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The Restoration Attempts on Sea Otter Habitat after the Exxon Valdez Oil Spill in Prince William Sound

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Introduction

The night of March 23, 1989 a tragedy struck in the Gulf of Alaska. The *Exxon Valdez* tanker ship carrying thousands of barrels of oil ran aground and its hull cracked open. Much of this crude oil spilled out into the Prince William Sound (PWS) region of Alaska. This spillage affected numerous ecosystems in the area. From the marine habitat to the forested areas, the impact of the spill was felt all over the region. Deaths occurred in the thousands of numerous species of plants, animals and fish. People from all over Alaska aided in the cleanup and the restoration efforts in PWS. The restoration of the site included removal of oil and habitat restoration.

One of the species that was affected by this tragedy was *Enhydra lutris*, commonly known as the sea otter. Already struggling to combat the low populations occurring after the fur trade of the early 1900's, this species was faced with another drastic blow to population numbers. This paper will look at the habitat of the sea otter, the population numbers pre and post spill, what types of methods were used to clean to habitat of the sea otter, and whether or not the attempts were successful in restoring the existing communities. It should be noted that the primary purpose of restoration was not focused on sea otter habitat, it was just one of many areas affected by the restoration efforts. To understand the site background information will be given to aid in understanding the spill in relation to the site.

Background

Prince William Sound (PWS) is located on the southern side of Alaska by the top of the Gulf of Alaska. It is an arc of 850 miles (1368 km) extending from the Aleutian Islands (west) to the islands of southeast Alaska. The site has a full range of seasonal change, including glacial activities that are the largest outside of Antarctica and Greenland. The open water areas of PWS are the approximate size of Chesapeake Bay, with over 2,000 miles (3219 km) of shoreline (Stewart et al. 1991). The site is home many different marine mammals and birds, along with hosting nesting areas for numerous species of fish. Located on the southeast side of PWS is Bligh Island. In association with the island is a reef system that range from 13-40 feet (4-12 meters) deep (Davidson, 1990). These reefs will be the indirect cause of the *Exxon Valdez* oil spill.

The tanker carrying 11 million gallons (42 million liters0, of Prudhoe Bay crude oil tried to navigate its way through a specified corridor. The corridor was narrow with the Bligh Reef on one side of it. The tanker hit the reef causing the hull to rip open, spilling the oil (Birkland, 1998). Western PWS took the majority of the spill injury that night (Botelho et al., 1997). After the spill, the state and federal governments led the initial clean up. Once initial efforts were completed, both state and federal governments sued the Exxon Corp. Once trial was done, Exxon was found responsible for the spill and a civil settlement of $971.2 million was decided. At this point the Exxon Valdez Oil Spill Trustee Council was formed to determine the allocation of the funds. The funds were used for five main areas: reimbursements, research, monitoring and general restoration, habitat protection, restoration reserve and public information, science management and administration (Wolmac, 2001 personal communication).

The spill occurred immediately before the biologically active season in PWS. Major migrations of marine life took place in the two months following the spill as many organisms were beginning crucial periods in their life cycles. The spill did not interrupt the migration of schools of fish, but did kill many migrating birds as well as a number of sea otters (Stewart et al., 1991).

Sea Otter Community

Prior to the spill, PWS was minimally degraded. The sea otter, *Enhydra lutris*, had been making a recovery in the Gulf of Alaska after the fur harvest that took place from 1741-1911. In 1911, the sea otters came under protection by the federal government. The populations of otters are estimated to have grown 9% each year after 1911 (Paine, 1996). In 1985, 4,747 otters were counted throughout PWS (Bodkin & Ballachey, 1997). In western PWS otters were thought to have a population of close to 826 pre-spill (Garshelis & Johnson, 2001). These population numbers show that there were numerous otters in the PWS area pre-spill, however, no comprehensive surveys were done in the PWS area prior to the spill. Many of the population numbers that have been found are based on estimates of post spill carcass recovery (Garshelis, 1997).

Sea otters rely on benthic species for their food supply, so they are limited to the areas where they can dive for the prey easily (Bodkin & Ballachey, 1997). Otters can feed on more than 30 different types of shellfish and other prey. The diet of the otter is specific based on the area in which it lives and personal taste choices (Cohn, 1998). The otters will congregate on shorelines and on kelp beds to rest, eat and play. These areas are normally 40 meters or less in depth (Bodkin & Ballachey, 1997). The kelp stands provide shelter and food for the fish, shellfish, and urchins that the otters feed on. They also aid in the protection of the otters from their predators. Studies have shown that there is a direct correlation between sea otter populations and the amount of kelp and sea urchins present in the area. Higher numbers of otters means higher populations of kelp and fewer sea urchins. When the otters are taken away, the kelp begins to disappear due to the urchins feeding (Cohn, 1998).

The Restoration

The primary focus was on restoring the landscape to the original form prior to the spill (Botelho et al., 1997). Since the oil treatments revolved around shoreline ecosystems a number of different treatments were considered to rid shorelines of the oil. The main purpose in the clean-up process was to remove as much oil as possible with out harming any of the surviving ecosystems. The clean up efforts were designed to minimize spread of oil to non-contaminated sites. There were five main methods of removing the oil from the shoreline: manual, hydraulic, mechanical, chemical, and bioremediation. To accomplish efficient clean-up, PWS was divided up into sectors to make it easier to determine the type of treatment needed. Teams with over 1000 personnel were made to conduct the cleaning operations in various sectors (Mearns, 1996)

There was a wide range of manual cleanup methods used. Hand washing, hand picking, raking, and vegetation cutting were among the manual methods of cleanup on the shoreline. Tar balls were picked up by hand, oil that was pooled was manually taken care of by tilling, raking and shoveling with hand tools, Seaweed was cut and removed by hand along with other vegetation that was harmed by the oil (Mearns, 1996). Although this method was the most time consuming and achieved much of the oil removal, there was no data that expressed how much of the shoreline was cleaned by this method or any of the other methods mentioned below.

Hydraulic cleaning took place by using cold, warm or hot seawater with low, moderate or high-pressure sprayers. High-volume flushing of the areas took place after the shoreline was sprayed down. The shoreline was steam cleaned and some areas were flooded forcefully (Mearns, 1996). High pressure flushing did not take place due to the fact that organisms and substrate would have been removed along with the oil. This method removed an estimated 15-27% of the oil from the rocks (Paine et al., 1996).

If the area contaminated was composed of boulders, mechanical treatment was used. Mechanical treatment utilized backhoes, tractors and front-end loaders to dig out beach material and redistribute it. Steel cables tines were used to agitate the sediment to release oil before the tides had a chance to rise (Mearns, 1996).

Bioremediation was used most extensively. Bioremediation accelerates chemical degradation of oil remaining after the mechanical and manual treatments were unsuccessful. The beginning of the bioremediation process involved application of slow-release pellets that contained nitrogen and phosphorous fertilizers, Customblen™ (Mearns, 1996). These fertilizers were added to the shoreline to test whether or not biodegradation accelerated without causing eutrophication of the coastal sites (Paine et al., 1996). No chemical (other than bioremediation) treatments were utilized on the shoreline treatments after 1989 due to regulation changes (Mearns, 1996).

No matter how hard a section might have been to access, or how saturated it was, all shoreline was treated. Each section was given individual attention and treatments varied from three to ten different treatments. Treatments occurred from 1989-1991 (Mearns, 1996). Today there are still treatments being done to remove the residual hydrocarbons from sediments and shorelines (Paine et al., 1996).

Restoration and the Sea Otters

Just prior to the spill, the populations of otters were estimated as high as 10,000 (Stewart et al., 1991). About 1,000 carcasses were recovered following the spill. Many others were presumed to be dead but the bodies were not found. Mortality rates of adults and juveniles were high in 1990 and 1991 due to oil still remaining in the ecosystem of the sea otters. From 1990-1993 an estimated 2800 otters died in total after the spill in PWS (Botelho et al., 1997). Approximately 357 otters were captured and taken to rehabilitation stations, out of these 357 otters, 197 of them were eventually released and 25 of them were moved to permanent holding facilities (Paine et al., 1996).

After the tanker spilled the oil all over PWS, sea otters were extremely vulnerable to the oil (Bodkin & Ballachey, 1997). Since the otters spend most of their time on the surface they rely on their dense fur, which has an entrapped layer of air that aids in the buoyancy and insulation. Contamination from oil on the fur of the otters increases heat production and grooming. Otters have a hard time compensating for this increase in metabolism. Also the oil decreases the insulation and buoyancy of the otter making them more vulnerable in the northern climates (Johnson & Garshelis, 1995). While grooming, otters consume mass quantities of oil which cause many digestive problems. Numerous otters died due to liver and kidney problems associated with hydrocarbon ingestion (Botelho et al., 1997).

Sea otter populations had the most numerical and visible impact, most of the money flowed towards them. An estimate $18.3 million was used for capture and rehabilitation of the oiled otters and $3-4 million was granted for damage assessment and research of the otters. Later analysis determined that rehabilitation of the otters cost $80,000 for each individual animal (Paine, 1996).

Otter Recovery

Post-spill emphasis was placed on research and monitoring after the restoration. After reimbursement to federal and state governments after cleanup work was completed, $180 million was dedicated to research, monitoring and restoration efforts. An additional $108 million was put into a savings account with the full understanding that the restoration may occur for decades after the time of the spill. Along with restoration reserves a total of $423.1 million was set dedicated to habitat protection, science management, public information and administrative duties. Reserve funds are being looked at to aid in other restorations (Mearns et al., 1998).

Sea otter recovery is underway for much of the area. However, there have been some areas that have been reported to not be recovering, these areas are in the heavily oiled bays in western PWS. In 1997 there were still some biochemical evidence of the oil exposure to sea otters in the northern part of PWS (Botelho et al., 1999). In un-oiled areas of PWS a population increase of 14% was seen. Populations of otters in the oiled areas of PWS experienced a 35% decrease. These percentages were based on data received pre-spill (Botelho et al., 1997).

By 1992 and estimated 2% of the original oil remained on the beaches, and there was some oil found in sediment in 1997. There have also been reports of toxic components persisting where the oil is protected from weathering. From 1996-1998 wild otters in oiled areas had significantly higher hydrocarbons than the otters from un-oiled areas. This suggests that there is continued contaminant exposure to the otters (Monson et al., 2000).

Otters from all ages have shown elevated mortality rates in the nine years after the spill. Otters that were 4-5 years old during 1989 have shown long-term effects of the spill. There was immediate loss of otters in the aftermath of the spill, but there are long-term important changes that limited recovery. Although some research has shown the populations of otters to be increasing, there is also an increased mortality rate of those otters that have been exposed to the oil spill (Monson et al., 2000). Observations have shown that otters spend more time resting and less time feeding after the spill. The decrease in the amount of food present for the otters to consume could be an influence on behaviors observed. However, these conditions are improving in the western PWS but not in northern PWS (Garshelis & Johnson, 2001).

Due to the spill 1,200 miles (1931 km), of marine shoreline is being monitored through the habitat protection program. New research and monitoring methods have been developed after the spill. New aerial surveying has been developed to monitor sea otter populations. New information has arisen on understanding reproductive rates of sea otters, which helps understand the recovery after the fur trade. Methods include trapping and tagging of the sea otters from the PWS area to track movement, population and seasonal activity (Botelho et al., 1999).

Since many of the plants had to be removed by hand to prevent any spreading of the oil to further areas, a food source was depleted from the sea otter and from the prey that the otters feed on, these plants are contained in the intertidal communities. The intertidal communities are important to the sea otters. The numbers of plants and invertebrates (kelp, sea urchins, etc.) are less abundant now in the oiled areas than in the un-oiled areas. Both the spill and clean up efforts affect the recolonization of these communities. The seaweed, *Fucus gardneri* (rockweed, popweed) was reduced in abundance during the spill. The rockweed has not fully recovered; the key to intertidal communities recovering is by recolonization of this plant. Addition of these plants should take place to ensure the success of intertidal community reestablishment (Botelho et al., 1999).

Sea urchin (part of the intertidal communities) populations grew due to the lack of otters present. There was a plentiful population of food for the otters in the early 1900’s for them to draw on. Sea urchin populations were effected by the spill and other intertidal species have yet to fully recover (Botelho et al., 1999). There is a smaller food source in the area for otters to draw on making it tougher for them to fully recover. To aid the sea otter recovery, more focus has to be put on restoring these intertidal communities of benthic species and the different plant communities.

Although there is little evidence of intertidal communities and plant life recovering, there has been no effort to catalyze restoration of these communities. The natural processes of the area are being left alone to see if colonization will take place on its own. To date, there has been no research money requested for restoration of plant communities in the intertidal area. Also, there has been no money dedicated to direct study of sea urchin and intertidal recolonization techniques after the spill (Womac, Personal Communication).

Recolonization experiments have been done in sample plots to determine whether meiofaunal colonies will be able to colonize on oiled sediments. These experiments began in 1990 to study the long term effects of the degrading oiled sediments on the meiofauna. These studies have failed to demonstrate any negative effects on the colonies. In fact rapid colonization was found in these experiments (Fleeger et al., 1996).

There are future research projects on the horizon to study intertidal communities. In February of 2001, funding from the Exxon Valdez Oil Spill Trustee Council was requested to evaluate the amount of oil remaining in the intertidal communities. This project will take place in two phases. Phase one, from October – November, will be the project planning process. Phase two, from December to September, will sample the shorelines for surface and subsurface hydrocarbon residue. 8 km, 5 miles, will be sampled by digging more than 8,000 pits to quantify subsurface oil (EVOSTC, 2001).

Conclusion

Although the sea otter has been listed as fully recovered, the population deficit of 35% in the spill area indicates recovery remains incomplete. The restoration plan of the Exxon Valdez Oil Spill Trustee Council had only been partially met in the past years. They still need to focus on habitat restoration. Much of the research conducted during the past 10 years has concerned effects of the spill on animals. While the research findings will help in quicker treatments for future spills, they need to look at repopulation processes. In addition, intertidal community restoration requires attention.

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