Seasons in the Field:

Reflections from a Career Studying the Consequences of Catastrophe


U.S. Geological Survey


New York Times

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My Standard Disclaimer…

The views, opinions, alternative facts, and blatant lies portrayed herein, are those of the author and do not necessarily reflect the views of the National Oceanic and Atmospheric Administration or the U.S. Department of Commerce. And certainly no one higher up the food chain. #plausibledeniability #fakenews

New Carissa, 1999

Cosco Busan, 2007

Whatcom Creek pipeline, 1999

Bayou Perot, 2007

Mosier derailment, 2016

Selendang Ayu, 2004


Alaska Flight 261, 2000

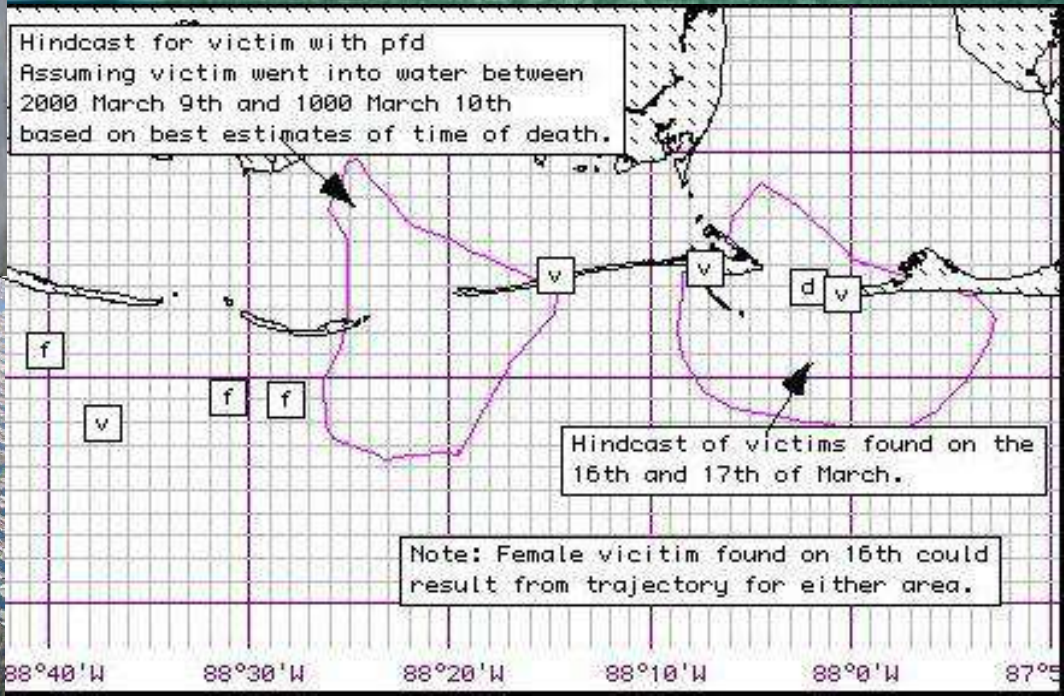

Japan tsunami debris, 2014


Powell Duffryn tank storage facility, 1995


Chevron Empire, 2005


Atlantic right whale carcass, 2007


Murphy Oil, 2005



1989…

2010…

Photo: USCG, Stephen Lehmann

Thoughts & Lessons…

…from Post-Incident Monitoring of/Research on Major U.S. Spills

- *Incident overviews*
- *Spill-response-focused monitoring*
- *Impact assessment monitoring*
- *Broader lessons learned*
- *Closing thoughts and apologies*

Torrey Canyon – March 1967

Recolonization of Rocky Shores in Cornwall After Use of Toxic Dispersants to Clean Up the *Torrey Canyon* Spill[1]

A. J. SOUTHWARD AND EVE C. SOUTHWARD

Marine Biological Association, Citadel Hill, Plymouth, U.K.

SOUTHWARD, A. J., AND E. C. SOUTHWARD. 1978. Recolonization of rocky shores in Cornwall after use of toxic dispersants to clean up the *Torrey Canyon* spill. J. Fish. Res. Board Can. 35: 682–706.

Fourteen thousand tons of Kuwait crude oil, reduced from 18 000 tons by weathering at sea, was stranded along 150 km of the coast of West Cornwall, England, in March 1967. The oil was treated with 10 000 tons of toxic dispersants during cleaning operations. By itself the oil was not very toxic, although it killed some limpets and barnacles, and most of the mortalities that followed cleaning were due to the dispersants. There was a graded effect. Most animals and some algae were killed on the shores treated heavily with dispersants, while a few animals and most algae survived in places less heavily treated. However, long stretches of coast were contaminated to some extent by drifting of patches of oil and dispersants along the shore and by indiscriminate dispersant use in remote coves. The general sequence of recolonization was similar to that which has been found after small-scale experiments, where the rocks were scraped clean, or where limpets were removed, but took longer to complete. There was first a rapid "greening" by the alga *Enteromorpha*; then a heavy settlement and growth of perennial brown algae (*Fucus* species), leading to loss of surviving barnacles. A settlement of limpets and other grazing animals followed, with eventual removal or loss of the brown algae. The final phases were a reduction in the limpet population and a resettlement of barnacles. Lightly oiled, wave-beaten rocks that received light dispersant treatment showed the most complete return to normal, taking about 5–8 yr; heavily oiled places that received repeated application of dispersants have taken 9–10 yr and may not be completely normal yet. Most common species returned within 10 yr, but one rare hermit crab is still missing from places directly treated with dispersants. The early recolonization by algae resulted in a raising of the upper limit of *Laminaria digitata* and *Himanthalia elongata* by as much as 2 m in wave-beaten places, demonstrating that grazing pressure by limpets must be one of the factors controlling the zonation of these plants. Later, other species of plants and animals were found higher up the shore than usual, under the shade and shelter provided by the dense canopy of *Fucus*. Fluctuations in the populations of algae and herbivorous animals during the course of the recolonization illustrate the importance of biological interactions in controlling the structure of intertidal communities. Pollution disturbance affects the herbivores more than plants, hence the point of stability of the community is shifted towards the sheltered shore condition of low species richness and greater biomass.

Key words: petroleum, dispersant, rocky shore, *Torrey Canyon*, recolonization, coastal ecology, pollution

Fifty years after the wreck of the *Torrey Canyon*

The work of the Marine Biological Association of the UK on acute impacts and subsequent recovery

The *Torrey Canyon* was wrecked on 18th March 1967 on the Pollard Rock of the Seven Stones reef, 15 miles (25 km) from Land's End, Cornwall, UK (Figure 1). The 970 foot (300 m) tanker was bound for oil refineries at Milford Haven with 117,000 tons of Kuwait crude oil. She struck the rocks at 17 knots, tearing open six of her 18 storage tanks and less severely damaging the others. Salvage attempts failed. The ship progressively broke up over the next six weeks due to storm damage and bombing on the 28th, 29th and 30th March in an attempt to burn up the oil. She finished a submerged, broken wreck, being officially declared to contain no more oil towards the end of April 1967.

At the time, the *Torrey Canyon* oil spill attracted much media attention and political intervention. The Prime Minister at the time, Harold Wilson, took a personal interest. He had a holiday home on the Isles of Scilly, seven miles to the southwest of the wreck. It was also the first spill involving the first generation of super-tankers. Furthermore, it was treated – excessively in many instances – by the first generation of dispersants. These were in effect industrial cleaning agents – euphemistically called detergents at the time (e.g. Smith 1968). More damage was done by the dispersant applied (10,000 tons) than by the oil itself (14,000 tons) that came ashore in west Cornwall.

All the staff of the Marine Biological Association of the UK (MBA) were mobilised to deal with the environmental impacts of the spill for six weeks (Smith 1968). The MBA's research vessel *Sarsia* was on the scene within a week or so after the wreck. MBA staff members Alan and Eve Southward were subsequently involved in long-term studies of recovery of rocky shores for the next ten years or so (Southward 1979, Southward and Southward 1978), continued in concert with Steve Hawkins since 1980 at one of the worst affected shores – Porthleven (Hawkins et al. 1983, Hawkins et al. 2002, Hawkins and Southward 1992, Hawkins et al. in press, in prep.) and more recently (since 2002) with Nova Mieszkowska.

A network of shores had been studied in the southwest of England for over a decade before the spill (Southward 1967), primarily to understand the influence of climatic fluctuations on intertidal species, particularly barnacles (Southward and Crisp 1954, 1956). These observations were subsequently maintained by the Southwards (e.g. Southward 1991, Southward et al. 1995) and continued by Steve Hawkins, Nova Mieszkowska and co-workers (e.g., Hawkins et al. 2003, 2008, 2009, Mieszkowska et al. 2006, 2014a,b, Mieszkowska and Sugden 2016) (Fig. 1). The trajectory of recovery following the *Torrey Canyon* oil spill was determined by interaction with climate fluctuations and other sources of chronic pollution such as Tributyltin from anti-fouling paints (Bryan et al. 1986, Spence et al. 1990).

Smith (1968)

Some Facts About *Exxon Valdez*

- *Tanker grounded March 24, 1989*
- *Alaskan crude oil en route from Valdez, Alaska, to Long Beach, California*
- *Vessel turned to avoid ice in shipping lanes and struck Bligh Reef*
- *40.8 - 42.2 million litres spilled*
- *Resulted in major changes to U.S. spill preparation and response*

What I'll Discuss re: *Exxon Valdez*

- *Long-term shoreline monitoring program focused on response impacts*
- *Pictures are worth…a lot*
- *Follow-on experiment based on monitoring results*
- *Marine mammal impacts inferred from long-term monitoring*

T/V *Exxon Valdez*: 24 March, 1989

Getty Images

Exxon Valdez Shoreline Cleanup

Erich Gundlach

Exxon Valdez Oil Spill Trustee Council

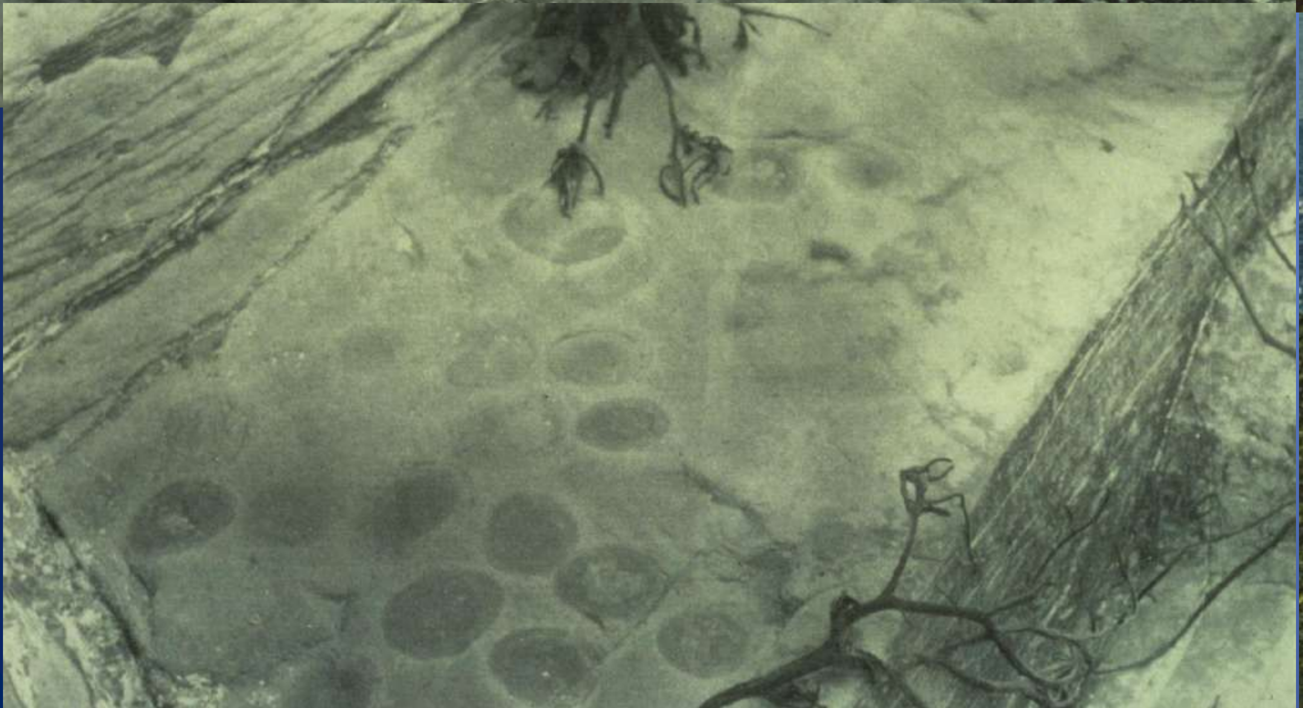
Exxon Valdez Shoreline Cleanup

Exxon Valdez: Recovery from Cleanup

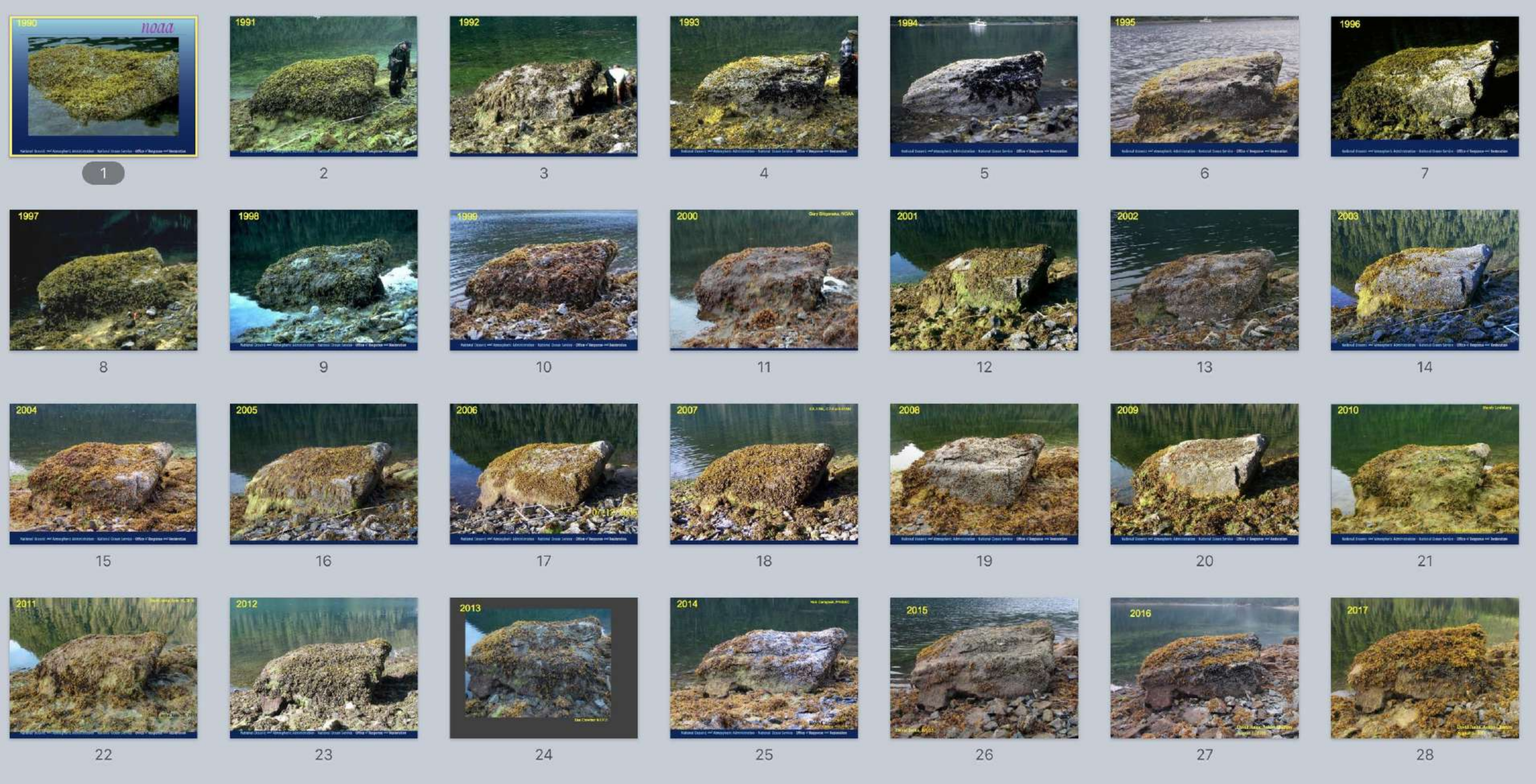
Initially: a greater degree of recovery was necessary at washed sites, but little difference could be discerned between washed & unwashed sites after around three years.

Torrey Canyon: Smith (1968)

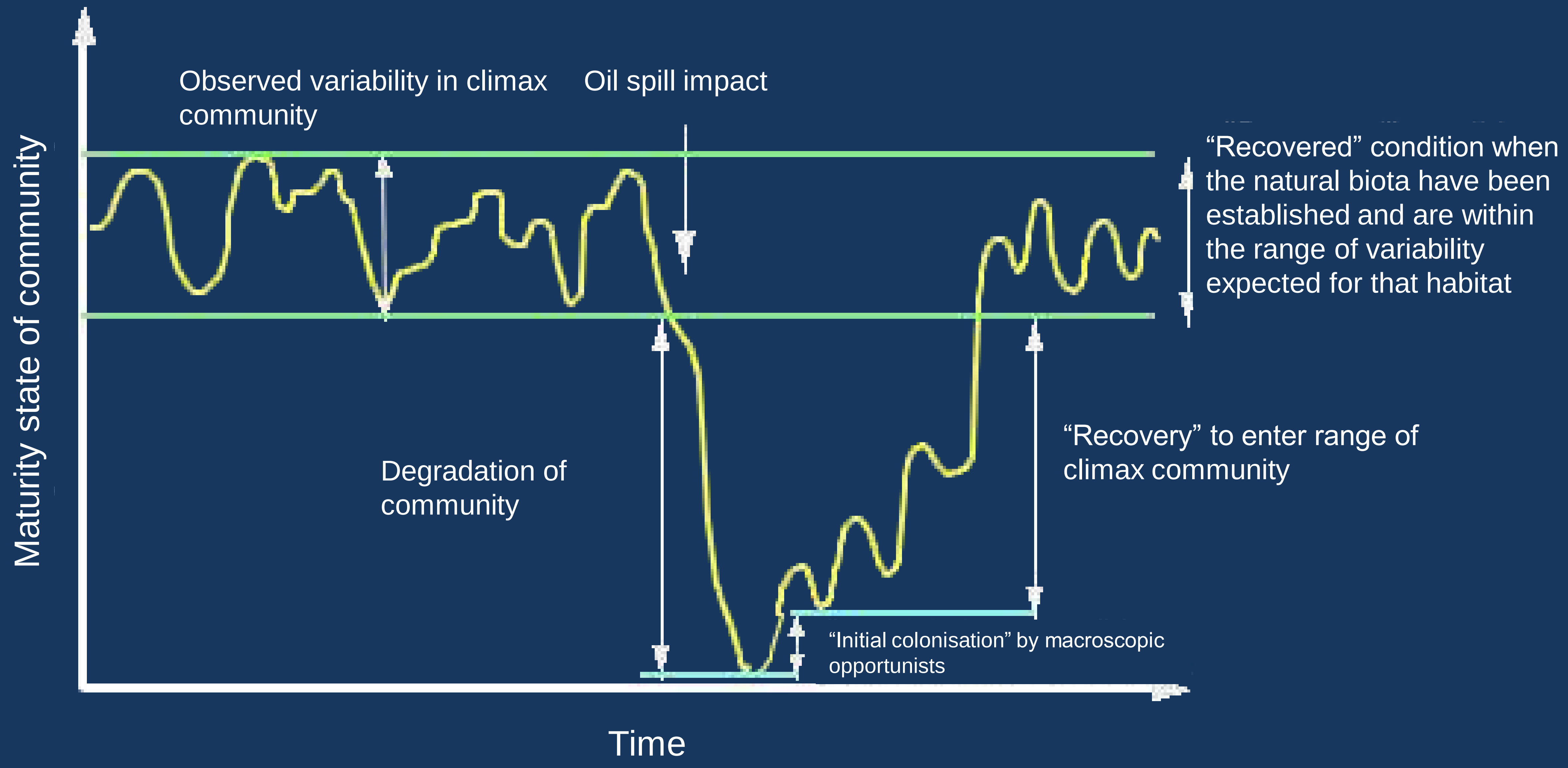





Exxon Valdez: The Legacy of Mearns Rock

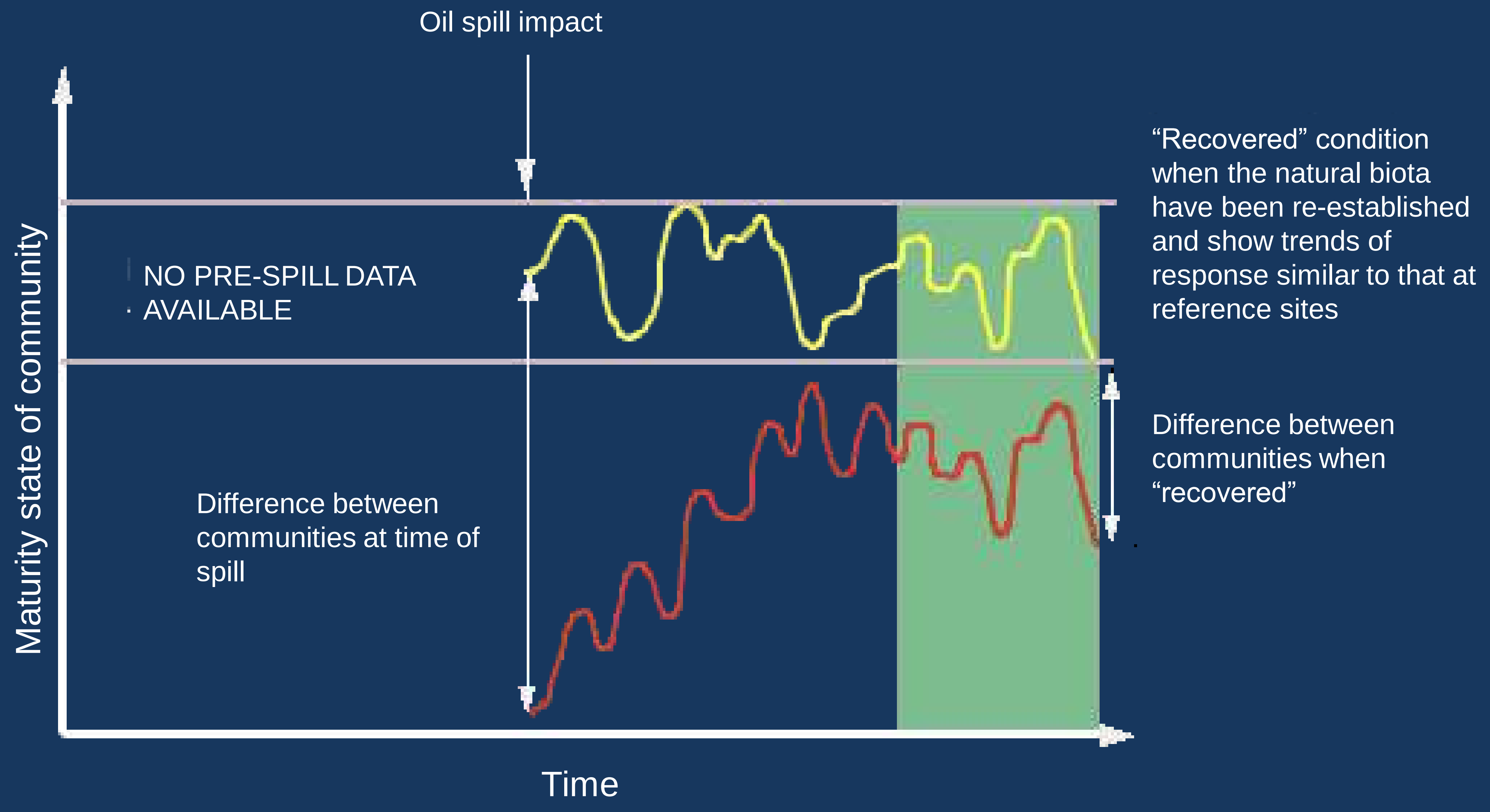


Oil Spill Response Tradeoffs: Idealized Recovery



Sell et al.,(1995)

Recovery from Spills: *Exxon Valdez* "Parallelism"



Lower Herring Bay Experiment:
2000-2012

Lower Herring Bay Experiment:
2000-2012

Lessons Learned from *Exxon Valdez* Response Monitoring

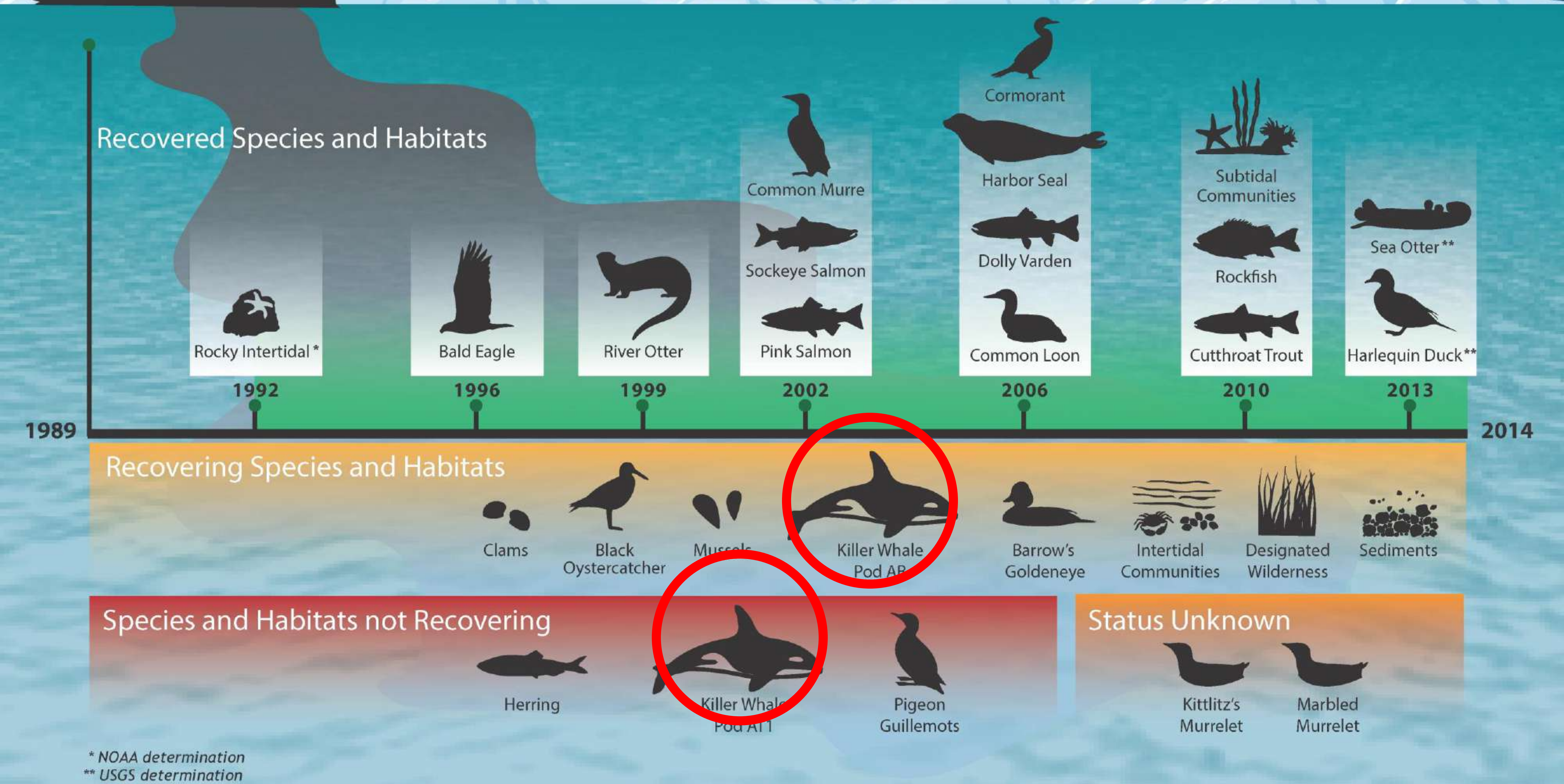
- *Short-term intertidal damage from cleanup diminished within 2-3 years*
- *Recovery from physical disturbance precedes biological recovery*
- *Drivers of change unrelated to spill can complicate impact assessment*
- *Utility & criticality of "set aside" sites*

Footnote: *Exxon Valdez* Lingering Oil

Disc Island, Prince William Sound, 4 June 2018…

David Janka, R/V *Auklet*

Timeline of Recovery from *Exxon Valdez* Spill



Pre-*Exxon Valdez* Assumptions about Cetaceans & Oil

"On the whole, it is quite improbable that a species or population of cetaceans will be disabled by a spill at sea, whatever the likelihood that one or a few animals might be affected or even killed."

J.R. Geraci, in Sea Mammals and Oil: Confronting the Risks

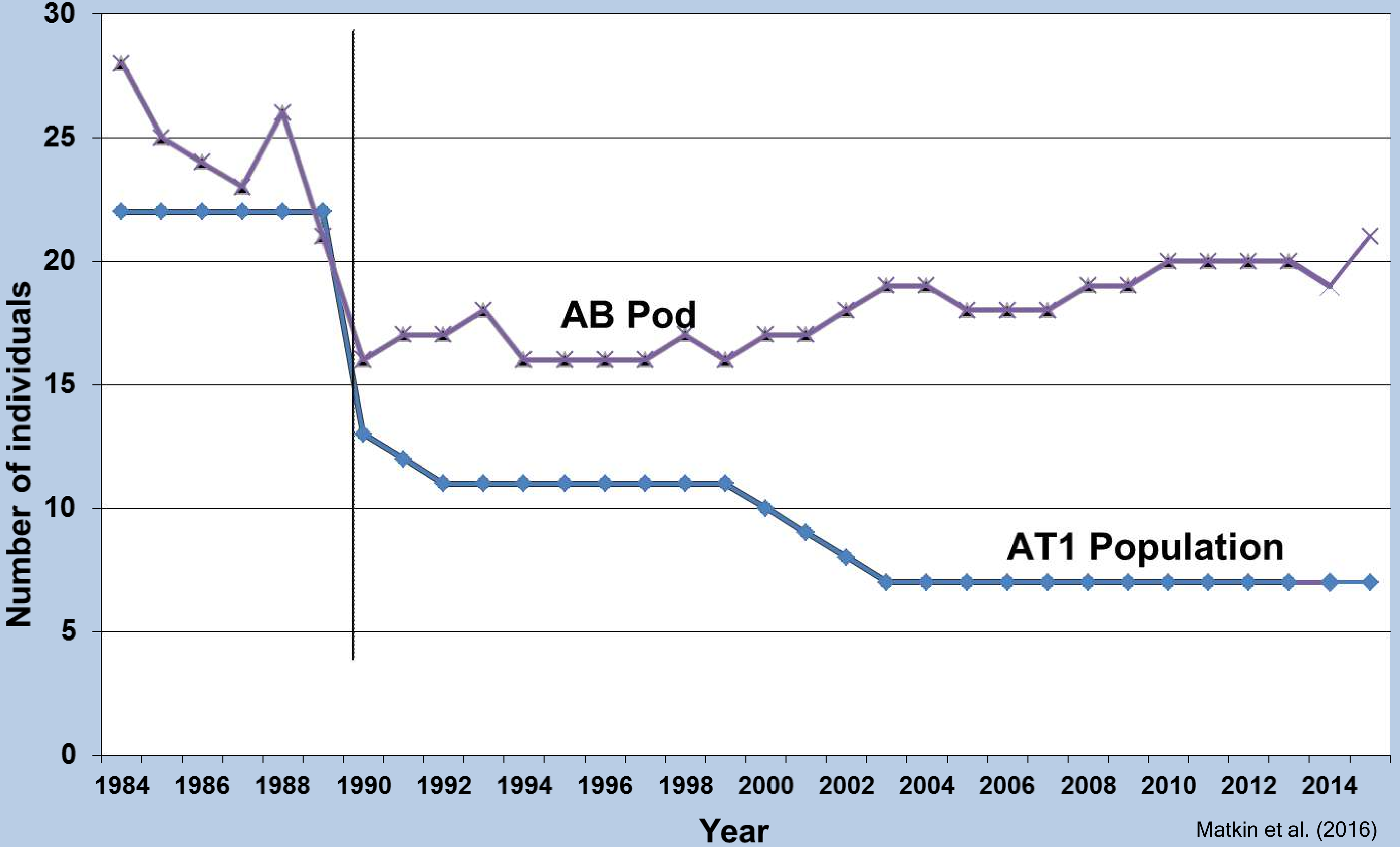
"An assessment of the toxicological literature and of the available empirical data on EVOS leads to the conclusion that direct, long-term sublethal toxic effects on wildlife appear to be very unlikely."

R. Hartung, in *Exxon Valdez* Oil Spill: Fate and Effects in Alaskan Waters

Prince William Sound Orca Trends, 1984-2014

Craig Matkin/

Dan Lawn



Matkin et al. (2016)

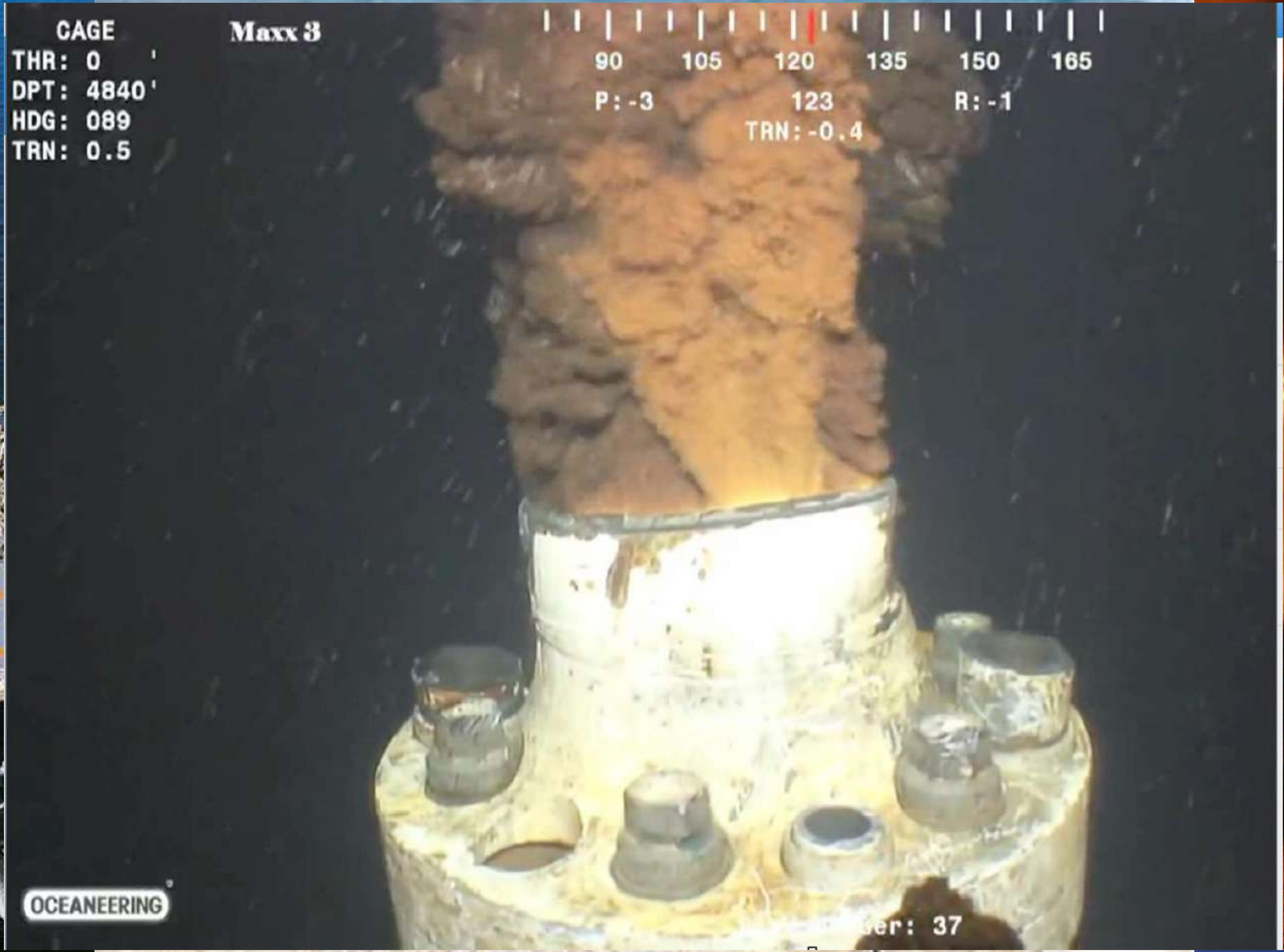
Angeles Times

Some Facts About *Deepwater Horizon*

…(aka Macondo, MC252)

- *Mobile Offshore Drilling Unit working BP lease, Mississippi Canyon 252, 80 km off Louisiana coast*
- *Exploded 20 April 2010, 11 fatalities*
- *Sank 21 April, mostly uncontrolled flow for 87 days*
- *515 million - 779 million litres South Louisiana crude*
- *42.8% liquid petroleum, 57.2% gas at source (21 June)*
- *Maximum personnel 47,282 (8 July)*
- *Closed fisheries maximum 229,271 sq. km (2 June)*

Post-*Deepwater Horizon* Research & Monitoring



What I’ll Discuss re: *Deepwater Horizon*

…(aka Macondo, MC252)

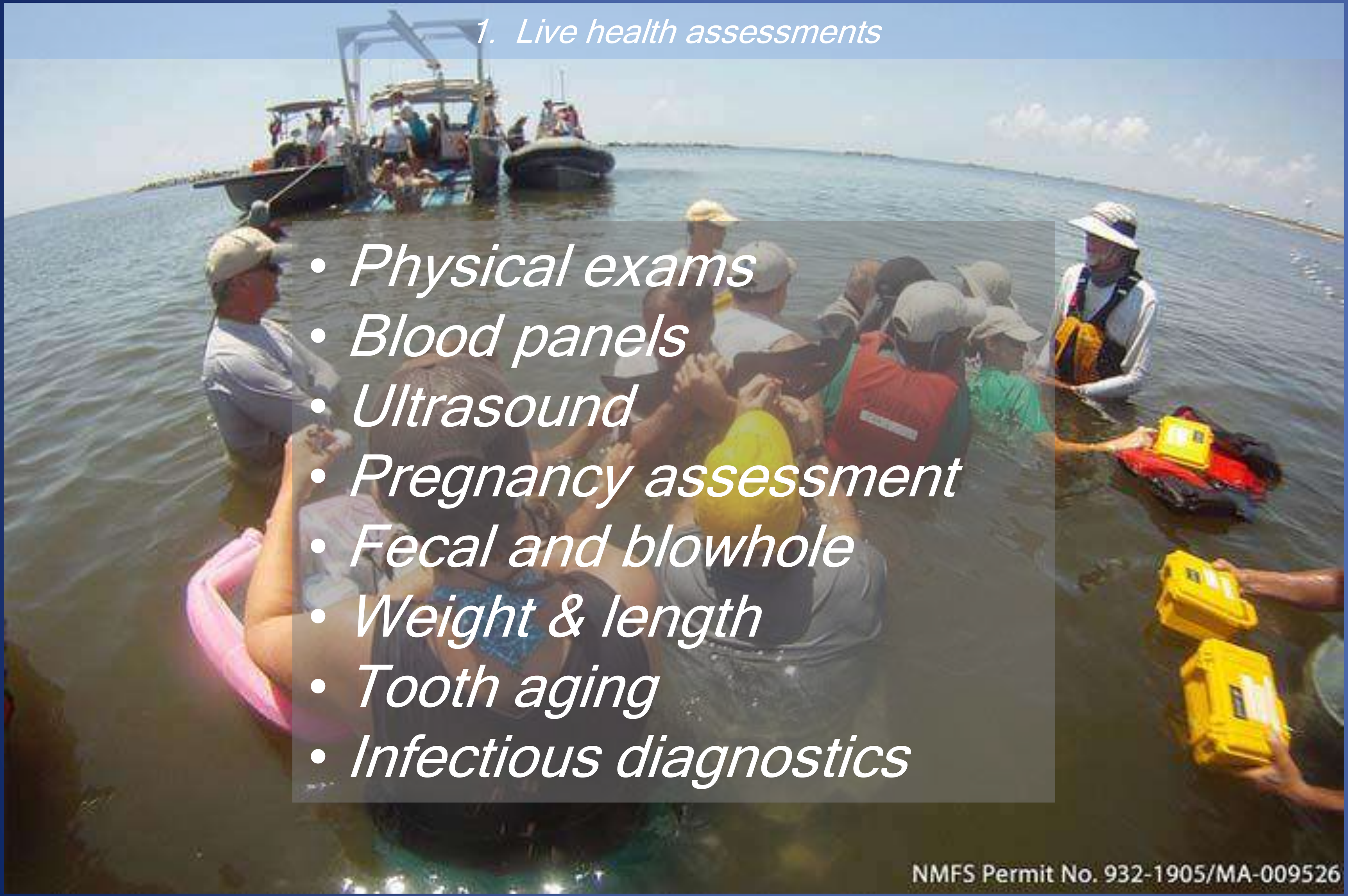
- *Intensive studies of marine mammal (dolphin) impacts in heavily oiled location*
- *Consistency & “constellation” of impacts across species*
- *Marsh impact, cleanup, and remediation studies during and after response*


NOAA/Ron Wooten

NOAA/Ron Wooten

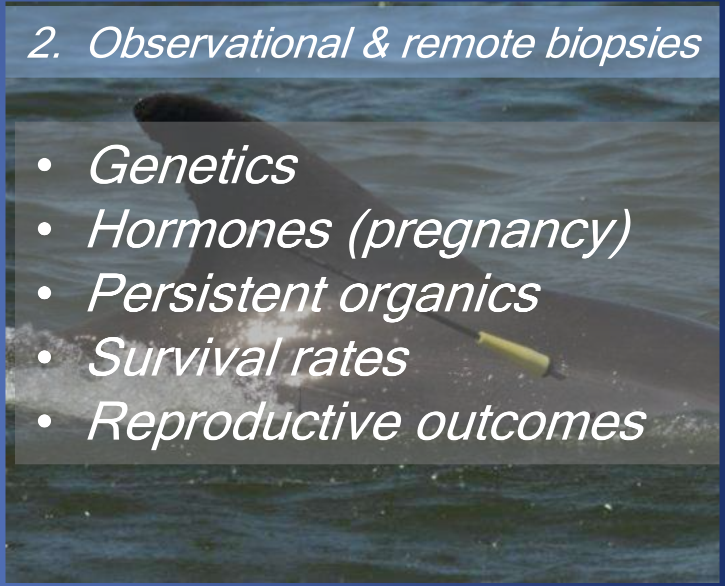
Mandy Tumlin/Louisiana Department of Fish & Wildlife

Deepwater Horizon Bottlenose Dolphin Assessments



1. *Live health assessments*

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



2. *Observational & remote biopsies*

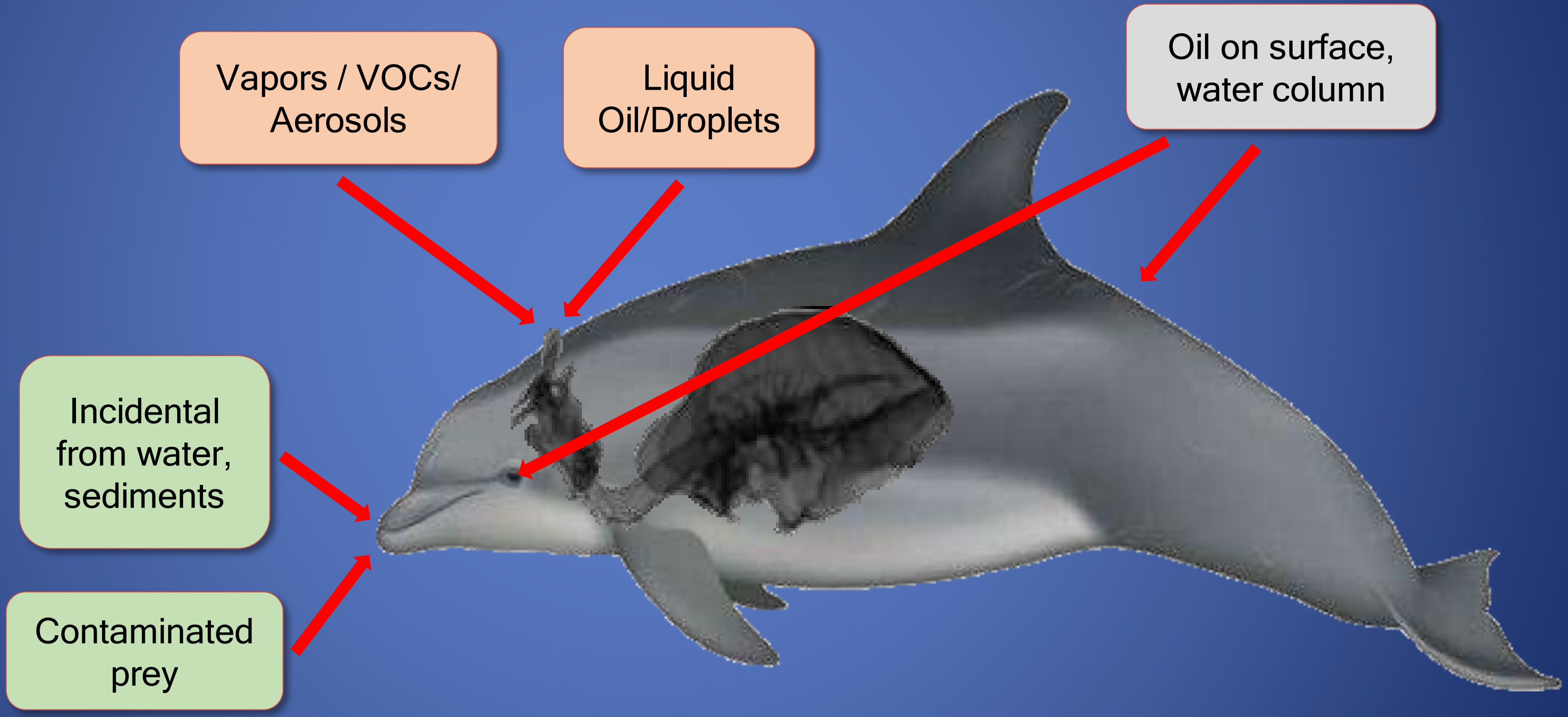
- *Genetics*
- *Hormones (pregnancy)*
- *Persistent organics*
- *Survival rates*
- *Reproductive outcomes*

3. *Stranded & dead dolphin tissues*

- *Demographics*
- *Weight & length*
- *Gross observations*
- *Full histology set (tissues)*
- *Infectious & biotoxin diagnostics*

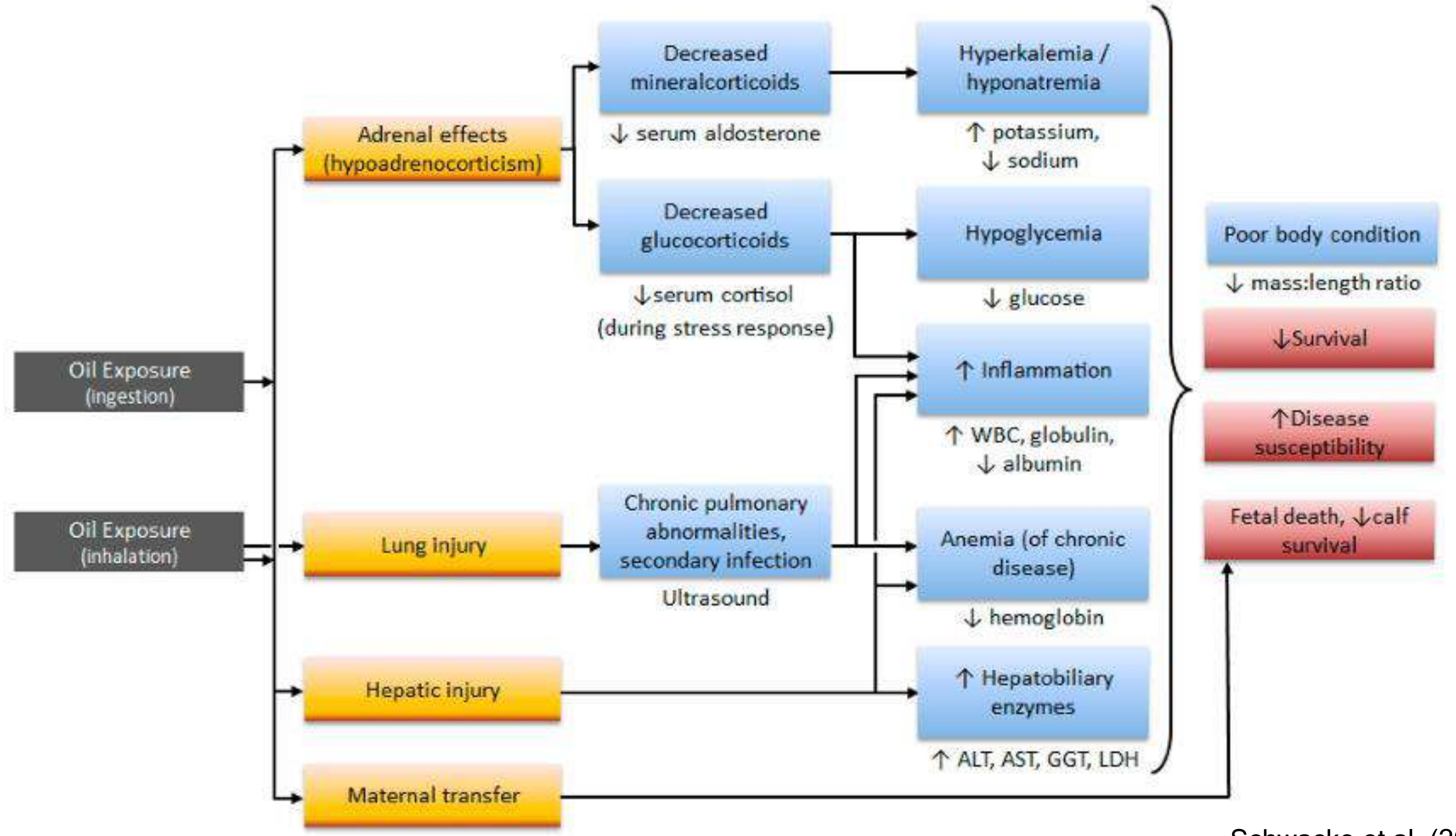
Marine Mammal (Cetacean) Routes of Exposure

- *Inhalation*
- *Dermal & ocular contact*



- *Ingestion*

Conceptual Model of Oiled Dolphin Health Effects

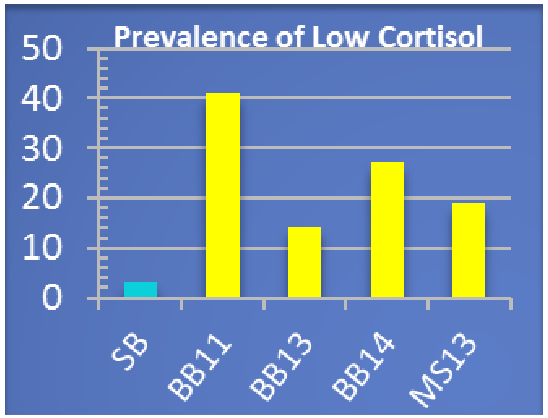


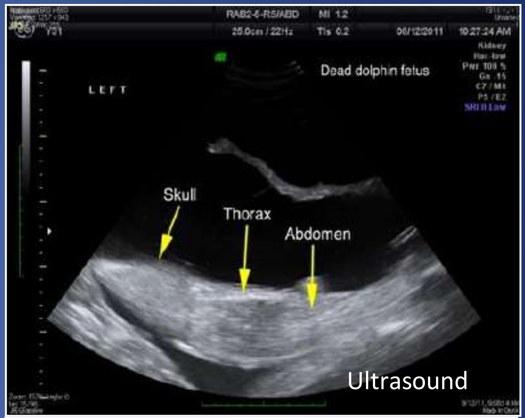
Schwacke et al. (2013)

Deepwater Horizon Dolphin Injury Assessment Findings

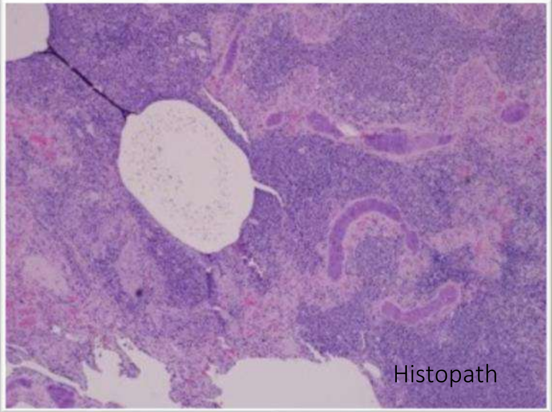
Moderate-Severe Lung Disease	Impaired Stress Response / Adrenal Injury	Increased Mortality Rates	Low Reproductive Success Rates

LIVE ANIMALS



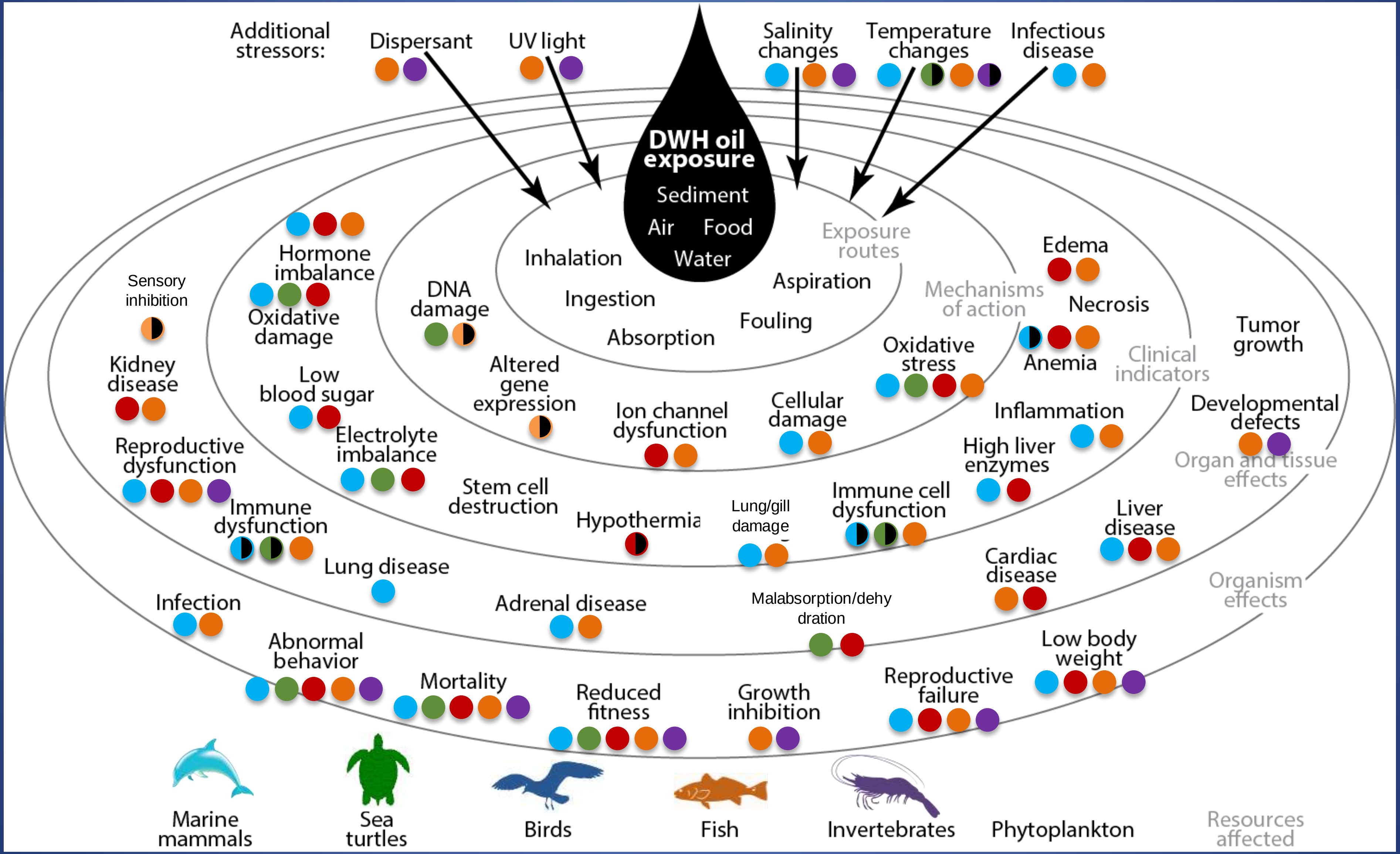


DEAD ANIMALS



Mammal exposure to DWH oil contributed to the largest, longest lasting marine mammal Unusual Mortality Event (UME) recorded in the northern Gulf of Mexico (>1000 stranded)

DWH Physiological Oil Response "Constellation"



Deepwater Horizon Natural Resource Damage Assessment Trustees (2016)

Amoco Cadiz, Ile Grande Marsh 1978

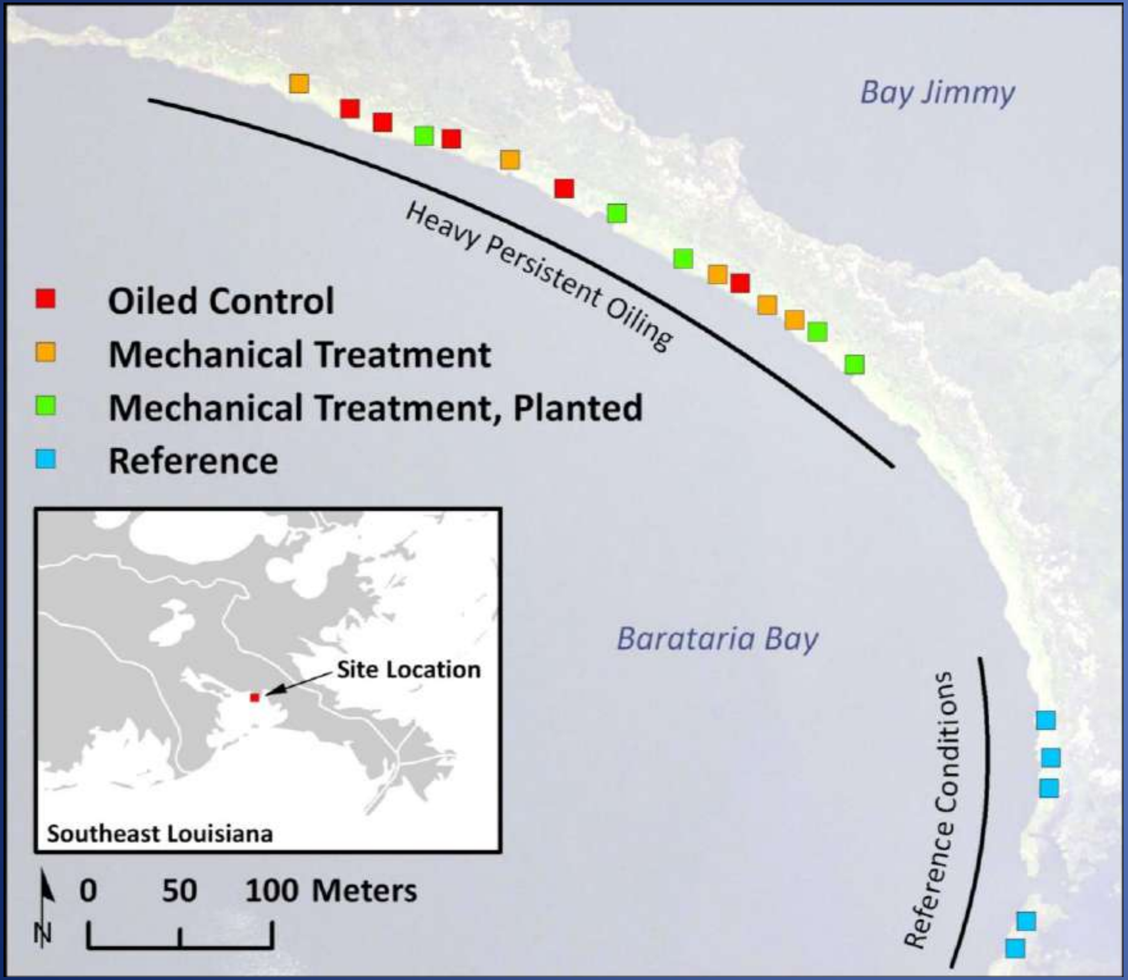
Eric Gundlach


Los Angeles Times/Carolyn Cole

Deepwater Horizon, Bay Jimmy 2010

Deepwater Horizon:

Bay Jimmy (Barataria Bay), Louisiana Test Plots




Reference 2013


Oiled Control 2013


Mechanical Treatment 2013


Mechanical + Planting 2013

Response/Restoration

Deepwater Horizon Marsh Monitoring Conclusions

- ***Did shoreline treatment improve oiling conditions and recovery?***

  Yes, over first few years especially, but with some negative side effects in some cases.

- ***Did planting after treatment help even more?***

  Yes, to a large degree, especially for vegetation recovery, invertebrates have been slower to recover but still improved; no downsides observed.

- ***What would we do next time in similar situation?***

  Recommendation: carefully tailor treatment type and intensity, and follow immediately with planting.

Some General Findings…

…from Monitoring/Research on *Exxon Valdez* & *Deepwater Horizon*

- *Long-term monitoring of impact and recovery from major oil spills has shown that marine habitats are resilient…*
- *…but not invulnerable*
    - *Marine mammals and other long-lived, slow-reproducing organisms are sensitive*
- *The case for leaving (some) sites oiled and untreated*
- *Post-incident monitoring should begin during the incident; in some cases, restoration should begin early as well*


F/V Deep Sea, Penn Cove, WA, 2012
…or, not all interesting monitoring takes place at huge spills…
Kasia Pierzga/Whidbey Examiner

USCG/15 May 2012

C. Andersen/Washington Department of Ecology

F/V *Deep Sea* – Penn Cove WA

Our "Small Science" Hypotheses

- *Oil would be at the surface and not contaminate submerged (>1 m) mussels;*
- *If they were contaminated, depuration half-life of PAHs would be several days to several weeks following completion of the response*

C. Andersen/Washington Department of Ecology

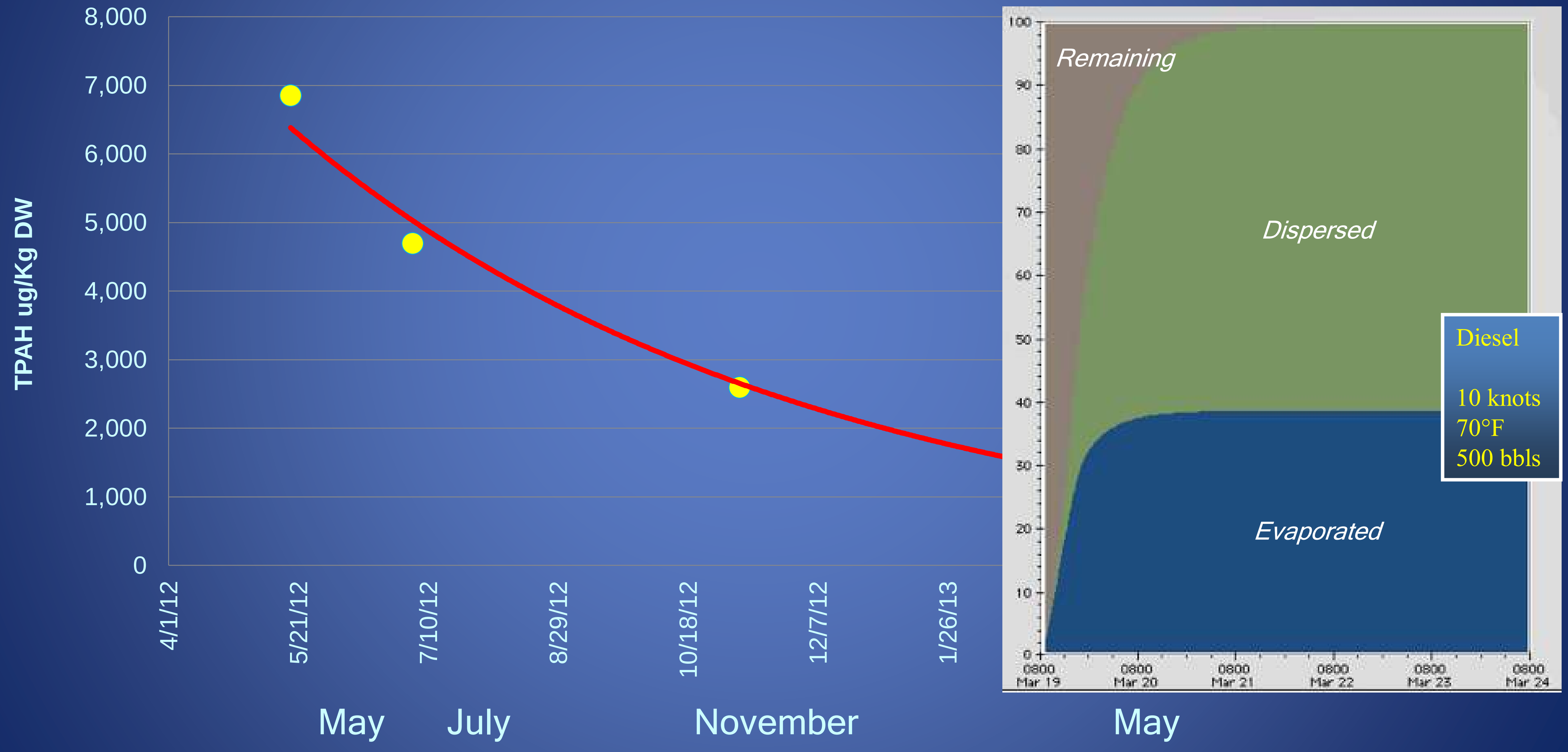

Alan Mearns/NOAA

F/V *Deep Sea* – Penn Cove WA

Our “Small Science” Hypotheses

- *We were wrong.*

tPAHs in Penn Cove Float Mussels



1989... → 2018...

Final Thoughts…

Why Post-Incident Monitoring?

"What is past is prologue."

William Shakespeare, The Tempest, Act II Scene I

"Life can only be understood backwards; but it must be lived forwards."

Søren Kierkegaard, Journals, 1843

"Those who ignore the past are condemned to repeat it."

George Santayana, The Life of Reason, 1905