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

Dr Norman Duke  (norman.duke@jcu.edu.au)

Mangrove Hub  (www.mangrovewatch.org.au)

www.TropWATER.com
Oil spill impacts on mangroves

Further reading ...

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...

<table>
<thead>
<tr>
<th>Incident</th>
<th>Spill Year</th>
<th>Location (tidal range in m)</th>
<th>Type of Oil*</th>
<th>Oil Released (tonnes)</th>
<th>Mangrove Oiled (ha)</th>
<th>Mangrove Killed (ha)</th>
<th>Recovery Estimate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argea Prima</td>
<td>1962</td>
<td>Guayamilla Harbour, <em>Puerto Rico</em></td>
<td>CO</td>
<td>10,000</td>
<td>YES</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Tanker, unspecified</td>
<td>1966</td>
<td>Arabian Gulf, <em>Qatar</em></td>
<td>CO</td>
<td>13,000</td>
<td>Likely</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>General Colocotronis</td>
<td>1968</td>
<td>Eleuthera Island, <em>Bahamas</em></td>
<td>CO</td>
<td>4,878</td>
<td>Likely</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Ocean Eagle</td>
<td>1968</td>
<td>San Juan, <em>Puerto</em></td>
<td>CO</td>
<td>9,252</td>
<td>Likely</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>World Glory</td>
<td>1968</td>
<td>Durban, <em>Africa</em></td>
<td>CO</td>
<td>44,058</td>
<td>Likely</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td><em>Witwater</em></td>
<td>1968</td>
<td>Bahia Las Minas (0.6), <em>Panama</em></td>
<td>D, BFO</td>
<td>2,544</td>
<td>~490</td>
<td>49</td>
<td>80+</td>
</tr>
<tr>
<td><em>Oceanic Grandeur</em></td>
<td>1970</td>
<td>Torres Strait (2.6), <em>QLD, Australia</em></td>
<td>CO</td>
<td>&lt;4,100</td>
<td>~10</td>
<td>1</td>
<td>90-100</td>
</tr>
</tbody>
</table>

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.
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
How to MangroveWatch

- 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.
How to MangroveWatch
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.
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 spills impact on mangroves
## Recovery Phases

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

- Oiled area
- Oil type
- Tidal flushing
Recovery – tidal flushing

NOTE:
Single incidents of oiling only
Mangrove Regeneration vs. Recovery Time & Canopy Height

Influence of repeated oil contamination
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
Experimental work on oil spill impacts on mangroves – lack of recent studies

![Bar chart showing mangrove presence (%) in reported oil spill incidents from 1960s to 2010s. The chart includes categories for likely oiled, observed oiled, area measured, and reported dead. The chart highlights a significant decrease in reported dead mangroves from the 1980s to the 2010s.]
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 management of oil spill incidents
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!
Questions?

www.TropWATER.com