A Three-Year Study at Winsor Cove

Salt Marsh Grasses and #2 Fuel Oil

By George R. Hampson and Edwin T. Moul

The marsh grass community in a small cove in Massachusetts that was affected by spilled oil from a barge in October of 1974 has shown a progressive resistance to reestablish itself over the last three years. The sediments in some areas around the marsh grass roots contain high concentrations of petroleum hydrocarbons, which have impregnated the peat substrate. Erosion rates over the three-year period have been 24 times greater than those at a nearby control site.

These findings stem from a spill of undetermined amount that occurred on October 9, 1974. On that date, the barge *Bouchard No. 65,* loaded with 73,000 barrels of Number 2 fuel oil, hit a submerged object while traveling northeast into Buzzards Bay. She was then towed to the west entrance of the Cape Cod Canal, where she was anchored at the entrance to Hog Island Channel (Figure 1). By the day following the accident, an undetermined amount of oil had escaped from the 2.4-meter split in the *Bouchard's* hull, and strong southwest winds were driving the slick ashore on Bassett's Island and into Red Brook Harbor. This oil remained on the surface in this area for approximately 10 days.

The initial rough seas had made it impossible to contain the spill by use of a "boom." As is often the case, oil containment both at sea and on land is ineffective because of excessive wind conditions and lack of proper organization in the clean-up operation. In this case, much of the oil released from the barge escaped the confines of the boom.

Shortly after the oil came ashore, there were signs of massive kills of marine life — crabs, snails, soft- and hard-shell clams, and so on. A total of 4,360 invertebrates, comprising 110 species (2 of which were fish), were collected in eight separate samplings. This article, however, will not deal with this aspect of the spill, but will focus on the effect of the oil on the marsh grasses at Winsor Cove.

About three weeks after the spill, we noticed that the marsh plants in Winsor Cove — *Spartina, Salicornia, Limonium* — were exhibiting the same "browning" effect from Number 2 oil as seen in the West Falmouth spill of 1969 (see page 15). In contrast, a nearby

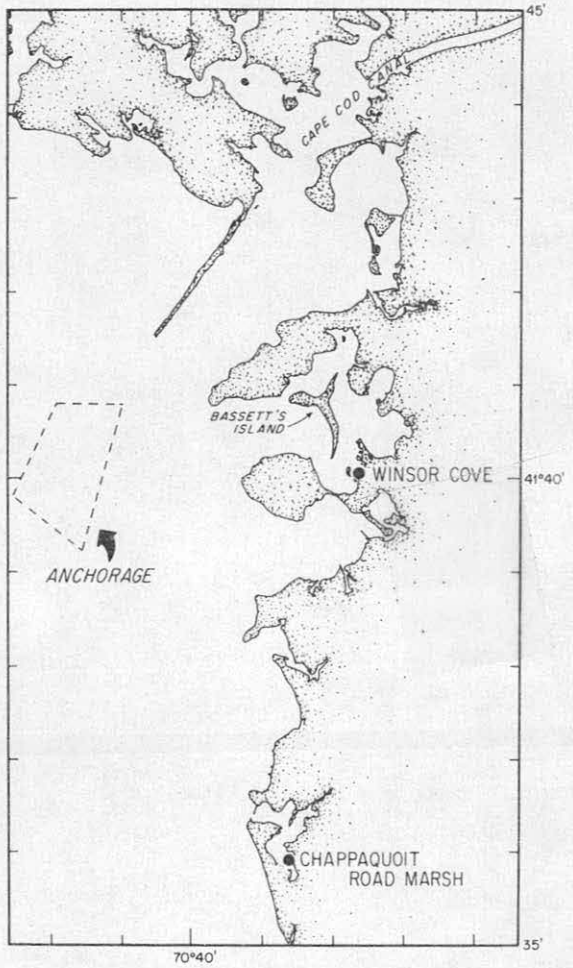


Figure 1. The Winsor Cove area on Buzzards Bay, Massachusetts.

marsh at Chappaquoit in West Falmouth Harbor showed no evidence of "browning" or discoloration, thus making it an obvious candidate for a "reference" station.

In Winsor Cove and off Chappaquoit Road a series of quadrats were established, running perpendicular from the low to the high waterline. An aluminum frame (41 x 35 centimeters) was used as a boundary marker, and the first quadrat was placed at the water's edge. The locations of the 18 successive quadrats were determined by a series of wooden stakes that were driven into the marsh. The species and individual stem counts

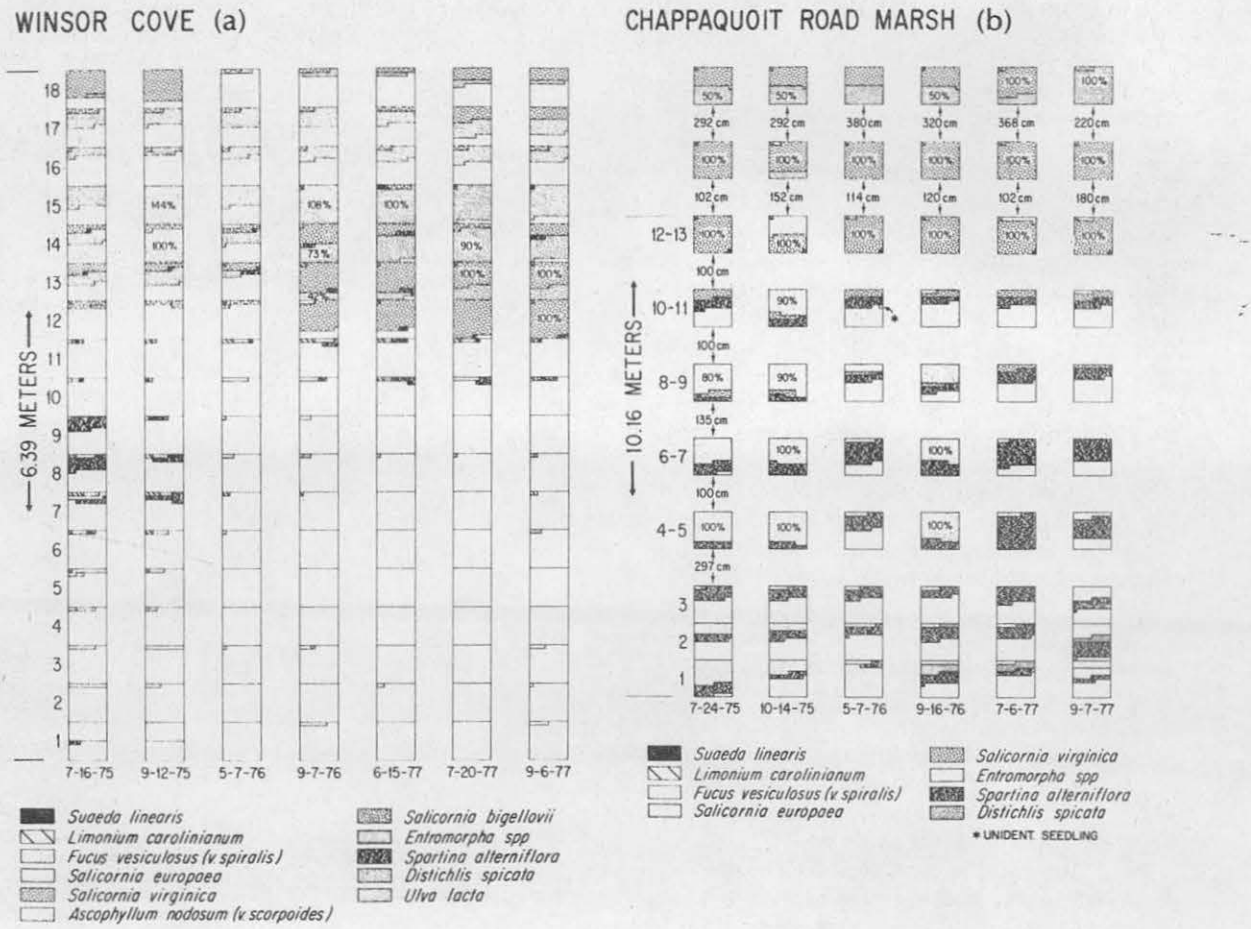


Figure 2. Quadrat species composition during sampling study. Winsor Cove (a); Chappaquoit (b).

of the marine grasses within each plot were recorded from July 15, 1975 to September 7, 1977. Figure 2a and b are comparative graphs for Winsor Cove and Chappaquoit, showing the quadrat species composition during each sampling period for the length of the study.

The Chappaquoit station was selected because of its similarity in flora, prevailing winds, and protection from wave erosion. The control transect was arranged differently in that all the quadrats were not adjacent, primarily due to a more gradual marsh slope. In some cases within a floral community, quadrats were spaced apart in order to reduce excessive repetition of data.

Precise photographic stations were established with permanent markers in Winsor Cove on October 23, 1974. The photographs accompanying this article document the growth of *Spartina alterniflora* and *Salicornia* before and after decomposition (Figures 3 and 4).

Since the *Bouchard* spill, the depauperate marsh grass community in Winsor Cove has not significantly reestablished itself either by reseeding or by rhizome growth. In the spring of each year, some species sparsely regenerate a few seedlings or stems (*Limonium* and *Fucus*), but by late summer, the majority of the new recruitments are either absent or remain seedlings or dwarfed specimens.

Spartina Growth Measurements

In September 1976 and 1977, a series of comparative random height measurements were made of *Spartina alterniflora* stems growing in Winsor Cove and at the control site in West Falmouth. The polluted marsh was roughly divided into an upper and lower marsh

as determined by the noticeable boundary between a highly stressed plant growth — the lower zone located within quadrats 1 to 11, and the somewhat more productive higher zone between 12 to 18. The control station also was divided into a comparative upper and lower marsh zone, and measurements were made at similar times.

Results over three years show that generally plants found growing on the upper slope were larger and more abundant than identical species measured in the lower zone. However, the reduced *mean stem counts* of *Spartina* recorded in the transect did not show any significant difference between the low and high marsh. The greatest dissimilarity between these two zones was found in *mean stem* heights, where a 2 to 4-fold difference was measured between the low and high marsh in Winsor Cove.

These variations in growth can be attributed to the fact that the substrate of the lower intertidal zone was more impregnated with fuel oil because of the absorptive ability of the peat and its proximity to the tide range. In this zone, exposure to initial oiling was more frequent than on the upper slope, which sometimes was beyond the reach of high tide. In addition, the substrate of the upper marsh was generally sandier and more susceptible to purging from tidal exchange. In the control site, data consistently showed a greater *Spartina* stem count in both high and low zones in comparison with the effected area, with the exception of the seepage area, which we will discuss next. Stem height in both zones was significantly greater than Winsor Cove in 1976. However, the values of the lower and upper marsh were similar by 1977.

Seepage Area

Water seepage continually passed over the sediments in the lower marsh during low tide at Winsor Cove. Therefore, the base of the plants was continually being flushed with a surface flow of water that prevented the plants and sediments from becoming heavily impregnated with oil. It is significant that the surface substrate in the seepage area was sandy mud mixed with coarse gravel. In this zone, *Spartina alterniflora* regeneration was only marginally affected by the spill, and growth exceeded that found elsewhere in the Winsor Cove area. This drainage area, in conjunction with the sand-gravel substrate, probably aided in flushing the initial oil from the *Spartina* roots, and served as an insulating factor from the chronic pollution thereafter. The usual strong odor of oil found in the sediments and in the peat at Winsor Cove was lacking in this area. Also, a source of nutrient enrichment might have been contained in the seepage water, thereby contributing to growth enhancement.

Burk's Study

A study by J. C. Burk (1977) includes a four-year analysis of vegetation polluted by a fuel oil spill in a freshwater marsh off Mill River in Northampton, Massachusetts. Data on long-term marsh destruction show similarities to results from the Winsor Cove study. Eighteen out of the 45 total plant species found before the spill were not present the following season. Perennial species were generally less affected than annuals. However, in Winsor Cove, a high mortality and persistent impairment of growth was evident in both perennials and annuals. As found in Winsor Cove, certain species in Mill River continued to decline in abundance during the second season. Vegetation in Mill River in the "high marsh" and "mid-marsh" zones had substantially recovered by the third and fourth years, and the "low marsh" was unaffected. In Winsor Cove, however, the low marsh is still acutely affected and the less impacted high marsh has begun to recover in terms of average stem heights. As previously mentioned, in Winsor Cove the mean stem number in both zones remained far below comparable numbers calculated from the control marsh.

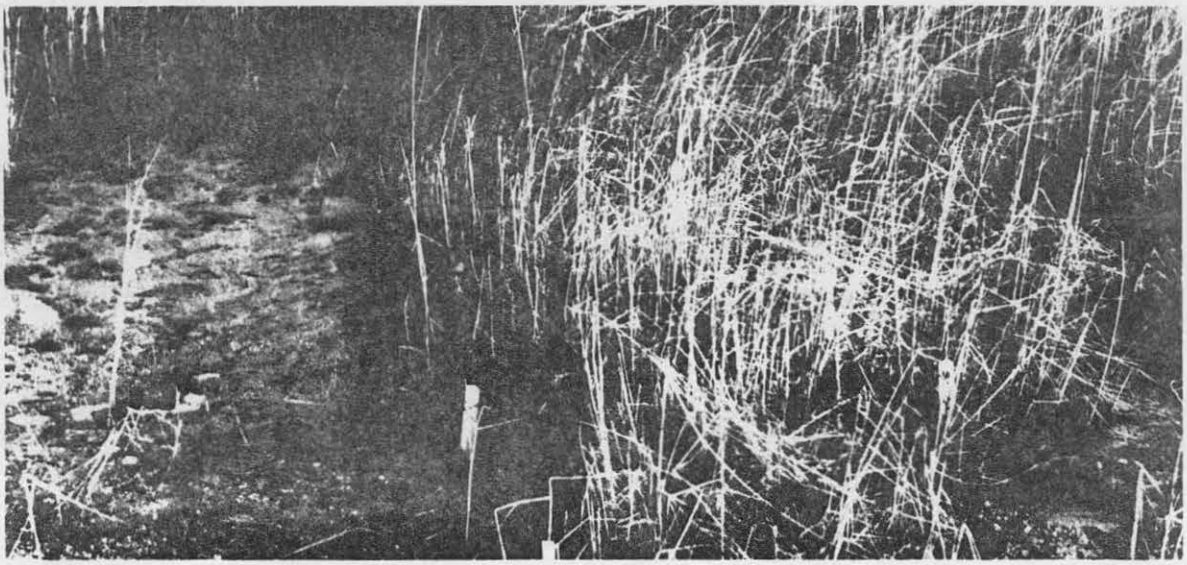
In addition to the endemic species composition of a salt versus a freshwater flora, one of the major differences between these two studies was the influence of tidal amplitude and mixing through wave action. In the marine intertidal zone, a wider vertical area between low and high water was accessible to direct exposure to oil, whereas in the river, the oil was restricted to a smaller area due to the absence of tidal exchange.

Other Findings Assayed

J. M. Baker (1970) states that "oils vary in toxicity according to content of low boiling compounds, unsaturated compounds, aromatics and acids." Greatest acute damage

(A)

(B)



(C)

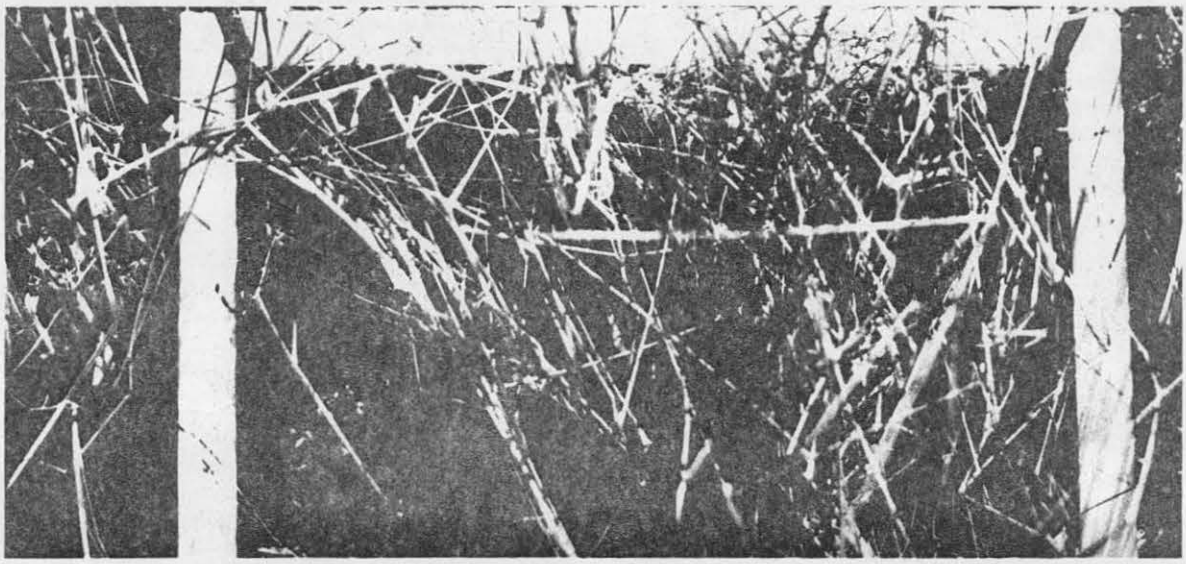
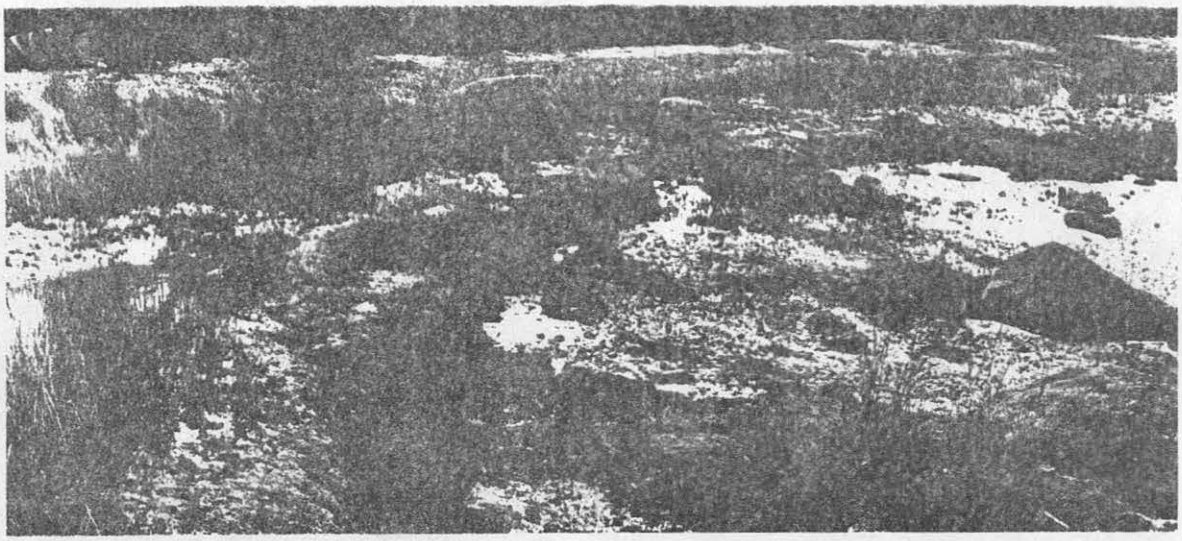
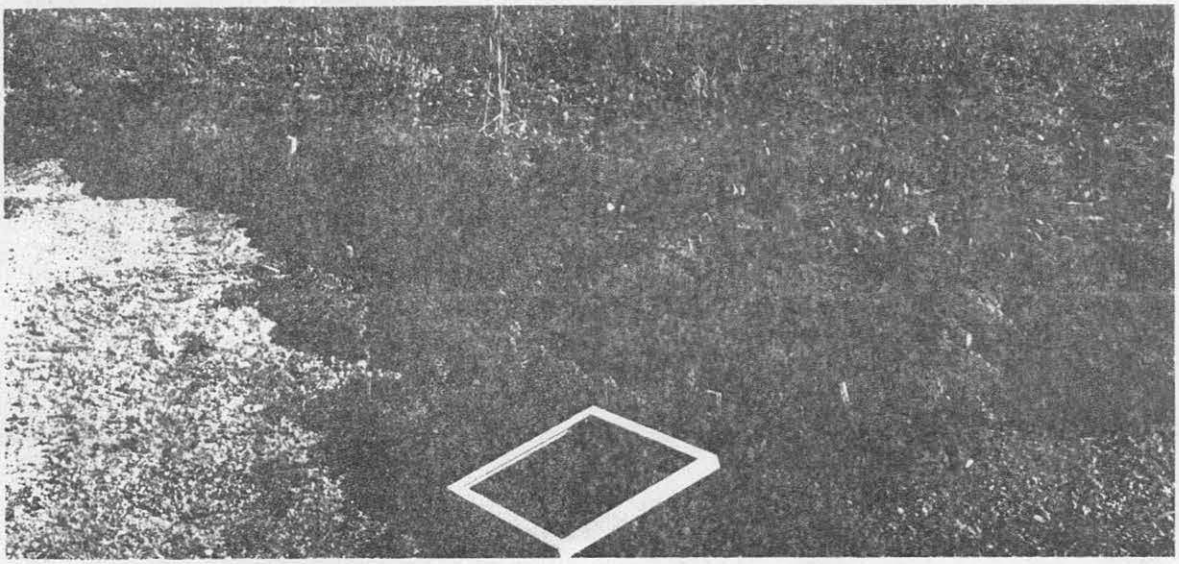
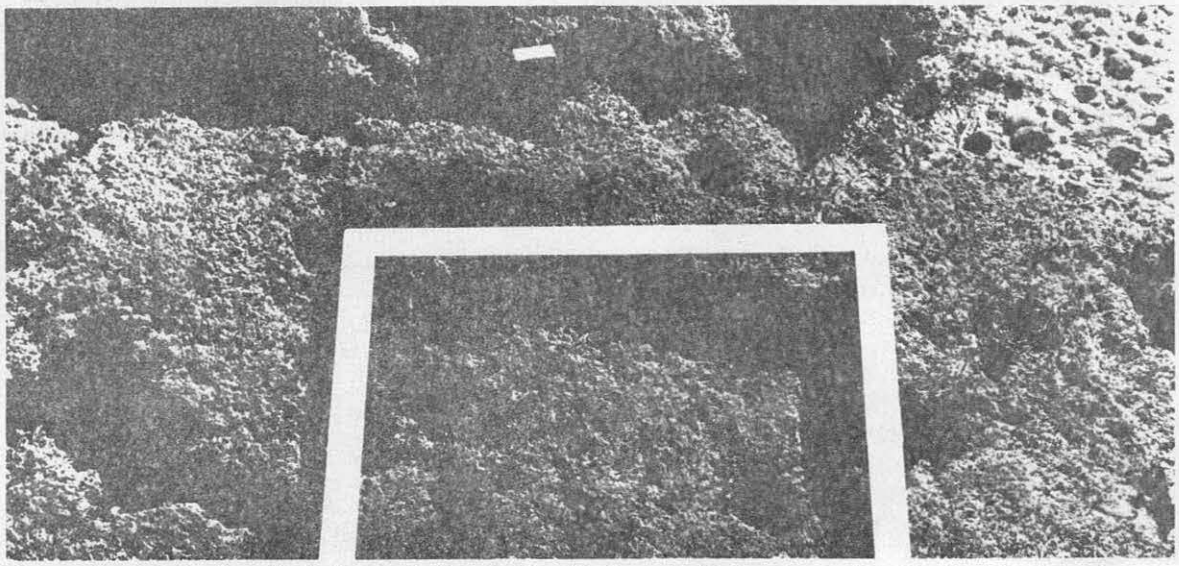


Figure 3. Photographic stations in Winsor Cove. Photographs A and B, taken in October of 1974, show an overview of the proposed site of the transect; C shows quadrat Number 1. These illustrate the density of marsh grasses existing





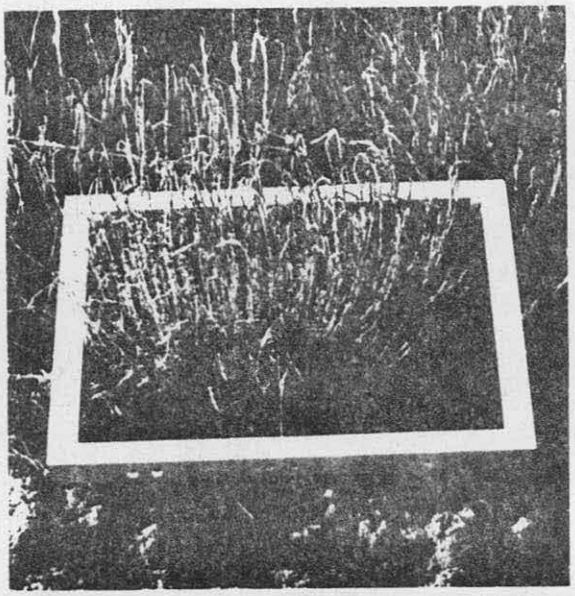
(E)

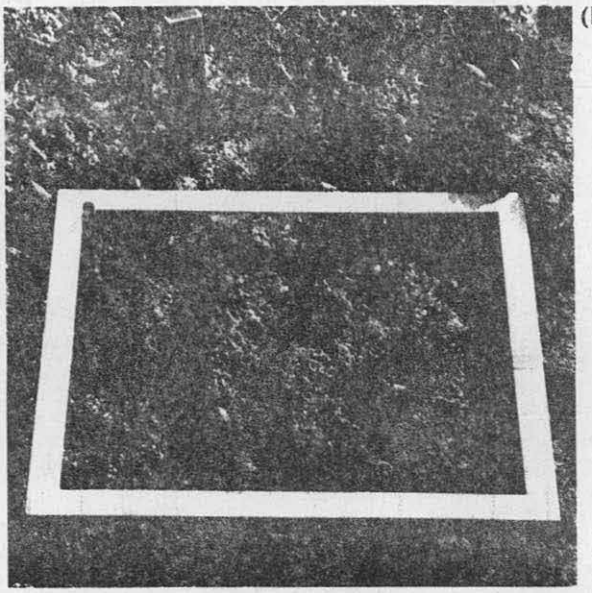


(F)

close to the water's edge prior to the marsh degeneration. Photographs D, E, and F are of the identical sites taken in September 1977, three years later. Note the total absence of the Spartina *stand in the lower marsh zone.*

(G)





(H)

Figure 4. Salicornia *stand in October 1974 (G) and in September 1977 (H). As with the* Spartina *in Figure 3, the* Salicornia *plot shows little regeneration of high plant growth.*

generally is caused by the "very toxic oxidized oils and aromatics, which stop respiration and cause widespread injury and death"; the total severity being dependent on the constituents and amount of oil, the environmental conditions, and the species of plant involved.

A review on the effects of oil and its components on algae by P.Y. O'Brien and P.S. Dixon (1976) relate several studies that also show the relatively less harmful effects that weathered oil has on salt marsh plants.

C. H. Hershner (1977) and Baker (1971) mention that investigations seem to confirm that marshes are able to withstand or recover rather quickly from a "single dose" of oil. However, Winsor Cove, which could essentially be categorized as having a "single dose" type oil spill, actually involved a series of frequent, repetitive applications of oil that were the result of tidal oscillations and wind direction. Harbors, rivers, and embayments are very susceptible to this repetitive type of exposure.

During the initial spill, environmental conditions were such that the oil collected in the protected cove with the slick remaining a few days. The substrate of the Winsor Cove marsh, acting as a natural sink, became heavily impregnated with oil because of the marsh's porosity and interstitial absorption. In the absence of adequate oxygen and flushing, weathering of the impregnated oil was extremely limited. Slow, chronic discharge of buried oil contained toxic aromatics that leached to the surface substrate, causing a continuous stress on plant regeneration.

The Winsor Cove spill was not unique. The same results were evident in the West Falmouth oil spill study previously mentioned. Similarly, D. W. Mayo and others (1975) reported fresh oil leaching from saturated sediments up to 18 months following the initial detection of a spill involving JP5 jet fuel and Number 2 oil in Long Cove, Searsport, Maine. The Bunker C oil spill in Chedabucto Bay, Nova Scotia (see page 31), also revealed a slow release of petroleum hydrocarbons from saturated sediments and rooted eelgrass over at least five years.

George R. Hampson is a Research Associate in the Biology Department, Woods Hole Oceanographic Institution. Edwin T. Moul is Professor Emeritus of the Biology Department of Rutgers University and presently is doing research in the Gray Museum at the Marine Biological Laboratory, Woods Hole, Massachusetts.

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