at 10:05 AM
To: malcolm gore <malcolm.gore@clearcoastllc.com>
Cc: Peter Egan <peter.egan@total.com>
Subject: RE: Finasol OSR 52 Sample Request

Hello Malcolm,

Thank you for getting back with me regarding the purchase. Yes, the information below is correct, with a mail stop at room 166. Can you send to me the invoice via email so I can provide to the purchase card holder to make the purchase?

Thank you in advance,

Robyn

<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>

Robyn N. Conmy, Ph.D.

Research Ecologist

USEPA/NRMRL/LRPCD

26 West MLK Drive

Cincinnati, Ohio 45268

513-569-7090 (office)

513-431-1970 (EPA mobile)

727-692-5333 (Personal mobile)

conmy.robyn@epa.gov

From: Malcolm Gore [mailto:malcolm.gore@clearcoastllc.com]
Sent: Monday, April 25, 2016 10:57 AM
To: Conmy, Robyn <Conmy.Robyn@epa.gov>
Cc: Peter Egan <peter.egan@total.com>
Subject: Finasol OSR 52 Sample Request

Hello Robin

I am writing with respect to your email below regarding a sample request of Total Finasol OSR 52.

Clear Coast is the custodian of the product stored here in Houston for Total.

I will arrange the sample as requested.

Please confirm the following:

Contact:

Robyn Conmy 513-569-7090 (office)

Deliver to:

26 West MLK Drive

Cincinnati, Ohio 45268

513-569-7090 (office)

Quantity:

2 US Gallons.

On receipt of confirmation I will get the samples drawn, packaged and dispatched.

Regards

Malcolm

Malcolm Gore

President

CLEAR COAST

+1 832 244 1533

malcolm.gore@clearcoastllc.com

www.clearcoastllc.com

From: Conmy, Robyn
Sent: Monday, April 18, 2016 10:47 AM
To: 'peter.egan@total.com' <peter.egan@total.com>
Cc: Wilson, Gregory <Wilson.Gregory@epa.gov>; Principe, Vanessa <Principe.Vanessa@epa.gov>
Subject: purchase of Finasol OSR52

Mr. Egan,

This follows up our telephone conversation of April 11.

As discussed, EPA is seeking to acquire a number of dispersant products listed on the NCP Subpart J Product Schedule for the purposes of both toxicity and efficacy testing. The product testing is intended to further inform currently proposed regulatory actions under Subpart J of the National Contingency Plan. The products will in addition be used to support our general research in the area of oil spill response.

Your product Finasol OSR52 has been identified as one of interest, as it is commonly stockpiled in the U.S. Not only could the product be encountered when presented with a response situation, but including this dispersant product in toxicity and efficacy testing studies will also allow for comparison and consistency with other existing and ongoing studies by EPA and other federal agencies. EPA's Office of Research and Development (ORD) will be conducting the dispersant studies.

At this time we are seeking 2 U.S. gallons of the product.

We appreciate your time and attention to this request.

Respectfully,

Robyn Conmy

<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>/<>

Robyn N. Conmy, Ph.D.

Research Ecologist

USEPA/NRMRL/LRPCD

26 West MLK Drive

Cincinnati, Ohio 45268

513-569-7090 (office)

513-431-1970 (EPA mobile)

727-692-5333 (Personal mobile)

conmy.robyn@epa.gov

To: Conmy, Robyn[Conmy.Robyn@epa.gov]
From: Holder, Edith
Sent: Tue 12/15/2015 3:14:09 AM
Subject: BSEE report review
BSEEreport_elh.pdf
REview_BSEE_report.docx

Edith L. Holder

Pegasus Technical Services, Inc.

On-Site Contractor to the U.S. EPA

ORD/NRMRL/LRPCD

26 W. Martin Luther King Dr.

Cincinnati, OH 45268

Phone: 513-569-7178

Email: holder.edith@epa.gov

To: Medley, Lori[lori.medley@bsee.gov]; Conmy, Robyn[Conmy.Robyn@epa.gov]; steve.lehmann@noaa.gov[steve.lehmann@noaa.gov]; Melchert, Elena[Elena.Melchert@hq.doe.gov]; Weaver, James (USCG)[James.D.Weaver@uscg.mil]; Miller, Eric[eric.miller@bsee.gov]; Thompson, Sara (ECY)[STHO461@ECY.WA.GOV]; nancy.kinner@unh.edu[nancy.kinner@unh.edu]; Mandsager, Kathy[kathy.mandsager@unh.edu]; Kinner, Peter[Peter.Kinner@unh.edu]
From: Vocke, William CIV
Sent: Wed 9/30/2015 6:24:50 PM
Subject: Approved ICCOPR R&T Plan
Approved 2015 ICCOPR R&T Plan - PrePrinting Version.pdf

R&T Plan Workgroup members (past & present).

It is with great pleasure that my first email transmitting the "APPROVED ICCOPR Oil Pollution Research and Technology Plan" is to the workgroup members and support staff that worked so hard to develop this first update to the plan in 18 years. Together we worked through many research issues and in the end selected a set of research priorities and developed a plan that should advance the state of the science.

Attached I the approved R&T Plan, which was approved by ICCOPR at the FY2015 Fourth Quarter meeting on September 29, 2015. This version is available for public release. I have a technical editor working on it to clean up any formatting or typo issues and prepare it for printing.

I want to thank each of you for sharing your insights and your contributions to this process. I look forward to working with you as this plan is implemented.

Bill Vocke
ICCOPR Executive Director
(202) 372-2019

OIL POLLUTION RESEARCH AND TECHNOLOGY PLAN

Fiscal Years 2015-2021

INTERAGENCY COORDINATING COMMITEE
ON OIL POLLUTION RESEARCH (ICCOPR)

September 2015

DISCLAIMER

This Oil Pollution Research and Technology Plan (OPRTP) presents the collective opinion of the 15 departments and agencies that constitute the members of Interagency Coordinating Committee on Oil Pollution Research (ICCOPR), regarding the status and current focus of the federal oil pollution research, development, and demonstration program (established pursuant to section 7001(c) of the Oil Pollution Act of 1990 (33 U.S.C. 2761(c))). The statements, positions, and research priorities contained in this OPRTP may not necessarily reflect the views or policies of an individual department or agency, including any component of a department or agency that is a member of ICCOPR. This OPRTP does not establish any regulatory requirement or interpretation, nor implies the need to establish a new regulatory requirement or modify an existing regulatory requirement.

ED_001324_00000360-00002

TABLE OF CONTENTS

TABLE OF CONTENTS III
LIST OF FIGURES XI
LIST OF TABLES XII
LIST OF ACRONYMS XIII
DEFINITIONS XXI
EXECUTIVE SUMMARY 1
INTRODUCTION 3
Background 3
Purpose of the Plan 4
Scope and Use of the Plan 4
PART ONE – OIL POLLUTION RESEARCH 7
1. The Need for Oil Pollution Research 7
1.1 U.S. Oil Production 8
1.2 History of Oil Spills in the U.S. 12
1.3 Analysis of the Oil Spill System 15
1.4 Exploration and Production Facilities 16
1.5 Onshore and Offshore Pipelines 17
1.6 Railroads 19
1.7 Refining and Storage Operations 21
1.8 Maritime and Riverine Transport - Tank Vessels (Ships & Barges) and Non-Tank Vessels 22
1.9 Oil Tankers 24
1.10 Regional and Geographic Areas of Interest 25
2. Federal Oil Pollution Research 27
2.1 ICCOPR 27
2.1.1. Origin 27
2.1.2. ICCOPR Membership 27
2.1.2.1 U.S. Coast Guard (USCG) 29
2.1.2.2 National Oceanic and Atmospheric Administration (NOAA) 29
2.1.2.3 National Institute of Standards and Technology (NIST) 30
2.1.2.4 U.S. Department of Energy (DOE) 31

ED_001324_00000360-00003

2.1.2.5 Bureau of Safety and Environmental Enforcement (BSEE) 31
2.1.2.6 Bureau of Ocean Energy Management (BOEM) 32
2.1.2.7 U.S. Fish and Wildlife Service (USFWS) 32
2.1.2.8 Maritime Administration (MARAD) 33
2.1.2.9 Pipeline & Hazardous Materials Safety Administration (PHMSA) 33
2.1.2.10 US Army Corps of Engineers (USACE) 34
2.1.2.11 U.S. Navy (USN) 34
2.1.2.12 U.S. Fire Administration (USFA) 35
2.1.2.13 U.S. Environmental Protection Agency (EPA) 35
2.1.2.14 National Aeronautics and Space Administration (NASA) 36
2.1.2.15 U.S. Arctic Research Commission (USARC) 36
2.2. Other Federal Stakeholders and Entities 37
2.2.1 Arctic Executive Steering Committee (AESC) 37
2.2.2 Federal Oil Spill Team for Emergency Response Remote Sensing (FOSTERRS) 37
2.2.3 Federal Rail Administration (FRA) 37
2.2.4 U.S. Geologic Survey (USGS) 38
2.2.5 Gulf Coast Ecosystem Restoration Council 38
2.2.6 Gulf of Mexico Fishery Management Council (GMFMC) 38
2.2.7 U.S. Marine Mammal Commission (MMC) 39
2.2.8 National Institute of Environmental Health Sciences (NIEHS) 39
2.2.9 U.S. National Response Team (NRT) - Science and Technology (S&T) Committee 40
2.2.10 National Science Foundation (NSF) 40
2.2.11 NOAA RESTORE Act Science Program 40
2.2.12 North American Wetlands Conservation Act (NAWCA) Gulf of Mexico Funds 41
2.3 Federal Research Laboratories and Testing Facilities 41
2.3.1 Ohmsett 41
2.3.2 USCG Research & Development Center (RDC) 42
2.3.3 USCG RDC Joint Maritime Test Facility 42
2.3.4 USCG Marine Safety Laboratory 42
2.3.5 U.S. EPA National Risk Management Research Laboratory (NRMRL) 42
2.3.6 Cold Regions Research and Engineering Laboratory (CRREL) 43
2.3.7 U.S. Army Engineer Research and Development Center (ERDC) 43
2.3.8 Hollings Marine Laboratory (HML) 43

ED_001324_00000360-00004

2.2.9 U.S. Naval Research Laboratory (NRL) Stennis Space Center 44
2.3.10 Pacific Northwest National Laboratory (PNNL) 44
2.3.11 Coastal and Ocean Research Vessels 45
2.3.10.1 USCG Cutter Healy 45
2.3.11.2 EPA Vessels 45
2.3.11.3 MARAD Vessels 45
2.3.11.4 NOAA Vessels 45
2.3.12 Oil Spill Field Research 46
3. Non-Federal Oil Pollution Research Entities 47
3.1 State Organizations 47
3.1.1 Alaska Department of Environmental Conservation (ADEC) 47
3.1.2 California Office of Oil Spill Prevention and Response (CAOSPR) 47
3.1.3 Florida 48
3.1.4 Louisiana Applied and Educational Oil Spill Research and Development Program (OSRADP) 48
3.1.5 Gulf States Marine Fisheries Commission (GSMFC) 48
3.1.6 Minnesota National Crude Oil Spill Fate and Natural Attenuation Site 49
3.1.7 Pacific States/British Columbia Oil Spill Task Force (PSBCOSTF) 49
3.1.8 Texas General Land Office (TXGLO) 49
3.1.9 Washington Department of Ecology (WADOE) 50
3.2 Industry 50
3.2.1 American Petroleum Institute Joint Industry Task Force (API JITF) 50
3.2.2 American Salvage Association (ASA) 51
3.2.3 Association of Petroleum Industry Co-op Managers (APICOM) 51
3.2.4 Industry Technical Advisory Committee (ITAC) 52
3.2.5 International Maritime Organization (IMO) 52
3.2.6 International Petroleum Industry Environmental Conservation Association (IPIECA) 52
3.2.7 International Spill Control Organization (ISCO) 53
3.2.8 International Tanker Owners Pollution Federation (ITOPF) 5 3
3.2.9 Oil Spill Response (OSR) Joint Industry Program (JIP) 53
3.2.10 Petroleum Environmental Research Forum (PERF) 53
3.2.11 Pipeline Research Council International (PRCI) 54
3.2.12 Spill Control Association of America (SCAA) 54

ED_001324_00000360-00005

3.3 Independent Research Interests 54
3.3.1 Cook Inlet Regional Citizen's Advisory Committee (CIRCAC)....55
3.3.2 Gulf of Mexico Alliance (GOMA)....55
3.3.3 Gulf of Mexico Research Initiative (GoMRI) 55
3.3.4 Gulf Restoration Science Programs Ad Hoc Coordination Forum 56
3.3.5 National Academy of Sciences Gulf Research Program (GRP) 56
3.3.6 National Fish and Wildlife Federation (NFWF) 56
3.3.7 Ocean Energy Safety Institute (OESI)....56
3.3.8 Oil Spill Recovery Institute (OSRI) 57
3.3.9 Pew Charitable Trusts (PCT) Arctic Science Program 58
3.3.10 Prince William Sound Regional Citizen's Advisory Committee (PWSRCAC) 58
3.3.11 Ship Structure Committee 58
3.4 Academia 58
3.4.1 Gulf of Mexico Research Consortia....59
3.4.2 Gulf of Mexico University Research Collaborative (GOMURC) 60
3.4.3 Harte Research Institute for Gulf of Mexico Studies....61
3.4.4 NOAA's Sea Grant Program....61
3.4.5 National University Rail (NURail) Center 61
3.4.6 Oil Spill Academic Task Force (OSATF) 62
3.4.7 Scripps Institution of Oceanography (SIO) 62
3.4.8 UAA/SIT Center of Excellence for Maritime Research (CMR)....62
3.4.9 UAF Arctic Center for Oil-Spill Research & Education (A-CORE) 62
3.4.10 U.S. Coast Guard Academy 63
3.4.11 University of New Hampshire (UNH) Oil Spill Centers....63
3.4.12 Woods Hole Oceanographic Institution (WHOI) 63
3.5 International Efforts 64
3.5.1 Arctic Council 64
3.5.2 Australia 65
3.5.3 Canada....65
3.5.4 Centre of Documentation, Research and Experimentation on Accidental Water Pollution (CEDRE)....66
3.5.5 China....66
3.5.6 European Union (EU) 66

ED_001324_00000360-00006

3.5.7 France 67
3.5.8 Kill-Spill 68
3.5.9 Mexico 68
3.5.10 Norway 68
3.5.11 Russia 69
3.5.12 SINTEF 69
3.5.13 United Kingdom (UK) 69
3.6 Non-Federal Oil Pollution Testing Facilities 70
3.6.1 Bedford Institute of Oceanography Center for Offshore Oil, Gas and Energy Research (BIO COOGER) 70
3.6.2 CEDRE Technical Facilities 70
3.6.3 Churchill Marine Observatory. 71
3.6.4 Ocean Coastal Research Engineering (OCRE) 71
3.6.5 PRCI Technology Development Center 71
3.6.6 SINTEF Sealab 72
3.6.7 Southwest Research Institute (SwRI) 72
3.6.8 Texas A&M Corpus Christi Center for Coastal Studies (CCS) 72
4. Structuring Oil Pollution Research 75
4.1 Introduction to the Oil Spill Research Framework 75
4.2 Classes 76
4.3 Standing Research Areas (SRAs) 77
4.3.1 Prevention SRAs 78
4.3.1.1 Human Error Factors [1000 series] 78
4.3.1.2 Offshore Facilities and Systems [1100 series] 79
4.3.1.3 Onshore Facilities and Systems [1200 series] 80
4.3.1.4 Waterways Management [1300 series] 80
4.3.1.5 Vessel Design [1400 series] 80
4.3.1.6 Drilling [1500 series] 81
4.3.1.7 Rail & Truck Transportation [1600 series] 82
4.3.1.8 Pipeline Systems [1700 series] 82
4.3.2 Preparedness SRAs 83
4.3.2.1 Pre-spill Baseline Studies [2000 series] 83
4.3.2.2 Response Management Systems [2100 series] 83

ED_001324_00000360-00007

4.3.3 Response SRAs 84
4.3.3.1 Structural Damage Assessment and Salvage [3000 series] 84
4.3.3.2 At Source Control and Containment [3100 series] 84
4.3.3.3 Chemical and Physical Behavior Modeling [3200 series] 85
4.3.3.4 Oil Spill Detection and Surveillance [3300 series] 86
4.3.3.5 In- and On-water Containment and Recovery [3400 series] 86
4.3.3.6 Shoreline Containment and Recovery [3500 series] 87
4.3.3.7 Dispersants [3600 series] 87
4.3.3.8 In-situ Burning [3700 series] 88
4.3.3.9 Alternative Countermeasures [3800 series] 89
4.3.3.10 Oily and Oil Waste Disposal [3900 series] 89
4.3.3.11 Bioremediation [4000 series] 90
4.3.4 Injury Assessment and Restoration SRAs 90
4.3.4.1 Environmental Impacts and Ecosystem Recovery [4100 series] 90
4.3.4.2 Environmental Restoration Methods and Technologies [4200 series] 91
4.3.4.3 Human Safety and Health [4300 series] 91
4.3.4.4 Sociological and Economic Impacts [4400 series] 92
4.4 Research Needs 92
4.5 Projects 93
5. Knowledge Transfer and Advancement 95
5.1 Factors Affecting Research and Technology Program Success 95
5.1.1 Funding 95
5.1.2 Continuity of Research 97
5.1.3 Field Testing 97
5.1.4 Building the Next Generation of Researchers 98
5.1.5 Public Perceptions 99
5.2 Communicating Research and Technology Efforts 99
5.2.1 ICCOPR OPRTP 99
5.2.2 ICCOPR Biennial Reports to Congress 100
5.2.3 ICCOPR Meetings 100
5.2.4 Meetings with Non-Federal Entities 100
5.2.5 Demonstration Projects 100
5.2.6 Conferences 101

ED_001324_00000360-00008

5.2.7 Workshops and Seminars 102
5.2.8 Publications 102
5.2.9 Newsletters 103
5.2.10 Internet and Social Media 103
5.3 Monitoring the Status of Oil Pollution Technologies 103
PART TWO – ESTABLISHING RESEARCH PRIORITIES 105
6. Oil Pollution Research Needs Identification and Prioritization Process 105
6.1 Research Needs Identification Process 106
6.1.2 Extraction and Consolidation of R&D Needs 111
6.1.3 Assignment of Research Needs to an SRA 111
6.2 Research Need Prioritization Process 111
6.2.1 Development of Research Needs Survey 112
6.2.2 Administration of Survey to SMEs 114
6.2.3 Processing of Survey Results 114
6.2.4 Identification of Top Priority Research Needs for Each SRA 114
7. Noteworthy Oil Spill Incidents 117
7.1 Vessels Spills 117
7.2 Offshore Drilling Operations 121
7.3 On-Shore Pipeline Spills 124
7.4 Facility Spills 127
7.5 Railroad Spills 128
8. Current State of Oil Pollution Knowledge 131
8.1 National Research Council - Oil Spill Dispersants: Efficacy and Effects 131
8.2 The Coastal Response Research Center Workshops 132
8.3 Department of Energy (DOE) Programs 138
8.4 Ultra-Deepwater Advisory Committee Annual Plan Reviews 139
8.5 Deepwater Horizon Oil Spill Principal Investigator Conferences 140
8.6 Deepwater Horizon Incident Specific Preparedness Review 140
8.7 National Commission on BP Deepwater Horizon - Final Report 142
8.8 Public Meetings, Letters, and Reports Submitted to ICCOPR 143
8.9 National Research Council: Responding to Oil Spills in the U.S. Arctic Marine Environment 144
8.10 National Petroleum Council: Arctic Potential – Realizing the Promise of U.S. Arctic Oil

ED_001324_00000360-00009

and Gas Resources....144
8.11 Industry Reports....145
8.12 Prince William Sound Oil Spill Recovery Institute (OSRI) Research Plan 2011-2015 (February 2010)....146
9. Oil Spill Research and Technology Priorities....147
9.1 Prevention Priority Research Needs....150
9.1.1 Human Error Factors Priorities (Section 4.3.1.1)....150
9.1.2 Offshore Facilities and Systems Priorities (Section 4.3.1.2)....151
9.1.3 Onshore Facilities and Systems Priorities (Section 4.3.1.3)....151
9.1.4 Waterways Management Priorities (Section 4.3.1.4)....152
9.1.5 Vessel Design Priorities (Section 4.3.1.5)....152
9.1.6 Drilling Priorities (Section 4.3.1.6)....153
9.2 Preparedness Priority Research Needs....157
9.2.2 Response Management Systems Priorities (Section 4.3.2.2)....158
9.3 Response Priority Research Needs....160
9.3.1 Structural Damage Assessment and Salvage Priorities (Section 4.3.3.1)....160
9.3.2 At-Source Control and Containment Priorities (Section 4.3.3.2)....160
9.3.3 Chemical and Physical Modeling and Behavior Priorities (4.3.3.3)....161
9.3.4 Oil Spill Detection and Surveillance Priorities (Section 4.3.3.4)....163
9.3.5 In- and On-water Containment and Recovery Priorities (Section 4.3.3.5)....164
9.3.6 Shore Containment and Recovery Priorities (Section 4.3.3.6)....165
9.3.7 Dispersants Priorities (Section 4.3.3.7)....166
9.3.8 *In Situ* Burning (ISB) Priorities (Section 4.3.3.8)....168
9.3.9 Alternative Chemical Countermeasures Priorities (Section 4.3.3.9)....169
9.3.10 Oily and Oil Waste Disposal Priorities (Section 4.3.3.10)....170
9.3.11 Bioremediation and Biodegradation Priorities (Section 4.3.3.11)....171
9.4 Injury Assessment and Restoration Priority Research Needs....172
9.4.1 Environmental Impacts and Ecosystem Recovery Priorities (Section 4.3.4.1)....172
9.4.2 Environmental Restoration Methods and Technologies Priorities (Section 4.3.4.2) 174
9.4.3 Human Safety and Health Priorities (Section 4.3.4.3)....174
9.4.4 Sociological and Economic Impacts Priorities (Section 4.3.4.4)....175
References....177
APPENDICES....189

ED_001324_00000360-00010

LIST OF FIGURES

Figure 1-1: The start of the commercial oil industry in the U.S. – Oil Creek, PA, 1859 (Source: Drake Wells Museum) 7

Figure 1-2: The Lakeview Gusher, CA; the US's single largest well blowout, 1910. (Source: San Joaquin Valley Geology) 7

Figure 1-3. Petroleum and other Liquid Estimated Consumption, Production and Net Imports (in million bpd) for 1949 – 2014 in the U.S. Source: EIA, 2015. 9

Figure 1-4 Domestic Shale gas plays. Source: EIA 2015 10

Figure 1-5: Location of U.S. Refineries and Refining Capacity. EIA 2015 11

Figure 1-6 Movement of crude oil (MBBL) by pipeline, tanker barge and rail tor refinery areas. Source: EIA 2015. 11

Figure 1-7 A comparison of crude oil movements by rail from 2010 and 2014. Source EIA 2015 12

Figure 1-8: Average Annual Oil Spillage from Petroleum Industry Sources by Decade. Etkin, 2009. 13

Figure 1-10 Barrels of Oil Spilled by Pipelines (1995-2014) 18

Table 1-6: U.S. Oil spills from vessels 2001-2010. (USCG, 2012) 23

Figure 1-11: Seaborne oil trade and oil spill trends 24

ED_001324_00000360-00011

LIST OF TABLES

Average Annual Oil Spillage from Petroleum Industry Sources, bbls. Modified From Etkin, 2009 .14
U.S. Gross Inputs to Refineries (Thousands of Barrels per Day) 21
Spill Events that Occurred in the Path of Hurricane Katrina (2005) 22
U.S. Oil Spills from Vessels – 2001 - 2010. From: USCG, 2012 23

ED_001324_00000360-00012

LIST OF ACRONYMS

A-CORE	Arctic Center for Oil-Spill Research & Education
AAR	After Action Review
AC	Area Committee
ACP	Area Committee Plan
ADEC	Alaska Department of Environmental Conservation
ADEQ	Arkansas Division of Environmental Quality
AESC	Arctic Executive Steering Committee
AIP	Australian Institute of Petroleum
AMOSC	Australian Marine Oil Spill Centre
AMSA	Australian Maritime Safety Authority
API	American Petroleum Institute
APICOM	Association of Petroleum Industry Co-op Managers
ARTES	Alternative Response Technologies Evaluation System
BAST	Best Available and Safest Technology
bbl (s)	Barrel (equals 42 U.S. Gallons)
BIO COOGER	DFO Canada's Bedford Institute of Oceanography Center for Offshore Oil, Gas and Energy Research
BOEM	Bureau of Ocean Energy Management
BOEMRE	[former] Bureau of Ocean Energy Management, Regulation and Enforcement
BP	British Petroleum
Bpd	Barrels per day
BSEE	Bureau of Safety & Environmental Enforcement
CAOSPR	California Office of Oil Spill Prevention and Response
CASP	Center for Arctic Study & Policy
CEC	CEDRE Experimentation Column
CEDRE	Centre of Documentation, Research and Experimentation on Accidental Water Pollution
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Resource, Compensation, and Liability Act
CFR	Code of Federal Regulations
CGHQ	Coast Guard Headquarters
CIRCAC	Cook Inlet Regional Citizen's Advisory Committee
CMR	Center of Excellence for Maritime Research
COP	Common Operating Picture
CPF	Coastal Protection Fund
CRADA	Cooperative Research and Development Agreement
CRRC	Coastal Response Research Center
CRREL	Cold Regions Research and Engineering Laboratory

ED_001324_00000360-00013

CSE	Center for Spills in the Environment
CSIRO	Commonwealth Scientific and Industrial Research Organization
CWA	Clean Water Act
DDO	Dispersants and dispersed oil
DECC	Department of Energy and Climate Change
DFO	Department of Fisheries and Oceans Canada
DHHS	Department of Health and Human Services
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DOR	Dispersant to Oil Ratio
DOT	Department of Transportation
DWH	*Deepwater Horizon*
E&P	Exploration & Production
EC	Environment Canada; European Union
EDDM	Environmental Disasters Data Management
EDRC	Effective Daily Recovery Capacity
EDRP	Emergency Disaster Recovery Program
EEZ	Exclusive Economic Zone
EIA	U.S. Energy Information Administration
EMERCOM	Russian Ministry of Civil Defense, Emergencies and Disaster Response
EMSA	European Maritime Safety Agency
EOI	Expression of Interest
EOP	Executive Office of the President
EPA	Environmental Protection Agency
EPAct	Energy Policy Act of 2005
EPPR	Emergency Prevention, Preparedness and Response Working Group
ERA	Environmental Risk Assessments
ERDC	U.S. Army Engineer Research and Development Center
ERRC	European Response Coordination Center
ERT	Environmental Response Team
ERW	Electric resistance welded pipe
ESA	Endangered Species Act
ESB	Environmental Specimen Bank
ESI	Environmental Sensitivity Index
ESP	Environmental Studies Program
EU	European Union
FACA	Federal Advisory Committee Act
FMSAS	Florida Marine Spill Analysis System

ED_001324_00000360-00014

FEMA	Federal Emergency Management Agency
FIO	Florida Institute of Oceanography
FOSC	Federal-On Scene Coordinator
FOSTERRS	Federal Oil Spill Team for Emergency Response Remote Sensing
FWPCA	Federal Water Pollution Control Administration
GIRG	Global Industry Response Group
GIS	Geographic Information Systems
GMFMC	Gulf of Mexico Fishery Management Council
GOMA	Gulf of Mexico Alliance
GoMRI	Gulf of Mexico Research Initiative
GOMURC	Gulf of Mexico University Research Collaborative
GRP	[National Academy of Science] Gulf Research Program
GSMFC	Gulf States Marine Fisheries Commission
HAZMAT	Hazardous Material
HML	Hollings Marine Laboratory
HMTA	Hazardous Materials Transportation Act
ICCOPR	Interagency Coordinating Committee on Oil Pollution Research
ICS	Incident Command System
ILI	In-Line Inspection
IMO	International Maritime Organization
IOM	Institute of Medicine
IOOS	Integrated Ocean Observing System
IOSC	International Oil Spill Conference
IPIECA	International Petroleum Industry Environmental Conservation Association
ISB	In-situ Burn
ISCO	International Spill Control Organization
ISPR	Incident Specific Preparedness Reviews
ITAC	Industry Technical Advisory Committee
ITOPF	International Tanker Owners Pollution Federation Limited
JITF	Joint Industry Oil Spill Preparedness and Response Task Force
JIP	Joint Industry Programme; Joint Industry Program
LEGEEPA	General Law of Ecological Equilibrium and Environmental Protection
LiDAR	Light Detection and Ranging
LNG	Liquefied Natural Gas
MARAD	Maritime Administration
MARPOL	Marine Pollution (International convention for the Prevention of Pollution from Ships)
MCA	Maritime and Coastguard Agency
MER	Marine Environmental Response
META	Maritime Environmental and Technical Assistance
MMC	U.S. Marine Mammal Commission

ED_001324_00000360-00015

MMPA	Marine Mammal Protection Act
MMS	[former] Minerals Management Service
MOC-A	Marine Operations Center, Atlantic
MOC-P	Marine Operations Center, Pacific
MOC-PI	Marine Operations Center, Pacific Islands
MODU	Mobile Offshore Drilling Units
MPCSA	State Marine Pollution Control, Salvage and Rescue Administration
MPD	Managed pressure drilling
MRCC	Marine Rescue Coordination Centres
MSA	China Maritime Safety Administration
MSL	USCG Marine Safety Laboratory
MTBE	Methyl Tertiary Butyl Ether
NAS	National Academy of Sciences
NASA	National Aeronautics & Space Administration
NAVSEA	Naval Sea Systems Command
NAWCA	North American Wetlands Conservation Act
NDRF	National Defense Reserve Fleet
NEBA	Net Environmental Benefit Analysis
NEPA	National Environmental Policy Act
NCP	National Contingency Plan
NETL	DOE's National Energy Technology Laboratory
NFWF	National Fish and Wildlife Federation
NGO	Non-governmental Organization
NIEHS	National Institute of Environmental Health Sciences
NIH	National Institutes of Health
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPC	National Petroleum Council
NPFC	U.S. Coast Guard's National Pollution Funds Center
NRC	National Response Center; National Research Council
NRDA	Natural Resource Damage Assessment
NRDAR	Natural Resource Damage Assessment and Restoration
NRF	National Response Framework
NRL	U.S. Naval Research Laboratory
NRMR	U.S. EPA National Risk Management Research Laboratory
NRP	National Response Plan
NRT	National Response Team
S&T	National Response Team Science & Technology Committee
NSAR	National Strategy for the Arctic Region
NSCS	National Spill Control School

ED_001324_00000360-00016

NSF	National Science Foundation
NSTC	National Science and Technology Council
NTIS	National Technical Information Service
NTNU	Norwegian University of Science and Technology
NTSB	National Transportation Safety Board
NURail	National University Rail (NURail) Center
OCRE	Ocean Coastal Research Engineering
OCS	Outer Continental Shelf
ODRP	Oil Disaster Recovery Program
OESI	Ocean Energy Safety Institute
OGP	Oil and Gas Producers
OMAO	NOAA's Office of Marine and Aviation Operations
OPA 90	Oil Pollution Act of 1990
OPRTP	Oil Pollution Research & Technology Plan
OR&R	NOAA Office of Response & Restoration
OSC	On Scene Coordinator
OSHA	Occupational Safety & Health Administration
OSPR	Oil Spill Preparedness and Response
OSRADP	Oil Spill Research and Development Program
OSRI	Oil Spill Recovery Institute
OSRO	Oil Spill Removal Organization
OSP	Oil Sands Products
OSLTF	Oil Spill Liability Trust Fund
OST	[Executive Office of the President] Office of Science & Technology
OSV	Ocean Survey Vessel
OSWG	Oil Spill Working Group
PAJ	Petroleum Association of Japan
PCT	Pew Charitable Trusts
PEMEX	Petróleos Mexicanos
PERF	Petroleum Environmental Research Forum
PHMSA	Pipeline & Hazardous Materials Safety Administration
PI	Principal investigators
P.L.	Public Law
PNNL	Pacific Northwest National Laboratory
PRCI	Pipeline Research Council International
PRI	Paleontological Research Institution
PROMAM	Navy's Marine Environment Protection Division
PSBCOSTF	Pacific States/British Columbia Oil Spill Task Force
PTSA	Port and Tanker Safety Act of 1978
PWS	Prince William Sound

ED_001324_00000360-00017

PWSA	Ports and Waterways Safety Act of 1972
PWSRCAC	Prince William Sound Regional Citizen's Advisory Committee
RAPID	Rapid Response Research
RAR	Resources at Risk
RDC	Coast Guard Research & Development Center
RDT&E	Research, Development, Test, and Evaluation
R&D	Research & Development
R&T	Research & Technology
RESTORE	Resources and Ecosystem Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act
RFP	Request for Proposal
ROV	Remotely Operated Vehicle
ROW	Right of Way
RP	Responsible Party
RRT	Regional Response Team
RSPA	[former] Research and Special Projects Administration
S&T	Science and Technology
SCAA	Spill Control Association of America
SCAT	Shoreline Cleanup Assessment Technique
SETAC	Society of Environmental Toxicology and Chemistry
SIO	Scripps Institution of Oceanography
SIT	Stevens Institute of Technology
SMART	Special Monitoring of Applied Response Technologies
SME	Subject Matter Expert
SONS	Spill of National Significance
SPCC	Spill Prevention, Control & Countermeasures
SRA	Standing Research Areas
SRM	Standard Reference Materials
SSC	NOAA Scientific Support Coordinator
SUPSALV	NAVSEA Supervisor of Salvage and Diving
SwRI	Southwest Research Institute
TCEQ	Texas Commission on Environmental Quality
TDC	Technology Development Center
TPWD	Texas Parks and Wildlife Department
TRB	Transportation Research Board
TXGLO	Texas General Land Office
UAA	University of Alaska Anchorage
UAF	University of Alaska Fairbanks
UDAC	Ultra-Deepwater Advisory Committee
UDW	Ultra-Deepwater

ED_001324_00000360-00018

UIUC	University of Illinois Urbana
UNEP	United Nations Environment Programme
UNH	University of New Hampshire
USACE	United States Army Corps of Engineers
USARC	United States Arctic Research Commission
USCG	United States Coast Guard
USGS	United States Geological Survey
USFA	United States Fire Administration
USFWS	United States Fish and Wildlife Service
USN	United States Navy
UTC	University Transportation Center
VOC	Volatile Organic Compound
VTS	Vessel Traffic Service
VTSS	Vessel Traffic Service / Separation
WADOE	Washington Department of Ecology
WHOI	Woods Hole Oceanographic Institution

ED_001324_00000360-00019

THIS PAGE INTENTIONALLY LEFT BLANK.

ED_001324_00000360-00020

DEFINITIONS

ICCOPR uses the following definitions solely for purposes of this Oil Pollution Research and Technology Plan (OPRTP). These definitions do not reflect all existing/relevant statutory and/or regulatory definitions and do not supersede any statutory or regulatory requirements.

Allision is the running of one vessel against another vessel or structure that is stationary. An allision is different from a collision in that a collision is the running of two moving vessels against each other.

Applied Research is any systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met, in this case related to advancing knowledge about oil spill prevention, preparedness, response, mitigation, and restoration/recovery.

Basic Research is any systematic study directed toward fuller knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind.

Baseline Study refers to studies conducted to gather a set of critical observations or data that provide a basis for comparing conditions before and after an action or event. Baseline studies document the ecological and socioeconomic conditions of an area before an oil system activity or potential spill occurs. These studies provide a basis for assessing changes or damages that occur as a result of the activities or a spill.

Collision means the running of two vessels against each other (both under power). A collision is different from an allision where only a single vessel is underway and strikes a stationary vessel or structure.

Damages means injury to natural resources, to real or personal property, loss of subsistence use of natural resources, loss of governmental revenues, loss of profits or earning capacity, and increased cost of additional public services. Damages also include the cost of assessing these injuries. Removal costs and damages covered by OPA 90 are defined in 33 U.S.C § 2702(b)(2).

Demonstration refers to activities that are part of research or development (i.e., that are intended to prove or to test whether a technology or method does, in fact, work). Demonstrations intended primarily to make information available about new technologies or methods should not be included in this definition (NSF, 2009).

Development is any systematic application of knowledge or understanding, directed toward the production of useful materials, devices, and systems or methods,

ED_001324_00000360-00021

including design, development, and improvement of prototypes and new processes to meet specific requirements.

Discharge means any emission (other than natural seepage), intentional or unintentional, and includes, but is not limited to spilling, leaking, pumping, pouring, emitting, or dumping of oil that is not permitted.

Dispersants means those chemical agents that emulsify, disperse, or solubilize oil into the water column or promote the surface spreading of oil slicks to facilitate dispersal of the oil into the water column

Facility means any structure, group of structures, equipment, or device (other than a vessel) that is used for one or more of the following purposes: exploring for, drilling for, producing, storing, handling, transferring, processing, or transporting oil. This term includes any motor vehicle, rolling stock, or pipeline used for one or more of these purposes. The OPA 90 definition of a facility is codified at 33 U.S.C § 2702(b)(2).

National Contingency Plan (NCP) refers to the National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR Part 300), the federal government's blueprint for responding to both oil spills and hazardous substance releases. The NCP is the result of efforts to develop a national response capability and promote coordination among the hierarchy of responders and contingency plans.

Natural Resource Damage Assessment (or assessment) means the process of collecting and analyzing information to evaluate the nature and extent of injuries resulting from an incident, and determine the restoration actions needed to bring injured natural resources and services back to baseline and make the environment and public whole for interim losses.

Natural Resources, for purposes of injury assessment and restoration, refers to land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States (including the resources of the exclusive economic zone), any State or local government or Indian tribe, or any foreign government. Natural resources, for other purposes, may include minerals such as oil and gas.

Oil refers to oil of any kind or in any form, including, but not limited to, petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged spoil. It may also refer to: fats, oils, or greases of animal, fish, or marine mammal origin; vegetable oils, including oils from seeds, nuts, fruits, or kernels; and, other oils and greases, including synthetic and mineral oils. The CWA definition of oil is codified at 33 U.S.C. § 1251 *et seq.*; the OPA definition of oil is codified at 33 U.S.C. § 2701 *et seq.*

ED_001324_00000360-00022

The ***Oil Pollution Act of 1990*** (OPA 90), codified at 33 U.S.C § 2701 *et seq.*, is a law that amended the Clean Water Act (CWA) and addressed the wide range of problems associated with preventing, responding to, and paying for oil pollution incidents in navigable waters of the United States. Title VII of OPA 90 established ICCOPR.

An ***Oil Spill*** is a non-permitted occurrence or series of occurrences having the same origin, involving one or more vessels, facilities, or any combination thereof, resulting in the discharge or substantial threat of discharge of oil into or upon navigable waters of the United States, adjoining shorelines, or the exclusive economic zone (e.g., oil spill in coastal waters from a tanker). This term also includes discharges of oil on land with the potential to reach any waters of the United States.

Oil Spill Response Organizations (OSROs) are companies that specialize in cleaning up oil spills. They often serve as contractors or subcontractors for spill response efforts.

An ***On-Scene Coordinator*** (OSC) is the federal official pre-designated by EPA or the USCG to coordinate and direct responses under Subpart D of the NCP. It also refers to a designated representative of a lead Federal agency to coordinate and direct removal actions under Subpart E of the NCP. General responsibilities of OSCs are found in 40 CFR 300.120. OSCs are sometimes referred to as Federal On-Scene Coordinators (FOSCs).

The ***Ports and Waterways Safety Act*** (PWSA) 1972, as amended by the Port and Tanker Safety Act of 1978 (PTSA), and the Oil Pollution Act of 1990 (OPA), is designed to promote navigation, vessel safety, and protection of the marine environment. The PWSA authorizes the U.S. Coast Guard (USCG) to establish vessel traffic service/separation (VTSS) schemes for ports, harbors, and other waters subject to congested vessel traffic.

The ***Ports and Tanker Safety Act*** (PTSA) of 1978 amended the PWSA. Under the PTSA, Congress found that navigation and vessel safety and protection of the marine environment are matters of major national importance and that increased vessel traffic in the nation's ports and waterways creates substantial hazard to life, property or the marine environment. In addition, increased supervision of vessel and port operations was deemed necessary.

Preparedness is an activity, program, or system developed prior to an oil spill to support and enhance the ability of personnel and organizations to prevent, respond to, and recover from an oil spill or other adverse event.

Prevention is an on-going activity to minimize the likelihood of discharges of oil into the environment. Prevention may be a long-term approach to looking at the

ED_001324_00000360-00023

fundamentals of minimizing the potential of oil spills with the goal to identify, minimize, and mitigate risks.

Release means any spilling, leaking, pumping, pouring, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of oil into the environment.

Research is the systematic study directed toward fuller scientific knowledge or understanding of the subject studied. (NSF, 2009)

Response includes all activities involved in containing and cleaning up oil in order to: 1: maintain safety of human life; 2: stabilize a situation to preclude it from worsening, and; 3: minimize adverse environmental and socioeconomic impacts by coordinating all containment and removal activities to carry out a timely, effective response.

The ***Responsible Party*** (RP) of an incident is the person, business, or entity that has been identified as owning or operating a vessel or facility that caused an oil spill. The OPA definition of responsible party is codified at 33 U.S.C. § 2701 *et seq*.

Restoration is the process of restoring an affected area or resource to its pre-incident state. Restoration can take several months to many years and may require technical and financial assistance from a variety of sources. Restoration efforts are primarily concerned with actions that involve rebuilding destroyed property, re-employment of effected stakeholders, rehabilitating, replacing, or acquiring the equivalent of injured natural resources and the services they provided prior to the damage being inflicted and the repair of other essential infrastructure.

Submerged and subsurface oil refers to oil that is not floating on the water surface.

Surface Washing Agent is any product that removes oil from solid surfaces, such as beaches and rocks, through a detergency mechanism and does not involve dispersing or solubilizing the oil into the water column.

Technology is the study, development, and application of devices, machines and techniques for manufacturing and productive processes. Technology also includes tools, equipment, and methods or methodologies that apply scientific knowledge or tools. For purposes of this plan, technology represents the application of knowledge or widgets to the development and/or usage of equipment, systems and organizational capabilities for oil spill prevention, preparedness, response, and restoration.

Vessel means every description of watercraft or other artificial contrivance used, or capable of being used, as a means of transportation on water.

ED_001324_00000360-00024

EXECUTIVE SUMMARY

Title VII of the Oil Pollution Act of 1990 (OPA 90) established the Interagency Coordinating Committee on Oil Pollution Research (ICCOPR) to coordinate a comprehensive program of oil pollution research, technology development, and demonstration. Pursuant to Section 7001(b) of OPA 90, ICCOPR developed the Oil Pollution Research and Technology Plan (OPRTP) to implement the Federal research and development program.

ICCOPR published its first version of the OPRTP in 1992 and published a revised version in 1997. These two versions provided an initial baseline assessment and analysis of: agency roles and responsibilities; status of knowledge of oil pollution prevention, response, and mitigation technologies; priority research and development needs; and an estimate of resources and time needed to implement the program.

The purpose of the FY 2015-2021 version of the OPRTP, and subsequent revisions, is to provide current assessments of the oil pollution research needs and priorities. ICCOPR intends to update this OPRTP every six years to reflect advancements in oil pollution technology and changing research needs. This ongoing planning process will capitalize on the unique roles and responsibilities of member agencies to address oil pollution research and development needs and maintain awareness of research needs.

This version of the OPRTP includes two parts. Part One, Oil Pollution Research, explains why oil pollution research is needed, the parties that are involved in the research, and presents ICCOPR's Oil Pollution Research Categorization Framework for tracking research activities and successes. Part Two, Establishing Research Priorities, presents ICCOPR's priority Research Needs. It also explains the process that ICCOPR used to identify the research gaps and priorities, noteworthy oil spill events, and the current state of oil pollution knowledge. In future versions, Part One will remain relatively static; however, Part Two is expected to change significantly as research advances the state of knowledge and priority Research Needs are successfully addressed.

The Introduction and Chapter 1, The Need for Oil Pollution Research, describes the historical basis for oil pollution research and reviews trends in oil spills from different sources. ICCOPR member agencies share responsibilities to monitor changes in the oil spill system and find opportunities to improve technologies to meet changing needs. ICCOPR recognizes that activities in the Arctic and Alaska, the Gulf of Mexico, inland areas, and the Atlantic Outer Continental Shelf are all of high importance at this time.

Chapter 2, Federal Oil Pollution Research, describes the Federal entities involved in oil pollution research including the ICCOPR member agencies, other Federal research organizations and facilities. Similarly, Chapter 3, Non-Federal Oil Pollution Research Entities, describes state, industry, independent organizations, academia, and international oil pollution research entities.

ED_001324_00000360-00025

Chapter 4, Structuring Oil Pollution Research, presents ICCOPR's Oil Pollution Research Categorization Framework, which provides a common language and planning framework that would enable researchers and interested parties to identify and track research in each topic area. The Framework groups research into four broad Classes: Prevention, Preparedness, Response, and Injury Assessment and Restoration. ICCOPR further classified research within each Class into 25 Standing Research Areas (SRAs), which represent the most common research themes encountered for oil spills.

Chapter 5, Knowledge Transfer and Advancement, describes ICCOPR's efforts to promote continuous improvement in the nation's ability to address oil pollution by monitoring the state of knowledge and adjusting the program to meet changing needs. The R&T planning process emphasizes and strengthens the roles and responsibilities of the member agencies to assure that research advances the capabilities to reduce oil pollution.

Chapter 6, Oil Pollution Research Needs Identification and Prioritization Process, documents the process ICCOPR employed to establish the research priorities. ICCOPR established an R&T Working Group that identified more than 900 research gaps, consolidated them into 570 unique Research Needs, and evaluated them with the assistance of the results from a survey of 280 subject matter experts.

Chapter 7, Noteworthy Oil Spill Incidents, describes important oil spill events and lists the oil pollution research gaps that they illuminated. Spills associated with vessels, drilling operations, on-shore pipelines, facilities, and railroads are included.

Chapter 8, Current State of Oil Pollution Knowledge, describes the sources and mechanisms that ICCOPR uses to obtain and share information on research needs and accomplishments.

Chapter 9, Oil Spill Research and Technology Research Priorities, presents ICCOPR's priority Research Needs. ICCOPR identified three top priorities for each SRA. For SRAs with a large number of Research Needs (i.e., Dispersants), ICCOPR established subcategories of similar research. Three priority Research Needs were assigned to each subcategory.

There are eight SRAs and 33 priorities within the Prevention Class. Two SRAs and 12 priorities are in the Preparedness Class. The Response Class has the largest number of priorities with 72 in 11 SRAs. The four SRAs in the Injury Assessment and Restoration Class have 33 priorities.

ED_001324_00000360-00026

INTRODUCTION

Title VII of the Oil Pollution Act of 1990 (OPA 90) established the Interagency Coordinating Committee on Oil Pollution Research (ICCOPR) 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 shall foster cost-effective research mechanisms, including the joint funding of research." Section 7001(c) of OPA 90 required ICCOPR to establish a Federal oil pollution research and development (R&D) program. Pursuant to Section 7001(b) of OPA 90, ICCOPR developed the Oil Pollution Research and Technology Plan (OPRTP) to implement the Federal research and development program.

Background

Federal oil pollution research efforts began to take shape in the late 1960s following the *Torrey Canyon* oil spill off the coast of England. At that time, the U.S. had neither the technical or operational capacity to deal with a large oil spill in the marine environment (EOP-OST, 1969). The Federal government developed the first National Contingency Plan (FWPCA, 1968) to address oil spills and began extensive oil pollution research over the next 20 years. Coordination of the Federal research efforts was informal and on an ad hoc basis through conferences, workshops, and committees of researchers scheduling their projects at the Ohmsett facility. The challenges posed by the response to the *Exxon Valdez* oil spill in 1989 revealed the need for Federal agencies to better coordinate their research. Efforts to coordinate the research resulted in Title VII of OPA 90 and the first requirement for a comprehensive and coordinated research and technology plan.

ICCOPR submitted the original OPRTP to Congress in April 1992. As directed by OPA 90, ICCOPR provided the OPRTP to the National Research Council's (NRC's) Committee on Oil Spill Research and Development for review. Using input from the NRC's Marine Board, ICCOPR started a revision of the plan in May 1993 to include topics related to spill prevention, human factors, and the field testing/demonstration of developed response technologies. ICCOPR released a revised version in April 1997, which identified 21 research areas divided into three levels of priority and served as a strategic planning document for ICCOPR to communicate and coordinate research needs.

This version of the OPRTP is the first in a new series of revisions covering six-year planning cycles, and presents ICCOPR's coordinated research and technology plan for FY 2015-2021. This ongoing planning process will capitalize on the unique roles and responsibilities of member agencies to address oil pollution research and development needs and maintain awareness of research needs.

ED_001324_00000360-00027

Purpose of the Plan

The 1992 version of the OPRTP provided Congress with an implementation plan for the new research and development program established by OPA 90. That version, and the 1997 revisions, provided an initial baseline assessment and analysis of: agency roles and responsibilities; status of knowledge of oil pollution prevention, response, and mitigation technologies; priority research and development needs; and an estimate of resources and time needed to implement the program. The purpose of the FY 2015-2021 version, and subsequent revisions, is to provide current assessments of the oil pollution research needs and priorities. To that end, the principal objectives of the OPRTP are to:

1. define common research themes related to oil pollution research;
2. identify on a regular basis the knowledge gaps associated with common research themes and recommend what gaps should be considered as high research priorities within them;
3. act as an umbrella or connecting document with other strategic Federal research plans (or accomplishment reports) that also address research support for oil pollution topics;
4. document the interagency research coordination process, as well as the feedback processes developed by Federal research, management and regulatory agencies; and
5. promote research information transfer between the government, the public and other stakeholders.
6. encourage and track efforts to implement improvements and technological change within agency roles and responsibilities via updates in the biennial reports to Congress.

Scope and Use of the Plan

This OPRTP provides a basis for coordinating research to address oil pollution issues in the U.S. It is primarily directed at Federal agencies with responsibilities for conducting or funding oil pollution research, but can serve as a research planning guide for industry, academia, State governments, research institutions, and other nations.

Research, in the context of the OPRTP, includes both basic and applied studies that are considered as peer-reviewed and published as well as studies reported in the "grey literature," which is publically available scientific literature that has not been peer reviewed. The following National Science Foundation definitions apply with respect to the OPRTP:

- **Basic research** is any systematic study directed toward fuller knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind.
- **Applied research** is any systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met. ICCOPR

ED_001324_00000360-00028

interprets this to mean studies to advance knowledge about oil spill prevention, preparedness, response, mitigation, and restoration/recovery.

- **Development** is any systematic application of knowledge or understanding, directed toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements.
- **Technology** is defined as making, usage, and knowledge of tools, machines, techniques, crafts, systems or methods of organization in order to solve a problem or perform a specific function. ICCOPR believes this definition represents the application of knowledge as well as the development and usage of the equipment, systems and organizational capabilities concerning oil spill prevention, preparedness, response, mitigation, and restoration/recovery.

At the federal level, this OPRTP provides information that can be used as a basis to conduct interagency coordination and track progress toward addressing the nation's research needs. It can also help Federal agencies:

1. identify high-priority research emphasis areas;
2. promote needed research based on priorities; and
3. synchronize and collaborate research activities to avoid overlapping research efforts.
4. track progress of key efforts to aid implementation of needed improvements.

ICCOPR recognizes that there are a large number of oil pollution research programs conducted by non-Federal organizations and the private sector. This OPRTP provides these entities with ICCOPR's recommendations on research areas that will best address the nation's oil pollution research needs.

ED_001324_00000360-00029

THIS PAGE INTENTIONALLY LEFT BLANK

ED_001324_00000360-00030

PART ONE – OIL POLLUTION RESEARCH

1. The Need for Oil Pollution Research

Oil is a dominant source of energy in the United States, supplying the nation with approximately 40 percent of its energy needs (Ramseur, 2012). Oil provides fuel for the transportation, industrial, and residential sectors and serves as a primary feedstock for making plastics. Oil is expected to remain a major source of energy in the U.S. for at least the next several decades. With historical, current and projected use and constant movement, it is inevitable that spills will occur.

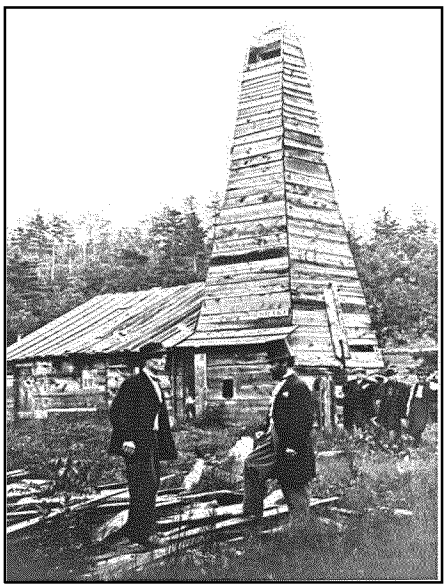


Figure 1-1: The start of the commercial oil industry in the U.S. – Oil Creek, PA, 1859 (Source: Drake Wells Museum)

Spills of oil in the U.S. accompanied the inception of early commercial efforts for petroleum drilling in the early 19th century in the United States and continue to this day. The first oil discovery was on land at Oil Creek, Pennsylvania in 1859 by George Bissel and Edwin Drake (Figure 1-1) (Pees, 2004). This success quickly led to additional commercial investments in oil drilling refining and marketing in the western Appalachian Mountains, where oil seeps were common. Commercial drilling projects rapidly spread to include areas in Southern California, Kansas, Oklahoma, Arkansas, North Louisiana and Texas by the late 1890's.

In 1910, the largest onshore blowout in the U.S. and the world occurred at the Lakeview No. 1 well in the San Joaquin Valley, CA (Figure 1-2). The initial flow estimates ranged from 125,000 barrels per day (bpd) at the start to 90,000 bpd after a month. The well remained uncontrolled for 544 days with an estimated 9.4 million bbl of crude being released into the environment (one barrel = 42 U.S. gallons).

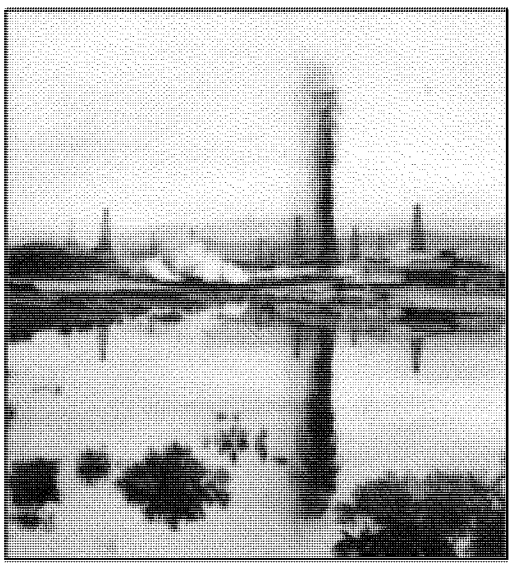


Figure 1-2: The Lakeview Gusher, CA; the US's single largest well blowout, 1910. (Source: San Joaquin Valley Geology)

Oil spills continued to occur but it wasn't until the late 1960s that the national attention focused on the need to address the problems associated with oil spills. In 1967, reaction in the U.S. to the *Torrey Canyon* oil spill off the coast of England resulted in the creation of the original National Multiagency Oil and Hazardous Materials Contingency Plan in 1968 (FWPCA, 1968). That Plan was superseded in 1970 when the Council on Environmental Quality (CEQ) published the National Oil and Hazardous Materials Pollution

ED_001324_00000360-00031

Contingency Plan in the Federal Register at 35 FR 8508 (CEQ, 1970). In 1969, a well blowout and undersea faults spilled an estimated 42 million gallons of oil into the Santa Barbara Channel, one of the largest environmental disasters in the U.S. (NOAA, 2014). This spill increased awareness of oil pollution problems and contributed to creation of the U.S. Environmental Protection Agency, the National Environmental Policy Act, and the National Marine Sanctuaries system. It also prompted several federal agencies to begin oil pollution research programs.

Oil pollution research must continually evolve to keep pace with new oil spill risks and environments where they occur. The process by which oil is produced, processed, and delivered to consumers is ever evolving. The oil industry opens new areas for exploration and production as technological advances make the ventures profitable. In turn, the location and methods of transporting that oil to markets shifts, affecting the potential locations and types of oil spills. For example, the opening of the Alaska North Slope and the Trans-Alaska Pipeline necessitated transportation of crude oil by tanker through Prince William Sound, site of the *Exxon Valdez* oil spill. Similarly, the technological advances that allow deep water oil exploration and production also pose new hazards and risks as evidenced by the British Petroleum (BP) *Deepwater Horizon* oil spill. Those spills posed new response challenges and revealed the need for additional oil pollution research.

There will continue to be a need for oil pollution research as long as there is a demand for oil-based products. Human errors, mechanical failures, natural events, and accidents all have the potential to cause spills. This chapter examines the oil production system and patterns of oil spills that affect the oil pollution research needs addressed in this OPRTP.

1.1 U.S. Oil Production

Figure 1-3 shows the U.S. Energy Information Administration (EIA) Annual Energy Review 2015 (EIA, 2015) and provides a review on the production, import and consumption for petroleum and other liquids for the last 60 years (from 1949 to 2014). The U.S. has experienced a steadily increasing consumption rate that quickly outstripped the U.S. petroleum production capabilities, resulting in a regular increase in net imports of petroleum products to address the shortfall beginning in 1970. Domestic production of oil continued to decrease until 2008 when new finds and improved drilling capabilities began to increase U.S. field production.

ED_001324_00000360-00032

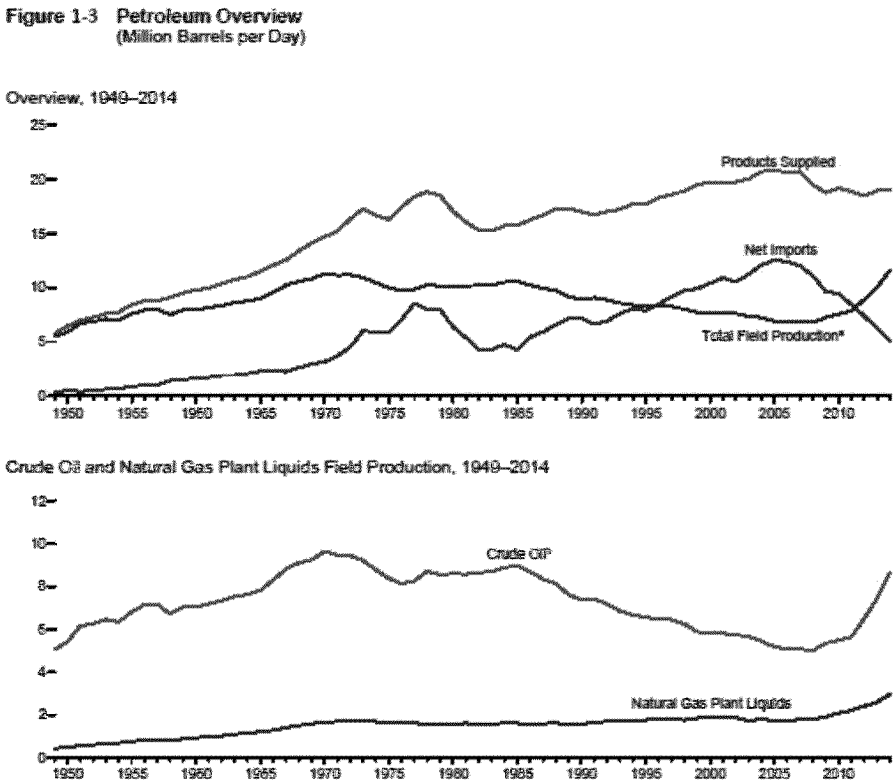


Figure 1-3. Petroleum and other Liquid Estimated Consumption, Production and Net Imports (in million bpd) for 1949 – 2014 in the U.S. Source: EIA. 2015.

Of particular note was the discovery of the Bakken field in North Dakota, Montana and in Canada (Figure 1-4). Significant increases in domestic production from these discoveries resulted in a decrease in net oil imports as shown in Figure 1-3. The increase in production of natural gas has also led to a decrease in net imports. The application of hydraulic fracturing and horizontal drilling technologies caused a significant increase in Bakken production since 2000. By the end of 2010, oil production rates had reached 458,000 bbls per day, outstripping the pipeline capacity to ship oil out of the Bakken. The result was an expansion of rail transportation to move the crude oil to refineries or ports for export.

Shale oil and natural gas resources are found in shale formations that contain significant accumulations of natural gas and/or oil (Figure 1-4). The Barnett Shale in Texas has been producing natural gas for more than a decade. Information gained from developing the Barnett Shale provided the initial technology template for developing other shale plays in the U. S. Another important shale gas play is the Marcellus Shale in the eastern U. S. While the Barnett and Marcellus formations are well-known shale gas plays in the United States, more than 30 U.S. states overlie shale formations. The Marcellus natural gas trend, which encompasses 104,000 square miles and stretches across Pennsylvania and West Virginia, and into southeast Ohio and upstate New York, is the largest source of natural gas in the United States, and production was still growing rapidly as of 2014.

ED_001324_00000360-00033

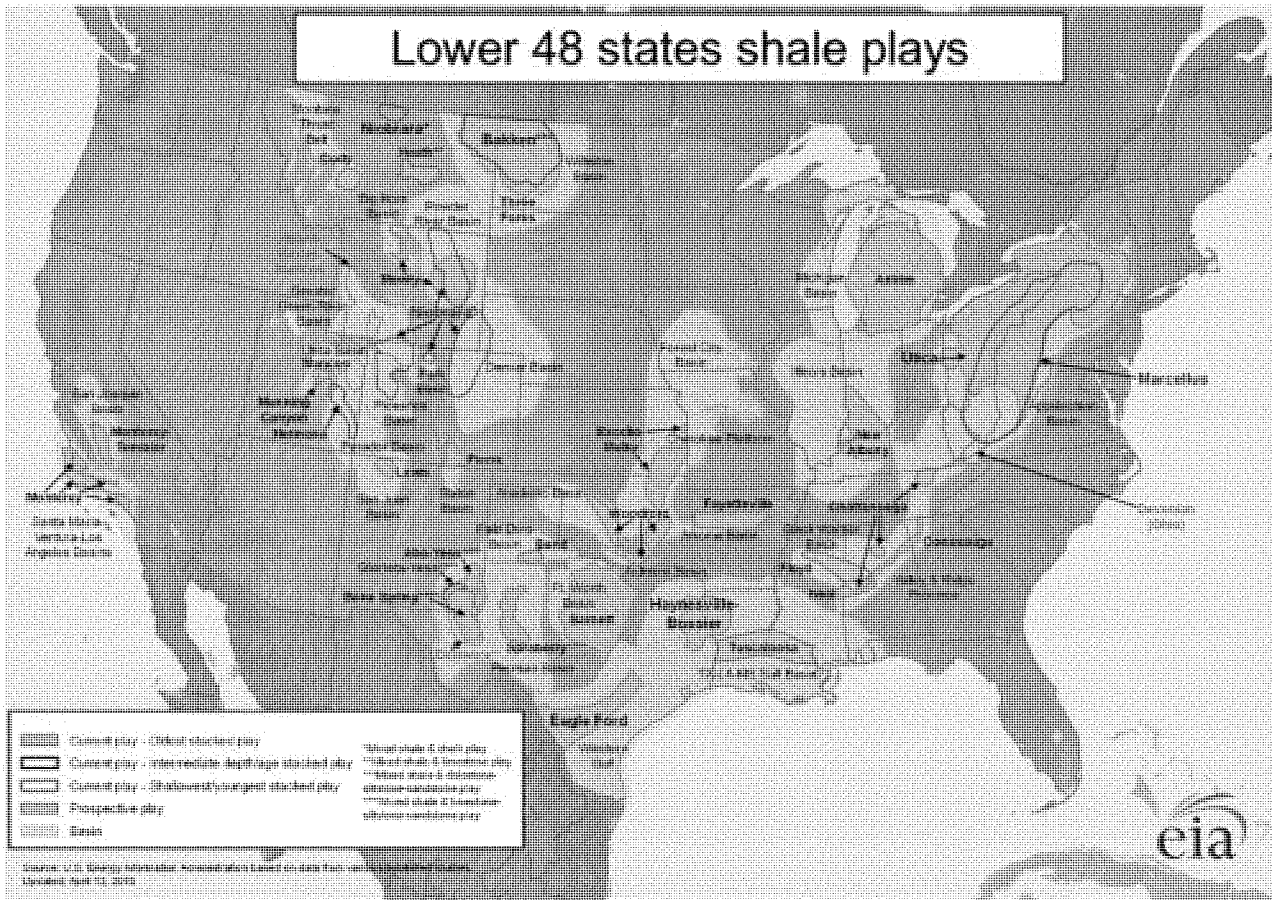


Figure 1-4 Domestic Shale gas plays. Source: EIA 2015

Figure 1-5 shows the location of refineries in the U.S. Figure 1-6 shows the substantial increase in transportation of petroleum from the Midwest to other parts of the country where the refinery capacity exists. The greatest overall volumes were transported to the Gulf coast. The 2010 to 2014 period reflects the increase in U.S. production in the shale-producing locations.

The significant increase in petroleum being transported within the U.S. has taxed the available pipeline capacity significantly. In order to meet some of the increased demand, there has been a significant increase in rail transportation of crude oil.

The large increase in U.S. and North American petroleum production has resulted in a significant change in the transportation patterns. The production from the Bakken field and the Canadian oil sands products (OSP) areas have resulted in a significant change in the number trains and tank cars carrying petroleum. The Association of American Railroads (2015) reports that the number of rail tankers carrying crude oil and petroleum products in the U.S. increased from just under 19,000 carloads in 2008 to more than 1,033,000 carloads in 2014. Figure 1-7 shows the change in the number of rail cars and the change in train movements between 2010 and 2014; this represents the time period when the development of Bakken oil began to be significant.

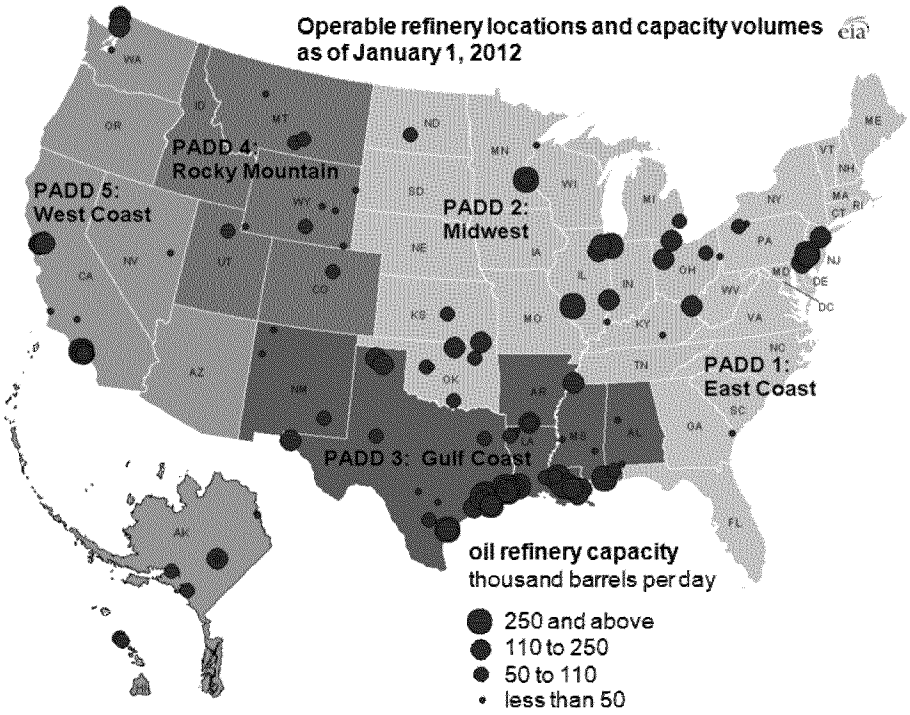


Figure 1-5: Location of U.S. Refineries and Refining Capacity. EIA 2015.

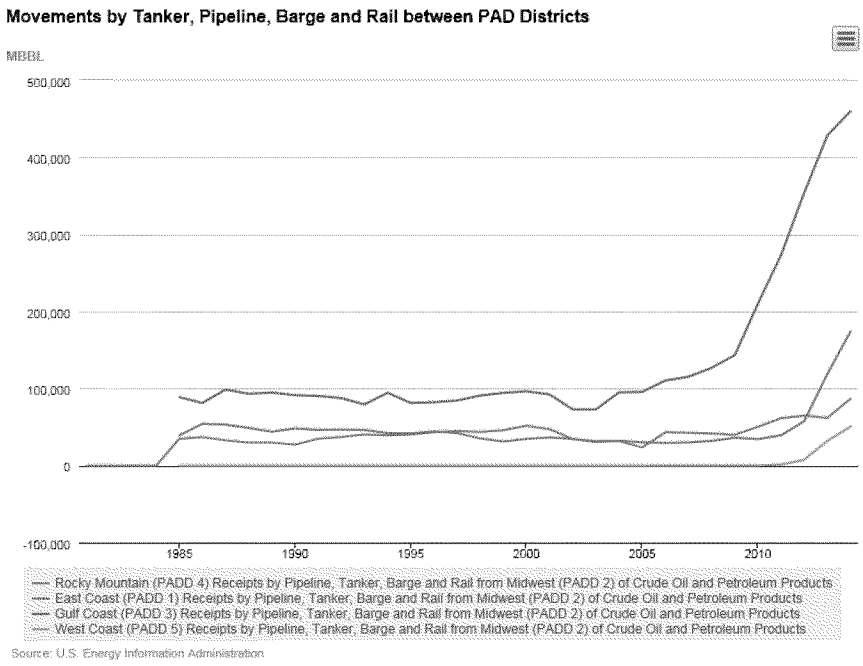


Figure 1-6 Movement of crude oil (MBBL) by pipeline, tanker barge and rail tor refinery areas. Source: EIA 2015.

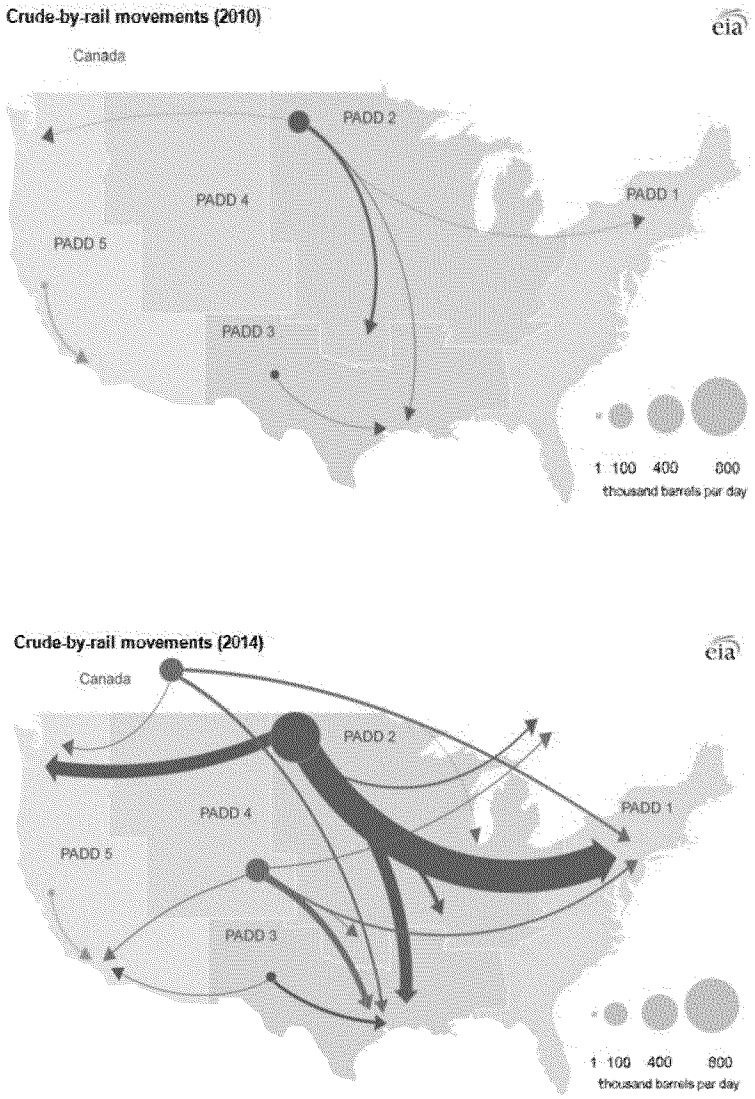
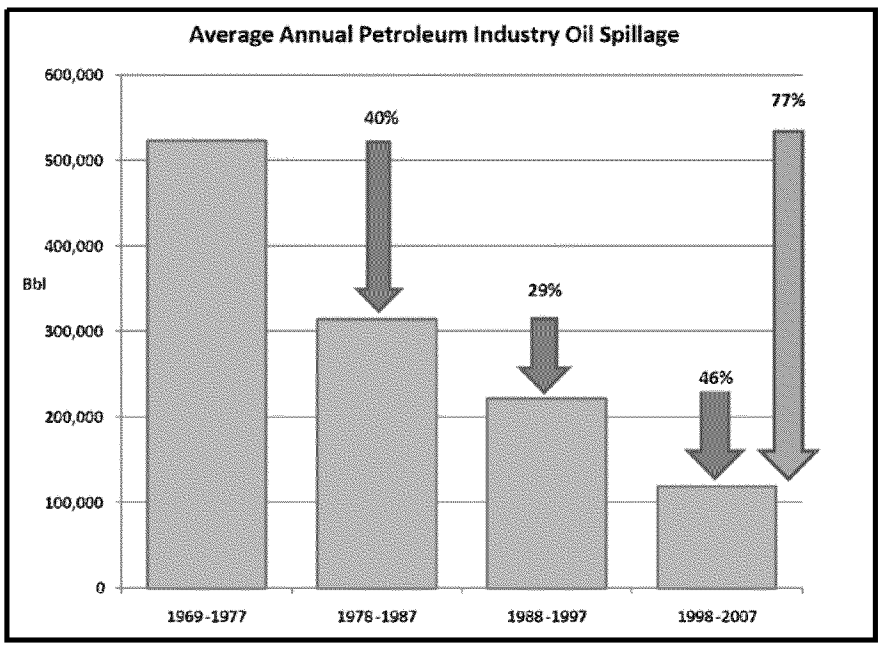


Figure 1-7 A comparison of crude oil movements by rail from 2010 and 2014. Source EIA 2015.

1.2 History of Oil Spills in the U.S.

From 1973 to 1990, an average of 2.8 million bbl of oil was spilled every year. Since 1990, that number has reduced to 35,700 bbl a year. Based on data between 1973 and 2009, the annual number and volume of oil spills declined, and in some cases dramatically (Etkin, 2009). Total petroleum industry spillage has decreased consistently over the last 40 years through 2007 (Figure 1-8). Table 1-1 summarizes the average annual oil spillage from petroleum industry

sources, including: spillage related to oil exploration and production platforms and offshore pipelines; spillage from coastal and inland pipelines, tank vessels, railroads, and tanker trucks; spillage from oil refineries; and spillage at gas stations. By multiplying the average annual spill volumes for each decade by 10, the total volume spilled (as recorded) from 1969 to 2007 would approximately equal 17.5 million bbls. (See Table 1-1.)



*NOTE: The average annual oil spillage volumes represented here are gathered from petroleum industry spillage sources, including: spillage related to oil exploration and production, platforms and offshore pipelines; spillage from coastal and inland pipelines; spillage from oil transport by tank vessels, railroads, and tanker trucks; spillage from oil refineries; and spillage from gas stations.

Figure 1-8: Average Annual Oil Spillage from Petroleum Industry Sources by Decade. Etkin, 2009.

These figures do not address any other significant spillage events in the U.S. after 2007, which would include the 2010 Macondo/*Deepwater Horizon* (DWH) well blowout and oil spill and the 2010 Enbridge Pipeline release in the Kalamazoo River in Michigan or any other significant spillage events in the U.S. after 2007. The 4.9 million bbls spilled during the *Deepwater Horizon* oil spill (USCG, 2011b) would reverse this downward trend and increase the total volume spilled between 1969 and 2007 by nearly 1400 percent; this incident represents nearly 95% of the total volume spilled from all oil platforms in the last 42 years. In general, the very largest spills, which constitute only 0.4% of the total spills, comprise 90.6% of the total volume spilled in the U.S. for the period 1988 – 2007.

ED_001324_00000360-00037

Average Annual Oil Spillage from Petroleum Industry Sources, bbls. Modified From Etkin, 2009				
Source	1969-1977	1978-1987	1988-1997	1998-2007
PRODUCTION	31,435	8,701	15,183	9,938
Offshore Platform Spills	25,858	1,344	1,814	1,273
Offshore Pipelines	4,48	3,462	8,127	2,614
Offshore Supply Vessels	95	245	48	10
Inland Production Wells	1,000	3,650	5,194	6,041
REFINING	3,000	3,512	15,015	12,136
Refinery Spills	3,000	3,512	15,015	12,136
TRANSPORT	488,662	301,645	190,753	96,393
Inland Pipelines	259,340	181,196	118,297	76,754
Tanker Trucks	3,000	4,888	5,213	9,181
Railroads	2,000	2,322	2,164	1,431
Tank Ships	192,492	60,250	42,197	3,598
Tank Barges	31,830	52,989	22,882	5,429
STORAGE AND CONSUMPTION	118,523	97,206	278,525	77,613
Non-Tank Vessels (Cargo Ships)*	5,000	6,786	2,817	1,602
Other Vessels*	14,858	6,574	6,301	4,167
Gas Stations and Truck Stops	1,195	1,195	1,564	814
Residential*	150	179	518	498
Aircraft*	3,700	3,714	3,862	4,044
Inland EPA-Regulated Facilities*	30,000	34,740	245,017	59,676
Coastal Facilities (Non-refining)*	62,220	42,781	15,059	4,230
Inland Unknown*	900	967	2,198	516
Motor Vehicles*	500	270	1,189	2,066
AVERAGE ANNUAL TOTALS	641,620	411,064	499,476	196,080
ESTIMATED DECADE TOTAL	6,416,200	4,110,640	4,994,760	1,960,800
ESTIMATED GRAND TOTAL SPILLAGE for 1969 – 2007	17,482,400 bbls (734,560,800 gallons)			
*Additional storage and consumption data for the 1969-1977 period was provided by Dagmar Schmidt Etkin, 2011, personal communications.				

Table 1-1: Average Annual Oil Spillage from Petroleum Industry Sources, bbl. (Modified from Etkin, 2009).

ED_001324_00000360-00038

1.3 Analysis of the Oil Spill System

In their Congressionally-mandated review of the 1992 OPRTP, the National Research Council (NRC) Marine Board recommended "…an analysis of the marine oil spill system, which consists of a variety of subsystems beginning with drilling for oil and ending at delivery of the product to the consumer." The oil spill system described by the NRC consists of all components and nodes of the oil supply chain (see Figure 1-9) including all aspects of the oil handling and transport processes, succeeding environments affected as a spill spreads, and intervention techniques for preventing or minimizing environmental damage (Marine Board, 1993; 1994). The NRC advocated that such an approach would identify critical nodes of potential failure within the system where ICCOPR could focus its research planning efforts.

ICCOPR agreed with the NRC on the value of a systems analysis approach in research planning but full implementation of the approach has been beyond the funding capabilities of the ICCOPR membership. In 2007, the USCG Research & Development Center (RDC) completed a system analysis of the response system and used the results to identify and evaluate research opportunities as part of strategic planning to improve spill response (VanHaverbeke, 2012). ICCOPR member agencies also have expertise on specific components of the oil spill system. This base of knowledge on the system components provides a general framework from which ICCOPR plans its research coordination, funding allocations, and measures of effectiveness. The oil spill research categorization scheme discussed in Chapter 4 reflects how ICCOPR used its understanding of the oil supply chain and oil spill response system to focus research planning as envisioned by the NRC.

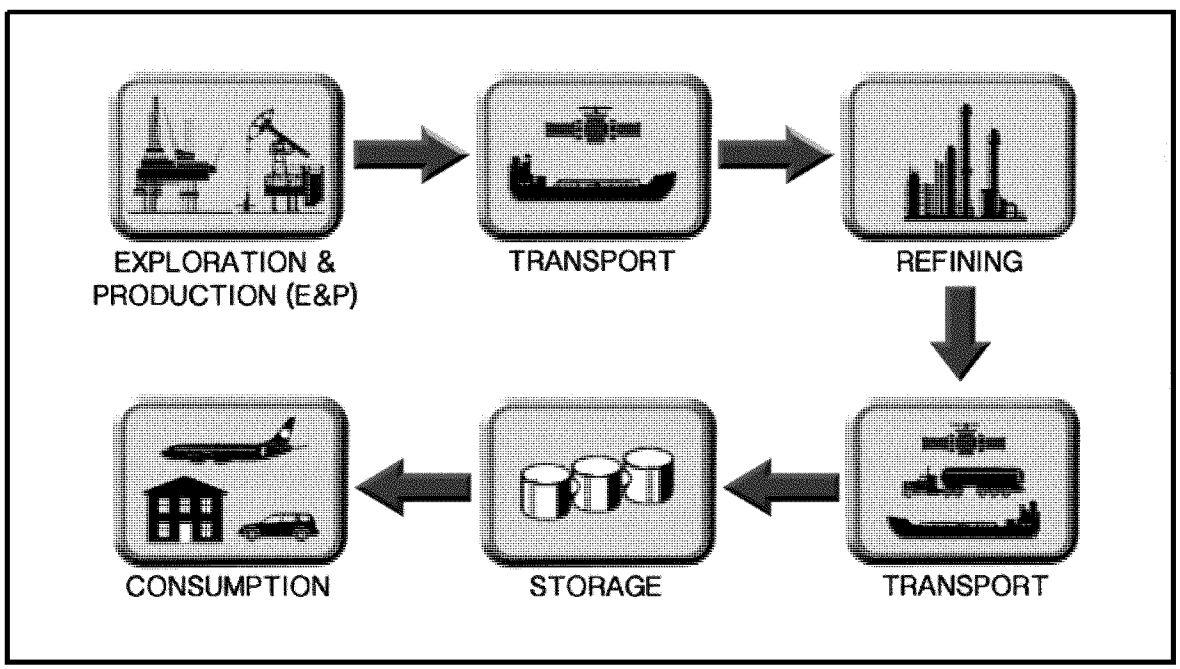


Figure 1-9: Oil Supply Chain.

ED_001324_00000360-00039

For planning R&D activities, the oil supply chain for petroleum oils consists of five subsystems (Figure 1-9):

- **Subsystem 1-Exploration and Production Facilities** - This is the origination point of crude oil and includes onshore and offshore exploration and production facilities.
- **Subsystem 2-Transportation** - This is the transportation of foreign and domestic oil products (generally crude oil) to refineries in the U.S. either by tank vessel (ship and barge), pipeline (offshore and onshore), tank railcar (unit trains), or tanker trucks.
- **Subsystem 3- Refining** - Refining of crude oil into petroleum products including the storage of crude oil, actual refining operations, storage of refined products, and the loading of refined products on tank vessels (ship and barge), tank railcars, and tanker trucks. In addition, refining would also encompass those activities that produce biofuels or vegetable oils. The latter products present many common and novel challenges compared to their traditional petroleum counterparts.
- **Subsystem 4- Transport / Storage/Distribution** - This subsystem involves the transportation of refined products to a bulk distribution storage facility by various modes of transportation, (e.g., product pipeline, tank vessel (ship and barge), tanker truck, tank railcars). Imported refined products would enter the U.S. system, as well as exported refined products would leave the U.S. system at this point. Tanker trucks may also deliver direct from refinery storage to the end user, e.g., residence or retail gas station.
- **Subsystem 5-Consumption/Consumer/Retail/Industrial** - This subsystem includes the retail gas station and the residential home heating oil segments of the oil system as well as industrial users (e.g. electric generation facilities).

There are available historic data to support claims that the improved safety and operating procedures implemented have generally reduced the risk of a spill at any point along the system. However, because accidents cannot be completely eliminated, efforts to improve pollution prevention and response must be sustained. In the following section, five potential high risk spill sources (exploration & production, vessels, onshore and offshore pipelines, railroads and refineries / bulk terminals) are examined to highlight existing weaknesses and concerns, and the efforts being made to address them.

1.4 Exploration and Production Facilities

The spill record for domestic drilling and production over the past 30 years suggested that technology and procedures for preventing oil spills were being employed effectively. However, that trend was interrupted in 2010 when the DWH drilling rig experienced an uncontrollable well blowout and oil spill. Even with modern equipment and modern safety measures, spills are a part of the oil and gas industry. The DWH blowout occurred when human errors circumvented the modern technological safeguards designed to prevent such an accident.

ED_001324_00000360-00040

> "Current technology enables drilling in water twice as deep as Macondo. Drilling at such depths requires all parties to set their standards still higher for difficult issues such as remote containment systems in water depths with extreme pressures and very limited human access, as well as different geological pressures and formations and mixes of hydrocarbons. Desire to tap resources in deeper waters should be accompanied by equivalent investments in subsea equipment, operator training, research and development for containment and response technologies, demonstrated financial capacity, and continuous improvement in and communication of industry practices devoted to safety." *(National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011)*

Due to the rising energy demands in developed economies and dramatically rising levels of consumption in emerging economies, the world's appetite for oil and other fuels will continue growing for the foreseeable future. This demand will increase pressure for continued and new oil and gas exploration in challenging environments including in the Arctic and in deep and ultra-deep waters. It will also encourage exploration and production of unconventional resources (e.g., oil sands) and the increased use of advanced technologies (e.g., hydraulic fracturing and horizontal drilling).

1.5 Onshore and Offshore Pipelines

Approximately 2.6 million miles of pipelines provide an efficient and fundamentally safe means of transporting gases and liquids. They are an integral part of the U.S. energy supply and provide vital links to other critical infrastructure such as power plants, airports, and military bases. Currently, there are 199,157 miles of pipelines that carry volatile, flammable, or toxic materials with the potential to cause public injury and environmental damage.

Canadian oil exports to the U.S. have been increasing rapidly, primarily due to growing extraction from the oil sands in Western Canada. Oil sands are a mixture of clay, sand, water, and heavy black viscous oil known as bitumen. After extraction, the bitumen is converted into an oil sands product (OSP) suitable for pipeline transport. Canada's OSPs are exported as either light, upgraded synthetic crude ("syncrude") or a heavy crude oil that is a blend of bitumen diluted with lighter hydrocarbons ("dilbit") to ease transport. The bulk of oil sands' supply growth is expected to be in the form of dilbit.

The expansion of petroleum pipelines from Canada has generated considerable controversy in the U.S. One specific area of concern was the potential new risks of the OSPs to pipeline integrity. An NRC panel (TRB, 2013) concluded, however, that diluted bitumen does not have any unique properties that make it more likely to cause internal failure of pipelines than other types of crude oil. However, additional research is needed to understand the fate and transport of unconventional oils, relative to that of traditional crude oils and refined products.

ED_001324_00000360-00041

In the 49 year period between 1964 and 2012, there were 79 oil spills from pipelines on the Outer Continental Shelf according to BSEE (2015) statistics, or about 1.6 per year. However, 25 of those spills were caused by damage from a series of hurricanes in the Gulf of Mexico in 2004, 2005, and 2008. Otherwise, spills from offshore pipelines occur at a rate of about one per year.

Both government and industry have taken numerous steps to improve pipeline safety over the last 10 years such as improved corrosion resistance, integrity testing, and requirements to identify pipelines before digging. According to PHMSA, pipelines are extremely safe when compared to other modes of energy transportation relative to the volumes of products transported (PHMSA, 2007). The trend is down, however, major pipeline incidents in 2010 and 2011 suggest that more work is needed. Figure 1-10 and Table 1-2 provide information from PHMSA on pipeline oil spills over the past 20 years.

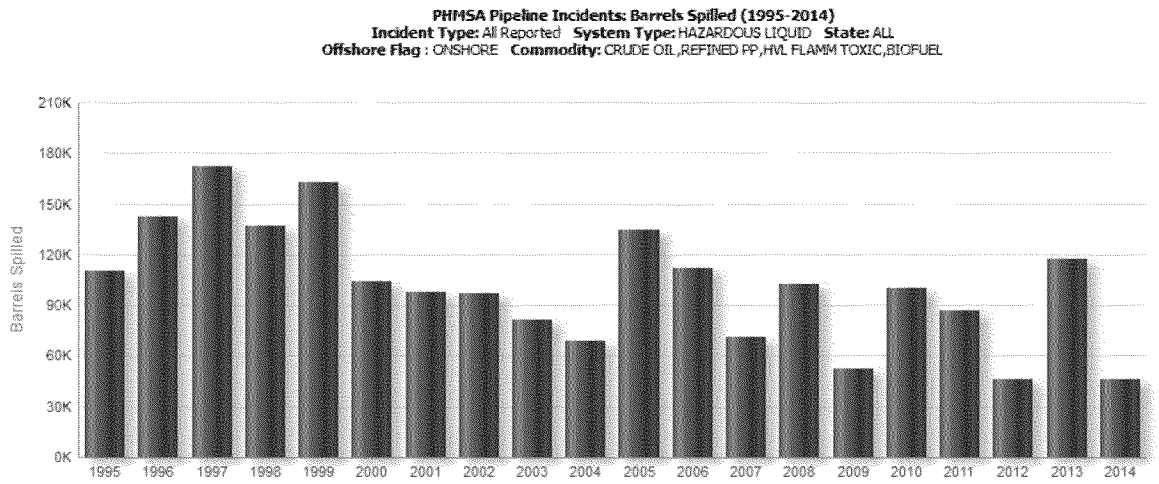


Figure 1-10 Barrels of Oil Spilled by Pipelines (1995-2014)

ED_001324_00000360-00042

PHMSA Pipeline Incidents: (1995-2014)
Incident Type: All Reported **System Type:** HAZARDOUS LIQUID **State:** ALL
Offshore Flag : ONSHORE **Commodity:** CRUDE OIL,REFINED PP,HVL FLAMM TOXIC,BIOFUEL

Calendar Year	Number	Fatalities	Injuries	Property Damage As Reported	Barrels Spilled	Net Barrels Lost
1995	176	0	9	$31,575,189	109,865	0
1996	180	3	7	$74,543,311	141,994	0
1997	155	0	2	$40,836,392	171,988	0
1998	133	1	5	$52,048,979	136,760	0
1999	151	4	17	$81,722,760	162,637	0
2000	131	1	4	$130,605,839	103,806	0
2001	121	0	9	$24,684,499	97,852	0
2002	442	1	0	$49,258,448	96,809	0
2003	421	0	0	$67,314,774	81,292	0
2004	355	5	16	$83,996,433	68,840	0
2005	340	2	2	$275,460,922	134,614	0
2006	326	0	2	$52,848,585	112,029	0
2007	321	4	9	$59,509,192	71,032	0
2008	360	2	2	$136,858,894	101,940	0
2009	325	0	1	$58,112,827	52,437	0
2010	340	1	4	$1,066,323,312	100,223	49,116
2011	339	1	2	$268,056,467	86,490	54,832
2012	359	3	4	$143,694,837	45,861	29,315
2013	392	1	5	$276,271,799	117,415	85,799
2014	438	0	0	$101,402,847	45,975	20,612
Grand Total	**5,805**	**29**	**100**	**$3,075,126,306**	**2,039,859**	**239,675**

Table 1-2, PHMSA Pipeline Spill Statistics (1995-2014)

1.6 Railroads

New technologies and high global oil prices have made it economical for energy companies to develop shale oil and oil sands petroleum reserves in the United States and Canada. The challenge is getting the oil from the oil fields to the appropriate refineries across North America so they can process the oil. That has created an opportunity for railroads to fulfill the transportation demand. In 2011, railroads and other facility and transportation businesses began building loading facilities and adding tank cars to compete with pipelines for a piece of this transportation demand.

The movement of Bakken oil and OSP occurs via unit trains, which can be composed of more than 100 tank cars, all carrying the same cargo. Tank cars are typically double-lined and made of hardened steel to survive a derailment. With the increased use of unit trains there has been an increase in the number of significant spills from derailments.

The American Petroleum Institute's Analysis of U.S. Oil Spillage (Etkin, 2009), which tracks oil spill statistics up through 2007 data, stated that railroads spilled 1,400 bbl of oil annually as cargo in tank cars and as fuel. This was a 34% reduction from the previous decade (1990s). The Association of American Railroads (2015a,b) reports that the number of rail tankers carrying

ED_001324_00000360-00043

crude oil and petroleum products in the U.S. increased from just under 19,000 carloads in 2008 to more than 1,033,000 carloads in 2014. The Federal Railroad Administration (FRA) statistics indicate number of train accidents has continued to decrease from 2005-2014 (Table 1-3). The number of hazmat releases has decreased also over this time period, although the level of damages over $1 million dollars has remained constant. However, the increased transportation of crude oil resulted in a number of significant rail accidents that resulted in damages and deaths. (See section 7.1.5)

In 2014, the U.S. Department of Transportation (DOT) began a comprehensive rulemaking proposal to improve the safe transportation of large quantities of flammable materials by rail - particularly crude oil, denatured alcohol, and ethanol/gasoline mixtures - because of the concern for the quantity of Bakken crude transported by rail and the increase in number of accidents. DOT proposed enhanced tank car standards, a classification and testing program for mined gases and liquids, and new operational requirements for high-hazard flammable trains that include braking controls and speed restrictions. Within two years it proposes the phase out of the use of older DOT 111 tank cars for the shipment of packing group I flammable liquids, including most Bakken crude oil, unless the tank cars are retrofitted to comply with new tank car design standards.

Category(1)	CY05	CY06	CY07	CY08	CY09	CY10	CY11	CY12	CY13	CY14
Freight Train Accidents(2)	3266	2998	2693	2481	1912	1902	2022	1760	1822	1736
Hazmat cars Damaged or Derailed (3)	915	1041	1056	750	743	708	665	671	822	779
Hazmat Releases(4)	39	30	46	21	22	21	21	26	18	15
Cars Releasing	52	71	76	37	44	40	66	50	78	26
Damages >100k	526	571	540	481	385	423	407	347	406	381
Damages >1mil.	57	59	69	52	52	57	53	43	66	58
Deaths	33	6	9	27	4	8	6	9	11	2

(1) Calendar years
(2) Not including crossing collisions and other accidents with death
(3) Total hazard material cars damaged
(4) Accidents with hazard material releases

Table 1-3: Number of Train Accidents and Hazmat Releases 2005-2014. (FRA 2015)

ED_001324_00000360-00044

1.7 Refining and Storage Operations

Potentially damaging discharges of crude oil or petroleum products in a refinery or at a bulk storage terminal can and do occur at every point in this system (offloading, storage, loading), and the factors that can influence the occurrence of these accidental discharges includes: the design, construction, maintenance, and operational activities; and human factors (e.g. training).

Despite a decrease in the number of domestic refineries between 1982 and 2010, the U.S. combined daily throughputs have slowly increased from about 12 million up to approximately 15 million bbl/day (Table 1-4). Increased throughput has occurred in spite of decreased numbers of refineries, because remaining refineries operate at increased capacities/efficiencies to compensate for the lack of production at decommissioned older refineries.

U.S. Gross Inputs to Refineries (Thousands of Barrels per Day)										
Decade	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
1980s						12,165	12,826	13,003	13,447	13,551
1990s	13,610	13,508	13,600	13,851	14,032	14,119	14,337	14,838	15,113	15,080
2000s	15,299	15,352	15,180	15,508	15,783	15,578	15,602	15,450	15,027	14,659
2010s	15,177	15,289								
Source: U.S. Energy Information Administration (EIA), 2012.										

Table 1-4: U.S. Gross Inputs to Refineries (Thousands of Barrels per Day)

Thousands of above ground crude oil and refined product storage tanks are in service at refineries and other oil/product handling/storage facilities. Buried pipelines within refinery boundaries represent another source of leaks. Aging domestic refinery infrastructure increases the risk of spillage and better systems are needed to detect potential problems. Another possible source of leakage is the refinery process line.

On June 19, 2006, a violent rain storm compromised a waste oil tank at the CITGO Refinery on the Calcasieu River, near Sulfur, Louisiana. Oil booms initially contained the spilled oil but subsequently failed and oil spread down the Calcasieu River and into Calcasieu Lake. The spill released up to an estimated 71,000 bbls (approximately 3 million gallons) of waste oil into the environment. The exact amount of oil spilled and the amount reaching the water is still unknown. Hurricane Katrina also caused considerable damage and oil spills from the refineries and bulk storage terminals in the storm's path (Table 1-5).

ED_001324_00000360-00045

Spill Events that Occurred in the Path of Hurricane Katrina (2005)	
Spill Location	Quantity (bbls)
Bass Enterprises (Cox Bay)	90,000
Shell (Pilot Town)	25,000
Chevron (Empire)	23,600
Murphy Oil (Meraux and Chalmette)	19,500
Bass Enterprises (Pointe à la Hache)	10,980
Chevron (Port Fourchon)	1,260
Venice Energy Services (Venice)	595
Shell Pipeline Oil (Naim)	320
Sundown Energy (West Potash)	310
Source: Pine, 2006	

Table 1-5: Spill Events that Occurred in the Path of Hurricane Katrina (2005).

1.8 Maritime and Riverine Transport - Tank Vessels (Ships & Barges) and Non-Tank Vessels

A combination of Federal, State, and international authorities are responsible for regulating oil spills from vessels in the U.S. They are collectively responsible for creating and implementing legislation to prevent oil spills and handling the decisions and procedures that follow in the aftermath.

There has been a reduction of operational and accidental oil spillage in the U.S. that can largely be attributed to the domestic and international regulations that have improved shipping safety and increased limits of liability for oil spills. These regulations required the phase-out of single hull tank vessels (ships and barges) and development of new tank vessels designs for double hulls to reduce accidental discharges in the event of grounding, collision, and allisions. Operational preventative measures including mandatory tug escorts for tank ships transiting through environmentally-sensitive areas in ports may also have contributed to the downward spillage trend by ensuring immediate assistance to a vessel experiencing a loss of propulsion or steerage.

Section 703 of the Coast Guard Authorization Act of 2010 directed the USCG to conduct a study of oil spills involving commercial vessel sources between 2001 through 2010 (Table 1-6). The Coast Guard released the study in May 2012 and reported that a small number of vessel casualties resulted in the greatest percentage of the overall spill volume. The data also show that most spills do not involve vessel casualties. These non-casualty spills are termed "operational"

ED_001324_00000360-00046

spills. The report addressed casualty and non-casualty groupings separately in order to identify their respective causal factors. The report defined a non-casualty spill as one in which the only reported occurrence is an oil spill (i.e., the incident did not involve an allision or collision).

U.S. Oil Spills from Vessels – 2001 - 2010. From: USCG, 2012		
Vessel Type	Spills	Barrels
MODU*	259	9,842
Tank Barge	1,318	75,044
Tank Ship	426	30,070
Freight Ship	893	17,284
Fishing Vessel	3,619	8,746
Tow / Tugboat	2,965	6,956
Public Vessel	486	3,077
OSV / Oil Recovery	883	2,334
Recreational	5,058	1,696
Unclassified Vessel	2,479	1,511
Passenger	1,100	8,66
Industrial Vessel	604	675
Freight Barge	407	408
Research Vessel	162	107
Other	51	11
TOTALS	**20,710**	**158,633**

*MODU- Mobile Offshore Drilling Units

Table 1-6: U.S. Oil spills from vessels 2001-2010. (USCG, 2012)

The study concluded that the most frequently reported human factors were inattention, procedural errors and situational awareness. However, while the study focused on human factors, it found that more than half of all discharges were the result of material failure. Vessel casualty statistics showed that the combination of material failure and loss of vessel control led to some of the largest oil spill volumes from 2001 through 2010. Material failure was a significant factor for propulsion and steering problems. The potential for damage due to allision, collision, or grounding is significant when such failures occur on large vessels, (e.g. tank ships, freight ships). According to industry feedback, material failures are also a significant factor in near-miss incidents.

ED_001324_00000360-00047

1.9 Oil Tankers

Stricter regulations and improved operations of oil tankers has reduced the number of large (> 5,000 bbls, or 7 tonnes) and medium (50 – 5,000 bbls) oil spills from tankers globally, as well as in the U.S. despite an increase in marine transportation of oil. Following the grounding of the single-hull tank vessel *Exxon Valdez*, OPA 90 mandated that all newly built tank vessels have double hulls and that single-hull tank vessels be phased out and replaced by double-hulled vessels by January 1, 2015 for operations in the U.S. waters. Similarly, requirements stemming from the International Convention for the Prevention of Pollution from Ships (MARPOL) have increased the safety of tanker transport.

The International Tanker Owners Pollution Federation Limited (ITOPF), which tracks oil spills from tankers, reports that 19 of the 20 largest spills from tankers occurred before 1970 (ITOPF, 2015). Figure 1–11 shows the trend in oil tanker transport and the number of spills. Figure 1-12 shows the downward trend in oil spills from tankers since 1970 according to ITOPF.

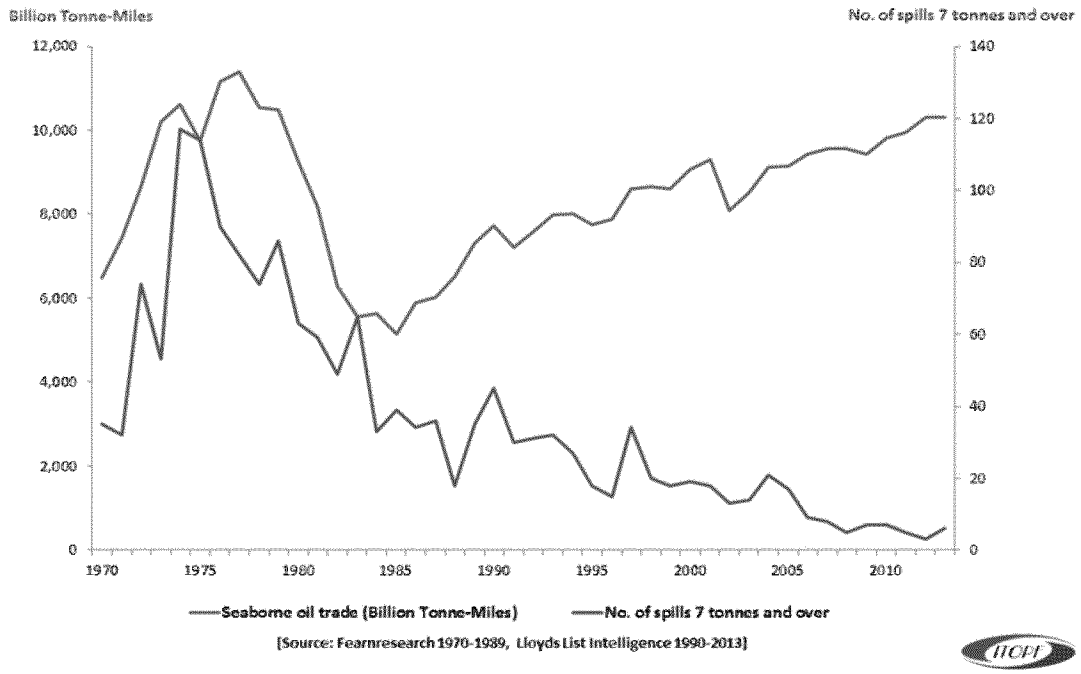


Figure 1-11: Seaborne oil trade and oil spill trends

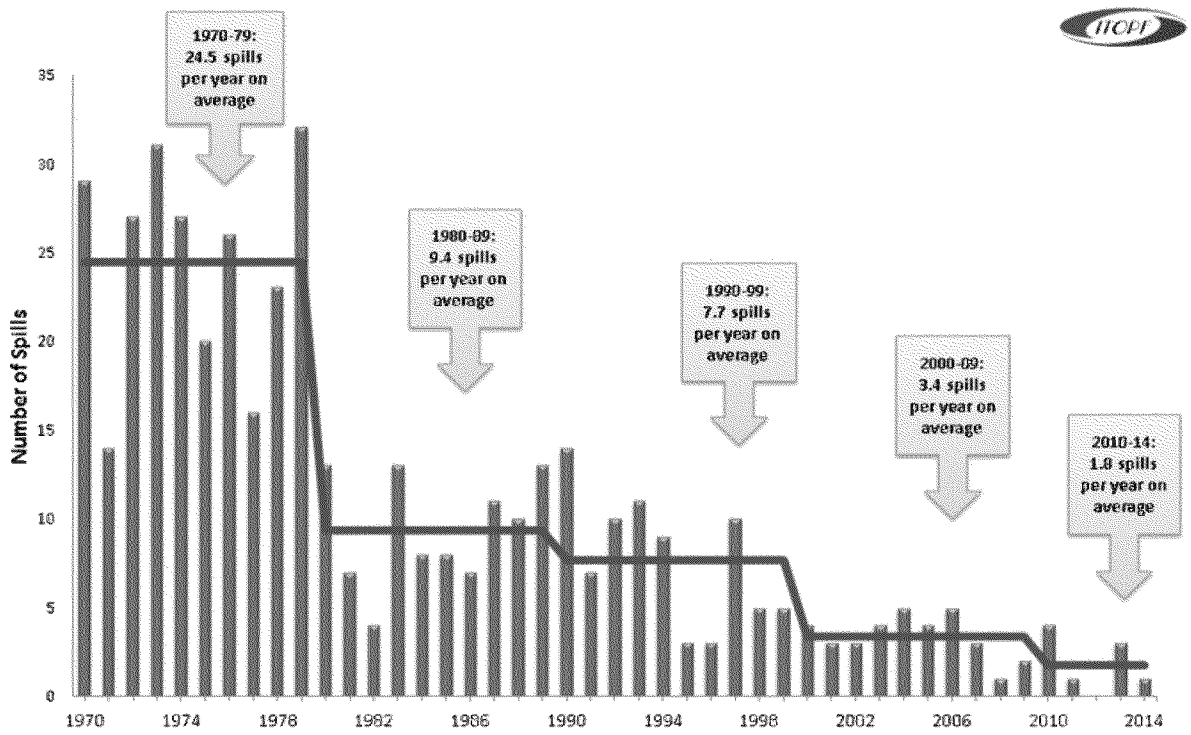


Figure 1-12: Number of Large Spills (>5,000 bbls) from 1970-2014 (ITOPF, 2014)

1.10 Regional and Geographic Areas of Interest

ICCOPR considers regional issues an important element in executing an effective oil pollution R&T program. The applicability of research results can vary significantly between geographic regions due to their unique environmental characteristics. Regional issues are prevalent in the Arctic with its potential for new oil exploitation and related activity, and in the Gulf of Mexico where ultra-deepwater drilling and injury assessment and restoration activity from the *Deepwater Horizon* spill continues. Inland regions, likewise, have evolving issues related to onshore shale oil, oil sand products development, and pipeline and rail transportation safety. Development of other OCS regions will raise their own geographically-specific issues. In its research planning efforts, ICCOPR maintains visibility of regional issues by coordinating with RRTs, states, and regional research groups.

ICCOPR considers the following regional and geographic areas to be of high importance at this time or during the next six-year planning cycle:

The Arctic and Alaska – The extent of sea ice in the Arctic and Alaskan waters has diminished in recent years, a trend that is expected to continue for the foreseeable future. The oil industry is expanding exploration and production operations into the Arctic region as conditions change to make operations feasible in the region. One oil company is drilling in the Arctic Ocean during the 2015 summer season. Understanding and overcoming the operational and logistical

ED_001324_00000360-00049

challenges of responding to an oil spill in the Arctic region is a major focus of ICCOPR member research planning. This focus is reflected in the number of research priorities (see Chapter 9) that apply directly to Arctic conditions.

Gulf of Mexico – The Gulf of Mexico has abundant oil and gas resources, which results in extensive exploration and production activity. Advances in drilling technology have enabled industry to expand operations into progressively deeper areas of the Gulf. It is also the site of two of the largest oil spills from well blowouts, Macondo/*Deepwater Horizon* and *Ixtoc*, as well as numerous other spills. Federal and state agencies are continuing to conduct studies to determine the short- and long-term effects of the *Deepwater Horizon* oil spill. Both Federal and non-Federal Gulf of Mexico research programs established because of the *Deepwater Horizon* oil spill will continue through the next several years.

Inland Areas – As discussed in Section 1.1, the production of oil and gas from the shale plays in the U.S. and tar sand regions in Canada has dramatically increased over the past five years. The resulting increase in oil shipments by rail and pipeline has elevated the importance of research to prevent and prepare for oil spills from train accidents or pipeline breaks. In addition, the potential for these spills to affect freshwater rivers and lakes necessitates greater emphasis on research into non-marine response techniques.

Atlantic Outer Continental Shelf (OCS) – At present, there are no active oil and gas leases in any of the four Atlantic OCS planning areas. However, the Bureau of Ocean Energy Management (BOEM) Draft Proposed Plan for 2017-2022 proposes one lease sale in the Atlantic in 2021. Preparation for leasing in the Atlantic will involve pre-spill baseline studies to document environmental conditions prior to exploration and drilling.

ED_001324_00000360-00050

2. Federal Oil Pollution Research

ICCOPR serves to coordinate research by its member federal agencies and other federal research entities to promote a coordinated approach to addressing oil pollution issues. This section describes ICCOPR and the other federal research entities.

2.1 ICCOPR

2.1.1. Origin

Congress created ICCOPR in the Oil Pollution Act of 1990 (OPA 90). The Committee's membership, roles, and responsibilities are outlined in the original Public Law (P.L.) that mandated its creation, as amended and codified in the United States Code. Consequently, when referencing ICCOPR, it is generally cited with: *Oil Pollution Act of 1990, § 7001, 104 Stat. 484, 559-564 (1990) (33 U.S.C. 2761).*

ICCOPR is charged with two general responsibilities: (1) to prepare a comprehensive, coordinated federal oil pollution research and development plan; 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. ICCOPR reports on its activities to Congress every two years.

2.1.2. ICCOPR Membership

ICCOPR is comprised of fifteen federal independent agencies, departments, and department components. The U.S. Coast Guard (USCG) chairs ICCOPR. The National Oceanic and Atmospheric Administration (NOAA), the Bureau of Safety and Environmental Enforcement (BSEE), and the Environmental Protection Agency (EPA) rotate as the vice-chair every two years.

OPA 90 originally stipulated that ICCOPR include representatives from: the Department of Commerce, including NOAA and the National Institute of Standards and Technology (NIST); the Department of Energy (DOE): the Department of the Interior (DOI), including the Minerals Management Service (MMS) and the US Fish and Wildlife Service (USFWS); the Department of Transportation (DOT), including the USCG, the Maritime Administration (MARAD), and the Research and Special Projects Administration (RSPA); the Department of Defense, including the U.S. Army Corps of Engineers (USACE) and the Navy; the EPA; the National Aeronautics and Space Administration; and the US Fire Administration (USFA) in the Federal Emergency Management Agency (FEMA).

Today ICCOPR's original membership remains mostly intact but with some recent changes (Table 2.1). In 2012, the DOI reorganized MMS to form BSEE and the Bureau of Ocean Energy Management (BOEM) – both of which are now members of ICCOPR. Additionally, the USCG and FEMA reorganized under the DHS and DOT re-designated the RSPA as the Pipeline and

ED_001324_00000360-00051

Hazardous Materials Safety Administration (PHMSA). In 2013, ICCOPR welcomed its newest member, the U.S. Arctic Research Commission (USARC), to help address emerging issues associated with the Arctic and cold weather environments.

Table 2.1 - ICCOPR Membership

Member	Current Department	Notes
USCG	Homeland Security	Transferred from Transportation
FEMA/USFA	Homeland Security	Originally Independent
MARAD	Transportation	
PHMSA	Transportation	Agency renamed from RSPA
USFWS	Interior	
BSEE	Interior	Formerly part of MMS
BOEM	Interior	Formerly part of MMS
NOAA	Commerce	
NIST	Commerce	
Navy	Defense	
USACE	Defense	
DOE	Energy	
EPA	Independent	
NASA	Independent	
USARC	Independent	Added in 2013

ICCOPR membership may continue to evolve to fully address new research challenges when agency missions change or there are changes in patterns of oil exploration, production, and transportation. OPA 90 provides that the President may designate other agencies as members of ICCOPR. The President delegated this power to the Secretary of the "Department in which the Coast Guard (USCG) operates" through Executive Order 12777 (October 18, 1991) Section 8 (h) and as amended by Executive Order 13286 (March 5, 2003). The Secretary of Homeland Security delegated this power to the USCG Commandant in DHS Delegation No. 0170.1, II.80. ICCOPR may also invite other federal agencies to participate in a non-voting observer role. Currently the U.S. Geological Survey (USGS) is participating in ICCOPR as a non-voting observer.

ED_001324_00000360-00052

The diversity of ICCOPR's membership reflects Congress' intent to adequately address the full spectrum of oil spill preparedness, response, and restoration research. Each organization in ICCOPR bears unique regulatory responsibilities, research capabilities, and/or technical expertise that collectively give ICCOPR its knowledge and networks for tackling varying oil pollution research and technology issues. The following sections briefly discuss each of ICCOPR's member organizations and their connections to oil pollution research. Some organizations directly oversee oil pollution research programs while others provide guidance and resource support or specialized expertise.

2.1.2.1 U.S. Coast Guard (USCG)

The USCG serves as the Chair of ICCOPR in accordance with OPA 90. It also serves as the vice-chair of the National Response Team (NRT) and a co-chair of Regional Response Teams (RRTs). The USCG, together with the EPA, has the primary responsibility for federal oil spill response activities. In accordance with the National Contingency Plan (NCP), the USCG is the lead agency for response to spills in the U.S. coastal zone as defined in 40 CFR 300.5.

The USCG provides pre-designated Federal On-Scene Coordinators (FOSCs) for spills in the coastal zone (all United States waters). In addition to spill response, the Coast Guard also has statutory and operational responsibility for oversight of ship design and construction, periodic vessel inspections, investigation of marine casualties, waterway management and port safety and security (including the regulation of hazardous cargoes). These activities all help the USCG improve pollution prevention and response capabilities.

Since 1969, the USCG Research & Development Center (RDC) in New London, Connecticut, has been the Coast Guard's sole facility performing applied oil pollution research, development, test, and evaluation (RDT&E) experimentation and demonstrations.

The USCG also hosts the National Response Center (NRC), which serves as the NRT communications center and the official federal point of contact for pollution incident reports. The National Contingency Plan (40 CFR Part 300) requires that the NRC be notified in the event of an oil spill into navigable water. The U.S. Coast Guard's National Pollution Funds Center (NPFC) administers the Oil Spill Liability Trust Fund (OSLTF) and provides funding from the OSLTF Emergency Fund for responses, compensates claimants for cleanup costs and damages, and takes action to recover costs from responsible parties. The NPFC also provides funding from the OSLTF Principal Fund for operations and for research and development.

2.1.2.2 National Oceanic and Atmospheric Administration (NOAA)

NOAA serves as a rotating Vice Chair of ICCOPR. NOAA provides science, service and stewardship for the oceans and atmosphere; with a goal of healthy ecosystems, communities and economies that are resilient in the face of change. Many components of NOAA may support response to a major oil spill (including the National Ocean Service, National Weather Service;

ED_001324_00000360-00053

the National Marine Fisheries Service; the National Environmental Satellite, Data and Information Service; and the Office of Marine and Aviation Operations). A core component of the support is NOAA's Office of Response and Restoration (OR&R) and its network of Scientific Support Coordinators (SSCs) who respond to approximately 120 oil spills annually, primarily in the coastal zone. These SSCs serve as the primary scientific advisors to Federal On-Scene Coordinators (FOSCs), coordinating scientific expertise from federal and State agencies, academia, industry and the local community (40 CFR 300.145). NOAA support includes assessments of hazards, predictions of fate and behavior (trajectories), recommendations on cleanup and mitigation methods and endpoints, emergency consultations on protected resources, environmental information and data management, wildlife operations, meteorological, hydrological and oceanographic observations and forecasts and satellite imagery access and analysis.

NOAA supports the NRT and RRTs as delegated Department of Commerce representatives and serves on workgroups and area committees on activities associated with preparedness, assessment and restoration. NOAA applies and develops tools for emergency response support, transitioning research into operations. In coordination with states and other federal agencies, NOAA produces environmental sensitivity maps, which rank coastal areas by sensitivity to oil and identify priority locations to be protected in a spill. Federal, State and local agencies use these maps to plan and respond to oil spills.

As a Federal Natural Resource Trustee for living marine resources and their habitat, NOAA is required to assess the injuries that result from an oil spill, to determine and recover monetary compensation and, using those sums, to restore, rehabilitate or recover the equivalent of the damaged resources. NOAA is also responsible for the issuance and implementation of regulations governing oil spill damage assessment.

2.1.2.3 National Institute of Standards and Technology (NIST)

Founded in 1901, NIST is a non-regulatory federal agency within the U.S. Department of Commerce. NIST's mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life. NIST has a long history of scientific, technical and measurement support to other federal agencies and U.S. industry on a reimbursable basis.

NIST maintains unique measurement facilities and has an experienced technical staff able to assist with oil spill response and oil pollution research providing a wide variety of scientific and measurement services. NIST's most recent activities relating to oil spills include developing protocols for sampling of protected species, providing for archival for marine animal specimens associated with oil spills, conducting interlaboratory comparison exercises for laboratories involved in assessing oil contamination, providing measurements of contamination in archived marine mammals and seabirds, and assisting with measuring oil flow from well blow-outs. NIST develops Standard Reference Materials (SRMs) for crude oil and other fossil-fuel materials

ED_001324_00000360-00054

and additionally has groups involved with research in Fire and Pipeline Safety. NIST maintains and manages the Marine Environmental Specimen Bank (ESB) that contains marine mammal samples dating back as far as the Exxon Valdez oil spill damage assessment and includes marine organism samples from the Pacific Islands, Alaska, and coastal regions of the lower 48 states. NIST has worked more than 30 years developing environmental specimen banking technology so that samples can be used to understand environmental exposure and effects from oil and other contaminants. Because samples have been collected continuously from many locations they provide a resource in the event of a spill to establish pre-spill baseline conditions.

2.1.2.4 U.S. Department of Energy (DOE)

The DOE works to ensure America's energy security and prosperity by addressing energy and environmental challenges with research and technology solutions. This includes ensuring the prudent development of America's oil and natural gas resources through R&D that improves the safety and environmental performance of oil and natural gas exploration and production.

In its offshore research program, DOE works toward mitigating the risks and challenges associated with drilling and production operations through a research portfolio dedicated to oil spill prevention. Completed and ongoing research focus on the following areas: geologic uncertainty; drilling and completions; surface systems and umbilicals; and subsea systems reliability/automated safety systems.

Onshore DOE focuses on prudent development of unconventional oil and gas resources with emphasis on resource characterization, protecting water quality, increasing water availability, protecting air quality, and reducing induced seismicity associated with waste water injection. The advent of shale gas development also brings a host of safety and environmental issues, including: 1) demand for water for use in hydraulic fracturing; 2) protection of drinking water aquifers; 3) evaluation of the safety of chemicals used in fracturing; 4) environmental impacts resulting from the treatment and/or disposal of produced or fracturing flowback water; 5) air quality impacts; and 6) community safety issues.

DOE's National Energy Technology Laboratory (NETL) conducts laboratory, field, and modeling-based research on offshore oil spill prevention, focusing on reducing the risk and mitigating the risk of a loss of well control that leads to spills. Onshore modeling includes life cycle analysis of natural gas, and modeling of methane emissions.

2.1.2.5 Bureau of Safety and Environmental Enforcement (BSEE)

The DOI's BSEE serves as a rotating Vice Chair of ICCOPR. The Bureau works to promote safety, protect the environment, and conserve energy resources offshore through vigorous regulatory oversight and enforcement. The BSEE develops standards and regulations to enhance operational safety and environmental protection in connection with the exploration and development of offshore oil, natural gas, and renewable energy sources on the U.S. Outer

ED_001324_00000360-00055

Continental Shelf (OCS); and undertakes actions to ensure compliance with those standards and regulations. BSEE has two research programs that support its mission. The Technology Assessment Program supports research regarding operational safety and pollution prevention related to offshore oil and natural gas and renewable energy exploration and development. The Oil Spill Response Research Program is dedicated to improving oil spill response options. The major focus of the program is to support BSEE's mission of ensuring offshore operators are prepared to respond to any potential oil spill. Research is conducted to improve the methods and technologies used for oil spill detection, containment, treatment, recovery and cleanup.

As part of ensuring that offshore operators are prepared to respond to an oil spill BSEE conducts oil spill response plan reviews, government-initiated unannounced exercises, equipment inspections, and audits of oil spill removal organizations and spill management training. Risks identified through these activities are mitigated by directed changes to plans, training programs, equipment, response strategies, and BSEE-funded research projects.

The BSEE also manages the operation of the national Oil Spill Response Research & Renewable Energy Test Facility (Ohmsett), the only facility where full-scale oil spill response equipment testing, research, and training can be conducted in a marine environment with oil under controlled environmental conditions (waves and oil types). OPA 90 mandated continued operation of Ohmsett. (See Section 2.3.1.)

2.1.2.6 Bureau of Ocean Energy Management (BOEM)

The DOI's BOEM manages the exploration and development of the nation's offshore resources on the U.S. Outer Continental Shelf (OCS). It seeks to appropriately balance economic development, energy independence, and environmental protection through oil and gas leases, renewable energy development and environmental reviews and studies. BOEM conducts studies to improve pre-spill baseline information and estimates of oil-spill transport, fate, and impacts to the environment. BOEM manages an Environmental Studies Program (ESP), which, since 1973, has included: development and use of oil transport and weathering models; measurement of oil effects in laboratory and field conditions on marine organisms including birds, fish, and mammals; identification of sensitive biological resources; and assessment of the social and economic impacts of oil development. While some of the ESP consists of in-house investigations, BOEM manages a substantially larger program that is conducted by contractors, industry, universities, and other federal agencies. Interagency coordination of this program is overseen by the National Ocean Pollution Policy Board and the Interagency Arctic Research Policy Committee, in addition to review provided by the OCS Scientific Committee.

2.1.2.7 U.S. Fish and Wildlife Service (USFWS)

The DOI's USFWS has trustee responsibility for migratory birds, threatened and endangered species, certain marine mammals, anadromous and catadromous fish, and national wildlife refuge lands. The USFWS is the primary DOI Bureau that responds to oil spills, provides

ED_001324_00000360-00056

information and advice on safeguarding sensitive habitats and protected species (including advice on use of dispersants and other chemicals), and oversees the rescue and the rehabilitation of oiled birds and certain marine mammals. It works closely with state fish and wildlife agencies to ensure the protection of potentially affected fish and wildlife and takes an active role in protecting USFWS lands, such as national wildlife refuges. USFWS, in its role as trustee, is also the most active DOI bureau in natural resource damage assessment and restorations (NRDAR). In addition to civil actions, USFWS may also pursue criminal violations of the Migratory Bird Treaty Act, Marine Mammal Protection Act, and the Endangered Species Act.

The USFWS R&D efforts are focused on identifying chemical pollutants and their metabolites in biological tissues; defining and mapping wetlands, other critical habitats and natural resources; inventorying species of particular concern, including threatened and endangered species; developing biological indicators and economic tools for damage assessment; and determining biological requirements for sustaining viable populations and habitats and identifying factors contributing to their demise. The USFWS R&D efforts support the needs of the DOI in meeting the operational needs and the requirements of OPA 90.

2.1.2.8 Maritime Administration (MARAD)

The DOT's MARAD is tasked with promoting the use of waterborne transportation and its seamless integration with other segments of the transportation system, and the viability of the U.S. merchant marine. MARAD's role in maritime transportation spans many areas involving ships and shipping, shipbuilding, port operations, vessel operations, national security, environment, and safety. MARAD supports the Maritime Environmental and Technical Assistance (META) program, which focuses on environmental research and demonstration projects. The Maritime Administration collaborates extensively with stakeholders from all transportation sectors and modes in order to accomplish its mission to improve and strengthen the U.S. marine transportation system. Through long range planning and analysis, the Maritime Administration's Office of Policy and Plans looks ahead and develops plans for integrating the Maritime Administration's activities with those of other appropriate government agencies, as well as private sector marine transportation stakeholders.

2.1.2.9 Pipeline & Hazardous Materials Safety Administration (PHMSA)

The mission of DOT's PHMSA is to protect people and the environment from the risks of hazardous materials transportation by establishing national policy, setting and enforcing standards, providing education, and conducting research to prevent oil spills and hazardous materials incidents. PHMSA's Office of Pipeline Safety promulgates and enforces regulations addressing the design, construction, operation and maintenance of pipeline systems. PHMSA's Pipeline Safety Research Program supports the PHMSA mission by: 1) funding technology development research; and 2) generating and sharing new technical knowledge with decision makers in support of planning, evaluating, and implementing pipeline safety programs. This

ED_001324_00000360-00057

research focus is providing near-term solutions that will increase the safety, reduce environmental impact and improve reliability of the Nation's pipeline system.

PHMSA, via its Office of Hazardous Materials Safety, also provides support to federal agencies in oil spill related areas such as logistics management, transportation infrastructure, telecommunications, command and control systems, expert computer systems, facilities maintenance management, mobilization preparedness and hazardous materials transportation by any mode.

2.1.2.10 US Army Corps of Engineers (USACE)

The USACE has specialized equipment and personnel that can be used in oil spill response activities. The Corps has responsibilities for maintaining navigation channels, removing obstructions, performing structural repairs, and maintaining hydropower electric generating equipment. Their Engineer Research and Development Center (ERDC) conducts research and development (R&D) in support of the Soldier, military installations and civil works projects (water resources, environmental missions, etc.) as well as for other federal agencies, state and municipal authorities, and with U.S. industry through innovative work agreements. USACE ERDC has seven laboratories in four states: Construction and Engineering Research laboratory in Champaign, Illinois; Cold Regions Research and Engineering Laboratory (CRREL) in Hanover, New Hampshire; Geospatial Research Laboratory in Alexandria, Virginia; and the Coastal and Hydraulics, Geotechnical and Structures, Environmental, and Information Technology Laboratories in Vicksburg, Mississippi. CRREL, maintains unique cold facilities to conduct research on oil spill detection and response in Arctic and other ice covered waters. Other USACE research with applicability to oil pollution issues include providing technical support on wind and wave effects, diffusion, remote sensing, satellite imaging, image enhancement systems, alternative methods for removing oil, shoreline cleanup and environmental evaluation, effects and mitigation.

The Corps also assists in design and construction and, on a reimbursable basis, provides technical manpower and support for any federal agency involved in any aspect of research and development described in this Plan. Special note should be made of USACE capabilities for assisting in the engineering aspects of conducting various research projects. As the nation's environmental engineer, the USACE manages one of the largest federal environmental missions: restoring degraded ecosystems; constructing sustainable facilities; regulating waterways; managing natural resources; and cleaning up contaminated sites from past military activities.

2.1.2.11 U.S. Navy (USN)

NAVSEA's Directorate of Ocean Engineering, Supervisor of Salvage and Diving (SUPSALV) experts provided technical, operational, and emergency capabilities in marine salvage, pollution abatement, diving, diving system certification, and underwater ship husbandry to improve Fleet readiness and capability across the globe. SUPSALV has been the Navy's oil pollution experts

ED_001324_00000360-00058

since the 1970s, as required by the Federal Water Pollution Control Act. The USN has expertise in preventing and responding to oil spills from ships. Upon the request of an On-Scene Coordinator, the USN may provide technical assistance in the ocean engineering disciplines of marine salvage, shipboard damage control, pollution abatement, diving, diving system certification, and underwater ship husbandry. The USN also owns specialized containment, collection, and removal equipment designed for salvage-related and near shore to open-sea pollution incidents. The equipment design and systems make it transportable and sustainable in the field. The USN has successfully deployed and operated its equipment at almost every major oil spill in the past 35 years.

2.1.2.12 U.S. Fire Administration (USFA)

As an entity of FEMA, USFA provides national leadership to foster a solid foundation for fire and emergency services stakeholders in prevention, preparedness, and response. The Agency was established by Public Law 93-498, the Federal Fire Prevention and Control Act of 1974, which called for: 1) the establishment of a National Fire Academy to advance the professional development of the fire service personnel and of other persons engaged in fire prevention and control activities; 2) a technology program of development, testing, and evaluation of equipment for use by the Nation's fire, rescue, and civil defense services; and 3) the operation of a National Fire Data Center for the selection, analysis, publication, and dissemination of information related to the prevention, occurrence, control and results of fires of all types; and ; 4) education of the public to overcome public indifference toward fire and fire prevention. USFA focuses on supplementing, not duplicating, existing programs of training, technology and research, data collection and analysis, and public education. While USFA does not directly conduct oil spill pollution research, it provides valuable emergency service expertise and connectivity to a number of emergency management programs.

2.1.2.13 U.S. Environmental Protection Agency (EPA)

The EPA serves as the Chair of the National Response Team (NRT), as co-chair of all the Regional Response Teams (RRTs), and as a rotating Vice Chair for ICCOPR. EPA works closely with the USCG in coastal spill response activities. In accordance with the National Contingency Plan (NCP), the EPA is the lead agency for response to spills in the U.S. inland zone. The EPA provides pre-designated On-Scene Coordinators (OSCs) for the inland zone, and maintains assets that can be used for command, control, and surveillance of oil spills. EPA also provides legal expertise on the interpretation of applicable environmental statutes.

The EPA issues and implements federal regulations regarding oil spills under the Clean Water Act, including the NCP. It implements spill prevention regulations for non-transportation-related facilities. Also, through Subpart J of the NCP, EPA maintains a Product Schedule of dispersants and other oil spill mitigating substances and regulates their use during spill response.

ED_001324_00000360-00059

The EPA provides expertise on cleanup technologies and the environmental effects of oil spills. Its Environmental Response Team (ERT) is a group of highly trained scientists and engineers whose capabilities include multimedia sampling and analysis, hazard evaluation, contamination monitoring, cleanup techniques, and overall technical support to the OSCs. The EPA's R&D activities include the development of test protocols to evaluate the efficacy and toxicity of spill mitigating agents (e.g., dispersants), and research to determine the fate and effects of oil following a spill.

2.1.2.14 National Aeronautics and Space Administration (NASA)

NASA develops and maintains several technologically advanced airborne and satellite systems suitable for spill observation and mapping. The agency's multi-disciplinary team of scientists, engineers and computer modelers also analyzes vast archives of data for insights into Earth's interconnected systems -- atmosphere, ocean, ice, land, and biosphere; and openly provides that data to the global community. They design and deploy airborne, ground-based and ocean-going field campaigns to study the earth from the heights of the stratosphere to the depths of the ocean to the remote ice caps at the poles. NASA also works with other government agencies and partner organizations to apply NASA data and computer models to improve decision-making and problem solving.

2.1.2.15 U.S. Arctic Research Commission (USARC)

The USARC is an independent federal agency created by the Arctic Research and Policy Act of 1984, as amended. It consists of a nonpartisan advisory body of scientists, physicians, indigenous leaders, and industry representatives appointed by the President of the U.S. and supported by staff located in Washington, D.C. and Anchorage, AK. The Commission sets U.S. Arctic research policy and builds cooperative links in Arctic research including: 1) the U.S. Arctic research program; 2) to international research partners, and; 3) Alaska. The law requires the Commission to comment to Congress on the progress of the executive branch in reaching goals set by the Commission and on their adoption by the Interagency Arctic Research and Policy Committee. The Commission plays an active role in the work of several interagency committees, including the Arctic Policy Group, chaired by the U.S. Department of State, which oversees U.S. participation in the eight-nation Arctic Council. The Commission is a statutory member of: the North Pacific Research Board and the North Slope Science Initiative. USARC is also a member of: various committees of the National Ocean Governance Structure; the interagency Extended Continental Shelf Task Force; the Scientific Ice Expeditions Interagency Committee, involving U.S. Navy nuclear submarines in the Arctic; the Alaska Ocean Observing System; the International Permafrost Association; and the Consortium for Ocean Leadership.

ED_001324_00000360-00060

2.2. Other Federal Stakeholders and Entities

Several Federal stakeholders and organizations also conduct research or affect oil pollution research. These include Federal independent organizations (i.e., committees, councils), agencies not currently members of ICCOPR, and ICCOPR member components that do not actively participate within ICCOPR. Other entities set Federal policies that guide or focus research initiatives on specific topics. ICCOPR maintains awareness of these stakeholders and works with them to coordinate research efforts.

2.2.1 Arctic Executive Steering Committee (AESC)

The AESC was formed in 2015 by Executive Order to provide guidance to executive departments and agencies (agencies) and enhance coordination of Federal Arctic policies across agencies and offices, and, where applicable, with State, local, and Alaska Native tribal governments and similar Alaska Native organizations, academic and research institutions, and the private and nonprofit sectors. The AESC provides guidance and coordinate efforts to implement the priorities, objectives, activities, and responsibilities identified in National Security Presidential Directive 66/Homeland Security Presidential Directive 25, Arctic Region Policy, the National Strategy for the Arctic Region (NSAR), the NSAR Implementation Plan (NSAR-IP), and related agency plans. The AESC does not conduct oil pollution research but can influence the policies guiding research in the Arctic.

2.2.2 Federal Oil Spill Team for Emergency Response Remote Sensing (FOSTERRS)

The Federal Oil Spill Team for Emergency Response Remote Sensing (FOSTERRS) is an interagency working group organized in 2015 to facilitate the sharing of remote sensing capabilities and to discuss improvements in disaster response using remote sensing. Specifically, FOSTERRS seeks to connect agency information on airborne and space borne asset's availability, limitations, capabilities and performance, and ancillary data needs to stake holders and responders. FOSTERRS includes members from agencies (NOAA, NASA, and USGS) with remote sensing assets and key end users. It also reaches out to the larger community involved in marine disaster response and the development and implementation of remote sensing best practices.

2.2.3 Federal Rail Administration (FRA)

The Department of Transportation Act of 1966 created the FRA with a mission to enable the safe, reliable, and efficient movement of people and goods for a strong America, now and in the future. It is one of ten agencies within the DOT concerned with intermodal transportation.

FRA's Office of Railroad Safety promotes and regulates safety throughout the Nation's railroad industry. The office executes its regulatory and inspection responsibilities through a diverse staff

ED_001324_00000360-00061

of railroad safety experts who are responsible for five safety disciplines focusing on compliance and enforcement in:

- Hazardous Materials;
- Motive Power and Equipment;
- Operating Practices;
- Signal and Train Control; and
- Track.

2.2.4 U.S. Geologic Survey (USGS)

The USGS supports an array of scientific capabilities and assets that address many elements of oil pollution research. As a science agency for DOI, the USGS provides science leadership and collaborations with other federal agencies during oil spill response. USGS research capabilities related to oil pollution include the development of objective and reliable scientific information needed to inform policies and practices that help avoid exposure to toxic substances, mitigate environmental deterioration from contaminants, provide cost-effective cleanup and waste-disposal strategies, and reduce future risk of contamination. USGS science primarily focuses on inland area but also includes near-shore and off-shore environments.

USGS oil pollution related capabilities include long-term monitoring of the Exxon Valdez, Deepwater Horizon, and inland oil spills. Also, the USGS Patuxent Wildlife Research Center has been studying the effects of crude oil and petroleum products on birds since the late 1970's. The USGS Coastal and Marine Program develops 3-D hydrodynamic models that can predict the nearshore sources, transport, and fate of oil. The USGS Energy Program provides capabilities to characterize chemical fingerprints of oil to identify sources of tar balls and support post-spill shoreline assessments.

2.2.5 Gulf Coast Ecosystem Restoration Council

The RESTORE Act established a Gulf Coast Ecosystem Restoration Council (the Council), which is comprised of governors from the five affected Gulf States, the Secretaries from the U.S. Departments of the Interior, Commerce, Agriculture, and Homeland Security as well as the Secretary of the Army and the Administrator of the U.S. Environmental Protection Agency. The Gulf States recommended and President Obama appointed the Secretary of Commerce as the Council's Chair.

2.2.6 Gulf of Mexico Fishery Management Council (GMFMC)

The GMFMC is one of eight regional Fishery Management Councils established by the Fishery Conservation and Management Act of 1976. The Council prepares fishery management plans designed to manage fishery resources from where state waters end, out to the 200-mile limit of the Gulf of Mexico. These waters are also known as the Exclusive Economic Zone (EEZ). The

ED_001324_00000360-00062

Council consists of voting members from the NMFS, the five Gulf state marine resource management agencies, and nominees by the State governors. In addition, there are four nonvoting members representing the USCG, U.S. Fish and Wildlife Service, Department of State, and the Gulf States Marine Fisheries Commission. The GMFMC provides an advisory role in directing scientists on where to focus their research. Current priorities include research on species recovering from the Deepwater Horizon oil spill and broad research on long-term fisheries data.

2.2.7 U.S. Marine Mammal Commission (MMC)

The MMC is an independent agency of the U.S. government established under Title II of the Marine Mammal Protection Act (MMPA). The Commission provides independent oversight of the marine mammal conservation policies and programs of federal agencies. The Commission's main roles with respect to oil spills are oversight of the agencies charged with response, assessment, and restoration activities, and convening of interagency working groups to coordinate those activities.

The Commission, in consultation with its Committee of Scientific Advisors on Marine Mammals, has prepared a report "Assessing the Long-term Effects of the BP Deepwater Horizon Oil Spill on Marine Mammals in the Gulf of Mexico: A Statement of Research Needs" (2011). The objectives of the report were to (1) guide assessment of the long-term effects of the Gulf spill and associated risk factors on marine mammals, (2) guide mitigation and restoration efforts for Gulf marine mammal populations, (3) help track the changes in the Gulf ecosystem, including recovery and restoration, and (4) help guide assessment of future spills in the Gulf and elsewhere.

The Commission administers a small annual grant program that supports projects aimed at meeting the conservation and protection goals of the MMPA. In addition, the Commission has initiated an annual survey of federally funded research on marine mammals to determine the nature of research conducted or supported by each agency. Information from the survey is used to assess ways to target and enhance specific marine mammal research and conservation activities.

2.2.8 National Institute of Environmental Health Sciences (NIEHS)

NIEHS is one of 27 research institutes and centers that comprise the National Institutes of Health (NIH) of the Department of Health and Human Services (DHHS). The mission of the NIEHS is to reduce the burden of human illness and disability by understanding how the environment influences the development and progression of human disease. The NIEHS, part of the NIH, activated programs throughout the institute to provide timely and responsive services following the DWH oil spill.

In June 2010, NIEHS initiated the GuLF STUDY to conduct research on the health of the workers and volunteers most directly involved in responding to the Deepwater Horizon oil spill.

ED_001324_00000360-00063

The GuLF STUDY will help determine if oil spills and the exposure to crude oil and dispersants, affects physical and mental health. Almost 33,000 cleanup workers are enrolled in the 10-year health study, making a significant contribution to their communities and to answering important public health questions.

2.2.9 U.S. National Response Team (NRT) - Science and Technology (S&T) Committee

The NRT is an organization of 15 federal departments and agencies responsible for coordinating emergency preparedness and response to oil and hazardous substance pollution incidents. The EPA and the USCG serve as Chair and Vice Chair respectively. The NCP and the Code of Federal Regulations (40 CFR part 300) outline the role of the NRT and Regional Response Teams (RRTs). Various federal statutes cite the NRT and RRTs including the Superfund Amendments and Reauthorization Act - Title III and the Hazardous Materials Transportation Act (HMTA).

The NRT's S&T Committee provides a forum to fulfill the NRT's NCP delegated responsibilities in R&D. Specifically, NCP regulation 40 CFR 300.110(h)(6) lists as one of the NRT's responsibilities "Monitoring response-related research and development, testing, and evaluation activities of NRT agencies to enhance coordination, avoid duplication of effort, and facilitate research in support of response activities." Additionally, 40 CFR 300.110(g) states, "the NRT may consider and make recommendations to appropriate agencies on ... necessary research, development, demonstration, and evaluation to improve response capabilities."

2.2.10 National Science Foundation (NSF)

The NSF is an independent federal agency created by Congress in 1950 "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense…" The NSF is the funding source for approximately 24 percent of all federally supported basic research conducted by America's colleges and universities. NSF fulfills their mission chiefly by issuing limited-term grants to fund specific research proposals judged to be the most promising by a rigorous and objective merit-review system. Currently, they issue about 11,000 new awards per year, with an average duration of three years. NSF-funded research addresses a number of scientific areas with applications to oil pollution research including engineering, materials science, biology, and the Arctic. NSF also has a Rapid Response Research (RAPID) mechanism that enables research on unanticipated events such as the *Deepwater Horizon* oil spill.

2.2.11 NOAA RESTORE Act Science Program

In 2012, the U.S. Congress passed (P.L. 112-141) the "Resources and Ecosystem Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act" (RESTORE Act). The RESTORE Act transfers 80% of all administrative and civil penalties paid by responsible parties in connection with the Deepwater Horizon incident to a Gulf Coast Restoration Trust

ED_001324_00000360-00064

Fund. The RESTORE Act also establishes several programs, funded by the Trust Fund, to aid in the ecological and economic recovery of the Gulf Coast states. Under Section 1604 of the RESTORE Act directed NOAA to establish a Gulf Coast Ecosystem Restoration Science, Observation, Monitoring, and Technology Program (NOAA RESTORE Act Science Program). This program is to be funded by 2.5 percent of the Gulf Coast Ecosystem Restoration Trust Fund plus 25 percent of the Trust Fund accrued interest. The Program can expend funds for marine and estuarine research; marine and estuarine ecosystem monitoring and ocean observation; data collection and stock assessments; pilot programs for fishery independent data and reduction of exploitation of spawning aggregations; and cooperative research.

2.2.12 North American Wetlands Conservation Act (NAWCA) Gulf of Mexico Funds

The NAWCA provides matching grants from the North American Wetlands Conservation Fund to organizations and individuals who have developed partnerships to carry out wetlands conservation projects in the United States, Canada, and Mexico for the benefit of wetlands-associated migratory birds and other wildlife. As part of their criminal settlement agreement, BP paid $100 million to the Fund for the purpose of wetlands restoration and conservation located in states bordering the Gulf of Mexico or otherwise designed to benefit migratory bird species and other wildlife affected by the Macondo oil spill. The USFWS administers the Fund. The restoration projects include research to monitor and evaluate restoration success.

2.3 Federal Research Laboratories and Testing Facilities

Several federal facilities and locations provide opportunities for both federal and non-federal oil pollution research.

2.3.1 Ohmsett

Ohmsett, located at the Naval Weapons Station Earle Waterfront in Leonardo, New Jersey, is managed by BSEE. The facility includes an above ground concrete test tank that is one of the largest of its kind, measuring 203 meters long by 20 meters wide by 3.4 meters deep. The tank holds with 2.6 million gallons of crystal clear saltwater.

The Ohmsett test tank allows testing of full-scale oil pollution response equipment. The tank includes a wave generator that creates realistic sea environments, while state-of-the-art data collection and video systems record test results. The facility has proven to be ideal for testing equipment, evaluating acquisition options, and validating research findings.

Government agencies, academia, public and private companies use Ohmsett as a research center to test oil spill containment/clean-up equipment and techniques, to test new designs in response equipment, and to conduct training with actual oil spill response technologies.

ED_001324_00000360-00065

2.3.2 USCG Research & Development Center (RDC)

The RDC, located in New London, Conn. is the USCG's sole facility performing research, development, and test and evaluation in support of the service's major missions. The RDC is responsible for evaluating the feasibility and affordability of mission execution solutions and providing operational and risk-management analysis at all stages of the acquisition process.

At any given time, the RDT&E program is working on more than 80 projects that support USCG requirements across all mission areas. The program also provides Coast Guard leadership with knowledge necessary for making strategic decisions. The RDT&E program leverages partnerships with academia and other government agencies. The RDC also leverages Cooperative Research and Development Agreements (CRADAs) under the Technology Transfer Act to work with private industry to anticipate and research solutions to current and future technological challenges.

2.3.3 USCG RDC Joint Maritime Test Facility

The USCG RDC's Joint Maritime Test Facility *In Situ* Burn Pan is working in conjunction with the Naval Research Laboratory and the BSEE to refurbish its *in-situ* burn test pan located on Little Sand Island in Mobile, Alabama. The burn pan is the nation's only permitted open air *in-situ* burn pan for fire boom research. Once refurbished, this burn pan will help the RDC's Joint Maritime Test Facility meet its mission to support the maritime safety efforts by providing full-scale tests and evaluation under close to actual operating and environmental conditions.

2.3.4 USCG Marine Safety Laboratory

The USCG Marine Safety Laboratory (MSL) provides forensic oil analysis and expert testimony in support of the oil pollution law enforcement efforts for Marine Investigators, Districts, Hearing Officers, National Pollution Funds Center, Department of Justice, and other federal agencies. The MSL is the USCG's sole facility for performing forensic oil analysis.

2.3.5 U.S. EPA National Risk Management Research Laboratory (NRMRL)

The NRMRL is EPA's premiere laboratory for risk management research. It conducts research at the basic level, as well as bench-scale and pilot-scale levels, to explore innovative solutions to pollution problems. Environmental risk management seeks to determine what environmental risks exist and how to manage those risk in a way best suited to protect human health and the environment. Its mission is to advance scientific and engineering solutions to manage current and future environmental risk.

NRMRL's research directly supports efforts to manage chemical risks, clean up hazardous waste sites, protect water, reduce greenhouse gas emissions, and improve air quality.

ED_001324_00000360-00066

2.3.6 Cold Regions Research and Engineering Laboratory (CRREL)

CRREL, located in Hanover, New Hampshire is one of seven US Army Corps of Engineers (USACE) Engineering Research and Development Center (ERDC) laboratories. The laboratory's mission is to solve interdisciplinary and strategically important problems by advancing and applying science and engineering to complex environments, materials and processes in all seasons and climates, with unique core competencies related to the Earth's cold regions. CRREL maintains several unique and specialized research facilities at its Hanover, New Hampshire location, to include: 26 low-temperature research cold rooms; a refrigerated Ice Engineering Facility comprised of a 12,800 square foot research area, a 3,600 square foot by 8 foot deep test basin, and a 120 foot long water flume with tilting bed; a 1,320 square foot by 7 foot deep outdoor Geophysical Research Facility; a 40 foot working length portable wave tank that can be located indoors within a cold facility for year round cold research or outdoors to support in situ burn tests; and a 29,000 square foot environmentally controlled Frost Effects Research Facility. CRREL also maintains a research permafrost tunnel in Fox, Alaska, a 135-acre permafrost research site near Fairbanks, Alaska, and has project offices in Anchorage and Fairbanks, Alaska. CRREL works with partners from industry, government agencies, and educational institutions, to develop scientific tools that can aid in effective oil spill response, and provides unique facilities and cold region expertise to stake-holders to create effective spill response techniques for ice covered environments.

2.3.7 U.S. Army Engineer Research and Development Center (ERDC)

The ERDC is the world's largest laboratory primarily devoted to civil engineering and environmental sciences research, development, test, and evaluation. The ERDC, which includes seven laboratories located in four geographic locations, provides a broad array of services ranging from basic research to test and evaluation. The ERDC Laboratories maintain state of the art modeling and experimentation facilities which support a broad array of capabilities in oil spill response from modeling impacts to remediation techniques.

ERDC capabilities to support Oil Spill efforts are categorized into three phases. Phase 1, Emergency Response/Mitigation, includes those activities that that enhance the ability to conduct emergency response and mitigation. Phase 2, Remediation, includes activities designed to support tasks such as active intervention to ameliorate the oil contamination. Phase 3, Recovery/Long Term Monitoring/Assessment, includes activities supporting the monitoring and assessment of long term environmental impacts associate with the spill.

2.3.8 Hollings Marine Laboratory (HML)

The Hollings Marine Laboratory is located in Charleston, SC and was established as a joint facility combining partners from NOAA, NIST, the Medical University of South Carolina, the College of Charleston, and the South Carolina Department of Natural Resources. The laboratory is operated by the NOAA National Ocean Service and houses NIST's Environmental Specimen

ED_001324_00000360-00067

Bank, NIST and NOAA environmental chemistry laboratories, as well as NOAA personnel and facilities for assessing the health of living marine resources. Immediately after the Deepwater Horizon oil spill, the co-location of NOAA and NIST personnel was instrumental in planning and mounting NOAA's response to the event with regard to, sample archival, monitoring protected species and evaluating data quality being produced by different laboratories providing chemistry data related to the spill. Oil spill-related research continues at the HML with projects including aiming to understand biomarkers of oil exposure in protected species and exploring the effects of dispersants on marine organisms and humans.

2.2.9 U.S. Naval Research Laboratory (NRL) Stennis Space Center

The NRL detachment at Stennis Space Center focuses on marine geosciences, oceanography, and underwater acoustics. The Oceanography Division and the Marine Geosciences Division conduct studies applicable to oil pollution research.

The Oceanography Division is known for its combination of theoretical, numerical, and experimental approaches to oceanographic problems. The Division numerically models the ocean on the world's most powerful supercomputers and operates a number of highly sophisticated graphics systems to visualize ocean model results. The Division maintains two satellite receiving systems, a computer network with automated processing capabilities for ocean color and advanced optical instrumentation and calibration facilities.

The Marine Geosciences Division conducts a broadly-based, multidisciplinary program of scientific research and advanced technology development directed towards maritime and other national applications of geosciences, geospatial information and related technologies. Research includes investigations of basic processes within ocean basins and littoral regions. The Division develops models, sensors, techniques and systems to exploit this knowledge for applications to enhance Navy and Marine Corps systems, plans and operations

2.3.10 Pacific Northwest National Laboratory (PNNL)

The PNNL's Marine Sciences Laboratory (MSL), located in Sequim, Washington on the Strait of Juan de Fuca, provides a platform for marine and freshwater ecological research, instrument and method development, and biotechnology research. The laboratory has regional access to oceans and rivers that have experienced human impacts ranging from the uninhabited and protected coastlines of Olympic National Park to heavily developed shores around Seattle and Tacoma. The Marine Research Operations' Wet Laboratory provides a large space in which to perform innovative, water-oriented research. A variety of indoor and outdoor tank configurations provide capacity for bench-scale tests through large-scale outdoor mesocosm systems and for other studies using aquatic plants and animals.

ED_001324_00000360-00068

2.3.11 Coastal and Ocean Research Vessels

2.3.10.1 USCG Cutter Healy

The USCG's cutter *Healy* is designed to conduct a wide range of research activities, providing more than 4,200 square feet of scientific laboratory space, numerous electronic sensor systems, and accommodations for up to 50 scientists. HEALY is designed to break 4½ feet of ice continuously at three knots and can operate in temperatures as low as -50 °F. *Healy* substantially enhances the U.S. Arctic research capability. It serves as a platform for research activities as part of the Arctic Shield demonstrations where components of an Arctic oil spill response are tested. *Healy* is also a capable platform for supporting other potential missions in the polar regions, including logistics, search and rescue, ship escort, environmental protection, and enforcement of laws and treaties.

2.3.11.2 EPA Vessels

The EPA operates two ships that monitor and assess impacts from ecological disturbances and ocean-based human activities on the ocean, Great Lakes, and coastal waters. EPA's Ocean Survey Vessel (OSV) *Bold* operates under the statutory requirement to monitor the deposition of dredged materials under the Marine Protection, Research, and Sanctuaries Act of 1972. This Act regulates intentional ocean disposal of materials, authorizes any related research and provides for the designation and regulation of marine sanctuaries. OSV *Bold* operates in the Atlantic and Pacific Oceans and the Caribbean Sea to monitor water quality, effects of dredged material, coral reef health, and other special assessments.

EPA's Great Lakes National Program Office based in Chicago, Illinois operates R/V *Lake Guardian*, which conducts monitoring programs that sample the water, aquatic life, sediments, and air in order to assess the health of the Great Lakes ecosystem.

2.3.11.3 MARAD Vessels

MARAD operates the National Defense Reserve Fleet (NDRF) of 100 ships that are available for use during oil spill exercises, providing housing during a spill response, or for education and training. The NDRF is available to support emergency shipping operations during war and national emergencies. The fleet has anchorages in Fort Eustis, Virginia; Beaumont, Texas; Suisun Bay in Benicia, California; and at designated port facility berths.

2.3.11.4 NOAA Vessels

NOAA's Office of Marine and Aviation Operations (OMAO) operates a wide assortment of hydrographic survey, oceanographic research, and fisheries survey vessels. Five ships located in the Pacific are managed by the Marine Operations Center, Pacific (MOC-P) in Newport, Oregon. Nine ships located in the Atlantic are managed by the Marine Operations Center,

ED_001324_00000360-00069

Atlantic (MOC-A) in Norfolk, Virginia. Two ships located in Hawaii are managed by the Marine Operations Center, Pacific Islands (MOC-PI).

NOAA's research and survey ships compose the largest fleet of federal research ships in the nation. The fleet ranges from large oceanographic research vessels capable of exploring the world's deepest ocean, to smaller ships responsible for charting the shallow bays and inlets of the United States. The fleet supports a wide range of marine activities including fisheries research, nautical charting, and ocean and climate studies.

The OMAO's aircrafts operate throughout the world providing a wide range of capabilities including hurricane reconnaissance and research, marine mammal and fisheries assessment, and coastal mapping.

2.3.12 Oil Spill Field Research

Federal oil pollution research is not limited to research facilities and laboratories. Oil spills can provide opportunities for federal agencies to conduct research on the fate, effects, and physical and chemical behavior of the spilled oil and the responses to the spills in the natural environment. NOAA and USGS have ongoing research projects to study the long-term fate and effects of the *Exxon Valdez* oil spill. The *Deepwater Horizon* oil spill is also providing many opportunities to study both the near-term and long-term effects of the spill and response. Other potential research locations include the Santa Barbara oil seeps off the California coast and the submerged Taylor Energy platform in the Gulf of Mexico, which is a continuing source of sheens.

Intentional releases have been used by many countries, most notably Norway, to demonstrate the effectiveness of spill control equipment or processes. Under controlled circumstances, these releases may provide an opportunity to conduct tests under actual spill conditions.

ED_001324_00000360-00070

3. Non-Federal Oil Pollution Research Entities

Consistent with the mandates of OPA 90, ICCOPR cooperates with research programs of state governments, industry, academia, non-government organizations/institutions, and other nations. The cooperation of federal and non-federal entities provides whole community approach to oil pollution research. The following sections describe non-federal entities that conduct or sponsor oil pollution research.

3.1 State Organizations

Several coastal states have established oil pollution research programs. These programs are in states affected by previous oil spills or where there are active oil exploration and production activities. Increasing shale oil production has prompted other states to study the risks of hydraulic fracturing and transporting oil by rail and pipeline. This section describes on-going state research programs.

3.1.1 Alaska Department of Environmental Conservation (ADEC)

Judgments entered in the criminal cases for the *Exxon Valdez* oil spill resulted in appropriation of funds to the State of Alaska to enhance the ability of the State and industry to respond to oil spills. A total of $2,500,000 was made available to ADEC for projects under this program. The funds are used for research programs directed toward the prevention, containment, cleanup and amelioration of oil spills in Alaska. In cooperation with other stakeholders, ADEC has developed a list of more than 30 R&D projects dealing with such subjects as cleanup technology, non-mechanical response techniques, the fate and effects of spilled oil, oil-spill contingency planning and preparedness, spill response training, incident-management systems and spill prevention. Alaskan oil-spill response cooperatives, private consultants, universities, and other state and federal agencies have conducted research under the program.

3.1.2 California Office of Oil Spill Prevention and Response (CAOSPR)

As both a prevention and response organization, CAOSPR has the Department of Fish and Game's public trustee and custodial responsibilities for protecting, managing and restoring the state's fish, wildlife, and plants. It is one of the few state agencies in the nation with both major pollution response authority and public trustee authority for wildlife and habitat. This mandate ensures that prevention, preparedness, restoration and response will provide the best protection for California's natural resources.

In 2014 California expanded the CAOSPR program to cover all state surface waters at risk of oil spills from any source, including pipelines, production facilities, and the increasing shipments of oil transported by railroads. This expansion provided critical administrative funding for industry preparedness, spill response, and continued coordination with local, state and federal government along with industry and non-governmental organizations.

ED_001324_00000360-00071

3.1.3 Florida

The Oil Spill Academic Task Force (OSATF) is a consortium of scientists and scholars from institutions in the State University System as well as from five of Florida's private universities and two marine laboratories working in collaboration with the Florida Department of Environmental Protection (DEP). The OSATF brings together expertise and resources to assist the state of Florida and the Gulf region in responding to and studying the Deepwater Horizon oil spill.

The Fish and Wildlife Research Institute's work includes assessment and restoration of ecosystems and studies of freshwater and marine fisheries, aquatic and terrestrial wildlife, imperiled species, and red tides. The institute develops the information science required to analyze and disseminate research products, and engages in outreach activities to complement all programs.

The Florida Marine Spill Analysis System (FMSAS) is a powerful geographic information system (GIS) application that allows users to conduct oil spill planning activities and manage response and mitigation efforts during an actual spill. Spill planning and response activities have always relied on maps and charts to display information. From simple notes on nautical charts to specialized maps showing the location of sensitive resources or the location of an oil slick, many of the essential information components of planning and response actions require geospatial data. The FMSAS is designed to address five aspects of oil spill management:

- Contingency planning;
- On-scene spill tracking and "Resources At Risk" (RAR) analysis;
- Long-term monitoring;
- Damage assessment; and
- General oil spill GIS data management.

3.1.4 Louisiana Applied and Educational Oil Spill Research and Development Program (OSRADP)

The Louisiana OSRADP provided oil spill planners and response personnel with practical, scientifically-sound and cost effective spill prevention, management and mitigation tools for two decades until 2011 when OSRADP became part of the Center for Energy Studies.

3.1.5 Gulf States Marine Fisheries Commission (GSMFC)

The Gulf States Marine Fisheries Commission was established by an act of Congress (P.L. 81-66) in 1949 as a compact of the five Gulf States with a charge to: "to promote better utilization of the fisheries, marine, shell and anadromous, of the seaboard of the Gulf of Mexico, by the development of a joint program for the promotion and protection of such fisheries and the prevention of the physical waste of the fisheries from any cause."

The GSMFC Oil Disaster Recovery Program (ODRP) evolved from the receipt of $15 million dollars in October of 2010 and aims to improve the public perception and confidence in Gulf of

Mexico seafood following the 2010 *Deepwater Horizon* oil disaster. Funding for this program, like that of the post-Katrina Emergency Disaster Recovery Program (EDRP), came from the U.S. Congress following fishery disaster declarations by the U.S. Secretary of Commerce. Scheduled to be completed in September of 2015, the activities under the program are identified through an ad-hoc advisory committee consisting of the marine resource directors from each of the five Gulf of Mexico states. Under this component, multiple post-disaster recovery elements were executed to address issues relative to improving both the perception of and confidence in Gulf of Mexico seafood products.

3.1.6 Minnesota National Crude Oil Spill Fate and Natural Attenuation Site

The Minnesota National Crude Oil Spill Fate and Natural Attenuation Site dates back to 1979, when a dramatic pipeline rupture released 10,000 bbl of crude petroleum to the land surface and shallow subsurface. In 1983, research began at the site through the support of the USGS' Toxic Substances Hydrology Program. Continuing USGS support has allowed hundreds of scientists from across the globe to visit this "underground observatory" and study the effects of a terrestrial crude oil spill including the physical, chemical and biological processes driving the degradation and transport of crude petroleum. Research from the site has been included in more than 200 scientific papers.

In 2008 and 2009, the Minnesota Pollution Control Agency, Enbridge Energy LLC, the USGS and Beltrami County created several agreements to formally establish the "National Crude Oil Spill Research Site in Bemidji, Minn." The objective of these agreements is to create a self-sustaining research facility that brings academic researchers and practitioners (e.g., consultants, petroleum and pipeline industry representatives and pollution control officials) together thereby linking novel ideas to practical, on-the-ground applications.

3.1.7 Pacific States/British Columbia Oil Spill Task Force (PSBCOSTF)

In 1989, following the *Nestucca* and *Exxon Valdez* oil spills, the Governors of Alaska, Washington, Oregon, and California, and the Premier of British Columbia, signed a Memorandum of Agreement that authorized PSBCOSTF. These events highlighted their common concerns regarding oil spill risks and the need for cooperation across shared borders. In June 2001, a revised Memorandum of Cooperation was adopted to include the State of Hawaii and expand the focus to spill preparedness and prevention needs of the 21st century. Now in its third decade, the PSBCOSTF provides a forum where its members can work with stakeholders from the Western US and Canada to implement regional initiatives that protect 56,660 miles of coastline from Alaska to California and the Hawaiian archipelago.

3.1.8 Texas General Land Office (TXGLO)

The TXGLO is a national leader in oil spill research. The TXGLO R&D program has funded groundbreaking work on oil dispersants, shoreline cleaners, bioremediation and high-frequency

ED_001324_00000360-00073

radar. The R&D program is improving response technology and developing alternative methods for removing oil from coastal waters.

Over the years, the TXGLO has coordinated with other state agencies, the state's higher education institutions and private industry to establish viable research projects for oil spill prevention and response. Funded projects have involved preventive technologies, spill detection, environmental data collection, chemical countermeasures, recovered materials management and in situ burning

The TXGLO, as a NRDA Trustee, acts on behalf of the public to identify the injured natural resources and determine the extent of the impact. They also recover damages from the responsible party to plan and carry out restoration activities. In addition to the TXGLO, two other state agencies are designated as NRDA trustees: the Texas Parks and Wildlife Department (TPWD) and the Texas Commission on Environmental Quality (TCEQ).

3.1.9 Washington Department of Ecology (WADOE)

The WADOE has program offices for oil pollution prevention, preparedness, and response, which include resource damage assessments and recovery. The Department conducts studies on the risks of oil transportation through the state and provides guidance to industry and the public on oil pollution issues. WADOE also manages a Coastal Protection Fund (CPF) that collects monies from oil and hazardous materials spill damage assessments and penalties. The CPF uses the money to fund projects to: restore or enhance public natural resources; investigate long-term effects of oil spills; and develop and implement aquatic land geographic information systems. Funds may also be allocated for R&D on the causes, effects, and removal of pollution caused by the discharge of oil.

3.2 Industry

The oil industry plays an important part in oil pollution research. Industry approaches to exploration, production, transportation, and spill prevention evolve as new techniques are identified or new resources are found. Industry has several research programs to improve their practices to prevent oil spills and to better respond to spills when they occur.

3.2.1 American Petroleum Institute Joint Industry Task Force (API JITF)

In the wake of the *Deepwater Horizon* oil spill of 2010, the petroleum industry launched four JITFs to critically assess capabilities and performance. Each JITF used subject matter experts to identify best practices in offshore drilling operations and oil spill response and to share that knowledge across industry with the goal of ensuring environmental protection through enhanced safety.

ED_001324_00000360-00074

The Oil Spill Preparedness and Response JITF examined industry's ability to respond to a "Spill of National Significance (SONS)" and the actual response to the *Deepwater Horizon* oil spill. This program covers:

- Spill Response Planning
- Oils Sensing and Tracking
- Dispersant
- In Situ Burning
- Mechanical recovery
- Shoreline protection
- Alternate response technologies

The industry has also has also begun to improve public outreach in a number of focus areas including:

- Oil spill preparedness and response framework;
- Net environmental benefit analysis (NEBA);
- Role of dispersants in oil spill response;
- Tiered preparedness and response framework;
- Incident management system; and
- Regulatory approval and use of dispersants.

The JITF also initiated subcommittees to address response issues related to inland spills including railroad spills and pipeline emergency response.

3.2.2 American Salvage Association (ASA)

The ASA was created in 2000 as an association of professional salvors dedicated to improving marine casualty response in North American coastal and inland waters. The ASA promotes cooperation among its members and works with Federal and state agencies to identify ways to improve salvage and firefighting response capabilities. The ASA encourages research to identify risks from sunken vessels and uses its members' experience to identify areas for additional research or technology development.

3.2.3 Association of Petroleum Industry Co-op Managers (APICOM)

APICOM, founded in 1972, is an association of unaffiliated petroleum industry oil spill cooperative managers. APICOM exists for the purpose of exchanging information related to the management of an oil spill response cooperative. It also serves as a forum for the exchange of ideas related to oil spill response technologies, operations, regulations and other issues of common interest to its members.

ED_001324_00000360-00075

3.2.4 Industry Technical Advisory Committee (ITAC)

The ITAC includes members from the oil spill response community within the oil industry, and other organizations that have oil pollution preparedness and response as their principal goal. ITAC acts as a focal point for technical issues and as a forum for exchanging information on preparedness, oil spill response operations, response technology and response training.

3.2.5 International Maritime Organization (IMO)

The IMO is a specialized agency of the United Nations, which is responsible for measures to improve the safety and security of international shipping and to prevent marine pollution from ships. It is also involved in legal matters, including liability and compensation issues and the facilitation of international maritime traffic. IMO's governing body is the assembly, made up of all 170 Member States, which meets once every two years. The Maritime Safety, Marine Environment Protection, Legal, Technical Co-operation and Facilitation Committees, and a number of sub-committees carry out the main technical work. Since 1967, the IMO has adopted a series of conventions covering prevention of marine pollution by ships, preparedness and response to incidents involving oil and hazardous and noxious substances, prevention of use of harmful anti-fouling systems and the international convention on ballast water management to prevent the spread of harmful aquatic organisms in ballast water.

3.2.6 International Petroleum Industry Environmental Conservation Association (IPIECA)

IPIECA is the global oil and gas industry association for environmental and social issues. It develops, shares, and promotes good practices and knowledge to help the industry improve its environmental and social performance. It is the industry's principal channel of communication with the United Nations.

IPIECA's Oil Spill Working Group (OSWG) was established in 1987 and serves as a key international industry forum to help improve oil spill contingency planning and response around the world. The OSWG aims to improve oil spill preparedness and response around the world by:

- Enabling members to exchange information and best practices
- Supporting industry and government cooperation at all levels
- Encouraging ratification and implementation of relevant international conventions
- Promoting the principle of 'Net Environmental Benefit Analysis' and the 'Tiered Response' approach to designing response strategies; and
- Developing and communicating the industry's views and activities to external audiences'

ED_001324_00000360-00076

3.2.7 International Spill Control Organization (ISCO)

The International Spill Control Organization (ISCO) is a not-for-profit organization incorporated in London in 1984 with membership in 36 countries around the world. ISCO aims to raise worldwide preparedness and co-operation in response to oil and chemical spills, to promote technical development and professional competency, and to provide a focus for making the knowledge and experience of spill control professionals available to IMO, United Nations Environment Programme (UNEP), European Commission (EC) and other organizations. ISCO provides organizations with information on experiences, problems solved, and lessons learned by spill responders. They also keep the spill response community informed of new developments and news through their website and newsletters.

3.2.8 International Tanker Owners Pollution Federation (ITOPF)

ITOPF is a not-for-profit organization established on behalf of the world's ship owners and their insurers to promote effective response to marine spills of oil, chemicals, and other hazardous substances. ITOPF provides a range of technical services including emergency response, advice on clean up techniques, pollution damage assessment, assistance with spill response planning, and training. It is recognized and respected globally as a source of objective technical expertise in the area of accidental spills of oil and chemicals from ships and ITOPF is a source of comprehensive information on marine pollution. Investing in R&D is one way ITOPF meets this objective. ITOPF invests in R&D to help fulfill their mission of promoting effective response to marine spills of oil, chemicals and other substances.

3.2.9 Oil Spill Response (OSR) Joint Industry Program (JIP)

The OSR JIP is an initiative of the Oil and Gas Producers (OGP) to address issues related to the Macondo well blowout. In response to the incident, the OGP formed the Global Industry Response Group (GIRG), which was tasked to identify the key issues that could prevent recurrence of such an incident and identify learning opportunities on both the causation, and the subsequent response to the incident. The OSR JIP has initiated discreet projects or supported projects of other groups in many oil spill related subject areas resulting from the OGP GIRG-OSR studies.

3.2.10 Petroleum Environmental Research Forum (PERF)

The PERF is a research and development joint venture, formed to provide a stimulus to and forum for the collection, exchange, and analysis of research information relating to the development of technology for health, environment and safety, waste reduction and system security in the petroleum industry. PERF is a non-profit organization of member corporations in the petroleum industry. PERF does not itself participate in research projects but provides a forum for members to collect, exchange, and research information relating to practical and

ED_001324_00000360-00077

theoretical science and technology concerning the petroleum industry and a mechanism to establish joint research projects in the field.

3.2.11 Pipeline Research Council International (PRCI)

The PRCI was established in 1952 as the Pipeline Research Committee of the American Gas Association to address the problem of long-running brittle fractures in natural gas transmission pipelines. In substantially solving that problem within two years, the committee demonstrated the benefit of industry collaboration and leveraging voluntary industry funding. Unique among all pipeline research organizations, the mission of PRCI is to be the global leader in collaborative energy pipeline research that provides safe, reliable, environmentally conscious and efficient means of energy delivery. The committee will be used to improve current inspection and integrity assessment technologies, and to promote the development of new technologies for pipeline integrity management.

Some of PRCI's recent research has addressed:

- Corrosion — location and assessment;
- Mechanical damage — location and assessment;
- Right of Way (ROW) monitoring;
- Growth of construction defects;
- Compressor and pump station; and
- Measurement.

3.2.12 Spill Control Association of America (SCAA)

SCAA organized in 1973 to actively promote the interests of all groups within the spill response community. They represent spill response contractors, manufacturers, distributors, consultants, instructors, government and training institutions and corporations working in the industry. SCAA partners with the USCG and the Association of Petroleum Industry Co-op Managers (APICOM) in the quality partnership for marine safety and environmental protection, which was created to improve the effectiveness of spill response and to promote sound risk management among/between private and governmental response organizations.

3.3 Independent Research Interests

Several independent organizations conduct or manage oil pollution research programs. These include non-governmental organizations, non-profit organizations, and committees with a mix of memberships including citizens, industry, and government organizations.

ED_001324_00000360-00078

3.3.1 Cook Inlet Regional Citizen's Advisory Committee (CIRCAC)

OPA 90 established CIRCAC to create an avenue for public participation in the oversight of the Cook Inlet oil industry. Since its inception, the CIRCAC has formed environmental monitoring and oil spill prevention programs to promote safe production and transportation of oil in Cook Inlet. These programs seek to develop an understanding of efficacy, fate, transport, and effects of oil and oil treated by various response methods likely to be used on oil spills in the area of concern. It also monitors the biological and chemical environment in Cook Inlet and nearby areas to detect effects of oil industry operations. The CIRCAC also has a Coastal Habitat Mapping Program to assess coastal habitats with an oil spill prevention and response tool that incorporates detailed coastal habitat data.

3.3.2 Gulf of Mexico Alliance (GOMA)

The Gulf State Governors established the Gulf of Mexico Alliance (GOMA) in 2004 in response to the President's Ocean Action Plan. GOMA's mission is to enhance the ecological and economic health of the Gulf region by encouraging collaboration among government agencies, businesses, education providers and non-governmental organizations. It is a state-led network of partners working together on projects related to the priority issues identified by the Governors in early discussions. The GOMA structure allows federal and state agency partners to focus funding priorities on the needs of the Gulf, and it provides a forum to share knowledge, expertise, and collaborate to reduce duplication of efforts.

3.3.3 Gulf of Mexico Research Initiative (GoMRI)

On May 24, 2010, shortly after the *Deepwater Horizon* oil spill, BP announced a $500 million commitment to fund a Gulf of Mexico Research Initiative (GoMRI), a 10-year independent research program designed to study the effects of the oil spill and its associated response on the environment and public health in the Gulf of Mexico. GoMRI awards funds competitively for scientists to investigate the impacts of the oil, dispersed oil, and dispersants on the ecosystems of the Gulf of Mexico and affected coastal States in a broad context of improving fundamental understanding of the dynamics of such events and their environmental stresses and public health implications. GoMRI also seeks to develop improved spill mitigation, oil and gas detection, characterization and remediation technologies.

As directed by an independent 20-member Research Board, GoMRI issues grants for independent scientific research conducted primarily at academic institutions in the U.S. Gulf Coast States. However, institutions from outside the Gulf region, as well as for-profit entities, can participate. The funds are distributed using peer evaluations (National Science Board Process) and are used strictly for research activities such as sampling, modeling and studies, but not acquisition of infrastructure. Researchers are required to publish their results in peer-reviewed scientific journals with no requirement for BP approval.

ED_001324_00000360-00079

The ultimate goal of GoMRI is to improve society's ability to understand, respond to and mitigate the impacts of petroleum pollution and related stressors of the marine and coastal ecosystems, with an emphasis on conditions found in the Gulf of Mexico. Knowledge accrued will be applied to restoration and to improving the long-term environmental health of the Gulf of Mexico.

3.3.4 Gulf Restoration Science Programs Ad Hoc Coordination Forum

The Gulf Restoration Science Programs Ad Hoc Coordination Forum serves to provide regular communication and coordination on Gulf of Mexico restoration related science between the ecological sciences programs funded from criminal penalties, settlement agreements, and programs funded due to the Deepwater Horizon oil spill.

3.3.5 National Academy of Sciences Gulf Research Program (GRP)

As part of the criminal settlement agreements following the *Deepwater Horizon* Oil Spill, the federal government asked the National Academy of Sciences (NAS) to establish a new program to fund and conduct activities to enhance oil system safety, human health, and environmental resources in the Gulf of Mexico and other U.S. outer continental shelf regions that support oil and gas production. The settlement agreements provide a total of $500 million over the first five years of the 30-year program. The Gulf Research Program works to enhance oil system safety and the protection of human health and the environment in the Gulf of Mexico and other U.S. outer continental shelf areas by seeking to improve understanding of the region's interconnecting human, environmental, and energy systems and fostering application of these insights to benefit Gulf communities, ecosystems, and the Nation. Initial funding of projects began in 2015.

3.3.6 National Fish and Wildlife Federation (NFWF)

Congress created NFWF in 1984. They serve as a non-profit agency to aid in the protection and restoration of fish and wildlife and their habitats. The BP and Transocean Settlement Agreements with the United States established NFWF's Gulf Environmental Benefit Fund to support projects that remedy harm to natural resources (habitats, species) where there has been injury to, or destruction of, loss of, or loss of use of those resources resulting from the *Deepwater Horizon* oil spill. The Fund will distribute $2.544 billion for projects that contribute significantly to restoring and maintaining the ecological functions of landscape-scale coastal habitats, ensuring long-term viability and resilience of habitats, restoring and maintaining the ecological integrity of priority coastal bays and estuaries, and replenishing and protecting living resources.

3.3.7 Ocean Energy Safety Institute (OESI)

The OESI was established under BSEE sponsorship to facilitate research and development, training of Federal workers to remain current on state-of the art technology associated with oil and gas development. It provides recommendations and technical assistance on the

ED_001324_00000360-00080

determination of Best Available and Safest Technology (BAST), and implementation of operational improvements in the areas of offshore drilling safety and environmental protection, blowout containment and oil spill response. The OESI is a collaborative initiative involving government, academia and scientific experts.

The Texas A&M Engineering Experiment Station's (TEES) Mary Kay O'Connor Process Safety Center manages the OESI, in partnership with the University of Texas at Austin and the University of Houston. The OESI provides a forum for dialogue, shared learning and cooperative research among academia, government, industry, and other non-governmental organizations, in offshore energy-related technologies and activities that ensure safe and environmentally responsible offshore operations.

Specific objectives of OESI are:

- Develop a program of research, technical assistance, and education that serves as a center of expertise in offshore oil and gas exploration, development, and production technology, including technology specific to deepwater and Arctic exploration and development;
- Provide recommendations and technical assistance to the Bureau of Safety and Environmental Enforcement (BSEE) and the Bureau of Ocean Energy Management (BOEM) related to emerging technologies and the determination of BAST, and environmentally sound oil and gas development practices on the Outer Continental Shelf (OCS);
- Provide recommendations and technical assistance related to geological and geophysical sciences relevant to understanding the technical challenges of exploration and development, such as reservoir characteristics, geohazards, and worst case discharge analyses;
- Develop and maintain a domestic and international equipment failure reporting system and database of critical equipment failures related to control of the well that will allow the Institute to identify reliability issues and industry trends. This system should engage both the user and manufacturer of the equipment;
- Engage employees of the Federal agencies to participate in research and training to remain current on state-of-the-art technology associated with offshore oil and gas development;
- Promote collaboration among Federal agencies, industry, standards organizations, academia, and the National Academy of Sciences.

3.3.8 Oil Spill Recovery Institute (OSRI)

OPA 90 established OSRI (http://pws-osri.org/) in response to the 1989 *Exxon Valdez* oil spill. The Prince William Sound Science Center, a non-profit research and education organization located in Cordova, Alaska, administers and houses OSRI. The Congressional mandate given to OSRI is to: 1) identify and develop the best available techniques, equipment and materials for dealing with oil spills in the Arctic and sub-Arctic marine environment; 2) complement federal

ED_001324_00000360-00081

and state damage assessment efforts and determine, document, assess and understand the long-range effects of Arctic and sub-Arctic oil spills on the natural resources of Prince William Sound; and, 3) understand and document the effects to the environment, the economy and the lifestyle and well-being of the people who are dependent on those resources. Subsequent legislation has provided OSRI with a funding mechanism to assure the research continues as long as oil exploration and development occurs in Alaska. Since 1998, OSRI has awarded approximately one million dollars a year to support a wide range of projects.

3.3.9 Pew Charitable Trusts (PCT) Arctic Science Program

The PCT's Arctic Science Program engages in numerous scientific activities to support conservation campaigns throughout the Arctic. These efforts include original fieldwork, analyses of existing data, and the sharing of scientific findings with a range of audiences. Scientists provide expertise on marine conservation-related issues to the U.S., Canada, Greenland, and elsewhere.

3.3.10 Prince William Sound Regional Citizen's Advisory Committee (PWSRCAC)

OPA 90 established the PWSRCAC to promote partnership and cooperation among local citizens, industry and government. The PWSRCAC conducts long-term environmental monitoring program and oil spill prevention programs to promote safe production and transportation of oil in Prince William Sound. Its programs include a hydrocarbon toxicity project to study and address the gaps in knowledge regarding chronic toxic effects of oil, dispersed oil, and *in-situ* burn residue under study conditions similar to the cold marine Alaskan waters.

3.3.11 Ship Structure Committee

Since its inception in 1943, the Ship Structure Committee has sponsored and coordinated R&D projects to improve ship design, construction, operation, inspection, maintenance, and repair methodologies. The Committee's mission is to enhance the safety of life at sea, promote technology and education advancements in marine transportation, and to protect the marine environment. This is done through advocating, participating in, and supporting cooperative R&D in structural design, life cycle risk management of marine structures, and production technologies. The Committee includes representatives from the USCG, Navy, MARAD, American Bureau of Shipping, Transport Canada, Defense Research and Development Canada Atlantic, and the Society of Naval Architects and Engineers.

3.4 Academia

Extensive oil pollution research is conducted at academic institutions, either individually or as part of university consortia. These entities provide opportunities to explore basic and applied scientific concepts to address oil pollution issues.

ED_001324_00000360-00082

3.4.1 Gulf of Mexico Research Consortia

Several university research consortia have been created to study the effects of the Deepwater Horizon oil spill. These consortia bring together researchers from universities, research institutes and other academic entities to collaborate on scientific studies in the Gulf of Mexico. The consortia activities combine research with scientific knowledge of the ecosystems of the Gulf of Mexico to advance the understanding of interactions that occurred and continue to occur among the marine and coastal ecosystems, oil, and dispersants produced by the oil spill.

GoMRI (see Section 3.3.3) provides funding for these consortia or their individual studies. To date, GoMRI issued four one-year block grants in 2010 followed by a series of Request for Proposals (RFPs) for academic consortia and individual investigators to propose research ideas. To date, GoMRI funded 15 different consortia in two rounds of grants, as shown on Table 3-1. In their funding decisions, GoMRI emphasizes: interdisciplinary science and technology involving experts in physical, chemical, geological, and biological oceanography; marine biology; coastal and reef ecosystems, fisheries and wildlife ecology; public health; and associated development of physical, chemical, and biological instrumentation, advanced modeling, and informatics. The activities combine research with scientific knowledge of the ecosystems of the Gulf of Mexico to advance the understanding of interactions that occurred and continue to occur among the marine and coastal ecosystems, oil, and dispersants produced by the oil spill.

Table 4-1: GoMRI-funded Consortia 2010-2014

Consortia	2010 Block Grants	2011 Consortia	2014 Consortia
Florida Inst. of Oceanography	X		
Louisiana State University (LSU)	X		
Marine Environmental Science Consortium	X		
Northern Gulf Institute	X		
Center for Integrated Modeling and Analysis of Gulf Ecosystems (C-IMAGE)		X	X
Consortium for Advanced Research on Transport of Hydrocarbon in the Environment (CARTHE)		X	X
Consortium for the Molecular Engineering of Dispersant Systems (C-MEDS)		X	
Coastal Waters Consortium (CWC)		X	X
Gulf of Mexico Integrated Spill Response Consortium		X	

ED_001324_00000360-00083

(GISR)		
Deepsea to Coast Connectivity in the Eastern Gulf of Mexico (DEEP-C)	X	
Dispersion Research on Oil: Physics and Plankton Studies (DROPPS)	X	X
Ecosystem Impacts of Oil and Gas Inputs to the Gulf (ECOGIG)	X	X
Aggregation and Degradation of Dispersants and Oil by Microbial Exopolymers (ADDOMEx)		X
Alabama Center for Ecological Resilience (ACER)		X
Consortium for Oil Spill Exposure Pathways in Coastal River-Dominated Ecosystems (CONCORDE)		X
Consortium for Resilient Gulf Communities (CRGC)		X
Deep-Pelagic Nekton Dynamics of the Gulf of Mexico (DEEPEND)		X
Littoral Acoustic Demonstration Center - Gulf Ecological Monitoring and Modeling (LADC-GEMM)		X
Relationship of Effects of Cardiac Outcomes in Fish for Validation of Ecological Risk (RECOVER)		X

3.4.2 Gulf of Mexico University Research Collaborative (GOMURC)

Universities across five U.S. Gulf of Mexico states initiated several marine research consortia over the past decades. GOMURC's region-wide alliance of these consortia promotes large-scale, long-term research initiatives required to address Gulf ecosystem-wide stressors such as oil spills, hurricanes, and climate change. GOMURC's mission goals and objectives include advocating for science and education activities that support science-based policies to restore and sustain Gulf natural resources and economy. The following five university consortia members of GOMURC represent 80 universities in the Gulf States:

- Alabama Marine Environmental Sciences Consortium, led by Dauphin Island Sea Lab;
- Florida Institute of Oceanography (FIO), led by University of South Florida;
- Louisiana Universities Gulf Research Collaborative, led by Louisiana State University;
- Mississippi Research Consortium, led by University of Southern Mississippi; and
- Texas Research Consortium, led by the Texas A&M University-Corpus Christi

ED_001324_00000360-00084

3.4.3 Harte Research Institute for Gulf of Mexico Studies

The Harte Research Institute, an endowed research component of Texas A&M University-Corpus Christi, is dedicated to advancing the long-term sustainable use and conservation of the Gulf of Mexico. The Institute serves as a research center of excellence in generating and disseminating knowledge about the Gulf of Mexico ecosystem and its critical role in the economies of the North American region. The Institute's ecosystems group focuses on environmental flows and the effects of deep sea oil and gas activities.

3.4.4 NOAA's Sea Grant Program

NOAA's National Sea Grant College Program is a network of 33 individual programs located in universities in every coastal and Great Lakes state, Puerto Rico, Lake Champlain and Guam. These programs serve as the core of a dynamic, national university-based network of over 300 institutions involving more than 3,000 scientists, engineers, educators, students and outreach experts. The network engages the power of academia and a wide variety of partners to address issues such as coastal hazards, sustainable coastal development, and seafood safety.

3.4.5 National University Rail (NURail) Center

In January 2012, the U.S. Department of Transportation awarded a grant of $3.5 million to a multi-university consortium led by University of Illinois Urbana (UIUC) to establish a rail transportation and engineering research center. Headquartered within the Department of Civil and Environmental Engineering at UICC, NURail is a consortium of seven partner colleges and universities with a combination of strengths in railway transportation engineering research and education in North America. The NURail is the first University Transportation Center (UTC) focused solely on rail and concentrates on rail education and research to improve railroad safety, efficiency and reliability. Particular focus is on challenges associated with rail corridors in which higher-speed passenger trains share infrastructure with freight trains.

The NURail has identified six thematic research topics that will be the subject of strategic development planning and ongoing technical research:

- Integrated railroad vehicle/track interaction and dynamic;
- Railroad safety and risk;
- Rail network capacity analysis and planning,
- Urban, regional and high-speed passenger rail implementation
- Multimodal freight transportation; and
- Funding, finance, community and economic development.

ED_001324_00000360-00085

3.4.6 Oil Spill Academic Task Force (OSATF)

The Oil Spill Academic Task Force (OSATF) is a consortium of scientists and scholars from institutions in Florida's State University System as well as from five of Florida's private universities and two marine laboratories working in collaboration with the Florida Department of Environmental Protection (DEP). The OSATF brings together expertise and resources to assist the state of Florida and the Gulf region in responding to and studying the Deepwater Horizon oil spill.

3.4.7 Scripps Institution of Oceanography (SIO)

SIO, a department of the University of California San Diego, is one of the oldest and largest centers for ocean, earth and atmospheric science research, education, and public service in the world. Research at Scripps encompasses physical, chemical, biological, geological, and geophysical studies of the oceans, earth, and planets. Researchers at SIO engage in basic research to expand our knowledge and understanding of natural hazards, including earthquakes, volcanoes, tsunamis, storm waves, floods, erosion, hurricanes, tornadoes, wildfires, and harmful algal blooms, as well as their impacts.

Some important programs include: the Southern California Coastal Ocean Observing System's real-time surface current mapping network for tracking and mitigating response to oil spills and improving search and rescue operations and safe boating; and the ANZA Seismic Network, providing real-time seismic information for Southern California.

3.4.8 UAA/SIT Center of Excellence for Maritime Research (CMR)

The DHS Science and Technology (S&T) Directorate selected the University of Alaska Anchorage (UAA) and the Stevens Institute of Technology (SIT) as co-leads for a Center of Excellence for Maritime Research (CMR). The CMR will provide research to identify better ways to create transparency in the maritime domain along coastal regions and inland waterways, while integrating information and intelligence among stakeholders. DHS charged the CMR to develop new ideas to address these challenges, provide a scientific basis, and develop new approaches for USCG and other DHS maritime missions.

3.4.9 UAF Arctic Center for Oil-Spill Research & Education (A-CORE)

The University of Alaska-Fairbanks (UAF) A-CORE is a leading academic institution in Arctic research that focuses on research applicable to Arctic oil spills. A-CORE partners with state and federal agencies, industry, and other academic institutions to support wise decision-making concerning Arctic oil spill response and prevention by working to fill gaps in existing knowledge.

In March 2015, UAF began operating the *Sikuliaq*, a new 261-foot oceanographic research vessel owned by the National Science Foundation. The *Sikuliaq* can cut through 2.5 feet of first-

ED_001324_00000360-00086

year sea ice and is the only ice-capable vessel in the U.S. academic research fleet. The ship is outfitted with state-of-the-art equipment to bring scientists to previously inaccessible ice-choked polar regions of the globe. The *Sikuliaq* will advance polar and sub-polar research. *Sikuliaq* can accommodate up to 24 scientists and students, including those with disabilities.

3.4.10 U.S. Coast Guard Academy

The United States Coast Guard Academy is the Department of Homeland Security's only institution of higher education. Academy cadets as well as faculty continue to undertake academic research in oil spill science, policy, and in marine engineering. The Academy also provides education to cadets in these fields.

The United States Coast Guard established a Center for Arctic Study & Policy (CASP) at the Academy to promote academic research on Arctic policy and strategy by facilitating collaboration, partnerships, and dialogue among specialists from academia, government, tribal organizations, non-governmental organizations (NGOs), industry, and the USCG. CASP serves as an operationally-focused academic think tank to promote research, broaden partnerships, and educate future leaders about the complexities of this unique region. Through collaborative efforts, the Center will promote effective solutions to address present and future Arctic maritime challenges as the Coast Guard increases its Arctic presence.

3.4.11 University of New Hampshire (UNH) Oil Spill Centers

UNH in Durham, NH, administers the Coastal Response Research Center (CRRC) and the Center for Spills in the Environment (CSE). CRRC was established in 2004 as a partnership between the NOAA Office of Response and Restoration (OR&R) and UNH. The CRRC partnership stimulates innovation in spill preparedness, response, assessment, and recovery strategies. The primary purpose of the CRRC is to bring together the resources of non-governmental scientists and the field expertise of OR&R to conduct and oversee basic and applied research, conduct outreach, and encourage strategic partnerships in spill response, assessment and restoration.

The CSE expands the scope of interaction and cooperation with the private sector, other governmental agencies and universities. The CSE involves individuals and institutions, public and private, at local, regional, national and international levels in identifying needs, evaluating and demonstrating promising technologies, and fostering their use as part of new, integrative approaches to response and restoration.

3.4.12 Woods Hole Oceanographic Institution (WHOI)

WHOI is a non-profit oceanographic research organization with a mission to explore and understand the ocean and to educate scientists, students, decision-makers, and the public. WHOI scientists and engineers maintain expertise across a range of oceanographic research areas. They work collaboratively within and across six research departments to advance knowledge of the

ED_001324_00000360-00087

global ocean and its fundamental importance to other planetary systems. WHOI research provides information of value to a wide range of ICCOPR research areas including pre-spill baseline studies, injury assessment and restoration, and multiple response research areas.

3.5 International Efforts

Oil pollution is a global issue and requires international cooperation and research to address. ICCOPR and its members work cooperatively with other nations and international entities to conduct research and to better respond to oil spills.

3.5.1 Arctic Council

The Ottawa Declaration of 1996 formally established the Arctic Council as a high level intergovernmental forum to provide a means for promoting cooperation, coordination and interaction among the Arctic States, with the involvement of the Arctic indigenous communities and other Arctic inhabitants on common issues, in particular issues of sustainable development and environmental protection. Arctic Council member states are: Canada, Denmark (including Greenland and the Faroe Islands), Finland, Iceland, Norway, Russian Federation, Sweden, and the United States.

The Council established a series of guidelines intended to define a set of recommended practices and outline strategic actions for consideration by those responsible for regulation of offshore oil and gas activities (including transportation and related onshore activities) in the Arctic. The goal is for regulators to identify the key aspects related to protection of human health and safety and protection of the environment for the management of offshore activities, remaining sufficiently flexible in the application of these regimes to permit alternative regulatory approaches. In May, 2013, all member agencies of the Arctic Council signed the "Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic," providing support for interactions between all eight parties relative to response and preparedness. The eight Arctic nations have different systems with different emphases on the division of responsibility between the operator and the regulator. The Council's goal is to assist regulators in developing standards that are consistently applied and enforced for all offshore Arctic oil and gas operators.

The Council established an Emergency Prevention, Preparedness and Response Working Group (EPPR) to addresses various aspects of prevention, preparedness and response to environmental emergencies in the Arctic. The goal of the EPPR Working Group is to contribute to the protection of the Arctic environment from the threat or impact that may result from an accidental release of pollutants or radionuclides. In addition, the Working Group considers questions related to the consequences of natural disasters.

ED_001324_00000360-00088

3.5.2 Australia

Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO) helps to unlock Australia's offshore oil and gas resources through research focused on the safe, efficient and sustainable use of their marine natural resources. CSIRO works with industry, government agencies, and academia to provide scientific knowledge and advice for offshore oil and gas; it conducts research and provides advice on the environmental, economic and social factors associated with the entire oil and gas value chain (CSIRO 2015).

The primary objective for Australia is to develop the knowledge and technology to prevent marine incidents and understand pre-spill ecosystems so should an incident occur Australia is prepared to respond effectively. CSIRO has conducted a significant amount of research in a wide variety of areas that support a broad array of prevention and response initiatives. Recent research projects include:

- BLUElink ocean forecasting technology;
- Hydrocarbon sensor arrays to monitor the movement of hydrocarbons during an oil spill;
- Hydrocarbon fingerprinting technique;
- The Hydrates flow loop simulation techniques to help to prevent pipeline blockages;
- Microbial degradation research;
- Biomarker research;
- Dispersant assessments; and
- Ecotoxicology assessments.

The Australian Maritime Safety Authority (AMSA), a federal government self-funded maritime safety agency established in 1990, is responsible for providing a national response capability for marine pollution. The AMSA administers the "National Plan to Combat Pollution of the Sea by Oil and other Noxious and Hazardous Substances", a cooperative arrangement between the federal, state and northern territory (NT) Governments and the shipping, oil exploration and chemical industries, emergency services, and fire brigades.

The oil industry maintains resources for spills occurring at their facilities. For incidents that may require beyond individual company capabilities, the Australian Institute of Petroleum (AIP) through its Australian Marine Oil Spill Centre (AMOSC) subsidiary has established the AMOS Plan formalizing mutual aid arrangements among member companies.

3.5.3 Canada

Environment Canada (EC) is a diverse science-based organization that implements the Government of Canada's environmental agenda. It provides science and technology to support decisions about the environment. The EC conducts and publishes 80 percent of its research in collaboration with external researchers. The EC operates 15 research institutes and laboratories,

ED_001324_00000360-00089

seven storm prediction centers, and 32 water survey offices. The EC has worked with EPA, MMS (now BSEE), and the Navy to conduct oil pollution research at the Ohmsett facility since the early 1970s.

The Department of Fisheries and Oceans Canada (DFO) has Canada's most complex and comprehensive science programs, in terms of function and geography. Its program areas applicable to oil pollution research address ecosystem effects of energy production and operational oceanography. The DFO's research on ecosystem effects addresses expanded energy development in Canada, mainly offshore oil and gas, hydroelectricity, and oil sands. The DFO's operational oceanography programs study oceanic processes and circulation patterns to predict the ocean's present and future state, and include ocean modeling, ecosystem modeling, and near-shore processes.

3.5.4 Centre of Documentation, Research and Experimentation on Accidental Water Pollution (CEDRE)

CEDRE is a not-for-profit association created as part of the measures taken in the aftermath of the Amoco Cadiz oil spill. CEDRE's headquarters, technical facilities and the majority of its personnel are based in Brest, Brittany, France. It provides advice and expertise to the authorities responsible for oil spill response for marine waters and inland surface waters. CEDRE's advice and expertise is available to foreign authorities or private companies. CEDRE conducts its own research projects and contributes to French and international research programs. Their main research and development activities focus on themes of: enhancing knowledge in the field of spill response; fate of oil and chemicals on the surface and in the water column; response equipment and product assessments; and spill impact and post-spill monitoring.

3.5.5 China

The China Maritime Safety Administration (MSA), part of the Ministry of Transport, has the mandate to investigate and respond to marine pollution incidents in Chinese waters. The China MSA headquarters in Beijing provides central control with 14 subordinate bureaus and about 100 local branches along the coast and the Yangtze River. In recent years, China promulgated a series of new pollution regulations relating to ships, which progressively came into force in the period 2010-12. These cover a wide range of issues, including oil pollution response planning, pre-spill clean-up arrangements, and the emergency handling of pollution accidents. Regulations have also introduced a domestic ship-source oil pollution compensation fund.

3.5.6 European Union (EU)

Since 1978, the EU has played a vital role in the response to marine pollution and today its role has become even greater with the response coordination ensured by its European Response

ED_001324_00000360-00090

Coordination Center (ERRC) and with marine pollution preparedness and response services provided by the European Maritime Safety Agency (EMSA).

EMSA assumes the leading role in ensuring a uniform and effective level of maritime safety, maritime security, prevention of and response to pollution caused by ships as well as response to marine pollution caused by oil and gas installations, and provide technical and scientific assistance to the European Commission and member states. EMSA manages a network of standby at-sea oil spill recovery vessels based in all the regional seas of Europe. These normally commercial vessels that cease their normal activities and quickly move to the scene of the oil spill upon request. The agency also provides satellite imagery for detection and monitoring of oil spills, pollution response experts to give operational and technical assistance, and information service for chemical spills at sea.

In September 2008, the European Commission, the EU's executive body, issued their Communication on 'A European Strategy for Marine and Maritime Research' delineated an action plan for better integration of research between the maritime and marine communities in order to address the problems of marine degradation caused by human activities and develop new technologies for sustainable development of maritime activities.

The European Commission is currently funding projects aimed at developing new technologies to mitigate the effects of pollution in the seas and oceans. The 'Argomarine' project ('Automatic oil spill recognition and geopositioning integrated in a marine monitoring network') is one example.

3.5.7 France

Oil represents approximately one-third of France's total primary energy consumption and that share has been falling over the past 10 years. France imports crude oil through three major sea ports (Marseille, Le Havre, and Saint-Nazaire). France has very little domestic natural gas production, and since the French government banned the use of hydraulic fracturing, France imports natural gas through a variety of cross-border pipelines from the Netherlands, Norway, and Russia. France also imports liquefied natural gas (LNG) from countries around the world, notably Algeria , Nigeria, Qatar, and Egypt.

Response arrangements are governed by the "at sea pollution response" section of ORSEC MARITIME (Organisation de la Réponse de SÉcurité Civile), France's civil defense plan. Responsibility for preparing for and conducting clean-up operations at sea lies with one of three Maritime Préfets (one for the Mediterranean Sea, one for the Atlantic and one for the North Sea/Channel). The Maritime Préfet will work in cooperation with the Secrétariat Général de la Mer who has the authority to access the various stockpiles of equipment. Coordination of sea and shoreline clean-up would be supervised locally by a permanent conference with representatives of the Maritime Préfet and the Préfet of the particular Department concerned.

ED_001324_00000360-00091

3.5.8 Kill-Spill

Kill-Spill is an EU-funded research program with the mission to develop highly efficient, economically- and environmentally-viable biotechnological solutions for the clean-up of oil spills caused by maritime transport or offshore oil exploration and related processes. The program will deliver innovative biotechnological tools for oil spills remediation.

These new developments include biosensors to monitor hydrocarbon degradation, new environmentally-friendly dispersants and adsorbents, combined microbial and additives formulations, multifunctional bioremediation agents, and tools for sediments decontamination. The impact and toxicity of these newly developed products will be evaluated; and they will be validated in mesocosms and on actual oil spills.

3.5.9 Mexico

A National Contingency Plan was developed in 1981 by a sub-committee of the Mexican Inter-Departmental Commission for Environmental Health. It aims to establish a national response network and provide overall coordination of resources in the event of a spill. The Mexican navy maintains a regional and local organizational structure to implement the National Plan at these levels. Under the General Law of Ecological Equilibrium and Environmental Protection (LEGEEPA), overall responsibility for oil pollution matters in Mexican ports and territorial waters rests with the Mexican navy. Response to a spill is likely to be initiated through the Navy's Marine Environment Protection Division (PROMAM). Assistance is also likely to be sought from the national oil company, Petróleos Mexicanos (PEMEX).

3.5.10 Norway

As a major energy nation, Norway has a particular responsibility to ensure an adequate energy supply and to develop knowledge and technology for efficient and sustainable energy systems. Norway has significant expertise in petroleum and hydropower science and engineering. In addition, Norway is conducting important research efforts in the field of environment and climate research. Despite extensive recovery of petroleum resources during the past 30 years, the petroleum industry still represents a large potential for future value creation in Norway. Research and technological innovation, combined with strict environmental regulations and other policy instruments, are needed to make the environmental impact of the exploration and production of oil and gas as small as possible.

The Norwegian Government's goal is to be a pioneer in developing an integrated, ecosystem-based management regime for marine areas. The purpose of this management plan is to provide a framework for the sustainable use of natural resources and ecosystem services derived from the North Sea and Skagerrak and at the same time maintain the structure, functioning, productivity

ED_001324_00000360-00092

and diversity of the area's ecosystems. Norway utilizes its major universities to conduct major research programs with respect to oil and gas.

3.5.11 Russia

The Federal Agency of Maritime and River Transport, part of the Ministry of Transport, is the federal executive body with responsibility for preparedness and response for oil spill incidents in Russia. Oil pollution response is assigned to the State Marine Pollution Control, Salvage and Rescue Administration (MPCSA). The MPCSA is responsible for the Marine Rescue Coordination Centres (MRCC), which serves as the focal point for communication during marine spill incidents at the regional level. The "Federal Contingency Plan on Oil Spill Prevention and Response at Sea" was adopted by the Ministry of Transport, the Ministry of Natural Resources and the Ministry of Civil Defense, Emergencies and Disaster Response (EMERCOM) in July 2003. The Plan complies with IMO Guidelines on contingency planning. There are three levels of planning: local, regional and federal. Ports, oil terminals, and harbors have local contingency plans and capabilities which, if exceeded, can be supplemented by regional plans and resources.

3.5.12 SINTEF

SINTEF is the largest independent research organization in Scandinavia, which operates in partnership with the Norwegian University of Science and Technology (NTNU) in Trondheim. NTNU personnel work on SINTEF projects, and many SINTEF staff members teach at NTNU. SINTEF is known worldwide for its work on oil spills, dispersants, and is one of the world's largest independent research organizations within the oil spill research community and offers expertise in many areas, including:

- Studies of oil weathering;
- Characterization of oil spills including thickness and chemistry;
- Oil spill identification - "fingerprinting";
- Marine environmental technology development;
- Surface water chemistry;
- Net Environmental Benefit Analysis (NEBA) oil spills in the Arctic; and
- Subsea and deepwater releases.

3.5.13 United Kingdom (UK)

The Department of Energy and Climate Change (DECC) works to insure that the UK has secure, clean, affordable energy supplies and promotes international action to mitigate climate change.

DECC is a ministerial department, supported by nine agencies and public bodies. The Oil and Gas Authority, an executive office of the DECC, works with government and industry to make sure that the UK gets the maximum economic benefit from its oil and gas reserves. The Oil and

ED_001324_00000360-00093

Gas Authority is responsible for regulating offshore and onshore oil and gas operations in the UK including:

- Oil and gas licensing;
- Oil and gas exploration and production;
- Oil and gas fields and wells;
- Oil and gas infrastructure; and
- Carbon capture and storage (CCS) licensing.

The Maritime and Coastguard Agency (MCA) is the UK's authority responsible for the provision of response procedures designed to deal with any emergency at sea that threatens or causes actual pollution. The national contingency plan for marine pollution from shipping and offshore installations sets out revised procedures for incident response. The national contingency plan ("National Contingency Plan for Marine Pollution from Shipping and Offshore Installations") underwent a major review in 2000, was revised again in 2006 to take advantage of lessons learned during actual incidents and major exercises, and is currently under review. MCA develops and participates in maritime exercises designed to maintain the operational readiness of its staff and equipment. The Counter Pollution and Response Branch also organizes training courses for local authorities to prepare their staff when responding to shoreline pollution.

3.6 Non-Federal Oil Pollution Testing Facilities

Several non-federal facilities provide opportunities for oil pollution testing.

3.6.1 Bedford Institute of Oceanography Center for Offshore Oil, Gas and Energy Research (BIO COOGER)

The DFO Canada's BIO COOGER, located in Dartmouth, Nova Scotia, maintains a wave tank facility for oil pollution research. Each tank measures 32 m long, 0.6 m wide, and 2 m high (1.5 m water depth; 28,800 L volume). Water from the Bedford Basin of Halifax Harbor is pumped into the tanks through a coarse (25 μm pore size) and fine (5 μm pore size) serial filtration system. The tanks are capable of generating various types of wave energies in either static or flow-through mode. Breaking and non-breaking waves (computer-controlled flat-type wave maker) provide mixing energies to achieve dispersant effectiveness similar to that of field conditions. The tanks are equipped with subsea injection systems from pressurized, heated canisters. Experiments benefit from the ability of the tanks to be drained and cleaned (tank walls, bottom, wave maker and absorbers) after each experiment to remove all oil and surfactants.

3.6.2 CEDRE Technical Facilities

CEDRE's technical facilities cover 300 acres and constitute a completely watertight area, which includes a man-made beach, water body, and a deep-water basin. These facilities allow full scale

ED_001324_00000360-00094

simulation of real life spills in an environmentally friendly manner. The CEDRE Experimentation Column (CEC) is a tool to study the behavior of a substance as it rises up or settles through the water column. The facilities include a flume tank, or Polludrome, that is designed to simulate offshore, shoreline and river conditions on a pilot scale. The facilities also include a greenhouse for experimentation on living organisms.

3.6.3 Churchill Marine Observatory.

A multi-government, multi-university research centre is being developed in Churchill, Manitoba, Canada. The Churchill Marine Observatory will be a multidisciplinary research facility where researchers will study the detection, impact and mitigation of oil spills in sea ice and investigate issues facing Arctic marine transportation. The research will help address technological, scientific and economic issues pertaining to Arctic marine transportation and oil and gas exploration and development throughout the Arctic. The facility is scheduled to open in 2017.

3.6.4 Ocean Coastal Research Engineering (OCRE)

The National Research Council of Canada's OCRE assists industry and government to develop solutions to engineering challenges within ocean, coastal and river environments with a particular focus on harsh and extreme conditions. The approach includes physical and numerical modeling, engineering analysis, technology development, as well as full scale experiments and field work conducted with the support of a comprehensive suite of world-class model test basins and tanks capable of reproducing a wide range of ice, wave, current and wind conditions. OCRE provides technology and facilities to support problems related to: the Arctic; marine infrastructure, and; marine vehicles. OCRE maintains several testing facilities that provide real world conditions:

- Coastal wave basin;
- Offshore engineering basin;
- Multidirectional wave basin;
- Large area basin;
- Ice tank;
- Coastal wave basin; and
- Multidirectional wave basin.

3.6.5 PRCI Technology Development Center

The Pipeline Research Council International (PRCI) opened its new Technology Development Center (TDC) in Houston, Texas in July 2015. The TDC covers eight acres, including a state-of-the-art pull test facility, an over 20,000 sq. ft. workshop, and test facility with an additional 9,000 sq. ft. of office and meeting space. The TDC will provide the industry with an independent third

ED_001324_00000360-00095

party site to fully understand the capabilities of current pipeline tools and to guide the development of new technologies needed to push toward that goal.

3.6.6 SINTEF Sealab

SINTEF Sealab is a cooperative effort of SINTEF Fisheries and Aquaculture and the Norwegian University of Science and Technology (NTNU) and offers a variety of experimental facilities covering the key elements of marine food webs. The emphasis is on developing experimental systems that simulate natural processes and mimic the fate, behavior and effects of pollutants in the recipient.

The SINTEF Sealab provides:

- Cold climate laboratories with basin facilities;
- Chemical and microbiological laboratories;
- Ecotoxicological laboratories;
- Oil spill research facilities;
    - Shoreline basins;
    - Simulated seabed basin;
    - Dynamic and static test basins/systems; and
    - Tank facilities for subsea studies.

3.6.7 Southwest Research Institute (SwRI)

The Chemical Engineering Department at SwRI specializes in finding solutions to difficult problems and providing exacting services. Staff expertise and world-class facilities provide services such as wastewater cleanup, catalyst screening, pilot plant design and operation, reaction kinetics and enthalpy analyses. Typical services include;

- Analytical testing;
- Personal safety equipment testing;
- Waste disposal characterization; and
- Waste cleanup.

An Ocean Simulation Lab at SwRI provides government and commercial clients with quality facilities and experienced staff to conduct testing and performance evaluation services in more than 10,500 square feet of air conditioned laboratory space and 12 ocean simulation test chambers that range in pressures to 30,000 psig and sizes to 90-inch diameter. Capabilities are available for the complete evaluation of your marine products including: development of testing procedures; test design; test setup; and static and cyclic structural/pressure/thermal testing.

3.6.8 Texas A&M Corpus Christi Center for Coastal Studies (CCS)

The CCS comprises 10,000 square feet of office and laboratory space within the Carlos F. Truan

ED_001324_00000360-00096

Natural Resources Center. The CCS facilities include:

- Plankton laboratory;
- Marine ecotoxicology laboratory;
- Marine invertebrate environmental physiology laboratory; and
- Benthic ecology laboratory.

The National Spill Control School (NSCS) was established in 1977 and was named as a consulting, training, and research resource for the National Response Team in OPA 90. The NSCS offers specialized hands-on OSHA mandated training for professionals and workers in the oil spill, hazardous material (HAZMAT), and emergency management industries as well as others in exploration, production, and transportation who deal with spill prevention, planning, and response.

ED_001324_00000360-00097

THIS PAGE INTENTIONALLY LEFT BLANK

ED_001324_00000360-00098

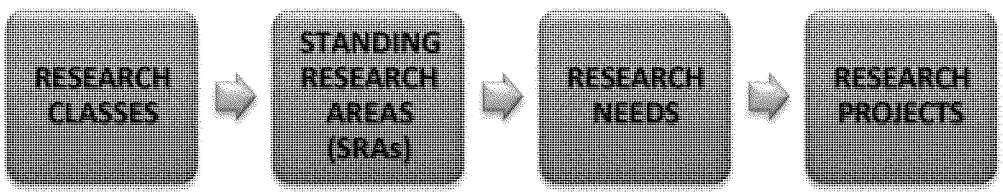
4. Structuring Oil Pollution Research

The field of oil pollution research covers an array of subjects depending on the interests and needs of researcher or the research funding institution. The focus of oil pollution research extends well beyond removing or mitigating spilled oil from the environment to involve other themes such as developing new means for preventing oil discharges, assessing impacts on the natural and human environment, and restoring an affected ecosystem as best as possible to pre-spill conditions. Each of these areas includes a broad spectrum of subjects and topics for oil pollution research, which creates challenges for tracking research activities.

ICCOPR established a new Oil Pollution Research Categorization Framework to provide a common language and planning framework that would enable researchers and interested parties to identify and track research in each topic area. This new approach will be used by ICCOPR to better facilitate communication with Congress, Federal partners, industry, academia, and the general public. It provides a basis for the 15 member organizations to translate their different research needs and perspectives into one federal voice through ICCOPR.

4.1 Introduction to the Oil Spill Research Framework

The Categorization Framework provides a hierarchy of terms to classify, discuss, and prioritize oil pollution research. It is analogous to the taxonomic classification of organisms (i.e., Kingdom, Phylum, Class, Order, Family, Genus, and Species). ICCOPR's oil pollution research classification scheme contains four elements:



Research Classes and Standing Research Areas (SRAs) are generally fixed while the Research Needs and Projects assigned to the SRAs will vary over time. Each of these categorization terms is defined later in this chapter. The following example shows how this new classification scheme works for one project:

Class: Prevention
SRA: Pipeline Systems
Need: Develop advanced pipeline break sensing technologies
Project: Smart Pipeline Network – Seal Sensor System (PHMSA DTRT57-12-C-10050)

Chapter 9 of this OPRTP provides a prioritized list of current Research Needs suggested for 2015-2012 for each SRA. Throughout the six-year life of this Plan, ICCOPR will monitor relevant planned, ongoing, and completed Projects to gauge how government, NGOs, industry,

ED_001324_00000360-00099

and academia are addressing the published priority Research Needs. ICCOPR will use this information to provide updates on research progress in the Biennial Reports to Congress and to modify or replace existing Research Needs. At the end of the 6-year cycle, ICCOPR will revise the OPRTP for the next 6-year cycle and include a summary of the previous version's accomplishments and a new set of prioritized Research Needs.

4.2 Classes

The overarching Oil Pollution Research Categorization Framework includes four Classes that represent the general groupings of oil spill research: Preparedness, Prevention, Response, and Injury Assessment and Restoration. Figure 4-1 depicts this framework of Classes. It shows that the research in each Class can inform and support the research from other Classes and that the Preparedness Class plays a central role in supporting the others. ICCOPR's member organizations may conduct or support research across one or multiple Classes depending on their specific mission, regulatory responsibilities, and/or expertise.

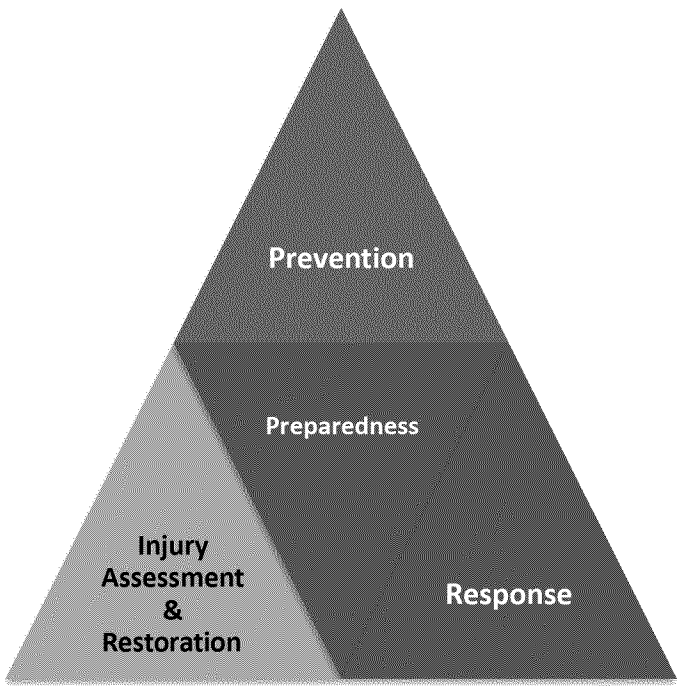


Figure 4.1. The Oil Pollution Research Categorization Framework Classes

ED_001324_00000360-00100

The following section describes the research pertinent to each Class.

Prevention Class

Research that supports the development of practices and technologies designed to predict, reduce, or eliminate the likelihood of discharges, or minimize the volume of oil discharges into the environment.

Preparedness Class

Research that supports the activities, programs, and systems developed prior to an oil spill to improve the planning, decision-making and management processes needed for responding to and recovering from oil spills.

Response Class

Research that supports techniques and technologies that address the immediate and short-term effects of an oil spill and encompasses all activities involved in containing, cleaning up, treating, and disposing oil in order to: 1) maintain safety of human life; 2) stabilize a situation to preclude further damage; and, 3) minimize adverse environmental and socioeconomic effects.

Injury Assessment and Restoration Class

Research that involves the collection and analysis of information to: 1) evaluate the nature and extent of environmental, human health, and socioeconomic injuries resulting from an incident; 2) determine the restoration actions needed to restore natural resources and their services to pre-spill conditions; and, 3) make the environment and public whole after interim losses.

4.3 Standing Research Areas (SRAs)

The backbone of ICCOPR's oil pollution research categorization scheme is the SRAs that exist within the four Classes. The SRAs represent the most common research themes encountered for oil spills – many of which have been studied over several decades. Their topical content supports the themes of the Classes for which they are assigned. For this OPRTP, ICCOPR identified 25 SRAs within the four Classes. The number of SRAs will, for the most part, remain consistent; however, changes may occur based on emerging research themes. Specifically, ICCOPR is monitoring on-going activities to determine whether the current SRA structure adequately addresses worker exposure and hydraulic fracturing issues. If not, ICCOPR may add additional SRAs.

Table 4.1 lists the current SRAs by Research Class. ICCOPR uses a numbering scheme to facilitate tracking of research within each SRA (1000 – 4400). The numbering series associated with each SRA is included in the SRA descriptions in the subsections below and in Appendix A.

ED_001324_00000360-00101

Table 4-1. Standing Research Areas assigned within the four research Classes.

Prevention	Preparedness	Response	Injury Assessment & Restoration
• Human Error Factors • Offshore Facilities and Systems • Onshore Facilities and Systems • Waterways Management • Vessel Design • Drilling • Rail & Truck Transportation • Pipeline Systems	• Pre-spill Baseline Studies • Response Management Systems	• Structural Damage Assessment and Salvage • At Source Control and Containment • Chemical and Physical Behavior Modeling • Oil Spill Detection and Surveillance • In- and On-water Containment and Recovery • Shore Containment and Recovery • Dispersants • In-situ Burning • Alternative Countermeasures • Oily and Oil Waste Disposal • Bioremediation	• Environmental Impacts and Ecosystem Recovery • Environmental Restoration Methods and Technologies • Human Safety and Health • Sociological and Economic Impacts

4.3.1 Prevention SRAs

ICCOPR has identified eight SRAs that address development of practices and technologies designed to reduce or eliminate the likelihood of oil discharges into the environment and to reduce the potential for consequences of any oil discharges on life, property, and the environment.

4.3.1.1 Human Error Factors [1000 series]

Description: This SRA focuses on how human performance and factors contribute to accidents in the oil production/transportation system. It includes the development of advanced methods and systems for training operational personnel, basic research on operating personnel performance in preventing oil spills (safe navigation on vessels, proper oil transfer practices, analysis/evaluation of equipment monitoring systems, decision-making processes), and the

ED_001324_00000360-00102

development of methods and technologies to evaluate the ability and knowledge of operating personnel in performing their duties. This may extend to evaluation of the overall management culture and its ability to foster the appropriate organizational safety, preparedness and response operating environment.

Importance: A significant proportion of accidents in oil production/transportation and related industries are attributed to "human errors." A Coast Guard analysis of oil spill causes found that human error factors were responsible for more than one third of non-casualty discharges from ships (USCG, 2012). Non-casualty spills typically include spills from actions such as overfilling of tanks and equipment failures not related to a vessel accident. More than half of these human errors were due to inattention, but also resulted from inadequate training, management and organizational culture. Identifying and solving various human error factors can significantly reduce oil spills at far less cost than more expensive technology-based solutions once the oil is discharged into the environment.

4.3.1.2 Offshore Facilities and Systems [1100 series]

Description: This SRA includes: offshore exploration and development wells, platforms, and well control systems; the methods, techniques, and equipment for system reliability inspections; systems to detect, prevent, and mitigate oil and gas discharges; and equipment to regain control of a well blowout or any other accidental discharge. It also includes transfer equipment, storage units, and piping used to transfer oil within the offshore system and connect the system to transfer pipelines. This technology is relevant for the multiple operating environments of exploration and production activities (e.g., Arctic, shallow, deep and ultra-deep waters).

Importance: Offshore oil and gas facilities are responsible for a significant percentage of oil and natural gas production in the U.S. Globally, three of the ten largest oil spills came from offshore facilities, including the *Deepwater Horizon* oil spill, the largest marine oil spill in U.S. history. (Oil & Gas IQ, 2015) Important new and potential offshore discoveries will continue to be made in frontier environments of increasingly deeper waters and arctic conditions, creating new technical challenges. Research is needed to determine the effects of deepwater conditions, ice forces, and increasingly severe weather conditions (hurricanes, blizzards, etc.) on offshore structures built in these environments. Research is also needed to address issues due to the aging of existing offshore facility infrastructure. Older well spills result from both internal damage (chemical/mechanical corrosion) and external damage (e.g., electrochemical corrosion, mechanical damage, and structural failures). Advanced system designs and the effective application of improved inspection technologies have the potential to detect problems before failures occur, while improved leak detection and well control systems have the ability to identify leaks when they are still small and can be quickly isolated and mitigated to minimize spillage.

ED_001324_00000360-00103

4.3.1.3 Onshore Facilities and Systems [1200 series]

Description: This SRA includes designs, techniques, operational procedures and equipment for fixed onshore facilities including wells. It covers inspections and systems to detect, prevent, and mitigate oil and gas discharges from the facilities and their systems, including transfer equipment, storage, and piping.

Importance: A significant number of discharges occur from onshore facilities, coastal bunkering facilities, and cargo transfer operations. Studies conducted by industry estimate that almost a third of oil discharges between 1998 and 2007 occurred at inland facilities subject to EPA's Spill Prevention, Control, and Countermeasures (SPCC) program (API, 2009). Advanced system designs and the effective application of improved inspection technology have the potential to detect, or predict the likelihood of potential failures before they occur. Improved leak detection systems have the ability to identify leaks quickly, potentially reducing the size and impacts of the discharge. It is also important to understand the ability of onshore structures to withstand changes in soil bearing capacity caused by changes in the climate and other factors.

4.3.1.4 Waterways Management [1300 series]

Description: This SRA includes methods, equipment, and integrated systems designed to improve navigation at sea and in ports, rivers, and inland waterways. It includes on-board navigation systems, such as integrated navigation and bridge systems and collision avoidance systems. It also includes systems external to the vessel, such as vessel traffic and tracking systems, navigational aids and piloting systems, as well as includes general research into navigation risks, the effects of navigational safety programs, and the development of decision support tools for waterways management efforts. This SRA includes development of navigational channel maintenance programs and analysis of voyage pre-planning processes.

Importance: A navigation-related marine casualty, such as a collision, allision, or grounding, causes most major spills from vessels underway. Collisions are when two moving vessels run into each other. Allisions are when a moving vessel strikes a stationary object such as a bridge abutment or an anchored ship. Groundings occur when a vessel runs ashore or strikes the bottom. According to ITOPF (2015), these causes accounted for 59 percent of large tanker spills in open waters and about 99 percent of tanker spills in restricted or inland waters. Improving navigation and waterways management, particularly in congested port areas and the approaches to ports, can prevent many of these accidents. In addition, improved waterways management can facilitate safe navigation through the Arctic and other ice-infested waterways as shipping increases in these areas.

4.3.1.5 Vessel Design [1400 series]

Description: This SRA includes the development, physical and numerical modeling, and testing of advanced tanker and barge designs to make these vessels less susceptible to damage and less

ED_001324_00000360-00104

likely to spill their cargoes into the waterways if an accidental grounding, collision or structural failure occurs. This SRA also includes research on non-tank vessel designs (e.g., double-hulled fuel and lube oil tanks) to minimize the possibility of spillage from collisions, allisions, and groundings.

Importance: OPA 90 required a phased in double-hull program for all tank vessels entering U.S. ports with all remaining tank barges having double hulls by January 1, 2014. Additional research and development is needed to verify these design approaches and investigate other measures to reduce oil spillage from tank vessel damage. IMO Regulation 12A established double-hull fuel tank construction for certain vessels. Congress has likewise considered double-hull fuel tank requirements for non-tank vessels to minimize the possibility of discharges from groundings, collisions, and allisions. In addition, the anticipated increase in shipping in the Arctic seas has created a need to evaluate and develop new vessel designs to ensure safe operations under arctic conditions where ice filled waters and icing conditions around ships and structures create additional structural stresses and corrosion hazards.

4.3.1.6 Drilling [1500 series]

Description: This SRA focuses on: the design, construction, and placement of wells (shallow, deepwater and ultra-deepwater, and onshore); materials, sensors, and systems needed for offshore drilling and production platforms, and well heads/risers; and techniques and equipment for well and facility monitoring and inspection under extreme pressure and temperature environments. Also included are efforts aimed at understanding the chemical and physical characteristics for the full range of petroleum oils under varying conditions of pressure and temperature; predicting their phase/state, behavior and their physical interaction with other materials in the environment (e.g., rock and sediments); and their impact on engineered systems. Example issues include: early kick detection; systems for communicating and responding to changes in downhole parameters; strategies and methods for training operational personnel on the use of advanced technology; systems to detect and prevent oil and gas discharges; and well-head systems and equipment to control wild wells and cap well blowouts.

Importance: The trend toward drilling in deep- and ultra-deepwater and Arctic conditions increases the difficulty in responding to a well blowout and oil spill. Systems to improve safe drilling operations and prevent loss of well control need to adjust as drilling operations advance into deeper waters and the Arctic. Of key importance is the ability to detect changes in rock and fluid properties at the bit-rock interface or even in the rock and fluids ahead of the bit so that measures can be taken to bring the well under control. Advanced system designs and materials, and the effective application of improved sensors, monitoring systems, and more in depth inspection technology have the potential to detect and measure well integrity and prevent failures, while improved leak detection and other systems have the ability to identify leaks while they are still small and can be quickly isolated and mitigated to prevent or minimize spillage. A fundamental understanding of the chemical and phase behavior, especially under extreme

ED_001324_00000360-00105

conditions of pressure and temperature and effects on engineered systems is critical to effective well construction planning, long-term monitoring, and long-term well integrity.

4.3.1.7 Rail & Truck Transportation [1600 series]

Description: This SRA includes the development and testing of rail and truck transport system designs, operations, and infrastructure to make oil tanks less susceptible to damage and loss of cargo during normal operations, train accidents and derailments, or truck accidents. This SRA includes evaluation of vehicle designs, construction materials, spill prevention devices, and loading/unloading systems and equipment. It also includes evaluations of: the physical and chemical characteristics and behavior of the crude oils being shipped, the effects of those characteristics on the tanks during operations and under accident conditions, and systems to control these characteristics. This SRA also includes evaluations of safety systems and processes to: manage the movement and composition of trains and trucks carrying crude oil, prevent accidents and derailments, select preferred shipping routes, and respond safely to an oil spill emergency.

Importance: North America has experienced a rapid expansion in crude oil supply due to the growing non-conventional oil production activities such as the oil sands products (OSP) from Canada and shale oil from the Bakken fields in North Dakota and Montana as well as the Eagle Ford and Permian Basins in Texas. This expansion in supply resulted in a four-fold increase in the number of crude oil rail car shipments in the past five years. Similarly, crude oil imports from Canada have increased more than 20-fold since 2011. A series of major US crude oil unit train accidents and the Lac Mégantic, Quebec disaster, which resulted in 47 deaths and destroyed much of the town, have underscored the need for safe rail transport of crude oil. The DOT has issued a safety warning that the crude oils being shipped by rail from the Bakken region may be more flammable than traditional heavy crude oil. In May 2015, the DOT issued a final rule to strengthen safety of tank cars transporting flammable liquids.

4.3.1.8 Pipeline Systems [1700 series]

Description: This SRA includes the development, operation, monitoring, and inspection of offshore and onshore pipeline systems used to transport oil between facilities. It covers the pipeline system design, procedures, and equipment for pipeline operations and inspection protocols to prevent, detect, and mitigate oil discharges. Pipeline research under this SRA also includes technologies to prevent (detection/characterization and repair of anomalies before failure) and detect failures, as well as monitor/control systems that can rapidly isolate and shut down operations in order to minimize spillage when failures occur.

Importance: A significant number of oil discharges occur from the more than 182,000 miles of hazardous liquid pipelines in the U.S. PHMSA (2015) pipeline spill statistics document that between 1995 and 2014, there were 2,694 significant hazardous liquid pipeline incidents, 2,614 (97 percent) were onshore. These incidents accounted for the discharge of about 2.2 million

ED_001324_00000360-00106

barrels and more than three billion dollars in property damages. Several major pipeline spills have occurred causing significant damage to aquatic environments and residential areas. Other pipeline spills in remote areas have gone undetected for long periods of time. Advanced system designs and the effective application of improved inspection technology have the potential to detect potential failures before they occur, while improved detection systems have the ability to identify leaks quickly, potentially reducing the size and effects of the discharge.

4.3.2 Preparedness SRAs

The two SRAs under the Preparedness Class cover research that: 1) supports the collection of baseline data needed to assess the effects of oil spills under the Injury Assessment and Restoration Class, and 2) develops information management tools and systems to improve the ability of response organizations and responders to collect and analyze information during an incident.

4.3.2.1 Pre-spill Baseline Studies [2000 series]

Description: This SRA includes research to characterize and analyze baseline data on the natural environment, human health, and socio-economic characteristics in areas at risk for oil spills. Research includes risk assessments conducted in areas involved in the oil production and transportation systems to identify locations most at risk from pollution events and therefore priority candidates for baseline studies. Baseline information and studies may include: location and population data on species and their habitats, especially ecologically sensitive species; the epidemiology/human health characteristics of people in potential impact areas; and potential community and economic impacts in these areas (e.g., tourism, commercial/recreational fishing, and seafood industry).

Importance: Having baseline information and data enables scientists to compare pre-and post-oil spill changes in natural, human health, and socio-economic systems to support response decision-making and post-spill damage assessments and restoration activities. It is common to conduct a credible post-spill environmental and economic damage assessment without pre-spill baseline information, using reference sites that were not contaminated for comparative studies. However, the availability of pre-spill baseline information makes the post-spill natural and socio-economic damage assessment task much easier, accurate, and more defensible. Essentially, the better environmental and economic systems are understood before a pollution event, the easier it will be to assess changes to those systems, estimate damage and develop appropriate restoration strategies afterward.

4.3.2.2 Response Management Systems [2100 series]

Description: This SRA includes analysis and development of systems to manage how data and information are collected, analyzed, documented, and shared between and among, the planning/preparedness and response communities, the Incident Command System (ICS), and the

ED_001324_00000360-00107

public. These systems are used to integrate diverse sets of narrative, graphic, and video information and many sets and types of raw and analyzed data. Examples of oil spill information systems include: ICS forms; computer systems; data management software and databases; Geographic Information Systems (GIS); routing, spill and incident management tracking systems; electronic mail and web content; documents, photographs, and video management and archiving systems; communication systems; public information messages and protocols; and graphical displays.

Importance: Information management and decision-making tools are critical to successfully planning for and managing a response and meeting external demands for information about an incident. These systems provide a tool for the incident command to obtain a common operating picture of an incident, to make resource management decisions, and to share appropriate information with all relevant parties. Improving the accuracy and timeliness of the data increases the ability of the incident command to stay abreast of changing situations. Efficient information systems also provide personnel with timely information to give to the public and media, which have a high demand for information to support the 24-hour news cycle.

4.3.3 Response SRAs

The Response Class of research includes 11 SRAs that support improvements to the activities, technologies, techniques, and equipment used during response operations. These SRAs cover all areas from oil detection, behavior modeling, cleanup, and waste disposal.

4.3.3.1 Structural Damage Assessment and Salvage [3000 series]

Description: This SRA includes the development of methodologies and equipment to assess the extent of damage to a stricken vessel caused by collision, allision, grounding, or improper hull stresses during cargo transfers or explosion. This area also includes development of methods and technology to graphically present the implications of various measures that can be implemented to stabilize the vessel's condition, reduce the potential for further pollution, and allow it to be moved safely for repairs or disposal.

Importance: A critical consideration in responding to a casualty is stabilizing the condition of the vessel to prevent loss of life, minimize loss of property, and prevent or minimize discharges of oil. To accomplish this, on-scene personnel must be able to rapidly assess the overall structural integrity and hydrodynamic stability of the vessel to determine the appropriate response measures.

4.3.3.2 At Source Control and Containment [3100 series]

Description: This SRA includes the development of methods, systems, and equipment for containing and recovering the oil at or from the source and for mitigating oil flow from a damaged vessel, onshore/offshore pipeline, and an exploration or production platform,

ED_001324_00000360-00108

temporarily abandoned (plugged) well, or well head once the spill has begun. Such technologies include well-head capping systems, remotely operated vehicles (ROVs) for subsea containment activities, and patching, plugging and sealing systems. This technology is applicable to all geographic/environmental areas (Arctic, terrestrial, water surface, subsurface shallow, and deep and ultra-deep water).

Importance: The logistical difficulties, enormous costs, and limited success experienced during on-water and shoreline cleanup operations make clear the advantages of containing or recovering oil within, or at least near, the source of the oil flow. Recent technological breakthroughs arose from experiences acquired during the 2010 *Deepwater Horizon* oil spill incident. Additional advances in this area could provide substantial return on R&D investment to contain/recover oil at the source and thereby reduce the extent of contamination and ecological and socio-economic impacts if a spill occurs.

4.3.3.3 Chemical and Physical Behavior Modeling [3200 series]

Description: This SRA includes laboratory and theoretical research and field studies aimed at understanding the behavior and characteristics of the full range of petroleum oils including: behavior and transport in the environment, partitioning of hydrocarbon constituents, and physical interaction with other materials in the environment (rock, sediments, and ice). It includes studies of oil behavior and changes throughout the water column from deepwater blowouts. There is particular interest in non-conventional oils such as those produced in the Bakken and Canadian Tars sands (diluted bitumen (dilbit) and synthetic bitumen (synbit)). It also includes the development and verification of numerical models to predict the surface and subsurface movement and weathering (i.e., spreading, evaporation, dispersion, and dissolution) of oil spills. This SRA also includes methodologies to provide accurate model input data to verify model outputs. This SRA includes development of user-friendly programs to enhance contingency planning and to serve as training aides for spill response teams. Models should be available for various spill scenarios at specific locations for different tidal, current, and weather conditions to pre-plan potential boom deployment strategies and estimate response resource needs.

Importance: Predicting the trajectory (movement) and the weathering of spilled oil, its resultant physical properties and behavior in the water, and the extent of contamination are all critical to identifying the appropriate mix of spill response equipment and countermeasures. A fundamental understanding of the fate (chemical behavior and transport) and effects of oil in the environment is critical to effective contingency planning, response operations management, long-term monitoring, and restoration. In addition, knowledge of longer-term fractionation and transport of hydrocarbons, coupled with potential effects on aquatic resources, provide valuable information to help focus monitoring efforts and develop environmentally-relevant restoration plans.

ED_001324_00000360-00109

4.3.3.4 Oil Spill Detection and Surveillance [3300 series]

Description: This SRA principally refers to methods and equipment for characterizing and monitoring oil pre- and post-implementation of response options, and the detection of unknown discharges. This SRA includes surface and subsurface oil spill surveillance including devices, sensors, and systems for detecting and tracking oil spills, determining the area and thickness of the oil slick, and measuring the physical properties of the oil. Examples of equipment considered in this area are: surface oil spill tracking buoys; airborne remote sensors and data analysis systems; fluorometers and light-scattering sensors; and satellite remote sensing data and on/in-water oil detection devices with the ability to conduct nighttime and low light recovery operations. It includes research that provides information to support development of monitoring protocols for subsea and surface responses or improvements to existing ones such as the NRT Atypical guidance or the SMART guidance, as applicable. This SRA also includes evaluation of techniques for autonomous sensing operations and reporting from remote locations where logistical challenges limit human accessibility.

Importance: Finding and characterizing areas of subsurface or submerged oil in onshore (inland) and offshore waters remains a significant research and technology need. Surveillance technologies provide opportunities to locate spills and their source, determine their extent and volume, provide important data to support response operations, and determine the effectiveness of response. The ability to locate concentrations of oil and track slick movements for countermeasures and cleanup planning supports response operations. Thickness and physical properties measurement allow responders to determine the feasibility of mechanical recovery, *in situ* burning and dispersant use. The data obtained from the surveillance can facilitate the efficient deployment of resources for response operations. Surveillance data from response operations can also be useful for improving and validating spill behavior models.

4.3.3.5 In- and On-water Containment and Recovery [3400 series]

Description: This SRA includes the development of methods, equipment, and materials for physically containing and removing oil from the surface of the water, the water column, or on the bottom of the sea/river bed. This SRA focuses on improving traditional equipment such as booms, skimmers, and sorbent materials, as well as developing new approaches to surface containment, and equipment and systems specific to containment and recovery of subsurface oils.

Importance: Mechanical recovery is often the preferred option to physically remove oil from the environment because the use of these devices to respond to oil spills generally does not pose the potential for additional environmental harm. Containment booms are subject to entrainment and splash over when they encounter certain current velocities or wave heights, thereby reducing their containment effectiveness. Developing new boom designs could improve oil containment across a wider range of environmental conditions, including ice-infested and brash-ice infested

ED_001324_00000360-00110

waters. Mechanical recovery is often the most viable recovery option since it is not subject to agency pre-approval requirements (as are the use of dispersant and *in situ* burning (ISB)). The total average on-water recovery effectiveness for larger spills ranges from 5-30 percent of the oil spilled depending upon the type of oil spilled, ambient conditions, and available equipment. Improvements in the speed of skimmer advance and encounter rates, onboard separation/decanting, and enhanced skimming abilities at higher speeds and wave heights, and rapid systems for temporary oil storage of skimmers could significantly improve mechanical recovery efficiencies. Existing technologies have limited success in recovering oil suspended in the water column or located on the sea/river bed.

4.3.3.6 Shoreline Containment and Recovery [3500 series]

Description: This SRA covers new methods, treating agents, and equipment for removing oil from shorelines, as well as mitigating the environmental impact of oil that cannot be removed. Specifically, this SRA includes water washing and flooding techniques, the use of chemical treating agents, and novel applications of mechanical removal techniques and equipment. It also includes analysis, evaluation and decision-making (risk and benefits) for the use of active shoreline oil removal techniques versus passive naturally-occurring processes.

Importance: Oil spills that impact shorelines often result in oiling of natural resources (e.g., beaches, marshes, coral reefs, mangroves) and man-made structures (e.g., breakwaters, seawalls, piers, vessels). Removing the oil or mitigating the impacts of the oil requires a range of viable technologies that can remove/mitigate the oil while minimizing environmental damage from the technology. Implementing technologies also requires knowledge of the relative benefits of foregoing cleanup activities and allowing natural processes to remove the oil.

4.3.3.7 Dispersants [3600 series]

Description: This SRA addresses the use of chemical products designed to interact with marine oil slicks by reducing the oil/water interfacial tension and breaking up the slick into tiny droplets with the aid of wave or other energy sources. Research areas for dispersants include: developing appropriate dispersant applications for cold weather and deep sea environments; increasing dispersant effectiveness for water surface and subsurface applications (e.g., effective on a wider viscosity and emulsification range, and calm sea conditions); reducing ecological effects of individual dispersant components and combined components in the water column; refining vessel, aircraft, and subsurface application methodologies and equipment; developing enhanced monitoring methods and systems for determining the effectiveness of surface and subsurface application of dispersants; determining how to distinguish physically versus chemically dispersed oil; studying the distribution and impact of the chemicals and dispersed oil in the environment; and understanding regional variations in dispersant performance and environmental effects. This SRA may include characterization to enhance the ability to predict dispersant effectiveness on various oil types and at varying application rates, including the

ED_001324_00000360-00111

effectiveness of dispersants on weathered/emulsified oils and in a range of water salinities. This SRA also encompasses studies to determine the suitability of subsea application of dispersants in the Arctic region where the unique conditions (e.g., shallow depths, water salinity, ice-infested water, under-ice discharges) could influence their fate and effects. An important supporting activity is the development of an information database on dispersant product effectiveness, application procedures, and effects. Since dispersants shift the risk from the surface to the water column, additional research is needed to address questions about the potential acute and chronic effects of dispersants on water column organisms and populations at various depths.

Importance: Dispersants are an important tool in spill response when it is critical to mitigate oil slicks, especially those that are large and offshore. Refinements in dispersant formulations to improve their effectiveness, reduce environmental effects, and/or increase understanding about their potential benefits and risks, can allow dispersants to remain a viable option, especially for large offshore spills and other areas where mechanical techniques can fall short in reaching desired levels of effectiveness to remediate spilled oil. Research is needed to address environmental tradeoffs, worker and public health exposures and provide the conditions under which they may be used appropriately.

4.3.3.8 In-situ Burning [3700 series]

Description: This SRA includes equipment and techniques required to ignite and sustain combustion of oil spills on the water, along shorelines, and on land. A source of ignition must be present for the mix of fuel (e.g., oil) and oxidant (e.g. oxygen) in a slick to burn. Because slick thickness is a key variable in determining whether the oil will burn, this research area includes development of equipment such as fire-resistant booms and herders to concentrate the slick thickness, and improved ignition devices. This SRA also includes developing knowledge of the conditions under which this equipment and technique can be applied effectively, including evaluation of use in frigid (i.e., Arctic) environments, where cold conditions and ice limit operational effectiveness of mechanical containment and recovery of spilled oil. This SRA also includes research to develop new methods to enhance burn efficiency and burn weathered, emulsified, and more viscous oils. Research into the production of residuals including soot and other ISB residues, and the techniques and equipment to recover these residues is also included in this SRA.

Importance: The *Deepwater Horizon* incident demonstrated that ISB is a very promising technique for removing large amounts of oil from the surface of the water. For example, on a single day (on June 18, 2010), 16 on-water ISBs resulted in removal of approximately 60,000 barrels of oil from the Gulf of Mexico (USCG, 2011). Another benefit of this technology is that it also reduces the extent of onshore disposal of recovered oil. In addition it can be an effective method of mitigating spills on land and in coastal areas by removing the spilled oil from the surface in lieu of the potential for damage caused by certain mechanical removal techniques or

ED_001324_00000360-00112

longer-term, passive natural degradation processes. An important consideration in Arctic regions is how soot deposition affects the thickness of snow and ice.

4.3.3.9 Alternative Countermeasures [3800 series]

Description: This SRA includes the development and use of various spill response chemicals to treat oil slicks on the surface of the water making the oil more amenable to other recovery techniques, such as mechanical recovery and ISB. These chemicals include solidifiers, herding agents, elasticity modifiers, shoreline pre-treatment agents, and emulsion treating agents (demulsifiers). Development activities include improving chemical formulations, refining application techniques, and conducting studies of effectiveness and environmental effects.

Importance: Alternative countermeasure employing chemicals to treat oil slicks are not frequently used but, in certain cases, can be very effective in improving oil recovery and oil impact mitigation. At present, the countermeasures included in this SRA would typically be used on smaller spills close to shore due to the logistics involved in using them. Their use for larger spills is currently limited. However, development of new formulations of these agents has the potential to increase their utility. Emulsion breakers used on recovered oil could decrease the amount of material for disposal.

4.3.3.10 Oily and Oil Waste Disposal [3900 series]

Description: This SRA includes study and development of analytical methods, procedures, equipment and techniques to manage and dispose of oil, oily water, oiled soils, and oiled debris recovered during both on-water and on land oil pollution incidents. Specific technologies include, but are not limited to, waste segregation, temporary storage, solidification and stabilization prior to landfill disposal or recycling, oil reclamation, incineration, and biological treatment (i.e., land farming and composting). It also includes techniques and equipment for onsite oil-water separation, filtration, and decanting operations that would reduce the volumes of oil/water material that would need to be handled, transported, and disposed.

Importance: Disposal of oil and oiled debris can be a significant problem during major spills, particularly in remote areas. Oil in water tends to emulsify (wave action results in water becoming incorporated into the oil forming "mousse"). Emulsified oil generally occupies a larger volume than the same amount of fresh oil, making waste disposal a significant issue during spill response. In addition to waste recovered during the active response, waste is also generated by decontamination activities, such as cleaning of oiled vessels, hard booms and skimmers, and mechanical shoreline cleanup equipment. Disposal of decontamination waste will likely include the oil, water, and cleaning agents, which further complicates waste disposal options. Research is needed to advance recycling opportunities and disposal treatment technologies for recovered oil waste and reduce the overall waste following a significant oil spill.

ED_001324_00000360-00113

4.3.3.11 Bioremediation [4000 series]

Description: This SRA includes research and technology to exploit the capabilities of microorganisms and plants to accelerate the rate of degradation of oil typically through aerobic degradation, but also through anaerobic degradation processes. Bioremediation is largely an *in-situ* technology as *ex-situ* use requires excavation and further manipulations that may have a greater potential for environmental harm. Research and development opportunities include the development of methodologies for the use of nutrient enrichment and possibly microbes to accelerate the biodegradation process on land, a process called bio-augmentation. This topic area also covers research to understand the conditions needed for effective bioremediation in the presence or absence of dispersants, herders, and other chemical agents. In areas such as coastal wetlands, where stranded oil may have penetrated into the anaerobic subsurface, this research area would include studies to wick the oil up to the surface where aerobic conditions and nutrient enrichment may result in enhanced biodegradation. This SRA also includes development of methodologies to apply bioremediation for more effective response and restoration efforts. For purposes of this OPRTP, bioremediation includes phytoremediation (remediation using plants), a longer-term restoration technique.

Importance: Bioremediation in many cases is used as a polishing step to follow mechanical recovery or other ex-situ treatment strategies. Bioremediation is a less-intrusive alternative to mechanical recovery techniques. This is especially important in environmental habitats and sensitive areas that could be seriously damaged by the use of mechanical recovery techniques

4.3.4 Injury Assessment and Restoration SRAs

The four SRAs in the Injury Assessment and Restoration Class address the development of strategies to recovery from the effects of an oil spill by determining the level of effects and the implications of those effects on the environmental and sociological resources of the affected area. These SRAs primarily support the Natural Resource Damage Assessment (NRDA) process as well as the need to improve restoration techniques and determine ways to minimize the adverse effects of response activities.

4.3.4.1 Environmental Impacts and Ecosystem Recovery [4100 series]

Description: This SRA includes laboratory research, field studies, and modeling efforts to better understand and predict the short- and long-term effects of oil spills at the ecosystem level. It includes research into the short- and long-term recovery of various types of environments and the chronic effects of oil spills on habitat, species, recovery and rehabilitation of wildlife, and community structures. This SRA includes the effects of the oil and the countermeasures and cleanup techniques used to remove the oil. It also includes research to determine the rate of ecosystem recovery both with and without countermeasures and cleanup.

ED_001324_00000360-00114

Importance: This research provides important feedback on the effectiveness of past responses, forms the basis for future decision-making during spill response, and provides input for damage assessment, restoration planning, and development of decision support tools. Knowledge of the environmental and ecosystem effects of different response measures provides decision-makers the opportunity to identify and select methods that maximize recovery and reduce the adverse effects of response.

4.3.4.2 Environmental Restoration Methods and Technologies [4200 series]

Description: This SRA includes development of methods and technologies to facilitate and accelerate the recovery of resources following an oil spill. It includes research into the effectiveness of approaches for environmental restoration. It also includes evaluations and comparisons of the factors affecting success of the restoration methods and technologies. It also involves studying previous restoration efforts, as well as natural recovery, to better understand ways to improve or enhance future recovery from oil spills.

Importance: OPA 90 mandated restoration activities and specifically required that funds obtained through damage assessment and compensation litigation be expended on restoration activities. However, very few proven methods, technologies, or monitoring protocols exist to support restoration activities. Knowing the conditions affecting the success of the methods and technologies provides decision makers with tools for selecting the approaches that would enhance the chance for successful restoration.

4.3.4.3 Human Safety and Health [4300 series]

Description: This SRA includes studies on the effects of spilled oil and oil spill response activities on human health and safety for both workers and the public. It includes the study of oil weathering throughout the water column and the potential concerns relative to worker health and safety. It focuses on the development of monitoring instruments, procedures, and processes to inform personnel engaged in oil spill response activities, as well as the general public, who could be affected by the oil spill and response options. It also includes studies of the safety of fish and shellfish in a spill area to determine if they are safe to market and consume. Research on seafood safety may include petrochemical toxicology and profiling, risk analysis, sampling and testing methodology development, and risk communications.

Importance: Protecting the health and safety of responders and the public is the highest priority during a response. Potential hazards in dealing with oil include fire and explosion, vapor toxicity, and danger from dermal exposure. Physical health hazards can be acute or chronic. There are processes and procedures that can be implemented to reduce these potential hazards. However, some hazards require a further understanding of how oil behaves to inform the potential concerns relative to worker health and safety. Benzene, for example, can present a potential for chronic health hazards such as leukemia, for which an understanding of oil weathering would inform the needed levels of protection. Response operations conducted on the water or shoreline present

ED_001324_00000360-00115

inherent dangers to personnel health and safety ranging from trips, falls, and cuts; injuries from equipment accidents; working in extreme weather conditions (e.g., heat stroke and freezing); and working around environmental hazards. Some response options present additional health concerns such as: the chemicals in dispersants and oil, other chemical countermeasures; bioremediation; and ISB fires. An additional aspect of human health and safety is seafood safety, which is a complex topic involving sampling and analytical plans, equipment and methods, and data interpretation to assess the potential effects on the health of consumers. Development of health and safety techniques and equipment to mitigate these hazards helps the incident command meet its fundamental responsibility to safeguard both responders and the public.

4.3.4.4 Sociological and Economic Impacts [4400 series]

Description: This SRA includes studies on how oil spills and the response to oil spills affect the sociological fabric of communities and their economies. Disciplines encompassed in this research area include sociology, economics, behavioral sciences, political science, and law. It also involves studies on risk communication and community resilience.

Importance: Research is needed to improve communication of risk, decrease scientific uncertainty, and address socioeconomic concerns associated with oil spills. Oil spills and spill response may cause high levels of stress and psychological trauma, including post-traumatic stress. These effects may begin at the individual level and frequently spread to other members of families, and communities whose culture and livelihood are dependent upon the waters and shorelines near an oil spill. Unemployment and loss of income are additional stressors on peoples' lives. Oil spills can also adversely affect social relationships and have disastrous effects on specific individuals and communities in areas where livelihoods depend on use of renewable resources (e.g., fishing). An oil spill can affect the economic livelihood and aspirations of a family as well as an entire community. Typically, the commercial and recreational fisheries and tourism industries experience the greatest economic effects, although a significant number of other economic sectors also may be affected. Research that supplies a broad understanding of the human dimensions of oil spill hazards and identifies better ways to engage and share information using risk communication principles could enhance future decisions concerning sociological and economic effects on community stakeholders and assist those communities in successfully overcoming these obstacles.

4.4 Research Needs

This category represents the research gaps that ICCOPR identified within the SRAs. ICCOPR identifies oil pollution Research Needs during the OPRTP planning cycle through a number of means, including:

- Reports on research programs and results;

ED_001324_00000360-00116

- Analyses of lessons learned from recent oil spill incidents;
- Data and information shared at various workshops, conferences, and technical and policy meetings;
- Development or enactment of new regulations;
- Input shared and collected from correspondence, quarterly meetings, or scheduled public meetings;
- Numbers and types of research projects conducted/managed by industry, academia, and non-governmental organizations; and
- Forecasts of issues or problems associated with changes or expansion in any aspect of the energy distribution system.

For this FY2015-2021 version of the OPRTP, ICCOPR compiled a new baseline list of Research Needs that incorporates those needs identified in previous versions and new ones identified since 1997 as described in Chapter 9. Future versions of the OPRTP will: 1) update the needs to remove those already addressed; and, 2) add new needs that ICCOPR identifies through the needs identification process.

4.5 Projects

Projects are the specific research experiments and studies conducted by a primary investigator that addresses a Research Need. Projects involve a methodological study or technology development with assigned budgets, resources, and personnel. ICCOPR tracks projects conducted by any entity, not just those conducted specifically by ICCOPR member organizations. ICCOPR recognizes the value of research projects by other entities and encourages its partners from industry, NGOs, state research programs, research institutions, academia, and international organizations to identify and pursue projects that address the needs.

ICCOPR will monitor oil pollution research projects from any identified source and classify identified needs within the Research Categorization Framework by SRA. ICCOPR will use the lists of projects and information on the research results as a basis for assessing how well the Research Needs were addressed.

ED_001324_00000360-00117

THIS PAGE INTENTIONALLY LEFT BLANK.

ED_001324_00000360-00118

5. Knowledge Transfer and Advancement

ICCOPR's ultimate goal for the research and technology (R&T) program is to advance information, technologies and regulations that increase the effectiveness of oil spill prevention, preparedness, response, and injury assessment and restoration efforts. The R&T planning process emphasizes and strengthens the roles and responsibilities of the member agencies to assure that research advances the capabilities to reduce oil pollution. The degree to which practitioners implement the results of the R&T program will depend upon the success of the research and how well results are communicated to the oil spill response community. As part of the program, ICCOPR promotes continuous improvement by monitoring the state of knowledge and adjusting the program to meet changing needs.

5.1 Factors Affecting Research and Technology Program Success

The success of the federal oil pollution R&T program depends on several factors: 1) funding; 2) continuity of research; 3) field testing; 4) regional issues; 5) development of new researchers; and, 6) public perception. The importance of these factors to the success of the federal program is discussed below.

5.1.1 Funding

A steady funding stream at appropriate levels is a primary factor to support a successful R&T program. Funding for oil pollution research has been a recognized challenge since the passage of OPA 90. In their review of the 1992 OPRTP, the NAS Marine Board (1993) acknowledged the need for steady funding:

> "An important unresolved issue is funding. The continued evolution and effectiveness of the (OPRTP) plan is in doubt because the additional funding authorized by Congress has not been appropriated. Moreover, little funding under OPA 90 is expected. This short term funding approach poses a significant barrier to most multi-year research. For example, scientists cannot undertake basic research dealing with the nature of oil and sea water mixtures and their response to mechanical and chemical treatment, oceanic environments, and time, because several years of laboratory work and additional time for field testing would be required." *(NAS, Marine Board Commission on Engineering Technical Systems, 1993)*

The Marine Board also noted the problems caused by the boom and bust cycle of research and funding efforts for oil spill cleanup technology:

> "Research and development (R&D) related to oil spills follows a boom-and-bust cycle. After catastrophic spills, when the acute effects of oiled beaches, polluted waterways, and dying wildlife are featured in all the media, there is public outcry and political interest, accompanied by calls for action, for more research, and for better prevention and control measures. Later, as acute effects fade, but longer term and less obvious

ED_001324_00000360-00119

> problems may continue, public interest-and with it political interest-fade. By the time the calls for action are translated into R&D plans, the interest is gone, and the plans typically are neither supported nor funded. When the next catastrophe occurs, everyone wonders why no one has learned more about how to deal with the problem since the last spill. The phenomenon of cyclical attention and lack of sustained interest and resources, coupled with the natural distribution of research assignments among a group of agencies with different underlying responsibilities, has made it difficult to create a coherently planned R&D program." *(NAS, Marine Board Commission on Engineering Technical Systems, 1993)*

Similarly, the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling (2011) discussed the continued need for funding at an appropriate level:

> "The technology available for cleaning up oil spills has improved only incrementally since 1990. Federal research and development programs in this area are underfunded: In fact, Congress has never appropriated even half the full amount authorized by the Oil Pollution Act of 1990 for oil spill research and development. In addition, the major oil companies have committed minimal resources to in-house research and development related to spill response technology. Oil spill removal organizations are underfunded in general and dedicate few if any resources to research and development..."
>
> "Recommendation: Congress should provide mandatory funding for oil spill response research and development and provide incentives for private-sector research and development." *(National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011)*

The oil production and distribution system is constantly changing, posing new challenges to managing oil pollution. Wells are being drilled at increasingly greater water depths and in more challenging environments. A warming Arctic Ocean is expected to lead to greater activity there, both in exploration and transportation. Exploration of onshore shale oils and oil sands products, along with transportation by rail and pipeline is also increasing. The ability of research and technology efforts to keep pace with the challenges will be affected by long-term funding levels.

ICCOPR does not receive funding for research. Instead, ICCOPR members fund research using their agency's annual budget appropriations or the Oil Spill Liability Trust Fund (OSLTF) R&T funds. At this time, ICCOPR agencies with access to the OSLTF R&T funds are the USCG, EPA, BSEE, and PHMSA. However, federal budgetary rules count any funds withdrawn from the OSLTF for research purposes against an agency's overall budget, which means that oil pollution research initiatives still must compete against other agency missions to obtain funding. The National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling (2011) made the following comment on the funding levels for oil pollution research:

ED_001324_00000360-00120

> "Specifically, Congress should provide mandatory funding (i.e. funding not subject to the annual appropriations process) at a level equal to or greater than the amount authorized by the Oil Pollution Act of 1990 to increase federal funding for oil spill response research by agencies such as Interior, the Coast Guard, EPA, and NOAA—including NOAA's Office of Response and Restoration."

While mandatory funding, not subject to appropriations, may be impractical, Federal funding for coordinated Federal research, presumably through ICCOPR, is generally recognized as beneficial to the goal of improved prevention of and response to oil spills.

ICCOPR initially used Regional Research Grants authorized by Section 7001(c)(8) of OPA 90 to address regional oil spill issues. The objective of the Regional Research Program was to "coordinate a program of competitive grants to universities or other research institutions, or groups of universities or research institutions, for the purposes of conducting a coordinated research program related to the regional aspects of oil pollution, such as prevention, removal, mitigation, and the effects of discharged oil on regional environments." Congress authorized funding for the program for the fiscal years 1991 through 1995 but not for subsequent years. ICCOPR will consider additional Regional Research Grants if Congress authorizes funding in the future.

5.1.2 Continuity of Research

The ability of research programs or projects to continue to their logical conclusion is an important factor in successfully addressing oil pollution research needs. Changing agency missions, funding priorities, staffing, or site access may interrupt research programs. Breaks in research continuity, if long enough, can result in a "hiatus effect" where key knowledge or learning opportunities are lost. Particularly vulnerable are studies that measure trends over time (i.e., baseline and impact assessment biological studies, oil fate and effects studies, ocean current monitoring). The institutional knowledge resulting from research efforts can also be lost when program lapses or changes prompt employees to leave their federal positions.

5.1.3 Field Testing

ICCOPR recognizes that field testing is a valuable tool to validate laboratory results and to study techniques, treatments and equipment *in situ*. In 1993, the NAS Marine Board recommended that the federal R&T program include controlled field experiments that involve a deliberate, limited discharge of oil to advance research areas (i.e., oil dispersants, ISB, incineration, and bioremediation). The NAS Marine Board noted that laboratory experiments alone cannot replicate real-world process interactions and variables, and accidental spills provide limited learning opportunities because data on pre-spill conditions and/or spill volume usually are lacking. An independent report, "Responding to Oil Spill in the U.S. Arctic Marine Environment", also echoed the need for field testing (NRC, 2014). The report noted that

ED_001324_00000360-00121

countries such as Norway have consistently supported this type of research by permitting controlled spills when clear research needs, methods, and goals have been identified, and responsible cleanup and monitoring plans have been established.

Field tests may be justified when laboratory or other simulated settings (e.g., test tanks) cannot address specific Research Needs and no other open water research projects have addressed them. Experiments in large test tanks (i.e., Ohmsett) provide opportunities to simulate real environmental conditions and bridge the gap between laboratory and actual field experiments; however, they cannot completely replicate actual field conditions. ICCOPR will continue working with policy makers and permitting authorities to explore field testing opportunities. Field tests may be justified when laboratory or other simulated settings (e.g., test tanks) cannot address specific Research Needs and no other open water research projects have addressed them.

5.1.4 Building the Next Generation of Researchers

The federal oil pollution R&T program needs an adequate pool of researchers and policy makers interested in oil pollution research to replace those that are retiring or leaving for other opportunities. College students need to view the oil pollution management and research fields as a viable career path. Interest in pursuing these areas is strongest in the years following a major spill (i.e. *Exxon Valdez*, *Deepwater Horizon*) and decreases as events fade from national consciousness. Thus, generating and maintaining interest by college students about to enter the workforce in oil spill R&T careers is an important element of ICCOPR's efforts.

Several of the ICCOPR member agencies have programs to encourage students to become interested in oil pollution research or management. NOAA and the University of New Hampshire's Coastal Response Research Center (CRRC), educate students on issues related to oil spills and response and works with other university programs to encourage academic interest in the field. The U.S. Coast Guard Academy includes environmental protection and marine safety topics across its curriculum in many forms ranging from drilling technology and petroleum chemistry to the history of spills of national significance. In particular the Marine and Environmental Science major includes specific courses in geochemistry, analytical chemistry, and petroleum and oil spill science, and the Engineering Department offers marine engineering courses focused on the needs of the prevention community. Cadet research projects, which are part of their curriculum, from the Science and Engineering Departments often address oil spill issues.

NASA's DEVELOP National Program fosters an interdisciplinary research environment for students, where applied science research projects are conducted under the guidance of the agency and its partner science advisors. DEVELOP is unique in that young professionals lead projects that utilize NASA Earth observations to address community concerns and public policy issues, including oil pollution research.

ED_001324_00000360-00122

The International Oil Spill Conference (IOSC) Executive Committee, which includes several ICCOPR members, offers a scholarship program and student awards to promote interest in oil pollution research.

ICCOPR also provides annual advice to the NAS GRP on the direction of the GRP program, which includes education and training. A key program objective of the GRP is to support the development of future professionals and leaders in science, industry, health, policy, and education who can apply cross-boundary approaches to critical issues that span oil system safety, human health, and environmental resources.

The DOI's Youth Initiative includes outreach to students at the Ohmsett facility and at the annual Clean Gulf Conference. At the 2014 Clean Gulf Conference several ICCOPR members participated in a day-long outreach session with a local high school's Advanced Placement environmental science class.

5.1.5 Public Perceptions

The NAS Marine Board observed that public reactions and perceptions can play a significant part in making oil spill response decisions, regardless of their scientific validity. Adverse reactions to the use of a technology can lead to political pressures to limit its use. In 2010, public concerns about the use of dispersants during the *Deepwater Horizon* oil spill response prompted interest groups and state agencies to oppose the use of dispersants. Such opposition may increase the need for research to provide additional validation of dispersant safety and efficacy before approval as a response option. The ICCOPR agencies' research programs need to recognize public perceptions about different technologies and factor them into decisions about research initiatives.

5.2 Communicating Research and Technology Efforts

Researchers must effectively communicate their results to the broader oil spill research and response communities to provide the greatest benefit from their efforts. There are many avenues for transferring research knowledge (i.e., meetings, conferences, workshop, seminars, papers, presentations, journal publications, consensus-based best practice reports, and websites of organizations involved or interested in spill response). ICCOPR views communication as a two-way street and uses a variety of mechanisms, discussed below, to transfer research knowledge to stakeholders and to learn of advances by non-federal researchers.

5.2.1 ICCOPR OPRTP

OPA 90 established the ICCOPR OPRTP as the mechanism to inform Congress and the public on the status of oil pollution technologies, research needs and priorities, and agency roles and responsibilities. The 1992 and 1997 versions of the OPRTP provided ICCOPR's assessments of the state of knowledge at that time. This 2015 version updates the assessment of oil pollution

ED_001324_00000360-00123

R&T. ICCOPR intends for future versions of the OPRTP to serve as information sharing documents that provide the current federal perspective on oil pollution research. ICCOPR plans to update the OPRTP every six years to maintain timely information and may publish supplements if warranted.

5.2.2 ICCOPR Biennial Reports to Congress

Section 7001(e) of OPA 90 requires that ICCOPR submit a report biennially on its activities and those of its members during the previous two fiscal years and the anticipated activities for the next two fiscal years. The ICCOPR Biennial Reports to Congress serve as a reference document on ICCOPR activities, member initiatives, and planned activities. Appendices to the reports provide listings of publications by ICCOPR member agencies and descriptions of their research projects.

5.2.3 ICCOPR Meetings

ICCOPR conducts quarterly membership meetings and special meetings with interested stakeholders. The quarterly meetings include a session for agencies to present updates and share results of their research and development efforts. These sessions promotes coordination and collaboration among member agencies. The quarterly meetings also include time for presentations from invited speakers to discuss subjects of interest to the membership.

ICCOPR conducts public and other special meetings with outside organizations to discuss their issues and share oil pollution related information. ICCOPR conducted public meetings to gather input as part of efforts to revitalize ICCOPR and to identify areas of concern for future oil pollution research.

5.2.4 Meetings with Non-Federal Entities

ICCOPR participates in meetings with industry, state governments, NGOs, associations, academia, and other nations to exchange information and promote collaboration and cooperation. Stakeholders frequently ask ICCOPR to address these bodies to explain federal research priorities and initiatives. ICCOPR will continue participating in these meetings and encourage the entities to address the ICCOPR priority Research Needs.

5.2.5 Demonstration Projects

Section 7001(c)(6) of OPA 90 directed that ICCOPR conduct Port Oil Pollution Minimization Demonstration Projects in New York, New Orleans, and Los Angeles/Long Beach. The Great Lakes Oil Pollution Research and Development Act of 1990 amended OPA 90 to include a fourth demonstration in ports of the Great Lakes. ICCOPR conducted two demonstration projects in New Orleans (December 1994) and New York (October 1995). After these first two projects were completed, the USCG determined that they were cost prohibitive and ICCOPR

ED_001324_00000360-00124

agreed that the objectives for the demonstration projects requirement could be met through other means (ICCOPR, 2003). Since 1995, ICCOPR has addressed the objectives through interagency participation in, and support for, regularly scheduled domestic and international oil spill conferences (i.e., IOSC, Interspill, Spillcon).

In 2014, BSEE sponsored a demonstration of oil spill response processes at the 2014 IOSC in Savannah, Georgia. The theme of the On Water and Aerial Technical Demonstration was "A Complete Spill Response System." The objective is to demonstrate oil spill response resources involving new and existing technology configured to increase the response effectiveness through improved detection, tracking and increased encounter and recovery rates.

The 45-minute demonstration on the Savannah River followed a scripted, simulated spill scenario that included: a remote oil detection device that initiated an oil spill alert message with coordinates to the responsible party, spill management team, identified OSROs, and USCG Sector or Captain of the Port and interested parties. Surface oil spill response vessels, unmanned aerial vehicles and submersible response equipment all participated in the joint response effort. A mobile command center managed the demonstration and broadcast information via a live feed to conference participants.

ICCOPR and its member agencies will consider future demonstrations of response technologies within budgetary considerations.

5.2.6 Conferences

Participation in conferences is an important way to communicate research results, showcase technology, and provide opportunities for researchers and response professionals to interact. ICCOPR and its member agencies sponsor, support, and participate in several oil spill-related conferences domestically and internationally. Primary conferences promoted by ICCOPR include:

- International Oil Spill Conference (triennial in U.S.),
- Interspill (triennial in Europe),
- Spillcon (triennial in Australia),
- Clean Pacific (biennial) and Clean Gulf Conferences (annual),
- Offshore Technology Conference (annual),
- Gulf Oil Spill & Ecosystem Science Conference (annual), and
- Arctic Marine Oilspill Program Technical Seminars (annual).

These domestic and international conferences include both technical programs and equipment tradeshows that present the latest issues, products, and technologies available for oil spill and hazardous materials response, spill prevention, marine salvage, cleanup and remediation,

ED_001324_00000360-00125

professional services, and regulatory compliance.

The American Petroleum Institute (API) and the IOSC Executive Committee, which includes several of the ICCOPR agency representatives, worked to make all papers presented at the IOSC since its inception in 1969 available free of charge on the internet (http://ioscproceedings.org/loi/). This service provides a wealth of information specific to the oil spill research community.

5.2.7 Workshops and Seminars

Workshops and seminars are widely used in the oil pollution control community to bring together professionals to discuss specific topics and challenges. ICCOPR member agencies sponsor workshops on a wide variety of topics that address priority research issues.

5.2.8 Publications

The researchers funded by ICCOPR are encouraged to publish their research in peer reviewed journals, conference proceedings, books, special reports, and other publications. Literature generated from research could be from researchers within the traditional oil spill community or from academic scientists and engineers. Research published in peer-review journals, especially ones with high impact factors have value in oil spill litigation cases.

Examples of high impact factor peer-review journals and publications that address marine pollution topics include:

- *Applied and Environmental Microbiology,*
- *Environmental Science & Technology (SETAC),*
- *Environmental Toxicology and Chemistry,*
- *Human and Environmental Risk Assessment,*
- *Journal of the American Medical Association,*
- *Journal of Petroleum Technology*
- *Journal of Toxicology and Environmental Health,*
- *Marine Pollution Bulletin,*
- *Microbial Ecology Journal of Environmental Monitoring,*
- *Nature,*
- *Science, and*
- *Water Research.*

ED_001324_00000360-00126

5.2.9 Newsletters

ICCOPR monitors newsletters published by many organizations that announce news of their activities, highlight specific programs or initiatives, or summarize advancements in R&T. In addition, several of the ICCOPR member agencies also publish newsletters addressing elements of their oil pollution research missions.

5.2.10 Internet and Social Media

ICCOPR and the member agencies use the internet as a tool to provide oil spill research results and news to stakeholders and other users. ICCOPR maintains an internet site (www.uscg.mil/iccopr) to: share documents, provide links to other programs and resources, distribute research reports, announce conferences and other events, and provide news about research developments.

Some of the ICCOPR member agencies maintain websites and are using blogs and social media platforms (i.e., Facebook and Twitter) to share information with the public and researchers.

5.3 Monitoring the Status of Oil Pollution Technologies

The 2015-2021 version of the OPRTP marks a new baseline in ICCOPR's oil pollution research planning efforts, documenting the status of oil pollution Research Needs at the start of the planning process. Future OPRTP revisions, to be issued every six years, will include revised assessments of the status of oil pollution R&T.

Throughout each six-year planning cycle, ICCOPR will track newly identified Research Needs conducted by members, federal partners, NGOs, academia, and industry. ICCOPR will use the Oil Pollution Research Characterization Framework and research protocol described in Chapter 6 of this OPRTP, to compile information on studies that address future priority Research Needs.

ICCOPR will also assess the compiled information to determine the degree to which the priority Research Needs from the previous plan were addressed and then develop a new set of research priorities for the subsequent planning period. ICCOPR may also issue supplements to the OPRTP during a planning cycle to address emerging Research Needs that increase in priority. ICCOPR may periodically review after action reports, GAO reports, and other sources of identified gaps to inform the Oil Pollution Research Characterization Framework for future research needs

ED_001324_00000360-00127

THIS PAGE INTENTIONALLY LEFT BLANK.

ED_001324_00000360-00128

PART TWO – ESTABLISHING RESEARCH PRIORITIES

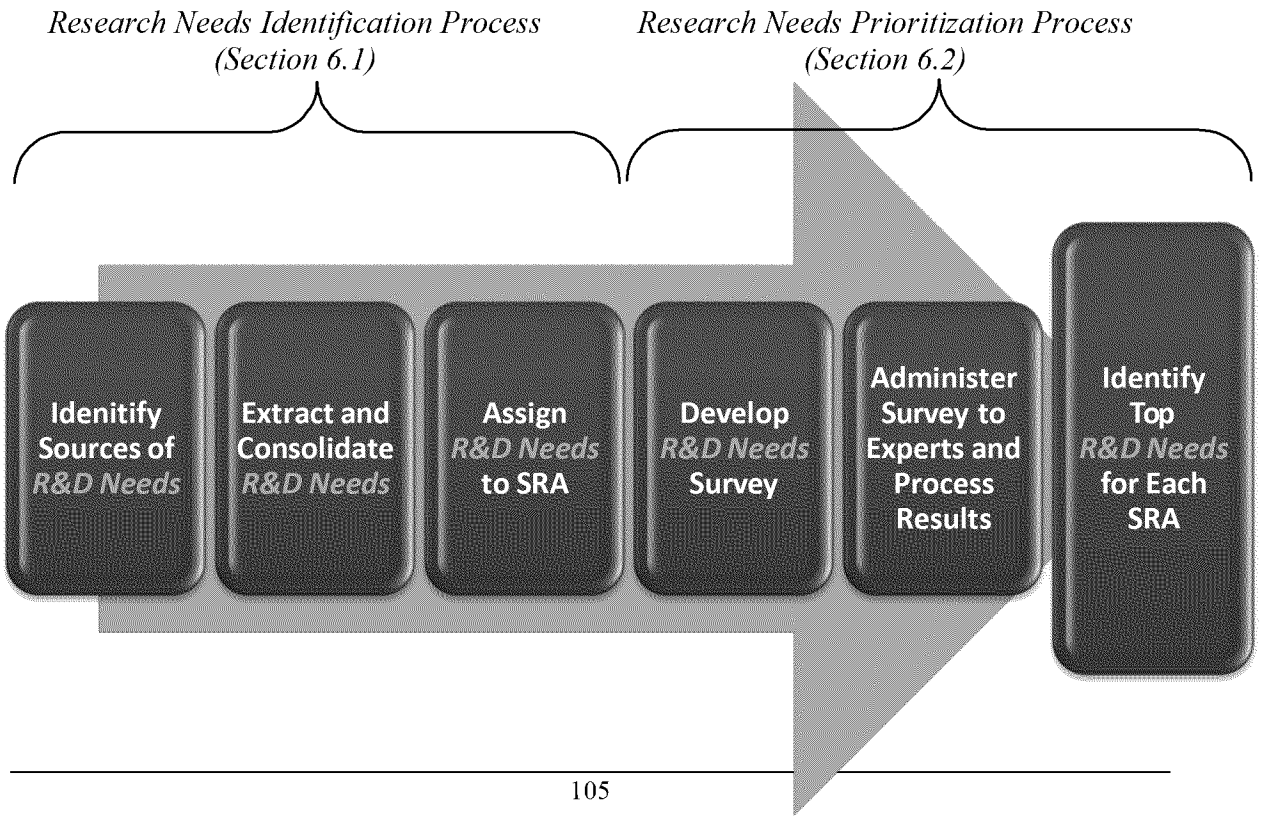
6. Oil Pollution Research Needs Identification and Prioritization Process

A significant number of oil pollution incidents have occurred and a substantial amount of research has been conducted since the completion of the 1997 version of the Oil Pollution Research and Technology Plan (OPRTP). In order to update the OPRTP, ICCOPR needed to develop a process for reviewing the lessons learned from these incidents and addressing any recommendations and gaps noted in the completed research.

ICCOPR established a Research and Technology (R&T) Workgroup with representatives from BSEE, DOE, EPA, NOAA, and USCG to lead development of the revised OPRTP and the Needs Identification and Prioritization Process. The R&T Workgroup was responsible for defining the SRAs, reviewing the Research Needs, and developing the proposed list of research priorities for overall ICCOPR approval.

This chapter describes the systematic process used by the R&T Workgroup to identify and prioritize the nation's future oil pollution Research Needs. Sections 6.1 and 6.2 describe in detail the elements of the process (Figure 6-1). Appendices B through E provide supporting information to the process.

Figure 6-1. Major steps in the Research Needs Identification and Prioritization Processes



ED_001324_00000360-00129

6.1 Research Needs Identification Process

The Research Needs identification process consisted of three steps: 1) identification of Research sources; 2) extracting Research Needs and consolidating them into a database; and, 3) assigning Research Needs to SRAs (Figure 6-1). Research Needs were identified through internet searches; discussions with experts; and detailed review of reports, meeting notes and workshop summaries. The R&T Workgroup considered sources that were published prior to initiation of the identification process in 2013. Needs identified in sources published after the process began will be evaluated and prioritized in the next planning cycle.

6.1.1 Identification of Sources of Research Needs

The first step was to identify all possible sources of new Research Needs published since the 1997 version of the OPRT Plan was released. For purposes of this plan, ICCOPR defined sources as: accident case studies; published papers; research reports; workshop or meeting proceedings; white papers; lessons learned; and agency or organizational opinions. More than 50 unique sources were identified as describing Research Needs that should be included in the database. Examples of sources reviewed include: oil spill incident after-action reports; the 1992 and 1997 versions of the OPRTP; Coastal Response Research Center (CRRC) workshop reports; ICCOPR Public Meeting transcripts; interagency reports; research solicitations and publications.

A complete list of the initial sources reviewed can be found in Table 6-1 and Appendix C. Although it was not possible to review every potential source of oil pollution Research Needs since 1997, the sources used in this plan addressed all of the initial set of 23 SRAs and were viewed as representing a comprehensive list.

Table 6-1. List of Sources Reviewed for Research Needs

Sources Reviewed for the ICCOPR Research Needs (by date)
Title 33 U.S. Code Chapter 40 Subchapter IV 2761 (Aug 1990)
Interagency Coordinating Committee on Oil Pollution Research and Technology Plan (April 1992)
Interagency Coordinating Committee on Oil Pollution Research and Technology Plan (1997)
Coastal Response Research Center - Research and Development Priorities: An Oil Spill Workshop (November 2003)

ED_001324_00000360-00130

Coastal Response Research Center – Workshop: Research & Development Needs For Making Decisions Regarding Dispersing Oil (September 2005)
National Research Council. Oil Spill Dispersants: Efficacy and Effects. Washington, DC: The National Academies Press (2005)
Potentially Polluting Wrecks in Marine Waters: An Issue Paper Prepared for the 2005 International Oil Spill Conference (2005)
EPA Act 2005 Section 999A(b)(4) DOE National Energy Technology Laboratory Complementary Research Program (2005)
Coastal Response Research Center – Workshop: R&D Needs for Addressing the Human Dimensions of Oil Spills (June 2006)
Coastal Response Research Center - Submerged Oil Workshop Report (December 2006)
DOE 2007 Annual Plan Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Research and Development Program, Report (January 2008)
DOE 2009 Annual Plan Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Research and Development Program, Report (December 2008)
Coastal Response Research Center - R&D Priorities: Oil Spill Workshop (March 2009)
House of Representatives, Committee on Science & Technology "A New Direction for Federal Oil Spill Research & Development" (June 2009)
DOE 2010 Annual Plan Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Research and Development Program, Report (December 2009)
Wreck Oil Removal Program Overview (2009)
Prince William Sound Oil Spill Recovery Institute Research Plan 2011-2015 (February 2010)
Gulf of Mexico Research Initiative: Research Themes (May 2010)
Interagency Coordinating Committee on Oil Pollution Research Public Meetings - West (May 2010)
Pacific States/British Columbia Oil Spill Task Force Letter to Interagency Coordinating Committee on Oil Pollution Research (May 2010)

ED_001324_00000360-00131

House of Representatives, Committee on Science & Technology "Deluge of Oil Highlights Research & Technology Needs for Effective Cleanup of Oil Spills" (June 9, 2010)
U.S. Arctic Research Commission - White Paper (July 2010)
Interagency Coordinating Committee on Oil Pollution Research Public Meetings - East (September 2010)
Marine Mammal Commission Letter to Interagency Coordinating Committee on Oil Pollution Research (September 2010)
National Science and Technology Council Joint Subcommittee on Ocean Science and Technology - DWH Oil Spill Principal Investigator Conference Report (October 2010)
Interagency Coordinating Committee on Oil Pollution Research Public Meetings - Gulf (November 2010)
National Academy of Sciences Institutes of Medicine Research priorities for Assessing Health Effects from the Gulf of Mexico Oil Spill (2010)
Deepwater Horizon Incident Specific Preparedness Review (January 2011)
Environmental Protection Agency Draft Oil Spill Research Strategy (January 2011)
National Commission on BP Deepwater Horizon - Final Report (January 2011)
Ultra-Deepwater Advisory Committee 2011 Plan: Comments, Findings and Recommendations (April 2011)
Coastal Response Research Center - Coordinating R&D on Oil Spill Response In the Wake of Deepwater Horizon (July 2011)
Assessing the Long-term Effects of the BP Deepwater Horizon Oil Spill on Marine Mammals in the Gulf of Mexico: A Statement of Research Needs (August 2011)
DOE 2011 Annual Plan Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Research and Development Program, Report To Congress (August 2011)
U.S. Department of Energy - 2011 Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources R&D Program (August 2011)
Science Advisory Board Review of Environmental Protection Agency's Draft Oil Spill Research Strategy (September 2011)

ED_001324_00000360-00132

National Science and Technology Council's Joint Subcommittee on Ocean Science and Technology - Deepwater Horizon Oil Spill Principal Investigator Conference Final Report (October 2011)
Oil Spill Preparedness and Response Joint Industry Task Force (November 2011)
U.S. Geological Survey. An Evaluation of the Science Needs to Inform Decisions on Outer Continental Shelf Energy Development in the Chukchi and Beaufort Seas (2011)
International Association of Oil and Gas Producers - Joint Industry Programme Solicitation for Expression of Interest (EOI) on Arctic Oil Spills (February 2012)
Coastal Response Research Center - The Future of Dispersant Use in Oil Spill Response Initiative (March 2012)
Ultra-Deepwater Advisory Committee 2012 Plan: Comments, Findings and Recommendations (March 2012)
OESC Letter Recommendations to BSEE Department of the Interior (April 2012)
U.S. Government Accountability Office Oil Dispersants Report (May 2012)
Government and Industry Pipeline Forum (July 2012)
DOE 2012 Annual Plan Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Research and Development Program, Report To Congress (August 2012)
OESC Letter Recommendations to BSEE Department of the Interior (August 2012)
U.S. Department of Energy - Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources R&D Program (August 2012)
Ultra-Deepwater Advisory Committee 2013 Draft Plan: Findings and Recommendations (November 2012)
Center for Spills in the Environment Alberta Oil Sands Workshop for Maine DEP and U.S. EPA Region 1 (December 2012)
Bureau of Safety and Environmental Enforcement - BAA Proposed Research on Oil Spill Response Operations (2012)
OESC Letter Recommendations to BSEE Department of the Interior (January 2013)

ED_001324_00000360-00133

Center for Spills in the Environment Oil Spill Dispersant Research Workshop Report (March 2013)
Oil Spill Simulants Materials: Workshop Proceedings (March 2013)
University of Washington Transporting Alberta Oil Sands Products: Defining the Issues and Assessing the Risks (March 2013)
Center for Spills in the Environment Alberta Oil Sands Workshop for Washington State Department of Ecology, the Regional Response Team 10 and the Pacific States/British Columbia Oil Spill Task Force (April 2013)
DOE 2013 Annual Plan Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Research and Development Program, Report To Congress (June 2013)
NRC An Ecosystem Approach to Assessing the Impact of the Deepwater Horizon Spill in the Gulf of Mexico (2013)
TRB Effect of Diluted Bitumen on Crude Oil Transmission Pipelines Special Report 311 (2013)

During the Prioritization Process, the R&T Workgroup increased the number of SRAs to 25 by adding a new "Rail and Truck Transport" SRA and redefining the Onshore and Offshore facilities SRAs to create a new "Pipeline" SRA. The R&T Workgroup reviewed the new and revised SRAs and determined that additional review of sources for the Rail and Truck Transport SRA and the Onshore Facilities SRA were needed. The R&T Workgroup used experts at PHMSA and the EPA to obtain information on potential missing needs for these two SRAs. Table 6-2 lists the supplemental sources reviewed to determine additional Research Needs.

Table 6-2. List of Supplemental Sources Reviewed for Research Needs

Supplemental Sources Reviewed for the ICCOPR Research Needs (by date)
FRA Research Review Conference (2012)
USDOT Emergency Order on Transport of Bakken Crude Oil (2014)
Federal Railroad Administrator Prepared Remarks - 50th Meeting of the Railroad Safety Advisory Committee (2014)
Discussions with U.S. EPA Office of Solid Waste (2014)

ED_001324_00000360-00134

Discussions with PHMSA Office of Pipeline Safety (2014)

6.1.2 Extraction and Consolidation of R&D Needs

A searchable Excel database was created to record information on the source, the applicable environment and the frequency the Research Need was mentioned in the sources reviewed. Initially, more than 900 Research Needs were identified from the source material. After elimination of duplicated Research Needs, the final list consisted of 570 separate Research Needs. This list of 570 Research Needs is located in Appendix B. The original list of more than 900 Research Needs was archived for future use.

6.1.3 Assignment of Research Needs to an SRA

The last step in the Needs Identification Process involved assigning each of the 570 Research Needs to one of the 25 SRAs described in Chapter 4 of this based on the definition of each SRA. Some SRAs had a much larger number of Research Needs than others. SRAs with a large number of needs were further divided into SRA subcategories. The rationale for using subcategories is described in Section 6.2. Figure 6-2 shows an example of the column headings for a typical entry in the Research Needs database.

Figure 6-2 Sample from the Research Needs Database

Standing Research Area (SRA)	SRA Subcategory	Research Need and Key Research Concept	Sources	Physical Location	Sources
Dispersants	Behavior	Constituents - Study chemistry data for individual dispersant components in the oil droplets during the DWH spill.	CRRC - The Future of Dispersant Use in Oil Spill Response Initiative (2012)	Marine and Estuarine	1

6.2 Research Need Prioritization Process

The ICCOPR R&T Workgroup determined that the most effective Needs prioritization process for this OPRTP was to develop a survey (Figure 6-1) that could be distributed to Subject Matter Experts (SMEs) (e.g., scientists, policy makers) familiar with current oil spill research needs. In some areas, there was a need to include state agency, academic, or industry experts in order to find the right expertise to address the R&D Needs

ED_001324_00000360-00135

questions. The Workgroup determined, however, that in no SRA category or subgroup should non-federal employees exceed the number of Federal SMEs. The survey results helped ICCOPR identify and prioritize the most important Research Needs within each SRA.

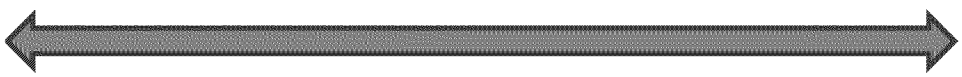
The R&T Workgroup created subcategories for 11 SRAs with a large number of Research Needs to reduce the number of Research Needs that each SME was required to evaluate. The decision to use this approach was based on the experience of UNH Survey Center experts (managers of the survey) who indicated that "survey fatigue" often occurs if a participant is asked to answer a large number of questions, thus affecting the validity of the results. Appendices D through F provide the survey technical report and examples of the survey instrument and results.

The Workgroup compiled a set of proposed priority research Needs for the SRAs and SRA subcategories and presented them to the whole ICCOPR for approval.

6.2.1 Development of Research Needs Survey

The R&T Workgroup developed and debated a series of key questions that reflected the various aspects of the research process and selected the following questions for the survey:

Question 1 - How important is this Research Need in improving any or all of the following: spill prevention, preparedness, response, and/or impact assessment/restoration? (Via sliding scale)



Low Medium High

Question 2 - Some research is designed to answer a small detail which refines our understanding of a research problem while other research answers key questions that become the building blocks for further advancements. Please estimate where this Research Need fits in this spectrum of oil pollution research (Via sliding scale)

Small Detail/Nuance Building Block/Key Question

Question 3 - What would be the estimated cost of the research to answer this Research Need? (Via text box)

Fill in blank text box

Example 50000000; no commas or dollar sign

ED_001324_00000360-00136

Question 4 - How soon would the results of this specific Research Need improve any or all of the following: spill prevention, preparedness, response, or impact assessment/restoration? (Via sliding scale)

Short (<2 year) 2-5 years Long (>5 years)

Question 5 - Solving research problems can require multiple steps. Some research projects take the initial steps while others will be the final step. Please estimate where this Research Need fits in the lifespan of solving a research problem. (Via sliding scale)

Initial Step Final Step

Questions 1-5 were designed to refer to a specific Research Need within the SRA or SRA subcategory that a SME was assigned. Questions 6 and 7 were designed to be asked at the end of the survey and refer to all of the Research Needs evaluated by an SME.

Question 6 - Of the research needs that you reviewed today, which rise to the top? For each, list (up to 3) impediments (other than cost or time to completion) for these top research Needs you identified. (Answers via text box)

Fill in blank text box

Question 7 - Are there any research needs related to this subject area that you feel need to be addressed, but were not on this list? (Answers via text box)

Fill in blank text box

In addition to the questions described above, the R&T Workgroup decided to ask each SME to provide a range of dollar values that they would expect for research projects associated with their assigned SRA or SRA subcategory. This information was intended to allow the R&T Workgroup to calibrate the difference in project costs between SMEs with different backgrounds and different types of research experience. Unfortunately, the number of responses to the inquiry on potential costs were limited and too variable to be

ED_001324_00000360-00137

of significant value to the decision making process.

The UNH Survey Center built and designed the survey instrument, in conjunction with the CRRC and the R&T Workgroup. A total of 46 separate surveys were developed, one for each SRA or SRA subcategory. Appendix E provides a sample of the survey for one of the Research Needs.

6.2.2 Administration of Survey to SMEs

The R&T Workgroup recruited 285 SMEs to provide at least five SMEs for each of the SRAs and SRA subcategories. These SMEs were selected for their knowledge and expertise in particular SRAs. Responses were received from 223 of these experts; 185 federal employees and 38 non-federal personnel. Survey groups were designed to include a majority of federal employees to avoid Federal Advisory Committee Act (FACA) issues. The UNH Survey Center administered the confidential survey and tabulated the scores.

6.2.3 Processing of Survey Results

In order to determine the highest priority Research Needs, the Survey Center calculated a mean and standard deviation for each of the questions using the answers provided by the SMEs. Questions #3 about costs could not be used in the final scoring because many SMEs did not answer it. The R&T Workgroup weighted the remaining questions based on its knowledge of their importance.

1. How important is this Research Need in improving any or all of the following: spill prevention, preparedness, response, and/or impact assessment/restoration? Weighting **55%**
2. Some research is designed to answer a small detail which refines our understanding of a research problem while other research answers key questions that become the building blocks for further advancements. Weighting **30%**
3. What would be the estimated cost of the research to answer this Research Need? Weighting **0%**
4. How soon would the results of this specific Research Need improve any or all of the following: spill prevention, preparedness, response, or impact assessment/restoration? Weighting **15%**

6.2.4 Identification of Top Priority Research Needs for Each SRA

The priority Research Needs were established based on a review and vote by ICCOPR on the recommended priorities selected by the R&T Workgroup during a series of working sessions during the summer of 2014. The R&T Workgroup's iterative process to select

ED_001324_00000360-00138

the recommended priorities consisted of the following steps:

- Evaluate statistical ranking and analysis of survey results. The UNH Survey Center provided a ranking of Research Needs by the raw and weighted scores and the standard deviations of both scores. The R&T Workgroup used these initial rankings as a starting point for discussions.

- Review missing Needs. Several SMEs identified potentially missing Research Needs in their responses to Question 7. The R&T Workgroup reviewed the suggestions to determine whether a different SRA or SRA subcategory included the Research Need. The R&T Workgroup added missing Research Needs to the appropriate SRA or SRA subcategory and assigned an appropriate rank based on the members' expert opinion.

- Consolidate research Needs. In many cases, an SRA or SRA subcategory listed similar Research Needs. The R&T Workgroup reviewed these similarities and consolidated them where appropriate. The draft ranking was adjusted to reflect the importance of the consolidated Research Need.

- Determine top three recommended priority Needs. The R&T Workgroup considered several factors in making its final recommendation on the three most important Research Needs for each SRA or SRA subcategory: 1) whether the impediments as listed by the SMEs in answer to Question 6 would prevent or severely limit the potential research to resolve the Need; 2) whether completed or ongoing research had already addressed the Research Need; and 3) did the results of Question 5 and 6 distinguish between similarly ranked Research Needs (however, this last factor was rarely necessary). The R&T Workgroup unanimously agreed upon the top three suggested priority Research Needs for each SRA or SRA subcategory before they were presented to the full ICCOPR.

- Develop the final description of each recommended priority Research Need. The R&T Workgroup reviewed the language of each SRA and the associated priority Research Needs to ensure each description was clearly articulated and consistent with the SRA definition.

- Obtain ICCOPR member feedback. The R&T Workgroup sent its draft list of priorities to the full ICCOPR membership for review and comment. The R&T Workgroup adjudicated the comments through discussions with commenting members and a meeting of the R&T Workgroup.

ED_001324_00000360-00139

- Finalize recommended priorities. The R&T Workgroup made its final edits to the recommendations based on the comment adjudication process and met on August 19, 2014 to formally vote on a final set of recommended priorities. The recommendations were sent to the full ICCOPR membership for consideration and adoption.

The full ICCOPR membership discussed the proposed SRA descriptions and the priority Research Needs at the Quarterly Meeting on September 17, 2014. Minor wording changes were made to two Research Needs based on the discussions, and by unanimous vote, ICCOPR adopted the top three priority Needs for each SRA and SRA subcategory as presented in Chapter 9.

ED_001324_00000360-00140

7. Noteworthy Oil Spill Incidents

This chapter provides a summary review of noteworthy oil spills since ICCOPR released the 1997 version of the OPRTP. The case studies describe the incidents, the significant causal factors, response issues, and the identified Research Needs. This section is organized chronologically by the type of incident as classified by the National Response Center:

- Vessel Spills (tank and non-tank),
- Offshore Drilling Operations,
- On-shore Pipeline Spills,
- Facility Spills, and
- Railroad Spills.

Information on the spill and response measures described in the case studies was acquired from various sources including: NOAA's Office of Response and Restoration's IncidentNews (www.incidentnews.noaa.gov) for open water spills; the EPA's OSC website (www.epaosc.gov) for inland spills; and State agency information and DOT reports. The Research Needs listed below the incident summaries were taken from Incident Specific Preparedness Reviews (ISPRs), NOAA OR&R reports; and contracted After Action Reviews (AARs) where available. In cases where specific no Research Needs were identified, the R&T Workgroup reviewed the case study information for applicable Research Needs.

7.1 Vessels Spills

Major spills from tankers have been declining globally for several decades according to ITOPF (2015). However, Spills from all vessels remain an on-going concern. The USCG (2012) reported that between 2001 and 2010 there were 20,710 spills from vessels responsible for more than 6.6 million gallons of oil. Tank barges accounted for more than 60 percent of the volume spilled.

TB Penn

In July 2000, the Tank Barge *Penn 460* ruptured and released ~12,600 gallons of No. 6 fuel oil into Narragansett Bay, Rhode Island, an active fishing and lobstering location. The spill oiled two miles of shoreline and numerous birds. Response measures included: the booming of heavily contaminated areas and surface skimming; low pressure flushing of shoreline and sediments; the use of sorbents and snares (passive collection) near the McAllister Hazardous Waste Landfill; a bird capture program for oiled birds;

ED_001324_00000360-00141

informational handouts on tar balls to the public; and fishery closures in the immediate area.

This incident is an example of a barge tank rupture that leaked heavy fuel oil into an estuary important for fishing and recreation. There were no specific research recommendations following the spill; however, the response action emphasized the need for further research in the following SRA areas:

- **In- and On-water Containment and Recovery (SRA 3400)** - improve boom and surface skimming equipment.
- **Shore Containment and Recovery (SRA 3500) -** develop improved methods for shoreline cleanup.
- **Environmental Impacts and Recovery (SRA 4100) -** develop improved methods of impact assessment and recovery (for fisheries and avian species).
- **Sociological and Human Impacts (SRA 4400) -** determine impacts to humans related to estuarine spills.

T/V Athos I

In November 2004, the single hull tanker *T/V Athos I* struck a submerged object and spilled approximately 264,000 gallons of heavy Venezuelan crude oil into the Delaware River creating a 20-mile slick that affected 214 miles of shoreline across four states (Pennsylvania, Delaware, New Jersey, and Maryland), with some of the oil submerged below the surface. The investigation by the USCG concluded that the vessel struck a submerged U-shaped pipeline while maneuvering en-route to its berth. The pipeline punctured the vessel's bottom plating in the ballast and cargo tanks.

Response included vessel stabilization and prevention of further discharge; facilitation of vessel traffic, as needed; deployment of protective booms and snares; skimming, collection and recovery of floating oil; enforcement of a safety zone; and collection and rehabilitation of injured wildlife. Economic losses were incurred due to delays in transportation on the Delaware River. The Salem Nuclear Power Plant shut down two reactors because submerged oil was identified in the sediment below some water intakes. The Plant shutdown affected regional electrical generation.

This incident was important for its identification of needed technology improvements including: subsurface object detection and the detection, tracking, mapping and recovery of subsurface and submerged oil. Although there were no specific recommendations for future research as a result of the spill and response actions, this spill highlighted the need for research in the following SRAs:

- **Vessel Design (SRA 1400)** - develop double hull designs.

ED_001324_00000360-00142

- **Structural Damage Assessment (SRA 3000) -** develop methods to determine vessel damage.
- **Environmental Impacts and Recovery (SRA 4100) -** develop better methods of wildlife rehabilitation.
- **Sociological and Economic Impacts (SRA 4400) -** study impacts related to primary and secondary economic impacts and costs.

M/V Selendang Ayu

During a large storm in December 2004, the *M/V Selendang Ayu*, carrying a cargo of soybeans, lost power and grounded on the west side of Unalaska Island, Alaska, where it broke into two and released 337,000 gallons of IFO-380 fuel oil, marine diesel, a small amount of lube oil as well as its soybean cargo. Most of the oil was carried onto the rocky shorelines of Makushin and Skan Bays. Half of the vessel sank, while the other half remained afloat, harboring fuel with the potential for additional releases.

Response measures included employing SCAT, an assessment process used for all spills where shorelines are impacted, and manual shoreline cleanup. The potential of an additional release from the floating half of the vessel triggered testing and approval for dispersants and *in situ* burning (ISB), which were not employed. After the initial response, cleanup was halted until April 2005 due to deteriorating winter weather conditions. In the spring, most shorelines were manually cleaned and dry mechanical tilling and berm relocation techniques were used where appropriate. Response actions continued during the weather-permitting seasons until June 2006.

This incident highlighted the difficulty of response operations in the Arctic environment and the availability of suitable response technologies in cold, icy conditions. The After Action Review for the *M/V Selendang Ayu* incident discussed the following specific R&D Needs (Wood & Associates, 2005):

- **Response Management Systems (SRA 2100) -** improve information sharing, including identification of response equipment and resource availability.
- **Chemical/Physical Modeling (SRA 3200) -** develop methods to determine the transportation and fate of oil in Arctic waters.
- **In and On-water Containment and Recovery (SRA 3400) -** develop measures of containment for application in Arctic conditions.
- **Shoreline Containment and Recovery (SRA 3500) -** develop technology improvements for Arctic shorelines and weather conditions.

T/V Bow Mariner

In February 2004, the *T/V Bow Mariner* crew was engaged in cleaning residual Methyl Tertiary Butyl Ether (MTBE) from a cargo tank while in transit. The MTBE caught fire

ED_001324_00000360-00143

and exploded and the ship sank about 45 nautical miles east of Virginia. Twenty-one men died in the incident and all the cargo was lost. The vessel was carrying 3,188,711 gallons of ethanol, 192,904 gallons of No. 6 fuel oil, and 48,266 gallons of diesel, which were all released during the incident. An ignition of a fuel/air mixture, either on deck or in the cargo tanks, caused this casualty; the precise source was not determined. The ethanol, which is miscible in water and diesel oil were dispersed rapidly. The fuel oil created an oil slick that required mechanical recovery. Response actions included fishery closures, and mechanical recovery using skimmers; the vessel was not salvaged. Corexit 9527 was tested for dispersants; however, it was not used due to the cold temperatures and the degree of oil weathering.

A significant contributing factor to this casualty was the failure of the operator, Ceres Hellenic Enterprises, Ltd., and the senior officers of the *Bow Mariner*, to properly implement the company and vessel Safety, Quality and Environmental Protection Management System (USCG, 2005). Although specific R&D Needs were not identified, this incident highlighted the need for research in key SRAs:

- **Human Error Factors (SRA 1000) -** study explosion hazards related to tank cleaning operations
- **Human Error Factors (SRA 1000) -** develop manuals for safe tank cleaning procedures.
- **Human Error Factors (SRA 1000) -** develop adequate training on tank cleaning procedures for crews of vessels carrying explosive materials.
- **Human Error Factors (SRA 1000) -** develop adequate training for multicultural crew cohesiveness.
- **In- and On-water Containment and Recovery (SRA 3400) -** study methods of containment and recovery of ethanol and alternative fuels.
- **Dispersants (SRA 3600) -** study the effectiveness of dispersants in cold water and with weathered oil.

M/V Cosco Busan

In November 2007, the container ship *M/V Cosco Busan* spilled 53,569 gallons of heavy fuel oil from its bunker tanks into San Francisco Bay after the vessel struck the San Francisco-Oakland Bay Bridge in thick fog. The source of the incident was not a tanker transporting crude oil as a component of the oil production and transportation system, but rather a non-tank vessel engaged in maritime commerce spilling oil used to fuel the ship. Investigators concluded that the vessel's pilot was impaired from his use of prescription pharmaceuticals, while piloting the container vessel, which rendered him unable to properly use the onboard radar and electronic navigation charts. The USCG Vessel Traffic Service (VTS) failed to warn the pilot that the vessel was headed for the bridge.

ED_001324_00000360-00144

The master of the *M/V Cosco Busan* did not implement several procedures found in the company safety management system related to safe vessel operations, which placed the vessel, crew and environment at risk.

The spill oiled about 200 miles of coastline. The near shore location, the type of oil, and proximity to sensitive and valuable coastal resources resulted in a substantial response. Response activities included: deployment of containment boom; mechanical collection and removal; natural attenuation; beach closures due to health and safety concerns with the fuel oil and; and oiled bird capture and cleaning programs.

This incident was an important driver for research needs involving human error, crew fitness, and waterways management because of the potential to prevent this incident and others like it had these needs been addressed. The ISPR for the *M/V Cosco Busan* (USCG, 2008a,b) noted these specific R&D Needs:

- **Human Error Factor (SRA 1000) -** develop protocols to report changes in crew fitness to the USCG, in a timely manner, including any substantive changes in their medical status or medications.
- **Waterways Management (SRA 1300) -** develop technology improvements to improve vessel traffic monitoring and communications.
- **Response Management Systems (SRA 2100) -** develop improvements to information management systems that provide timely and accurate information for the Federal On-scene Coordinator about the extent of the spill.
- **Environmental Impacts and Recovery (SRA 4100) -** develop improvements to aid in effective bird capture techniques and identify priorities and resources needed to provide the most effective wildlife rescue.
- **Environmental Impacts and Recovery (SRA 4100) -** develop a framework to make beach closure and reopening decisions and incorporate those into local government plans (coordinated through the Area Contingency Plan (ACP)).
- **Human Health and Safety (SRA 4300) -** develop protocols needed to close, open or restrict fisheries after a spill that are written into emergency plans and develop expedited tests to check whether impacted fish are a health risk.
- **Sociological and Economic Impacts (SRA 4400) -** evaluate proper use of and methods to monitor the use of social media during and after spills.

7.2 Offshore Drilling Operations

The explosion and collapse of the *Deepwater Horizon* drilling platform resulted in the largest marine oil spill in history and revealed several Research Needs associated with offshore drilling operations.

ED_001324_00000360-00145

***Deepwater Horizon (DWH)* Oil Spill**

In April 2010, an estimated 205.8 million gallons of oil began flowing from a subsea well blowout that followed an explosion and collapse of the *Deepwater Horizon* platform (also called the Macondo 252 well) during exploratory drilling. The platform was located approximately 50 miles south of the coast of Louisiana in waters about 5,000 ft. deep. The explosion on the drill rig killed 11 men and injured 17 others. For approximately three months, efforts to stop the flow at the source were unsuccessful until response operations temporarily capped the well on July 15, 2010. The complete well closure occurred on September 18, 2010. The resultant oil spill caused damage to deepwater and nearshore marine and wildlife habitats across the Gulf States and to the Gulf's fishing and tourism industries.

This spill was declared a Spill of National Significance (SONS). Response to the *Deepwater Horizon* spill was diverse and conducted on a larger scale than any previous efforts. Different response mechanisms were deployed depending on the day, the weather conditions, and the amount and location of oiled shoreline. This included: ISB, subsea and surface dispersant use, booming, and skimming. Application of 1.84 million gallons of dispersants, both aerially and sub-sea at the wellhead, was unprecedented, as was the use of controlled ISB (a global record of 411 individual burns were conducted). This spill was the first where dispersants were applied subsea at the wellhead. Existing options failed to satisfy the public expectations, which led to the testing and evaluation of more than 120,000 response technologies through the Alternative Response Technologies Evaluation System (ARTES) Program.

The magnitude and spatial extent of this spill resulted in the collection of a large amount of monitoring and experimental data. A substantial amount of research studying the effects of the spill and the response on the Gulf of Mexico are ongoing. The incident report (USCG, 2011) highlighted the following R&D Needs:

- **Pre-Baseline (SRA 2000)** - ensure minimum standards and consistency for Gulf of Mexico Area Contingency Plans (ACPs).
- **Pre-Baseline (SRA 2000) -** identify Environmentally Sensitive Areas (ESAs).
- **Source Control and Containment (SRA 3100) -** develop improved technology and response protocols for well blowouts.
- **Response Management Systems (SRA 2100) -** develop systems to better meet the needs of oil spill response organizations.
- **Response Management Systems (SRA 2100) -** establish standards and processes for rapid collection, processing, correlation, analysis and distribution of satellite imagery and oil thickness sensors to direct spill response operations with real-time data.

ED_001324_00000360-00146

- **Oil Spill Detection and Surveillance (SRA 3300) -** develop improvements for subsea oil detection.
- **Oil Spill Detection and Surveillance (SRA 3300) -** develop and use enhanced SMART monitoring technologies and protocols in offshore environments.
- **Oil Spill Detection and Surveillance (SRA 3300) -** develop technology to determine oil slick thickness.
- **In- and On-water Containment and Recovery (SRA 3400) -** develop improved and more efficient skimmers and mechanical recovery equipment.
- **In- and On-water Containment and Recovery (SRA 3400) -** use a fully operational Common Operating Picture (COP) available during drills, exercises, and actual events.
- **In- and On-water Containment and Recovery (SRA 3400) -** develop protocols for thorough, independent testing and evaluation of response technologies prior to being used on a spill.
- **Dispersants (SRA 3600) -** study the toxicity of dispersants as a function of oil and dispersant types, and different environments.
- **Dispersants (SRA 3600) -** study dispersant efficacy including volumetric limitations of applications.
- **Dispersants (SRA 3600) -** study dispersant efficacy in mitigation of environmental impacts.
- **Dispersants (SRA 3600) -** develop methods and programs to monitor and track large, dispersed oil plumes.
- **Dispersants (SRA 3600) -** conduct a case study analysis of all aspects of dispersant use including environmental effects of dispersants and dispersed oil.
- **Dispersants (SRA 3600) -** study the effectiveness of dispersants under different environmental conditions (e.g., subsea).
- **ISB (SRA 3700) -** study where ISB can be used as a response option and areas where it can be subject to expedited approval.
- **ISB (SRA 3700) -** study the performance of various fire boom designs and improve technologies for water-cooled and reusable booms.
- **Sociological and Economic Impacts (SRA 4400) -** develop outreach programs for, and incorporate state and local emergency managers into, spill preparedness and response.
- **Sociological and Economic Impacts (SRA 4400) -** Spill of National Significance (SONS) doctrine should be adapted to be more inclusive of state, local and tribal governments in a response.

ED_001324_00000360-00147

7.3 On-Shore Pipeline Spills

There are more than 300 oil and hazardous liquid spills annually along the more than 199,000 miles of hazardous liquid pipelines in the U.S. according to PHMSA statistics. Three such spills illustrate the types of Research Needs for pipeline spills.

Enbridge Pipeline

In July 2010, an Enbridge Energy Partners LLP pipeline (30-in. diameter) ruptured near Marshall, Michigan and spilled an estimated 843,000 gallons of crude oil produced from bitumen sands, also known as oil sands products (OSP). The rupture released the oil into Talmadge Creek and it then flowed into the Kalamazoo River, a Lake Michigan tributary. Heavy rains at the time of the incident affected spill behavior and transport causing the river to overtop existing dams and carry the OSP downstream contaminating 35 miles of the Kalamazoo River. The rains resulted during a 25-year flood event that also carried the OSP into the adjacent floodplain.

At the height of the response, more than 2,500 people were working along the impacted river and shoreline. Response measures for this spill included: fish advisories, river closure for dredging operations to remove sunken oil and oil in sediments, and deployment of sediment traps for oil that was not removed during dredging. A significant portion of the oil submerged in the river making detection and recovery difficult. Numerous methods were tried to recover the submerged oil because globules continued to rise from the bottom when bottom sediments were disturbed. Identification of submerged oil was determined by manually disturbing the sediments with a pole. Oil sheens would form where there was submerged oil. Vacuums or passive methods removed the oil. Passive methods of recovery in place continued for a long period after the spill.

Research Needs influenced by this spill included submerged oil detection and recovery for large areas, and cleanup methods for OSP in floodplains. Additional research needs identified by the NRDA team included:

- **Pipeline Systems (SRA 1700) -** develop new advanced technology for sensing pipeline leaks that will reduce leak detection false alarms for new construction and existing pipelines.
- **Pipeline Systems (SRA 1700) -** improve and develop in-line inspection (ILI) to locate and size defects in girth welds and for long seam defects including cracks in electric resistance welded pipe (ERW).
- **Chemical and Physical Modeling and Behavior (SRA 3200) -** study the behavior of OSP when spilled into rivers including weathering and interactions with sediments.

ED_001324_00000360-00148

- **Oil Spill Detection and Surveillance (SRA 3300) -** improve technology for detection of submerged oil in rivers.
- **Environmental Impacts and Recovery (SRA 4100) -** study the lethal and sublethal impacts of OSP on biota.
- **Environmental Impacts and Recovery (SRA 4100) -** study the impacts of cleanup activity on subtidal and floodplain habitats.
- **Human Health and Safety (SRA 4300) -** study the impacts of air quality on the community and responders from OSP spills.
- **Sociological and Economic Impacts (SRA 4400) -** study the impacts related to lost recreational opportunities from spills.

Yellowstone River Pipeline

On July 1, 2011, a break occurred in a 12 in. pipeline, owned by ExxonMobil Pipeline Company, under the Yellowstone River, 20 miles upstream from Billings, Montana. The ruptured pipeline leaked an estimated 63,000 gallons into the river before the pipeline was closed. USEPA led the response in close coordination with the State of Montana and other federal agencies. EPA's primary concern was protecting people's health and the environment. The river also is known for Yellowstone River cutthroat trout, a Montana fish of concern.

When the Yellowstone River dropped below pre-spill water levels, oil residue was visible in many areas, including some agricultural lands. Farmers were given instructions for crops and livestock. USEPA held ExxonMobil, the responsible party, accountable for assessment, cleanup and restoration. Cleanup crews recovered only about 420 gallons of crude.

As in the case of the Kalamazoo River, the amount of oil spilled was much higher than it might have been due to that lack of coordination and communication among the pipeline operators. In both cases, there was a substantial delay in closing the valves to shut off the flow. In the Yellowstone River incident, it was estimated two-thirds of the spill volume were attributable to the delay. Although there were no specific recommendations for R&D, this spill emphasized the need for:

- **Human Error Factor (SRA 1000) -** better training and coordination for operators.
- **Pipeline Systems (SRA 1700) -** research on methods of inspection of buried pipelines for erosion.
- **Pipeline Systems (SRA 1700) -** improve existing leak detection technology and health monitoring sensors that are miniaturized, automatic, and robust enough to withstand harsh environments.

ED_001324_00000360-00149

- **Environmental Impacts and Recovery (SRA 4100) -** research on the potential impacts of OSP on freshwater fisheries.
- **Environmental Impacts and Recovery (SRA 4100) -** research on the potential impacts and restoration of OSP on crops and livestock.

Pegasus Pipeline

ExxonMobil's Pegasus pipeline carries 3,990,000 gallons per day of crude oil a distance of 850 miles from Patoka, Illinois to Nederland, Texas. The spill occurred on March 29, 2013, when the pipeline carrying Canadian Wabasca heavy crude from the Athabasca oil sands ruptured in Mayflower, Arkansas, about 25 miles northwest of Little Rock. A reported 210,000 - 294,000 gallons of crude were spilled. Approximately 3,990,000 gallons of oil mixed with water were recovered by March 31. Twenty-two homes were evacuated. The EPA classified the leak as a major spill.

The crude oil entered a suburban neighborhood through a leak in the 20 in. pipeline, which was buried an average of two feet below ground. The oil flowed into storm drains leading to nearby Lake Conway, used for recreational fishing. First responders, including fire fighters, city employees, county road crews and police built dikes to block culverts and stop the crude from further fouling the lake. ExxonMobil deployed 3,600 feet of containment boom around the lake. By early morning on March 30, there was no more oil spilling from the pipeline.

The EPA and ExxonMobil conducted air quality monitoring. Overall, air emissions in the community were below levels likely to cause health effects to the public. The Arkansas Division of Environmental Quality (ADEQ) closely reviewed the cleanup, continued to monitor the surface water in the affected areas, and posted regular updates. Although reports identified no specific Research Needs, those that were evident from the Mayflower pipeline spill are similar to Research Needs from the Enbridge Kalamazoo OSP spill:

- **Pipeline Systems (SRA 1700) -** improve and develop in-line inspection (ILI) to locate and size defects in girth welds and long seam defects including cracks in electric resistance welded pipe (ERW).
- **Chemical and Physical Modeling and Behavior (SRA 3200) -** research on OSP weathering and interactions with sediments.
- **Environmental Impacts and Recovery (SRA 4100) -** more research on the impacts of cleanup on habitats.
- **Health and Safety (SRA 4300) -** research on air quality monitoring protocols for OSP spills.

ED_001324_00000360-00150

7.4 Facility Spills

Severe weather events, most notably hurricanes in the Gulf of Mexico and the East Coast, were responsible for several spills from facilities in the inland areas in recent years.

Hurricanes Katrina and Rita

Gulf of Mexico Hurricanes Katrina and Rita caused multi-state pollution events in 2005. In total, there were over 500 spills resulting from these storms. Storm damage caused above ground storage facilities to spill an estimated 8 million gallons of oil. The largest spill totaled 3.78 million gallons. It came from facilities operated by Bass Enterprises Production Company in Cox Bay, just east of Port Sulphur in Plaquemines Parish, LA. Another Bass Enterprises spill totaling 461,000 gallons occurred near Pointe a la Hache, LA. The second-largest spill, 1,050,000 gallons, was from a broken pipeline owned by Shell Pipeline Co. near Pilot Town, LA. Chevron Oil is believed to have spilled 991,000 gallons near Empire, LA and 53,000 gallons near Port Fourchon, LA, while Venice Energy Services Co. is believed responsible for the discharge of 840,000 gallons near Venice, LA. Shell also was responsible for 13,440 gallons discharged near Nairn, also in Plaquemines.

These incidents indicated a significant need to have more effective response plans for spills caused by natural disasters. In 2005, the National Response Plan (NRP) was revised into the National Response Framework (NRF), which established a single, comprehensive approach to domestic incident management to prevent, prepare for, respond to, and recover from all hazards including terrorist attacks, major natural disasters, and other emergencies.

The response actions during these storms although not specifically identified in reports, indicate the need for R&D in the following areas:

- **Pre-Spill Baseline (SRA 2000) -** research to identify ESA species and other sensitive or important resources near fixed petroleum facilities.
- **Response Management Systems (SRA 2100) -** develop systems that support response actions for multiple spills during natural disasters.
- **In- and On-water Containment and Recovery (SRA 3400) -** identify and pre-place equipment to support facility responses during natural disasters.

Super Storm Sandy

On October 29, 2012, Hurricane Sandy, also known as Super Storm Sandy, made landfall in New Jersey and caused severe damage in the New York and New Jersey metropolitan area. Official estimates indicate that 336,000 gallons of diesel fuel from the Motiva oil tank facility in Woodbridge, N.J spilled into the Arthur Kill, a tidal strait, after the Sandy

ED_001324_00000360-00151

storm surge lifted a storage tank and it ruptured. The USCG reported that a secondary containment tank caught most of the oil and that the liquid that escaped moved into the Arthur Kill where booms contained the oil. Two hundred responders were on scene to contain the spill. Initially, an acrid stench filled the air. Air samples collected by the USCG at Arthur Kill showed levels within acceptable thresholds within two days. On the adjacent land, a vacuum truck removed a diesel-and-water mixture next to a local park along the Arthur Kill. Although not specifically identified, the response to this type of storm reflected the research needs for:

- **Response Management Systems (SRA 2100) -** ability to rapidly respond to multiple spills during natural disasters.
- **In- and On-water Containment and Recovery (SRA 3400) -** establish pre-placed equipment to respond to onshore facility spills.

7.5 Railroad Spills

Increased oil production of Bakken crude and Canadian Tar Sands along with limitations on pipeline capacity has resulted in a four-fold increase in rail shipments of crude oil between 2010 and 2014. Two derailments illustrate the types of issues that arise with spills from railroad accidents.

Parkers Prairie Train Accident

On March 27, 2013, a mile-long train hauling oil from Canada derailed in western Minnesota and leaked its crude; the leak was the first major spill of the newly developed North American crude. Fourteen of the 94 cars of the Canadian Pacific mixed freight train left the tracks about 150 miles northwest of Minneapolis near the town of Parkers Prairie. The Minnesota Pollution Control Agency reported three tank cars ruptured and leaked an estimated 20,000 to 30,000 gallons. Cold weather made the crude thicker, hindering the ability to recover the oil.

This incident indicates the need for R&D in the following areas:

- **Rail and Truck Transportation (SRA 1600) -** evaluate accident and incident trends to identify ways to minimize the incident rate of leaks, spills, and damage to the environment due to oil spills.
- **Rail and Truck Transportation (SRA 1600) -** evaluate alternative tank car designs and modifications to minimize risk of oil spills during accidents.
- **In and On-water Containment and Recovery (SRA 3400)** - conduct field tests of cleanup techniques and create protocols for various habitats and conditions.

ED_001324_00000360-00152

Lac-Mégantic Train Accident

On July 5, 2013, a unit train with 72 cars of Bakken crude oil stopped at Nantes, Quebec. The engineer parked and left the train in accordance with an expected shift change. At approximately 00:56 hours on July 6, 2013, the train started to move down the track. It rolled down the approximately 1.2% grade into the center of the small tourist town of Lac-Mégantic, derailed and the locomotives detached from the rest of the train. Since there were no signals or track circuits, the rail traffic controller had no initial indication of the runaway train. Many of the derailed tank cars full of oil exploded and burned in the heart of the commercial district. The accident killed forty-seven people.

Canada's Transportation Safety Board investigated the incident and determined "the braking was insufficient to hold" the runaway train and that the crude was very volatile. The Board also found the tank cars were mislabeled and the crude was more flammable than originally thought. The deadly accident spurred USDOT's Federal Railroad Administration (FRA), to improve safety standards, specifically for the transport of hazardous materials. "No train or vehicles transporting specified hazardous materials can be left unattended on a mainline track or side track outside a yard or terminal, unless specifically authorized." New safety procedures are now in place in the U.S. to reduce the potential for any future incidents occurring. These procedures include requirements for notification prior to leaving an unattended train and mandatory safety inspections by first responders. FRA (2015) also proposed new regulations regarding rail cars carrying crude oil.

This incident indicates additional Research Needs for trains carrying oil in these SRAs:

- **Human Error Factor (SRA 1000) -** increase training in the areas of communication and safety for trainman and dispatchers.
- **Human Error Factors (SRA 1000) -** develop programs for vessel crews to improve their understanding of automated vessel functions.
- **Railway and Truck Transport (SRA 1600) -** analyze hazards and develop corresponding mitigation methods and technologies for headspace gases in tank cars.
- **Railway and Truck Transport (SRA 1600) -** evaluate and determine minimum crew size requirements for safe operations of unit trains.
- **Human Safety and Health (SRA 4300) -** develop protocols for first responders and railroad workers to improve safety and communications in locations where railroads are carrying hazardous cargos.
- **Human Safety and Health (SRA 4300) -** study the impacts of burning crude oil on first responders and residents.
- **Sociological and Economic Impacts (SRA 4400) -** study the economic impacts of a major train disaster on a small community.

ED_001324_00000360-00153

THIS PAGE INTENTIONALLY LEFT BLANK.

ED_001324_00000360-00154

8. Current State of Oil Pollution Knowledge

The ICCOPR research and technology planning process involves continually assessing the current state of oil pollution knowledge. ICCOPR and its members continue to monitor and participate in a wide range of studies, workshops, and other events to gain insight into the state of knowledge regarding oil spill prevention, preparedness, response, and impact assessment and restoration. This chapter highlights some of the major sources of information since the 1997 version of the OPRTP was issued.

8.1 National Research Council - Oil Spill Dispersants: Efficacy and Effects

In 2005, the MMS, NOAA, USCG, and API funded the National Research Council (NRC) to convene a committee of experts to review the state of knowledge on the use of dispersants as a response technology for oil spills. They asked NRC to identify the adequacy of existing information and ongoing research regarding the efficacy and effects of dispersants. The study focused on: understanding the limitations imposed by the various methods used in previous studies; recommending steps to better understand the efficacy of dispersant use; and the effect of dispersed oil on freshwater, estuarine, and marine environments. The NRC completed the report well before the *Deepwater Horizon* oil spill and therefore did not envision the extensive use of dispersants during that response.

The NRC Committee emphasized the need to conduct bench-scale and meso-scale testing in order to be able to better control the environmental factors that are present in large-scale field experiments. They specifically recommended:

- Studies to better predict the effectiveness of dispersants for different oil types and environmental conditions;
- Bench-scale experiments to test effectiveness over a wide range of operating conditions;
- Investigations of the kinetics and transformation products of dispersed oil biodegradation at conditions that represent those that follow significant dilution of the dispersed oil plume;
- Toxicity studies to determine the mechanisms of acute and sublethal toxicity to key organisms from exposure to dispersed oil;
- Wave-tank studies that specifically address the chemical treatment of weathered oil emulsions; and
- Studies to quantify the weathering rates and final fate of chemically dispersed oil droplets compared with undispersed oil.

ED_001324_00000360-00155

8.2 The Coastal Response Research Center Workshops

The Coastal Response Research Center (CRRC) was established as a partnership between the NOAA OR&R, and the University of New Hampshire (UNH) in 2003. The CRRC's complementary organization is the Center for Spills in the Environment (CSE). CSE receives funding from sources other than NOAA.

The primary purpose of the CRRC and CSE is to bring together the resources of a research-oriented university and the expertise of governmental agencies, NGOs, academia and industry to conduct and oversee basic and applied research, conduct outreach, and encourage strategic partnerships in spill response, assessment and restoration. The CRRC and CSE hosted numerous workshops that brought together national and international oil spill experts to discuss future R&D Needs. The following workshops identified Research Needs that are important to the improvement of oil spill response and the understanding of potential effects:

- Research & Development Priorities: An Oil Spill Workshop (November 2003)
- Research & Development Needs For Making Decisions Regarding Dispersing Oil (September 2005)
- R&D Needs for Addressing the Human Dimensions of Oil Spills (June 2006)
- Submerged Oil Workshop Report (December 2006)
- R&D Priorities: Oil Spill Workshop (March 2009)
- Coordinating R&D on Oil Spill Response In the Wake of *Deepwater Horizon* (July 2011)
- A Forum – Oil Spill Research (January 2012)
- The Future of Dispersant Use in Oil Spill Response Initiative (March 2012)
- Oil Spill Dispersant Research Forum (March 2013)
- Alberta Oil Sands Workshop (April 2013) Washington State Department of Ecology, the Regional Response Team 10 and Pacific States/British Columbia Oil Spill Task Force (April 2013)
- Environmental Disaster Data Management Workshop (September 2014)

Research and Development Priorities: An Oil Spill Workshop (November 2003)

This CRRC workshop provided a foundation for a NOAA R&D strategic plan and a road map for funding decisions for five years. The participants considered Research Needs and then prioritized them in terms of short- and long-term research objectives, cost effectiveness, and applicability to response and restoration actions.

The topics were grouped into themes because many overlapped or were similar:

- Physical Transport Forecasting;
- Oil Weathering: Data Development and Modeling;

ED_001324_00000360-00156

- Ecosystem Services: Identification and Valuation;
- Communication: Public and Stakeholder Participation in Response and Restoration;
- Restoration Review;
- Chronic Effects of Oil at Individual and Habitat Levels;
- Methods and Techniques; and
- New Tools for Restoration and Recovery.

Research & Development Needs For Making Decisions Regarding Dispersing Oil (September 2005)

This CRRC workshop used the major topic recommendations from the 2005 NRC study on dispersant efficacy and effects to serve as the basis for the workshop discussion. The NRC report provided recommendations for major research topic areas within six R&D categories:

- chemical effectiveness of dispersant formulations;
- operational effectiveness parameters;
- hydrodynamics and integration of data needed to develop modeling capabilities to predict and evaluate dispersant effectiveness;
- short- and long-term toxicity of dispersants and dispersed oil;
- long-term fate of dispersants and dispersed oil, including biodegradation; and
- development of relevant exposure regimes.

R&D Needs for Addressing the Human Dimensions of Oil Spills (June 2006)

The goal of the CRRC Human Dimensions of Oil Spills Workshop was to bring together a broad spectrum of human dimensions researchers and oil spill practitioners, including industry representatives and regulators, to develop a list of research needs on human dimensions that the Center could use in Request for Proposals (RFPs) and announcements from other funding entities. CRRC specifically designed the workshop to gather holistic perspectives and feedback from all stakeholder groups involved in oil spill response and restoration.

Six research topics were noted as critical components to incorporate into NRDA and other spill response processes. They were:

- Human Use Dimensions;
- Risk Communication;
- Valuing Natural Resources;
- Social Impacts;
- Subsistence;

ED_001324_00000360-00157

- Coordination in Response and Restoration; and
- Environmental Ethics.

Submerged Oil Workshop (December 2006)

The overall goal of this CRRC workshop was to identify Research Needs information on submerged oil pertaining to the following response and restoration topics:

- Detection and Monitoring;
- Fate and Transport;
- Containment and Recovery (including Protection of Water Intakes); and
- Effects and Restoration.

R&D Priorities: Oil Spill Workshop (March 2009)

This CRRC workshop focused on areas where significant Research Needs still existed. This was a follow-up to the 2003 CRRC five-year R&D Needs Workshop. Participants were asked to discuss the needs in the areas of:

- **Spill Response During Disasters** - This area addressed issues that are encountered during natural (e.g., earthquakes, hurricanes, floods) or anthropogenic (e.g., accidents) disasters resulting in nearshore and offshore oil spills. Planning and implementation gaps and health and safety issues were the primary focus.

- **Response Technologies** - This research area addressed planning, implementation, technology and effectiveness issues for response (i.e., bioremediation, surface washing agents, solidifiers, sorbents, dispersants, and ISB).

- **Acquisition, Synthesis and Management of Information** - This research topic focused on practices and methodologies for accessing and using remote-sensing data, real-time observational data systems, electronic data collection via field surveys, and geographic information systems (GIS).

- **Human Dimensions** - This research topic addressed the human dimension as part of a response, including: 1) minimizing social impacts and subsequent response activities; 2) developing strategies to address the long-term socioeconomic effects oil spills have on a region's culture and vitality; 3) translating and incorporating social science research, methodologies, and initiatives into individual and collective response plans; and 4) assessing where social science research "fits" into the spill management structure.

- **Ecological Monitoring and Recovery Following Spills** – This research area focused on: 1) understanding long-term ecological recovery to make informed

ED_001324_00000360-00158

decisions from response to restoration; 2) understanding the ecological factors affecting recovery rates; 3) developing ecological 'metrics' that can be applied by resource managers to develop restoration projects that best compensate for lost resources.

- **Biofuels** – This topic addressed research on first generation biofuel blends in terms of spill response technologies and determination of fate and effects after a spill.
- **Ecological Effects of Oil Spills** – This topic addressed issues around the long-term effects of residual oil in the environment, including the levels and types of adverse effects resulting when oil remains, and the effects of an oil spill that may be magnified by the clean-up technologies.
- **Environmental Forensics** - This topic focused on chemical fingerprinting methods to determine the source and extent of oil resulting from an incident. This information can be important for clean-up, assessment, recovery, monitoring, and associated liability issues.

Coordinating R&D on Oil Spill Response in the Wake of Deepwater Horizon (April 2011)

The CSE organized this workshop to bring together experts from across a broad spectrum of organizations to address the state of future oil spill response research and practices. The overarching goals were to: (1) develop an updated list of Research Needs for response related to dispersant efficacy and effects, spill trajectory modeling, detection of surface and subsurface oil, human dimensions in spill response, seafood safety monitoring and information management; and (2) create a dialogue between researchers and responders in order to ensure translation of research results into practice.

A Forum –Oil Spill Research (January 2012)

The goal of this forum is to encourage dialogue among Principal investigators (PI's) of current research related to oil spill response (e.g., GoMRI, NSF) and industry and government representatives in order to coordinate R&D activities regarding future oil spill response in the wake of the *Deepwater Horizon*.

The objectives of this forum were to review previous and on-going R&D conducted by academic, governmental agencies and industry; present newly funded projects so that everyone is aware of what types of research are being conducted; and evaluate mechanisms for scientific exchange and coordination of oil spill response R&D efforts going forward.

ED_001324_00000360-00159

As defined for this forum, oil spill response R&D encompassed any of the following topics:

- Physical, Chemical and Biological Fate and Transport;
- Biological Effects - Resources at Risk;
- Response Technologies;
- Oil Spill Modeling;
- Monitoring and Detection of Surface, Subsurface and Dispersed Oil;
- Human Dimensions and Risk Communication.

The Future of Dispersant Use in Oil Spill Response Initiative (March 2012)

CRRC convened this workshop with the goal of bringing together federal and state representatives, academic scientists, responders, and other stakeholders to discuss the future of dispersant use in spill response in the United States. The overall goals for the workshop were to:

- Build a fact-based consensus on the trade-offs associated with dispersant use;
- Evaluate the current state-of-knowledge on the monitoring, behavior, effects, and fate of dispersants;
- Identify information gaps; and
- Recommend R&D topics to help inform dispersant use in future spill response.

Oil Spill Dispersant Research Forum (March 2013)

Coordination with research, technology, application, and response is needed to optimize dispersant efficacy and effectiveness. After the *Deepwater Horizon* oil spill, there was an increase of research on dispersants and dispersed oil, with a large amount of research coming from the Gulf of Mexico Research Initiative (GoMRI), BSEE, and industry.

This workshop focuses on enhancing communication about dispersant related research and its application, use, and transition to spill response efforts. It was convened with the goal of encouraging, opening, and continuing dialogue among principal investigators (PIs) of research related to dispersant use and response practitioners. The overall objective was to review prior and current research and development (R&D) conducted by academia, government agencies and industry and evaluate mechanisms for scientific exchange and coordination of these efforts. Specific objectives were to:

- Learn about on-going and newly funded R&D on dispersants and dispersed oil (DDO);
- Determine how on-going and new R&D on DDO can improve dispersant use (assuming that dispersants will continue to be a tool in some spill responses);

ED_001324_00000360-00160

- Develop mechanisms for information exchange/interaction among researchers, practitioners and public/nongovernmental organizations regarding DDO;
- Explore data needs, tradeoffs, and decisions of practitioners regarding DDO before, during and after spills; and
- Identify potential R&D efforts on DDO that could improve dispersant use during future spills offshore. Other goals were to (1) encourage and continue dialogue on DDO among researchers, spill practitioners and NGO's; and 2) foster mechanisms to enhance public understanding;
- Common themes across breakout groups at the meeting included: enhancing and continuing communication between researchers and responders regarding DDO; increasing public outreach and education; and improving comprehensive and transparent transition of research from laboratory to field application. Modeling is a tool that could act as a potential bridge between laboratory research and field application.

Alberta Oil Sands Workshop (April 2013)

The Washington Department of Ecology contacted the University of New Hampshire's CSE to conduct a workshop for relevant state and Federal agencies on the important issues related to OSP characteristics, transportation and response planning. A similar training was conducted for the State of Maine related to transport of OSP and Bakken crude through that State.

The first day of the workshop was an open forum, which provided information to a broad group of stakeholders from the region. The second day was a working session for response practitioners to focus on issues related to potential OSP spill scenarios. Task groups were given four potential scenarios to test the current understanding of OSP and identify future information and other needs. The breakout groups identified actions that could be taken to improve both near- and longer-term OSP spill response.

Environmental Disaster Data Management Workshop (September 2014)

In the wake of the *Deepwater Horizon* oil spill, the significant body of information, including new research, has highlighted the need for improved coordination of data management. It is common for multiple organizations to collect data that vary significantly in quality, collection methods, access, and other factors that affect use by others. These differences result in limitations for use of the data including comparing results or making inferences.

The Environmental Disasters Data Management (EDDM) Workshop, organized by NOAA's OR&R with assistance from CRRC, was the beginning of a project to foster communication between collectors, managers, and users of with a goal to identify and

ED_001324_00000360-00161

establish best practices for orderly collection, storage, and retrieval of data. The objectives of the EDDM project are to:

- Engage the community of data users, data managers, and data collectors to foster a culture of applying consistent terms and concepts, data flow, and quality assurance and control;
- Provide oversight in the establishment and integration of foundational, baseline data collected prior to an environmental event;
- Provide best-practice guidance for data and metadata management
- Suggest infrastructure design elements to facilitate quick and efficient search, discovery, and retrieval of data; and
- Define the characteristics of a "gold standard" data management plan for appropriate data sampling, formatting, reliability, and retrievability.

8.3 Department of Energy (DOE) Programs

DOE's ongoing research within the Office of Fossil Energy is focused on the prudent development of domestic oil and gas resources. Onshore research is coordinated with the USEPA and the Department of the Interior (DOI)/US Geological Survey (USGS). The three agencies jointly developed a framework for Federal research that addresses how to safely and prudently develop the Nation's unconventional oil and gas resources. The unique and specific core research competencies of each agency underpin the synergy of this research effort. This multiagency research strategy includes key research questions the agencies will address in a coordinated fashion. These research questions focus on protecting groundwater and air quality, reducing, reusing, and recycling water used in upstream exploration and production operations, reducing the surface and subsurface impacts of oil and gas exploration and production activities, and improve the understanding for the purpose of mitigating induced seismicity.

Offshore research is coordinated with the DOI/Bureau of Safety and Environmental Enforcement (BSEE). Prior to the BP Deepwater Horizon oil spill, DOE's offshore research had been directed at maximizing the value of the Nation's offshore oil and gas resources while protecting the environment. A recommendation of the President's National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling was that DOE should refocus its offshore research activities. In working with the DOI/BSEE Ocean Energy Safety Advisory Committee, DOE refocused its offshore research program on oil spill prevention. DOE's focus has since been on assessment and mitigation of the risk of loss of well control so as to prevent oil spills. Research pathways include: identification of geologic hazards, well control during the drilling and completion process, integrity of the surface facilities and umbilicals, and subsea reliability and automation.

ED_001324_00000360-00162

8.4 Ultra-Deepwater Advisory Committee Annual Plan Reviews

The Ultra-Deepwater Advisory Committee (UDAC) was formed in 2007 to advise the Secretary of Energy on the development and implementation of programs related to ultra-deepwater (UDW). The Committee, sunset in 2013, provided recommendations for incorporation into DOE's annual plan of research.

In 2011, the UDAC suggested that, because of the *Deepwater Horizon* accident, there should be projects aimed at placing additional measuring instruments in the well and/or at the wellhead to determine the nature of the well fluids, pressures, and their flow status in real time. They recommended that this work be combined with development of secure methods for transmitting the data to the surface and providing timely interpretation. Analysis of the *Deepwater Horizon* incident indicated that a lack of reliable information hampered control efforts from the initial blowout to the final capping of the well. The UDAC also recommended conducting studies of current subsea containment and capture technologies (hardware), including gap analyses and needs for future technologies with emphasis on subsea capture systems that are independent of surface facilities. Because a number of behavioral factors associated with operations, maintenance, and training contributed to the *Deepwater Horizon* incident, the UDAC recommended research aimed at discovering the fundamental attitudes of rig personnel and associated groups to health and safety issues.

In the 2012 review of the DOE offshore research plan, the UDAC indicated that there was a strong emphasis on the engineering aspects of increasing safety, but little attention was given to the aspects of human behavior regarding safety. However, given the causal factors in the *Deepwater Horizon* incident, research into how to conduct the human aspect of operations safety and how to use advanced decision support and backup systems is not only prudent, but also mandatory.

The UDAC indicated that information is limited regarding methods to prevent and respond to catastrophic events, and mitigate the negative impacts of spills in remote, harsh and sensitive environments. Environmental protection and personnel health and safety working in harsh, unique and sensitive marine habitats, such as Arctic waters and tropical coral reef areas, requires additional focus. To accomplish this, the UDAC recommended that a gap analysis be conducted to catalog and characterize the salient differences between operations in the Gulf of Mexico and those environments encountered in drilling and completion in unique and sensitive marine habitats, such as Arctic waters and tropical coral reef environments, to assess the risks that demand more research.

Finally to further improve safety, the UDAC recommended the present scope of expert (case-based) systems be determined, and then benefits and limitations be identified, as

ED_001324_00000360-00163

well as other applications (e.g., cementing, completions, wellbore design), that would reduce the risk when operating in deepwater.

8.5 Deepwater Horizon Oil Spill Principal Investigator Conferences

The *Deepwater Horizon* oil spill focused unprecedented attention on the Gulf of Mexico ecosystem. During the response to the *Deepwater Horizon* event, resource managers and researchers from across the country collaborated to conduct science, monitoring, and response activities to understand impacts from the spill. The data and information collected from those efforts have since been used to make progress towards the long-term goal of protecting and restoring public health and natural resources in the Gulf of Mexico.

In 2010 and 2011, the National Science and Technology Council's Joint Subcommittee on Ocean Science and Technology (NSTC JSOST) convened two major workshops in St. Petersburg, Florida of Principal Investigators (PIs) actively involved in research, sampling, and monitoring activities in response to the *Deepwater Horizon* incident. Each of the workshops was an opportunity for PIs to foster new collaborations, compare initial results, interact with federal agencies, and discuss recommendations for longer-term research activities.

> The October 2010 Conference had six breakout groups. Five groups addressed oil/dispersant: fate and extent; impacts and mitigation in the offshore; impacts and mitigation in coastal areas; impacts and mitigation on living marine resources; and impacts and mitigation on human health and socio-economic systems. The sixth group addressed the use of *in situ* and remote sensors, sampling, and systems for assessing the extent, fate, impacts, and mitigation of oil/dispersant.

The follow-on workshop in October 2011 was an opportunity for researchers to present results of studies that were in progress during the first conference in October 2010. The second conference provided a significant amount of information regarding the spill impacts, early recovery, and the scientific efforts to capture that information. Researchers presented numerous potential research needs going forward. As in the initial 2010 conference, the participants identified a series of overall recommendations and observations about gaps and needs for continued research and ways to improve scientific understanding of Gulf of Mexico science issues.

8.6 Deepwater Horizon Incident Specific Preparedness Review

In January 2011, the USCG Commandant chartered the Incident Specific Preparedness Review (ISPR) for the response to the *Deepwater Horizon* oil spill in 2010 to examine the implementation and effectiveness of the preparedness and response to the incident as

ED_001324_00000360-00164

it related to the National Contingency Plan, Area Contingency Plans, and other oil spill response plans. The report was divided into three main chapters: Planning and Plan Execution, Organization, and Resources and Readiness. The ISRP also provided a list of lessons learned and recommendations.

- **Planning and Preparedness** - There was a general weakness in the USCG's ability to respond to this type of large spill. The problems were the result of budget reductions organizational structure. The agency needs to reassess its readiness programmatically and reinvest to the extent that Marine Environmental Response (MER) is, once again, firmly established as one of the USCG's core competencies.
- **Area Contingency Plans** - The ISPR found these plans to be inadequate for this size of incident. The USCG needs to provide service-wide direction to all Area Committees, develop minimum standards for contingency plans, and establish an oversight, review, and compliance program.
- **Environmentally Sensitive Areas** - In some planning areas, the ESAs were not identified. In some plans where the areas were listed, they were not prioritized. In a few instances, ESAs did have protection strategies for the heavily affected areas. There must be a national planning process that identifies ESAs and ensures that there are trained personnel, equipment, and strategies adequate to protect these resources.
- **Alternative Response Technologies** - The use of two alternative response technologies, dispersants and ISB, proved critical to preventing wholesale impacts to ESAs. This was possible because the spill characteristics, location, and distribution of ESAs were favorable to the use of these technologies. However, important concerns and questions remain about their impacts on the environment, and more research is necessary before bringing them into the mainstream of spill response options. The use of dispersants during the *Deepwater Horizon* incident identified a need for a thorough review of this response option, its efficacy in minimizing environmental impacts, its overall effect on the environment, and conditions under which they are most effective. Dispersant protocols and authorization procedures should be established and articulated in ACPs. The National Response Team should require that all RRTs establish ISB guidelines as a viable response option in their area of responsibility, consistent with public health and safety issues.
- **Effective Daily Recovery Capacity (EDRC)** - EDRC is the planning standard used to estimate the rate at which mechanical means (e.g., skimmers) can recover an amount of oil and rate capabilities of oil spill removal organizations (OSROs). Revised EDRC requirements could stimulate OSROs to invest in response research and development, with the goal of developing skimmers and other recovery equipment that are more efficient.

ED_001324_00000360-00165

- **Funding** - Many of the recommendations provided in the report require additional or new funding. The *Deepwater Horizon* incident showed the response community and the public that a "business as usual" approach to funding would not work.
- **National Response Framework (NRF)** - The USCG should fully implement its policy on connectivity with the NRF, including an expanded outreach program to state and local emergency managers through sector participation with Local Emergency Planning Committees, and District participation with Regional Interagency Steering Committees.
- **Crisis Leadership** - The *Deepwater Horizon* incident placed individuals into crisis management roles, and not all were able to demonstrate the required leadership. The National Incident Command concept worked very well during this incident, and it provides a model for selecting individuals with the necessary crisis management skills to lead response efforts and to manage effectively future national incidents.
- **Lessons Learned** - The USCG needs to formally address lessons learned, institutionalize them through programmatic changes, and in some cases, through cultural changes.

8.7 National Commission on BP Deepwater Horizon - Final Report

In January 2011, the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling (Commission) issued their Report to the President – Deepwater: The Gulf Oil Disaster and the Future of Offshore Drilling. The Commission's complete recommendations in the report reflect the government's sweeping sovereign authority as owner of the seabed and water column and, as the regulator of activities there, with the overriding responsibility to manage and protect the valuable resources of the outer continental shelf (OCS) on behalf of current and future generations. The Commission's report grouped recommendations in nine distinct areas:

- Improving the safety of offshore operations through greater government oversight and control including a new regulatory organizational structure;
- Improving the safety of offshore operations by industry through greater emphasis on a more risk based approach to operations and safety;
- Safeguarding the environment;
- Strengthening oil spill response, planning, and capacity;
- Advancing well-containment capabilities;
- Overcoming the impacts of the *Deepwater Horizon* spill and restoring the Gulf;
- Ensuring financial responsibility;
- Promoting Congressional engagement to ensure responsible offshore drilling; and

ED_001324_00000360-00166

- Developing approaches for frontier regions to incorporate lessons learned during the *Deepwater Horizon* oil spill.

Within each of the major categories, the Commission had additional specific actions and recommendations to improve offshore drilling prevention, preparedness, response and environmental protection and restoration.

The Commission Staff Working Paper No. 7, "Response/Clean-up Technology Research & Development and the BP Deepwater Horizon Oil Spill," documented the state of research and development by the private sector and federal government specific to containment and well-control technology. The paper was provided to the full Commission for consideration as it deliberated it report to the President. The paper discussed three basic questions:

- Does the private sector invest less than the socially optimal amount in response/cleanup technology?
- Do federal agencies lack adequate long-term funding to maintain response/cleanup preparedness?
- Can the federal government and industry create a set of incentive for private companies and government agencies that would optimize levels of investment in response/cleanup technology?

The paper concluded that there was a response R&D gap. The paper suggested that the National Commission consider:

- Recommending language in OPA 90 to guarantee the full oil spill research authorization provided in the Act as originally intended.
- Recommending OPA 90 be amended to guarantee sustained and additional funding for Ohmsett.
- Recommending ways to stimulate the cleanup technology market and incentivize related R&D,
- Recommending that the EDRC regulations be revised to give an incentive for response companies to employ the most efficient recovery equipment.
- Recommending that EPA streamline the permitting process for open-water testing and that EPA loosen its oiled-water discharge requirements for technology testing purposes.

8.8 Public Meetings, Letters, and Reports Submitted to ICCOPR

As part of the R&T planning process, ICCOPR held three public meetings in 2010 to solicit input on future oil pollution research needs. ICOCPR advertised the public meetings in the Federal Register and conducted them on the West, East, and Gulf Coasts to obtain different regional interests and perspectives.

ED_001324_00000360-00167

In addition to the public meetings, ICCOPR also received letters from the Pacific States/British Columbia Oil Spill Task Force, the U.S. Arctic Research Commission, and the Marine Mammal Commission and a report entitled "Assessing the Long-term Effects of the BP Deepwater Horizon Oil Spill on Marine Mammals in the Gulf of Mexico: A Statement of Research Needs."

8.9 National Research Council: Responding to Oil Spills in the U.S. Arctic Marine Environment

A group of organizations requested that the National Research Council of the National Academy of Sciences conduct a study of the current capabilities to respond to oil spills in the Arctic. ICCOPR sponsors included the USCG, BSEE, BOEM, NOAA, and USARC. Other sponsors included API, Marine Mammal Commission, and OSRI. The report had four main sections: 1) Environmental Conditions and Natural Resources in the U.S. Arctic; 2) Arctic Oil Spill Response Research; 3) Operations, Logistics, and Coordination in an Arctic Oil Spill; and, 4) Strategies for Response and Mitigation. Each section described the current state of knowledge or capabilities of the U.S. response organizations and made recommendations for an effective prevention, preparedness, and response system.

NRC released the report after ICCOPR had completed the Research Needs Identification Process (see section 6.1) and was in the Needs Prioritization Process (see section 6.2). The R&T Plan Workgroup reviewed the NRC report and determined that the recommendations were consistent with the Research Needs already under consideration. The Workgroup used the NRC recommendations as a factor in selecting priority Research Needs.

8.10 National Petroleum Council: Arctic Potential – Realizing the Promise of U.S. Arctic Oil and Gas Resources

In 2013, the Secretary of Energy commissioned the National Petroleum Council (NPC) to conduct a comprehensive study considering the research and technology opportunities to enable prudent development of U.S. Arctic oil and gas resources. The study included an in-depth assessment of available offshore oil and gas technology, ongoing research, and research opportunities, in six areas:

- Ice characterization
- Oil and gas exploration and development
- Logistics and infrastructure
- Oil spill prevention and response
- Ecology, and
- Human environment.

ED_001324_00000360-00168

The report includes extensive information on the state of knowledge on Arctic technologies and operations, spill prevention and response capabilities, and the ecological and human environment. The NPC issued the Executive Summary of the report in March 2015 after ICCOPR had completed the prioritization process and was in the final stages of developing the text of this OPRTP. As such, the NPC report was issued too late for ICCOPR to consider it in developing this version of the Plan. However, ICCOPR will continue to review the NPC report and use it as a source of information.

8.11 Industry Reports

The oil and gas industry convened the Joint Industry Oil Spill Preparedness and Response (OSPR) Task Force (JITF) in June 2010 to evaluate procedures and lessons learned during the *Deepwater Horizon* oil spill response. The initial focus of the JITF was to identify potential opportunities for improvement to oil spill response systems in the areas of planning and coordination, optimization of each response tool, R&D, technology advancement, and training/education of all parties preparing for or responding to an oil spill. The JITF spent several months developing and prioritizing project plans to address each preliminary recommendation, and subsequently received approval and Industry funding for a multi-year work program. The JITF divided its recommendations into seven categories, or work streams:

- Planning;
- Dispersants;
- Shoreline protection and cleanup;
- Oil sensing and tracking;
- *In-situ* burning;
- Mechanical recovery; and
- Alternative technologies.

Nine oil and gas companies established the Arctic Oil Spill Response Technology Oil Joint Industry Programme (JIP) to further build on existing research and improve the technologies and methodologies for Arctic oil spill response. The goal of the JIP was to advance Arctic oil spill response strategies, improve equipment and increase understanding of potential impacts of oil on the Arctic marine environment. There were seven key areas of research addressed by the JIP specifically for the Arctic:

- Dispersants;
- Environmental effects;
- Trajectory modeling;
- Remote sensing;

ED_001324_00000360-00169

- Mechanical recovery;
- *In-situ burning*; and
- Field research.

8.12 Prince William Sound Oil Spill Recovery Institute (OSRI) Research Plan 2011-2015 (February 2010)

The Prince William Sound (PWS) Oil Spill Recovery Institute (OSRI) was authorized in 1990 by the United States Congress to "identify and develop the best available techniques, equipment, and materials for dealing with oil spills in the Arctic and sub-Arctic marine environments" (Title V, Section 5001, Oil Pollution Act of 1990). OPA 90 amendments in 1996 and 2005expanded the area of emphasis and extended the life of OSRI programs until one year after the completion of oil exploration and development efforts in Alaska.

OSRI sponsors research programs on physical oceanography and meteorology designed to improve the ability to forecast weather and ocean conditions. OSRI works with a wide array of industry and agency organizations to sponsor technological improvements for oil spill response. This includes contributing to the testing of new skimmer technologies, sensitivity index maps, and sponsoring workshops to identify best practices and research needs. It supports K-12 classroom programs and recently worked to include more technology in the education programs. With the increased desire by industry to develop offshore regions of the Arctic, there is greater emphasis on improving technologies for oil spill response in ice-laden waters.

OSRI's 2011-2015 Research Plan outlines the priority research areas that it will be funding:

- Interdisciplinary approaches to understanding the fate and effects of an oil spill in the Arctic and the recovery of that oil;
- Development of response tools to assist responders to mitigate the impact of spills in the Arctic; and
- Communication and education of the public on the issues related to oil spills in the Arctic.

ED_001324_00000360-00170

9. Oil Spill Research and Technology Priorities

ICCOPR selected 150 priority oil pollution Research Needs to address the 25 SRAs and SRA subcategories using the deliberative process described in Chapter 6. These priorities represent the federal opinion on where federal research programs should focus in order to make the most progress to addressing the overall Research Needs. Each federal agency should consider these priorities as they make their research investments. ICCOPR encourages non-federal research programs to use these priorities as well. ICCOPR will track progress toward addressing these priorities during the next planning cycle and establish a new set of priorities at that time.

ICCOPR organized the priority Research Needs by the four major Classes of research: Prevention, Preparedness, Response, and Injury Assessment and Restoration (Figure 9-1)

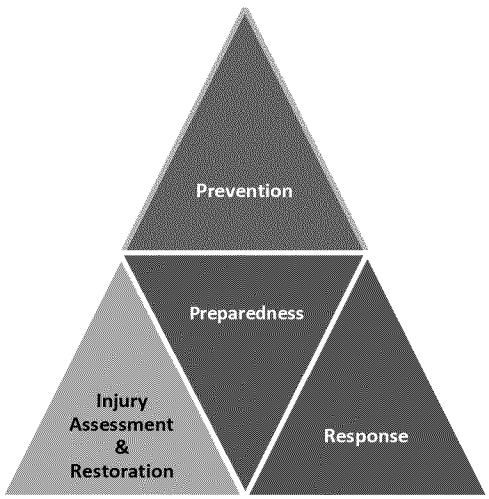


Figure 9-1 - The Oil Spill Research Categorization Framework

As discussed in Section 4.1, this framework embodies the concept that the research in each Class can inform and support the research from other classes; and that the Preparedness class plays a central role in supporting them all. Member organizations may conduct or support research in a single Class or multiple Classes depending on their specific mission, regulatory responsibilities, and/or expertise.

Table 9-1 lists the Classes and the SRAs they encompass. The following sections present the top priority Research Needs by Class and SRA or SRA subcategory. The order of the three priorities listed within an SRA or SRA subcategory is not indicative of their relative importance. All three are of equal importance. The Classes are:

Prevention Class - Research that supports the development of practices and technologies designed to reduce the likelihood of releases or minimize the volume of oil released into the environment.

Preparedness Class - Research that determines baseline conditions or supports the activities, programs, and systems typically developed prior to an oil spill to improve the

ED_001324_00000360-00171

planning, decision-making, and management processes needed for responding to and recovering from oil spills.

Response Class - Research that supports techniques and technologies that address the immediate and short-term effects of an oil spill and encompasses all activities involved in containing, cleaning up and treating oil in order to: 1) maintain safety of human life; 2) stabilize a situation to preclude it from worsening, and 3) minimize adverse environmental and socioeconomic effects.

Injury Assessment and Restoration Class - Research that involves the collection and analysis of information to evaluate the nature and extent of environmental, human health, and socioeconomic injuries resulting from an incident, and determine and refine the restoration actions needed to bring injured natural resources and services back to pre-spill conditions and make the environment and public whole after interim losses.

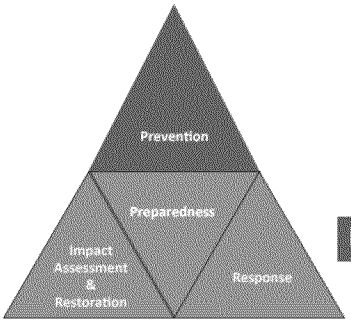
ED_001324_00000360-00172

Table 9-1 Standing Research Areas (SRAs) by Research Class

Prevention	Preparedness	Response	Injury Assessment & Restoration
• Human Error Factors • Offshore Facility and Systems • Onshore Facilities and Systems • Waterways Management • Vessel Design • Drilling • Rail & Truck Transportation • Pipeline Systems	• Pre-spill Baseline Studies • Response Management Systems	• Structural Damage Assessment and Salvage • At Source Control and Containment • Chemical and Physical Behavior Modeling • Oil Spill Detection and Surveillance • In- and On-water Containment and Recovery • Shore Containment and Recovery • Dispersants • In-situ Burning • Alternative Countermeasures • Oily and Oil Waste Disposal • Bioremediation	• Environmental Impacts and Ecosystem Recovery • Environmental Restoration Methods and Technologies • Human Safety and Health • Sociological and Economic Impacts

ED_001324_00000360-00173

9.1 Prevention Priority Research Needs



PREVENTION

9.1.1 Human Error Factors Priorities (Section 4.3.1.1)

This SRA focuses on how human performance and factors contribute to accidents in the oil production/transportation system. It includes the development of advanced methods and systems for training operational personnel, basic research on operating personnel performance in preventing oil spills (safe navigation on vessels, proper oil transfer practices, analysis/evaluation of equipment monitoring systems, decision-making processes), and the development of methods and technologies to evaluate the ability and knowledge of operating personnel in performing their duties. This may extend to evaluation of the overall management culture and its ability to foster the appropriate organizational safety, preparedness and response operating environment.

The priorities selected focus on improving the performance of individuals to reduce potential spills through better technology and improved training methods. ICCOPR selected Research Needs that emphasized development of innovative training methods by using simulations and gaming. At the operational level, improvements in instrumentation and data interpretation technology are essential to allow better decisions to be made on vessels, in ports, and on railway and pipeline transportation systems.

☐ Improve performance and decision-making by developing innovative training methods including readiness evaluations, gaming and simulators.
☐ Conduct research to determine current level of expertise for operators within modern transportation systems including marine, rail, truck, and pipeline.
☐ Improve and develop sensors; instrumentation; command electronics; and advanced data interpretation technologies and alert systems, including data analysis and expert systems to enhance decision-making capabilities.

ED_001324_00000360-00174

9.1.2 Offshore Facilities and Systems Priorities (Section 4.3.1.2)

This SRA includes: offshore exploration and development wells, platforms, and well control systems; the methods, techniques, and equipment for system reliability inspections; systems to detect, prevent, and mitigate oil and gas discharges; and equipment to regain control of a well blowout or any other accidental discharge. It also includes transfer equipment, storage units, and piping used to transfer oil within the offshore system and connect the system to transfer pipelines. This technology is relevant for the multiple operating environments of exploration and production activities (e.g., Arctic, shallow, deep and ultra-deep waters).

One of the selected priorities acknowledges the special conditions that occur in the Arctic. Another priority recognizes the need to address material integrity in deepwater, the Arctic and other frontier drilling locations.

☐ Evaluate corrosion and corrosion mitigation processes at the splash zone for offshore platforms.
☐ Study effects of ice forces, scour and gouging with respect to prevention of oil spills from offshore facilities.
☐ Conduct studies related to the longevity and integrity of metallic materials used under extreme conditions in relation to new surface treatments and alloys.

9.1.3 Onshore Facilities and Systems Priorities (Section 4.3.1.3)

This SRA includes designs, techniques, operational procedures and equipment for fixed onshore facilities including wells. It covers inspections and systems to detect, prevent, and mitigate oil and gas discharges from the facilities and their systems, including transfer equipment, storage, and piping.

The priorities for this SRA emphasize the need to improve the integrity and operations of onshore facilities. As in other SRAs, the priorities for Onshore Facilities recognize the need to address the effects of emerging crude and Arctic environments on facility infrastructure. There are two subcategories under this SRA: 1) Tank and Piping Inspection, Operations, Design, and Data; and, 2) Emerging Issues.

TANK AND PIPING INSPECTION, OPERATIONS, DESIGN, AND DATA
☐ Analyze upstream and/or downstream causes and magnitude of discharges from tanks, appurtenances, and associated piping.
☐ Develop improved methods and protocols used to determine the imperviousness of secondary containment structures.
☐ Evaluate the efficacy of sorbent and similar technologies used as oil spill control measures for storm water filtration and secondary containment shut-off drains.

ED_001324_00000360-00175

EMERGING ISSUES
Identify the effects of an aging oil storage infrastructure (tanks, appurtenances, and piping systems) and develop methodologies/protocols to predict/minimize failures.
Assess the effects of emerging crude oils and alternative fuels on tanks, appurtenances and piping.
Assess the effects of Arctic and cold weather environments on the operation and maintenance of tanks, appurtenances, and associated piping.

9.1.4 Waterways Management Priorities (Section 4.3.1.4)

This SRA includes methods, equipment, and integrated systems designed to improve navigation at sea and in ports, rivers, and inland waterways. It includes on-board navigation systems, such as integrated navigation and bridge systems and collision avoidance systems. It also includes systems external to the vessel, such as vessel traffic and tracking systems, navigational aids and piloting systems, as well as includes general research into navigation risks, the effects of navigational safety programs, and the development of decision support tools for waterways management efforts. This SRA includes development of navigational channel maintenance programs and analysis of voyage pre-planning processes.

The priorities selected recognize the special nature of operations and navigation in ice-infested waters of the Arctic. They also focus on the need to improve technology on ships and in ports for traffic control.

Improve navigation through enhanced piloting systems, electronic charts and information systems.
Improve systems and protocols needed for traffic control in ports.
Improve Arctic waterways management/vessel accident prevention, including improvements in (a) Arctic communications, (b) emergency response paradigms for vessel accidents (e.g., vessel foundering), (c) ice piloting requirements/qualifications, (d) Arctic weather, and (e) ice forecasting.

9.1.5 Vessel Design Priorities (Section 4.3.1.5)

This SRA includes the development, physical and numerical modeling, and testing of advanced tanker and barge designs to make these vessels less susceptible to damage and less likely to spill their cargoes into the waterways if an accidental grounding, collision or structural failure occurs. This SRA also includes research on non-tank vessel designs

ED_001324_00000360-00176

(e.g., double-hulled fuel and lube oil tanks) to minimize the possibility of spillage from collisions, allisions, and groundings.

The selection of priorities recognizes the significant progress made because of the double hull tanker design mandated by OPA '90. The priorities in this SRA emphasize the design of vessels for survivability during accidents and the tools and models necessary to assess the effectiveness of ship structures to estimate spill potential. ICCOPR recognizes the need for design improvements for operating in the extreme environments of the Arctic.

- Develop designs and methods to improve survivability of ships and structures in damaged condition.
- Develop improved analytical tools (procedures, computer models, and software) to evaluate performance of structures in collisions, allisions, and groundings, so that estimates of damage extent and loss of oil-tight boundaries are available.
- Develop improved designs and analytical tools (procedures, computer models, and software) for design and operation of ships and marine structures in extreme environments.

9.1.6 Drilling Priorities (Section 4.3.1.6)

This SRA focuses on: the design, construction, and placement of wells (deepwater and ultra-deepwater, and onshore); materials, sensors, and systems needed for offshore drilling and production platforms, and well heads/risers; and techniques and equipment for well and facility monitoring and inspection under extreme pressure and temperature environments. Also included are efforts aimed at understanding the chemical and physical characteristics for the full range of petroleum oils under varying conditions of pressure and temperature; predicting their phase/state, behavior and their physical interaction with other materials in the environment (e.g., rock and sediments); and their impact on engineered systems. Example issues include: early kick detection; systems for communicating and responding to changes in downhole parameters; strategies and methods for training operational personnel on the use of advanced technology; systems to detect and prevent oil and gas discharges; and well-head systems and equipment to control wild wells and cap well blowouts.

ICCOPR again recognizes the need to prioritize research that focuses on operational differences in the Arctic. Other research priorities focus on improving drilling systems and the knowledge of complex reservoir conditions to better assess potential incidents related to stratigraphy and hydrocarbon pathways. There are two subcategories to this SRA: Deepwater Drilling and Technology and Reservoir Characterization.

ED_001324_00000360-00177

DEEPWATER DRILLING AND TECHNOLOGY
☐ Evaluate subsea blowout preventer control pod batteries including assessments of battery design, life expectancy, performance, and reliability with respect to different manufacturers.
☐ Conduct a gap analysis on current managed pressure drilling (MPD) techniques to identify future critical needs.
☐ Study the interaction and potential for failure at the interface of each system (formation - cement - instrumentation) and develop advanced downhole tools to assess the integrity of the system *in situ*.
RESERVOIR CHARACTERIZATION
☐ Conduct research, including improved modeling, on the conditions (e.g., *in-situ* stress, sediment rheology, fluid pressure, flow rate, and blowout duration) where hydrocarbon pathways to the sea floor are established through hydraulic fractures and reactivated natural faults.
☐ Characterize reservoirs to identify geologic conditions, such as bounding strata weaknesses that need special engineering considerations to ensure hydrocarbon containment.
☐ Characterize reservoir conditions associated with offshore Arctic oil and gas provinces to identify potential issues in areas of offshore clathrates, sea ice, and other effects.

9.1.7 Rail and Truck Transportation Priorities (Section 4.3.1.7)

This SRA includes the development and testing of rail and truck transport system designs, operations, and infrastructure to make oil tanks less susceptible to damage and loss of cargo during normal operations, train accidents and derailments, or truck accidents. This SRA includes evaluation of vehicle designs, construction materials, spill prevention devices, and loading/unloading systems and equipment. It also includes evaluations of: the physical and chemical characteristics and behavior of the crude oils being shipped, the effects of those characteristics on the tanks during operations and under accident conditions, and systems to control these characteristics. This SRA also includes evaluations of safety systems and processes to: manage the movement and composition of trains and trucks carrying crude oil, prevent accidents and derailments, select preferred shipping routes, and respond safely to an oil spill emergency.

The selection of priorities under this SRA recognizes the increased volume of crude oil transported by rail and truck in response to the energy renaissance in the U.S. and

ED_001324_00000360-00178

Canada. ICCOPR also recognizes the unique characteristics of the crude oils transported by rail and trucks and the hazards they pose under accident conditions.

☐ Analyze hazards and develop corresponding mitigation methods/technologies for head space gases in tank cars.
☐ Evaluate accident and incident trends to identify ways to minimize the incident rate of leaks, spills, and damage to the environment due to oil spills.
☐ Evaluate alternative designs and modifications to minimize risk of oil spills during accidents.

9.1.8 Pipeline Systems Priorities (4.3.1.8)

This SRA includes the development, operation, monitoring, and inspection of offshore and onshore pipeline systems used to transport oil between facilities. It covers the pipeline system design, procedures, and equipment for pipeline operations and inspection protocols to prevent, detect, and mitigate oil discharges. Pipeline research under this SRA also includes technologies to prevent (detection/characterization and repair of anomalies before failure) and detect failures, as well as monitor/control systems that can rapidly isolate and shut down operations in order to minimize spillage when failures occur.

ICCOPR in the selection of priorities recognized the need for better detection technology to prevent incidents and protect human health. In the area of ensuring pipeline integrity, ICCOPR recognized the need to develop technology that will detect potential anomalies and failures in pipeline materials. There are two subcategories for this SRA: Materials and Integrity.

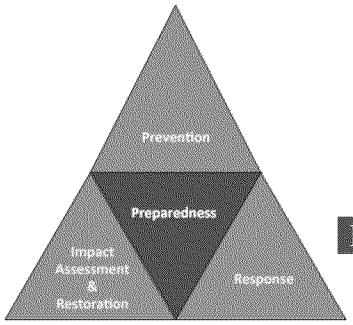
MATERIALS
☐ Develop new advanced technology for sensing pipeline leaks that will reduce leak detection false alarms for new construction and existing pipelines.
☐ Improve existing leak detection technology and health monitoring sensors so that they are miniaturized, automatic, robust and withstand harsh environments.
☐ Evaluate the performance, reliability and failure mechanisms of the use of composites technology for pipelines.
INTEGRITY
☐ Develop technology that detects the presence, location and separation between multiple utilities (underground, through various soil conditions) in a common corridor.

ED_001324_00000360-00179

- Improve and develop in-line inspection (ILI) to locate and size defects in girth welds and long seam defects including cracks in electric resistance welded (ERW) pipe.
- Assess the remaining integrity of pipelines that have multiple different anomalies in proximity.

ED_001324_00000360-00180

9.2 Preparedness Priority Research Needs



PREPAREDNESS

9.2.1 Pre-spill Baseline Studies Priorities (4.3.2.1)

This SRA includes research to characterize and analyze baseline data on the natural environment, human health, and socio-economic characteristics in areas at risk for oil spills. Research includes risk assessments conducted in areas involved in the oil production and transportation systems to identify locations most at risk from pollution events and therefore priority candidates for baseline studies. Baseline information and studies may include: location and population data on species and their habitats, especially ecologically sensitive species; the epidemiology/human health characteristics of people in potential impact areas; and potential community and economic impacts in these areas (e.g., tourism, commercial/recreational fishing, and seafood industry).

ICCOPR divided this SRA into three subcategories: Habitat and Species Baselines; Oceanographic and Geological Baselines; and Environmental Baseline Planning. In the area of habitat and species planning, there is an emphasis on the need to understand more about important Arctic species, intertidal habitats and species that are often impacted by oil spills, and the deepwater and ultra-deepwater habitats and microbiological assemblages (about which little is known). Some of these environments are or soon will be subject to drilling operations (e.g., Arctic, ultra-deepwater). ICCOPR also identified research needs related to understanding currents and coastal processes in areas where oil and gas extraction occurs to aid in future oil spill response or coastal protection should an incident occur. Research on the amount of variability that exists in baseline data is extremely important in order to document change, identify potential Natural Resource Damages, and establish restoration goals.

HABITATS AND SPECIES BASELINES
☐ Study ecological structure and population of key Arctic indicator species and protected species (including those with subsistence and ecosystem importance) particularly in areas that are likely to be explored/developed for oil and gas extraction in the near to mid- term.

ED_001324_00000360-00181

☐ Study and synthesize existing information for intertidal habitats (i.e., sand beaches, rocky and cobble habitats) regarding productivity, species diversity, community structure, and the effects of oil on these parameters, including recovery time, with consideration for regional variation.
☐ Study ecological structure and population of key indicator and protected species in deepwater and ultra-deepwater (including those with subsistence and ecosystem importance), particularly in areas that are likely to be explored/developed for oil and gas extraction in the near to mid-term.
OCEANOGRAPHIC AND GEOLOGICAL BASELINES
☐ Conduct a series of large-scale Arctic studies of oceanographic exchanges, shelf-basin exchanges via wind and eddies, coastal boundaries, under-ice river plumes, and sea-ice boundaries to better inform pre- and post-spill modeling and response.
☐ Develop a better understanding of coastal processes unique to the Gulf of Mexico (i.e., changing shorelines due to erosion, deposition from the Mississippi River) to help inform protection and recovery strategies for oil spills.
☐ Develop methodologies for using baseline flow characteristic data (such as tidal energy mapping and other energy sources) to support shallow water inlet protection strategies during oil spills.
ENVIRONMENTAL BASELINE PLANNING
☐ Develop models of background variability relative to habitat and species data in various environments where oil is transported or extracted so that the impacts from oil or other stressor(s) can be delineated from those of natural variation.
☐ Evaluate the adequacy of existing ecosystem-based scientific studies for legal defense of Natural Resource Damage Assessment (NRDA) injury assessments for Outer Continental Shelf areas that are currently in production or likely to be explored/developed.
☐ Conduct baseline studies of microbial communities in a variety of areas where oil is transported or extracted (e.g., Great Lakes, rivers, ports, offshore) and their potential for hydrocarbon degradation in the event of a spill.

9.2.2 Response Management Systems Priorities (Section 4.3.2.2)

This SRA includes analysis and development of systems to manage how data and information are collected, analyzed, documented, and shared between and among, the planning/preparedness and response communities, the Incident Command System (ICS), and the public. These systems are used to integrate diverse sets of narrative, graphic, and

video information and many sets and types of raw and analyzed data. Examples of oil spill information systems include: ICS forms; computer systems; data management software and databases; Geographic Information Systems (GIS); routing, spill and incident management tracking systems; electronic mail and web content; documents, photographs, and video management and archiving systems; communication systems; public information messages and protocols; and graphical displays.

ICCOPR priorities under this SRA recognize the need to upgrade information management systems, develop more rapid methods of incorporating data prior to and during a spill, and improve spill response planning tools. Improved pre-spill planning, development of information management tools, and incorporation of baseline data from current oil and gas extraction areas and potential frontier areas will greatly enhance response should an incident occur.

☐ Develop techniques and/or software for automatically translating data collected from different sources into common, usable formats.
☐ Develop spill planning and response tools based on gap analysis of the availability of countermeasures in different Arctic locations and seasons.
☐ Develop improved information systems for decision-making, including the use of data from coastal mapping, baseline data, and other data related to the environmental effects of oil discharges and cleanup technologies.

ED_001324_00000360-00183

9.3 Response Priority Research Needs

9.3.1 Structural Damage Assessment and Salvage Priorities (Section 4.3.3.1)

This SRA includes the development of methodologies and equipment to assess the extent of damage to a stricken vessel caused by collision, allision, grounding, or improper hull stresses during cargo transfers or explosion. This area also includes development of methods and technology to graphically present the implications of various measures that can be implemented to stabilize the vessel's condition, reduce the potential for further pollution, and allow it to be moved safely for repairs or disposal.

The priorities in this SRA include the need to improve technology to determine the oil and water interface in tanks and develop remote vehicles capable of assessing external integrity of vessel hulls. Another important priority is to evaluate existing wrecks that have the potential to leak petroleum products into marine water.

- Study methods for remotely and rapidly determining whether a cargo tank contains sea water and the extent of the water bottom (height of the oil/water interface from the bottom of the tank).
- Develop technologies and techniques to better determine the presence of oil and the probability of its release from specific sunken vessels.
- Develop improved use of remotely operated vehicles (ROVs) and emerging technologies for underwater assessment of vessel and marine structure integrity.

9.3.2 At-Source Control and Containment Priorities (Section 4.3.3.2)

This SRA includes the development of methods, systems, and equipment for containing and recovering the oil at or from the source and for mitigating oil flow from a damaged vessel, onshore/offshore pipeline, and an exploration or production platform, temporarily abandoned (plugged) well, or well head once the spill has begun. Such technologies include well-head capping systems, remotely operated vehicles (ROVs) for subsea

ED_001324_00000360-00184

containment activities, and patching, plugging and sealing systems. This technology is applicable to all geographic/environmental areas (Arctic, terrestrial, water surface, subsurface shallow, and deep and ultra-deep water).

ICCOPR selected priorities that reflect the difficulties in containing the well during the *Deepwater Horizon* oil spill. The priorities also reflect an anticipated need to provide at source containment in more extreme environments.

- ☐ Study the range of failure states and flow rates for which subsea containment may be required.
- ☐ Develop subsea containment equipment for integration into spill response operations, including relevant procedures and standards for training personnel.
- ☐ Determine how extreme environmental conditions affect at-source containment and control (including Arctic, ultra-deep and other extreme conditions).

9.3.3 Chemical and Physical Modeling and Behavior Priorities (4.3.3.3)

This SRA includes laboratory and theoretical research and field studies aimed at understanding the behavior and characteristics of the full range of petroleum oils including: behavior and transport in the environment, partitioning of hydrocarbon constituents, and physical interaction with other materials in the environment (rock, sediments, and ice). It includes studies of oil behavior and changes throughout the water column from deepwater blowouts. There is particular interest in non-conventional oils such as those produced in the Bakken and Canadian Tars sands (diluted bitumen (dilbit) and synthetic bitumen (synbit)). It also includes the development and verification of numerical models to predict the surface and subsurface movement and weathering (i.e., spreading, evaporation, dispersion, and dissolution) of oil spills. This SRA also includes methodologies to provide accurate model input data to verify model outputs. This SRA includes development of user-friendly programs to enhance contingency planning and to serve as training aides for spill response teams. Models should be available for various spill scenarios at specific locations for different tidal, current, and weather conditions to pre-plan potential boom deployment strategies and estimate response resource needs.

ICCOPR recognized the importance of addressing research needs related to understanding how oil behaves under differing conditions in both fresh and saltwater, and developing models to use during oil spills. ICCOPR specifically identified priority Research Needs to improve the understanding of how oil behaves in the Arctic and how new emerging oils such as oil sands products and Bakken crude oils behave in the environment. There are five subcategories for this SRA: 1) Arctic Behavior and

ED_001324_00000360-00185

Modeling; 2) Oil Behavior Models; 3) Transport Models; 4) Oceanographic Models; and, 5) Emerging Crudes.

ARCTIC BEHAVIOR AND MODELING
☐ Develop improved modeling tools and trajectory models in order to predict spreading of oil in different weather and ice conditions in the Arctic.
☐ Study the fate of oil in Arctic conditions; including open water, ice infested water and oil trapped in ice, particularly as it relates to the effectiveness of spill response countermeasures and the potential for ecosystem exposure.
☐ Study Arctic-based indigenous microbial populations in the water column and benthic sediment, and define rates of microbial processes to determine the role such communities have in the oil weathering process.
OIL BEHAVIOR MODELS
☐ Study the oil droplet size from deepwater blowouts, the thickness of surfacing oil and the behavior of dissolvable components.
☐ Study bottom substrate dynamics that might affect submerged oil fate and behavior.
☐ Study how oil degrades in intertidal and shallow subtidal habitats (e.g., cobble, pebble, sand, mud, mussel beds, mangrove, and marsh).
TRANSPORT MODELS
☐ Use best available scientific data on oil weathering and fate to develop and improve transport model parameters (e.g., volatilization, solubilization, emulsification, biodegradation).
☐ Develop/improve oil trajectory and fate models that can be used during spill response to predict the behavior and transport of dispersed oil and verify/validate them in an appropriately designed experimental setting or during actual spills.
☐ Develop a decision template or conceptual model of the conditions under which oil might become submerged that considers oil properties and environmental characteristics.
OCEANOGRAPHIC MODELS
☐ Link ocean circulation models to observations (e.g., ocean observing systems) to better incorporate real-time data.
☐ Increase development and availability of high resolution nearshore models.

ED_001324_00000360-00186

☐ Integrate upper sea-surface turbulence, with particular emphasis on quantifying horizontal and vertical diffusivities and the rate of energy dissipation, to improve 3D and 4D spill transport models.
EMERGING CRUDE (including oil sands products (OSP) and Bakken, etc.)
☐ Conduct research on the fate and transport of oil sands products in freshwater and marine environments.
☐ Study the persistence of oil sands products in marine and freshwater environments.
☐ Conduct research on the chemical and physical characteristics of various crudes (including blends of dilbit, synbit and Bakken crude) to better understand how to address spills.

9.3.4 Oil Spill Detection and Surveillance Priorities (Section 4.3.3.4)

This SRA principally refers to methods and equipment for characterizing and monitoring oil pre- and post-implementation of response options, and the detection of unknown discharges. This SRA includes surface and subsurface oil spill surveillance including devices, sensors, and systems for detecting and tracking oil spills, determining the area and thickness of the oil slick, and measuring the physical properties of the oil. Examples of equipment considered in this area are: surface oil spill tracking buoys; airborne remote sensors and data analysis systems; fluorometers and light-scattering sensors; and satellite remote sensing data and on/in-water oil detection devices with the ability to conduct nighttime and low light recovery operations. It includes research that provides information to support development of monitoring protocols for subsea and surface responses or improvements to existing ones such as the NRT Atypical guidance or the SMART guidance, as applicable. This SRA also includes evaluation of techniques for autonomous sensing operations and reporting from remote locations where logistical challenges limit human accessibility.

The priorities for this SRA focus on the development of improved technologies that can more rapidly and effectively identify the presence and the characteristics of oil in the water column and on the seafloor. These priorities would address some of the issues that arose from the *Deepwater Horizon* spill and may assist responders to react more effectively to future incidents. There are three subcategories for this SRA: Remote Detection, Monitoring, and Submerged Oil Detection.

ED_001324_00000360-00187

REMOTE DETECTION
☐ Develop technologies that enable remote oil spill detection and mapping in low visibility conditions (e.g., night, fog).
☐ Develop enhanced technology for detecting oil under ice, encapsulated in ice, and floating within broken ice fields.
☐ Identify specific characteristics of crude oil exposed to the full microwave radiation spectrum (at hyperspectral intervals) and develop high resolution sensors for oil spill visualization, detection and quantification.
MONITORING
☐ Develop a refined SMART or equivalent protocol and operational procedures for use during subsea and surface responses based on recent experiences.
☐ Develop technology to rapidly analyze physio-chemical properties of spilled oil to improve decision-making regarding dispersant use and *in situ* burning (ISB).
☐ Develop new technologies to improve oil, dispersant, and oil/dispersant detection in the water column and on the seafloor, and for monitoring dispersant effectiveness in the field.
SUBMERGED OIL DETECTION
☐ Study the potential of acoustic systems and Light Detection and Ranging (LiDAR), both individually and as packaged suites, to detect submerged oil on the seafloor and in the water column.
☐ Develop new or improve existing chemical sensors for detecting submerged oil.
☐ Develop methods to calibrate the degree of oiling on snare sampling systems with the amount of oil on the seafloor or in the water column.

9.3.5 In- and On-water Containment and Recovery Priorities (Section 4.3.3.5)

This SRA includes the development of methods, equipment, and materials for physically containing and removing oil from the surface of the water, the water column, or on the bottom of the sea/river bed. This SRA focuses on improving traditional equipment such as booms, skimmers, and sorbent materials, as well as developing new approaches to surface containment, and equipment and systems specific to containment and recovery of subsurface oils.

The priority Research Needs in this SRA focus on the Arctic and other northern areas where cold water and ice will require innovative methods and technologies. There was

ED_001324_00000360-00188

also recognition of the need for better technologies to control and recover submerged oil given the greater emphasis on deep and ultra-deep water drilling. ICCOPR acknowledged the need for better testing protocols for new technologies and methods and identified research priorities that could improve laboratory and field testing. ICCOPR identified priorities in two subcategories: Control and Recovery Technology, and Recovery Operations and Testing.

CONTROL AND RECOVERY TECHNOLOGY
☐ Develop new mechanical recovery methods/technologies for logistically challenging (e.g., cold water, ice, broken ice) Arctic conditions.
☐ Develop new tools to control and recover oil that is submerged, suspended in the water column, or on the seafloor.
☐ Develop control and recovery capabilities for oil in river conditions with pack ice and ice flows.
RECOVERY OPERATIONS AND TESTING
☐ Develop/improve standardized testing protocols (especially for wave tanks) that yield cross-comparability of results and establish practical oil recovery limits that are achievable during response operations.
☐ Conduct field tests of cleanup techniques and create protocols for various habitats and conditions, including Arctic conditions.
☐ Develop surrogates for different types of oil to be used for training and for research and development testing.

9.3.6 Shore Containment and Recovery Priorities (Section 4.3.3.6)

This SRA covers new methods, treating agents, and equipment for removing oil from shorelines, as well as mitigating the environmental impact of oil that cannot be removed. Specifically, this SRA includes water washing and flooding techniques, the use of chemical treating agents, and novel applications of mechanical removal techniques and equipment. It also includes analysis, evaluation and decision-making (risk and benefits) for the use of active shoreline oil removal techniques versus passive naturally-occurring processes.

ICCOPR recognizes the difficulty of relying solely on physical recovery on shorelines. Therefore, priorities in this SRA focus on developing chemicals that prevent shoreline contact.

ED_001324_00000360-00189

- Study the effectiveness of a range of technologies for shoreline or nearshore cleanup; including dispersants, bioremediation agents, shoreline cleaners, and mechanical methods.
- Study the effectiveness of surface washing for shoreline cleanup and develop standards for surface washing.
- Conduct research to assess the ability of chemicals to prevent oil from reaching or sticking to shorelines.

9.3.7 Dispersants Priorities (Section 4.3.3.7)

This SRA addresses the use of chemical products designed to interact with marine oil slicks by reducing the oil/water interfacial tension and breaking up the slick into tiny droplets with the aid of wave or other energy sources. Research areas for dispersants include: developing appropriate dispersant applications for cold weather and deep sea environments; increasing dispersant effectiveness for water surface and subsurface applications (e.g., effective on a wider viscosity and emulsification range, and calm sea conditions); reducing ecological effects of individual dispersant components and combined components in the water column; refining vessel, aircraft, and subsurface application methodologies and equipment; developing enhanced monitoring methods and systems for determining the effectiveness of surface and subsurface application of dispersants; determining how to distinguish physically versus chemically dispersed oil; studying the distribution and impact of the chemicals and dispersed oil in the environment; and understanding regional variations in dispersant performance and environmental effects. This SRA may include characterization to enhance the ability to predict dispersant effectiveness on various oil types and at varying application rates, including the effectiveness of dispersants on weathered/emulsified oils and in a range of water salinities. This SRA also encompasses studies to determine the suitability of subsea application of dispersants in the Arctic region where the unique conditions (e.g., shallow depths, water salinity, ice-infested water, under-ice discharges) could influence their fate and effects. An important supporting activity is the development of an information database on dispersant product effectiveness, application procedures, and effects. Since dispersants shift the risk from the surface to the water column, additional research is needed to address questions about the potential acute and chronic effects of dispersants on water column organisms and populations at various depths.

The *Deepwater Horizon* spill resulted in a very widespread use of dispersants and the first application of subsurface dispersants near the well head. This use of dispersants resulted in a significant interest in the effectiveness of dispersant use and its potential impacts. The importance of this SRA to future oil response is demonstrated by the large

ED_001324_00000360-00190

number of research needs identified. It is important to understand how dispersants behave in the environment and what their potential impacts are when applied. Specifically, ICCOPR identified Research Needs such as: dispersant use in Arctic conditions; the behavior of dispersants and dispersed oil in the environment; the toxicity of dispersants and dispersed oil; efficacy and effectiveness of dispersants; fate of dispersants and dispersed oil; and the application of subsurface dispersants.

This SRA includes six subcategories: Cold Weather and Ice Conditions, Behavior, Impacts, Efficacy and Effectiveness, Fate, and Subsurface. The Research Needs for this SRA include formulations appropriate for dispersant applications in cold weather and deep sea environments, and increasing dispersion effectiveness for water surface and subsurface applications.

COLD WEATHER AND ICE CONDITIONS
☐ Understand the "window of opportunity" for potential deployment of all dispersants in the Arctic and sub-Arctic.
☐ Study the best dispersants for different types of crude oil over a range of environmental conditions, including ice infested waters.
☐ Study the fate and effects of subsea application of dispersants in Arctic waters, including in ice infested water and under ice.
BEHAVIOR
☐ Study the transport and detection of oil, dispersants, and oil/dispersants in surface and subsurface environments, including deepwater.
☐ Study the impact of natural processes such as flocculation and hydrate encapsulation on oil and dispersed oil.
☐ Quantify degradation rates of chemically dispersed, physically dispersed, and undispersed oil, including biodegradation kinetics.
IMPACTS
☐ Improve protocols for testing toxicity of dispersants and other chemical agents to better represent real world exposure scenarios.
☐ Study and evaluate dispersant and dispersed oil chronic and sub-lethal effects on key species, and subsequent long-term ecological effects for varying real world exposure scenarios and durations.
☐ Collect existing dispersed oil toxicity data and studies to aid in risk-based decision-making regarding use of dispersants at spills.

ED_001324_00000360-00191

EFFICACY AND EFFECTIVENESS
☐ Study the relative effectiveness of various surface dispersant delivery techniques/systems.
☐ Study the effects of subsea dispersant application on subsequent mechanical recovery of oil.
☐ Develop methods and quantify the factors needed to scale results of laboratory and wave tank experiments so that they become more accurate indicators of real world effectiveness.
FATE
☐ Develop studies to quantify the weathering rates and final fate of chemically dispersed vs. physically-dispersed oil droplets under different scenarios.
☐ Study the differences in the effects of photolysis on undispersed, chemically dispersed, and physically dispersed oil droplets.
☐ Study the adhesiveness of physically and chemically dispersed oil on organisms and habitats, including how adhesion changes over time and with oil type.
SUBSURFACE
☐ Study the relationship between subsurface application of dispersants, the characteristics of oil at the surface, and the fate of oil constituents, including Volatile Organic Compounds (VOCs), in the water column and at the surface.
☐ Develop conditions of operability for dispersant use in the subsea, including the characteristics of the most effective dispersant, application methods, and dispersant to oil ratios.
☐ Conduct research involving the application of dispersants at high pressure and low temperatures including quantifying the mixing energy at the wellhead.

9.3.8 *In Situ* Burning (ISB) Priorities (Section 4.3.3.8)

This SRA includes equipment and techniques required to ignite and sustain combustion of oil spills on the water, along shorelines, and on land. A source of ignition must be present for the mix of fuel (e.g., oil) and oxidant (e.g. oxygen) in a slick to burn. Because slick thickness is a key variable in determining whether the oil will burn, this research area includes development of equipment such as fire-resistant booms and herders to concentrate the slick thickness, and improved ignition devices. This SRA also includes developing knowledge of the conditions under which this equipment and technique can

ED_001324_00000360-00192

be applied effectively, including evaluation of use in frigid (i.e., Arctic) environments, where cold conditions and ice limit operational effectiveness of mechanical containment and recovery of spilled oil. This SRA also includes research to develop new methods to enhance burn efficiency and burn weathered, emulsified, and more viscous oils. Research into the production of residuals including soot and other ISB residues, and the techniques and equipment to recover these residues is also included in this SRA.

The priorities for this SRA address issues related to potential public health and environmental health from the burning of oil. The ICCOPR priorities also emphasize the need for improved technology to address containment, sustain burning and understand the potential for application of ISB in Arctic and other special environments. There are two subcategories: 1) Effectiveness and 2) Impacts and Planning and Technology.

EFFECTIVENESS AND IMPACTS
☐ Develop improved pre- and post-spill plume modeling to determine whether an *in situ* burn should be conducted and facilitate decisions on measures to protect local populations, including the potential effect of "fall-out" from a smoke plume that goes over land-based subsistence resources.
☐ Study *in situ* burning residues, especially toxicity, physical properties, and bioavailability of contaminants contained within the residue matrix, especially regarding potential benthic community effects.
☐ Conduct additional research to improve *in situ* burning effectiveness in the Arctic and better define its applicability under various conditions.
PLANNING AND TECHNOLOGY
☐ Conduct a comparative study of *in situ* burning vs. mechanical, chemical and natural attenuation methods in cleanup of wetlands or marshy areas.
☐ Develop enhanced designs for containment of burning oil, such as reusable and high seas capable booms.
☐ Develop methods to improve and sustain combustion of emulsions.

9.3.9 Alternative Chemical Countermeasures Priorities (Section 4.3.3.9)

This SRA includes the development and use of various spill response chemicals to treat oil slicks on the surface of the water making the oil more amenable to other recovery techniques, such as mechanical recovery and ISB. These chemicals include solidifiers, herding agents, elasticity modifiers, shoreline pre-treatment agents, and emulsion treating agents (demulsifiers). Development activities include improving chemical formulations,

ED_001324_00000360-00193

refining application techniques, and conducting studies of effectiveness and environmental effects.

ICCOPR priorities in this SRA recognize the potential of alternate chemical treatments to break emulsions and herd oil slicks to enhance other response techniques.

☐ Study the potential use of chemical herders to enhance response capabilities of *in situ* burning, recovery of oil-in-ice, or recovery of oil in confined/covered spaces.
☐ Study the value and impact of chemical herders with respect to the timing for deployment of various countermeasures, particularly with respect to a second-stage recovery effort during ice melt to target oil that had previously been entrained in sea ice.
☐ Conduct laboratory and field tests of chemical agents for breaking or inhibiting emulsions.

9.3.10 Oily and Oil Waste Disposal Priorities (Section 4.3.3.10)

This SRA includes study and development of analytical methods, procedures, equipment and techniques to manage and dispose of oil, oily water, oiled soils, and oiled debris recovered during both on-water and on land oil pollution incidents. Specific technologies include, but are not limited to, waste segregation, temporary storage, solidification and stabilization prior to landfill disposal or recycling, oil reclamation, incineration, and biological treatment (i.e., land farming and composting). It also includes techniques and equipment for onsite oil-water separation, filtration, and decanting operations that would reduce the volumes of oil/water material that would need to be handled, transported, and disposed.

ICCOPR priorities for this SRA focus on storage, waste issues and recycling.

☐ Develop innovative techniques for oil/water separation decanting systems for various oil types.
☐ Develop methods to recycle sorbents and reduce the waste created by using sorbents as a recovery option.
☐ Develop methods to temporarily store or dispose of recovered oil/pollutants in remote or harsh environments.

ED_001324_00000360-00194

9.3.11 Bioremediation and Biodegradation Priorities (Section 4.3.3.11)

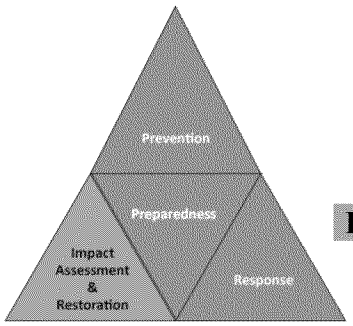
This SRA includes research and technology to exploit the capabilities of microorganisms and plants to accelerate the rate of degradation of oil typically through aerobic degradation, but also through anaerobic degradation processes. Bioremediation is largely an *in-situ* technology as *ex-situ* use requires excavation and further manipulations that may have a greater potential for environmental harm. Research and development opportunities include the development of methodologies for the use of nutrient enrichment and possibly microbes to accelerate the biodegradation process on land, a process called bio-augmentation. This topic area also covers research to understand the conditions needed for effective bioremediation in the presence or absence of dispersants, herders, and other chemical agents. In areas such as coastal wetlands, where stranded oil may have penetrated into the anaerobic subsurface, this research area would include studies to wick the oil up to the surface where aerobic conditions and nutrient enrichment may result in enhanced biodegradation. This SRA also includes development of methodologies to apply bioremediation for more effective response and restoration efforts. For purposes of this OPRTP, bioremediation includes phytoremediation (remediation using plants), a longer-term restoration technique.

ICOCPR priorities under this SRA focus on gaining a better understanding of the bioremediation process and the factors associated with its use in oil spill remediation.

☐ Study the relative effectiveness and environmental impacts of bioremediation technologies.
☐ Develop an improved understanding of bioremediation processes with a wider range of conditions/environments (e.g., cold water), multiple types of oil, nutrient enrichment, toxicity and eutrophication.
☐ Study the factors controlling bioavailability of petroleum hydrocarbons in estuarine and freshwater sediments.

ED_001324_00000360-00195

9.4 Injury Assessment and Restoration Priority Research Needs



INJURY ASSESSMENT AND RESTORATION

9.4.1 Environmental Impacts and Ecosystem Recovery Priorities (Section 4.3.4.1)

This SRA includes laboratory research, field studies, and modeling efforts to better understand and predict the short- and long-term effects of oil spills at the ecosystem level. It includes research into the short- and long-term recovery of various types of environments and the chronic effects of oil spills on habitat, species, recovery and rehabilitation of wildlife, and community structures. This SRA includes the effects of the oil and the countermeasures and cleanup techniques used to remove the oil. It also includes research to determine the rate of ecosystem recovery both with and without countermeasures and cleanup.

The priorities selected by ICCOPR reflect the continued need to assess the short- and long-term effects of the *Deepwater Horizon* oil spill through the NRDA process. ICCOIPR identified priorities within six subcategories for this SRA due to the large number of identified Research Needs: 1) Species Impacts; 2) Toxicological and Sub-lethal Impacts; 3) Submerged and Submerged Oil Impacts; 4) Ecosystem and Habitat Impacts; 5) Recovery; and 6) Risk Assessment and Impact Metrics.

SPECIES IMPACTS
☐ Study the effect of exposure to oil on: physiological functions of organisms (immune, reproductive, and other vital systems); potential impacts on individual fitness; and population vitality rates, abundance and trends.
☐ Develop an increased understanding of the environmental effects of *in situ* burning, chemical dispersants and herding agents on Arctic ecology.
☐ Conduct research that examines the state of knowledge of specific NRDA metrics that would help identify specific population, physiological, habitat, and exposure data to support future NRDA activities in Arctic areas that are likely to be explored/developed for oil and gas extraction in the near to mid-term.

ED_001324_00000360-00196

TOXICOLOGICAL AND SUB-LETHAL IMPACTS
☐ Develop relevant biological markers of exposure and guidelines for their use.
☐ Conduct research on key species to determine the long-term, sub-lethal effects of short-term exposure to oil.
☐ Study the bioavailability and toxicity of oil sands products in freshwater and marine environments.
SUNKEN AND SUBMERGED OIL IMPACTS
☐ Develop an understanding of the pathways of exposure and mechanisms of chronic toxicity of submerged oil to benthic communities.
☐ Develop approaches for long-term monitoring of the impacts of submerged oil spills after termination of cleanup efforts.
☐ Develop an understanding of the potential threats of chronic releases from sediments containing oil and oily residues.
ECOSYSTEM AND HABITAT IMPACTS
☐ Develop relevant exposure conditions (spatially and temporally) and examine connections between exposure and ecological effects.
☐ Develop an understanding of trophic and habitat linkages among organisms to incorporate into models predicting cascading effects.
☐ Develop an understanding of the difference between oil effects and natural stressors by assessing community structure and function for different habitats.
RECOVERY
☐ Study recovery rates of injured habitats using different types of oils and methods (e.g., previous spills, mesocosm, field studies).
☐ Develop conceptual models of service loss and recovery from key habitats, and gather the information necessary to parameterize recovery models.
☐ Conduct a study comparing environmental injury footprints and ecosystem recovery times after implementation of various response technologies and techniques.

ED_001324_00000360-00197

RISK ASSESSMENT AND IMPACT METRICS
☐ Develop models to estimate injury to natural resources encompassing a range of exposure scenarios to biota at different life stages.
☐ Conduct research to determine the best metrics for assessing injury and damages to natural resources.
☐ Conduct single species toxicity research to assess population effects and help risk-based decision-making during an event.

9.4.2 Environmental Restoration Methods and Technologies Priorities (Section 4.3.4.2)

This SRA includes development of methods and technologies to facilitate and accelerate the recovery of resources following an oil spill. It includes research into the effectiveness of approaches for environmental restoration. It also includes evaluations and comparisons of the factors affecting success of the restoration methods and technologies. It also involves studying previous restoration efforts, as well as natural recovery, to better understand ways to improve or enhance future recovery from oil spills.

ICCOPR recognized that the *Deepwater Horizon* oil spill, as well as other marine and onshore spills, offer opportunities to assess restoration techniques and improve the state of the art.

☐ Develop methods for restoration assessment (including establishing indicators and applying performance metrics) and estimation of restoration cost.
☐ Conduct comparative analysis of restoration vs. natural attenuation.
☐ Study the factors associated with long-term restoration success.

9.4.3 Human Safety and Health Priorities (Section 4.3.4.3)

This SRA includes studies on the effects of spilled oil and oil spill response activities on human health and safety for both workers and the public. It includes the study of oil weathering throughout the water column and the potential concerns relative to worker health and safety. It focuses on the development of monitoring instruments, procedures, and processes to inform personnel engaged in oil spill response activities, as well as the general public, who could be affected by the oil spill and response options. It also includes studies of the safety of fish and shellfish in a spill area to determine if they are safe to market and consume. Research on seafood safety may include petrochemical

ED_001324_00000360-00198

toxicology and profiling, risk analysis, sampling and testing methodology development, and risk communications.

The research priorities focus on worker safety and human exposure, as well as on seafood safety. The *Deepwater Horizon* spill has provided opportunities for short- and long-term monitoring of workers and the public related to these topics. There are two subcategories to this SRA: Safety and Human Exposure.

SAFETY
☐ Develop technologies, methods, and standards for protecting on-scene personnel, including the incorporation of training, adequate supervision, information databases, protective equipment, maximum exposure limits, and decontamination procedures.
☐ Study the levels of oil constituents, including Volatile Organic Compounds (VOCs), throughout the water column under different dispersant application scenarios (e.g., subsea, surface) and establish their contribution to potential worker health and safety issues.
☐ Conduct research on the short- and long-term safety of seafood following a spill or fisheries closure and develop methods to communicate these to the public.
HUMAN EXPOSURE
☐ Develop the framework needed to conduct rapid research response on human exposure during oil spills.
☐ Study the short- and long-term impacts to humans from exposure to contaminants from oil spills (e.g., dermal, oral (through seafood), and respiratory).
☐ Study the toxicological effects and the causal or correlative relationships between chemical (i.e., oil and dispersants) exposure and human health.

9.4.4 Sociological and Economic Impacts Priorities (Section 4.3.4.4)

This SRA includes studies on how oil spills and the response to oil spills affect the sociological fabric of communities and their economies. Disciplines encompassed in this research area include sociology, economics, behavioral sciences, political science, and law. It also involves studies on risk communication and community resilience.

The priorities in this SRA identify the need for improving communication methods and understanding the human and community impacts of a spill, particularly by improving

ED_001324_00000360-00199

research frameworks and studying previous spills. There are two subcategories in this SRA: Community and Economic Impacts, and Human Impacts.

COMMUNITY AND ECONOMIC IMPACTS
☐ Develop more effective models/frameworks for community/stakeholder involvement in oil spill planning, response and restoration.
☐ Develop improved methods for communicating risks and tradeoffs to various audiences, including tradeoffs of mechanical recovery, dispersant use, and other technologies.
☐ Study cumulative community vulnerability and resilience to past spills, including social impacts.
HUMAN IMPACTS
☐ Study the resilience of social-ecological systems to environmental disasters, including the degree of impact on human well-being from ecosystem services losses.
☐ Determine human/community impacts associated with a spill, including subsistence losses and culturally-significant natural resource injuries.
☐ Study the effects of media and community groups in shaping individual and public perceptions of a spill's impact.

ED_001324_00000360-00200

References

American Petroleum Institute (API). 2012. *API 2012 Oil and Gas Overview webpage.* Accessible from: http://www.api.org/oil-and-natural-gas-overview.aspx.

Association of American Railroads. *2015a. U.S. Rail Crude Oil Traffic*. June 2015. Available online: https://www.aar.org/BackgroundPapers/US Rail Crude Oil Traffic (June 2015).pdf.

Association of American Railroads. *2015b. Moving Crude Oil Safely by Rail*. June 2015. Available online: https://www.aar.org/BackgroundPapers/Moving Crude Oil Safely by Rail (July 2015).pdf.

Australian Maritime Safety Authority (AMSA). 2010. *Response to the Montara Wellhead Platform Incident. Report of the Incident Analysis Team*. March 2010. Available online from: http://www.amsa.gov.au/forms-and-publications/publications/montara_iat_report.pdf.

Battelle. 2005. *Hazardous Materials Serious Crash Analysis: Phase 2 Final Report.* Prepared for the DOT Federal Motor Carrier Safety Administration. April 2005. 134 pp. Available from: http://ntl.bts.gov/lib/51000/51300/51392/Hazardous-Materials-Serious-Crash-Analysis-Phase2-April2005.pdf.

Bosma, S. 2012. The Regulation of Marine Pollution Arising from Offshore Oil and Gas Facilities – An Evaluation of the Adequacy of Current Regulatory Regimes and the Responsibility of States to Implement a New Liability Regime. In: *Australian & New Zealand Maritime Law Journal*. Vol. 26:1. Available from: http://ssl.law.uq.edu.au/journals/index.php/maritimejournal/article/view/179/221.

Bureau of Reclamation Glossary. Retrieved September 21, 2012, from website: http://www.expertglossary.com/definition/.

Burkhard, J., P. Stark, and L. Smith. 2010. *Oil Well Blowout and the Future of Deepwater E & P.* IHS Cambridge Energy Research Associates– Energy Strategy, May 2010.

Bureau of Safety and Environmental Enforcement (BSEE). 2012. *"BAA Proposed Research on Oil Spill Response Operations."*

Cantwell, M. 2012. 2012. *Introduction of Oil Spill Research and Technology Act of 2012 (S. 3298).* Introduced June 15, 2012. Available for viewing online at: http://www.govtrack.us/congress/bills/112/s3298 and from Senator Catwell's website at: http://www.cantwell.senate.gov/public/index.cfm/press?ID=707fda1b-2646-4b3b-b671-ef7a85b37c1d.

ED_001324_00000360-00201

Center for Spills in the Environment (CSE). 2012. *"Alberta Oil Sands Workshop for Maine DEP and U.S. EPA Region 1."* Portland, ME. December 4-5, 2012. http://crrc.unh.edu/workshop/cse/alberta-oil-sands-training.

Center for Spills in the Environment (CSE). 2013. *"Oil Spill Dispersant Research Workshop Report."* Baton Rouge, LA, March 12-13, 2013, http://crrc.unh.edu/workshop/cse/oil-spill-dispersant-research-forum.

Center for Spills in the Environment (CSE). 2013. *"Alberta Oil Sands Workshop for Washington State Department of Ecology, the Regional Response Team 10 and the Pacific States/British Columbia Oil Spill Task Force"*. Seattle, WA. April 16-17, 2013. http://crrc.unh.edu/workshop/cse/oil-sands-products-forum-working-group.

Chambers, R. 2009. *Editorial Introduction: Vulnerability, Coping and Policy*. *Institute of Development Studies (IDS) Bulletin*, Vol., 20, Issue No. 2, Institute of Development Studies, 1-7. 1759-5436. mp200002001.x. Available from: http://dx.doi.org/10.1111/j.1759-5436.1989.mp20002001.x.

Coastal Response Research Center (CRRC). 2006. *Research & Development Needs For Addressing the Human Dimensions of Oil Spills*. University of New Hampshire http://www.crrc.unh.edu/publications/human_dimensions_report.pdf.

Coastal Response Research Center. (November 2003). "*Research and Development Priorities: An Oil Spill Workshop.*" http://crrc.unh.edu/workshop/crrc/research-development-priorities-oil-spill-workshop.

Coastal Response Research Center. (September 2005). *"Workshop: Research & Development Needs for Making Decisions Regarding Dispersing Oil."* http://crrc.unh.edu/workshop/crrc/research-development-needs-making-decisions-regarding-dispersing-oil.

Coastal Response Research Center. (June 2006). *"Workshop: Research Needs for Addressing the Human Dimensions of Oil Spills."* http://crrc.unh.edu/workshop/crrc/research-needs-human-dimensions-oil-spill-response.

Coastal Response Research Center. (December 2006). *"Submerged Oil Workshop Report."* http://crrc.unh.edu/workshop/crrc/submerged-oil-state-practice.

Coastal Response Research Center. 2009 *"R&D Priorities: Oil Spill Workshop"*. March 2009 http://crrc.unh.edu/workshop/crrc/2009-research-development-priorities.

Coastal Response Research Center. 2011. *"Coordinating R&D on Oil Spill Response in the Wake of Deepwater Horizon."* July 2011. Available at: http://crrc.unh.edu/workshop/crrc/coordinating-rd-oil-spill-response-wake-deepwater-horizon.

ED_001324_00000360-00202

Coastal Response Research Center. 2012. *"The Future of Dispersant Use in Oil Spill Response Initiatives."* March 2012. Available at: http://crrc.unh.edu/workshop/crrc/future-dispersant-use-spill-response.

Coastal Response Research Center. 2014. *"Environmental Data Management Workshop."* September 2014. Available at: http://crrc.unh.edu/workshops/EDDM.

Commonwealth Scientific and Industrial Research Organization (CSIRO). 2015. "*Offshore oil and Gas*." http://www.csiro.au/en/Research/EF/Areas/Oil-gas-and-fuels/Offshore-oil-and-gas.

Council on Environmental Quality (CEQ). 1970. National Oil and Hazardous Materials Pollution Contingency Plan. June 1970

Department of Energy (DOE). 2008a. *"2007 Annual Plan Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Research and Development Program."* DOE/NETL-2007/1294. January 2008a

Department of Energy (DOE). 2008b. *"2008 Annual Plan for the Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Research and Development Program."* DOE/NETL-2008/1315. August 2008

Department of Energy (DOE). 2008c. *"2009 Annual Plan Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Research and Development Program, Report."* DOE/NETL-2009/1343. December 2008

Department of Energy (DOE). 2009. *"2010 Annual Plan Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Research and Development Program, Report."* DOE/NETL-2009/1384. December 2009

Department of Energy (DOE). 2011. *"2011 Annual Plan Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Research and Development Program, Report To Congress."* August 2011

Department of Energy (DOE). 2012. *"2012 Annual Plan Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Research and Development Program, Report To Congress."* August 2012

Department of Energy (DOE). 2013. "*2013 Annual Plan Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Research and Development Program, Report To Congress*." June 2013.

Energy Policy Act. *2005. Section 999A (b)(4) DOE National Energy Technology Laboratory Complementary Research Program".*

Environmental Protection Agency, Office of Research and Development. 2011. *"Draft Oil Spill Research Strategy."* January 12, 2011

ED_001324_00000360-00203

Environmental Protection Agency. 2014. *"EPA Office of Solid Waste - Personal Communication."*

Etkin, D.S. 2011. Personal Communication. September 26, 2011.

Etkin, D.S. 2009. *Analysis of U.S. Oil Spillage*. API Publication 356. The American Petroleum Institute, Regulatory and Scientific Affairs Department. Washington, D.C.: American Petroleum Insitute. 86 p. August 2009. Available from: http://www.api.org/environment-health-and-safety/clean-water/oil-spill-prevention-and-response/spills-and-releases.aspx.

EOP-OST. 1969. *The Oil Spill Problem: First Report of the President's Panel on Oil Spills*, U.S. Executive Office of the President (EOP) Office of Science & Technology (OST), Washington, D.C. 1969

Executive Order 12777. *Implementation of §311 of the Federal Water Pollution Control Act of 1972, as amended, and the Oil Pollution Act 18 October 1991.*October 18, 1991.

Executive Order 13286 of February 28, 2003. *Amendment of Executive Orders, and Other Actions, in Connection With the Transfer of Certain Functions to the Secretary of Homeland Security*. (68 Fed. Reg. 10619), March 5, 2003.

Federal Railroad Administration (FRA). 2012. *"2012 FRA Research Review Conference."* Available at: https://www.fra.dot.gov/Page/P0486.

Federal Railroad Administration (FRA). 2014. *"Federal Railroad Administrator Prepared Remarks - 50th Meeting of the Railroad Safety Advisory Committee."* October 31, 2013

Federal Railroad Administration (FRA). 2015. *"Tank Car Safety."* https://www.fra.dot.gov/Page/P0515.

Federal Water Pollution Control Administration (FWPCA). 1968. *National Multiagency Oil and Hazardous Materials Contingency Plan.* September 1968. NTIS Ascension Number PB-216 561

Gulf of Mexico Research Initiative. 2010. *"Gulf of Mexico Research Initiative: Research Themes."* May 2010. http://research.gulfresearchinitiative.org.

Gulf of Mexico Research Initiative. 2015. *"Gulf of Mexico Research Initiative: Program Update."* http://research.gulfresearchinitiative.org/research-awards/.

Hamberger, E. R. and M.D. Manion. 2011. *Joint Statement Before the U.S. House of Representatives Committee on Transportation and Infrastructure. Hearing on the Rail Safety Improvement Act of 2008, March 17, 2011.* Association of American Railroads, 22 pp. Available from: www.aar.org/.../~/.../2011-03-17-testimony-railsafetyact.pdf.ashx.

ED_001324_00000360-00204

Hersman, D.A.P. 2011. *Highway Accident Report – Rollover of a Truck-Tractor and Cargo Tank Semitrailer, Indianapolis, Indiana, October 22, 2009*. Opening Statement at the 26 July 2011 NTSB Board Meeting. Available from: http://www.ntsb.gov/news/speeches/hersman/daph110726o.html.

H.R. 3609 (107th): *Pipeline Safety Improvement Act of 2002*. Amendment of Title 49, U.S.C. Available from: www.gpo.gov.

H.R. 5782 (109th): *Pipeline Inspection, Protection, Enforcement, and Safety Act of 2006*. Amendment of Title 49, U.S.C. Available from: www.gpo.gov.

House of Representatives, Committee on Science & Technology. 2009. *"A New Direction for Federal Oil Spill Research & Development."* Serial No. 111-29. June 4, 2009.

House of Representatives, Committee on Science & Technology. 2010. *"Deluge of Oil Highlights Research & Technology Needs for Effective Cleanup of Oil Spills."* (June 2010)

International Association of Oil and Gas Producers. 2012. *"International Association of Oil and Gas Producers - Joint Industry Programme Solicitation for Expression of Interest (EOI) on Arctic Oil Spills"* February 2012

Interagency Coordinating Committee on Oil Pollution Research.1992. *"Oil Pollution Research and Technology Plan."* April 1992.

Interagency Coordinating Committee on Oil Pollution Research. 1997. *"Oil Pollution Research and Technology Plan."* April 1997

Interagency Coordinating Committee on Oil Pollution Research. 2003. "Report to Congress on the *Interagency Coordinating Committee on Oil Pollution Research [Biennial Report to Congress for FY 2001 & 2002]."October 2003*

Interagency Coordinating Committee on Oil Pollution Research. 2010. *"Interagency Coordinating Committee on Oil Pollution Research Public Meetings – West."* May 2010

Interagency Coordinating Committee on Oil Pollution Research. 2010. *"Interagency Coordinating Committee on Oil Pollution Research Public Meetings – East."* September 2010

Interagency Coordinating Committee on Oil Pollution Research. 2010. *"Interagency Coordinating Committee on Oil Pollution Research Public Meetings – Gulf."* November 2010

Interagency Coordinating Committee on Oil Pollution Research. 2010. *"Public Meetings, Letters, and Reports Submitted to ICCOPR as Part of the R&T Planning Process."*

ED_001324_00000360-00205

International Oil Spill Conference (IOSC). 2014. *"2014 Conference On-Water and Aerial Technical Demonstration: A Complete Spill Response System."*

International Tanker Owners Pollution Federation (ITOPF). 2015. *"Country Profiles."*Available at: http://www.itopf.com/knowledge-resources/

International Tanker Owners Pollution Federation (ITOPF). 2015. Oil Tanker Spill Statistics 2014. ITOPF, London, United Kingdom. January 2015.

Joint Industry Task Force Oil Spill Preparedness and Response. 2011. Progress Report on Industry Recommendations to Improve Oil Spill Preparedness and Response. November 30, 2011.

Michel, J., T. Gilbert, D.S. Etkin, R. Urban, J. Waldron, and C.T. Blocksidge. 2005. *An Issue Paper Prepared for the 2005 International Oil Spill Conference: "Potentially Polluting Wrecks in Marine Waters:*. International Oil Spill Conference Proceedings: May 2005, Vol. 2005, No. 1, pp. 1-40. **doi:** http://dx.doi.org/10.7901/2169-3358-2005-1-1.

National Research Council Marine Board. 1993. *Review of the Interagency Oil Pollution Research and Technology Plan: First Report on the Committee on Oil Spill Research and Development*. Prepared by the National Academy Press, Washington D.C. Marine Board, Commission on Engineering and Technical Systems, National Research Council. 54 pp. Available from: http://www.uscg.mil/iccopr/files/Marine Board Review-First Report-1993.pdf.

National Research Council Marine Board. 1994. *Review of the Interagency Oil Pollution Research and Technology Plan: Final Report on the Committee on Oil Spill Research and Development*. Prepared by the National Academy Press, Washington D.C. Marine Board, Commission on Engineering and Technical Systems, National Research Council. 8 pp. Available from: http://www.uscg.mil/iccopr/files/Marine Board Review-Final Report-1994.pdf.

Marine Mammal Commission. 2010. *"Letter to LT Tracy Wirth: Comments for the Interagency Coordinating Committee on Oil Pollution Research on Priorities for Oil Pollution Research."* September 9, 2010

Marine Mammals Commission. 2011. *"Assessing the Long-term Effects of the BP Deepwater Horizon Oil Spill on Marine Mammals in the Gulf of Mexico: A Statement of Research Needs."* August 2011

Massey, A. 2012. Interspill 2012 Keynote Speaker – Chief Executive, UK Maritime & Coast Guard Agency. Available from: http://www.interspill.org/previous-events/2012/.

McCoy, M.A. and J.A. Salerno (Eds.). 2010. *IOM (Institute of Medicine): Assessing the effects of the Gulf of Mexico oil spill on human health: A summary of the June*

ED_001324_00000360-00206

2010 workshop. August 10, 2010. Washington, D.C: The National Academies Press. Available from: http://www.iom.edu/Reports/2010/Assessing-the-Effects-of-the-Gulf-of-Mexico-Oil-Spill-on-Human-Health.aspx.

National Academy of Sciences Institutes of Medicine. 2010. *"National Academy of Sciences Institutes of Medicine Research Priorities for Assessing Health Effects from the Gulf of Mexico Oil Spill."*

National Commission on BP Deepwater Horizon. 2011. *"National Commission on BP Deepwater Horizon - Final Report."* January 2011

National Commission on BP Deepwater Horizon. 2011. *"National Commission on BP Deepwater Horizon – Response/Clean-up Technology Research & Development and the BP Deepwater Horizon Oil Spill." Staff Working Paper No. 7.* Updated January 2011

National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. 2011. *Deepwater: The Gulf Oil Disaster and the Future of Offshore Drilling. Report to the President.* ISBN: 978-0-16-087371-3, 398 pp. Available from: http://www.oilspillcommission.gov/final-report.

National Petroleum Council. 2015. *"Arctic Potential – Realizing the Promise of U.S. Arctic Oil and Gas Resources."* March 27, 2015

National Research Council. 2013. *"An Ecosystem Services Approach to Assessing the Impacts of the Deepwater Horizon Oil Spill in the Gulf of Mexico."*

National Research Council. 2014. *Responding to Oil Spills in the U.S. Arctic Marine Environment.* Washington, DC: The National Academies Press. Available from: http://www.nap.edu/catalog/18625/responding-to-oil-spills-in-the-us-arctic-marine-environment

National Research Council. 2005. *"Oil Spill Dispersants: Efficacy and Effects."* Washington, DC: The National Academies Press. Available from: http://www.nap.edu/catalog/11283/oil-spill-dispersants-efficacy-and-effects.

National Science and Technology Council, Subcommittee on Ocean Science and Technology. 2010. *"Deepwater Horizon Oil Spill Principal Investigator Workshop, October 25-26, 2011: Final Report."* Washington, DC. 91pp.

NOAA. 2014. *45 Years after the Santa Barbara Oil Spill, Looking at a Historic Disaster Through Technology.* January 26, 2014. Webpage: http://response.restoration.noaa.gov/about/media/45-years-after-santa-barbara-oil-spill-looking-historic-disaster-through-technology.html . Last accessed May 20, 2015.

ED_001324_00000360-00207

O'Brien, M. 2011. *New Horizons? Dealing with Major Oil Spills from Non-Tanker Sources*. Keynote presentation at the Petroleum Association of Japan (PAJ) - Oil Spill Workshop 2011, Tokyo, Japan, March 2nd

Ocean Energy Safety Advisory Committee. (April 2012). *"Letter of Recommendations to BSEE Department of the Interior."*

Ocean Energy Safety Advisory Committee. 2012. "Letter *of Recommendations to BSEE Department of the Interior.*" October 15, 2012

Ocean Energy Safety Advisory Committee. 2013. "Letter *of Recommendations to BSEE Department of the Interior.*" January 25, 2013

Oil & Gas IQ. 2015. The 10 Biggest Oil Spills in World History (online). Last accessed April 10, 2015 at.: http://www.oilandgasiq.com/integrity-hse-maintenance/articles/the-10-biggest-oil-spills-in-world-history-part-8/Paleontological Research Institution (PRI) History of Oil Website – available from: http://www.priweb.org/ed/pgws/history/pennsylvania/pennsylvania.html.

Pacific States/British Columbia Oil Spill Task Force. 2010. *"Pacific States/British Columbia Oil Spill Task Force Letter to Interagency Coordinating Committee on Oil Pollution Research."* May 19, 2010

Parfomak, P.W. 2011. *Keeping America's Pipelines Safe and Secure: Key Issues for Congress*. Washington D.C. UNT Digital Library. July 11, 2011. Available from: http://digital.library.unt.edu/ark:/67531/metadc96681/.

Pees, Samuel T. 2004. "Oil History: The Drake Chapters." Website last accessed July 20, 2015 at http://www.petroleumhistory.org/OilHistory/pages/drake/drake.html.

PHMSA. 2012. *Government and Industry Pipeline Forum, Arlington, VA, July 18-19, 2012.*

Picou, J.S. and D.A. Gill. 1996. *The Exxon Valdez Oil Spill and Chronic Psychological Stress*. In: *American Fisheries Society Symposium*. 18:879-893.

Pine, John C. 2006. "Hurricane Katrina and Oil Spills: Impact on Coastal and Ocean Environments." *Oceanography* 19.2 (2006): 37-39. The Oceanography Society. Available from: http://www.tos.org/oceanography/archive/19-2_pine.pdf.

Pipeline and Hazardous Materials Safety Administration (PHMSA). 2014. *"Office of Pipeline Safety - Personal Communications."*

Pipeline and Hazardous Materials Safety Administration (PHMSA). 2015. http://www.phmsa.dot.gov/.

Pipeline and Hazardous Materials Safety Administration (PHMSA). 2007. Safe Pipelines FAQs. Website last updated August 29, 2007. Website available at: http://phmsa.dot.gov/about/faq.

ED_001324_00000360-00208

Pipeline and Hazardous Materials Safety Administration (PHMSA). 2015. Pipeline Incident 20 Year Trends (searchable database last accessed April 10, 2015. Available at: https://hip.phmsa.dot.gov/analyticsSOAP/saw.dll?Portalpages.

Prince William Sound Oil Spill Recovery Institute. 2010. *"Research Plan 2011-2015."* February 2010

Prince William Sound Regional Citizens' Advisory Council. 2013. *"Oil Spill Simulants Materials: Workshop Proceedings."* May 2013 Final

Ramseur, J.L. 2011. *Liability and Compensation Issues Raised by the 2010 Gulf Oil Spill*. Congressional Research Service Report R41679, 27 pp. March 11, 2011. Available from: http://assets.opencrs.com/rpts/R41679_20110311.pdf.

Ramseur, J L. 2012. *Oil Spills in U.S. Coastal Waters: Background and Governance*. Congressional Research Service. January 11, 2012

Ritchie, L.A., D.A. Gill and J.S. Picou. 2011. *The BP Disaster as an Exxon Valdez Rerun Contexts*. *American Sociological Association*, 10:3, pp. 30-35. ISSN 1536-5042, electronic ISSN 1537-6052. Available from: http://contexts.sagepub.com. doi: 10.1177/1536504211418454.

Rothblum, A.M. 2000. *Human Error and Marine Safety*. Paper presented at the *National Safety Council Congress and Expo*, Orlando, FL, Oct. 13-20, 2000. Available from: http://www.bowles-langley.com/wp-content/files_mf/humanerrorandmarinesafety26.pdf.

Steering Committee for the NASA Technology Roadmaps: National Research Council of the National Academies. 2012. *NASA Space Technology Roadmaps and Priorities: Restoring NASA's Technological Edge and Paving the Way for a New Era in Space*. 122 pp. ISBN 978-0-309-25362-8. Available from: http://www.nap.edu/catalog.php?record_id=13354.

Thébaud, O., D. Bailly, J. Hay, and J. Pérez. 2003 "*The cost of oil pollution at sea: an analysis of the process of damage valuation and compensation following oil spills.*" 13 pp. Available from: http://otvm.uvigo.es/investigacion/informes/documentos/archivos/Prestige_Hayet al.pdf.

Transportation Research Board (TRB). 2013. *"Effect of Diluted Bitumen on Crude Oil Transmission Pipelines Special Report 311."* Available from http://www.nap.edu/catalog/18381/trb-special-report-311-effects-of-diluted-bitumen-on-crude-oil-transmission-pipelines.

Title 33 U.S. Code Chapter 40 Subchapter IV 2761. 1990. *"Oil Pollution Act of 1990."* August 1990.

ED_001324_00000360-00209

Ultra-Deepwater Advisory Committee. 2011. *"2011 Plan: Comments, Findings and Recommendations."* April 2011.

Ultra-Deepwater Advisory Committee. 2012. *"2012 Plan: Comments, Findings and Recommendations."* March 2012.

Ultra-Deepwater Advisory Committee. 2012. *"2013 Draft Plan: Findings and Recommendations."* November 2012.

U.S. Arctic Research Commission (USARC). (July 2010). *"U.S. Arctic Research Commission - White Paper."*

U.S. Coast Guard. 2005. *Investigation into the Explosioni and Sinking of the Chemical Tanker Bow Mariner in the Atlantic Ocean on February 28, 2004 with Loss of Life and Pollution.* December 14, 2005.

U.S. Coast Guard. 2008a. *Incident Specific Preparedness Review (ISPR) M/V Cosco Busan Oil Spill in San Francisco Bay: Report on Initial Response Phase*. January 11, 2008

U.S. Coast Guard. 2008b. *Incident Specific Preparedness Review (ISPR) M/V Cosco Busan Oil Spill in San Francisco Bay: Part II and Final Report*. May 7, 2008

U.S. Coast Guard (USCG). 2011a. *"Deepwater Horizon Incident Specific Preparedness Review: Final Report."* January 2011

U.S. Coast Guard (USCG). 2011b. *"On Scene Coordinator Report on Deepwater Horizon Oil Spill."* August 17, 2011

U.S. Coast Guard (USCG). 2012. *Improvements to Reduce Human Error and Near Miss Incidents: 2012 Report to Congress, May 7, 2012*. 74 pp. Pub. L. 111-281, title VII – Oil Pollution Prevention, § 703 – Improvements to reduce human error and near miss incidents.

U.S. Congress. *1990. The Oil Pollution Act of 1990*. P.L. 101-380. 33 U.S.C. 2701, Chapter 40 – Oil Pollution, Subchapter 1 – Oil Pollution Liability and Compensation (§§2701- 2720).

U.S. Department of Transportation. 2014. *"Emergency Restriction/Prohibition Order [USDOT Emergency Order on Transport of Bakken Crude Oil.]"* EO Number: DOT-OST-2014-0067. May 7, 2014

U.S. Energy Information Administration (EIA). 2012. *Annual Energy Outlook 2012 with Projections to 2035*. DOE/EIA-0383(2012) / June 2012. 252 pp.

U.S. Energy Information Administration (EIA). 2015. *Annual Energy Outlook 2015 with Projections to 2040*. DOE/EIA-0383(2015) / April 2015. 154 pp. Available at: www.eia.gov/forecasts/aeo.

ED_001324_00000360-00210

U.S. Geological Survey (USGS). 2011. *"An Evaluation of the Science Needs to Inform Decisions on Outer Continental Shelf Energy Development in the Chukchi and Beaufort Seas."* June 2011

U.S. Government Accountability Office (GAO). 2012. *"Oil Dispersants Report."* GAO-12-58. May 30, 2012

VanHaverbeke, Mark. 2012. *Oil and Hazardous Materials Spill Response Technology Development, Strategic Plan*. CG-D-07-12. U.S. Coast Guard Research and Development Center, New London, CG. May 2012.

Vocke, William T. 2014. "*Building a Legacy of Research Coordination: A History of the ICCOPR from Exxon Valdez to Present Day*". International Oil Spill Conference Proceedings: May 2014, Vol.2014, No.1, pp93-101 Allen Press. **doi:** http://dx.doi.org/10.7901/2169-3358-2014.1.93.

Walker, A.H, D.L. Ducey Jr., S.J. Lacey, and J.R. Harrald. 1994. *Implementing an Effective Response Management System: A White Paper Prepared for the 1995 International Oil Spill Conference*. Technical Report IOSC-001. (API Publication No. 4621A. American Petroleum Institute, Washington, DC. December 1994,

Watkins, J.A. 2012. *BSEE reply to Ocean Energy Safety Advisory Committee Letter of Recommendations to BSEE Department of the Interior, dated May 17, 2012*. Letter dated August 10, 2012

Watkins, J.A. 2013. *BSEE reply to Ocean Energy Safety Advisory Committee Letter of Recommendations to BSEE Department of the Interior, dated October 15, 2012*. Letter dated January 4, 2013

Watkins, J.A. 2013. *BSEE reply to Ocean Energy Safety Advisory Committee Letter of Recommendations to BSEE Department of the Interior, dated January 25, 2013*. Letter dated August 14, 2013

Webler, T. and F. Lord. 2010. Planning for the human dimensions of oil spills. Environmental Management 45: 723-738. February 19, 2010. Available from: http://seri-us.org/content/planning-for-the-human-dimensions-of-oil-spills.

Webler, T., S. Tuler, F. Lord, and K. Dow. 2010. *Guidance for Incorporating Human Impacts and Vulnerabilities in Marine Oil Spill Contingency Planning: Final Report*. Report 10-003. December 2010. Greenfield, MA: Social and Environmental Research Institute. 42 pp.

White, I.C. 2002. *Factors Affecting the Cost of Oil Spills*. GAOCMAO Conference, Muscat, Oman, 12-14 May 2002. ITOPF, London. Available from: http://www.itopf.com/fileadmin/data/Documents/Papers/costs02.PDF.

ED_001324_00000360-00211

White, I.C. & F. C. Molloy. 2003. *Factors that Determine the Cost of Oil Spills*. International Oil Spill Conference Proceedings: April 2003, Vol. 2003, No. 1, pp. 1225-1229. **doi:** http://dx.doi.org/10.7901/2169-3358-2003-1-1225.

Wood & Associates. 2005. *M/V Selendang Ayu Incident After Action Review*. USCG – MSO Anchorage. July 31, 2005.

Wreck Oil Removal Program. 2009. *"Wreck Oil Removal Program Overview."*

ED_001324_00000360-00212

APPENDICES

A. Numbered List of Standing Research Areas (SRAs)

B. ICCOPR Standing Research Areas – 2014 Database

C. ICCOPR Standing Research Areas – 2014 Sources

D. Survey Technical Report

E. Sample of Research Priority Survey

F. Sample of Survey Data

ED_001324_00000360-00213

THIS PAGE INTENTIONALLY LEFT BLANK.

ED_001324_00000360-00214

To: Venkatapathy, Raghuraman[Venkatapathy.Raghuraman@epa.gov]
Cc: Schubauer-Berigan, Joseph[Schubauer-Berigan.Joseph@epa.gov]; Conmy, Robyn[Conmy.Robyn@epa.gov]
From: McClellan, Kim
Sent: Wed 9/16/2015 7:27:55 PM
Subject: Abstracts for 2016 GOMRI
ABSTRACT for Biodegradability of Dispersed Heavy Fuel Oil at 5 and 25 C_SAJ.docx
ABSTRACT for Biodegradation of Finasol OSR 52 and Dispersed Alaska North Slope Crude Oil at 5 C and 25 C_SAJ.docx

Hi Raghu,

After the internal technical review was performed, two abstracts needed editorial changes. (see above in the attached files). Robyn Conmy's Branch Chief, Joe Schubauer-Berigan, approved the editorial changes for these two abstracts. I am making the changes to these two abstracts before I submit the abstracts to the clearance process.

Thanks,

Kim

ABSTRACT

Biodegradability of Dispersed Heavy Fuel Oil at 5 and 25 C

Mobing Zhuang, Gulizhaer Abulikemu, Pablo Campo, Makram Suidan, Albert Venosa, and Robyn Conmy

2016 Gulf of Mexico Oil Spill & Ecosystem Science Conference

Fuel oil is produced by blending heavy residual oils with a lighter oil to meet specifications for viscosity and pour point. Compare to lighter oils, the high density and viscosity of fuel oil make it less susceptible to dispersion and biodegradation. Hence, heavy fuel oil spills could cause more serious damages to the environment and be more difficult to clean. The environmental impacts include coating of wildlife dwelling on water surface, depleting oxygen in the receiving environment, exposing toxic substance to aquatic species, and sediment contamination. Laboratory experiments were conducted to study the biodegradability of Intermediate Fuel Oil 120 (IFO-120) dispersed by Corexit 9500 (C9500) at 5 and 25 °C. The biodegradability of alkanes and aromatics in IFO-120 at both temperatures was studied in the presence and absence of dispersant. When compared with IFO-120 alone treatments, date indicated that the depletion rate of alkanes at both temperatures was unaffected by the presence of dispersant. Conversely, C9500 significantly improved the aromatics uptake as its presence shortened the lag phase at 25 °C from 4 to 2 days and increased their removal extent from 71 to 82%. At 5 °C, the addition of C9500 also improved the overall removal from 70 to 85%. Such enhancement effect could be explained by the promoting of dissolution of soluble aromatics in the presence of surfactants.

ABSTRACT

Biodegradation of Finasol OSR 52 and Dispersed Alaska North Slope Crude Oil at 5 C and 25 C

Yu Zhang, Pablo Campo, Ruta Deshpande, Mobing Zhuang, and Robyn Conmy

2016 Gulf of Mexico Oil Spill & Ecosystem Science Conference

A study was conducted with Finasol OSR 52 dispersant and Alaska North Slope (ANS) crude oil in sterile GP2 artificial seawater to explain the biodegradability of the dispersant as well as dispersed ANS. Two oil degrading cultures, isolated from the surface (meso) and deep sea (cryo) of the Gulf of Mexico, were enriched on ANS crude oil at 25 °C (meso) and 5 °C (cryo) were used as inocula. Time series concentrations for oil components (alkanes and aromatics) and an anionic surfactant in Finasol were determined. Results indicated that almost all the surfactant was biodegraded by meso culture, while remained at the lower temperature. Over 90% of the total alkane fraction was biodegraded for the oil with and without dispersant at both the temperatures. For the aromatic fraction, the cryo culture metabolized 76% of the aromatics in ANS alone and 64% in ANS dispersed with Finasol, whereas aromatics persisted in both oil alone and dispersed oil samples at 25 °C. The obtained results figured the effect of dispersant on the fate of spilled oil and rates of oil and dispersant biodegradation, which will be essential for dispersant usage.

Dispersant-to-Oil Ratio and Temperature Limitations on Droplet Size Distribution in a Subsurface Oil Release

Brian Robinson[1], Thomas King[1], Scott Ryan[1], Patrick Toole[1], Claire McIntyre[1], Michel Boufadel[2], Robyn Conmy[3], and Kenneth Lee[4]

[1] Centre for Offshore Oil, Gas and Energy Research (COOGER), Fisheries and Oceans Canada, Dartmouth, Nova Scotia, Canada

[2] Center for Natural Resources Development and Protection, Department of Civil and Environmental Engineering, New Jersey Institute of Technology, Newark, New Jersey, USA

[3] US Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio, USA

[4] Wealth from Oceans National Research Flagship, CSIRO, Australian Resources Research Centre, Kensington, WA, Australia

COOGER's most recent research is on the fate and behaviour of oil from a subsurface release in a rectangular flume tank (30 m^3) that is capable of producing current velocities of up to 5 cm/s. A series of experiments were conducted using four oil products (SLC, ANS, IFO 120, and gas condensate) and two dispersants (Corexit 9500 and Finasol OSR 52) at various dispersant-to-oil ratios (DOR: 0, 1:20, 1:100, and 1:200). Oil or oil/dispersant premixes were released into the tank using a high pressure subsurface injection system to investigate the effects of DOR and water temperature on oil droplet size distributions (DSD). DSD data was measured at two locations in the tank using LISST-100x particle size analyzers. For all oil products except IFO-120, a DOR of 1:20 produced DSD plots that were bimodal shaped and the majority of the droplets were < 70 µm in size. The two dispersants, applied at DORs of 1:100 and 1:200, produced similar DSD patterns in most cases, with the exception of IFO 120. The effects of water temperature were most notable in the IFO 120 treatment, the more viscous oil. Without dispersant application, the DSD pattern revealed droplet sizes >70 µm for all oil products, where most of the submerged oil rose to the water surface. Some differences were observed in the dispersed oil DSD generated by the two different dispersants.

Flume Tank Tests to Evaluate the Effect of Subsurface Dispersant Use on Surface VOC Emissions

Brian Robinson[1], Thomas King[1], Patrick Toole[1], Claire McIntyre[1], Scott Ryan[1], Robyn Conmy[2], Michel Boufadel[3], and Kenneth Lee[4]

[1] Centre for Offshore Oil, Gas and Energy Research (COOGER), Fisheries and Oceans Canada, Dartmouth, Nova Scotia, Canada

[2] US Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio, USA

[3] Center for Natural Resources Development and Protection, Department of Civil and Environmental Engineering, New Jersey Institute of Technology, Newark, New Jersey, USA

[4] Wealth from Oceans National Research Flagship, CSIRO, Australian Resources Research Centre, Kensington, WA, Australia

The use of chemical dispersants during the response to a well blowout is often promoted as a means of protecting onsite workers from exposure to Volatile Organic Compounds (VOCs), yet very little information is available to demonstrate the effect that subsurface dispersant use has on surface VOC emissions. To evaluate this claim, a series of experiments were conducted in a flume tank (30 m^3) located at the Bedford Institute of Oceanography. Four different hydrocarbon products (ANS, SLC, IFO-120, gas condensate) were tested to represent a range of different physical and chemical properties. Two dispersant products were used in four dispersant-to-oil treatments. The tank was equipped with a subsurface oil injection system used to release oil or oil/dispersant premix through a small diameter (2.4 mm) nozzle under high pressure, forming a plume of oil droplets. This plume was transported horizontally by water currents. Different droplet size distributions were formed, depending on the treatment, which affected the transport of the oil in the tank. Increased DOR resulted in decreased surface VOC concentrations for all four products. Compared to the non-treated oils, a DOR of 1:20 resulted in a 5 to 25x decrease, depending on the oil type, in surface VOC concentrations. This study demonstrated that the use of chemical dispersants on a subsurface oil release can reduce surface VOC emissions.

To: Holder, Edith[holder.edith@epa.gov]; Conmy, Robyn[Conmy.Robyn@epa.gov]
From: Sorial, George (sorialga)
Sent: Fri 12/11/2015 11:58:39 AM
Subject: RE: Urgent need of PCR results

Edie,

The PCR results will inform us if there are differences between the cultures. Do you know where the PCR analysis stands now. Some samples were sent in 2014 and other samples were sent on May 2015.

Thanks

George

George Sorial, PhD

Professor of Environmental Engineering &

Department Head

Department of Biomedical, Chemical, and Environmental Engineering (BCEE)

College of Engineering and Applied Science

University of Cincinnati

2901 Woodside Drive

P.O. Box 210012

Cincinnati, OH 45221-0012

Office: 701L Engineering Research Center (ERC)

Tel: (513) 556-2987

Fax: (513)556-4162

E-mail: George.Sorial@uc.edu

WEB: http://ceas.uc.edu/bcee.html

From: Holder, Edith [mailto:holder.edith@epa.gov]
Sent: Thursday, December 10, 2015 8:42 PM
To: Conmy, Robyn <Conmy.Robyn@epa.gov>; Sorial, George (sorialga) <SORIALGA@UCMAIL.UC.EDU>
Subject: RE: Urgent need of PCR results

Robyn and George,

This was discussed during the meeting at UC on Tuesday.

It is a mystery to me. The same cultures were used for all experiments. I grew a large quantity of each culture in November 2011. They have been in a freezer ever since with no temperature upsets.

For a test preparation, the needed number of vials are defrosted, contents mixed with sterile saline and centrifuged to remove glycerol. Then they are brought back to volume in saline and delivered to UC.

I am thinking about setting up a mini-experiment here on Tuesday when I defrost the culture for them to see if there is degradation here.

I don't see an easy answer.

Edie

From: Conmy, Robyn
Sent: Wednesday, December 09, 2015 12:15 PM
To: Sorial, George (sorialga) <SORIALGA@UCMAIL.UC.EDU>
Cc: Holder, Edith <holder.edith@epa.gov>
Subject: Re: Urgent need of PCR results

Hello George, I have cc'd Edie so that she can update you on this. The lack of degradation is troubling.

Robyn

Sent from my iPhone

On Dec 9, 2015, at 9:25 AM, Sorial, George (sorialga) <SORIALGA@UCMAIL.UC.EDU> wrote:

Hi Robyn,

As you know Yu Zhang was on WA4-05 Task1.1 (Finasol dispersant project). She used the same culture as Mobing's previous experiment (WA3-33). She set up an experiment in March, 2015 and got no degradation of PAHs for 25 C part experiment, as shown in the attachment plot. She repeated the 25 C experiment in August, 2015, and similar results were obtained. In order to figure out the difference between the two cultures, it is better to compare the PCR result of Yu's and Mobing's experiment. Mobing sent her PCR samples at the beginning of 2014 for WA3-33, and Yu sent her PCR samples in May, 2015. With respect to the PCR samples of the repeat experiment, they were sent to Edith recently. Up to now, we did not receive any feedback on the PCR analysis. I, therefore, request if you can push for PCR analysis to be done soon. This is important because Yu will be using the same culture for the next experiment which will be conducted next week.

Best Regards,

George

George Sorial, PhD

Professor of Environmental Engineering &

Department Head

Department of Biomedical, Chemical, and Environmental Engineering (BCEE)

College of Engineering and Applied Science

University of Cincinnati

2901 Woodside Drive

P.O. Box 210012

Cincinnati, OH 45221-0012

Office: 701L Engineering Research Center (ERC)

Tel: (513) 556-2987

Fax: (513)556-4162

E-mail: George.Sorial@uc.edu

WEB: http://ceas.uc.edu/bcee.html

<PAHs degradation comparison.docx>

To: Conmy, Robyn[Conmy.Robyn@epa.gov]; Sorial, George (sorialga)[SORIALGA@UCMAIL.UC.EDU]
From: Holder, Edith
Sent: Fri 12/11/2015 1:41:56 AM
Subject: RE: Urgent need of PCR results

Robyn and George,

This was discussed during the meeting at UC on Tuesday.

It is a mystery to me. The same cultures were used for all experiments. I grew a large quantity of each culture in November 2011. They have been in a freezer ever since with no temperature upsets.

For a test preparation, the needed number of vials are defrosted, contents mixed with sterile saline and centrifuged to remove glycerol. Then they are brought back to volume in saline and delivered to UC.

I am thinking about setting up a mini-experiment here on Tuesday when I defrost the culture for them to see if there is degradation here.

I don't see an easy answer.

Edie

From: Conmy, Robyn
Sent: Wednesday, December 09, 2015 12:15 PM
To: Sorial, George (sorialga) <SORIALGA@UCMAIL.UC.EDU>
Cc: Holder, Edith <holder.edith@epa.gov>
Subject: Re: Urgent need of PCR results

Hello George, I have cc'd Edie so that she can update you on this. The lack of degradation is

troubling.

Robyn

Sent from my iPhone

On Dec 9, 2015, at 9:25 AM, Sorial, George (sorialga) <SORIALGA@UCMAIL.UC.EDU> wrote:

Hi Robyn,

As you know Yu Zhang was on WA4-05 Task1.1 (Finasol dispersant project). She used the same culture as Mobing's previous experiment (WA3-33). She set up an experiment in March, 2015 and got no degradation of PAHs for 25 C part experiment, as shown in the attachment plot. She repeated the 25 C experiment in August, 2015, and similar results were obtained. In order to figure out the difference between the two cultures, it is better to compare the PCR result of Yu's and Mobing's experiment. Mobing sent her PCR samples at the beginning of 2014 for WA3-33, and Yu sent her PCR samples in May, 2015. With respect to the PCR samples of the repeat experiment, they were sent to Edith recently. Up to now, we did not receive any feedback on the PCR analysis. I, therefore, request if you can push for PCR analysis to be done soon. This is important because Yu will be using the same culture for the next experiment which will be conducted next week.

Best Regards,

George

George Sorial, PhD

Professor of Environmental Engineering &

Department Head

Department of Biomedical, Chemical, and Environmental Engineering (BCEE)

College of Engineering and Applied Science

University of Cincinnati

2901 Woodside Drive

P.O. Box 210012

Cincinnati, OH 45221-0012

Office: 701L Engineering Research Center (ERC)

Tel: (513) 556-2987

Fax: (513)556-4162

E-mail: George.Sorial@uc.edu

WEB: http://ceas.uc.edu/bcee.html

<PAHs degradation comparison.docx>

To: Conmy, Robyn[Conmy.Robyn@epa.gov]; Holder, Edith[holder.edith@epa.gov]
From: Musson, Steve
Sent: Thur 6/18/2015 12:37:14 PM
Subject: HASP 2014-033 Rev 1
HASP 2014-033 Rev 1.pdf
2014-033 Rev 1 Approval Copy.docx

Robyn,

Attached is a pdf of the whole HASP with the approval signatures included. Thought it may be easier for you to post by just printing this copy.

Steve

Stephen Musson, PhD, CIH, CHMM

Safety, Health, and Environmental Management Program Manager

US EPA National Risk Management Research Laboratory

26 W. Martin Luther King Drive

Cincinnati OH 45268

513-569-7969

Health and Safety Plan

Title: Oil Spill Research Including Work with Dispersants, Surface Washing Agents (SWAs), and Oil Degrading Microbes
Principal Investigator(s): Robyn Conmy, Edith Holder
Office: ORD
Laboratory: NRMRL
Division: LRPCD
Branch: ESMB
Building: AWBERC
Room/Lab #: 703, 701, 708, Constant Temperature Room 710

Approvals

I have read and approve the attached Health and Safety Plan in conformance with the ORD Facility Chemical Hygiene Plan and Health & Safety Plan Policy. I certify that the workplace hazards, routinely and non-routinely encountered by employees, during the described activities, and for which Personal Protective Equipment has been provided, have been assessed for the determination of Personal Protective Equipment required, in compliance with 29 CFR 1910 Subpart I.

Name	Phone	Signature	Date
Edith Holder	569-7178	EDITH HOLDER (affiliate)	Digitally signed by EDITH HOLDER (affiliate) DN: c=US, o=U.S. Government, ou=USEPA, ou=Staff, cn=EDITH HOLDER (affiliate), dnQualifier=0000036563 Date: 2015.06.01 15:08:59 -04'00'
PREPARER Dr. Robyn Conmy	569-7090	ROBYN CONMY	Digitally signed by ROBYN CONMY DN: c=US, o=U.S. Government, ou=USEPA, ou=Staff, cn=ROBYN CONMY, dnQualifier=0000041674 Date: 2015.06.15 10:20:34 -04'00'
PRINCIPAL INVESTIGATOR Dr. Joseph Schubauer-Berigan	569-7734		06/12/15
IMMEDIATE SUPERVISOR Dr. Raghu Venkatapathy	569-7077		06/17/2015
PTSI On-Site Manager			
(Additional Approvals: such as CO-PI or Contractor Manager) Steve Musson CHEMICAL HYGIENE OFFICER	569-7969		6/17/2015

Additional information on the completion of a Health & Safety Plan may be found at the SHEM Intranet Site.

Laboratory / Field Staff Concurrence

I have read, understood and will comply with all the requirements of the attached Health and Safety Plan, SDS's, and the rules contained in the U. S. EPA- Facilities Chemical Hygiene Plan. I have also had the opportunity to ask any questions, and had my questions satisfactorily answered prior to my beginning work under this plan.

Name (Print)	Employer (EPA, ORISE, Contractor name, etc.)	Lab (L), Field (F), or Both?	Signature	Date

ED_001324_00000378-00002

Project Description

Background:

Unintentional releases of oil into coastal waters may result in oil becoming stranded on shorelines. Oil that reaches the shoreline can have a severe effect on the local environment, including toxic exposures and smothering of biota in direct contact with the oil. Surface washing agents (SWAs) are chemical agents intended to enhance the removal of oil from shoreline surfaces, thereby minimizing detrimental effects to impacted biota. Dispersants are chemical agents intended to break up the oil by reducing the oil-water interfacial surface tension, which will eventually promote dispersion of oil droplets into the water column. It is necessary to evaluate the potential benefits as a remediation aide of these two classes of compounds as well as the long term ramifications to the environment of their use.

Indigenous bacteria have the capability of removing oil components by biodegradation. The capability of populations from different sources to biodegrade different oils as well as the interactions of microbial populations to the various dispersants and SWAs is a subject for current study.

Laboratory Activities

This laboratory has done previous studies looking at the effects of dispersants, SWA, bioremediation products, and microbes enriched from sediments and water. From an earlier QAAP 386-Q11-0, endorsed 7 June 2002: "The U.S. Environmental Protection Agency's (EPA) Oil Spill Research Program encompasses several major objectives: 1) to develop and/or conduct scientifically sound and defensible protocols for testing the effectiveness of commercial bioremediation products on crude and refined oil in various environments, 2) to develop and/or conduct chemical and microbiological methods for characterizing changes in the chemical and biological composition of oil-contaminated matrices, such as beach material, soil, or water; and 3) to conduct research defining the proper conditions needed to bring about oil spill cleanup in the field. Research to address these objectives was initiated under Quality Assurance Project Plan (QAPP)ID No. C-781-B. The work performed earlier used Alaskan oil and Alaskan cultures. The current research will include Gulf of Mexico oil and cultures, as well as other oils of interest such as Dilbit and freshwater cultures from the Enbridge spill in Kalamazoo, MI. If new spills occur, oil and sediments from the impacted site may come under investigation.

Analysis of oil in water will be measured by Fluorometry. Samples of oil that have been extracted into either methylene chloride or hexane will be measured using UV/Vis Spectrophotometry or GC/MS. The current work will use the methods listed in the following QAPPs and HASPS which can be found on the L drive under L:Public\NRMRL-PUB\Holder\OilSpill\HASP&QAPP:

\QAPP 490-Q5-0.doc Development of a Surface Washing Agent Testing Protocol endorsed October 2004
Amendment to QAPP 490-Q5-0 submitted November 2009, resubmitted to WAM July 2010 and to QA September 2010

\Natural Substrate SOP.doc The Natural Substrate Protocol for Determining Effectiveness of Surface Washing Agents

\SOP UV vis.doc Analysis of Oil Concentration in DCM by UV/VIS Spectrophotometry

\FDOM analysis.doc Standard Operating Protocol for Fluorescent Dissolved Organic Matter (FDOM)

In subdirectory QAPP 2013:
QAPP L-14866-QP-1-6 Development and Revision of Procedures for the Code of Federal Regulations (CFR) Appendix C to Part 300, Oil Spill Product Testing Protocols

Appendix A: Oil Dispersant Testing, Standard Operating Procedure for Determining Effectiveness of Oil Dispersants Using the Baffled Flask Test, May 2013

ED_001324_00000378-00003

Appendix B: Bioremediation Product Testing, Standard Operating Procedure for the Bioremediation Agent Effectiveness Test Protocol, May 2013

Appendix C: Oil Analysis SOPs, GC/MS procedures, May 2013
- SOP 1: Glassware Cleaning Procedure for Oil Spill Projects
- SOP 2: Preparation of Surrogate Recovery Standards
- SOP 3: Preparation of Internal Standard Solution
- SOP 4: Preparation of Working Standards, Check Standards, and Oil Standards for GC/MS Consistency.
- SOP 5: GC/MS Method for the Analysis of Crude Oil Samples

A QAPP for specific research utilizing fluorescence spectrometry will be developed when this research is initiated.

A majority of the analytical methods are common to multiple projects and activities conducted within the oil spill program. The analytical work covered under this HASP include experiments with oil dispersants, surface washing agents (SWA), and oil degrading bacteria enriched from natural sources. Abiotic testing of the dispersants and SWA testing will utilize different oils and different products, varying parameters of application, temperature, weathering effects, and substrate. Biotic experiments will include biodegradation studies using a sacrificial shake flask experimental design.

The instruments that will be used for measuring oil components are a Shimadzu UV 1800 Spectrophotometer, Horiba Fluorolog3 Spectrofluorometer, WetLabs, Inc. ECO Submersible Fluorometer, and Agilent 6890 Gas Chromatograph with a 5973 Mass Spectrometer Detector. For all experiments, solvent (water, dichloromethane (DCM) or hexane) extracts of oil will be produced for analytical measurement.

Room 703 is the base lab for the various activities. The GC/MS will be located in room 708. CTR 710 will be used for 5°C work and 708 for work at 25°C. Storage of oil is in 703, storage of frozen samples is in 701, and storage of refrigerated samples is in 701 and CTR 710.

The full notice regarding dichloromethane (DCM) is given at the end of this document.

Physical Hazards Summary

The physical hazards marked below have been identified as present during the performance of the project. Job hazards for specific steps are described in the Job Hazard Analysis Table at the end of the HASP. The RSO shall be included in the list of reviewers/approval for all plans incorporating radioactive materials, radioactive devices, or radiation sources. ***"L" is for Laboratory Activities; "F" is for Field Activities.***

Physical Hazards		**Physical Hazards**	
Electrical Hazards		Noise	
Radioactive Materials		Temperature	L
Non-Ionizing Radiation		Illumination	
Ionizing Radiation		Compressed Gas	L
Heavy Lifting		Sharp Objects / Tools	
Vibration		Slips, Trips, Falls	
UV light/radiation			
Other (Specify) Rotating Equipment (Laboratory Shaker)			L

PPE Summary

The PPE items marked below are required to be utilized during performance of the project. PPE requirements for specific steps are described in the Job Hazard Analysis Table at the end of the HASP. ***"L" is for Laboratory Activities; "F" is for Field Activities.***

ED_001324_00000378-00004

Face / Eye Protection	
Safety Glasses w/ Side Shields	L
Chemical Splash Goggles	L
Face Shield	L
Other (specify)	
Ear Protection	
Ear Plugs (Foam Inserts)	
Both Ear Plugs and Ear Muffs	
Ear Muffs	
Other (specify)	
Hand Protection	
Chemical – Nitrile disposable exam	L
Chemical - Latex disposable exam	
Chemical – Butyl disposable exam	
Chemical - Silver Shield®	L
Chemical – Ansel Barrier®	
Cotton	
Leather	
Cut Resistant (Kevlar ®)	
Other (specify) – thermal protective	L
Other (specify) – Polypropylene Gloves (see FDOM SOP)	L
Protective Clothing	
Lab Coat	L
Lab Apron	
Jumpsuit	
Shoe covers	
Oversleeves	
Other (specify)	

Equipment Requirements

The safety equipment/engineering controls marked below(X) are required to be utilized during performance of the project. Requirements for specific steps are described in the Job Hazard Analysis Table at the end of the HASP.

Chemical Fume Hood	x
Biological Safety Cabinet	
Walk-in / Bulking Hood	
Radiological Fume Hood	
Balance Enclosure	
Clear Air Bench (laminar flow hood)	
Spot Ventilation Unit (Snorkel)	
Local Exhaust Ventilation	
Canopy Hood	
Liquid Scintillation Counter	
Refrigerator / Freezer	x

ED_001324_00000378-00005

Deep Freezer	x
Other (specify) – spectrophotometer / shaker / GC/MS/ drying oven and muffle furnace	x

Chemicals to be Used

EPA utilizes an online service, Chemwatch, to provide Safety Data Sheets (SDS) to employees.
http://jr.chemwatch.net/chemwatch.web
Account: epa User Name: Everyone Password: *120270.*

If the SDS is not available through Chemwatch, a hardcopy of the manufacturer supplied SDS must be submitted to the SHEM office for upload to the Chemwatch system. . **ALL fields must be completed in the table below for all chemicals used in the project.**

Item #	Chemical Name	CAS#	Project Use	Disposal Method for Unused Chemicals	Notes
			Ex. Reagent, Standard, or Specific task #	S = Sink T = Trash W = Chemical Waste Program	(EPA waste codes, special hazards, ingredients, etc.)
1	Dichloromethane	75-09-2	Solvent	W	See special OSHA information at end of HASP. Carcinogen
2	Hexane	110-54-3	Solvent	W	
3	Petroleum Crude Oil	8002-05-9	Reagent	W	
4	Biodispers		Dispersant	W	
5	NEOS AB3000		Dispersant	W	
6	Sodium Sulfate	7757-82-6	Reagent	W	
7	Sea Salts (Sigma) (or Instant Ocean)	Mixture	Media	S or T	
8	Bushnell-Haas Broth		Media	S or T	
9	Sodium Chloride	7647-14-5	Media	S	
10	Potassium Chloride	7447-40-7	Media	S	
11	Potassium Bromide	7758-02-3	Media	W	
12	Sodium Borate	1303-96-4	Media	S	
13	Magnesium Chloride	7791-18-6	Media	S or T	
14	Calcium Chloride	10043-52-4	Media	S or T	
15	Strontium Chloride	10476-85-4	Media	W	
16	Sodium Bicarbonate	7757-82-6	Media	S or T	
17	Potassium Nitrate	7757-79-1	Media	W	
18	Iron Chloride	10025-77-1	Media	W	
19	Sodium Tripolyphosphate	7722-88-5	Media	W	
20	Sodium Hydroxide	1310-73-2	reagent	W	
21	Hydrochloric Acid	7647-01-0	Reagent, acid	W	

ED_001324_00000378-00006

Item #	Chemical Name	CAS#	Project Use	Disposal Method for Unused Chemicals	Notes
			Ex. Reagent, Standard, or Specific task #	S = Sink T = Trash W = Chemical Waste Program	(EPA waste codes, special hazards, ingredients, etc.)
			washing, fluorometry		
22	Acenaphthene	00083-32-9	standard	W	
23	Acenaphthylene	00208-96-8	standard	W	
24	Benzo(a)anthracene	00056-55-3	standard	W	
25	Biphenyl	00092-52-4	standard	W	
26	2,6-Dimethylnaphthalene	00581-42-0	standard	W	
27	3,6-Dimethylphenanthrene	01576-67-6	standard	W	
28	1-Methylnaphthalene	00090-12-0	standard	W	
29	2-Methylphenanthrene	02531-84-2	standard	W	
30	2,3,5-Trimethylnaphthalene	02245-38-7	standard	W	
31	Decane	00124-18-5	standard	W	
32	Undecane	01120-21-4	standard	W	
33	Dodecane	00112-40-3	standard	W	
34	Tridecane	00629-50-5	standard	W	
35	Tetradecane	00629-59-4	standard	W	
36	Pentadecane	00629-62-9	standard	W	
37	Hexadecane	00544-76-3	standard	W	
38	Heptadecane	00629-78-7	standard	W	
39	Octadecane	00593-45-3	standard	W	
40	Nonadecane	00629-92-5	standard	W	
41	Eicosane	00112-95-8	standard	W	
42	Heneicosane	00629-94-7	standard	W	
43	Docosane	00629-97-0	standard	W	
44	Tricosane	00638-67-5	standard	W	
45	Tetracosane	00646-31-1	standard	W	
46	Pentacosane	00629-99-2	standard	W	
47	Hexacosane	00630-01-3	standard	W	
48	n-Heptacosane	00593-49-7	standard	W	
49	Octacosane	00630-02-4	standard	W	
50	n-Nonacosane	00630-03-5	standard	W	
51	n-Triacontane	00638-68-6	standard	W	
52	n-Hentriacontane	00630-04-6	standard	W	
53	n-Dotriacontane	00544-85-4	standard	W	
54	n-Tritriacontane	00630-05-7	standard	W	
55	n-Tetratriacontane	14167-59-0	standard	W	
56	n-Pentatriacontane	00630-07-9	standard	W	

Item #	Chemical Name	CAS#	Project Use	Disposal Method for Unused Chemicals	Notes
			Ex. Reagent, Standard, or Specific task #	S = Sink T = Trash W = Chemical Waste Program	(EPA waste codes, special hazards, ingredients, etc.)
57	Naphthalene	00091-20-3	standard	W	
58	Fluorene	00086-73-7	standard	W	
59	Dibenzothiophene	00132-65-0	standard	W	
60	Phenanthrene	00085-01-8	standard	W	
61	Fluoranthene	00206-44-0	standard	W	
62	Pyrene	00129-00-0	standard	W	
63	Chrysene	00218-01-9	standard	W	
64	Benzo(b)fluoranthene	00205-99-2	standard	W	
65	Benzo(k)fluoranthene	00207-08-9	standard	W	
66	Benzo(e)pyrene	00192-97-2	standard	W	
67	Benzo(a)pyrene	00050-32-8	standard	W	
68	Perylene	00198-55-0	standard	W	
69	Indeno(1,2,3-cd)pyrene	00193-39-5	standard	W	
70	Dibenzo(a,h)anthracene	00053-70-3	standard	W	
71	Benzo(g,h,i)perylene	00191-24-2	standard	W	
72	Pristane	01921-70-6	standard	W	
73	Phytane	00638-36-8	standard	W	
74	Anthracene	00120-12-7	standard	W	
75	Benzo[*b*]naphtho[2,1[*d*]thiophene	239-35-0	standard	W	
76	5b-Cholestane	481-20-9	standard	W	
77	5a-Androstane	438-22-2	standard	W	
78	Hopane	1176-44-9	standard	W	
79	D22 n-Decane	16416-29-8	standard	W	
80	D34 n-Hexadecane	15716-08-2	standard	W	
81	D42 n-Eicosane	62369-67-9	standard	W	
82	D62 n-Triacontane	93952-07-9	standard	W	
83	D8-Naphthalene	1146-65-2	standard	W	
84	D10-Anthracene	1719-06-8	standard	W	
85	D12-Chrysene	1719-03-5	standard	W	
86	D12-Perylene	1520-96-3	standard	W	
87	D36-Heptadecane	39756-35-9	standard	W	
88	D50-Tetracosane	16416-32-3	standard	W	
89	D66-Dotriacontane	62369-68-0	standard	W	
90	D10-1-methylnaphthalene	1517-22-2	standard	W	
91	D10-Phenanthrene	1517-22-2	standard	W	
92	D10-Pyrene	1718-52-1	standard	W	
93	Ph buffers 4, 7, and 10	Varies	Calibration	S	

ED_001324_00000378-00008

Item #	Chemical Name	CAS#	Project Use	Disposal Method for Unused Chemicals	Notes
			Ex. Reagent, Standard, or Specific task #	S = Sink T = Trash W = Chemical Waste Program	(EPA waste codes, special hazards, ingredients, etc.)
94	Nitric Acid	7697-37-2	pH adjustment/ sand washing	W	
95	Methanol	67-56-1	fluorometry	W	
96	Rhodamine B	81-88-9	fluorometry	W	
97	Ethylene Glycol	107-21-1	fluorometry	W	
98	Quinine Sulfate Dihydrate	6119-70-6	fluorometry	W	
99	Sulfuric Acid	7664-93-9	Fluorometry, pH adjustment	W	
100	Dimethyldichlorosilane (5%) in Toluene	Mixture	Silanizing glassware	W	
101	Sodium Azide	26628-22-8	Microbial Growth Inhibitor	W	
102	Magnesium Sulfate	7487-88-9	Media	S or T	
103	Manganese Sulfate	10034-96-5	Media	S or T	
104	Boric Acid	10043-35-3	Media	S or T	
105	Zinc Sulfate	7446-20-0	Media	S or T	
106	Ammonium Molybdate	12054-85-2	Media	S or T	
107	Potassium Hydrogen Phosphate	7758-11-4	Media	S or T	
108	Potassium dihydrogen Phosphate	7778-77-0	Media	S or T	

Current Inventory of Crude Oils Line Item # 3 (May 2015)		
Anadarko	Endicott	Prudhoe Bay
ANS	Endicott (18% evaporated)	PXP 01
ANS 521	Esgravos	PXP 02
Arabian Light	FO2	Rock
BHP Billiton	Fuel 6	South Louisiana
Bonnie Light	Harmony	Sweet Synthetic
Bunker C	IFO 120	Terra Nova
Dilbit, Cold Lake	IFO 380	Venoco E-10
Dilbit, WCS	North Star	Venoco E-19
Doba	PER 038	
Elly	PER 040	

Current Inventory of Oil Spill Dispersants Line Items # 10-15 (May 2015)

ED_001324_00000378-00009

Accell Clean DWD	Finasol OSR52	Nokomis 3-F4
Biodispers	JD-2000	Saf-Ron Gold
Corexit 9500	NEOS AB3000	SX-100
Dispersit SPC1000	Nokomis 3-AA	ZI-400
FFT Solution		

Current Inventory of Oil Spill Surface Washing Agents Line Items # 4-9 (May 2015)		
ADP7	F500	Petroluxus
Aquaclean	Gold Crew SW	Petrotech 25
BG-Clean 401	Green Beast	Premier 99
Biosolve	Jep Marine Clean	Procleans PCR 107
CleanGreen Planet Wash	Marine Green Clean	Sandklene 950
Corexit 9580	Marine Green Clean Plus	SC-1000
Cytosol	Naturama G3 A-5	Simple Green
Dynamic Green	Nokomis 5W	Spillclean
Enviroclean	Nontox SWA	Superall #38
EPA Oil Field Solution™	Petro-Clean	

Biological Research

Does the project in any way involve manipulation of recombinant DNA?	No
If yes, are all proposed activities specifically exempted from the NIH Guidelines for Research Involving Recombinant DNA Molecules?	
Does the project in any way involve human subjects or biological materials obtained from human subjects?	No
If yes, is the project exempt from the Health and Human Services Policy for Protection of Human Subjects?	
Does the project involve animals requiring Institutional Animal Care & Use Committee (IACUC) approval? (includes vertebrate & invertebrates animals)	No

Biological Agents

(The Biosafety Level (BSL) and Animal Biosafety Level (ABSL) refer to specific combinations of work practices, safety equipment, and facility design elements utilized to minimize exposure of workers and the environment to infectious agents. Principal Investigators must perform an agent risk assessment to determine the BSL.)

Item #	Biological Agent (list all that apply)	BSL #	Source of Biological Agent	Vaccination Required?
1	Oil degrading bacteria isolated from environmental samples	1	Water or sediments	no

Waste Management

DCM, hexane, methanol, and crude oil wastes (dissolved in DCM) from analytical samples collected via separatory funnel, standards, and glassware rinsate should be disposed of through the SHEM hazardous wastes program due to solvent, oil and PAH contents. After washing gravel and sand with DCM, the DCM is drained into the waste container and the substrate is placed in the fume hood to allow the remaining DCM to evaporate off, before disposing of the cleaned substrate in the garbage.

Spent silanizing solution should be disposed throught the SHEM hazardous waste program.

ED_001324_00000378-00010

Original chemical reagents will be disposed as indicated in the chemical use table.

Any remaining fresh or seawater will be disposed of down the sink drain because no known hazardous wastes are involved.

Aqueous waste remaining after removal of DCM using a separatory funnel may be sink disposed. Any remaining DCM is placed in a hazardous waste container before dumping remaining water to sink.

Acid solution from sand/gravel cleaning will be collected and neutralized using sodium hydroxide to a pH between 5 and 9 and then disposed of down the sink.

Will Hazardous Waste Be Generated? yes Will the Treatability Exemption be Utilized? no

Sample Management

All samples will be labeled with sample descriptors including date, analyst, and constituents (solutes and solvents). They will be stored in the refrigerators in 701 or CTR710. They will be kept until data is approved and then disposed of using the Chemical Waste Program. Any enriched bacterial consortia will be frozen and kept in the -80 freezer in 701. They may be maintained indefinitely.

Hexane containing samples are flammable and should only be stored in refrigerators or freezers designed and labeled as approved for flammable material storage.

Spill Response

General spills are handled in accordance with the Chemical Hygiene Plan found at http://intranet.epa.gov/nerlintr/shem/lab_safety/docs/ChemHygiene.pdf

Small spills shall be wiped up by project personnel wearing proper PPE and the absorbent material bagged, labeled as to its hazardous constituents, then submitted to the SHEM Waste Program for proper disposal. In the event of a large solvent spill, SHEM will be contacted via x7997 or by way of security per the Chemical Hygiene Plan.

The spill of any bacterial consortia that have been enriched from environmental samples will be doused with either a 10% chlorine solution or 70% ethanol solution, allowed to sit for ~ 10 minutes and then wiped up. The wipes used will be placed in a biohazard bag for autoclaving.

The chemical spill kit is located: 701, 703, 708 - on the left side of the lab near the door.
710 – May use a spill kit from the other laboratories

ED_001324_00000378-00011

Authorized Personnel

Training and medical monitoring requirements will vary depending on the complexity and materials used in the process. Therefore, only personnel trained and monitored will be permitted to work under this plan. To be "authorized", employees must have completed the training and screenings selected below.

Mandatory for all researchers	
Initial Laboratory Safety	**X**
Current Chemical Hygiene Plan Laboratory Safety Refresher	**X**
Hazardous Waste Management (RCRA)	**X**
Project/Task Dependent	
Medical Surveillance	**X**
Respiratory Protection	
Biosafety / Blood borne Pathogens	
Initial Field Safety and/or 8 hour field safety refresher training in the fiscal year	
40 - hour HAZWOPER and/or 8 hour HAZWOPER refresher in the last 12 months	
Hearing Protection	
First Aid / CPR / AED	
DOT Hazardous Materials Awareness/Shipment	
Radiation Safety	
EPA Driver's Training	
EPA Boat Safety Training	
EPA Nanomaterials Health and Safety Awareness Training	
Other (specify) – Dichloromethane information (See below)	X

References:

ED_001324_00000378-00012

General Activities
Job Hazard Analysis, Controls, and PPE

Job Step/Operation	Room / Area	Potential Hazards/Risks	Recommended Action/Procedure	PPE Required
Preparation of artificial seawater and freshwaters	703	Little chemical hazard as it consists of salts. Irritants	Prepare chemical solutions in a CFH where possible	Lab coat, safety glasses with side shields, nitrile gloves, closed-toe shoes
Use of freezer	701	Thermal burns from the ultra low freezer	Use caution when handling items from the freezer	Thermal protective gloves Lab coat, safety glasses with side shields, nitrile gloves, closed-toe shoes
Use of autoclave	380	See chemical hygiene plan for Autoclave Hazard Analysis	See chemical hygiene plan for Autoclave Hazard Analysis	See chemical hygiene plan for Autoclave Hazard Analysis
Use of centrifuge		See chemical hygiene plan for Centrifuge Hazard Analysis	See chemical hygiene plan for Centrifuge Hazard Analysis	See chemical hygiene plan for Centrifuge Hazard Analysis
Preparation of dilute acid from concentrated acid for performing pH adjustments	703	Splash – chemical burns to exposed skin	Prepare solution in a chemical fume hood	Face shield – Lab coat, safety glasses with side shields, nitrile gloves, closed-toe shoes
Use of drying oven and muffle furnace	703	Burns	Caution with hot glassware. Let muffle furnace completely cool down before removing glassware.	Thermal protective gloves
CTR 710		Limited ventilation – build up of chemical vapors, inhalation of DCM and other toxic and carcinogenic chemical vapors	No open chemical container work should be performed in CTR 710. All containers should remain closed. Samples should be moved to a room with a CFH if necessary to open.	Lab coat, safety glasses with side shields, nitrile gloves, closed-toe shoes

ED_001324_00000378-00013

Job Hazard Analysis
SOP 1 Glassware Washing

Glassware Washing *** includes supplies, utensils and containers in contact with soil, extraction fluid, and/or leachate**			
Sequence of Basic Job Steps	**Potential Hazards**	**Recommended Action or Procedure**	**PPE Required**
Rinse loose debris from the surface	- Cross contamination from glassware to personnel – potential exposure - Splash or spray from rinsing – potential exposure - Potential breakage of glassware from cracks or defects – cuts / lacerations / contamination	- Inspect glassware before cleaning for cracks or other damage – discard in broken glass container if damage is noticed or suspected - use low pressure water to avoid splash and/or aerosolization of the contaminants - if any glassware is broken during cleaning – only remote means should be used to pick up any broken glass	- minimum of safety glasses, laboratory coat, and gauntlet length nitrile gloves
Wash with brush, soap, and water. Triple rinse with water. Soak in soap bath.	- Cross contamination from glassware to personnel – potential exposure - Splash or spray from rinsing – potential exposure - Potential breakage of glassware from cracks or defects – cuts / lacerations / contamination	- Inspect glassware before cleaning for cracks or other damage – discard in broken glass container if damage is noticed or suspected - use low pressure water to avoid splash and/or aerosolization of the contaminants - if any glassware is broken during cleaning – only remote means should be used to pick up any broken glass	- minimum of safety glasses, laboratory coat, and gauntlet length nitrile gloves
Drying object using drying racks	- potential for dropping the glassware, tools, etc. – breakage, spillage, contact with other surfaces - slip / trip / fall hazards from water spillage or splashing from the rinsing process	- ensure that the drying racks are placed to reduce any ergonomic hazard from stretching, or repetitive motion - follow the established emergency procedures for injuries or spills including immediate notification of your supervisor or 911 for life threatening cases (also x7777, direct contact to security)	- minimum of safety glasses, laboratory coat, and gauntlet length nitrile gloves

ED_001324_00000378-00014

SOP 2 -Preparation of a Surrogate Recovery Standard
Job Hazard Analysis, Controls, and PPE
SOP 3 - Preparation of Internal Standard Solution
Job Hazard Analysis, Controls, and PPE
SOP 4 - Preparation of Working Standards, Check Standards, and Oil Standards for GC/MS
Job Hazard Analysis, Controls, and PPE

Job Step/Operation	Potential Hazards/Risks	Recommended Action/Procedure	PPE Required
Weigh reagents **Dissolve reagents / wash beakers using methylene chloride** **Transfer the solution**	Reagents listed contain materials that are listed as carcinogens or potential for causing cancer, irritants, and are photosensitizers. Potential for illness upon inhalation and / or skin contact (chemical dermatitis, increase probability for sunburn)	Prepare the reagents / standards in a chemical fume hood only. Handle reagents in the smallest quantities possible and do not cross contaminate. DCM – attempt to not 'pour' DCM as the ST is low and tends to spread. Use the sash on a CFH for splash protection where possible. Review OSHA Regulated Substance Awareness for DCM.	Double gloves - Wear normal length nitrile gloves over silvershield gloves to maintain dexterity; Lab coat, safety glasses with side shields, and closed-toe shoes.
Pipetting	see chemical hygiene plan for pipetting recommendations	See chemical hygiene plan for pipetting recommendations	Double nitrile gloves and / or silvershield gloves (where dexterity is not an issue). Lab coat, safety glasses with side shields, and closed-toe shoes.

SOP 5 - GC/MS Method for the Analysis of Crude Oil
Job Hazard Analysis, Controls, and PPE

Job Step/Operation	Potential Hazards/Risks	Recommended Action/Procedure	PPE Required
Compressed Gas Usage (Helium)	See Chemical Hygiene Plan – JHA for Compressed Gas Cylinders	See Chemical Hygiene Plan – JHA for Compressed Gas Cylinders	See Chemical Hygiene Plan – JHA for Compressed Gas Cylinders
Solvent / standard / stock preparation	See JHA for SOP 2, 3, and 4)	See JHA for SOP 2, 3, and 4)	See JHA for SOP 2, 3, and 4)
GC Operation	Compressed Gases GC venting of toxic analytes	Ensure GC exhaust is routed to laboratory ventilation.	Lab coat, safety glasses, protective gloves

ED_001324_00000378-00015

SOPs

Analysis of Oil Concentration in DCM by UV/Vis Spectrophotometry and Spectrofluorometry

Job Hazard Analysis, Controls, and PPE

Job Step/Operation	Potential Hazards/Risks	Recommended Action/Procedure	PPE Required
Add DCM to crude oil **Syringe use** **Extraction with DCM (shaking and venting)** **Dispense / transfer solutions**	Reagents listed contain materials that are listed as carcinogens or potential for causing cancer, irritants, and are photosensitizers. Potential for illness upon inhalation and / or skin contact (chemical dermatitis, increase probability for sunburn)	Prepare the reagents / standards in a chemical fume hood only. Handle reagents in the smallest quantities possible and do not cross contaminate. DCM – attempt to not 'pour' DCM as the ST is low and tends to spread. Use the sash on a CFH for splash protection where possible. Review OSHA Regulated Substance Awareness for DCM.	Double gloves - Wear normal length nitrile gloves over silvershield gloves to maintain dexterity; Lab coat, safety glasses with side shields, and closed-toe shoes.
Pipetting	See chemical hygiene plan for pipetting recommendations	See chemical hygiene plan for pipetting recommendations	Double nitrile gloves and / or silvershield gloves (where dexterity is not an issue). Lab coat, safety glasses with side shields, and closed-toe shoes.
Operation of Spectrophotometer and Fluorometer	UV light exposure	Ensure all equipment guards are present and operable.	Nitrile gloves Lab coat, safety glasses with side shields, and closed-toe shoes.

SOP

The Baffled Flask Test for Determining Effectiveness of Dispersants

Job Hazard Analysis, Controls, and PPE

Job Step/Operation	Potential Hazards/Risks	Recommended Action/Procedure	PPE Required
Add DCM to crude oil and seawater **Syringe use** **Extraction with DCM (shaking and venting)** **Dispense / transfer solutions**	Reagents listed contain materials that are listed as carcinogens or potential for causing cancer, irritants, and are photosensitizers. Potential for illness upon inhalation and / or skin contact (chemical dermatitis, increase probability for sunburn)	Prepare the reagents / standards in a chemical fume hood only. Handle reagents in the smallest quantities possible and do not cross contaminate. DCM – attempt to not 'pour' DCM as the ST is low and tends to spread. Use the sash on a CFH for splash protection where possible. Review OSHA Regulated Substance Awareness for DCM.	Double gloves - Wear normal length nitrile gloves over silvershield gloves to maintain dexterity; Lab coat, safety glasses with side shields, and closed-toe shoes.
Pipetting	See chemical hygiene plan for pipetting recommendations	See chemical hygiene plan for pipetting recommendations	Double nitrile gloves and / or silvershield gloves (where dexterity is not an issue). Lab coat, safety glasses with side shields, and closed-toe shoes.
Extraction with DCM including shaking and venting	Reagents listed contain materials that are listed as carcinogens or potential for causing cancer, irritants, and are photosensitizers. Potential for illness upon inhalation and / or skin contact	Perform extraction in a chemical fume hood only. Handle reagents in the smallest quantities possible and do not cross contaminate. Use the sash on a CFH for splash protection where possible. This should	Double gloves - Wear normal length nitrile gloves over silvershield gloves to maintain dexterity; Lab coat, safety glasses with side shields, and closed-toe shoes.

ED_001324_00000378-00016

Job Step/Operation	Potential Hazards/Risks	Recommended Action/Procedure	PPE Required
	(chemical dermatitis, increase probability for sunburn)	**ONLY** be done in a CFH.	
Operation of Spectrophotometer or Spectrofluorometer	UV light exposure	Ensure all equipment guards are present and operable.	Nitrile gloves Lab coat, safety glasses with side shields, and closed-toe shoes.
Use of the shaker	Spills, mechanical issues with equipment	Ensure all equipment guards are present and operable. Ensure a periodic inspection of equipment.	Nitrile gloves Lab coat, safety glasses with side shields, and closed-toe shoes.

SOP - Natural Substrate Protocol
Job Hazard Analysis, Controls, and PPE

Job Step/Operation	Potential Hazards/Risks	Recommended Action/Procedure	PPE Required
Acid wash of the substrate	burns from acid contact from spills, splashes from bath	Conduct in chemical fume hood	Double nitrile gloves - Wear normal length nitrile gloves inside of elbow length nitrile gloves; Wear a face shield / chemical splash goggles.
Addition of crude oil	Reagents listed contain materials that are listed as carcinogens or potential for causing cancer, irritants, and are photosensitizers. Potential for illness upon inhalation and / or skin contact (chemical dermatitis, increase probability for sunburn) – see chemical hygiene plan for pipetting recommendations	Prepare the reagents / standards in a chemical fume hood only. Handle reagents in the smallest quantities possible and do not cross contaminate. Use the sash on a CFH for splash protection where possible. – see chemical hygiene plan for pipetting recommendations. Review OSHA Regulated Substance Awareness information below for DCM.	Double gloves - Wear normal length nitrile gloves over silvershield gloves to maintain dexterity; Lab coat, safety glasses with side shields, and closed-toe shoes.
Use of the shaker	skin chemical contact from splash or spill - eye chemical contact inhalation of chemicals contact injury with moving/rotating machinery	Work in a chemical fume hood when preparing reagents. Ensure all caps are tightly sealed. Ensure area is clear before starting shaker. Secure loose fitting clothing to prevent snagging by shaker.	Laboratory coat, and nitrile gloves; wear chemical splash goggles
DCM extraction	Reagents listed contain materials that are listed as carcinogens or potential for causing cancer, irritants, and are photosensitizers. Potential for illness upon inhalation and / or skin contact (chemical dermatitis, increase probability for sunburn)	Perform extraction in a chemical fume hood only. Handle reagents in the smallest quantities possible and do not to not cross contaminate. Use the sash on a CFH for splash protection where possible. This should **ONLY** be done in a CFH.	Double gloves - Wear normal length nitrile gloves over silvershield gloves to maintain dexterity; Lab coat, safety glasses with side shields, and closed-toe shoes.
UV spectrophotometry	eye chemical contact inhalation of chemicals skin chemical contact from splash or spill	Work in a chemical fume hood when handling reagents with respiratory warnings Handle quartz cuvet with secure grip to prevent dropping or breaking	wear a laboratory coat, and nitrile gloves; wear chemical splash goggles

ED_001324_00000378-00017

Methylene Chloride / Dichloromethane

Per OSHA regulation 29 CFR 1910.1052, an employer shall provide information and training for each affected employee prior to or at the time of initial assignment to a job involving potential exposure to methylene chloride. Through the use of laboratory fume hoods and procedures outlined in the laboratory chemical hygiene plan and the project health and safety plan, exposure above the regulatory action level is not expected. A full copy of the regulation is available on the OSHA website at www.OSHA.gov or through the SHEM Office. Other information on the safe use of methylene chloride is also available from the SHEM office and OSHA website.

DICHLOROMETHANE	ICSC: 0058
Methylene chloride DCM CH_2Cl_2 Molecular mass: 84.9 ICSC # 0058	CAS # 75-09-2 RTECS # PA8050000 UN # 1593 EC # 602-004-00-3 December 04, 2000 Validated

TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/ SYMPTOMS	PREVENTION	FIRST AID/ FIRE FIGHTING
FIRE	Combustible under specific conditions. Gives off irritating or toxic fumes (or gases) in a fire.		In case of fire in the surroundings: use appropriate extinguishing media.
EXPLOSION	Risk of fire and explosion (see Chemical Dangers).	Prevent build-up of electrostatic charges (e.g., by grounding).	In case of fire: keep drums, etc., cool by spraying with water.
EXPOSURE		PREVENT GENERATION OF MISTS! STRICT HYGIENE!	
• **INHALATION**	Dizziness. Drowsiness. Headache. Nausea. Weakness. Unconsciousness. Death.	Ventilation, local exhaust, or breathing protection.	Fresh air, rest. Artificial respiration may be needed. Refer for medical attention.

ED_001324_00000378-00018

•SKIN	Dry skin. Redness. Burning sensation.	Protective gloves. Protective clothing.	Remove contaminated clothes. Rinse and then wash skin with water and soap.
•EYES	Redness. Pain. Severe deep burns.	Safety goggles , face shield or eye protection in combination with breathing protection.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
•INGESTION	Abdominal pain. (Further see Inhalation).	Do not eat, drink, or smoke during work. Wash hands before eating.	Rinse mouth. Do NOT induce vomiting. Give plenty of water to drink. Rest.

SPILLAGE DISPOSAL	STORAGE	PACKAGING & LABELLING
Personal protection: filter respirator for organic gases and vapours. Do NOT let this chemical enter the environment. Ventilation. Collect leaking and spilled liquid in sealable containers as far as possible. Absorb remaining liquid in sand or inert absorbent and remove to safe place.	Separated from metals (see Chemical Dangers), food and feedstuffs . Cool. Ventilation along the floor.	Do not transport with food and feedstuffs. Xn symbol R: 40 S: (2-)23-24/25-36/37 UN Hazard Class: 6.1 UN Packing Group: III

I M P O R T A	**PHYSICAL STATE; APPEARANCE:** COLOURLESS LIQUID , WITH CHARACTERISTIC ODOUR. **PHYSICAL DANGERS:** The vapour is heavier than air. As a result of flow, agitation, etc., electrostatic charges can be generated. **CHEMICAL DANGERS:** On contact with hot surfaces or flames this substance decomposes forming toxic and corrosive fumes. Reacts violently with metals such as aluminium powder and magnesium powder, strong bases and strong oxidants causing fire and explosion hazard. Attacks some forms of	**ROUTES OF EXPOSURE:** The substance can be absorbed into the body by inhalation and by ingestion. **INHALATION RISK:** A harmful contamination of the air can be reached very quickly on evaporation of this substance at 20°C. **EFFECTS OF SHORT-TERM EXPOSURE:** The substance is irritating to the eyes , the skin and the respiratory tract . Exposure could cause lowering of consciousness. Exposure could cause the formation of methaemoglobin.

ED_001324_00000378-00019

N T D A T A	plastic rubber and coatings. **OCCUPATIONAL EXPOSURE LIMITS:** TLV: 50 ppm as TWA; A3 (confirmed animal carcinogen with unknown relevance to humans); BEI issued; (ACGIH 2004). MAK: Carcinogen category: 3A; (DFG 2004). OSHA PEL: 1910.1052 TWA 25 ppm ST 125 ppm NIOSH REL: Ca See Appendix A NIOSH IDLH: Ca 2300 ppm See: 75092	**EFFECTS OF LONG-TERM OR REPEATED EXPOSURE:** Repeated or prolonged contact with skin may cause dermatitis. The substance may have effects on the central nervous system and liver . This substance is possibly carcinogenic to humans.
PHYSICAL PROPERTIES	Boiling point: 40°C Melting point: -95.1°C Relative density (water = 1): 1.3 Solubility in water, g/100 ml at 20°C: 1.3 Vapour pressure, kPa at 20°C: 47.4	Relative vapour density (air = 1): 2.9 Relative density of the vapour/air-mixture at 20°C (air = 1): 1.9 Auto-ignition temperature: 556°C Explosive limits, vol% in air: 12-25 Octanol/water partition coefficient as log Pow: 1.25
ENVIRONMENTAL DATA	This substance may be hazardous in the environment; special attention should be given to ground water contamination.	

NOTES

Addition of small amounts of a flammable substance or an increase in the oxygen content of the air strongly enhances combustibility. Depending on the degree of exposure, periodic medical examination is suggested. The odour warning when the exposure limit value is exceeded is insufficient. Do NOT use in the vicinity of a fire or a hot surface, or during welding. R30 is a trade name. Card has been partly updated in April 2005. See section Occupational Exposure Limits.

Transport Emergency Card: TEC (R)-61S1593

NFPA Code: H2; F1; R0;

ADDITIONAL INFORMATION

ED_001324_00000378-00020

IMPORTANT LEGAL NOTICE:	Neither NIOSH, the CEC or the IPCS nor any person acting on behalf of NIOSH, the CEC or the IPCS is responsible for the use which might be made of this information. This card contains the collective views of the IPCS Peer Review Committee and may not reflect in all cases all the detailed requirements included in national legislation on the subject. The user should verify compliance of the cards with the relevant legislation in the country of use. The only modifications made to produce the U.S. version is inclusion of the OSHA PELs, NIOSH RELs and NIOSH IDLH values.

ED_001324_00000378-00021

To: Holder, Edith[holder.edith@epa.gov]
Cc: Conmy, Robyn[Conmy.Robyn@epa.gov]; Venkatapathy, Raghuraman[Venkatapathy.Raghuraman@epa.gov]; Schubauer-Berigan, Joseph[Schubauer-Berigan.Joseph@epa.gov]; Meghan Welch[meghan.welch@ptsied.com]
From: Musson, Steve
Sent: Wed 5/20/2015 8:24:30 PM
Subject: RE: HASP Annual Review Due

Thanks Edie,

I will keep looking too, maybe I can find them online somewhere.

Steve

From: Holder, Edith
Sent: Tuesday, May 19, 2015 4:02 PM
To: Musson, Steve
Cc: Conmy, Robyn; Venkatapathy, Raghuraman; Schubauer-Berigan, Joseph; Meghan Welch
Subject: RE: HASP Annual Review Due

Here are the records in our lab.

Biodispers and Dispersit SPC 1000 are old dispersants in our lab and are lines 11 and 12 of last year's HASP. The MSDS are not in my current notebook as we are not currently using them, but we will look for them in boxes of old records.

FFT Solution was just received in our lab, and we will follow up with the manufacturer for the SDS.

The SDS has been requested from the manufacturer of EPA Oil Field Solution, but we have not received it. An additional contact will be made.

Edie

Edith Holder

Pegasus Technical Services, Inc.

On-Site Contractor to the U.S. EPA

ORD/NRMRL/LRPCD

26 W. Martin Luther King Dr.

Cincinnati, OH 45268

Phone: 513-569-7178

Email: holder.edith@epa.gov

From: Musson, Steve
Sent: Tuesday, May 19, 2015 10:41 AM
To: Holder, Edith
Cc: Conmy, Robyn; Venkatapathy, Raghuraman; Schubauer-Berigan, Joseph
Subject: RE: HASP Annual Review Due

Hi Edie,

There were many new dispersants. I appreciate you taking the time to add them to the HASP. I want to stress that the lab is not allowed to receive any new chemicals until the HASP is revised before they are received. Otherwise EPA and Pegasus are not meeting OSHA regulations for Hazcom.

I tried to find as many MSDS/SDS online that I could for the dispersants/SWAs. But I have highlighted several that we do not have a MSDS/SDS on file and I could not find online. Please provide a copy of those. Once we get those we will be able to route the HASP. Until then, no

work is allowed using these highlighted items.

Steve

From: Holder, Edith
Sent: Thursday, May 14, 2015 2:36 PM
To: Musson, Steve
Cc: Conmy, Robyn
Subject: RE: HASP Annual Review Due

Steve,

Enclosed is a revised HASP. During the last year we have received more oils, dispersants, and SWA. Those products have been added in tables by category at the end of the chemical list. There are no other changes.

Edie

Edith Holder

Pegasus Technical Services, Inc.

On-Site Contractor to the U.S. EPA

ORD/NRMRL/LRPCD

26 W. Martin Luther King Dr.

Cincinnati, OH 45268

Phone: 513-569-7178

Email: holder.edith@epa.gov

From: Musson, Steve
Sent: Wednesday, May 13, 2015 10:09 AM
To: DelaCruz, Armah; Nadagouda, Mallikarjuna; Schaefer, Frank; Silvestri, Erin; Pressman, Jonathan; Wahman, David; Feldhake, David; quintero.maria@azdeq.gov; Shanks, Orin; Kelty, Catherine; Shoemaker, Jody; Varma, Rajender; Donohue, Maura; Pfaller, Stacy; Jewett, David; Hargrove, Kristie; Al-Abed, Souhail; Pinto, Patricio; Brooks, Michael; Wood, Lynn; Conmy, Robyn; Holder, Edith; Zaffiro, Alan; Batt, Angela; See, Mary Jean
Subject: HASP Annual Review Due

Everyone,

You are getting this email because your HASP is due for its annual review in May or June.

One of the staff listed below for each HASP, please take a moment to review the HASP and respond to this email by either:

1. State "The HASP is current and no changes need to be made"
2. State "The HASP is no longer necessary, please inactivate it"
3. Send the HASP back to me with any changes that need to be made to revise it.

Thanks,

Steve

Stephen Musson, PhD, CIH, CHMM

Safety, Health, and Environmental Management Program Manager

US EPA National Risk Management Research Laboratory

26 W. Martin Luther King Drive

Cincinnati OH 45268

513-569-7969

Division	LRPCD #	ASRD #	Rev #	Title	Date Review Due	Principal Investigator #1	Principal Investigator #2	Principal Investigator #3	Prepared by	Branch	Expiration Date
MCEA	2014-087	ORD	1	Cyanobacteria and their Cyanotoxins	6/16/2015	de la Cruz, Armah A.			de la Cruz, Armah A.	MiERB	3/31/
WSWRD	2014-030	ORD	1	Sulfate and Phosphate Removal using novel synthesized media	6/17/2015	Mohan, Gayathri Ram	Nadagouda,Mallikarjuna		Mohan, Gayathri Ram	IO	3/31/
TCAD	2013-033	ORD	2	Optimization of Bacillus anthracis Spore Recovery from Soil	6/18/2015	Schaefer, Erin	Shrestha, Erin		Feldhake, David	None Chosen	4/30/
WSWRD	2013-045	ORD	2	Chloraminated Drinking Water Distribution System Nitrification	5/15/2015	Pressman, Jonathan	Wahman, David		Quinter, Kalya	TTEB	6/30/
WSWRD	2013-047	ORD	0	Genome Fragment Enrichment	6/30/2015	Shanks, Orin			Kelty, Catherine	MCEB	6/30/
MCEA	2013-062	ORD	0	Measuring Sucralose In Recreational Waters To Identify Human-Based Fecal Pollution: A Pilot Study	6/15/2015	Shoemaker, Jody			Shoemaker, Jody	CERB	3/31/
STD	2014-003		0	Highly Selective Photosynthesis Processes over Visible-Light-Induced Micro- and Nano-structured Photocatalysts	5/29/2015	Baig, Nasir	Varma, Rajender		Baig, Nasir	GPB	1/31/
MCEA	2014-014	ORD	0	General Laboratory Practices Associated with Proteomic Research	5/30/2015	Donohue, Mary	Pfaller, Stacy		Donohue, Mary	MERB	3/31/
GWERD	2014-023	ORD	0	Laboratory 4	5/30/2015	Jewett, David			Hargrove, Kristie	ARTSB	3/30/
LRPCD	2014-		1	Metal Migration from Drinking	6/4/2015	Al-			Pinto, Patricia	WSMB	3/30/

	024		Water Treatment Plant (DWTP) Sludges and Landfill Soils under Different Redox Conditions		Abed,Souhail					
GWERD	20140032		Predicting DNAPL Source Zone and Plume Response Using Site Measured Characteristics	6/30/2015	Brooks,Michael	Wood,Lynn		Wood,Lynn	SRB	6/30/
LRPCD	20140033		Oil Spill Research Including Work with Dispersants, Surface Washing Agents (SWAs), and Oil Degrading Microbes	6/30/2015	Coomy,Robyn			Holder,Emily	ESMB	6/30/
SRMD	20140039		Second Laboratory Demonstration for Microcystins in Drinking Water using Solid-Phase Extraction and Liquid Chromatography/Mass Spectrometry	6/30/2015	Adams,William			Zaffiro,Alan	TSC	6/30/
EERD	20140016		Aquatic Studies Analytical Support using Solid Phase Extraction and Gas Chromatography/Mass Spectrometry	6/30/2015	Batt,Angela			See,Mary Jean	MIRB	6/30/