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Centre for Tropical Water and Aquatic Ecosystem Research



## Managing oil spill impacts on mangroves: *should we be concerned?*

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## Further reading ...

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Oil spill impacts on mangroves: Recommendations for operational planning and action based on a global review

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ABSTRACT

Mangrove tidal wetland habitats are recognized as highly vulnerable to large and chronic oil spills. This review of current literature and public databases covers the last 6 decades, summarizing global data on oil spill incidents affecting, or likely to have affected, mangrove habitat. Over this period, there have been at least 238 notable oil spills along mangrove shorelines worldwide. In total, at least 1.5 million tonnes of oil has been released into mangrove-lined coastal waters, either possibly up to around 1.8 million t/a of mangrove habitat, and killing at least 120,000 ha of mangrove vegetation since 1956. However, there were numerous limitations with incomplete reporting on oil spill impacts on mangrove and their recovery worldwide, a number of recommendations and suggestions are made for refining and updating standard operational procedures for responders, managers and researchers alike.

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Figure 1. Shipping accidents cause most oil spills that threaten mangrove and tidal wetland habitats, as with the 2007 oil spill at Port Cairns, Queensland, Australia.

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# Oil spill impacts on mangroves

Should we be concerned?

Prior oil spill incidents

Impacts on mangroves

Recovery and Rehabilitation

Experimental trials – field & tidal tanks

Better managing oil spill incidents



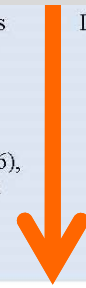


# Oil spill impacts on mangroves

Global database...

Incident	Spill Year	Location (tidal range in m)	Type of Oil"	Oil Released (tonnes)	Mangrove Oiled (ha)	Mangrove Killed (ha)	Recovery Estimate (%)
<i>USS Chehalis</i> NOAA 2016	1949	Pago Pago Harbor, <b>America Samoa</b>	D, JF	362	Likely	?	
<b>JP-5 Fuel Tank</b> Eoearth 2010	1958	Roosevelt Roads, Naval Air Station, <b>Puerto Rico</b>	BFO	50?	YES	?	
<i>Argea Prima</i> Diaz-Piferrer 1964; Baker 1982	1962	Guayanilla Harbour, <b>Puerto Rico</b>	CO	10,000	YES	?	
<b>Tanker, unspecified</b> El-Nemr 2006	1966	Arabian Gulf, <b>Qatar</b>	CO	13,000	Likely	?	
<i>General Colocotronis</i> NOAA 2016	1968	Eleuthera Island, <b>Bahama</b>	CO	4,878	Likely	?	
<i>Ocean Eagle</i> NOAA 2016	1968	San Juan <b>Puerto</b>		9,252	Likely	?	
<i>World Glory</i> NOAA 2016	1968	Durban, <b>Africa</b>		44,058	Likely	?	
<i>Witwater</i> Rützler & Sterrer. 1970; Duke et al., 1997; Eoearth 2010; NOAA 2014, 2016	1968	Bahia Las Minas (0.6), <b>Panama</b>	D, BFO	2,544	~490	49	80+
<i>Oceanic Grandeur</i> Duke & Burns, 2003; CEDRE 2015; AMSA, ITOPF 2016	1970	Torres Strait (2.6), QLD, <b>Australia</b>	CO	<4,100	~10	1	90-100

238  
reported  
incidents



Duke, N.C., 2016

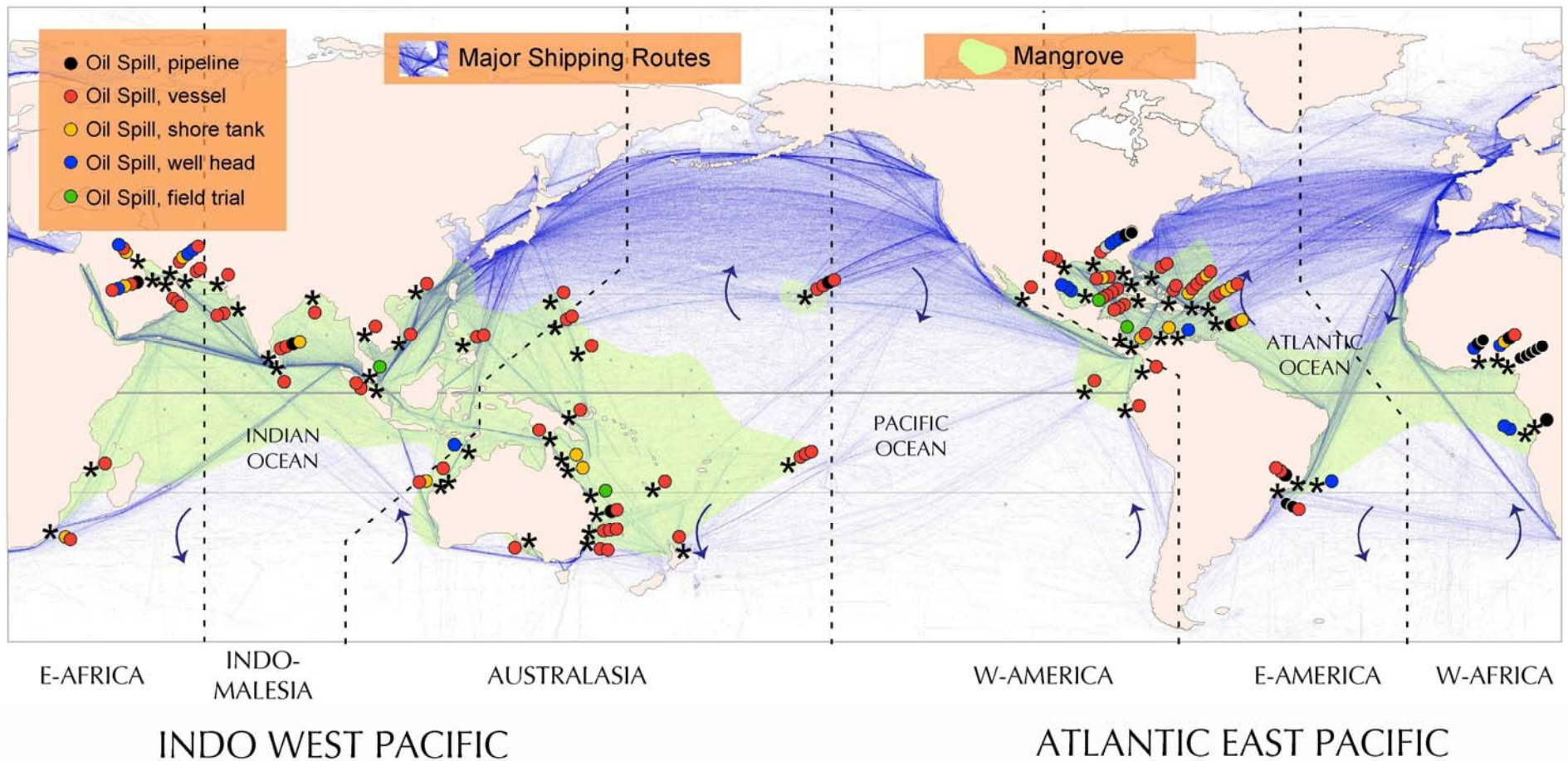
# Findings...

## Impacts of oil spills on mangrove habitat



- Mangroves highly vulnerable;
- At least 238 notable incidents – ranked for vessels, pipelines, shore tanks, well heads
- 5.5 million tonnes of oil released along mangrove shorelines
- 1.94 million ha of mangroves oiled
- 126,000 ha of mangrove loss and removal since 1958
- Worst affected region by numbers of incidents = East America 141 of 238
- Worst affected region by area of oiled mangroves = West Africa 18,665 ha
- Notable gaps and omission in the records
- Notable deterioration of reporting over 6 decades

# Oil spills impact on mangroves



Anywhere mangroves grow!

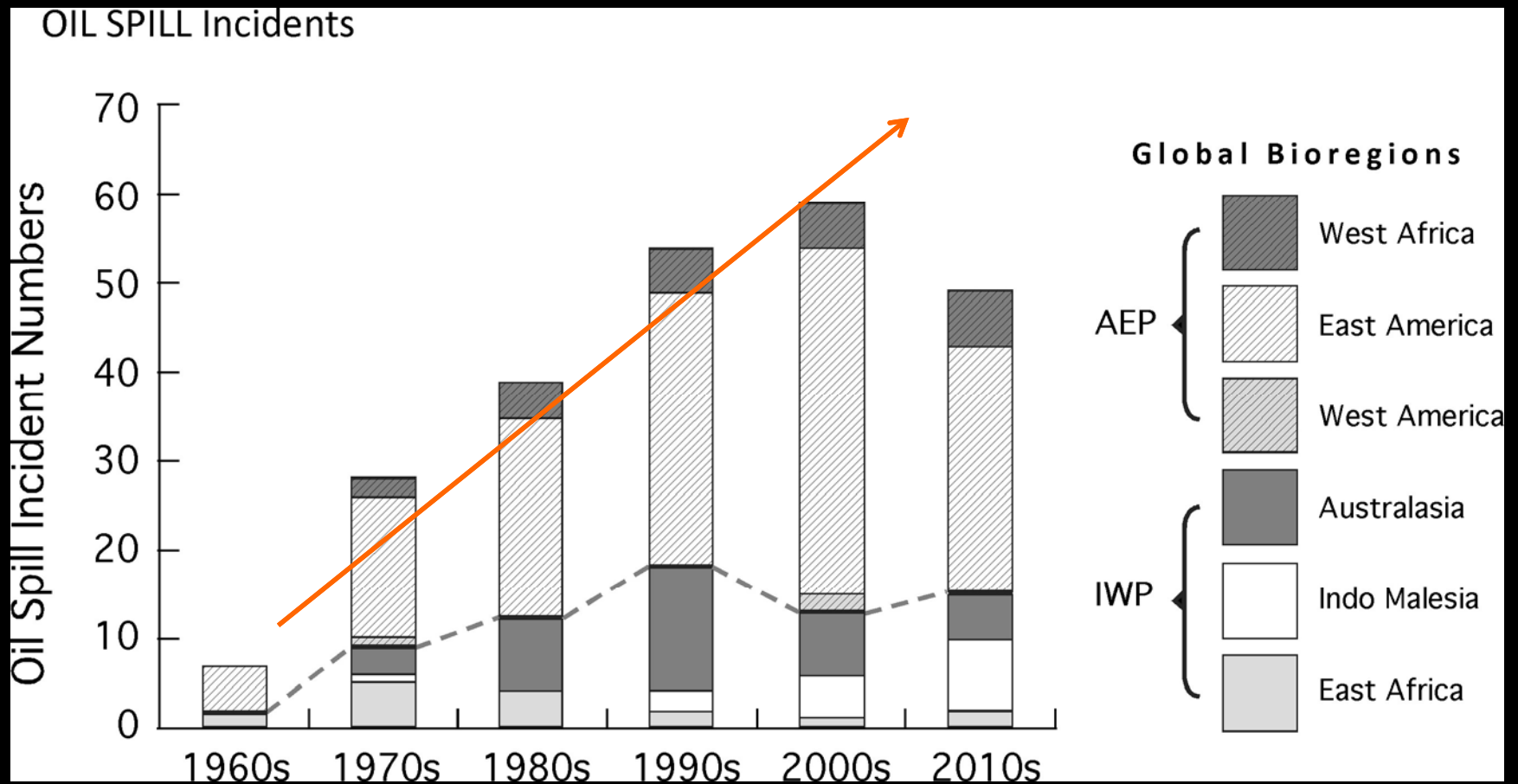




2007 oil spill in Port Curtis, Queensland Australia

# Oil spill incidents & mangroves

A summary of reported oil spill incidents affecting, or likely to have affected, mangrove habitat.





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- Suffocation
- Toxic shock
- Starvation



# Largest areas of oiled mangroves

## Habitat damage & impact – lethal and sublethal

Ten largest areas of **mangrove habitat oiled** include:

- Nigeria - Funiwa 5 Well blowout in 1980 oiling 5,107 ha;
- Pakistan - *Tasman Spirit* sinking in 2003 oiling around 1,000 ha;
- Nigeria - Pipeline rupture Bodo in 2008 oiling at least 1,000 ha;
- The Philippines - *Solar 1* sinking in 2006 oiling 650 ha;
- Panama - Texaco Refinery spill in 1986 oiling 377 ha;
- Nigeria - Pipeline sabotage, Bodo West in 2011 oiling 366 ha;
- Brazil - pipeline rupture near Sao Paulo in 1983 oiling around 300 ha;
- Micronesian islands of Yap - sinking of the *Kyowa Violet* in 2002 oiling 300 ha;
- India - sinking of the *MSC Chitra* in 2010 oiling around 200 ha; and
- Australia - the holing of the *Era* in 1992 oiling 100 ha.



# Largest areas of oil dead mangrove

## Habitat damage & impact – lethal

Ten largest areas of **mangrove habitat damage** reported have been:

- Nigeria - 340 ha killed by the Funiwa 5 well head spill in 1980;
- Nigeria - 200 ha killed by the Bodo pipeline rupture in 2008;
- Panama - 69 ha killed by the Texaco Refinery spill in 1986;
- Panama - 49 ha killed by the *Witwater* sinking spill in 1968;
- Nigeria - 32 ha killed by the Bodo West pipeline sabotage in 2011.
- Indonesia - 20 ha killed with the sinking of the *Showa Maru* in 1975;
- Puerto Rico - 12 ha killed with the Jet Fuel tank spill in 1999;
- Brazil - 10.5 ha killed by a Jet Fuel tank spill in 1999;
- Yap, Micronesia - 10 ha killed with the sinking of the *Kyowa Violet* in 2002; and
- Puerto Rico - 6 ha killed by an earlier Jet Fuel tank spill in 1986.



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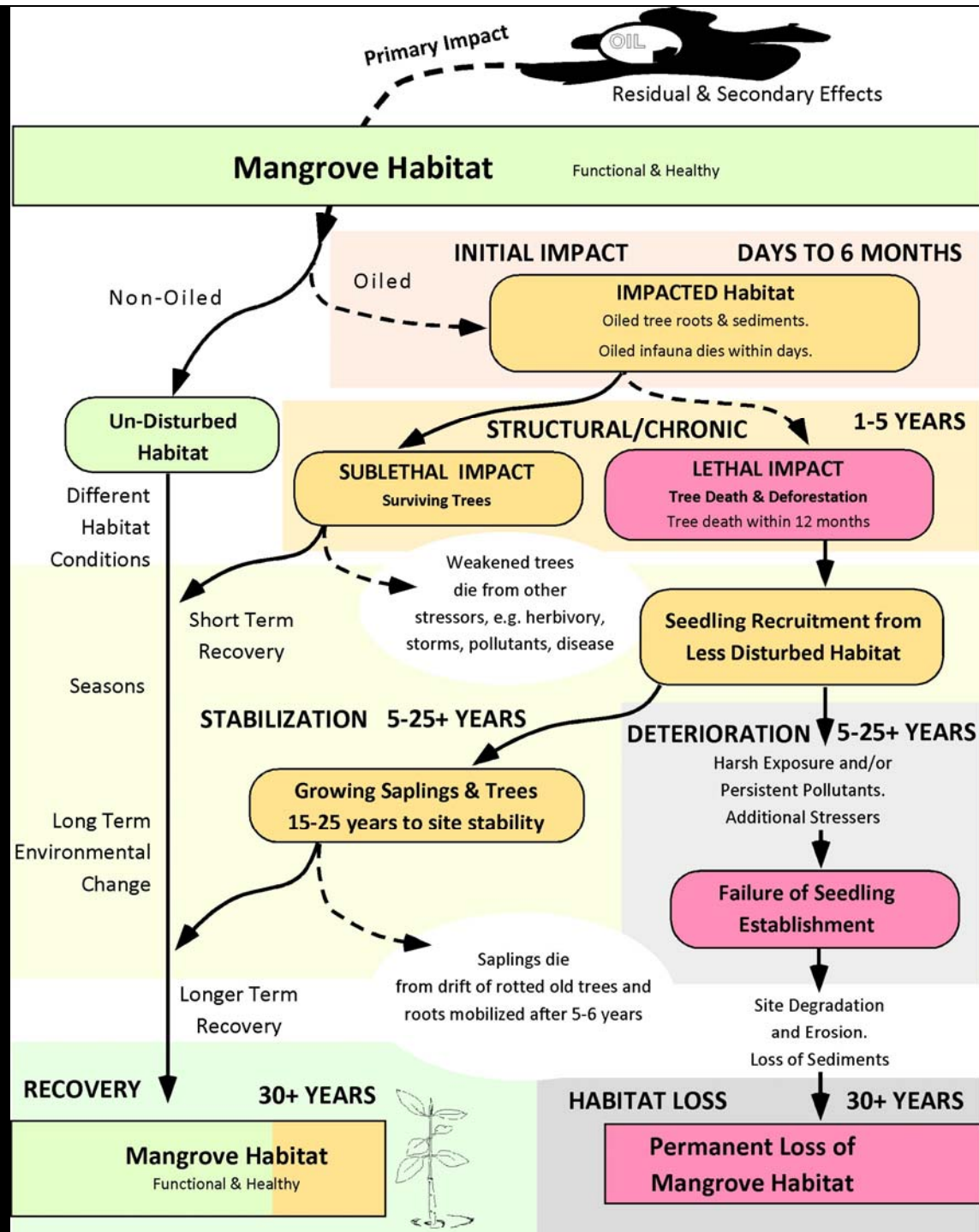
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# Oil spills impact on mangroves





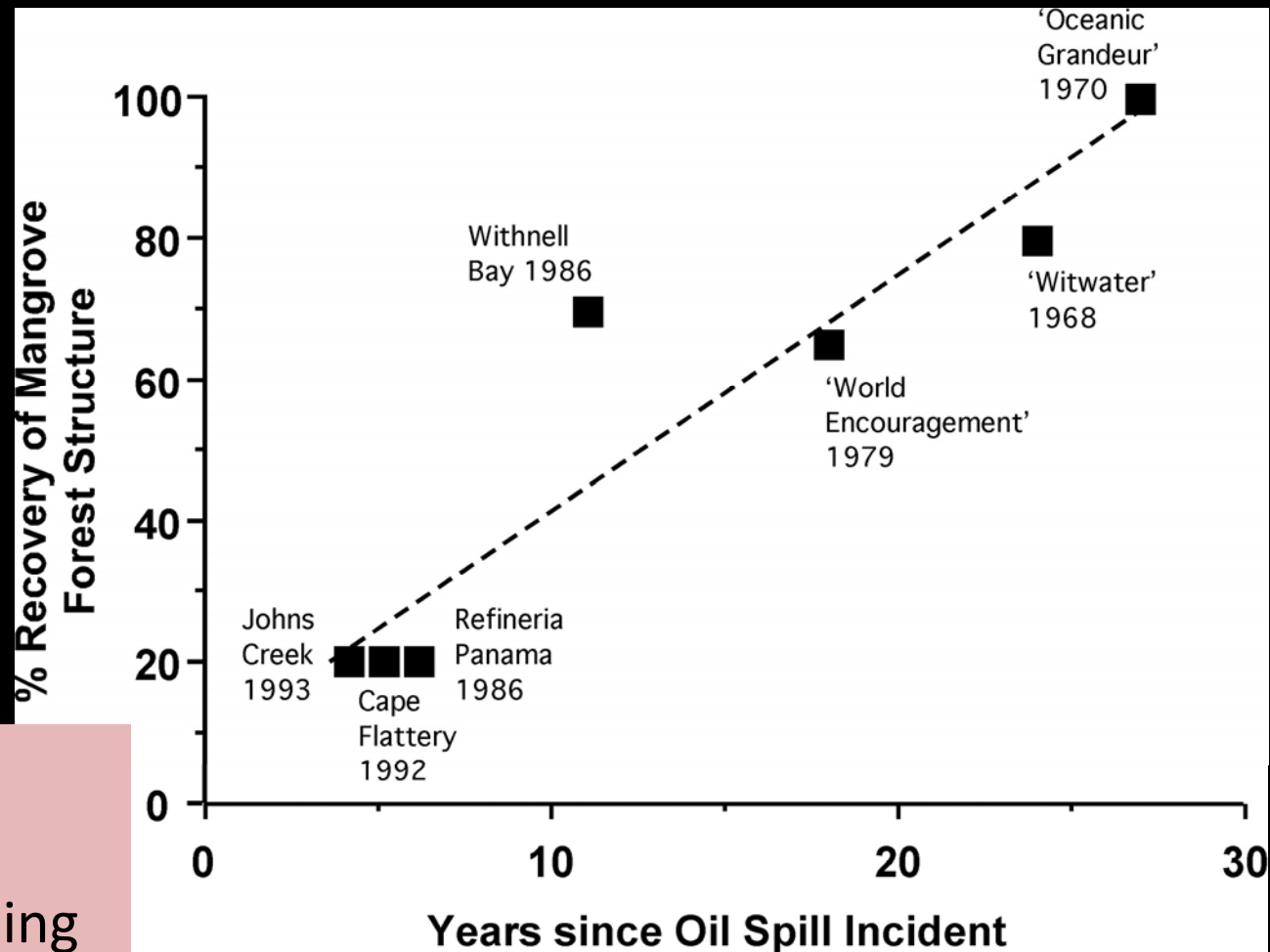
# Recovery phases



Recovery Phase of Gap	%Percent Recovery	Sub lethal Trajectory	Lethal Trajectory in Gap	Lethal State Representation in Gap
Natural pre-damage state	Reference condition	Foliage dense with yellowing leaf numbers less than 10%. Seedling bank under closed mature canopy.	Trees mostly alive throughout stand; occasional dead trees and up to ~10% light gaps in ambient conditions.	
1. Recently killed	Positive 1-10	Yellowing and loss of foliage in affected areas, and presence of dead, low-placed seedlings. Some surviving seedlings.	Tree death (within 6-12 months after spill), dead seedlings and saplings. Trees with dead yellow leaves and small twigs present. Mostly dead seedlings.	
2. Recovery preliminary	Positive 11-30	Loss of foliage in affected areas, and presence of dead, low-placed seedlings.	Deterioration of dead trees missing small branches and twigs. No appreciable recruitment, some seedlings.	
3. Recovery established	Positive 31-50	Foliage density in recovery with new growth. Re-establishment seedling bank under re-established canopies.	Deterioration of dead trees missing large branches and upper stems. Establishment of additional seedling recruits in open areas.	
4. Recovery progressed	Positive 51-70	Foliage density in recovery with new growth. Re-establishment seedling bank under re-established canopies.	Notable large stumps remain with some exposed roots. Saplings dominate in dense stands, in the forest gaps. Immature, low level canopy closure.	
5. Recovery advanced	Positive 71-90	Foliage density in recovery with new growth. Re-establishment seedling bank under re-established canopies.	Reduced remnant dead stumps & wood sections. Canopy closure advanced. Notable thinning of saplings and young seedlings present.	
6. Structural recovery in final stages of completion.	Positive 91-100	Normal foliage density with canopy closed. Site Maximal Canopy Height unaffected. Presence of seedling bank of 3-6 year old young plants, and a notable gap between mature canopy trees.	None or occasional remnant mature-sized stumps. Canopy closed. Damaged area Site Maximal Canopy Height restored. Formation of seedling bank of 3-6 year old recruits, notable class gap to mature canopy.	
Possible deterioration state post recovery, likely from phases 1 to 5	Negative condition	Foliage absent in impacted gap area	Dependent on state of gap degradation. Absence of integrated roots, living seedlings, saplings and young trees. Evidence of scouring.	

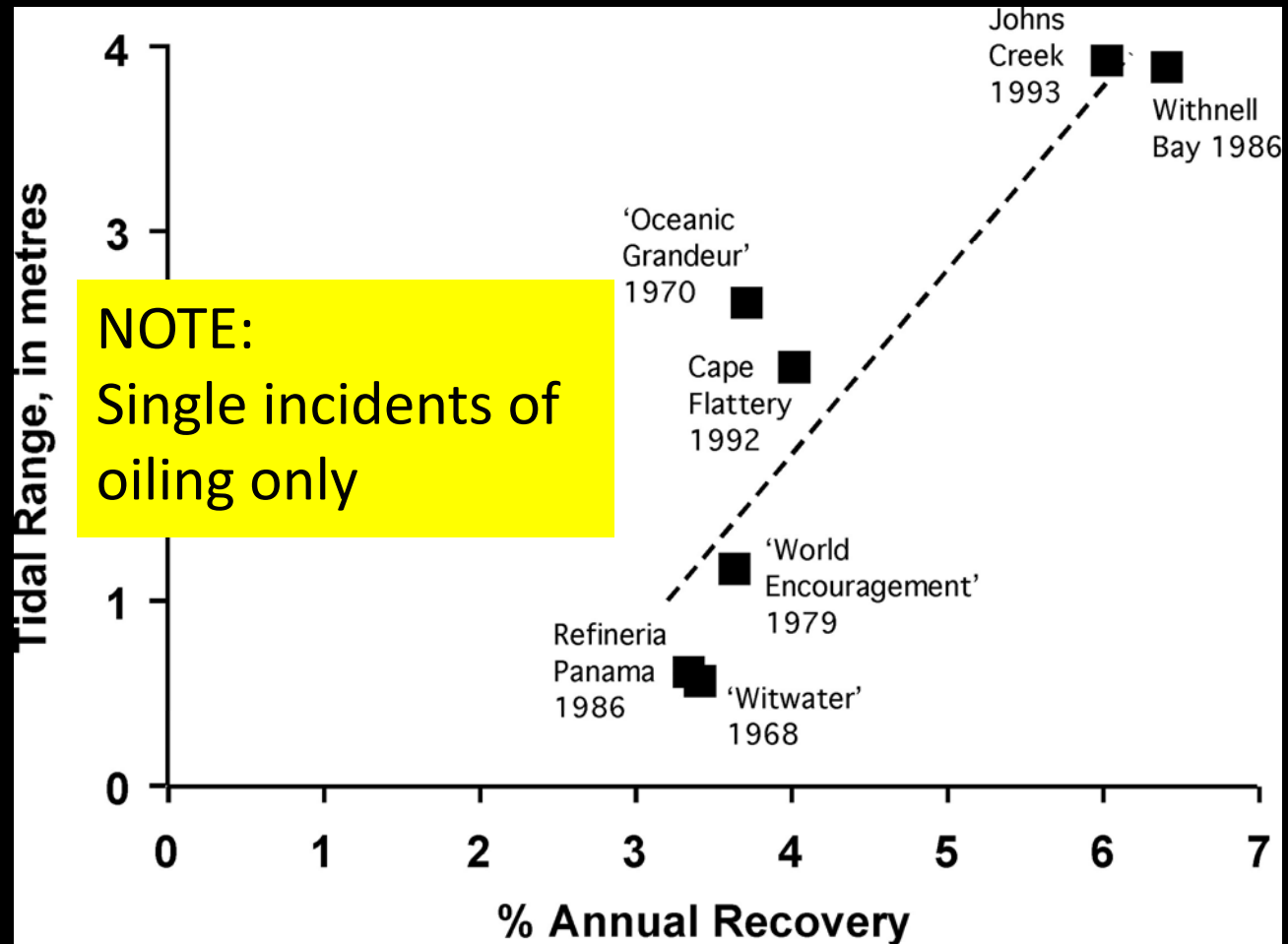


# Recovery time



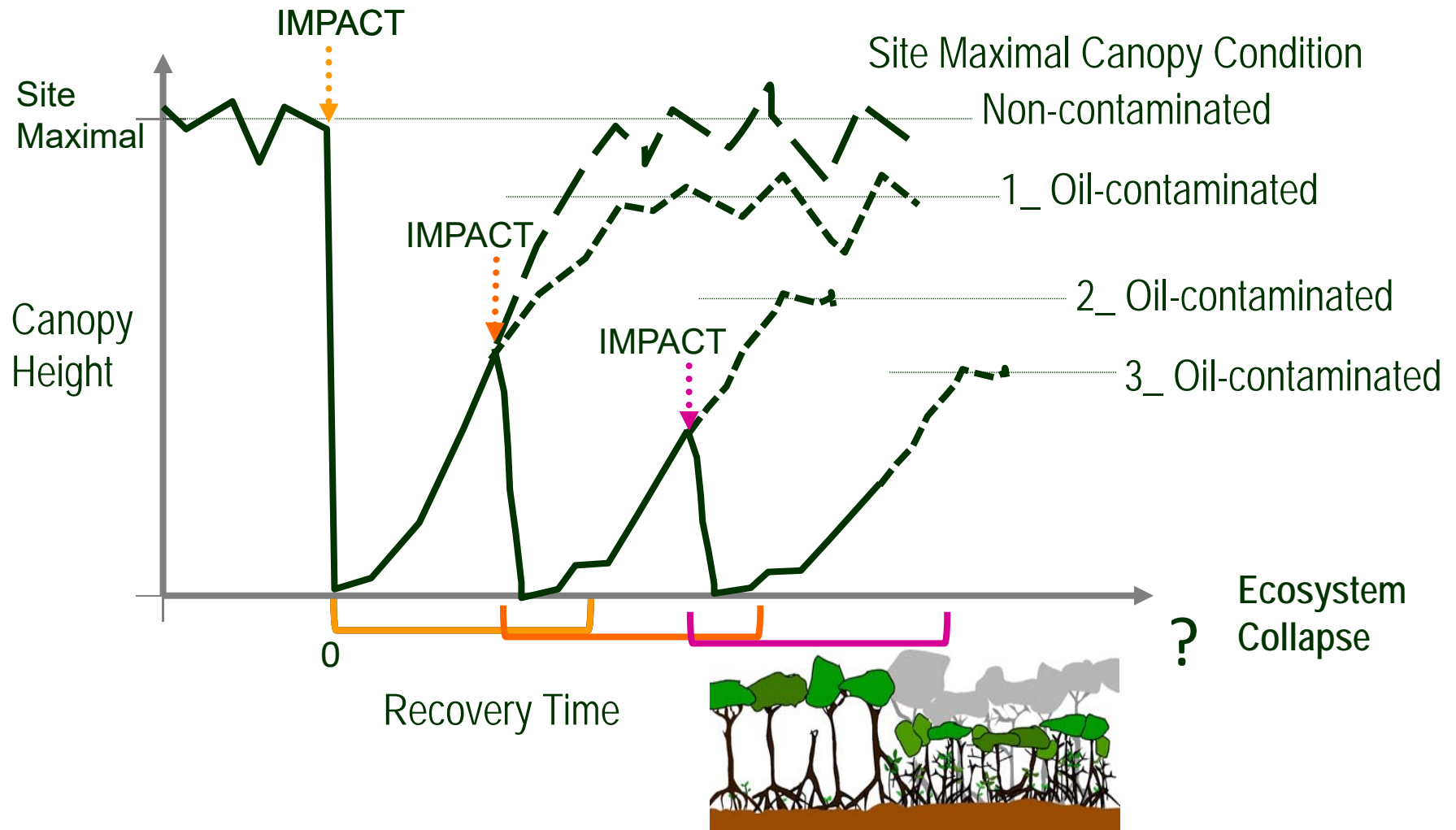
- Oiled area
- Oil type
- Tidal flushing

# Recovery – tidal flushing

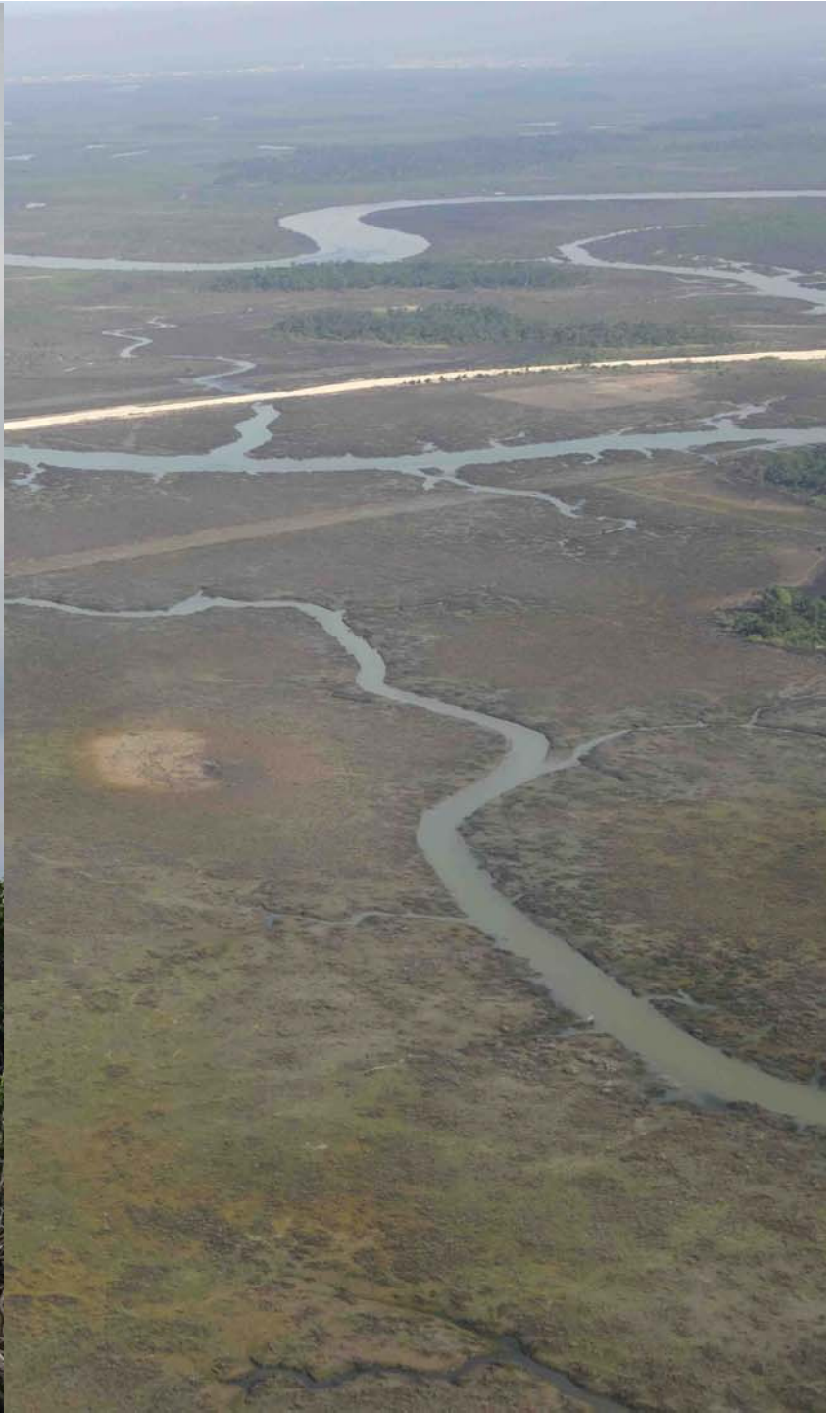


# Mangrove Regeneration vs. Recovery Time & Canopy Height

## Influence of repeated oil contamination







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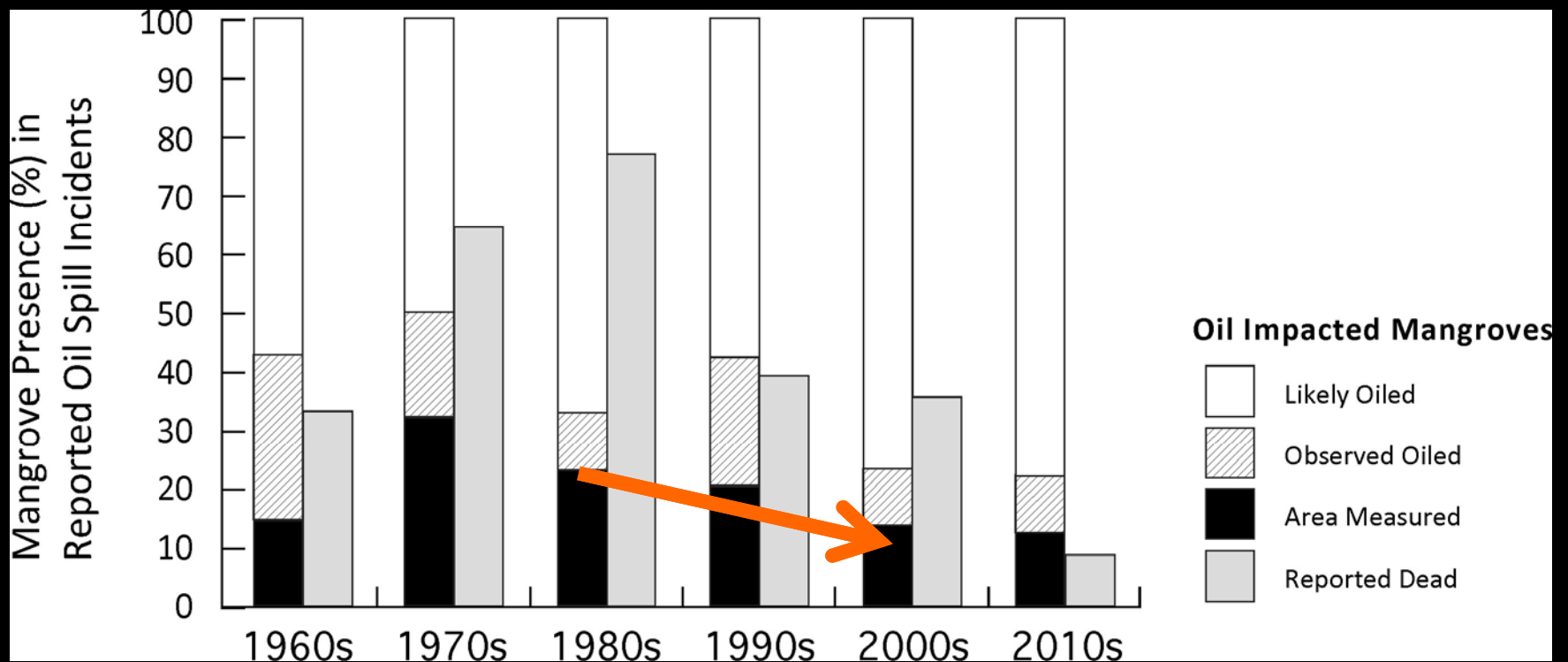
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## Experimental work on oil spill impacts on mangroves – lack of recent studies





# Oil spill impacts on mangroves

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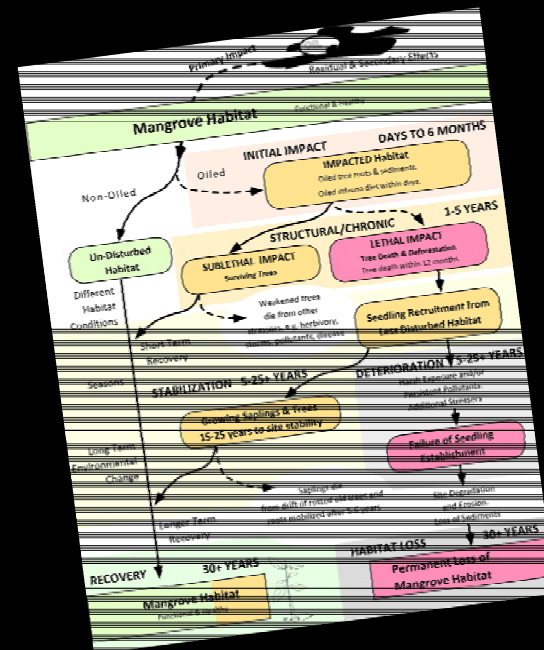
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# Recommendations

*better methods, more reporting ...*

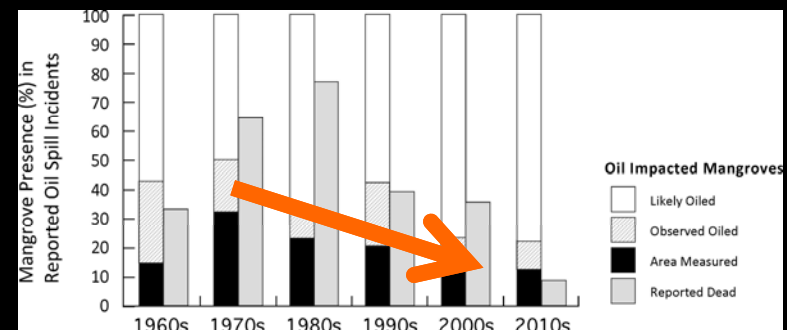
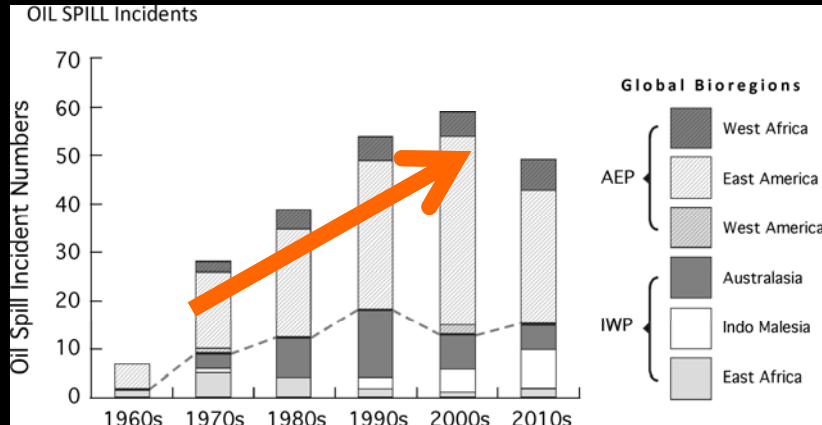


1. 'Response Plan' as Pre, During, Impact, Post (PDIP) spill
2. 'Report', record and make available publically, all relevant information about oil spill incidents
3. 'Establish baseline' condition of the oil- threatened mangrove shorelines
4. 'Collect data' on large oil spills in a standardized, expanded format
5. 'Record oil volume' the type, extent and concentrations
6. 'Post-spill monitoring of impacted habitat' to be conducted over 3-4 decades
7. 'Highest protection' for mangroves along exposed foreshores & fringing stands
8. 'Post-spill monitoring of impacted fauna' needs to continue for more than two years
9. 'Consider no-action default' and justify benefits versus habitat harm with intervention

# Concerns

## Should we be concerned?

- Oil spill releases have continued the same
- Incident numbers have increased in recent decades
- Notable gaps in the data available
- Recent decades decline in measurement and recording of oil spill impacts on mangroves

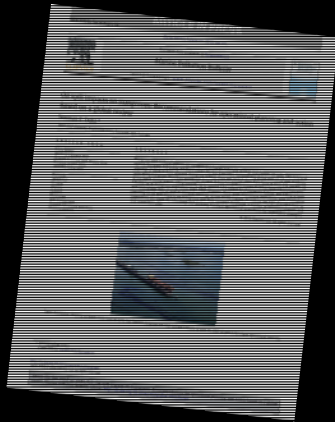




# Recommendations

## Managing & monitoring oiled mangrove habitat better

- Recommendations for improved record taking and monitoring
- Standard measures of impact
- Standard evaluations of recovery
- More reporting on incidents – past and present!







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A photograph of a mangrove forest with a person wading through the water, surrounded by dense mangrove roots and trees. Yellow and orange caution tape is strung across the area, indicating a research site.

Questions?

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