Sharing Gulf Science Discoveries for Management

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Emily Maung-Douglass, Louisiana Sea Grant
Christine Hale, Texas Sea Grant
Monica Wilson, Florida Sea Grant
Larissa Graham, Mississippi-Alabama Sea Grant

GOMA All-Hands Pre-Meeting Seminar
June 14, 2016
Gulf of Mexico Research Initiative

Management
Administered by Gulf of Mexico Alliance (GOMA)
20-member, independent research board

Gulf State Governors
Alabama, Florida, Louisiana, Mississippi, Texas

Alliance Management Team
Representatives from Gulf States, EPA, NOAA & DOI

Alliance Staff

Alliance Coordination Team

Gulf of Mexico Research Initiative

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Gulf of Mexico Research Initiative

$500 million, 10-year investment

**Goal** - Improve society’s ability to understand, respond to, and mitigate the effects of petroleum pollution and related stressors

**Focus areas:**

1. How do oil and dispersants **move around** the environment?
2. How do oil and dispersants **break down** over time?
3. How do oil and dispersants **impact the environment**?
4. How can **technology** be improved?
5. How do oil spills **impact people**?

Learn more at gulfresearchinitiative.org

gulfseagrant.org/oilspilloutreach
Funded Research to Date = $353.6M

Funding Recipients
• 42 states
• 278 academic institutions
• 18 countries

Funding by Location

- 71% Gulf States
- 26% Other States
- 3% International

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GoMRI Scientific Production

As of June 2016:

• 729 scientific peer-reviewed publications
• 2,869 scientific presentations and posters
• 3,341 people: 1,466 Scientists, 286 Post Docs, >1,000 graduate students

Photo credits from GoMRI website: Markus Huettel, Kim Nightingale

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<table>
<thead>
<tr>
<th>GOMA Priorities and GoMRI Investments</th>
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<tr>
<td><strong>Data and Monitoring</strong></td>
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<tr>
<td>GRIIDC database</td>
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<tr>
<td><strong>Habitat Resources</strong></td>
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<tr>
<td>Habitat (30+ projects)</td>
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<td><strong>Education and Engagement</strong></td>
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<tr>
<td>Stand alone and integrated projects</td>
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<tr>
<td><strong>Water Resources</strong></td>
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<tr>
<td>Dispersant (76 projects)</td>
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<td>Circulation (13 projects)</td>
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<tr>
<td><strong>Coastal Resilience</strong></td>
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<tr>
<td><strong>Wildlife and Fisheries</strong></td>
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<td>Fish (44+ projects)</td>
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</table>

[gulfseagrant.org/oilspilloutreach](gulfseagrant.org/oilspilloutreach)
Sea Grant Programs in our Gulf

Science-based
Non-advocacy
Embedded in and serve coastal communities
Regional team focused on oil spill science

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Why are we here today?

Science to **Application**

- Management
- Decision making
- Response to emergencies
- Response to misinterpretations
How are we making linkages?

Priority Issue Team Actions

8 Oil Spill Related Question and Answers

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What science?

- Peer reviewed
  - Science community
  - Agency reports
- Multiple sources
  - GoMRI
  - Programmatic Damage Assessment and Restoration Plan (PDARP)
  - Other agencies
  - Scientific journals

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Questions to think about

• How could the science presented today be incorporated into GOMA’s Action Plan III?

• How can or will you apply the information shared today in your day-to-day work (outside of GOMA)?

• What are other oil spill related questions or information needs do you have?
Questions to ask

• Questions at the end
• What are remaining science questions that will help you?
  • More outreach publications
  • More seminars
  • New products

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What habitats were impacted and how?

GOMA Action:
- Identify priority Gulf habitats to be assessed

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Coastal Habitats

• Wetlands
• Beaches
• Mangroves
• Corals

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Deepwater Horizon oil spill

1,313 miles of shorelines were oiled

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Oiling by State

1,313 miles of shoreline oiled across the Gulf

- Florida – 177 miles
- Alabama – 95 miles
- Mississippi – 157 miles
- Louisiana – 847 miles
- Texas – 35 miles
Wetland impacts

Coastal wetlands (52%)
Wetland impacts

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Wetland impacts

Oiling of marshes can lead to erosion.
May take up to two years to see impacts.

Bay Batiste/Barataria Bay

Unoiled site

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Oiled site
Wetland impacts

- Canopy chlorophyll content (CHL) – biochemical closely related to productivity and vegetation health
- Aboveground green biomass (GBM) – direct result of productivity
- Found June 2010 to be the worst month
Wetland response/cleanup techniques

Response:
- Mechanical containment
- Dispersant application
- *In-situ* burning
- Booms

Cleanup:
- Natural recovery
- Barriers
- Manual oil removal
- Sorbents
- Vacuuming
- Vegetation cutting
- Shoreline cleaning
- Bioremediation

http://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/resources
1,313 miles of shorelines were oiled

Sandy beaches (46%)

Beach impacts

NOAA ERMA

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Beach impacts

Oil washed onshore and, in some areas, was buried.

Buried oil and washed up surface residual balls and patties

Dunes

Beach

High tide line

Low tide line

Sand bar

Buried oil mats

Mississippi

Alabama

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In the lab:
Artificial tar balls
- 10 cm – buried
- 5 cm – mobile in surf
- <1 cm – hard to recover

Computer models

In the field:
Tar balls would wash up during relaxation phase of storms
(winds 30-50 mph, tides 1-5 ft)

Beach impacts
Beaches response/cleanup techniques

- Remove oil and oil debris
- Manual cleanup
- Focus should be on preventing vehicular and foot traffic from mixing into the sediments
- Mechanical reworking
Mangrove impacts

Effects of oil depends on:
• Oil type
• Elapsed time between spill and its stranding
• Wind and current conditions
• Tidal stage

Impacts:
• Mortality among propagules, seedlings, and juvenile trees
• Weakened state of trees
• Affect species living in the mangroves
Mangrove impacts

Impacts on epibiota (Proffitt, 1997):
• After spill – smothering or toxicity
• Long term – loss of surface area for attachment

Impacts of oil on water transport through mangrove roots (Tansel, 2015):
• Salt water – no drying
• Oil with and without dispersant - drying

Tansel (2015)
Mangrove Response/Cleanup Techniques

Response:
- Mechanical containment
- Dispersant application
- *In-situ* burning

Cleanup:
- Natural recovery
- Barriers/Berms
- Manual oil removal
- Sorbents
- Vacuuming
- Chemical
- Bioremediation

http://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/resources

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Coral impacts

Mesophotic – coral communities found at water depths where light penetration is low
Mesophotic coral impacts

Corals (gorgonian octocorals) experienced quantifiable negative impacts

Healthy in 2011

Injured in 2014

a

b

Swiftia exerta

Hypnogorgia pendula

Placogorgia sp.

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Deep sea coral impacts

Progression of injury to corals near Macondo wellhead

2010: Corals covered by flocculent material, coral tissues slough off

2011: Hydroids colonize corals

2012: Coral branch death

Hsing et al. 2013

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Corals Response/Restoration Techniques

Response:
- Limit physical contact
- Booms and skimmers
- In-situ burning
- Dispersants

Restoration:
- Reef crust should be stabilized
- Coral transplanting
- Natural recovery

http://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/resources

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Management plans
What are some ways that human health is protected during oil spills?

GOMA Action:
- Implement projects to reduce risks to human health associated with either natural hazards or anthropogenic sources
Dispersants and Oil Spills

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Polycyclic Aromatic Hydrocarbons (PAHs)

**Summer 2010**
Significant increases in PAH levels along coast post-DWH

**March 2011**
Return to pre-oiling levels

**Summer 2011**
Possibility of elevated PAH levels after storms and/or near-shore clean up
PAHs and Human Health

PAHs with Benchmarks for Human Health Available

- Naphthalene
- Acenaphthylene
- Fluorene
- Anthracene
- Pyrene


gulfseagrant.org/oilspilloutreach
PAHs and Human Health

PAHs and Human Health

PAHs and Human Health

PAHs and Human Health

Max $\sum_{33}^{PAHs}$ is 10x less than lowest EPA benchmark for single compound


www.gulfseagrant.org/oilspilloutreach
Dispersants

Orange Beach, AL  
Sept 2010 – Jan 2011

- Found chemicals also in dispersant
- Likely due to point and non-point sources, not Corexit.

Hayworth et. al 2012

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DOSS and Human Health

**DOSS**
- Primary agent in Corexit
- Highest level outside of area immediately surrounding well-head (3 km): 1 ppm
- 100x lower than lowest level known to harm to human liver


gulfseagrant.org/oilspilloutreach
Seafood Safety Testing

gulfseagrant.org/oilspilloutreach
# Seafood Safety Testing

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<th>FDA Level of Concern (ppb)</th>
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<td></td>
<td>Before Deepwater Horizon oil spill</td>
<td>After areas were reopened to fishing</td>
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<td><strong>Non-cancer-causing PAHs</strong></td>
<td></td>
<td></td>
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<tr>
<td>Anthracene</td>
<td>1,846,000</td>
<td>0.4</td>
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<td>3.9</td>
</tr>
<tr>
<td>Fluorene</td>
<td>246,000</td>
<td>1.7</td>
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<td>Benzo(k)fluoranthene</td>
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Source: gulfseagrant.org/oilspilloutreach
What oil spill-related stressors impact aquatic life and how?

GOMA Action

- Implement projects to reduce impacts from stressors on aquatic life in Gulf ecosystems
Stressor: Chemical Dispersant
Responses to Chemical Dispersant

**Mysid shrimp**
Slightly toxic (42 ppm)

**Inland silversides**
Practically non-toxic (130 ppm)

**Larvae**
Significant mortality 100 mg/L

**Juveniles**
Significant mortality 1000 mg/L

**Oyster gametes**
LC50 = 2.7 mg/L

Stressor: PAHs

- Benzo(b)fluoranthene
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- Acenaphthylene
- Fluorene
- Chrysene
- Indeno(1,2,3-cd)pyrene
- Benzo(a)pyrene
Responses to PAHs

Aquatic invertebrates

- Poorly developed detoxification system
  - Bioaccumulation in some species

- Unexpected findings
  - Gametes & Larvae
    - Impacts at PPM level
  - Adult oysters
    - No incorporation of oil-based compounds
Responses to PAHs

Higher order animals
  • Ability to metabolize PAHs
  • Genes as biomarkers

Gill filaments
Reference site
Heavily oiled site
Dubansky et al. (2013)
gulfseagrant.org/oilspilloutreach
Response to PAHs?

Sub-lethal impacts

- Increase in skin lesions on offshore marine fish
- Increase in PAHs in locations with lesioned fish
- PAHs found lesioned fish similar to PAHs in DWH oil samples
- Many factors in lesion formation
  - More study is required

Murawski et al. (2014)
gulfseagrant.org/oilspilloutreach
Responses to PAHs

Sub-lethal impacts

- Reduced hatching success
- Reduced swimming ability
- Reduced body size
- Heart complications
- Larval development
- Oxidative stress

Age at exposure matters!

Dubansky et al. (2013); Brweton et al. (2013); Mager et al. (2014); Crowe et al. (2014); Stieglitz et al. (2016); Esbaugh et al. (2016)

gulfseagrant.org/oilspilloutreach
How were species impacted by the spill and how does this link to impacted habitats?

GOMA Action:

- Identify and characterize linkages among focal species and their habitats.
- Compile and synthesize existing information regarding status and trends, threats, and habitat linkages of wildlife and fisheries species to identify key data gaps
Wildlife & Fisheries: sea turtles

Potential Impacts of Oil on Sea Turtles

- Oil on the shoreline can contaminate nesting females, nests, and hatchlings.
- Larger turtles can inhale oil vapors, ingest oil in prey or sediment, and become coated in oil at the surface.
- Winds and currents create ocean fronts, bringing together oil, dispersants and sargassum communities, causing prolonged floating oil exposure.
- Juvenile turtles ingest oil, inhale vapors and become fatally mired and overheated.
- Prey items may also be killed by becoming stuck in heavy oil or by dissolved oil components.
- Sargassum fouled by oil and dispersants can sink, leaving sargassum-dependent animals without food and cover and vulnerable to predators. Dead sea turtles may sink.

Source: NRDA

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Impacts to sea turtles

Total Sea Turtle Injury Quantification

- 35,000 hatchlings
- 55,000 – 160,000 small juveniles
- + 4,900 – 7,600 large juveniles/Adults

94,900 to 202,600 lost turtles

(Includes Kemp’s ridley, loggerhead, green, hawksbill, unidentified)

Source: NRDA

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Wildlife & Fisheries: birds

Total Avian Injury Quantification

51,600 - 84,500 birds (direct result of spill)  
+ 4,600 - 17,900 fledglings (lost reproduction)  

56,100 to 102,400 lost birds  
(93 different bird species)

High mortality

- Brown and white pelicans
- Double-crested cormorants
- Audubon’s shearwaters
- Northern gannets
- Clapper rails

- Black skimmers
- White ibis
- Laughing gulls
- Common loons
- Several species of terns

Source: NRDA


gulfseagrant.org/oilspilloutreach
Wildlife & Fisheries: fish populations

How do oil spills impact many different kinds of living things in an area or habitat?

How do oil spills impact a group of living things of the same species?

How do oil spills impact individual organisms?

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Wildlife & Fisheries: fish populations

Scientists found that population numbers of some fish and shrimp increased after the Deepwater Horizon oil spill.

Fodrie & Heck 2011; van Der Hamm & de Mutsert 2014

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Wildlife & Fisheries: blue crab populations

Blue crab pop. modeling study
• larval dispersal & settlement
• blue crab larvae virtually exposed to DWH oil
• species specific & location specific results useful for managers

Jones et al. 2015

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Wildlife & Fisheries: fish communities

- Fish habitat and fish behavior play a key role in PAH exposure and uptake.

- Golden tilefish experienced higher amounts of PAH, which increased over time (3 years).

- Red snapper and king snake eel displayed episodic PAH exposure.

Snyder et al. 2015

[Website Link: gulfseagrant.org/oilspilloutreach]
Do lab results scale up to the wild, and do they inform the population or community-level impact estimates?

GOMA Action:

- Prioritize research and monitoring needs based on proven methods and identified key data gaps.
- Utilize data and information to inform management practices and priorities that support conservation needs.
Wildlife & Fisheries: fish populations

ORGANISMS: 14 published studies (mostly lab); 9 species; genomic, physiological, developmental, reproductive, or survival costs in **95%** of cases

POPULATIONS: 1 published study; >50 species; stable (or increasing) populations (**100%** of cases)

Fodrie et al. 2014

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Wildlife & Fisheries

Organism to population: oil impact disconnect

Why?

- Lab-tested oil concen. too low for detection by fishes in nature
- Lagged or sublethal impacts do not determine fitness
- Species tested in the lab may not be representative
- Behavioral avoidance (spatial/dietary)
- High spatial & temporal variation in populations

Challenges

- Emigration & immigration after oiling
- Fishery closures obscure population declines
- Offsetting effects cascade through food webs
- Lagged/sublethal effects
- Other confounding environmental factors

Fodrie et al. 2014

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Wildlife & fisheries

More oil spill science & management info available

- Red snapper – diet shift connected to spill
- Dolphins – oiled habitats linked to unusual mortality event
- Plankton – spill linked to die-off and marine snow event
- New indicator species & methods for monitoring
- ...and more...come talk to us!

gulfseagrant.org/oilspilloutreach
What human communities were impacted by the spill and how?

GOMA Action:

- Assess the gaps to quantify and reduce risks within the natural, built, socioeconomic, and human health systems of Gulf Coast communities

[Link to Gulf Coast outreach information]
Impacts across the Gulf

Highly-impacted areas were identified based upon individual and business BP claims data\(^1\) and oil sample data from geographic points along the Gulf Coast.\(^2\)

Gulf Coast Population Impact Study
Children’s Health after the Oil Spill: A Four-State Study (2013)

\(^1\)Data obtained from the Gulf Coast Claims Facility (GCCF) & the
\(^2\)National Oceanic and Atmospheric Administration (NOAA)
Impacts to coastal communities

Those whose work, leisure, or family life was disrupted by the spill suffered from anxiety, depression, and negative mental health.

In Mississippi, some coastal residents experienced a worsened financial situation, social relationships, or physical health and more mentally unhealthy days compared to residents in the rest of the state.

In Louisiana, the oil spill disrupted the work, school, and social life of some coastal residents, which resulted in symptoms of anxiety, depression, and posttraumatic stress.

In Alabama, some coastal residents felt stress, anxiety, and depression and had more mentally unhealthy days compared to residents in the rest of state. Residents were also worried about air quality, safe seafood and their income or economic future.

In Florida, some coastal residents felt anxious and depressed especially if they experienced income loss from the spill. These feelings were observed even in areas where oil did not reach the shore.
Impacts to industries

Those that relied on jobs connected to the Gulf suffered more than others.

Impacts to industries

Fishing industry was hit harder than other industries.

“I’m not sure what to do right now... [In the past], things will always seem like they pop up .... But [this time]...I see it coming to an end really, really fast here. And...I’m just...really kind of scared. I mean, it costs a lot of money to live...” – Study participant (Cherry 2015)

Faced with:

- Closed waters
- Public perception
- Long-term uncertainty

Impacts to industries

Mobile County residents were twice as likely to have levels of severe stress a year after the spill.

**Mobile County**
- Higher concern for economic future
- Greater uncertainty for economic future of fishing industry
- Less education, lower income, lived in area longer

**Baldwin County**
- Higher level of exposure and reported more losses
- Appearance of restored tourism industry

Gill et al 2011, Gill et al 2014
Impacts to children

More than half of parents reported that their children were impacted by the spill.

Proportion of Children Exposed to Oil Spill and Reported Health Effects

Abramson et al 2013
What traits made communities more resilient?

GOMA Action:

- Assess the gaps to quantify and reduce risks within the natural, built, socioeconomic, and human health systems of Gulf Coast communities

[Website Link] gulfseagrant.org/oilspilloutreach
Community attachment

How attached community members are to one another and to the place where they live.

**Pro** – Provides a strong and caring network is in place which can help with recovery.

**Con** - Might not be willing to move somewhere else in order to make a new living; Fear the loss of their community.

Lee 2012, Cope 2013

gulfseagrant.org/oilspilloutreach
Communi ty attachment

Residents with high attachment

Feeling angry, worried, anxious, depressed, sad, nervous, afraid

Recovering better than others that were not attached to community

Right after spill

One year after spill

Their strong community networks and close personal relationships helped them overcome the disaster.

Lee 2012, Cope 2013

gulfseagrant.org/oilspilloutreach
Residents with high attachment,
in the fishing industry

Feeling angry, worried, anxious, depressed, sad, nervous, afraid

Still suffering, with some conditions worsening

Still facing hardships; Attachment made them less likely to want to leave home and pursue another livelihood. Social network contributes to a cycle of negative outlooks and stress.

Lee 2012, Cope 2013
Surviving past disasters

Scientists suggest that past disasters have taught these residents to adapt and cope with hard times.

“With Katrina, we knew what to do. We needed to rebuild. With the oil spill, we don’t know how long the recovery will take or if we will be able to recover.”
– Study participant (Osofsky 2011)

- Residents who suffered during Katrina:
  - Were more vulnerable to the effects of the oil spill
  - Rebounded faster from impacts
  - Viewed themselves as resilient

Osofsky et al 2015, Shenesey & Langhinrichsen-Rohling 2014
Scientists suggest that other factors also help residents to adapt and cope with hard times.

<table>
<thead>
<tr>
<th>Positive impact:</th>
<th>Negative impact:</th>
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<tr>
<td>• Meaning of life or the belief that they are living their life in a way that stays true to their core values</td>
<td>• Low income</td>
</tr>
<tr>
<td>• Community attachment</td>
<td>• Below the poverty line</td>
</tr>
<tr>
<td>• Living through past disasters</td>
<td>• Less social support</td>
</tr>
<tr>
<td>• Viewed themselves as resilient</td>
<td>• Community attachment</td>
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Shenesey & Langhinrichsen-Rohling 2014; Aiena et al 2015; Cherry et al 2015

gulfseagrant.org/oilspilloutreach
What resources are in place for the next oil disaster?

GOMA Action:

- Assess the gaps to quantify and reduce risks within the natural, built, socioeconomic, and human health systems of Gulf Coast communities
Building health infrastructure

Gulf Region Health Outreach Program

http://www.grhop.org/

Primary Care Capacity Project ($46.7 mil)
Expanding access to community-based primary care in 17 Gulf Coast counties and parishes

Mental and Behavioral Health Capacity Project ($36 mil)
Provide mental and behavioral health care and longer-term capacity-building resources to targeted communities
Training community members

Community Health Workers Training Project
Prepares individuals to:
• Bridge gaps between communities and service agencies
• Providing culturally appropriate health education
• Advocating on behalf of individuals and communities

Continuing Medical Education Credits
• Risks and Benefits of Seafood Consumption
• Airborne Exposures and Health Effects
• Reproductive Health Effects Dispersant Exposures and Health Effects

Peer listening
Training sessions provided to community members after Deepwater Horizon oil spill

Peer Listener Training Manual
Gulf of Mexico Edition

Sea Grant

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Monitoring health impacts

Deepwater Horizon Research Consortia

- The Women and Their Children's Health Study (WATCH) – LSU
- Gulf Resilience on Women's Health (GROWH) – Tulane
- Health Impact of Deepwater Horizon Spill in Eastern Gulf Coast Communities – Univ of FL
- Gulf Coast Health Alliance: Health Risks Related to the Macondo Spill (GC-HARMS) – Univ of TX Medical Branch

Gulf Long Term Follow-Up Study
A study of health of clean-up workers and volunteers who responded to the 2010 Deepwater Horizon oil spill

Association of Occupational and Environmental Clinics
Referral program for people who are suffering from exposure to the Deepwater Horizon oil spill

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Resources
Oil spill science outreach products

Visit us on the Web or sign up for our email updates.

gulfseagrant.org/oilspilloutreach
GoMRI news updates

gulfresearchinitiative.org/news-and-events/

GoMRI eNews

Study Reveals Oil Spill Changed Oxygen Conditions in Gulf Sediment
A team of scientists from Eckerd College and University of South Florida conducted a time-series sediment study to better understand impacts from the Deepwater Horizon oil spill.

Smithsonian Highlights Five Gulf Discoveries from Oil Spill Research
An exciting aspect of scientific research is unexpected discovery. While investigating impacts from the Deepwater Horizon oil spill, scientists made unanticipated, yet fundamentally important, discoveries that shape our understanding of ocean science and Gulf ecosystems.
GoMRI publications

research.gulfresearchinitiative.org
GRIIDC data

Gulf Research Initiative Info & Data Cooperative

data.gulfresearchinitiative.org

gulfseagrant.org/oilspilloutreach
GRIIDC data: Water quality

gulfseagrant.org/oilspilloutreach
Tools & data

DIVER - https://dwhdiver.orr.noaa.gov
Data Integration Visualization Exploration and Reporting

ERMA - https://gomex.erna.noaa.gov
Environmental Response Management Application

GCOOS - http://data.gcoos.org/
Gulf of Mexico Coastal Ocean Observing System

gulfseagrant.org/oilspilloutreach
Educational resources

GoMRI documentary & clips
http://www.screenscope.com/

Smithsonian Ocean Portal
ocean.si.edu/gulf-oil-spill-interactive

GoMRI educational resources
education.gulfresearchinitiative.org

AND MORE ...

gulfseagrant.org/oilspilloutreach
Gulf of Mexico Oil Spill & Ecosystem Science Conference 2017

February 6-9, 2017
Hyatt Regency Hotel, New Orleans, LA
Questions?

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Questions in Breakout Session

• How could the science presented today be incorporated into GOMA’s Action Plan III?

• How can or will you apply the information shared today in your day-to-day work (outside of GOMA)?

• What are other oil spill related questions or information needs do you have?