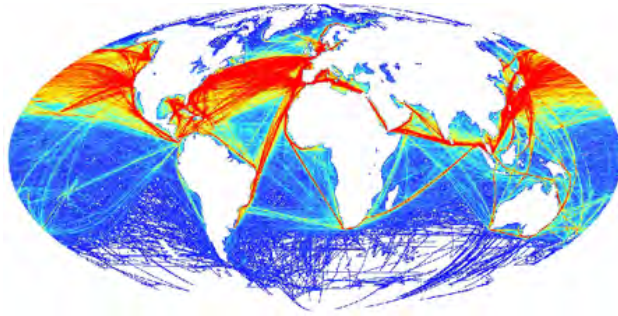


MV Marathassa spill in Vancouver: lessons learned

Peter S. Ross,
Carmen Morales & Mark Yunker



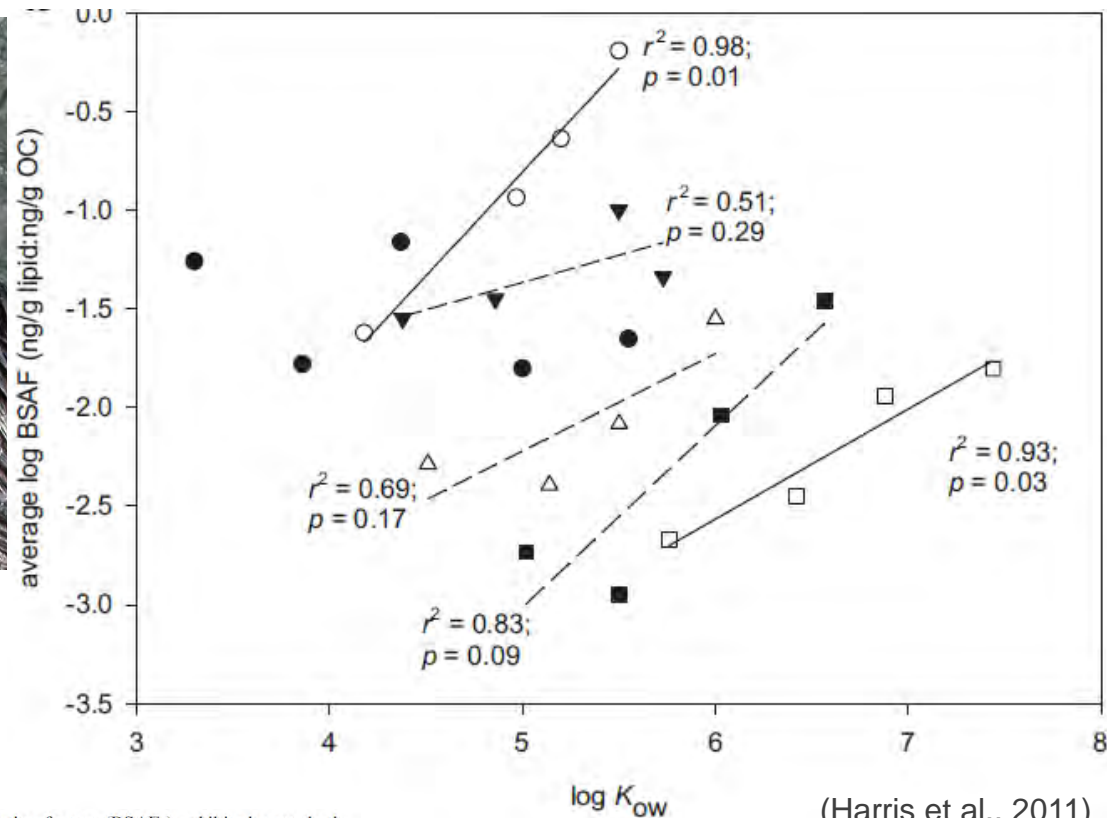
Despite representing a fraction of all fuels released into the ocean, spills are highly visible accidents with lingering impacts



Alkyl PAHs bioaccumulate in sea otters feeding on invertebrates



(Vancouver Aquarium)



(Harris et al., 2011)

Fig. 4. Biota-sediment accumulation factors (BSAFs) exhibited a quadratic relationship with increasing $\log K_{ow}$ values for parent PAHs (a). Interestingly, alkyl polycyclic aromatic hydrocarbons (PAHs) within groups exhibited increasing BSAFs with increasing $\log K_{ow}$ values, suggesting that the addition of alkyl groups led to greater retention (b). The BSAFs were calculated as the ratio of lipid-corrected PAH concentrations in a food-basket prey composite to organic carbon (OC)-corrected PAH concentrations reported elsewhere for sediments in the same area [27]. Solid circles = alkyl naphthalenes; open circles = alkyl fluorenes; solid triangles = alkyl dibenzothiophenes; open triangles = alkyl phenanthrene/anthracenes; solid squares = alkyl fluoranthene/pyrenes; open squares = alkyl benz[a]anthracenes/chrysenes.

April 8, 2015: *MV Marathassa* was anchored in English Bay: marine environment, 60 m deep, influenced by freshwater from the Fraser River



(CTV News)

- Major urban center
- Many recreational beaches
- Seabird, salmon and marine mammal habitat

Human error is the likely cause of the discharge of Bunker fuel

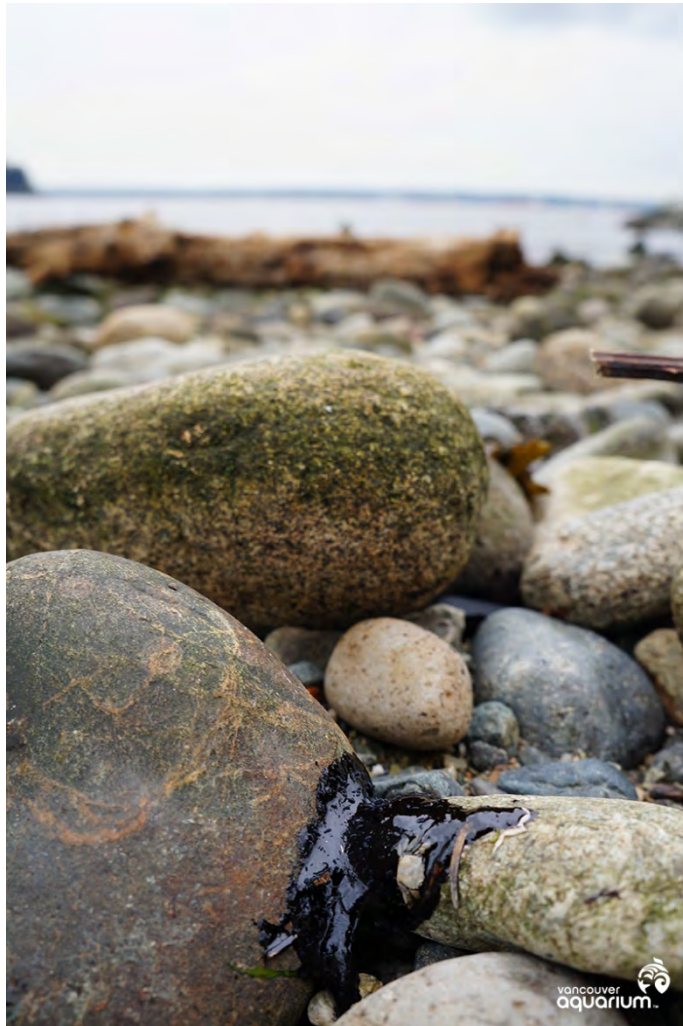
- Over 3,000 L of Bunker fuel was released from a grain carrier at anchor in English Bay;
- It took 14 hours for local emergency officials to be notified by Coast Guard, which led to considerable anger and distrust among responsible agencies;
- It took 6 days for samples to be collected for enforcement & official environmental monitoring;
- Independent sampling efforts were carried out by groups that normally would not carry out this work, including the Vancouver Aquarium, local municipalities and public health officials;
- Oil was visible on popular city beaches and shorelines, adding to public distress and critical media reports;
- Ultimately, the environmental impact was modest but political damage was done.



Oil was visible at the high tide line on shore at the City's most popular park (Stanley Park)



'Tar balls' appeared throughout the Vancouver shoreline region



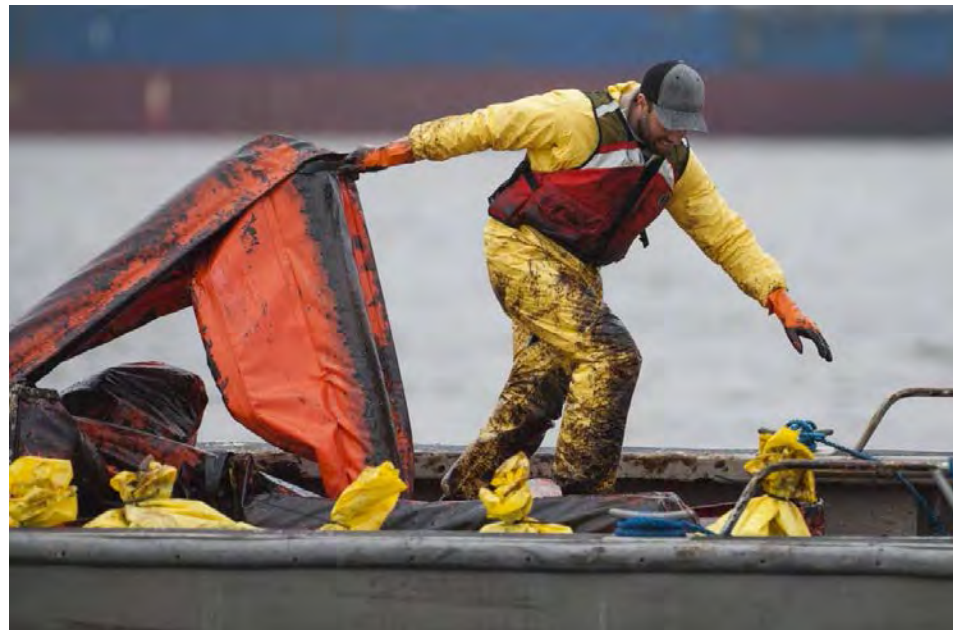
Cleanup crews (Western Canada Marine Response Corp) were deployed on the water and on shore



(WCMRC)



(DFO)



(Georgia Straight)

The spill took place near the Vancouver Aquarium, causing concern about risks to the facility, as well as local environment

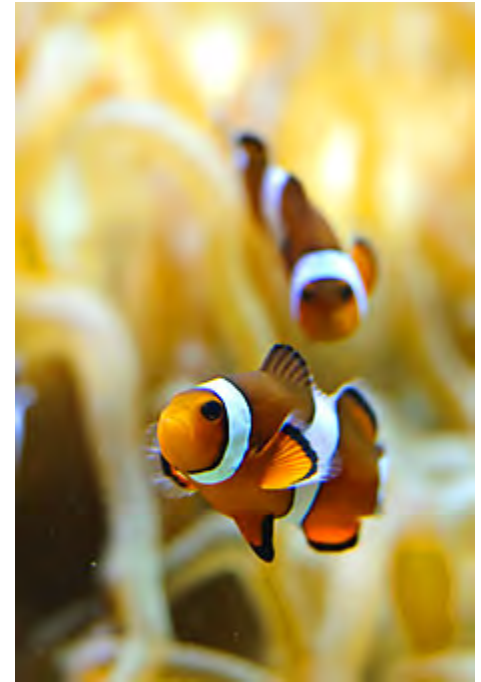
Vancouver Aquarium actions:

- Water management at the Aquarium;
- Dive operations at influent pipes;
- Marine wildlife surveys;
- Rescue and rehabilitation on alert for oiled wildlife;
- Risk-based assessment of hydrocarbons around Vancouver Aquarium;
- Communications and advice to emergency responders and Coast Guard.



Operational water emergency

- upon detection of vapors, surface sheen and oil on & in the water near the Aquarium water intake pipes, pumps were shut down and contained water was recirculated internally for the invertebrates, fish and marine mammals housed at the facility.
- Influent water was inspected visually. Water samples were collected and analysed.
- Shoreline surveys and sampling were carried out for analysis.
- A dive team was sent down to inspect influent lines and to collect sediment samples (also analysed) at depth.
- After 5 days of discontinuous closures, pumps were reactivated.



Marine mammal monitoring, rescue and rehabilitation preparedness

- Surveys were carried out at sea to document marine mammal presence in and around oiled areas.
- Rescue and rehabilitation teams were established and communications enacted with Oiled Wildlife Society teams.
- No oiled marine mammals were observed or taken into rehabilitation facilities.
- 30 waterfowl were impacted; many more likely affected.



The *MV Marathassa* spill: sample collection and analysis

- Upon learning of the spill, Science staff from the Vancouver Aquarium's Ocean Pollution Research Program surveyed the shoreline and water to collect samples of affected areas;
- Water influent at the Aquarium was collected;
- Samples were analysed for:
 - rapid screening
 - high resolution fingerprinting
- These and subsequent water, shore sediments, subsurface sediments, mussels sampling efforts were designed to shed light on the nature & extent of the spill and its risks to biota at a time when little was known.



First rapid analysis for hydrocarbons

- Thirteen environmental samples were submitted for the rapid analysis of CCME (F1-F4) in sediments and water, and PAHs in sediments, water and mussels.
- The methods used for the analysis:
 - CCME (F1-F4): GCFID, EPA 8260c R3 m, CCM PHC-CWS m
 - PAH: GCMS-SIM, EPA 8270d R4 m
 - PAH in tissue: GCMS, EPA 8270d
- First results (low resolution):
 - No volatiles in sediment
 - PAHs detected (low) in some sediment samples (high and low tide points)
 - No volatiles in water samples
 - No PAHs in water samples
 - Some xylene detected in a water sample
 - PAHs not detected in mussels



Other than 'oiled birds', how do we assess impacts or risks related to oil spills?

Comparison of hydrocarbon levels in sediment, water or biota to environmental quality guidelines (EQGs):

- Guidelines represent a useful management tool; they are designed to be easy.
- But guidelines have many limitations:
 - Do not protect all biota;
 - Are based on a limited number of lab-based studies;
 - Only consider a handful of the many hydrocarbons in fuels.



Forensics:

- Major interest over the last 30 years to identify the source of oil spills;
- To address responsibilities ('polluter'), assess penalties, and help recover cleanup costs;
- Challenges: complex nature of oils, weathering process.

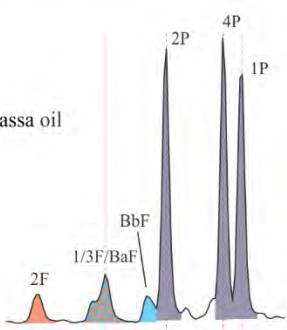
Hydrocarbon fingerprinting methodologies: High resolution and custom analyses



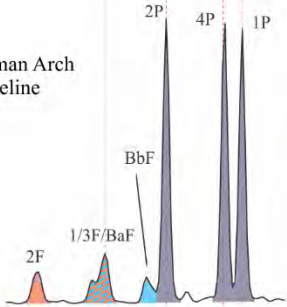
- Different approaches to fingerprinting analysis exist.
- Most frequently, the petroleum components that are analyzed include:
 - *n*-alkanes, acyclic isoprenoids and the unresolved complex mixture (UCM);
 - sterane and triterpene molecular markers (biomarkers);
 - unsubstituted polycyclic aromatic hydrocarbons (parent PAHs);
 - alkylated PAHs;
 - sulfur- and nitrogen-containing aromatic compounds.
- Generally a tiered analytical approach is used:
 - quantification of individual hydrocarbons;
 - comparison of compound ratios of source-specific marker compounds (e.g., target biomarkers and parent and alkyl PAHs);
 - assessment of the influence of weathering on the samples;
 - data integration and conclusions.
- The loss of *n*-alkanes and volatile PAHs evaluates the weathering process.
- Ratios of molecular markers and PAHs track the oil in water, beach sediments and invertebrates.

Stanley Park and Burrard Inlet shoreline oil samples matched *Marathassa* oil

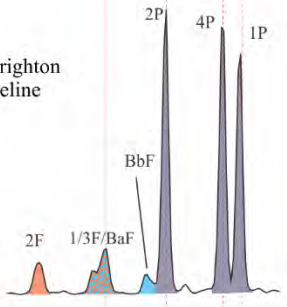
Marathassa oil



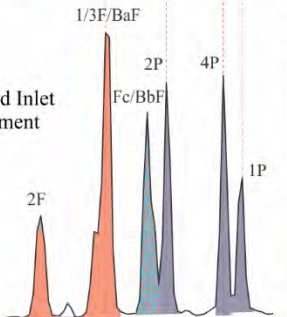
Lumberman Arch Shoreline



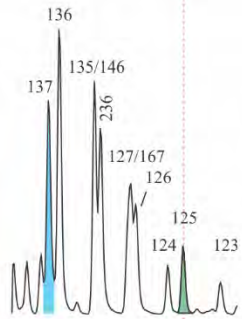
New Brighton Shoreline



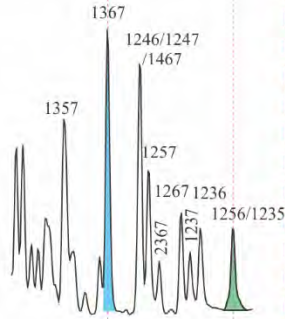
Burrard Inlet Sediment



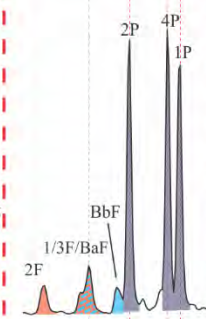
N3 - m/z 170



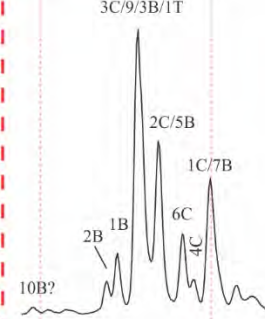
N4 - m/z 184



FP1 - m/z 216



BC1 - m/z 242



Marathassa Oil

Vancouver Aquarium shoreline

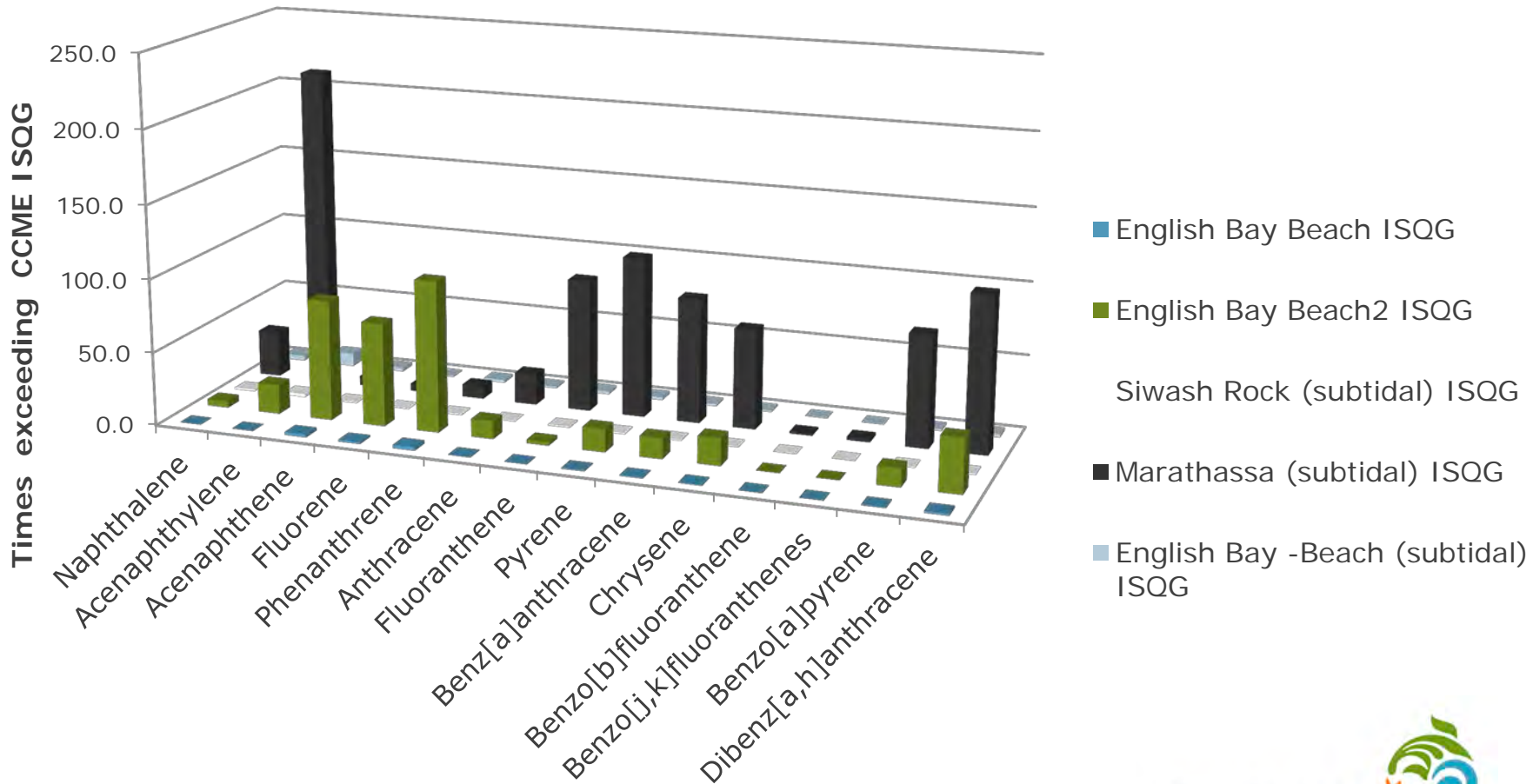


Match with Marathassa oil



Mixed signatures

Comparison to Sediment Quality Guidelines: Some samples collected after the spill exceeded CCME ISQGs



Provision of expert advice



- Staff of the Vancouver Aquarium ended up in the middle of an incident where little leadership could be found;
- As a result, staff provided advice and guidance to Tsleil-Waututh First Nation, the City of Vancouver, and ultimately, the Coast Guard Environmental Unit under Unified Command.
- These activities entailed literature research, conference calls, in situ meetings, document review and planning discussions.
- The Aquarium was subsequently a part of the Coast Guard-led Technical Advisory Group (TAG) and Project Management Office (PMO) for the *MV Marathassa*.
- An EIA is being produced by the Responsible Party.
- A post-incident 'hotwash' identified deficiencies and made recommendations for future incidents.
- A 3-day Coast Guard-led workshop will be held to design an area-based spill response framework.

Lessons learned: it is not just about responding, but *being prepared to respond*

- Both a response plan and an environmental monitoring plan need to be in place ahead of time;
- Samples need to be collected as soon as possible from the source (the 'parent' mixture) and the environment;
- High resolution analyses need to be carried out to inform source identification (fingerprinting);
- Risk assessment for ecological and human receptors must be considered;
- Pre-spill baseline 'signatures' are very important;
- Sediment cores and high quality data interpretation can inform historical sources of natural and anthropogenic hydrocarbons.

Thank you

- Tsleil-Waututh Nation
- City of Vancouver
- Fisheries and Oceans Canada
- Vancouver Aquarium staff
- Vancouver Police Department
- Maxxam Analytics
- AXYS Analytical Services