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# THE EFFECTS OF DIESEL FUEL ON A STREAM FAUNA[1]

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**The spillage of approximately 2,000 gallons of diesel fuel into Hayfork Creek, California, resulted in a large kill of invertebrates, fishes, and other life. Subsequent effects on the stream fauna are discussed. This study examines the increasing threat of pollution in remote areas due to the transportation of petrochemicals.**

## INTRODUCTION

Water pollution by petroleum products is a serious environmental problem, since oily substances contain toxic components and, in general, are stable compounds that can remain in an ecosystem for a relatively long time. Oil spills have caused widespread detrimental effects in California waters and elsewhere (McCaull 1969; Mitchell, et al. 1970; Blumer, et al. 1971; and Straughan 1971).

McKee (1956) reported that petroleum products can be detrimental to aquatic organisms in the following ways: (i) free oil and emulsions may act on the epithelial surfaces of fish, thereby interfering with respiration, or may coat and destroy algae and plankton, which remove sources of food; (ii) oily substances that settle to the bottom may coat and destroy benthal organisms, and interfere with spawning areas; (iii) soluble and emulsified material may be ingested by fish and thereby taint the flavor of the flesh, or water-soluble parts may have a direct toxic action on aquatic life; (iv) organic materials may deoxygenate the water sufficiently to kill fish; and (v) heavy coatings of free oil on the surface may interfere with reaeration and photosynthesis.

Distilled petroleum substances are immediately toxic to animal life. Gutsell (1921) found gasoline had a toxic effect on rainbow trout (*Salmo gairdneri*) at about 100 mg/liter. McKee and Wolf (1963) reported that agitated solutions of automobile gasoline at a concentration of 100 mg/liter and jet aviation fuel at 500 mg/liter is lethal to fingerling salmon (*Oncorhynchus* sp.). Diesel fuel is acutely toxic to rainbow trout within the range of 350 to 1,000 mg/liter (Richard Hansen, pers. comm.).

There are relatively few documented cases of oil pollution in freshwaters. In fact, Wilbur (1969) stated that there is such limited information on the effects of oily wastes in water on livestock and wildlife that any extended discussion would be futile. Swift et al. (1969) surveyed the literature on the biological and ecological effects following an oil spillage, noting that while some information is available on the damage that can occur, few quantitative and coherent data are available to assess past incidents or to predict potential effects in the future.

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The present study reports the detrimental effects of diesel fuel, a moderately toxic substance, on an unspoiled freshwater stream.

On July 28, 1970, the rear tank section fell off a truck on a sharp curve along U. S. Forest Service Road 2NO1. The accident occurred about 0.5 miles upstream from the 'fish ladders,' Hayfork Creek, a tributary of the Trinity River, Trinity County, California (about 7 air miles SSE of the town of Hayfork). The 4,000-gallon tank, reported to be about half full of diesel fuel, burst when it rolled down a steep canyon. Some of the fuel evaporated or soaked into the ground, but about 2,000 gallons entered the creek.

## MATERIALS AND METHODS

A survey of the biological effects of the diesel fuel spill in the creek was conducted from 1 to 2.5 miles downstream from the site of the accident because the pre-spill conditions in this area were well known. Field studies had been carried out along this part of the creek during the summers 1968 to 1969 and in June and July, 1970 (Bury 1972). The study area consisted of 36 pools varying in size from 5 to 50 yards long, mostly 10 to 20 yards, and 5 to 10 yards wide. The pools are 3 to 12 ft deep in the summer and are connected by long, shallow riffles 0.5 to 1 ft deep. For comparison of the effects of the diesel fuel on the stream fauna, the surveyed area was divided into 10 equal parts with each section 800 ft in length. Dead animals were counted in the study area from August 1 through 5 and then periodically until mid-September.

## EFFECTS ON THE FAUNA

The diesel fuel entered the study area about 36 hr after the accident. Initially a thin film of fuel extended entirely across the surface of the creek. The first effects were observed on the morning of July 31, 1970, when the normally clear waters turned a murky, brown color with visibility less than 1 ft and small droplets of fuel floated on the surface.

Most animals were adversely affected 1 to 4 days after the fuel entered the study area. Thousands of aquatic insects perished, especially water boatmen (Corixidae), belostamatid water bugs, water striders (Gerridae), adult and larval diving beetles (Dytiscidae), mayfly nymphs (Ephemeroptera), and dragonfly and damselfly nymphs (Odonata). Many crayfish (*Astacus* sp.) were actively moving in the creek during daylight hours, a condition which had not been noticed in previous years. Ten crayfish were found dead. Hundreds of aquatic leeches (Class Hirudinae) and freshwater planarians (Planariidae) were killed.

Over 2,500 fishes were killed, including about 1,000 lamprey ammocoetes (*Entosphenus tridentatus*), 688 small-scaled suckers (*Catostomus rimiculus*), 75 speckled dace (*Rhinichthys osculus*), and 849 rainbow trout (Table 1). Further, several fishes were seen near the surface, mouths gaping and then slowly sinking into the murky water. In one pool I observed a 7-inch trout moving slowly along the bottom upside down, and a 12-inch fish swimming on its side near the surface. Other trout in the pool remained almost motionless near the bottom, frequently gaping widely.

TABLE 1—**Vertebrate Losses Caused by Diesel Fuel Contamination of Hayfork Creek, 1970.**

| Section | Salmonid fishes | | | | | Suckers | Dace | Ammocoetes | Tadpoles | Snakes | Turtles | Birds | Total number |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 to 3 inches | 4 to 6 inches | 7 to 9 inches | 10 to 12 inches | 13 to 15 inches | 1 to 5 inches | 1 to 3 inches | 1 to 6 inches | | | | | |
| 1 | 150 | 12 | 1 | -- | -- | 256 | 15 | 321 | 380 | 6 | -- | -- | 1,141 |
| 2 | 109 | 5 | 1 | -- | -- | 113 | 20 | 137 | 263 | 3 | 1 | -- | 652 |
| 3 | 34 | 12 | 2 | -- | 1 | 23 | 1 | 53 | 319 | 8 | -- | -- | 453 |
| 4 | 18 | 12 | 1 | -- | -- | 13 | 1 | 53 | 140 | 6 | -- | -- | 244 |
| 5 | 112 | 10 | 7 | -- | 1 | 106 | 12 | 45 | 158 | 10 | -- | 1 | 462 |
| 6 | 57 | 7 | 3 | 1 | -- | 37 | 10 | 93 | 122 | 1 | -- | -- | 331 |
| 7 | 146 | 23 | 3 | -- | -- | 116 | 13 | 162 | 300 | 1 | -- | -- | 764 |
| 8 | 20 | 9 | 2 | -- | -- | 8 | 2 | 17 | 68 | -- | -- | -- | 126 |
| 9 | 74 | 9 | 2 | -- | -- | 15 | 1 | 60 | 35 | -- | -- | -- | 196 |
| 10 | 5 | -- | -- | -- | -- | 1 | -- | 35 | 58 | 1 | -- | -- | 100 |
| Total | 725 | 99 | 22 | 1 | 2 | 688 | 75 | 976 | 1,843 | 36 | 1 | 1 | 4,469 |

Tadpoles and partly metamorphosized individuals of the foothill yellow-legged frog (*Rana boylei*) were killed in large numbers. No adult frogs were found dead. Thirty-six western aquatic garter snakes (*Thamnophis couchi*) were killed. Several snakes were seen that appeared to be noticeably sluggish in their movements.

Subsequent to the initial toxic impact on the stream other effects were observed. Large quantities of dead animals and algae (*Spirogyra* sp., *Cladophora* sp., *Zygnema* sp.) sank to the bottom or formed floating mats. Some of the surface masses were 2 to 4 inches thick and covered several square yards. A log across the surface of one pool caused accumulation of floating material that covered an area 20 ft wide and 40 ft long. Loose aggregations of organic matter accumulated on the bottom where there was little current, and in places formed a slurry 6 to 12 inches deep. The organic matter putrefied rapidly and formed a layer of scum on the bottom of the creek. Most of the diesel fuel was flushed out of the study area 3 weeks after the spill, but some fuel remained trapped in the accumulations of dead organic matter and small slicks of fuel were observed until mid-September when observations ended.

On August 8, a dead common merganser (*Mergus merganser*) was found along the creek and its feathers were in disarray and smelled of diesel. On September 10, a pond turtle (*Clemmys marmorata*) measuring 5 inches in shell length was found dead on the bottom of a pool. Two young ones, alive, but in poor condition, were found on the shores of other pools. The eyes and necks of all these turtles were swollen. Movements of both young turtles were uncoordinated and they were unable to either swim or sink. Also, 30 pond turtles captured in early September had sloughed off pieces of epidermis on their appendages, and their necks and eyes were swollen.

## DISCUSSION AND CONCLUSIONS

The large die-off of animals was a direct result of the diesel fuel pollution. Only rarely was a dead animal found in the creek during prior studies, and usually these were due to predation. The toxicity of the fuel killed most animals on contact and, later, caused other detrimental effects to the stream fauna due to large quantities of putrefying organic matter.

Many fishes displayed unusual behavior due to irritating or immobilizing effects of the diesel fuel. Adult frogs were not killed, and their survival is related to their mode of life. Frogs usually rest along banks out of water and feed principally on live insects. Hundreds of tadpoles perished since they were directly exposed to the fuel in the water and, perhaps, ingested tainted algae. Garter snakes probably died because they regularly swim in the water and prey on tadpoles and fish. Exposure to the fuel and ingestion of food contaminated with fuel may have killed the pond turtle and common merganser.

There was a heavy concentration and prolonged exposure to the fuel in the upstream parts of the study area, and the mortalities were greater than in sections farther downstream where the fuel was diluted, evaporated, or dispersed sufficiently to have a reduced impact on the stream fauna. There were 2,952 dead vertebrates found in sections 1

through 5, and 1,517 in the downstream sections 6 through 10 (Table 1). Although no dead organisms were found farther than 5 miles downstream from the site of the spillage, chronic toxicity and other sublethal effects may have extended many miles along the creek.

Blumer et al. (1971) reported that hydrocarbons taken up into the fat and flesh of fish and shellfish are not removed by excretion or by internal metabolic processes, and that these substances remain in the animals for long periods of time, possibly for their entire lives. They state that crude oil and oil products are persistent poisons, resembling in their longevity DDT and other synthetic materials. It is expected that the diesel fuel pollution of Hayfork Creek resulted in long term effects on the stream fauna.

Caution in the transport of oily substances is obviously required to prevent accidental spills, especially in the vicinity of flowing waters because pollutants can be dispersed great distances in a relatively short time. Bönig (1965) reported that a great deal of oil pollution occurs in spite of safety measures. Persons who dispense or transport petroleum products need to be acutely aware of the great damage that these substances have on fisheries and wildlife resources.

The risk of accidental spills of petroleum products is an ever present danger of pollution to aquatic ecosystems and will undoubtedly increase with rising consumption and transportation of fossil fuels. This study indicates that oil pollution is a serious threat to life even in remote, unspoiled streams and rivers.

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