$3,452 to the University of Cincinnati for improvement in the diagnosis and treatment of cancer; $6,600 to the American College of Surgeons, Chicago, for a study of hospitals and clinics with reference to clinical cancer service; $4,200 to Dr. John J. Bittner, for a continuation of his studies on the relation of nursing to breast cancer in mice.

UNDER the direction of Edward P. Davis, topographical engineer of the U. S. Geological Survey, Glacier Park has been remapped. Prior to this summer no work had been done on the park since 1912. Twenty-five years later the National Park Service made several additions to the map of the U. S. Geological Survey. It is expected that the map will be available next year.

A SUB-OFFICE of the U. S. Geological Survey was recently established at Jackson, Mississippi, from which will be supervised the surface water investigational work conducted by the survey in cooperation with the state of Mississippi, as a result of cooperative funds provided by the last legislature. Edward B. Rice, associate engineer, will be in charge. He will be under the general supervision of the district office at Montgomery, Ala. A sub-office has also been established recently at Baton Rouge, La., resulting from cooperative surface water investigations started in that state. Ralph E. Marsh, assistant engineer, is in charge under the general supervision of the district office at Montgomery, Ala.

A SCIENTIFIC expedition left British Guiana on September 6 to collect specimens of the bird, animal and fresh-water fish life at the Roraima Plateau, on the British Guiana-Venezuela boundary. Members of the expedition include P. S. Peberdy, curator of the British Guiana Museum; A. Pinkus, representing the Michigan State Museum and the New York Botanical Garden, and T. Pain, curator of the Chelmsford and Essex Museum, England.

DISCUSSION

THE UNDERTOW

MOST of our elementary geological text-books contain definite statements regarding the existence and behavior of the undertow. It is described as a subaqueous, outward flowing current which is present when the wind blows perpendicularly on a lee shore. It is said to be caused by the piling up of the water as a result of the shoreward movement caused by the wind. This outward moving current is believed to have its movement modified at times so that it is slowed up or even temporarily reversed by each incoming wave, but its average movement is outward. It is generally regarded as being an important factor in the sorting and transportation of sediments on the underwater terrace.

However, some years ago Professor W. M. Davis[1] raised the question as to the actual existence of such a current and presented a rather complete argument to show that what had previously been regarded as the undertow was only the backwash of the waves which had been mistaken by more or less frightened swimmers for an outward moving current. He ended his article by asking skilled swimmers to send in accounts of their experiences with shore currents.

In the replies received some expressed a disbelief in the existence of dangerous outward flowing subaqueous currents; other experienced swimmers were just as certain that, at least along some shores, such currents are present and sent in detailed accounts of their experiences.[2]

These replies were summed up in an article by Professor Davis[3] and there the matter was dropped for a time.

Recently Professor F. P. Shepard again brought up the question in an article, "Undertow, Rip Tide or Rip Current"[4] in which he expresses a disbelief in the undertow as generally understood but describes river-like movements of the water perpendicular to the shoreline running outward at intervals from a lee shore. These currents reach the surface and are said to occur a few hundred yards apart along a shoreline on which the waves are breaking. For this type of water movement he proposes the term "rip current."

With the above in mind a study was undertaken the past summer for the purpose of determining the existence or non-existence of the undertow. While the investigations as conducted did not prove the existence of an undertow that might be dangerous to swimmers, yet if by the term "undertow" is meant a current below the water surface that moves outward approximately perpendicular to the shoreline then the investigations show very definitely the existence of such currents under certain conditions, and the inference is very strong that they may be swift and dangerous during storms.

Obviously, direct observation of the behavior of the movements of the water is very difficult on a large body of water when a heavy sea is running. Therefore it was decided to begin the study by giving attention to the behavior of small water bodies. The first observa-

1 SCIENCE, 61: 206–208, 1925.
2 SCIENCE, 61: 444, 468, 1925.
3 SCIENCE, 62: 30–33, 1925.
4 SCIENCE, 84: 181–182, 1936.

tions were made in a small body of clear water on the South Canadian River bottom near Norman, Oklahoma. This pond was about 20 feet long, 6 or 8 feet wide and 10 inches deep with a quite uniform slope from the sides toward the center. A wind with an estimated velocity of 12 miles an hour was blowing lengthwise of it. Observation of the water movement was made by using ink and a medicine dropper. A little ink liberated near the bottom about two feet out from shore showed a very definite movement of the water to windward. A drop of ink on the surface indicated a relatively rapid movement of water to leeward. This upper layer of moving water was about an inch deep. Here, then, was shown at once a decided undertow. Further investigations showed that the surface of the water in the pond was moving to leeward and that the water underneath was moving to windward. This bottom movement of the water extended clear to the windward side, thus substantiating the statement which is sometimes made that on the windward side of a water body there is often a subaqueous current moving inshore.

Along the shores that were parallel to the direction of wind the water below the surface moved out toward the center for a few inches and then gradually turned with the main body of the windward moving water.

At the windward end of the pond the water surface was smooth, but the waves gradually increased to leeward until they were about 1¼ inches high and produced a miniature surf. Later observations made on some of the artificial lakes in the Wichita Mountain Game Preserve gave similar results. These lakes were several hundred feet across and 10 to 40 feet deep. It was not possible at the time to get out more than a few feet from shore, but it was found that in all cases observed where the wind was blowing on shore there was a current beneath the surface moving outward, and on the windward side there was always a subaqueous current toward the shore. The velocity of these currents was estimated to be between 6 and 15 inches per second. Their velocity varied with the wind and with the depth of the water; the greater depth giving the slower movement. These undercurrents were generally quite steady with very little pulsating movement except in the shallow water close to shore. Close to the bottom the rate of movement of the water was considerably decreased because of friction and very little pick-up of sediment occurred at these velocities. However, when the bottom was disturbed and some of the sediment put into suspension it moved readily with the current.

With the coming of the summer vacation the locality of the investigations was changed to the lakes of western Michigan. Here the first studies were in connection with some small temporary ponds on the Lake Michigan beach some distance south of the entrance to White Lake Harbor. The results were the same as those noted above with the added observation that the returning subaqueous current shows a very strong tendency to follow channels on the bottom of the pond. This study brought out very clearly the fact that the subsurface water is extremely sensitive to the forces acting on it and travels most readily where it meets with the least resistance. Consequently, when currents are present in a body of water the direction and velocity of their movements is very largely determined by the direction of the channels that may be present and the size and shape of their cross-section. Keeping this in mind is very helpful in studying currents in larger water bodies.

Following these studies on small ponds, investigations were made of subsurface currents on several lakes ranging in size from 4 to 16 square miles. On these lakes work could be carried out by wading and by using rowboats when winds prevailed of a velocity that would prevent work on Lake Michigan. The clearness of water in lakes of this region is such that by using colored liquids water movements can be easily observed to a depth of several feet.

The first study was made on White Lake along a shoreline that was straight except for a small bay about 50 feet wide that made an indentation of 30 feet. The wind, which had a fetch of about a mile, was blowing on shore with a velocity of 11 miles per hour. The lake bottom sloped outward about two feet per hundred. Observations along the straight shoreline outward for 50 feet showed no appreciable currents except a slight littoral drift in a few places. However, in the median line of the small bay in water 14 inches deep there was a distinct subsurface current outward with a velocity of about one foot per second.

The next observations were made in a bay-like enclosure formed by two old docks, as shown in Fig. 1. The slope of the bottom from the shore outward is 28 feet per mile. The water is so quiet that there is a considerable growth of weeds in the south and southeast part of the bay. The wind, which was from the southwest with a velocity of 14 miles per hour, caused waves that were sufficient to toss a small rowboat considerably. There are no weeds in the north side of the bay, and along the old lumber dock a clear channel exists that deepens gradually to the west from the shore outward. Observations near where the old dock joined the shore showed that within about 25 feet of the shore the water was moving shorewards. The waves here were partly waves of translation. Whatever outward movement that was present was so hidden in the general confusion of the waters that it was not possible to detect any continuity. Between 25 and 50 feet from shore the water deepened from one foot to three

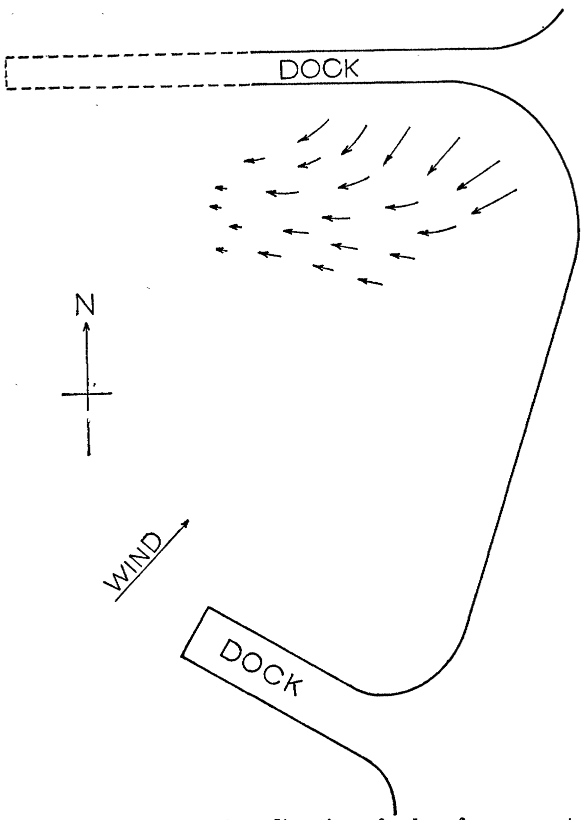

FIG. 1. The arrows show direction of subsurface currents.

feet. Here there was a steady definite outward moving undertow perpendicular to the shoreline with a velocity of one and a half to two feet per second. The wind was not entirely steady, and when the gusts held for two or three minutes the velocity of the undertow was increased considerably. About 50 feet from shore this subsurface current turned gradually and ran parallel with the old dock out toward the center of the lake. It was detected 75 to 100 feet further to the south but with decreasing intensity. As the current moved westward parallel with the dock it weakened as it came into deeper and deeper water until at a depth of six feet it had almost disappeared. It will be noted that this subsurface water was moving west, while the wind and waves were from the southwest.

Again on the northwest side of Silver Lake, which is circular in outline and about one and a half miles in diameter, a gentle southwest wind of five miles per hour gave waves about six inches high and five feet long. At 40 feet from shore in one and a half feet of water this caused a gentle but steady undertow.

Low ridges are frequently present on gently sloping under-water terraces on which there is a plentiful supply of sand. In the larger water bodies these ridges tend to be approximately parallel to the shoreline. They are probably built by the waves and currents during the heavier storms, but at other times they, themselves, exercise some control of the water movements. This was very noticeable on a part of Crystal Lake near Frankfort, Michigan. At Outlet Bay the underwater shelf extends out two thousand feet with a depth of only five feet at the outer edge. The bottom is of sand and gravel and the water is very clear. On this shelf are three sand ridges about one foot high and from 50 to 75 feet wide. The movement of the water on this shelf was carefully studied when the wind was blowing squarely into the bay from the north and the waves were about one and a half feet high. Between the beach and the first ridge, which was about 100 feet from the shore, no outward moving current could be detected, but there was some slight current at times parallel with the shore. However, on the offshore side of each ridge there was a definite but slow elliptical water movement as shown in Fig. 2. This was the general condition, although here

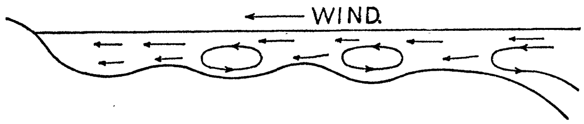

FIG. 2. Showing cross-section above the subaqueous terrace at Crystal Lake. Arrows show direction of currents.

and there a tendency toward a movement parallel to the ridges could be detected. So far as observed, the water movement over the ridges was toward shore but in some cases it was of an oscillating nature.

The studies described above were made on relatively small bodies of water. However, it is quite probable that the movements of water in small lakes are similar to the movements that take place in the larger water bodies under similar conditions. One strong indication of this is the uniformly successful results that have come from the use of working models at the U. S. Waterways Experiment Station at Vicksburg, Mississippi. Therefore these studies would indicate that with favorable conditions of wind, shoreline and bottom contour an undertow does exist.

O. F. EVANS

UNIVERSITY OF OKLAHOMA

FERTILITY AND INTELLIGENCE OF COLLEGE WOMEN

IN a previous communication[1] it was reported that college men scoring high on intelligence tests at matriculation produce more children in the first dozen years after graduation than do those scoring low and that the differential which is significant in this result is age at marriage. It was desired to learn whether the same is true of college women.

The class of 1927 of the Women's (now Pembroke)

[1] R. R. Willoughby, "Fertility and Intelligence of College Men," SCIENCE, 1938, 87, 86–7.