

In view of the important and more or less disastrous effect which the eruption of Katmai Volcano in June, 1912, had upon the fisheries, fur animals, and other animal and plant life of the Afognak Island Reservation, E. M. Ball, inspector, Alaska salmon fisheries, then at Afognak, was instructed to make a special investigation of the subject. He did so, and his report, which covers well many phases of the matter, is here presented.

The data which are presented in this report were obtained from two sources; direct examinations, and conversations with fishermen, boatmen, and miners. The results of personal investigations treat almost exclusively of conditions on Afognak Island; while the information received from individuals refers to localities beyond the reach of the writer. Where a number of opinions are concerned, each differing widely in essential features, it is not always easy to ascertain the facts. First reports are often unduly colored by the stress of the moment, and, therefore, in the light of subsequent events, are subject to modification. Enough is known, however, now three months after the eruption in question, to warrant the preparation of a brief report thereon, and its effect upon the animal and vegetable life of Afognak Island.

Description of volcano.—The Alaska Peninsula forms an important link in the chain of volcanoes which extend the entire length of the Pacific coast of the American Continents; and, as a region of volcanic activities, it is, perhaps, second only to the great centers of the Torrid Zone. These activities are made known by the smoking volcanoes of Redoubt and Iliamna on the shore of Cook Inlet, Pavlof on the western end of the peninsula, and Shishaldin on Unimak Island. Many others less notable occupy the intermediate territory, some of which are of comparatively recent discovery.

To this class belongs Katmai Volcano, a peak 7,500 feet high. It is located near latitude $58^{\circ} 16'$ and longitude 155° , or about 20 miles north of Katmai Bay and 60 miles west of Afognak. Information as to its general appearance is not obtainable, but prospectors and hunters who in other years had traveled through that section of the country tell us that the volcano is not marked by any great prominence and is not readily distinguishable from several peaks in its vicinity of approximately the same elevation. Neither they nor those who have always lived in this region have any knowledge either direct or traditional of its former activities. As far as the Kodiak group of islands is concerned, many believe that indications of a previous eruption can be found several inches below the surface of the ground in a layer of soil which in color and composition resembles the ashes now covering the islands; but the acceptance of such evidence as a scientific fact is questionable.

The eruption.—In the history of volcanoes elsewhere, it has been recorded that approaching eruptions were preceded by rumbling noises and trembling movements of the earth. In this instance, however, no warning was given to the people of Afognak

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that a volcanic outburst had occurred until mid afternoon, June 6, 1912, when a dark cloud was observed rising from the west. It is not improbable that there were light convulsions of the earth, which, because of their frequency in this region, passed unnoticed.

The day on which the eruption began was one of more than ordinary pleasantness. The warmth and brightness of the sun, coupled with a gentle breeze from the west, made it an ideal summer day. Air temperatures at morning, noon, and night were 52°, 58°, and 52° F., respectively; and water temperatures for the same hours were 41°, 42°, and 49° F.

Many interesting phenomena, particularly the rise, spread, and rapidity of the eastward movement of the ash clouds, might have been observed at the beginning of the eruption if the village of Afognak had been situated on the west coast of the island where the mountains of the mainland are clearly visible on bright days. Located as it is on the lowlands of the eastern shore, the view to the west is shut off by forest and mountains. For this reason the cloud attracted no attention until its crest rose high above the hills, when its blackness and otherwise peculiar aspect became the subject of some comment. The first impression received by those who had lived in other parts of the land was that a thunder storm, characteristic of more tropical regions, was approaching; but being unaccompanied by lightning and apparently no wind, the cloud was next supposed to be due to a probable fire on the peninsula. By this time the silence was ominous, and even the birds seemed to feel impending disaster, yet no special apprehension was noted among the people of the island.

The shower of ashes began about 6 p. m. The hills were then enveloped in an amber-colored haze, the sky was overcast in all directions except a narrow border along the northeastern horizon, and the air seemed strangely warm. As the storm progressed, the shower increased in density until absolute darkness prevailed; even artificial light could be detected only a short distance. This sudden and early darkness became all the more alarming, because during June there is no night in this latitude, merely twilight from 10 p. m. till 2 a. m.

Probably an hour after the ashes began falling the first rumbling noises were heard, suggestive of the detonation of distant blasting or firing of heavy artillery. Soon thereafter lightning was observed, the flashes becoming more frequent as the night advanced. Some observers describe these flashes as being balls of fire which would burst with a loud report into a shower of sparks. Thunder seemed nearly incessant. The highly electrified condition of the atmosphere was shown on the set of wireless instruments at the Federal hatchery. Although the aerial switch was open, tiny blue flames could be seen on the switchboard and the tuning and induction coils. Whenever the lightning flash was near these flames would shoot out with a keen report like that of a rifle. Associated with these phenomena were the earthquakes, which varied in violence from gentle vibrations to shocks that made the buildings creak and tremble. The most violent convulsions were of several seconds' duration and were usually attended by rumblings.

Beginning about noon, Thursday, June 6, and ending Sunday morning, the 9th, this eruption may have been a continuous operation; but observations made at Afognak seem to show that the discharges were intermittent. This conclusion is based on the fact that there were three distinct showers of ashes, separated by short intervals of comparative quiet.

The first break in the storm came on the morning of the 7th and continued for a space of 10 hours. About 4 o'clock that afternoon the second shower began, bringing with it all the phenomena of the first, but with renewed energies. This was the period of greatest distress to man and beast; to man, mentally, in that the end of it all was uncertain; to the beasts and birds in that there was no escape from the blinding, suffocating dust which was carried into every nook and crevice. Alarm was felt lest the ashes be followed by poisonous gases from which there could be likewise no possible escape. But after 23 hours of uninterrupted fury the second storm had spent itself.

Daylight came at 3 p. m. on Saturday the 8th, only to be dispelled in 5 hours by the third storm which, however, was of short duration and without the violence of the preceding storms. Though the air was full of ashes many days, Sunday morning marked the end of the eruption as far as it had any effect upon the daily seasons. Throughout the storms the air was cool and remarkably free from fumes; temperatures, after the sudden decline at the beginning of the eruption, fluctuated but little; air held close to 44° F., water at 39°.

Region affected.—The region affected by this eruption lies almost entirely east of the volcano. Though traces of dust have been reported from Fairbanks, Alaska, and British Columbia and Puget Sound points, the eastern limit to which any appreciable quantity of ashes was carried should be fixed well out in the North Pacific Ocean. To the west ashes are not found more than about 25 miles from the volcano. The ash clouds moved eastward across Shelikof Strait to Afognak and Kodiak Islands, spreading north and south as they advanced until by the time the one hundred and fifty-second meridian was reached they covered a zone nearly 150 miles in width. The northern boundary of this zone can be represented by a line extended from Hallo Bay on the peninsula northeastward to Barren Islands and beyond; its southern limit is shown by extending a line from a point 25 miles west of Katmai Bay to Cape Karluk, thence crossing Kodiak Island to Shearwater Bay. Within the affected zone as applied to the islands, a belt 50 miles wide with Kupreanof Strait as its center embraces the area most heavily covered with ashes.

Quantity and character of material ejected.—Over the central region ash fell to a depth of 10 inches. It is found in three layers, representing the three showers. The first layer, measuring 3 inches in depth, consists of fine gray sand whose grains are of three kinds; some are nearly white and opaque, others are transparent resembling small particles of sal ammoniac, and the rest are black or dark amber and susceptible to magnetic influences. The second layer, 5 inches deep, is composed entirely of fine brown dust, which when falling so filled the air that it affected the eyes, nasal passages, and throat of everyone. The third and uppermost layer measured 2 inches in depth and it also is a flour-like dust of a light gray color.

North and south from this central region the ashes gradually diminish in depth until the border of the affected area is reached, each layer being proportionately reduced.

Besides the dust and sand ejected by Katmai Volcano a considerable quantity of pumice stone was thrown out. These stones ranged in size from small particles to those several inches in diameter, and they varied in color as did the ashes. All this coarser material fell on the mainland not many miles from the volcano. The streams and rivers of the vicinity carried it to the ocean where it formed into large fields that were moved here and there by winds and tides and piled 2 or 3 feet deep on the beaches of the islands.

Immediate effect of eruption.—The winter and spring had been favorable seasons; deciduous bushes were opening into full foliage; perennial plants had made a remarkable growth, particularly in the lowlands; the birds of summer were nesting and filling the land with song; salmon were entering the streams and lakes and were appearing in good numbers in the bays; even the mosquitoes and sand flies were making their presence known. The snow had gone except on the tops of the hills; the lakes had been free from ice since early in February; streams were very clear and at their normal flow.

But in the immediate effect of this eruption, these things were laid waste and made hideous and appalling by the mantle of ashes which fell over them. Trees were loaded to the breaking point and the plants were in great part buried. With the possible exception of some of the small rodents, mammals were not seriously affected, only as it may have been more difficult to find food. But many of the smaller birds perished, while the living members of their species had flown to other regions. Only the eagles, ravens, magpies, gulls, and ptarmigans remained to the end in the face of destruction to their nests and young. Half-grown ravens were found dead

where they had fallen from the nest, driven therefrom no doubt by hunger or fright; and it seems probable that in like manner death came to all other young birds unable to fly. As the slightest interference or molestation is often enough to cause birds to forsake their nests, there is every reason to presume that all nests, whether built on the ground or in the trees and bushes, were abandoned under the shower of sand. Of all the birds on the island, the ptarmigans probably suffered greatest loss, for they alone were incapable of flight to regions beyond the stricken zone; and as they live, feed, and nest exclusively on the ground, and inhabit the higher untimbered sections of the southern end of the island where the greatest quantity of ashes fell, their suffering must have been acute and little hope can be entertained that all survived. The food supply was cut off, nests and young destroyed, and an endless field of dry ashes lay about them. The condition of the birds, however, did not more than equal the plight of the fish in the streams.

Many of the streams were occupied by spawning steelheads, and those lake-fed were filled with ascending red salmon. These fish, as long as they had strength to stand against the current, could not be moved by the turbid waters from obedience to the commands of nature; but as the water became almost liquid mud their gills were loaded with sediment until suffocation resulted and they were finally washed to the bays with the sand and mud. Fortunately the run of salmon had just begun and therefore the loss of fish for the whole island was small. An approximate loss of 4,000 red salmon resulted in the Letnik stream, where the fish were being held for cultural purposes. At the other fisheries the loss was negligible, but few fish having entered the streams.

Ocean waters, except where affected by streams, were only slightly discolored for a few days, and it did not seem possible that in waters of considerable depth there could be any great upsetting of natural conditions. It appears, however, that the change was great enough to cause the cod to abandon their banks; where heretofore they could be had in abundance none can now be taken.

Another most striking and noteworthy effect of this eruption on marine creatures was the destruction of sea urchins, which in large numbers were cast upon the shores or drifted about the bays and straits. There was also a considerable loss of mollusks, particularly clams and cockles, which is hard to understand in view of the fact that their native element is mud.

In order to determine, if possible, what had been the effect of the ashes upon the food supply of the fishes in fresh water, an examination was made of all the principal water systems of the island. It was found on the eastern half, which is heavily wooded with spruce and less mountainous than the western side, that the lakes and streams had not been choked with ashes and little wash from the surrounding country had taken place. In these waters, especially the lake and streams of Little Afognak, the supply of mollusks and worms was adequate and some larval forms were collected. No crustaceans could be found.

The streams and lakes of the west side of the island are almost destitute of fish food. In this more mountainous section where the fall of ashes was heavy, the streams were literally choked with sand and mud; old channels were obliterated and the water spread in a thin sheet over the meadows. Those discharging into lakes formed large sand bars at their mouths, sometimes several feet in depth and of considerable area.

In the examination of lakes, all operations were conducted from the shore and with much difficulty, there being such an accumulation of ashes in the lakes that the net was often filled and wrecked by overloading. But when successfully landed, the search through the sand for living creatures was often fruitless, only a few mollusks appearing as the result of efforts made on Paramanoff Lake and its streams. This region forms one of the most barren fields, not alone of small organisms but fish life as well, that can be found on the island. By seining in the creeks with the plankton net two small trout were caught, one about 3 inches long, the other about 5. In the

stomach of the smaller fish were eight minute worms, some sand and vegetable matter; the stomach of the larger specimen contained one maggot and three salmon eggs.

As a water system destitute of fish food, the Malena Lakes and streams comprise an area which is almost the equal of Paramanoff. Not taking into account the salmon that had entered the lakes to spawn, the only fish found in the upper lake were sticklebacks. In the lower lake, sticklebacks and salmon fingerlings were observed, and a mixed collection of about 40 specimens was made in order to ascertain by examination of stomach contents what food these fish were finding. Only juices were found in the stomachs of the salmon, and that was also very generally the case with the sticklebacks, though one specimen had eaten a small mollusk, and two or three others had found a few small worms. All of the fish were in a much emaciated condition, which alone would seem sufficient evidence of the scarcity of food.

Better conditions were found in the Letnik Lake region where the small streams had generally cleaned themselves of ashes by the end of August. From the gravel bottoms of these streams many mollusks and worms were collected. The larger streams were still gorged with sand, therefore it seems probable that whatever fish food may have abounded in them had been completely destroyed, and this view was confirmed by the unsuccessful efforts to find living organisms within those areas. In the shoal places of the lake, mollusks, large and small, were present in fair abundance, so also were small bugs and worms, but in the deeper waters dredgings were without results. Specimens of young fish were collected in the small streams and lake. Those from streams were strong and well fed, but the lake fish were lean and weak.

These investigations, however, offer no convincing proof that any great destruction of fish food resulted as a consequence of the eruption, though they may show an impoverished condition of the waters. Unfortunately nothing is known of the scarcity or abundance of fish food in these lakes and streams before the volcanic eruption. Data of that kind would now be valuable for purposes of comparison, for only in that way could the destruction be determined. The almost total absence of mosquitoes and sand flies during the summer is attributed to the immediate effect of the ashes upon their larval forms and breeding places; and this condition, coupled with the fact that these insects had been veritable pests in past summers, establishes conclusively that the weaker forms of life were destroyed in large numbers.

Later effects.—For several days after the eruption, the fate of vegetation on the southern part of the island could not be told. It seemed certain that the greater part of it could never penetrate or push its way through 10 inches of compact ash; the danger was wholly one of being smothered, as the ash possessed no inherent properties that would be detrimental to plant life. In the course of a few days, some of the more robust plants were able to throw off the weight of ash and continue their growth; but there was no general renewal of plant life until near the end of June, when the rains came and caused the hitherto unbroken surface to crack in all directions and break into small sections like parched clay. Through the interstices thus formed, plants made a remarkable growth, so that by the end of summer the hills and valleys were covered with a rank vegetation which, viewed from a distance, seemed barely less luxuriant than in previous seasons. Close examination, however, revealed the fact that this vegetation was made up almost exclusively of stout-stemmed plants, the most conspicuous members of the group being the hellebore, water hemlock, broad-leaved dock, and the fire-weed, which outnumbered all the other species.

But of all the plants, probably none will be as seriously affected as the mosses, not alone on account of their greater abundance but rather because of their delicacy. One species bears a berry which is an important food of the ptarmigan in the fall and early winter.

Associated with the mosses are the "marowskas" and cranberries, both of which are of some importance in that they form a part of the food supply of the people of the island. They were so nearly wiped out by the ash that none could be gathered this year.

The grasses suffered extensively on the southern end of the island; probably three-fourths of the crop was destroyed. This is an economic loss to the owners of cattle, for they have been unable to harvest sufficient hay to carry their stock through the winter. An abundant supply could be had from the northern end of the island where the grass was only slightly affected; but the people lack the means of transportation and, therefore, as available provender, it need be given no consideration.

If the destruction of plant life were expressed in figures, it would be fair to estimate that 70 per cent of the flora on the southern end of the island had been destroyed and that there was a gradual falling away to a loss of 20 per cent on the northern end.

The most amazing effect of the volcanic ash upon aquatic plants is shown by the retarded growth of the kelp on the reefs and rocks of the stricken region. Opinions differ as to the degree of injury. Many believe that the kelp is dead, and, as confirmation of their judgment, they point to its black and withered condition. But admitting that appearances strongly favor this view, it seems, nevertheless, too early to give unqualified endorsement thereto. The destruction of the kelp would mean an inestimable loss to the cattle, as it forms one of their staple foods during the winter and very materially helps out an inadequate supply of hay.

In the mountainous sections, the rains kept the streams and lakes very muddy, thus preventing or delaying the appearance of the salmon on the spawning grounds. About the middle of August so much ash was washed into the streams that several hundred spawning salmon perished in exactly the same manner as happened at the beginning of the eruption. It is an interesting evidence of the objectionable condition of these waters that many of the salmon would ascend the streams a short distance, and then return to the sea, repeating many times these erratic movements.

Of the ground-nesting birds, the ptarmigans are the most important and, perhaps, the ones most unlikely to nest in the ashes. Their nests are always carefully concealed in the dry grass and weeds of the open country or under the scrub spruce where the branches are close to the ground. All such places being covered with ashes, it seems improbable that any nests were built after the eruption, and this doubt is strengthened by the fact that no young birds were seen during the summer. On the other hand, the gulls resumed their nesting before the end of June, the ashes presenting no special hindrance to them, as they require very little material for nests. The number of ducks and small migratory birds breeding on the island was considerably less than usual.

Mammals in general were able to weather the distressing conditions, though at times they may have found it difficult to obtain food. In a way, the land otters are the most fortunate of these animals, for they can go to salt water for food when the fish are scarce in the lakes and streams.

Probable future effects.—The conditions of to-day do not warrant the assumption that the Kodiak group of islands has been permanently injured by this eruption, though a few years may be required for nature in her varied forms to work out a complete readjustment of these changes. Surely, the soil will be enriched and vegetation will renew itself until the islands are more luxuriantly clothed than ever; the wash of ashes from the hills will cease and the streams will eventually clear themselves. What enriches the soil may also enrich the waters by contributing to conditions that will bring about an increased supply of fish food which in turn means an increased supply of fish.

National Oceanic and Atmospheric Administration

Report of the United States Commissioner of Fisheries

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