Oil-Spill Response, Recovery and Remediation for the 21st Century

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The oil industry has been creating significant oil-spills on water since at least 1907.[1] These continue today, with hundreds of events through the decades. [2] In the minds of most people, the major on-water spill event in recent times is the Deepwater Horizon (BP Macondo) blow-out which began on April 20, 2010 in the Gulf of Mexico during an exploratory drilling exercise. The well was permanently sealed on September 19 – five months later. There is one continuing take-away from the decades of major on-water oil-spills - the oil industry is not good at cleaning up spills.

The Macondo oil blow-out released at least 4 million barrels (approximately 635 million litres) of crude. The U.S. government estimated over 4.2 million barrels remained in the environment after accounting for recovered oil.[3]

In industry parlance (taken from the International Tanker Owners Pollution Federation (ITOPF), a large spill is over 700 tonnes (approximately 800,000 litres). In the industry's mindset a small spill is anything less than 7 tonnes (approximately 8,000 litres), which ITOPF does not record or report.[4] (ITOPF reports only events related to moving oil by tanker ship, and no other oil industry activity such as drilling, on-land storage or pipelines. It also does not address spills from ships which are not tankers, like the *M/V Marathassa*, including fuel spills, oily bilge discharges, or cargoes of refined oil products.)

We are still building vessels today which run on oil, and transport oil. We are still exploring for oil in deeper and more hostile waters. Climate change means stronger storms and more

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[1] Wikipedia, *Thomas W. Lawson* (ship), https://en.wikipedia.org/wiki/Thomas_W._Lawson_(ship) [accessed 2019.03.30]

[2] Fingas, Merv. 2012. The Basics of Oil Spill Clean Up. New York: CRC PressGESAMP. (2007). Estimates of oil entering the marine environment from sea-based activities. IMO/FAO/UNESCO-IOC/UNIDO/ WMO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection, Reports and Studies 75. p. 96; Wikipedia, List of Oil Spills, https://en.wikipedia.org/wiki/List_of_oil_spills [accessed 2019.03.30]

[3] U.S. District Court for the Eastern District of Louisiana, *Findings of Fact and Conclusions of Law Phase Two Trial*, http://www.laed.uscourts.gov/sites/default/files/OilSpill/Orders/1152015FindingsPhaseTwo.pdf [accessed 2019.03.30]

[4] ITOPF, *Oil Tanker Spill Statistics 2018*, https://www.itopf.org/fileadmin/data/Documents/Company_Lit/Oil_Spill_Stats_2019.pdf [accessed 2019.03.30]

icebergs for the next 50 years. We will be cleaning up oil-spills for decades to come. We should do a better job.

The Oil Industry Spill Response Toolbox

The following descriptions comprise only a brief summary of the efficacy of the various techniques. More exhaustive critiques of these techniques and equipment are available with little effort using an Internet search engine. The purpose of covering current industry practice here is not to provide detailed descriptions, but to indicate why these approaches are unsuitable today.

Attenuation

Also called 'natural attenuation', this means doing nothing active. Evaporation, weathering and oil-consuming microbes break down the oil into volatile and heavy components; the latter which sink and decompose into less complex molecules. Thirty years after the *Exxon Valdez* spill, natural attenuation has still not reduced the spilled oil to the point of eliminating even its smell.[5]

Dispersants

Since May 2016, dispersants have been the approved tool of choice in Canada for dealing with oil-spills on open seawater. Specifically, Corexit EC9500A is the only spill treating agent (STA) approved by Environment and Climate Change Canada (ECCC), while Corexit EC9580A is the only product approved as a surface-washing agent.[6] This pre-approval means that the operator may apply the STA to the spill without additional permission from the Minister, despite evidence of harm done by Corexit EC9500A following the BP Macondo oil release, and a number of factors which indicate it has very limited effectiveness in Canadian coastal conditions (it is not

5 Popular media accounts based on local resident interviews confirm the legacy effects; https://www.hakaimagazine.com/news/wounded-wilderness-the-exxon-valdez-oil-spill-30-years-later/. Accounts by NOAA are more sanguine: https://oceanservice.noaa.gov/podcast/mar14/mw122-exxonvaldez.html.

6 Government of Canada, Regulations Establishing a List of Spill-treating Agents (Canada Oil and Gas Operations Act), http://www.gazette.gc.ca/rp-pr/p2/2016/2016-06-15/html/sor-dors108-eng.html [accessed 2019.03.31]

recommended for use in waters below 10 degrees C or with low salinity).[7] When Corexit EC9500A is effective, it breaks down oil droplets into smaller droplets, making the oil more bioavailable to marine life. Studies indicate that Corexit EC9500A plus oil is more toxic than the oil alone. For more on issues with Corexit, see the author's letter to the ECCC of February 2016 and the Lawrence Anthony Earth Organization report *Chemical Dispersants and the Clean Water Act*.[8] There are dozens of scientific papers since the Deepwater Horizon oil release which have studied the effects of using chemical dispersants, and bring the efficacy of dispersants into doubt, and connect them to negative environmental impacts.

In-Situ Burning

In-situ burning is the practice of adding an accelerant (usually a highly flammable petroleum product) to the existing spill, and then setting the combined mass on fire. The result is that a contained spill of oil on the water surface is turned into an uncontrolled cloud of thick acrid toxic smoke and soot which pollutes the air for many kilometres downwind, covering a much larger area than the spill. In short, more pollution is added to the existing pollution, turning a water pollution event into a water and air pollution event. It is equivalent to garbage incineration, but without controls or scrubbers. This technique can only be used if the waters and winds are calm and the actual spill amount is small and contained.

Herding & Skimming

Herding an oil-spill has traditionally been done using booms to encircle the spill mass, in the hope of creating a deeper pool of oil than would be the case if it spread. Current work focuses on using chemicals called "herders", including “solidifiers” which form a gel or semi-solid ring

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[7] Fingas, Merv. 2017. *A review of literature related to oil spill dispersants.* Report to Prince William Sound Regional Citizens’ Advisory Council; Joye, Samantha, et al. (2016). The Gulf of Mexico ecosystem, six years after the Macondo oil well blowout . *Deep-Sea Research II* 129: 4–19.;
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.* Retrieved from *http://www.gulfspillrestoration.noaa.gov/restoration-planning/gulf-plan ;* Prince William Sound Regional Citizens' Advisory Committee, *Dispersants, Salinity and Prince William Sound,* http://www.pwsrcac.org/wp-content/uploads/filebase/programs/environmental_monitoring/dispersants/dispersants_salinity_and_pws.pdf [accessed 2019.03.31].

[8] LAEO, *Chemical Dispersants and the Clean Water Act*, http://protectmarinelifenow.org/wp-content/uploads/2015/07/LAEO-ChemicalDispersantsexcerpt-5yranniv-Apr2015-PRINT.pdf [accessed 2019-04-07]

by solidifying the edge of the oiled area, which is faster than laying a conventional boom. Research on herding/solidifying agents is ongoing but current judgement suggests this approach will be limited to highly controlled environments and small spills.[9] With the spill stopped from spreading, various kinds of skimmers or vacuums are used to pick up the oil from the surface. Most conventional skimmers are small and mechanically complex, pick oil up slowly, and cannot operate effectively in waves or winds. Emulsification and other time-dependent effects of weathering render most skimming technologies inoperable.[10]

Booms are only effective at containing oil under favourable conditions. The U.S. Coast Guard sets out the following conditions for booms to be effective:

- **waves must be less than 0.3 metres** (12 inches)**, and**
- **currents must be 1 knot or less, and**
- **winds must be less than 5.5 m/s ≈ 12 mph ≈ 19 kph**

ITOPF also notes water current, wind and waves lead to oil escaping from booms.[11] Booms are also ineffective where ice is present. As an indication of how easily these thresholds are exceeded, the current in the St. Lawrence river (downstream from Quebec City and upstream from this conference site) range from 1.5 to 3 knots. The average wind speed in Sept-Iles (on land) is 14 kph, while wind speeds over 70 km/h are experienced most months.[12]

Absorbents

An absorbent is any material which will absorb oil. In the world of small spills on land, this can be sawdust, kitty litter, paper towels, etc. For spills on water, the materials used generally don't absorb water (hydrophobic) but do absorb oil. In general, these materials have to be retrieved manually and create a larger volume of toxic material for disposal than the original spill.

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[9] Fingas, Merv. 2017 *op cit.* ; Hum, G., Hamza, H., 2016. *Strategies for mitigating the impact of Dilbit released into marine environments.* BC Research Inc.; Motta, F., Stoyanov, S., Soares, J. 2018. Application of solidifiers for oil spill containment: a review. Chemosphere 194: 837-846

[10] Nuka Research Inc., 2018. *Assessment of Demulsification and Separation Technologies for Use in Offshore Oil Recovery Operations* Report to Bureau of Safety and Environmental Enforcement. https://www.bsee.gov/research-record/assessment-of-oil-demulsification-and-separation-technologies

[11] ITOPF, *Use of Booms in Oil Pollution Response,* https://www.itopf.org/fileadmin/data/Documents/TIPS%20TAPS/TIP_3_Use_of_Booms_in_Oil_Pollution_Response.pdf [accessed 2019-04-07]

[12] My Weather, *Weather Data for Sept-Iles,* http://www.myweather2.com/City-Town/Canada/Quebec/SeptIles/climate-profile.aspx [accessed 2019-04-07]

The Canadian Spill Response Regime

Spill Response Organizations (SROs) only respond to spills where one of their fee-paying clients is responsible for the spill. Once a spill is discovered, it frequently takes time to establish who the owner of the leaking asset is, and to see if they are on the paid-up client list. This slows putting response equipment on-site, beyond the time taken to travel from base to site. Oil-spills get worse with time, limited only by supply. In that regard, they are a lot like house fires which burn until they run out of fuel or are put out. We have learned to maintain fire departments which respond when a fire is discovered and without regard to who owns the house or is responsible for starting the fire, and should use that model for oil-spills. In Canada, SROs are licensed by Transport Canada.

The 4 major SROs in Canada are:

West Coast Marine Response Corporation (WCMRC) owned by:

- Imperial Oil
- Shell Canada
- Chevron (now Parkland)
- Suncor
- Trans Mountain;[13]

Eastern Canada Response Corporation (ECRC) owned by:

- Imperial Oil Limited
- Ultramar
- Shell Canada
- Suncor;[14]

Atlantic Environmental Response Team (ALERT) owned by Irving Oil;[15] and

Point Tupper Marine Services owned by Texas-based NuStar Energy.[16]

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[13] WCMRC, *Who Pays for Spill Response Organizations in Canada*, http://wcmrc.com/news/pays-spill-response-organizations-canada/ [accessed 2019-04-07]
[14] ECRC, *Links*, http://secure.ecrc.ca/en/links/default.asp [accessed 2019-04-07]
[15] ALERT, *Marine oil spill response & cleanup - Bay of Fundy*, https://www.alertinc.ca/about-us/ [accessed 2019-04-07]
[16] NuStar Energy LP, *Novia (sic) Scotia / Point Tupper*, http://nustarenergy.com/en-us/OurBusiness/Assets/Pages/TR_PTTUP.aspx [accessed 2019-04-07]

The SROs are compensated according to vessel-hours spent on the spill site, not the amount of oil they remove. Even when there is a big spill, the oil industry makes money from the clean-up response exercise.

RESTCo and Oil-Spills

RESTCo principals and associates have been assessing oil-spill consequences since the Beaufort Sea Project in the 1970s.[17]

RESTCo has developed a set of criteria for evaluating oil-spill response and remediation tools focusing on net environmental benefit, and we have reviewed and evaluated several.

RESTCo Spill Response Evaluation Criteria

1. The product is effective at removing oil from the environment
2. Recovered oil is stored in air-tight containment to stop evaporation of volatiles, stop the weathering process and retain value of the recovered oil
3. The product can be deployed quickly to the spill scene (the fire department model)
4. The product minimizes exposure of responders to the oil
5. The product does not increase the level of damage to the environment and human health, short term and long term
6. The product does not convert one environmental problem (spilled oil) into another (air pollution, pollution of the water column and water bottom, large quantities of toxic waste which must be disposed of at special sites)
7. The product is cost-effective compared to current practice - including the cost to the environment
8. The product contributes to the full remediation of the contaminated site(s)
9. Preferred products and techniques have broad applicability and complement each other.

RESTCo also supports the IDROS response philosophy: Immediate, Definitive Recovery of Oil Spills.[18]

[17] RESTCo, *Beaufort Sea Project* Reprints, https://www.restco.ca/BSP_Reprints.shtml [accessed 2019.03.31]
[18] Extreme Spill Technology, *Immediate Definitive Recovery of Oil Spills*, http://www.spilltechnology.com/ [accessed 2019-04-07]

An Updated Spill Response, Recovery and Remediation Toolbox

Building on the RESTCo evaluation criteria and some of the tools we have evaluated, RESTCo proposes an updated toolbox for dealing with oil-spills on water:

- A multi-function spill response vessel which can arrive on scene rapidly, carry out assessment, perform rescue operations if required, and begin the spill response attack
- The ability to recover spilled oil or oil products from the water surface, even in inclement weather
- Move recovered oil to off-vessel containment to provide a higher on-mission duty-cycle
- Deploy adsorbent-based spill containment, if appropriate
- Deliver to and spread bioremediant over the contaminated zone when oil recovery operations are finished
- Routine monitoring until the contaminated area is determined to have been remediated, based on appropriate local standards

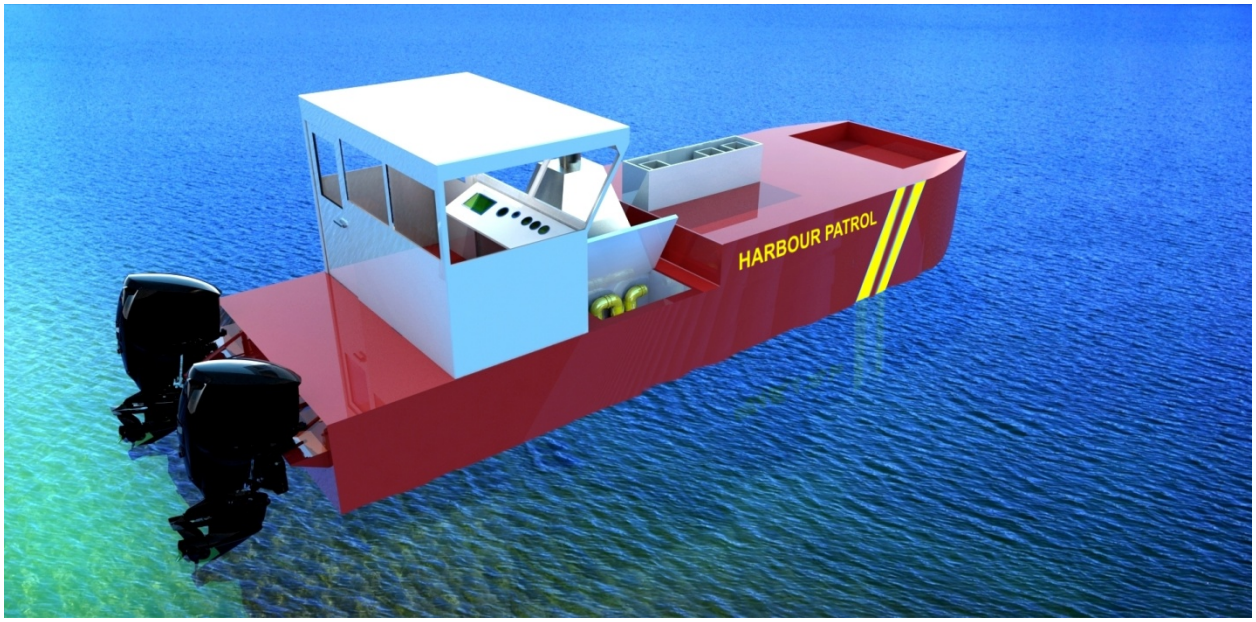
The Workboat (with Gravity Tower)

The boat with the gravity tower is capable of recovery rates over 90% in a pass based on third-party testing (Ohmsett)[19], in both calm water and waves. However, it is designed to be multi-functional so it can earn its keep on a daily basis, rather than being a single-function, dedicated 'wharf queen'. The sizing of the pump, required as part of the oil-recovery package, is large enough that it can also serve as a fire monitor or support pump-out operations. In work mode, the boat should have a large open-deck working area, suitable for carrying people, supplies or recovered material. A moon pool and hoist will be standard equipment, and can be used to support divers or lift items from below the surface.

In spill-recovery mode, the vessel can also carry other spill response tools, such as a camera drone to establish the nature and size of the spill zone, and tools and materials described in the following sections.

Crude oil recovered with this technology can be used as feedstock to a refinery. Other hydrocarbons recovered before being severely weathered can be used as heating fuel or for other purposes. The objective of this technology is to enable rapid response and recovery of spilled oil, removing it entirely from the environment.

[19] Oil Spill Response Research & Renewable Energy Test Facility, *The Ohmsett Gazette* (Fall/Winter 2012 issue), http://www.spilltechnology.com/Ohmsett%20Gazette%20Fall%202012%20Final_.pdf [accessed 2018-04-07]



6-metre Work Boat with Gravity Tower, Showing Pump Standpipes and Trash Collection Box at Bow

RESTCo is currently designing a trailerable shallow-draft version which could be used in creeks to get close to spill sources, and carry an ATV (or people or supplies) to an isolated land-based work zone. We envisage this boat being valuable as an urban flood response vessel (evacuation or pumping out basements or sandbagged buffer zones), or for rescue on small water bodies or ice (lightweight, self-powered, large flat bottom). It might also be suitable for use in marinas and small sheltered harbours.

RESTCo Shallow Water Skimmer 1/5th Scale Model

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Reusable Adsorbent Filter Fabric

This material is made from recycled plastic, and at end of life can be recycled as waste plastic. Mixtures of water and liquid hydrocarbons can be poured or pushed through the fabric, with only the water exiting; the oil is trapped in the fabric. When saturated, the fabric can be wrung out mechanically to recover captured oil (up to 85% of the amount can be released), then returned to service.

The product comes in a variety of standard formats, including adsorbent pads, filter socks, staked fences, curtain booms, boom covers, etc., and custom designs can be accommodated. (Canadian distributor product list.)

U.S. EPA listed.

Adsorbent, reusable boom cover and 15" square pads

Polymer Powder

Polymer powder is poured directly onto the oil and encapsulates the oil at a molecular level, forming a flexible mat and rendering the oil non-toxic. On a spill of several square metres, the powder can be poured around the edge of the spill to contain it and the contained oil can be removed using adsorbent, skimmers or vacuums, or one can simply use enough powder to capture all the oil. The chemically-inert, gelled mats can be retrieved manually, and unused material picked up, dried and stored for future use. No material or oil need be left in the environment.

The mats of bound oil can be burned as a solid fuel, or are safe for landfill. They could also be recycled into low-strength plastic products.

U.S. EPA listed.

Small Diesel Spill, Polymer Powder Applied, and Being Folded up for Removal

Bioremediation

An enzymatic concentrate (OSE II) is mixed with local water to create a solution which can be sprayed onto the spill surface. As a result, no invasive microbe species are introduced into the local environment, and there is no need to transport the water component of the mixture to the spill. The oil is rendered non-volatile on contact, and the oil is fully decomposed within days to weeks.

Typical bioremediants can be used on fresh water, soil, and marshy areas, as well as on sea-water. After evaluating one specific product, RESTCo sees bioremediation - and the above-mentioned product - as a valid, effective tool for oil-spill response and remediation. This product will not recover oil, but it will eliminate spilled oil from the environment.

U.S. EPA listed. More information available at bioremediationcanada.org.

Texas Crude Oil-Spill - Before and After Applying Bioremediant

Conclusion

The mainstream oil industry, including its SROs, has a response regime which inhibits rapid response and has consistently low effectiveness in removing spilled oil from the environment. Many of its key tools turn spilled oil on the water surface into different environmental problems, have limited effectiveness in Canadian conditions, or both. We can do better.

For ports and harbours, we can move to the 'volunteer fire department' model for oil-spill response instead of the insurance industry claims model to enable rapid response. We can shift to less expensive and more effective tools for spill response than are currently used by the SROs. We can enable community first responders to get on scene with appropriate equipment and materials and the training to use them. We can remediate contaminated waters and land to near pre-spill levels within months. We can do all this cost-effectively with solutions which are currently commercially available or being commercialized now.