Immediate and Long-term Impacts of the Deepwater Horizon Oil Spill on Bottlenose Dolphins in Barataria Bay, Louisiana

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31 Bay, Sound & Estuary (BSE) Tursiops truncatus Stocks

- Delineated in early 1990’s
- Based on studies in Sarasota Bay & Texas bays showing long-term, year-round site fidelity
- Infer isolated, resident populations in BSEs throughout the Gulf

Focus on Barataria Bay

Barataria Bay, Louisiana
Routes of Exposure

- **Vapors / VOCs / Aerosols**
- **Liquid Oil/Droplets**
- **Oil on surface, water column**

**Incidental from water, sediments**

**Contaminated prey**

**Inhalation**

**Ingestion**

**Dermal, ocular contact**
Susceptibility of the Dolphin Respiratory System to Inhaled Chemical Contaminants

Straight, rapid intake of surrounding > 10L air directly to lungs without protective cilia or nasal turbinates

Exchange 90% of deep lung air with every breath & extended breath hold

Double layer capillary beds to enable efficient movement of airborne compounds into blood

Approaches for Injury Assessment

**Live Dolphin Health Assessments**
- Physical exams
- Blood panels
- Ultrasound
- Pregnancy assessment
- Fecal and blowhole
- Weight & length
- Tooth aging
- Infectious diagnostics

**Observational Studies & Remote Biopsy Sampling**
- Genetics
- Hormones (pregnancy)
- Persistent contaminants (POPs)
- Survival rates
- Reproductive outcomes

**Stranded Dolphins & Dead Dolphin Tissue Evaluations**
- Demographics
- Weight & length
- Gross observations
- Full histology set (tissues)
- Infectious & biotoxin diagnostics
Injury Assessment Findings

Moderate-Severe Lung Disease

Impaired Stress Response / Adrenal Injury

Increased Mortality Rates

Low Reproductive Success Rates

Prevalence of Low Cortisol

LIVE ANIMALS

DEAD ANIMALS
Pulmonary Ultrasound

- Conducted during live dolphin health assessments
- 91 exams performed in Barataria Bay, LA
  - 29 in 2011
  - 30 in 2013
  - 32 in 2014
- 27 exams included from Sarasota Bay, FL as a reference

NMFS Permit Nos. 932-1905/MA-009526 (Barataria Bay); 522-1785 and 15543 (Sarasota Bay)
Findings: Lung Injury

- Live dolphins within oil spill footprint **5 times more likely** to have moderate to severe lung disease as compared to reference site.
- Primary **bacterial pneumonia** determined from dead dolphin necropsies (aspiration pneumonia common after-effect following hydrocarbon inhalation/ingestion in people).
- Over time since spill (2013-2014), shift toward more **chronic lung disease states**.
Case Example Y12: Severe Pulmonary Disease
Case Example Y12: Severe Pulmonary Disease

Baratara Bay Y12, August 2011

Y12, December 2011
Injury Assessment Findings

- Moderate-Severe Lung Disease
- Impaired Stress Response / Adrenal Injury
  - Prevalence of Low Cortisol
- Increased Mortality Rates
- Low Reproductive Success Rates

**LIVE ANIMALS**
- Ultrasound

**DEAD ANIMALS**
- Ultrasound
- Histopath
- Necropsy; LDWF
- Necropsy
Hypothalamus-adrenal-pituitary (HPA) axis injury

• Low concentrations of adrenal hormones (cortisol, aldosterone) in live dolphins
• Thin adrenal cortices in dead dolphins
• Both support adrenal insufficiency, consistent with experimental oil exposure studies

Injury Assessment Findings

- **LIVE ANIMALS**
  - Moderate-Severe Lung Disease
  - Ultrasound

- **DEAD ANIMALS**
  - Impaired Stress Response / Adrenal Injury
  - Histopath

- **Increased Mortality Rates**
  - Necropsy; LDWF

- **Low Reproductive Success Rates**
  - Ultrasound
  - Necropsy
Decreased Survival Rates

Low annual survival rates following DWH oil spill compared to prior studies using similar methods

Barataria Bay 2010-2013
~80-85%
(McDonald et al., submitted ESR)

Charleston Estuary
95.1%
Speakman et al. 2010

Sarasota Bay
96.2%
Wells & Scott 1990
Injury Assessment Findings

- **Moderate-Severe Lung Disease**
- **Impaired Stress Response / Adrenal Injury**
  - Prevalence of Low Cortisol
  - Increased Mortality Rates
- **Low Reproductive Success Rates**

**Live Animals**
- Ultrasound

**Dead Animals**
- Histopath
- Necropsy; LDWF
Low Reproductive Success Rates

Barataria Bay & Mississippi Sound
19% success rate

Sarasota Bay
83% success rate
Wells et al. 2014

Combined baseline
65% success rate

Lane et al. 2015, Proc Royal Soc; Kellar et al., Endangered Species Research, in press; DWH MMIQT 2015
Quantifying the Impact to Stocks

- Dolphins are long-lived, slow maturating (~8 yrs)
- Difficult to recover from loss of reproductive adults
- Just counting dead individuals does not fully describe impact to stock

Injuries were quantified using a population model that allows for consideration of long-term impacts to populations resulting from individual losses, and allows incorporation of reproductive effects and chronic health effects that slow population recovery.
Population Model Approach for Quantification

Baseline demographic parameters

Estimated pre-spill population size

Baseline population dynamics model

Injury: reduced survival, reduced fecundity

Injured population dynamics model

Number of years for population to recover within 95% of baseline trajectory

Lost cetacean years (shaded area)

Largest proportional decrease
Barataria Bay Population Model Predictions

- Predicts population will not return to positive growth until ~9 years post-spill
- At lowest point in injured trajectory (~9 yrs), proportional decrease from baseline trajectory is 0.51
- It will take nearly 40 years for the Barataria Bay stock to recover to its baseline trajectory

Figure: Schwacke et al. in press, ESR
Summary of Findings

• Significant health issues in dolphins from heavily oiled Barataria Bay immediately following DWH spill
  • Consistent with findings from other oil exposure studies, but the first documented oil-related health effects in cetaceans

• Low survival observed for at least 3 years following the spill; low reproductive success observed for at least 4 years following the spill

• Later sampling of Barataria Bay dolphins (2013-2014) revealed some improvement, but chronic health conditions (lung, HPA-axis) persist

• Stock will likely take decades to recover to baseline
Lingering Questions

• What are the underlying mechanisms for the reproductive failure and will the issue(s) resolve?
  • Ongoing Gulf of Mexico Research Initiative Project (GoMRI V)
  • Continued health assessment studies to understand mechanisms of reproductive failure and document recovery
  • Using Navy dolphin population to develop new diagnostic techniques and investigate adverse outcome pathways

• What will be the effects on dolphins associated with broader ecosystem impacts/changes from the spill? What will be the impact of ecosystem restoration efforts?

• What will be the effects on the Barataria Bay ecosystem from the decline of an apex predator?
This work was part of the DWH NRDA being conducted cooperatively among NOAA, other federal and state Trustees, and BP PLC.

The findings and conclusions in this paper are those of the authors and do not necessarily represent the view of NOAA or of any other natural resource Trustee for the BP/Deepwater Horizon NRDA.

For more information, please refer to: Deepwater Horizon Natural Resource Damage Assessment Trustees (2016) Deepwater Horizon oil spill: Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement. 
http://www.gulfspillrestoration.noaa.gov/restoration-planning/gulf-plan
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Georgia Aquarium

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Deepwater Horizon Oil Spill

April 2010

May 2010
Under the Oil Pollution Act, the purpose of a **Natural Resource Damage Assessment (NRDA)** is to determine type and amount of restoration needed to compensate the public for injuries to and lost use of their natural resources.
Low Reproductive Success Rates

Perinatal Deaths: Most died in the womb or very soon after birth (did not take a full breath)

- Barataria Bay & Mississippi Sound: 19% success rate
- Sarasota Bay: 83% success rate
- Combined baseline: 65% success rate

(Colegrove et al., Dis Aquat Org, 2016)

Lane et al. 2015, Proc Royal Soc; Kellar et al., Endangered Species Research, in press; DWH MMIQT 2015