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EXPERIMENTAL RECOVERY OF SEA OTTER CARCASSES AT KODIAK ISLAND, ALASKA, FOLLOWING THE EXXON VALDEZ OIL SPILL

On 24 March 1989, the T/V *Exxon Valdez* ran aground in Prince William Sound, Alaska, spilling approximately 11 million barrels of crude oil. Oil was deposited on beaches nearly 700 km from the spill site (Galt and Payton 1990, Piatt *et al.* 1990), affecting thousands of hectares of sea otter (*Enhydra lutris*) habitat. Two of the principal limitations in determining the initial effects of the Exxon Valdez oil spill on sea otter populations were a lack of recent population data, and a lack of information on the proportion of the total number of sea otters killed by the spill that were actually recovered.

In late April and early May oil spread to the Kodiak Archipelago. With the oil came wildlife rescue, beach cleanup, and other spill-response activities including searches for dead birds and mammals. We took this opportunity to assess experimentally the recovery of sea otter carcasses in the Kodiak Island area. Specifically, we were interested in the proportion of the total number of dead sea otters the recovered carcasses represented.

Twenty-five sea otter carcasses, collected earlier during spill-response operations, were removed from frozen storage. All carcasses were intact, with the exception of one specimen that was missing its head. Eighteen of the carcasses were large, presumably adults, two were subadults, and five were pups. The carcasses were in various stages of decomposition, and nine had varying amounts of oil on their pelage. Each carcass was marked in the interdigital webbing of one hind foot with a numbered white plastic tag. Carcasses were released individually in waters of northern Kodiak, southern Afognak, and Raspberry islands, generally within 200 m from shore. Carcasses were released in areas where otters were known to concentrate as determined from an ongoing radiotelemetry study (DeGange and Monson, unpublished data).

Carcasses were released as they became available between 27 May and 1 June. All of the carcasses except two floated when released.

Sixteen contract boats involved in beach clean-up, wildlife rescue, and carcass recovery were active during the spill response in the Kodiak Island/Alaska Peninsula area (Ford *et al.* 1991). Crews on these boats routinely collected dead birds and mammals when they were encountered. They were not notified of the release of the marked sea otter carcasses.

Five sea otter carcasses were recovered; all were adults. Three of the five carcasses were intact; the remaining two were partially scavenged. At least three of the five carcasses were found in the study area, two relatively close to their release sites. The recovery sites of the remaining two carcasses were unknown. We were unable to determine if carcasses were found in the water or on land.

Our results suggest a recovery of about 20% of the released carcasses. A 95% confidence interval for the recovery estimate of 20% ranged from 7%–41% (binomial sampling: Neave 1981).

Several factors influence the recovery of sea otter carcasses. First and most importantly is whether or not carcasses float or sink, which may be influenced by cause of death. Sea otters that are shot or die from other trauma usually float. Sea otters that drown may sink (A. Doroff, personal observation; J. Ames, personal communication). For seabirds, the longer a carcass is in the water the higher the probability it will sink (Ford *et al.* 1991). A portion of sea otters affected by oil from the Exxon Valdez and suffering thermal stress probably drowned and sank. Others sought refuge on land to avoid thermal stress thereby increasing their probability of recovery.

Drift patterns also will influence recoverability. Strong currents are common in our study area, and we suspect that some carcasses were swept out to sea. Strong winds also will move carcasses and affect the probability of a carcass coming ashore. Peculiar to our experiment is the effect of freezing on the floatation of carcasses. Thawed bird carcasses tend to float low in the water and sink more readily than fresh carcasses (Ford *et al.* 1991), making them less visible or less likely to come ashore.

Scavengers may remove carcasses from the beaches. Brown bears (*Ursus horribilis*) were occasionally seen in our study area and may have removed carcasses. The prevalent scavengers in the study area were bald eagles (*Haliaeetus*

leucocephalus) which may have carried away carcasses of pups but most likely would have left larger carcasses on the beach.

Lastly, marked sea otter carcasses may have lost their tags, potentially resulting in an underestimate of recovery. In a study of marked sea otter carcasses in California, some lost their tags due to rotting (J. Ames, personal communication). It is unknown if tag loss was a problem in the Kodiak study.

The applicability of our results to the overall recovery of sea otter carcasses following the Exxon Valdez oil spill is unknown. The timing and location of captures of live sea otters and recovery of carcasses suggest that sea otters in Prince William Sound and along the Kenai Peninsula were more heavily affected by oil than those at Kodiak Island (DeGange and Lensink 1990, Hill *et al.* 1990, Williams *et al.* 1990, Fish and Wildlife Service, unpublished data). These areas differ oceanographically, topographically, and in the amount of time and resources devoted to searching for live sea otters and carcasses after the spill. Ford *et al.* (1991) report that only 16 contract boats were active in the Kodiak Archipelago and along the Alaska Peninsula, compared to 40 for the Kenai Peninsula and 31 for Prince William Sound. Nevertheless, our results suggest that the number of sea otters that died as a result of the Exxon Valdez oil spill is much greater than the number of carcasses recovered (see Garrott *et al.* 1993).

Garrott *et al.* (1993) independently estimated that 19% of the sea otters killed in Prince William Sound during the oil spill were recovered, a result very similar to our own. Therefore, if we assume that the 781 spill-related sea otter carcasses found throughout the spill area represented 20% of the mortality, then about 3,905 sea otters (95% CI = 1,904–11,157) may have died. Garrott *et al.* (1993), using the same procedure, estimated that 4,600 sea otters died from the spill; however, they must have used an earlier carcass count that included animals that died from causes unrelated to the oil spill.

Only one other study has examined recovery of sea otter carcasses. Wendell *et al.* (1986) found that 4 of 12 (33%) sea otters incidentally taken in fishing nets set from boats in California, eventually came ashore and were found. That study may not be directly comparable to our own because all of the otters in the California study sank after marking, and their recovery was thought to be a function of the production of decomposition gas which may refloat carcasses (J. Ames, personal communication).

Our results are generally consistent with results from drift experiments with marine birds in which recovery varied from 0% to 59%, and averaged 17% (see review in Piatt *et al.* 1991). Piatt *et al.* (1990) suggested that 10%–30% of the marine birds killed as a result of the Exxon Valdez oil spill were recovered. Ford *et al.* (1991) using data collected from experiments conducted one year after the spill, estimated that 8% of the seabird carcasses were recovered.

It is difficult to generalize about recovery of marine mammal carcasses after mortality events since it is event and locality specific. Few data are available, various marine mammal species have differing floatation characteristics, environmental conditions may vary from place to place, and search intensity may be highly variable. For these reasons we strongly urge that statistically rigorous recovery experiments based on marked carcasses be an integral part of any

contingency plans developed for future environmental perturbations, and that these experiments be conducted at the time of the response to these events.

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