WHEN OIL IS THE LESSER OF TWO EVILS: COMPARATIVE RISK OF THE SHIPWRECK EMPIRE KNIGHT

Cornell Rosiu[1], Stephen Lehmann[2], David Sherry[3], Wyman Briggs[3], Peter Blanchard[4]

[1]USCG District 1, Boston, MA; [2]NOAA Office of Response and Restoration, Lowell, MA; [3]USCG Sector Northern New England, S. Portland, ME; [4]Maine DEP, Division of Response Services, Augusta, ME

INTRODUCTION

At the height of WWII in February of 1944, the 428-ft British ship EMPIRE KNIGHT (**FIGURE 1**) ran aground on Boon Island Ledge off York, Maine during a storm. It broke in two and sank with the stern section in 243-ft of water where it remains today. Her hull contained 10,000-bbls of diesel fuel oil, military tank and locomotive parts, 5-in cannon shells and 16,000-lbs of elemental mercury (Hg^0) stored in 221 glass and steel carboys (**FIGURE 2**). This poster summarizes the wreck disposition and its environmental assessment and ongoing monitoring.

FIGURE 1

FIGURE 2

In 1993, the U.S. Coast Guard (USCG) oversaw emergency removal of 1,200-lbs Hg^0 through a hole cut in stern cargo hold #5 representing <10% of the cargo of Hg^0 (**FIGURE 3**). The remainder was assumed to have migrated to the lower portion of the shipwreck beneath a cargo of military hardware and live ammunition.

FIGURE 3

EMPIRE KNIGHT site chronology

1944: Vessel runs aground and breaks apart.
1990: Wreck comes to the attention of D1 CG.
1993: CPN assigned & limited removal action.
1,200 lbs Hg^0 removed from cargo hold #5.
2,200 lbs Hg-contaminated debris removed.
15,000 lbs Hg^0 remained unaccounted, however.
1996: Safety zone established.
1998 - 2012: Monitoring results indicate best course of action is to monitor Hg periodically.
2013: NOAA RULET risk assessment published.

After the limited removal action, sediment and marine life were sampled and analyzed. Maximum total mercury in these media was several parts-per-million (mg/kg) inside hold #5 and 1-2 order-of-magnitude less around the wreck site. The spatial distribution of sediment mercury indicated the highest concentrations were closest to the wreck. Marine life sampled from around the site had <1 mg/kg (below the FDA action level).

In 1995, a permanent safety zone was established at a 1000-yd radius prohibiting activities such as commercial salvage that could spread contamination. Mercury is a priority pollutant that accumulates in marine life and can bio-magnify in the environment. In 1998, 2004 and 2012, blue mussels (*Mytilus edulis*) were used as a sensitive method of monitoring mercury in the environment. Objectives of the long-term monitoring were to answer the following questions:

1. Does mercury at the wreck site pose unacceptable risk to human health or the environment?
2. How do concentrations on-site compare across stations, up-current and at background?

NOAA published its *Remediation of Underwater Legacy Threats (RULET) Risk Assessment for Potentially Polluting Wrecks in U.S. Waters*, ranking shipwrecks nationwide on the likelihood and severity of oil discharges to the environment (NOAA, 2013a). EMPIRE KNIGHT was ranked 12th of 13 in USCG District 1 (Canada border to northern New Jersey) with an estimated "medium" risk and ≤10,000-bbls (≤420,000-gals) bunker marine diesel onboard. The present study enabled a comparison of the risks of onboard mercury and an oil discharge from the hull to the environment.

MATERIALS AND METHODS

Survey of the wreck site

A hydrographic survey of the shipwreck EMPIRE KNIGHT in 2011 updated the position and condition of the hull (**FIGURE 4**). Its position was refined to approx. 250-yds southeast of its previously charted position (**FIGURE 5**) but remains inside the permanent safety zone.

FIGURE 4

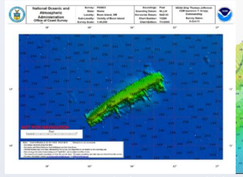
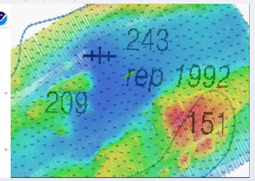


FIGURE 5



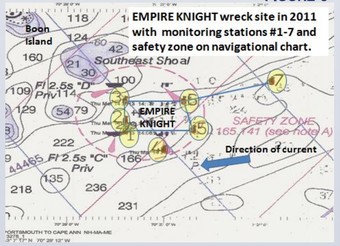
Construction and placement of blue mussel sample panels

In 2011, 1150 blue mussels (*Mytilis edulis*) were collected from an uncontaminated site ("Control") on the Maine coast previously determined to be free of elevated levels of mercury. Live mussels were selected in the size range of 40 to 50-mm to reduce data variability due to age. They were weighed and measured and divided into 42 composite samples of 25 individuals each and placed in cages within individual pockets of 0.25-inch plastic mesh bags. The cages were then suspended in seawater until deployed to the wreck .

Upon deployment, control mussels (unexposed) were shucked/frozen, representing the mercury concentration at time zero and the start of the 60-day deployment. Cages containing 25 live blue mussels each were deployed by station around the site at varying depths throughout the water column, 3-m off the bottom. Mid-depths were approx. 40-m off the bottom.

FIGURE 6

Six moorings (Stations 1 – 6) were placed in a circular array approx. 500-m from the updated shipwreck position (**FIGURE 6**). Station 7 was a reference station up-current of the wreck.



Sample collection and mercury analysis

Cages containing the live blue mussels were "incubated" on-site for approximately 60-days which is optimal to achieve peak mercury uptake based on the research literature (Maine DEP, 2003). After 60-days, cages containing live mussels were retrieved and individual mussels were weighed and measured. Soft tissue was removed composited by station and water depth. Each sample was labeled, frozen and shipped on dry ice under chain-of-custody to the USEPA Regional Environmental Laboratory (Chelmsford, MA). Analyses were run for total mercury, iron and aluminum (USEPA, 2012).

RESULTS AND DISCUSSION

Mercury bio-monitoring

Results of monitoring EMPIRE KNIGHT in 1998, 2004 and 2012 indicated mercury bioavailability was limited and did not pose unacceptable risk to human health or the environment. Mussels sampled on-site had higher concentrations compared to Control (background) (**FIGURE 7**). Concentrations did not differ by station or water depth (**FIGURE 8**). Analysis of the data in 2012 by iron-normalization sample-by-sample indicated mercury concentrations co-varied equally with iron (**FIGURE 9**) and may provide evidence of why mercury had limited bioavailability. Both metals can sorb particles suspended in the water column and are fed upon by marine organisms (Liu and Cai, 2011). After ingestion, particle-bound mercury and iron may travel the lumen of the gut and never become assimilated (Wang and Fisher, 1999). In this way, the 2012 data can support a conclusion of limited mercury bioavailability.

FIGURE 7

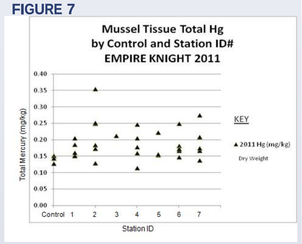


FIGURE 8

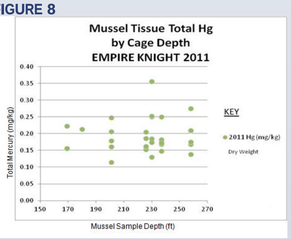
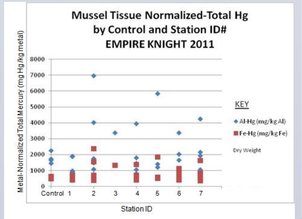


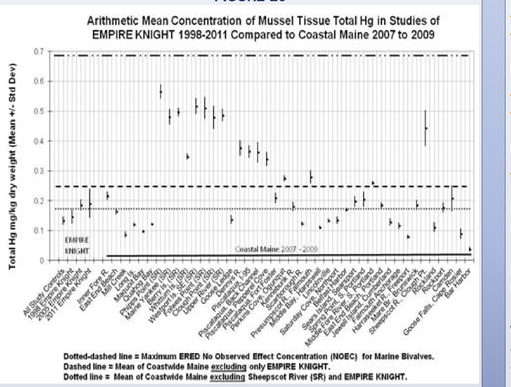
FIGURE 9



CONCLUSIONS

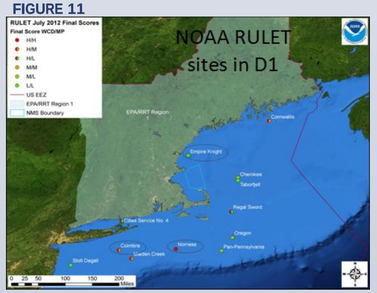
Results of monitoring EMPIRE KNIGHT in 1998, 2004 and 2012 indicate mercury does not pose unacceptable risk to human health or the environment. Moreover, average concentrations of mercury across the three years are less than averages in mussels sampled from 2007 to 2009 in areas of the Gulf of Maine coast that have no known point sources of mercury contamination (Maine Gulfwatch, 2007; 2009) (**FIGURE 10**).

FIGURE 10



NOAA ranks EMPIRE KNIGHT 12th among 13 RULET shipwrecks in USCG District 1 with "medium" risk of oil discharge (NOAA, 2013b) (**FIGURE 11**). Conclusions from the most recent study of EMPIRE KNIGHT indicate continued monitoring, with adjustments incorporating improved methods as necessary, is the best course of action (as opposed to another effort to remove additional mercury). Disturbing the wreck to recover oil onboard has the potential to spread contamination and make the mercury more bioavailable.

FIGURE 11



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James Stahlnecker, Maine Department of Environmental Protection

NOAA Emergency Response Division

CONTACT

For More Information, contact:
Cornell.J.Rosiu@uscg.mil
617-223-8434