Chapter 1 LINGERING OIL MONITORING

INTRODUCTION TO LINGERING OIL MONITORING

Dan Esler¹, Brenda Ballachey¹, Mark Carls², and Mandy Lindeberg²
¹U.S. Geological Survey, Alaska Science Center, 4210 University Drive, Anchorage, Alaska 99508
²NMFS, Alaska Fisheries Science Center, Auke Bay Laboratories, 17109 Pt. Lena Loop Road, Juneau, Alaska 99801

Introduction
Gulf Watch Alaska is funded by the Exxon Valdez Oil Spill Trustee Council (EVOSTC), and includes continued examination of effects of the oil spill, as well as monitoring of ecosystem variation that influences species and services injured by the spill. A major issue associated with prolonged recovery of some species is that of “lingering oil”, i.e., Exxon Valdez oil persisting in intertidal sediments with subsequent exposure and effects on nearshore wildlife. The Lingering Oil Component of Gulf Watch Alaska is designed to monitor the occurrence and state of lingering Exxon Valdez oil, and to evaluate direct effects on vulnerable wildlife species.

Background
Extent and Timeline of Diminishment of Lingering Oil
In March 1989, the T/V Exxon Valdez ran aground on Bligh Reef in eastern Prince William Sound (PWS), spilling an estimated 42 million liters of crude oil (Wolfe et al. 1994). In the days and weeks after the incident, spilled oil moved south and west through PWS and then into the Gulf of Alaska (Figure 1-1; Galt et al. 1991). Roughly 40% of the spilled oil landed on beaches within PWS (Galt et al. 1991), affecting at least 783 km of shoreline (Short et al. 2004). The extent and degree of oiling on shorelines decreased rapidly over the first few years after the spill, and it was assumed that remaining oil would be reduced to negligible amounts soon thereafter (Neff et al. 1995). However, observations up to 8 years after the spill indicated that oil remained in intertidal sediments of some beaches (Hayes and Michel 1999) leading to concerns that lingering oil could continue to have harmful effects on fish and wildlife populations, and the nearshore ecosystem.
Prompted by concerns about lingering Exxon Valdez oil, a study was initiated in 2001 (12 years after the spill) to evaluate the amount and distribution of lingering oil in PWS. Short et al. (2004) found that both surface residues and subsurface oil persisted on some beaches, including the majority of beaches that were classified as heavily or moderately oiled within 4 years of the spill. Surface deposits were highly weathered and largely transformed into asphalt-like material, which was considered to have low toxicity and low bioavailability and pose minimal threats to fish and wildlife. However, subsurface oil was liquid and much less weathered than surface residues (Hayes and Michel 1999), leading to concerns that the subsurface oil might be both bioavailable and toxic. Short et al. (2004) estimated that the areal extent of subsurface oil in 2001 was 7.8 ha and the mass of remaining oil was 55,600 kg. These were considered to be moderate underestimates, given several factors that would lead to a low bias (Short et al. 2006). For example, subsurface oil was found lower in the intertidal than anticipated, at elevations not sampled during the 2001 effort; this may have led to an underestimate by roughly 30% (Short et al. 2006). Despite uncertainty about the exact amount of lingering oil, all estimates were well under 1% of the amount thought to have originally stranded on PWS beaches. However, the mass and volume remaining and the toxic potential of subsurface oil elicited continued concerns about effects of lingering oil on wildlife populations.

Subsurface oil presumably has been declining in occurrence and extent over time, through disturbance of sediments associated with storm events, foraging by intertidal animals, including sea otters, and other releasing, weathering, and degrading processes. The rate at which attenuation occurs is unknown and presumably becomes progressively lower over time (Short et al. 2004, 2007, Integral 2006), with oil persisting longest in areas that are least susceptible to depletion processes (Short et al. 2007, Michel et al. 2010). As of the time of this report, it is known that some oil remains within sediments of some beaches of PWS (Li and Boufadel 2010, Xia and Boufadel 2011) (authors’ personal observations), and recent efforts have estimated the distribution of lingering oil patches (Michel et al. 2010). However, the current amount of lingering oil, and thus the degree to which it has declined since estimates were made using data from 2001 and 2003 (Short et al. 2004b), are not known. We note that residual Exxon Valdez oil also has persisted and remains in some areas outside of PWS (Irvine et al. 2006, 2014, Short et al. 2007); again, the amount of that oil is uncertain.
Exposure and Effects of Lingering Oil on Wildlife

For lingering oil to have effects on wildlife individuals and populations, animals must be exposed to that oil at levels that have meaningful biological consequences. This requires evaluation of the timeline and degree of exposure, as well as the timeline and degree of effects, which cannot be assumed to be the same and which vary considerably among species (see Esler et al., this report).

Following the Exxon Valdez oil spill, numerous studies indicated that wildlife continued to be exposed to oil well beyond the first weeks and months after the spill. Many of the studies of oil exposure were based on indicators of cytochrome P4501A (CYP1A) induction, which is elevated in animals when they are exposed to one of a limited number of compounds, including polycyclic aromatic hydrocarbons found in crude oil. Differences in indicators of oil exposure animals living in oiled and unoiled areas of PWS were largest and most persistent for animals in intertidal habitats, particularly those that consume benthic invertebrates that live on or in the sediment, such as harlequin ducks (Esler et al. 2010).

To assess potential for oil exposure in sea otters, a recent study (Bodkin et al. 2012) estimated the average number of times a sea otter would encounter oil annually at heavily oiled northern Knight Island, based on 19 sea otters with abdominally-implanted time and depth recorders. Bodkin et al. (2012) found that while 82 percent of the more than a million foraging dives were subtidal (not at risk for encountering lingering oil), all individuals foraged in intertidal zones at least some of the time. Each otter averaged between 8 and 91 intertidal foraging dives per day. From these data, Bodkin et al. (2012) estimated that sea otters would encounter subsurface lingering oil an average of 10 times each year, ranging from 2 to 24 times, depending on individual foraging routines and based on oil distributions in the early 2000s.

In summary, the body of evidence suggests that many intertidally-foraging vertebrates were exposed to lingering Exxon Valdez oil for years to decades post-spill. The data indicate improvement in conditions over time, with varying timelines of exposure among species (see Esler et al., this report). These findings not only indicate the expected pattern of declining exposure over time, they also support the conclusion that elevated levels observed earlier were related to exposure to Exxon Valdez oil when it was more abundant, rather than other contaminants.

As a result of evidence that sea otter and harlequin ducks were more vulnerable to effects of the Exxon Valdez oil spill than other wildlife (see Esler et al., this report), detailed examinations of population recovery have been conducted for these two species. Studies conducted prior to initiation of Gulf Watch Alaska indicated direct effects of exposure to lingering oil on both sea otters and harlequin ducks.

Recent Activities within Gulf Watch Alaska

The Lingering Oil component of Gulf Watch Alaska has focused on continued evaluation of exposure and population status of sea otters and harlequin ducks, the two species with strongest evidence of continued, direct effects of lingering oil. For harlequin ducks, these efforts have included continued monitoring of CYP1A induction to evaluate exposure to lingering oil. For sea otters, activities include collection of carcasses to document age class distributions of dying otters as an indicator of mortality patterns and aerial surveys to evaluate changes to abundance and distribution.

Recent evidence indicates both cessation of continued exposure to lingering Exxon Valdez oil, as well as recovery of sea otter and harlequin duck populations (see Esler et al., this report). As the signal from the oil spill diminishes, the value of the data collected during Gulf Watch Alaska becomes more relevant for understanding natural variation and interactions within the nearshore ecosystem.

Considerations for Future Directions

Although there is no evidence of continuing effects on wildlife, lingering Exxon Valdez oil remains within the beaches of PWS and elsewhere in the Gulf of Alaska. The amount of lingering oil is small relative to the amount that originally stranded (Short et al. 2004) and presumably has diminished since the last quantitative estimate was conducted in 2001 and 2003. A lingering oil monitoring survey will be conducted in PWS during the summer of 2015 at 10-12 sites known to have persistent subsurface Exxon Valdez oil. Continued monitoring of these sites will allow us to quantify how much oil remains and assess
the oil’s weathering state through time. Because the rate of change is expected to be slow, intermittent evaluation (e.g., once every 5 years) is likely adequate.

The body of work supported by the EVOSTC over a 25-year period, leading up to and including that of Gulf Watch Alaska, has led to an unprecedented understanding of the mechanisms and duration of effects on wildlife following a catastrophic oil spill. As presented by Esler et al. (this report), latest findings indicate that direct effects of lingering Exxon Valdez oil on wildlife in PWS are no longer detectable. Given the most recent findings, additional monitoring related to wildlife effects of lingering oil is unlikely to provide new information.

References


