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Search for the Loch Ness Monster

Robert H. Rines
Academy of Applied Science

Charles W. Wyckoff
Applied Photo Sciences, Inc.

Harold E. Edgerton
M.I.T.

Martin Klein
Klein Associates, Inc.

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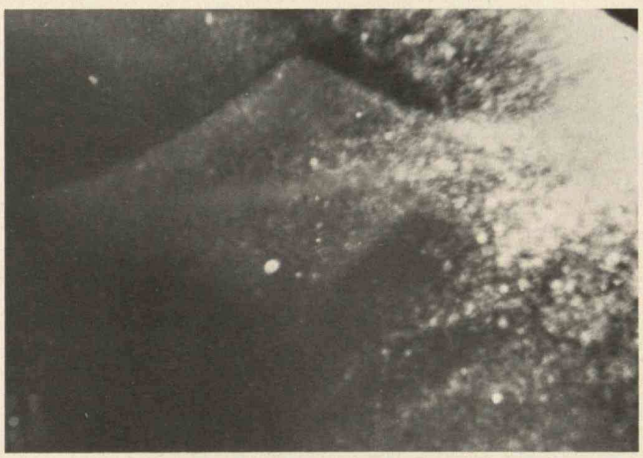
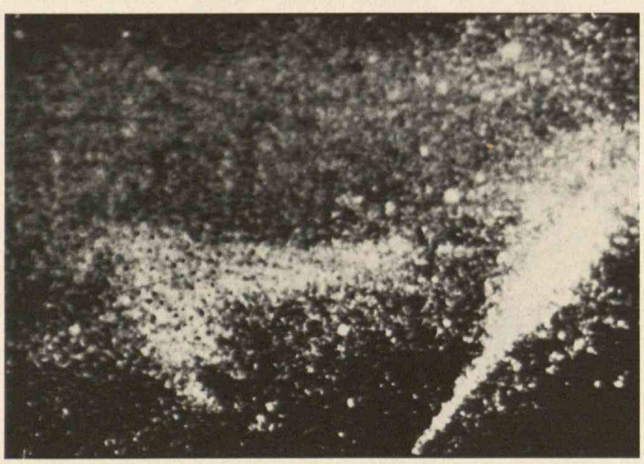
Search for the Loch Ness Monster

Photographs and sonar records obtained at Loch Ness, Scotland, in 1972 and 1975 provide additional evidence for a species of large aquatic creature — the "Loch Ness Monster" — inhabiting the loch.





The first underwater photographs of the "Loch Ness Monster" were these famous shots (shown computer-enhanced and duplicated with higher-than-normal photographic contrast) obtained by Dr. Rines and his colleagues in 1972. They offered tantalizing clues to an age-old mystery, which was heightened even further by the new photographs obtained in 1975. The above photographs are the famed "flipper" pictures, the second taken 45 seconds after the first. The difference in position of the flipper indicates movement. Measurements from these photographs indicate the flipper is about four to six feet long, which agrees well with measurements from sonar records obtained during the same period. The picture at the left is the 1972 "two-body" photograph, taken when the sonar record indicated the presence of two large objects. Their lengths and separation agree well with the sonar record. (Academy of Applied Science)

Above: Urquhart Bay in Loch Ness. The Enrick and Coiltie Rivers empty into the Bay from the right of the picture. The ruins of an abandoned castle stand on the promontory. Right: A three-dimensional map of Urquhart Bay, showing deep channels which the camera-strobe and sonar apparatus monitored in the 1972 and 1975 Academy of Applied Science Expeditions. The depth dimension is expanded to better show the contours. The Academy investigators reasoned that a fish-eating creature might lay in these valleys awaiting salmon swimming into rivers from the bay. (Copyright: Academy of Applied Science)

Loch Ness in northern Scotland is the largest freshwater lake in volume in Great Britain, and the third largest in Europe. Although it is only about 24 miles long and a mile or so wide, it more than compensates for this small surface area with its remarkable depth, a maximum reported at 975 feet, and 700 feet over much of its length. The sides of the loch slope downward precipitously away from the banks, and the bottom has been shown to be mainly a flat, vegetation-free plain of silt. Salmon, sea trout and elvers migrate from the sea into the loch and from there up several rivers running into it. There are resident populations of brown trout, eels, char, and stickleback, and the shallows harbor profusions of freshwater weeds. The waters of the loch are cold — at a fairly constant year-round temperature of about 42° F. — and extremely murky, due to the large amounts of suspended peat particles. Maximum underwater visibility is limited to a few feet.

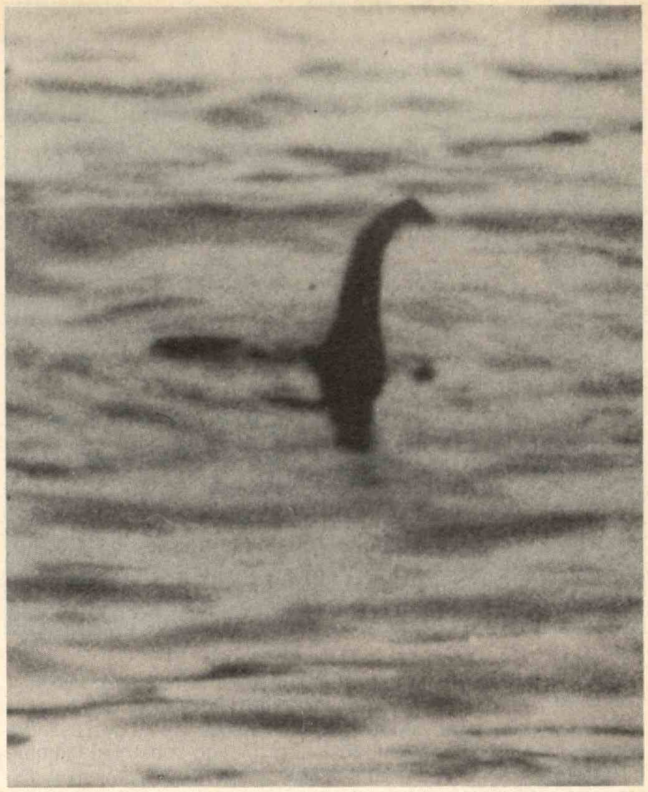
Even before the Highlands of Scotland were introduced to the outside world at the beginning of the Middle Ages, there were legends of large aquatic creatures in the lochs. The legend of the water horse or kelpie was widely believed, and still persists today. This creature was said to occupy lonely lochs and to lure weary travelers to their death. The first record of a large creature in Loch Ness was in 565 A.D. when Saint Columba, the man who brought the Christian religion to Scotland, was said to have encountered a large monster in the loch and frightened it off. Similar sketchy accounts of monsters, "floating islands," and "Leviathan creatures" appeared occasionally in journals and other records.

News of a monster in the loch was first widely disseminated in 1933 with the publication of several newspaper stories following completion of an auto roadway along the western shore. Since then the monster has been a more or less regular phenomenon, with literally hundreds of reputable sightings by laymen and scientists alike. Over the 50 years or so of modern sightings, descriptions of the monster have remained consistent. The creature is usually said to total about 20 feet long and possess one or two humps and a long, slender neck topped by a small head. Several observers have reported protruberances from the head, which has been described as bony and angular. The humps project several feet out of the water. The creature swims rapidly, submerges and surfaces creating a definite wake as it moves. It swims both with and against prevailing winds. The color has been consistently described as dark gray or brownish black, although some observers have reported a light streak down the "belly," and others have described dark blotches or cow-like dapples. Several observers report seeing fish and birds reacting to the appearance of the object.

Verified photographs and motion pictures of the phenomenon (particularly the motion picture obtained by British aeronautical engineer Tim Dinsdale) agree well with sighting reports: they show humps, and in one case, what appears to be a slender neck and head protruding from the water (*see photo on this page*).

Since the advent of sonar, numerous records have been made by fishermen, biologists and engineers of large, moving objects traveling underwater in the loch. These objects showed up as individual, large traces, readily distinguishable from the more fragmented echoes obtained from fish schools or water bubbles.

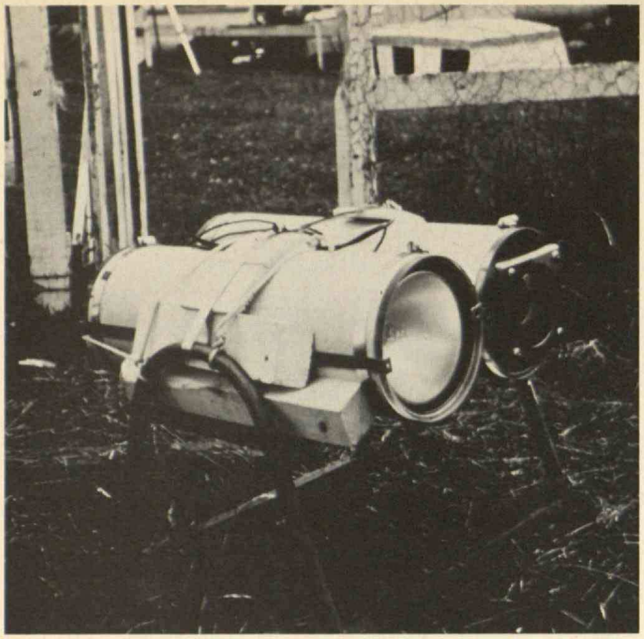
Thus, Loch Ness has a long history of reputable, consistent sightings, much of it compiled by the British Loch Ness Investigation Bureau, and modern techniques have yielded some physical evidence of large aquatic animals. It was this extensive network of circumstantial data that led the Academy of Applied Science to begin investigations in the loch in cooperation with the Bureau.

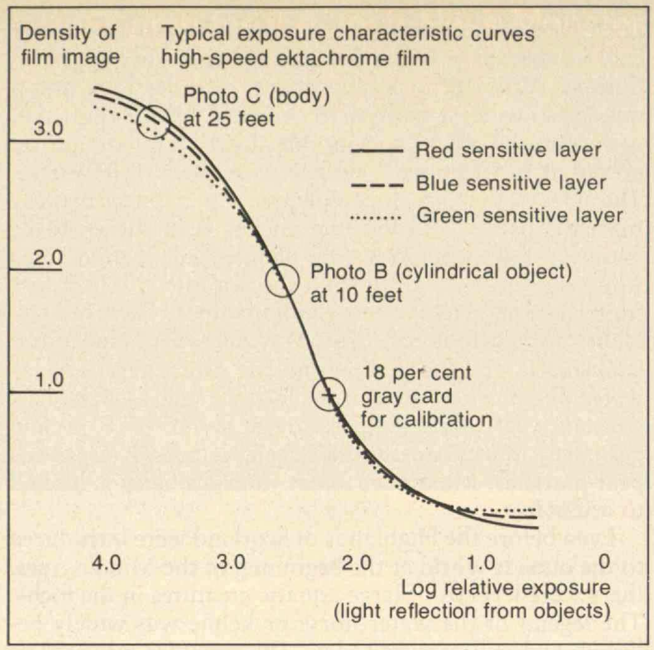


The "surgeon" photo, taken in 1934 by a London physician, is perhaps the most widely publicized photograph of the Loch Ness phenomenon. It has been alternatively explained as a bird's neck or an otter's tail, but no evidence of faking in the film negative has been discovered. This photograph is one of a pair, the second showing the object leaning "forward" as it submerges. (Associated Newspapers photograph)

The Academy, founded in 1963, consists of about 350 members, devoted to supporting unusual areas of research, and promoting interaction among scientists, inventors and industrialists.

The first Academy expedition to the loch, in 1970, attempted to confirm earlier sonar contacts with large loch creatures. Using a high-frequency, side-scan sonar designed by author Klein, several contacts were made. The most successful of these was the detection of something large passing through the sonar beam while the apparatus was attached to a pier in Urquhart Bay. About 15 minutes later, and then another ten minutes later, similar targets at further distances were detected. These objects were about 10 to 50 times larger than the fish detected many times before in the sonar beam and had a parallel-track characteristic appearance. These were definitely moving, solid objects coming in and out of the beam. The technique of using sonar to discriminate moving targets will be explained in more detail later.





Above: The camera-strobe system used in the 1972 expedition. The system consists of a 16-mm. time-lapse motion picture camera and a 50-watt-second strobe light, each housed in its own cylindrical case. Above right: A "D/logE" curve for high-speed Ektachrome tungsten-type film. Use of this characteristic curve allows the distance of a given object from the camera to be computed by the measurement of light reflected from the object. The curve is calibrated using photographs of objects at known distances. The light reflected from an unknown object can be translated into a distance measurement by referring to the curve. The points shown on the curve are for the various photographs taken in 1975 in Loch Ness. The three curves represent the light sensitivities to the three individual emulsion layers in the color film — red, green and blue.

The Camera-Strobe System

In 1972 the Academy's expedition added a camera-strobe light system developed by author Edgerton for the National Geographic Society to photograph underwater life. While Dr. Edgerton was not present at lochside, he assisted in both preparing the equipment and analyzing and critiquing the data.

The camera used in the Academy expedition consists of a 16-mm. time-lapse motion picture camera with a fixed-focus 10-mm.-focal-length lens operating at a relative aperture of f/1.8. The camera was synchronized with an electronic flash unit of about 50 watt-seconds power, and an adjustable timer capable of taking photographs from 3 to 90 seconds apart (*see above left*). With a 50-foot magazine of film in the camera, the unit can thus record 2,000 separate images over a 1¾- to 50-hour period. The camera and light were each housed in their own cylindrical, waterproof casings, and each had its own battery power source. The two were synchronized such that the strobe would flash when the camera shutter was wide open. The exposure time of the camera was .01 second and the flash duration was one millisecond. Each unit was activated by its own external switch, which was turned on just before the system was lowered into the water.

The film for the 1972 expedition was Kodachrome II, with an ASA of 25. This film allowed the system to photograph at about 10-foot distances in the water of the loch. In 1975, a better range was obtained through the use of high-speed Ektachrome tungsten-type film, with an ASA of 125. The tungsten type, or "indoor," film was used because, despite the daylight-quality of the strobe flash, the water acted as a yellow filter, which effectively "warmed" the color of the strobe flash to more nearly simulate tungsten light.

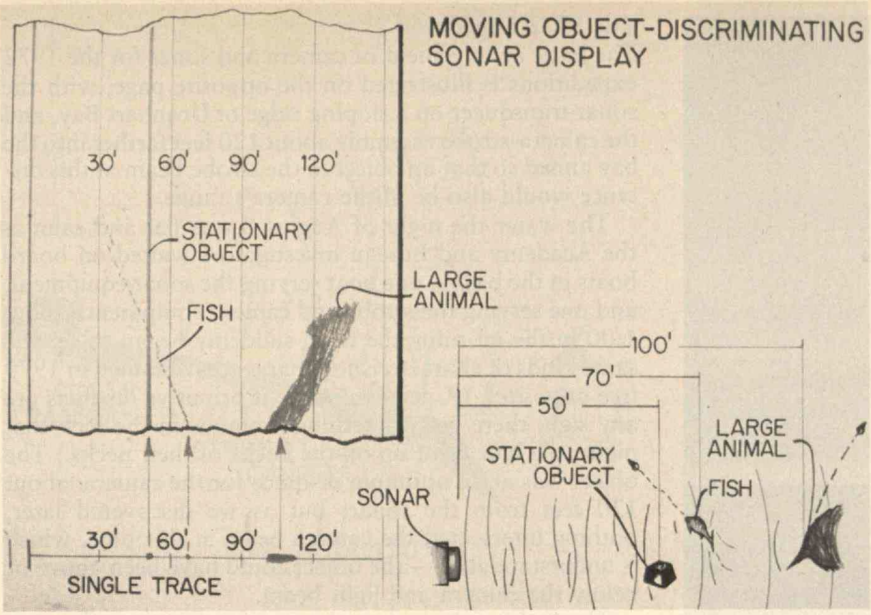
For the 1975 expedition, the previously described camera-strobe unit was used as a backup, and the primary camera was linked to the sonar system such that only the presence of a large object in the sonar beam would trigger the camera.

The peat-stained waters of the loch imposed severe constraints on the photographic system. The attenuation of light in the murky waters, in combination with the aperture of the camera lens and the speed of the film, precludes photographs at any distance greater than about 30 feet. At ranges approaching this, the resulting images are quite dark, and it should be kept in mind that the longer-distance photographs in this article have been lightened for publication.

The attenuation of light by the water did, however, have its positive side. From various calibration measurements, it was known how much optical density would be evidenced on the exposed film for a given distance of a photographed object from the camera-strobe system. To find out how far an unknown object was from the camera, one simply compared the optical density of the object with the known-distance object (*see p. 38*). From this distance information it was possible to determine the size of the object's image as measured in the frame. These measurements, it should be noted, are independent of any measurements obtained through sonar or by measuring how a photographed object intersects the cone of light emitted by the strobe. This latter method will be discussed later.

Side-Scan and Other Sonars

The sonar system used in 1970 was a Klein Associates



A moving-target-discriminating sonar trace — with the apparatus stationary — is a graph in which the vertical scale is time, and the horizontal scale distance. The straight line at the left indicates the outgoing sonar pulse. Stationary objects show up as vertical lines at various distances from the outgoing pulse, and moving objects generally show up as diagonally-oriented traces. Large moving objects will be portrayed as heavy, black traces, and small objects as lighter and sometimes discontinuous traces. (Academy of Applied Science)

HYDROSCAN side-scan sonar which used a frequency of 50 kiloHertz and a pulse length of 0.1 milliseconds, with five pulses emitted per second. In 1972 and 1975, a Raytheon Model DE 725C echo sounder was used which emitted a very short pulse at 200 kiloHertz.

Like the camera-strobe system, side-scan sonar has had an extensive history of use underwater. Usually towed behind a ship, it has been used in such applications as locating sunken ships and mapping the ocean-bottom in offshore oil exploration.

The sonar records, illustrated by the trace above, consist of a strip chart recording, in which the vertical line at the left represents the outgoing pulse, and the traces to the right, the reflections of that pulse from an object. The horizontal axis is thus distance, and the vertical axis time.

In the Loch Ness application, the aim was to detect and measure a large, moving object. So the sonar was mounted on a stationary platform placed on the sloping loch bottom, and the beam aimed horizontally out into the loch. This operating mode made the side-scan sonar a powerful tool for producing clear evidence of a moving creature, for there is no question that an object entering the stationary beam is in motion. Also, the stationary sonar obtains a long-term record of fixed objects on the loch floor — rocks, pilings, etc. These show up as straight lines on the recorder, and are recorded repeatedly. This allows any new pulses to be readily discriminated from objects already in the beam, and it can be said with certainty that the sonar is not simply reacting to background objects.

Sonar also readily discriminates between collections of small objects such as fish schools and large, solid objects. The former show up as collections of many, small tracings, as shown above, while the latter show up as solid, black tracings on the recorder. After the many hours author Klein spent monitoring the loch, and from experience in other waters of the world, he found it possible to distinguish large objects from collections of small ones. Other sonar experts were also asked to interpret the 1972 sonar traces, including Paul Skitzi of Raytheon Co.; R. Eide of Simrad Co., a sonar firm; John V. Bouyoucos of Hydroacoustics; and Ira Dyer of M.I.T.'s Department of Ocean Engineering. The actual arrangements of the camera, strobe, and sonar systems for the years 1972 and 1975 will be covered later.

Where to Look

The chances of a creature coming into camera range during the brief periods of the expeditions were quite small, considering the size of the loch and the apparent relative scarcity of sightings.

To increase the chances of observing the creature, Dr. Jan-Olaf Willums, formerly of M.I.T., performed a computer study to determine the best spot for study. Dr. Willums based his study on 258 reliable accounts of sightings between 1961 and 1970. These were collected by the Loch Ness Investigation Bureau. His correlations of the physical parameters of the sightings agree well with past experience. Eighty-four per cent of all sightings occurred during times of very calm surface conditions, and most of these sightings occurred during June, July, and August. (Of course, these results were just as likely due to visibility or to the habits of observers as to the habits of the creature.)

Seventy per cent of observers estimated the length of the object above the surface at about 20 feet or less; the mean of these measurements was 17 feet. Eighty-two per cent reported the height above the water of less than four feet. About half the observers could report a color — dark brown — and the other half reported black.

But the most important finding was that certain areas of the loch appeared far more productive than others in terms of sightings, at least on the basis of these data. Over half of the sightings occurred near river mouths and bays with active water movement, and Urquhart Bay alone was responsible for 57 of the 258 sightings. Again, this could have been because of the visibility of the bay from land or because of the habits of the observers, but at least the statistics give some idea of productive search areas. Also, corrections were made to allow for possible differ-

Calibration photographs of the bottom of Loch Ness. The top photo shows disturbed lake bottom with clouds of silt, and the bottom shot shows undisturbed bottom. (Academy of Applied Science)

ences in visibility from land of different areas. In any case, the scarcity of sightings even in productive areas helps explain why, of several hundred photographs taken, only a few produced positive results.

A three-dimensional map of Urquhart Bay was developed from bottom-sonar surveying (shown on page 26 with the depth dimension expanded) to determine the optimum placement for the equipment. It was determined that the equipment should be placed from 20 to 50 feet below the surface. The 1972 equipment was installed on an underwater ridge near Temple Pier in the Bay, aimed across a deep underwater valley. In 1975, the equipment was installed farther along the bay. We theorized that a fish-eating creature might lay in this valley awaiting salmon entering the river to spawn.

Another factor to be considered was the time of year to conduct our studies. Assuming that a large aquatic creature in the loch feeds on fish, it would be best to study the area when fish populations were high. It turns out that the bay is fed by two rivers — the Enrick and the Coiltie — and at various times of the year salmon and sea trout come into the bay to travel up these rivers to spawn. However, at certain times of the year, these rivers are dry; so we decided to wait for the coincidence of salmon spawning and dry rivers, which would cause the fish to collect in large numbers in the bay. This was the situation on August 8, 1972, when the first underwater pictures were obtained.

The 1972 Expedition

The basic arrangement of camera and sonar for the 1972 expeditions is illustrated on the opposite page, with the sonar transducer on a sloping ridge of Urquhart Bay, and the camera-strobe assembly about 120 feet farther into the bay aimed so that an object in the strobe beam at this distance would also be in the camera's range.

The water the night of August 8 was flat and calm as the Academy and Bureau investigators waited on board boats in the bay — one boat serving the sonar equipment, and one serving the strobe and camera equipment. About 1:00 in the morning the team suddenly began to see the same kinds of characteristic sonar traces obtained in 1970 (*see opposite*). (A personal note: if primitive instincts are any sign, there was something ominous in the loch that night; the hair went up on the backs of their necks.) The object was at an optimum distance for the camera, about 120 feet from the sonar; but as we discovered later, nothing intersected the camera beam at this time, which is understandable — the object could have been above or below the camera and light beam.

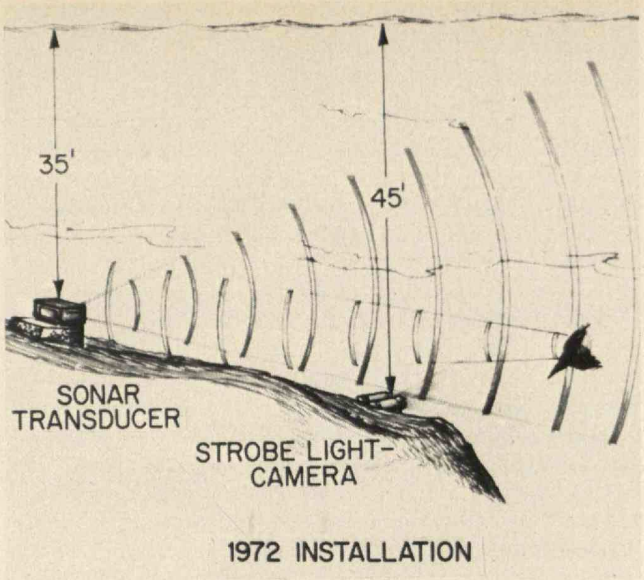
Then, about 40 minutes later, salmon were seen jumping away from something in the loch and this flight was also seen on the sonar. At the same time a large object came back into the beam, and a bit later still a second object of similar size. As you can see from the trace on the opposite page, these objects were separated by about 12 feet; they were, indeed, distinct objects. During this period photographs were obtained of what was in the beam, and these are shown on the first page of this article, in computer-enhanced versions.

The sonar chart was submitted to six experts including those named earlier, without informing them we had obtained any photographs, and they concluded that the tracings showed a large object with an approximate ten-foot "appendage," and still another large object separate from the first.

Thus, we had powerful corroborative evidence in the combination of the sonar record and the photographs and the respective dimensions available from each, particularly since we had calibrated our camera system by photographing various objects above and below the water. A typical calibration shot is shown on page 38.

Because of the murkiness of the water, the photographs obtained that night appear to be quite vague. However, when computer-enhanced, there appeared in two pictures the images of a flipper, and, in the third picture, two blobs (*see p. 25*). The flipper pictures, the second taken 45 seconds after the first, show the object in two different positions. The third picture shows what may be two bodies. It should be added that we did not recognize the existence of two bodies in the picture until the sonar experts informed us that there were two objects in the beam at about the same time. However, when the pictures were computer-enhanced, and we knew what to look for, the bodies became apparent. The relative optical measurements of this picture on the basis of densitometer measurements, confirm the sonar indication that the two objects are about 12 feet apart.

Besides the measurement from analyzing the sonar record, an independent measurement of the flipper was obtained by considering the image's size and the optical system of the camera. An inspection of the film frame showing the flipper immediately suggests that the center line of the flipper, running diagonally across the frame, is quite well in focus, whereas that portion of the image along the



Above: The arrangement of camera-strobe and sonar apparatus for the 1972 expedition to Loch Ness. At the right: The sonar trace obtained on August 9, 1972, showing two large moving objects in the beam. The faint vertical lines mark off distances of six feet. During this time period, the "flipper" photographs were obtained. Sonar experts, who were unaware of the photographs' existence, identified the lower right spike as a protruding appendage. The sonar experts concluded that two large creatures were shown half-way up in the record, separated by about 12 feet. (Academy of Applied Science)

right side of the frame is definitely out of focus. In order to appear in focus with this fixed-focus, 10-mm. lens, operating at f/1.8, the flipper cannot be closer than about four feet from the lens and would be, thus, about four to six feet long. If it were smaller and closer to the lens the image would appear to be out of focus and would very definitely be even more fuzzy than that illustrated here.

At this point we should, perhaps, say a few words about the process of computer enhancement. This technique has proven to be a reliable tool and a standard research technique in a variety of scientific disciplines. It has been used to clarify images from space probes, in forensics to help identify fingerprints, and in medical research to classify human chromosomes. In the technique, a spot of light of known and constant intensity is swept across the photographic transparency to be enhanced, usually in a raster pattern similar to that used in television. A photoelectric cell records the intensity of the light beam emerging from the other side of the transparency, and these encoded intensities are processed by the computer. The computer can be programmed to remove strong illumination gradients, that is, "smooth out" overexposed or underexposed spots, and correct other lighting artifacts in the picture. It can also increase the contrast between objects in the picture and background. The computer can make mathematical judgements only to enhance those patterns already evident on the photograph; it cannot create patterns where there are none.

The 1975 Expedition

The next successful expedition, in June, 1975, incorporated a number of new techniques into another camera-strobe system, to remedy some of the technical problems in the 1972 expedition. As noted earlier, we also switched to a more sensitive film for all photography.

The severe backscatter from the particulate matter in the water was reduced by putting about five feet between the strobe light and the camera. While this did improve picture quality, it did not affect the 30-foot or so limit on the camera-strobe's range. In addition, we increased the picture-taking frequency in the new unit to one frame every 15 seconds to give better time resolution. To give our camera-strobe system a longer active life in the loch, we also included a new triggering system in which the system was attached to the sonar through a computer constructed by United States Scientific Instruments. Only when an object with a cross-section of four to five feet entered the beam, at a distance of less than 40 feet, would the camera begin taking pictures.

As a backup system in the 1975 expedition, the 1972 apparatus was used, again separating the camera and light to minimize backscatter. The apparatus was mounted on a tubular frame, with a camera-light separation of about five feet. When suspended from the boat, the light would be on top flashing straight out into the water, and the camera hanging below aimed slightly upward. The backup system was set to take pictures at

The Environment in Loch Ness

This ecological analysis of Loch Ness is excerpted from the more extensive analysis of the phenomenon in The Monsters of Loch Ness *by Roy P. Mackal, The Swallow Press, Inc., Chicago, Illinois, 1976. Professor Mackal has been a Professor of Biochemistry at the University of Chicago for 20 years and is a director of the Loch Ness Investigation Bureau, which studied the Loch Ness phenomenon until 1972.*

In hypothesizing the existence of large creatures inhabiting Loch Ness, we must consider whether the physical and biological characteristics of the loch would even allow such a hypothesis. This analysis considers the various features of the loch, in relation to the categories into which a Loch Ness monster might fall — mammal, reptile, amphibian, fish, invertebrate. As you will see, the information thus far about the loch indicates it is quite capable of supporting a small, viable population of large predators.

The temperature of the loch is a relatively constant 42°F below the thermocline (the boundary between the variable upper layer and cold lower layer). The loch never freezes at its surface. The latitude of Loch Ness is 56°N, which normally would be almost subarctic if located more centrally in a large continental land mass, but the tremendous heat capacity of the North Atlantic and the warm Gulf Stream combine to reduce the extremes of heat and cold at that latitude of Scotland, producing warm winters and cool summers.

Living forms of the mammalian order sirenia — manatees, and dugongs, or sea cows — are restricted to tropical waters, but the extinct Steller's sea cow was a four-ton animal found in arctic waters, so there is no reason that such an aquatic mammal would not be at home in the waters of Loch Ness.

The low temperature of the loch seems to rule out a reptile hypothesis. However, studies at Woods Hole Oceanographic Institute on the large leatherback turtle have found that they readily maintain body temperatures and remain active in waters of 45°F. Dr. Wayne Friar and his colleagues placed two such animals in waters of this temperature for 24 hours and recorded a deep body temperature afterward of about 78°F. The underlying mechanism for such heat maintenance is probably heat production through muscular activity and heat retention aided by a large body mass. Further, the information regarding the size of the Loch Ness monsters indicates they are much larger than the leatherback turtle. This means a larger mass-to-surface-area ratio, making heat retention even more efficient.

In contrast to reptiles, amphibia have adapted to a very wide range of temperatures, from tropical regions to the permafrost regions of Siberia. Stability of the temperature is a prime requisite, which would make the constant year-through temperature in Loch Ness a most suitable environment for large aquatic amphibians.

Some have advanced the possibility that the Loch Ness monster is a large eel, and there is no question of the suitability of the temperature of the loch for eels, since small eels are thriving in the lake. Also, it has been suggested that the animal may be a mollusk (snails, squid, etc.), and the temperatures in Loch Ness present no problems for these creatures.

None of the candidate species is ruled out because of the freshwater conditions of the loch. Those animals, such as sirenia and reptiles, which are saltwater species could easily have swum up the rivers into the loch to escape predators or pursue prey, and could have adapted to the loch. Although the plesiosaur, one likely reptile candidate, was mainly, if not exclusively, a saltwater animal, fossil records have been discovered in areas indicating freshwater conditions.

Zoologists concerned with the Loch Ness creatures often ask: "But what would they eat?" Obviously no single animal could survive over the hundreds of years during which sightings have been reported, so the animals must be present in sufficient numbers to assure reproduction and to withstand attrition from disease and other natural causes. Such a group of large aquatic animals must consume a substantial amount of food. How much food is required for a particular kind of animal depends not only on its size, but also on its metabolic rate and energy requirements for maintaining its activities. An aquatic mammal, for instance, consumes food equal to 1 to 10 per cent of its own body weight per day. This requirement is the highest of any of the candidate categories, since mammals would be required to maintain a body temperature above that of the cold loch water. Daily food requirements for a variety of aquatic predators are 0.001 per cent to 1 per cent of body weight.

The requirement that Loch Ness monsters be predators stems from the low levels of plant life in the loch. The peat-stained water of the loch severely limits light penetration; consequently plant life grows only in a few shallow areas, being insufficient to support even a small group of large herbivores. Loch Ness is also lean in its content of freshwater plankton.

Many life forms in lakes such as Loch Ness ultimately depend on the sea for subsistence. The loch is connected to the sea via the River Ness, Loch Linnhe, and the two sections of the Caledonian Canal.

Although vegetation is lacking, fish could provide an adequate food supply for our Loch Ness monsters. The loch contains an abundance of sea trout, pike, stickleback, char, eels and salmon. And among these, salmon could be a key source of food for our colony of creatures.

We made a rough calculation of the number of these migrating salmon, working from a 1971 underwater photograph of the shoals of salmon migrating into the River Enrick, at the mouth of Urquhart Bay, to swim upstream and spawn.

From this photograph, we computed that the population density of fish in this entry zone into the river during migration was 0.2 fish per square foot. This would mean a population of about 300 fish in the 1400-square-foot entry zone to the river, which we reduce to 150 to account for the reduced densities in the outer fringes of the area.

From fish migration speeds and sizes, we calculated that about 36,000 fish per hour entered the river at the peak of the four-day migration, making an average migration rate, we believe, of 18,000 fish per hour. This means a total of about 1,700,000 fish may have entered the river to spawn during this period. This is not such an unusual figure; in Alaska's Kvichak River a migration of nine million sockeye salmon has been recorded in nine days. Also, it might seem that the entrance into the Enrick of that many salmon might hopelessly clog the river. However, we calculate that a given fish will spend only 12 hours in the river because of the proximity of the spawning grounds to the mouth, and that population densities in the river during spawning remain well below that which the fish easily tolerate at the river's mouth.

Since there are six major rivers like the Enrick entering the Loch Ness, plus some 30 smaller streams, we estimate that prior to their spawning, the Loch Ness could contain up to 13 million adult salmon. Using an average weight of ten pounds, this would mean a total weight of 65,000 tons. The periodic nature of this food supply would present no difficulty, because many aquatic carnivores feed heartily during annual cycles when food is plentiful and fast during lean periods. However, fish predators in Loch Ness do not have to wait a year: in addition to the inward migration of adult salmon for the spawning season, there is the outward migration of the two-year-old juveniles making their way to the sea. Thus, the migratory cycle produces within Loch Ness another and even greater food source, one not periodic but constant in its supply. Feeding in Loch Ness and its tributaries at any given time there may be up to 19 billion juvenile salmon with a total weight of 680,000 tons, according to our calculations.

How many predators might migratory salmon support? Considering only the juvenile salmon, if 10 per cent were lost per year to predation, this would mean a food supply of 68,000 tons. If the average predator consumed 1 per cent of its weight per day (365 per cent per year), this would mean the total body weight of predators in the loch would be 68,000 tons ÷ 3.65 = 18,600 tons. Assuming that the large unknown predators in the loch represent only 1 per cent of this predator weight, we arrive at a total weight of 186 tons (372,000 pounds). Sonar evidence and sightings suggest a length of 20 feet for the creatures, meaning a weight of 2,500 pounds. Thus 150 to 200 large creatures could be supported on the migratory juvenile salmon alone. If the creatures were smaller or their intake requirements more modest, this would raise the upper population limits even further. Of course all these figures are quite rough, and are meant only to make the point that there appear to be large stocks of migratory salmon, capable of supporting a viable population of large predators. Even if the upper limit of our salmon population estimate were reduced by tenfold, the juvenile salmon could still provide food for 15 to 20 large fish predators.

Could Loch Ness support a small population of large animals even if no migratory food were available? This question has been explored by A. W. Sheldon and S. P. Kerr of the Bedford Institute of Oceanography and by W. Scheider and P. Wallis, in two papers published in the journal *Limnology and Oceanography*. Both groups calculated a possible population density of monsters in Loch Ness based on estimated stocks of living organisms in the loch. Sheldon and Kerr calculated the range of the total mass of monsters as between 7,000 and 34,500 pounds. Assuming 220 pounds per monster, the number of monsters in the loch could be as many as 156. Scheider and Wallis used an alternate method of calculating, but arrived at similar biomass estimates — 34,600 pounds. They suggest that the total populations of our animals in Loch Ness might range, depending on weight, between ten large monsters and 157 small monsters.

Of the many candidates for the Loch Ness monster, the requirements that it be fish-eating rules out only the herbivorous sirenia. Plesiosaurs were superbly adapted for catching fish, and in some fossil remains, fish and other animals were found in the stomach cavity. Among amphibians, eels, and mollusks we also find very effective fish predators.

1.2-minute intervals, giving a potential recording time of 40 hours before reloading was necessary. Page 39 shows a diagram of the arrangement, with the sonar-controlled camera station installed on a bottom ledge, mounted on a concrete base, at a depth of 80 feet. The auxiliary system was suspended from a boat (at the expense of strained backs by Rines and Dinsdale) above the primary system, 40 feet beneath the surface and 40 feet above the bottom ledge. These distances are important because they indicate that at no time could the backup system have photographed the bottom in the murky water.

The cone of the strobe light can be used to gauge distances from the camera. The light cone and camera field intersect at about ten feet, so any object within the field of view and ten feet from the camera will be brightly illuminated, while anything 20 feet away will have its upper part in shadow. Also, objects close to the camera would be illuminated only by scattered light outside the main beam of the strobe light (*see p. 39*).

The sonar record did show large objects near the camera but we later discovered that the main camera had been blocked by silt stirred up from the mud bottom. We know the silt was stirred up by the animal, because divers confirmed that the camera was clean after it was put on the bottom. Fortunately, however, the auxiliary camera functioned properly and in one 24-hour period provided the pictures on the next pages. The preceding and following frames show that the object photographed is "new" and was not present in the camera's range in the period preceding and following. The frames also show that the camera was subjected to agitation before and/or after several of the photographs. Normally all that would appear on the film would be blackness as the strobe light flashed out into the murky loch waters.

Photograph **A**, taken at 9:45 p.m. on June 19, shows what appears to be a portion of a larger, pinkish object, in the lower left corner of the frame. Remember that these and subsequent photographs could not have been pictures of the bottom — it was too far away — and calibration photographs we have taken show that the smooth loch bottom shows little resemblance to the objects photographed, as you can see on page 30.

Photograph **B**, taken at 10:30 p.m., shows what appears to be a portion of a large cylindrical object, about ten feet from the camera. The distance was known, because light densitometer measurements showed that the reflected light, which made an exposure on the film, was that expected for a ten-foot distance. The cylindrical nature of the object is indicated because the light falls off regularly at the far and near edges, while light does not fall off from one end to the other. The distance from the near line of shadow, or terminator, to the far edge, or limb, indicates a diameter of about six feet.

Photograph **C**, taken about 4:32 a.m. on June 20, shows what appears to be upper torso, neck, and head of the "creature." The body surface is dappled.

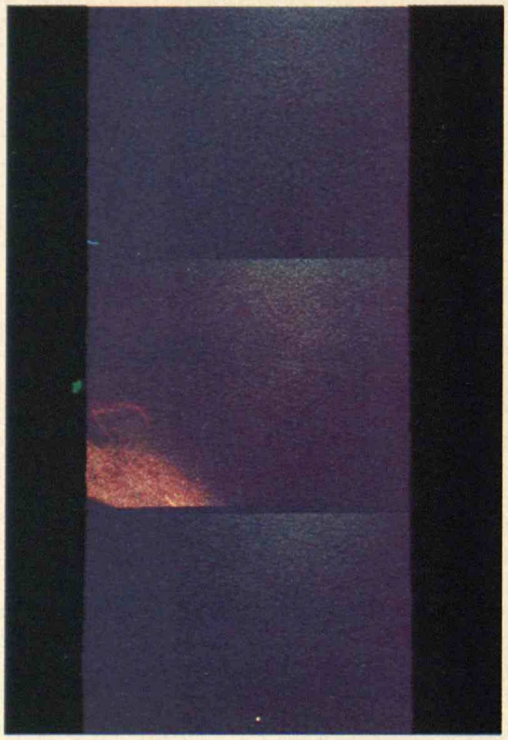
According to the densitometer measurements and the light-cone measurements mentioned earlier, the picture shows that the body was about 25 feet from the camera and extends from the bottom of the frame about one-quarter way into the frame. The neck would not be fully illuminated in such a position, but one could assume that the lit upper portion of the frame is connected to the lower portion.

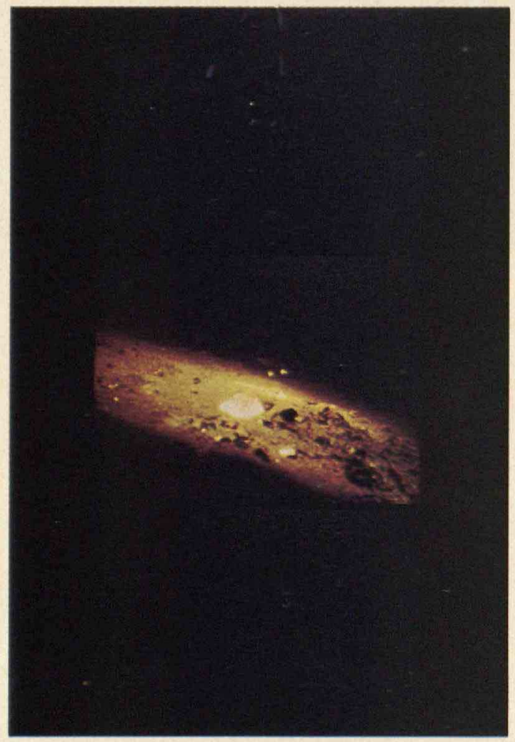
As we interpret it, the neck portion of the object ex-

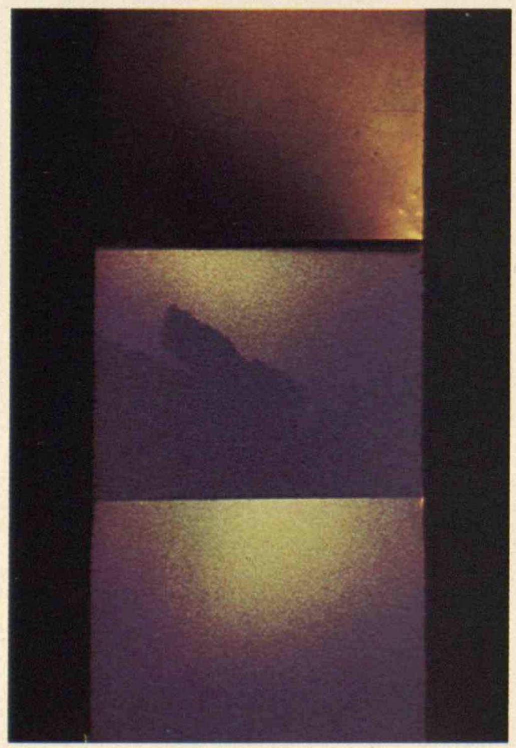
Continued on page 38

A At 9:45 p.m., June 19, 1975, the first unknown object was photographed by the backup system. Note that the object was not present in the preceding and following frames. (Academy of Applied Science)

B At 10:30 p.m., June 19, a large cylindrical object was photographed for a single frame only, and at a distance of ten feet from the camera. It is thought to be cylindrical because light falls off at the far and near edges, but not at the right or left edges. Measurements indicate a diameter of about six feet. (Academy of Applied Science)

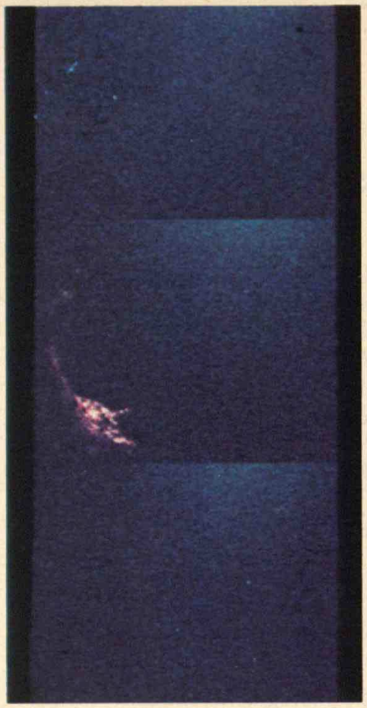




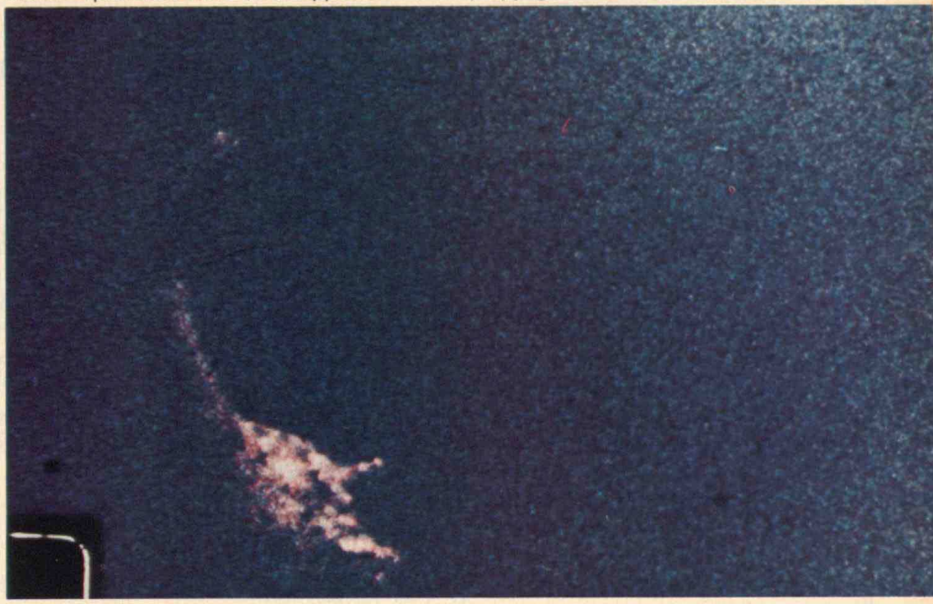


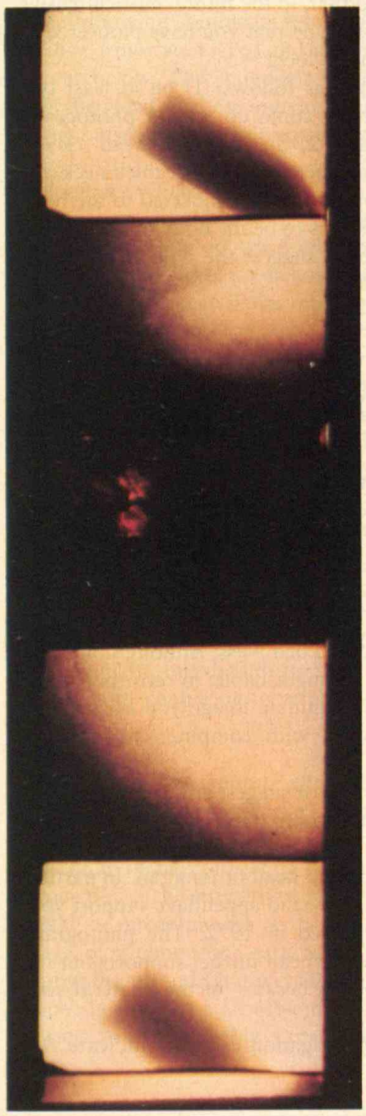
D Around 5:40 a.m., June 20, a photograph of another unidentified object was obtained. It was immediately preceded by evidence of the camera being perturbed and tilted upward toward the boat some 70°. (Academy of Applied Science)

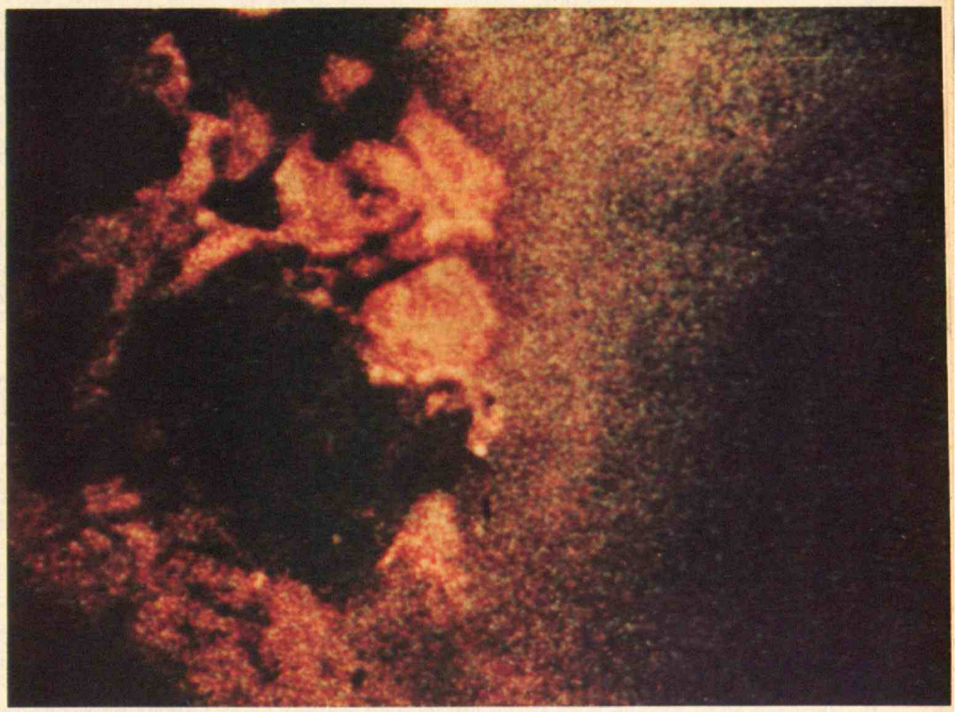
F A further photograph, obtained about 4:50 p.m., June 20, shows a silhouetted image slanting diagonally, in one frame only. It was obtained shortly after the camera was agitated. (Academy of Applied Science)



C At 4:32 a.m., June 20, a photograph was obtained on a single frame only of what appears to be the upper torso, neck and head of a living creature. (Photo taken between photos **B** and **D**; see opposite page.) Light cone and densitometer measurements indicate the body was at a distance of 25 feet, and, thus, that the object must have been about 20 feet long. (Copyright Academy of Applied Science)







E This series of seven frames (film strip at left; top and bottom not shown in full) was taken around 11:45 a.m., June 20 (between photos **D** and **F**; see opposite.) It records a period of major disturbance, with the camera swinging upward, in the middle of which the "head" photograph was obtained. The bilateral symmetry of the object strongly suggests that it is the head of a living creature. The object was about five feet from the camera, and about two feet long, although precision is impossible, because the entire object is not in the frame. (Copyright Academy of Applied Science) At the left: A painting by British naturalist Sir Peter Scott shows one interpretation of the "head" shot.

Scientists on the Loch Ness Photographs

The following are excerpts from statements by various experts, after having examined the 1972 and 1975 evidence on the Loch Ness phenomenon. Unless otherwise indicated they were all presented at a symposium on the subject in the British Parliament on December 10, 1975.

"The following statements represent my personal opinion. These statements do not represent an official view of the Smithsonian. The data gathered in 1972 consist of a 16-mm. film and a continuous sonar record. One part of the sonar record clearly shows a series of small objects and several larger objects. Sonar experts interpret the smaller objects as fish and the larger objects as animate objects in the 20- to 30-foot size range. I concur with this interpretation and further suggest that these are fish and the recently described *Nessiteras rhombopteryx,* previously known as the Loch Ness monsters.

"Computer enhancement of the 16-mm. film frames taken at the same time as the sonar record of large animate objects reveal a number of objects. The most distinct image is of a rhomboidal shape attached by a narrow base to a larger object. I interpret this as a flipper-like appendage protruding from the side of a robust body.

"The 1975 16-mm. film includes several frames containing images of objects which possess symmetrical profiles, which indicate that they are animate objects or parts thereof. I would suggest that one of the images is a portion of the body and neck, and another a head.

"I believe these data indicate the presence of large animals in Loch Ness but are insufficient to identify them. This new evidence on the existence of a population of large animals in Loch Ness should serve to encourage research on the natural history of Loch Ness and its plant and animal inhabitants, and remove the stigma of 'crackpot' from any scientist or group of scientists who wish to investigate the biological and limnological phemomena in Loch Ness."

George R. Zug, Ph.D.
Curator, Division of Reptiles and Amphibians
Smithsonian Institution
Washington, D.C.

"The following represents a personal opinion and does not represent an 'official' view of the Royal Ontario Museum. Having assessed the photographic and sonar evidence collected in 1972 and 1975 by investigators from the Boston Academy of Applied Science, and, having considered other data pertinent to the Loch Ness phenomenon, I have arrived at the following:

1) I have no reason to doubt the integrity of the investigators of the Boston Academy of Applied Science, or the authenticity of their data.
2) I am satisfied that there is a sufficient weight of evidence to support that there is an unexplained phenomenon of considerable interest in Loch Ness; the evidence suggests the presence of large aquatic animals.
3) The Loch Ness phenomenon should be the subject of a consolidated interdisciplinary research effort.
4) Steps should be taken to protect against irresponsible activities in and around Loch Ness."

Christopher McGowan, Ph.D.
Associate Curator
Department of Vertebrate Paleontology
Royal Ontario Museum
Toronto, Canada

"I personally find them [the photographs] extremely intriguing and sufficiently suggestive of a large aquatic animal to both urge and recommend that, in the future, more intensive investigations similar to the type that you have pioneered in the past be undertaken in the loch.

"My reasons for this are as follows: 1) on at least two separate occasions you have come up with a photograph suggestive of an appendage; 2) the so-called 'head' clearly seems to be a relatively small head on a rather thick neck and may match up with the object faintly connected to the body in the photograph which seems to be the body of a large animal . . . I am unable to even suggest the type of animal to which the head belongs."

A. W. Crompton
Professor of Biology
Director of the Museum of
Comparative Zoology
Harvard University
Cambridge, Massachusetts
(presented by Robert Needleman, Academy of Applied Science)

"The 1975 photographs certainly support the belief that a large aquatic animal inhabits Loch Ness. Although the identity of the creature is not distinguishable, in retrospect these photographs reconfirm the animate image you obtained in 1972, which was reinforced with computer-enhancement techniques.

"We are unable to interpret or suggest any assignment of a name to this creature . . . the photographs lead one to believe that the object is animate with proportionally large appendages and either a long neck and head or long tail. In particular the photograph of the body and appendage support your previous photographs obtained in 1972. The photograph which has been designated the head further supports our impression of an animate object because of the bilateral symmetry.

"The results of your investigation certainly indicate that additional evidence is needed and more action should be taken in the immediate future to solve this mystery. We hope that you will be able to continue your efforts to identify the creature. On the other hand, we must take whatever action feasible to protect the animal and its environment from man's direct actions once your evidence is made public and make sure that man's indirect actions on the environment through pollution, increased boat traffic, etc., does not prevent us from learning more about the creature or even more regrettably leads to its extinction."

David B. Stone, Chairman
Henry Lyman, Vice Chairman
John H. Prescott, Executive Director
New England Aquarium
Boston, Mass.

"The following comments represent the unanimous view of the five senior zoologists and palaeontologists whose names appear below. The statement should be taken to represent only the views of these individuals and not an 'official' view of the museum — in fact no such corporate view can exist.

Preliminary remarks

"— We have no grounds for doubting the authenticity of the photographs, nor do we doubt the integrity of the investigators, but we have no means of eliminating the possibility that a hoax has been perpetrated by a party unknown to the photographic team.

"— We believe that none of the (1975) photographs is sufficiently informative to *prove* the existence, far less the identity, of a large living animal. Therefore any comment on the photographs can only be speculative. The most that can be done would be to assess the probability of any interpretation being correct.

"With regard to the photographs taken in 1972 (one of which has been published in *The Photographic Journal*), Dr. Zug, of the United States National Museum of Natural History, has said that "computer enhancement of one frame produces a flipper-like object." We cannot disagree with this comment, but the information in this photograph is insufficient to enable us to attempt even the broadest identification.

Comments on the separate photographs (1975)

"Photographs 1 and 2 marked 'head' and 'neck': This probably should be interpreted as two objects since there is no trace of an image connecting the 'head' and 'neck.' If it were all one object the strength of the images of 'head' and 'neck' would be incompatible with the complete absence of an image of a connecting structure. We have no obvious interpretation. If indeed it were a single object, it would have a shape suggestive of an elasmosaur, but the outline is very blurred and conceivably various floating objects could assume this form. We are intrigued by the reflectivity of this object. It occurred to some of us that this might be attributable to the presence of a large number of small gas bubbles such as are found in the air sacs of the larvae of phantom midges (*Chaoborus* sp.) which are known to occur in large swarms. The movements of phantom midge larvae involve a pelagic nocturnal phase and a benthic diurnal phase. These insects are known to occur in Scottish lochs but we have no data on their abundance nor on the size of their swarms."

(With the exception of the "head" photograph the Museum scientists could not find the suggestion of an animal in the other 1975 pictures).

J. G. Sheals, Keeper of Zoology
G. B. Corbet, Deputy Keeper of Zoology
P. H. Greenwood, Fish Section,
Department of Zoology
H. W. Ball, Keeper of Palaeontology
A. J. Charig, Curator of Fossil Reptiles
Natural History Museum, London
(Statement issued November 20, 1975)

"As a naturalist I have been interested in the possibility of large animals in Loch Ness since 1958 and was a founder board member of the Loch Ness Investigation Bureau. I have watched at the lochside, dived in the Loch and flown over it in a glider. So far I have not been lucky enough to see one of the animals.

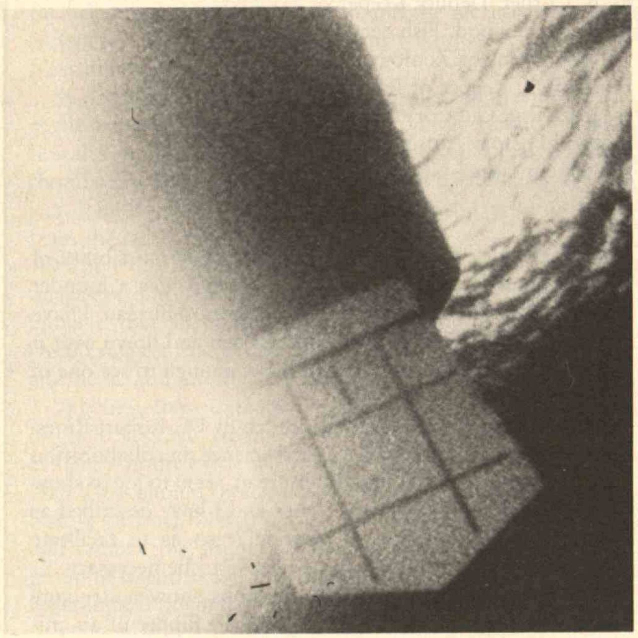
"The underwater photographs taken by Dr. Robert Rines' Team from the Academy of Applied Science, in collaboration with the Loch Ness Investigation Bureau, seem to me to show parts of an animal which Dr. Rines and I have described as *Nessiteras rhombopteryx*, in particular so as to facilitate conservation measures which we believe to be necessary.

"In particular two of the photographs show a structure which to my eye cannot be other than the flipper of an animal. The fact that there are two photographs taken about one minute apart which show a slight variation in shape is entirely consistent with consecutive aspects of an animal paddle which has moved slightly between pictures. To me the second picture makes the first enormously more significant.

"Another photograph shows what appears to be the head, neck and front of the body of one of the creatures which recalls the shape of certain fossil specimens from prehistory.

"In conjunction with a number of earlier records, on film and in still photographs, which cannot be explained in terms of known phenomena, the underwater pictures leave no further doubt in my mind that large animals exist in Loch Ness."

Peter Scott
Chairman, Survival Service Commission of
International Union for Conservation of Nature
Chairman, World Wildlife Fund.



A typical calibration shot of a known-size underwater object in Loch Ness. The object is about ten feet from the camera underwater. (Academy of Applied Science)

tends forward about ten feet, so the head would be only about 15 feet away from the camera, casting a shadow on the neck portion. Adding the length of the neck segment to the 8-foot body segment, one obtains a total length of about 18 feet, and the body probably extends for a considerable distance beyond the boundary frame of the picture. As in B, the torso is about 6 feet across.

Photograph D of an unidentified object at a distance of about eight feet was taken around 5:40 a.m., June 20.

Photograph E — a series of seven frames — was taken about 11:45 a.m. on June 20. The photographs preceding these show nothing in the camera's range. However, as the first frame of this series was taken, our apparatus apparently began to be rocked back and forth, quite unusual because we had never experienced any major currents in this part of the lake.

In the next frame the rocking motion had become so pronounced that the camera was swung up, aiming at the surface, and photographed the bottom of the boat (which is about 20 feet long, with a 7-foot beam). A measurement of the length of the boat in this frame indicates that the camera was about 35 feet below the boat, indicating that the apparatus had been lifted upward several feet. In the next frame, 1.2 minutes later, less of the boat shows.

Then, in the next frame we obtained the center shot; following this came more pictures of the water surface, and then blackness as before the episode.

The most likely interpretation of the center shot, it seems to us, is that it is of the head of a creature, with bilateral symmetry indicated, in half profile, with the nostrils and open mouth at the right, and several horn-like projections at the top. One interpretation of this photograph is shown in a painting by Sir Peter Scott beneath the frame. The object was about five feet from the camera, so it was illuminated only by scattered light outside the strobe beam and not the beam itself. Measurements indicate the "neck" to be about one-and-one-half feet thick, the "mouth" nine inches long and five inches wide, and the horn on the central ridge six inches long. There are two projections from the head, one before the "eye" on the near side, and the other, presumably, before the "eye" on the invisible far side. These projections are about ten inches apart. (Interestingly, this last measurement agrees well with the measurement of the distance between the tips of two projections producing parallel wakes photographed moving along the loch by Carol Rines, one day during the 1975 expedition. Photographs taken through a Questar telescope showed the wakes to move for a considerable distance along the loch, remaining parallel all the while — page 40.)

Because the entire "head" and details of its connection to the "neck" are not in the picture, it is impossible to make an accurate calculation of its size, but an estimation would be of about two feet long.

Photograph F was obtained about 4:50 p.m. and shows a rough-textured surface diagonally across the lower left portion of the frame. This picture was obtained shortly after the camera was violently disturbed again, as evidenced by photographs of the bottom of the boat, enlarged as if the camera had been moved upward.

It should be noted that throughout the film record were interspersed shots of eels, fish and other denizens of the loch.

Taken together, at the very least the 1972 and 1975 photographs, and the sonar evidence, agree well with one another and with past evidence that there is a species of large aquatic creature in Loch Ness. The 1975 body and neck resemble one of the objects in the 1972 series, as you can see on page 40.

Although we make no claim to being expert zoologists, we can find no combination of phenomena that account for these data as well as the simple explanation that a large creature inhabits the loch. Not even the experts have offered a plausible alternative explanation, in our view. In addition, there have been other investigations which suggest that the loch is capable of supporting a breeding population of such animals, and that physiological adaptation to the cold loch waters is quite feasible for a wide variety of candidate species.

It is a philosophic rule that if a given set of data has more than one explanation, the true explanation is probably the simplest one. To put it another way, "the shortest distance between two points is a straight line."

We submit that it is a patent violation of this rule to explain away our data, as well as the reputable historical data on the Loch Ness phenomenon as a complex series of mistaken sightings, equipment failures, artifacts or hoaxes.

In any case many scientists have at least now agreed that these phenomena bear further investigation (*see scientists' statements on pages 36 and 37*); further expeditions will soon be underway, and we hope better data will follow shortly.

Because of the strong indications our evidence gives of the existence of this large aquatic creature, Sir Peter Scott has taken the lead in bestowing the scientific name *Nessiteras rhombopteryx* upon it, so that it may be eligible for protective legislation. *Nessiteras* is a composite word combining the name of the loch with the Greek word *teras,* genitive *teratos,* which means marvel or wonder. The specific name *rhombopteryx* is a combination of the Greek *rhombos,* a diamond or lozenge shape, and the Greek *pteryx* meaning a fin or wing. Thus, the name is

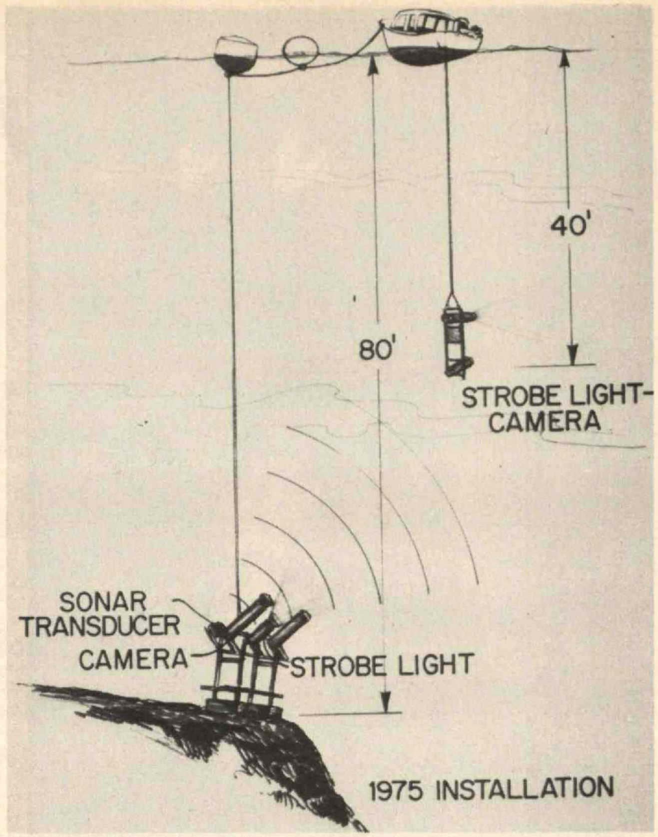
A Computer Expert on the Loch Ness Photos

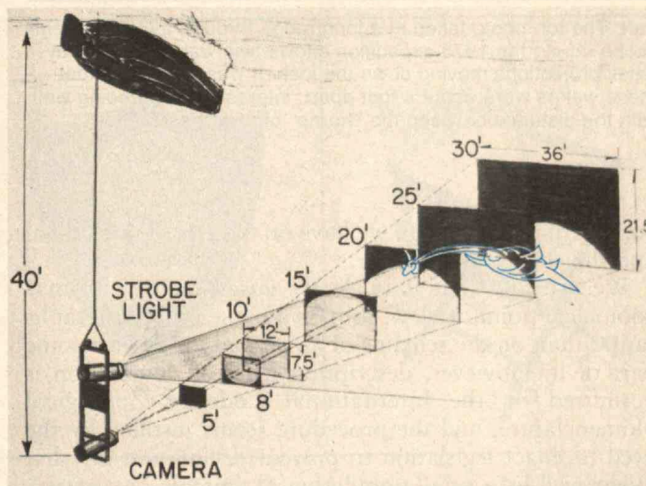
The following is from a report on the Loch Ness photographs by Alan Gillespie, a computer expert with the Jet Propulsion Laboratory, California Institute of Technology, who performed the computer enhancement on the photographs. It was presented at the symposium in Parliament by Isaac S. Blonder of the Academy of Applied Science.

"1972: Three frames taken while sonar showed large animals in or near the camera field of view themselves showed unusual shapes. These shapes were not artifacts, and did not appear in hundreds of frames taken when no sonar echoes were reported . . . Assuming ranges indicated by the sonar were correct, the size of the animal or animals seen in these pictures agreed with size estimated from the sonar record. One animal may have had a 16-foot body.

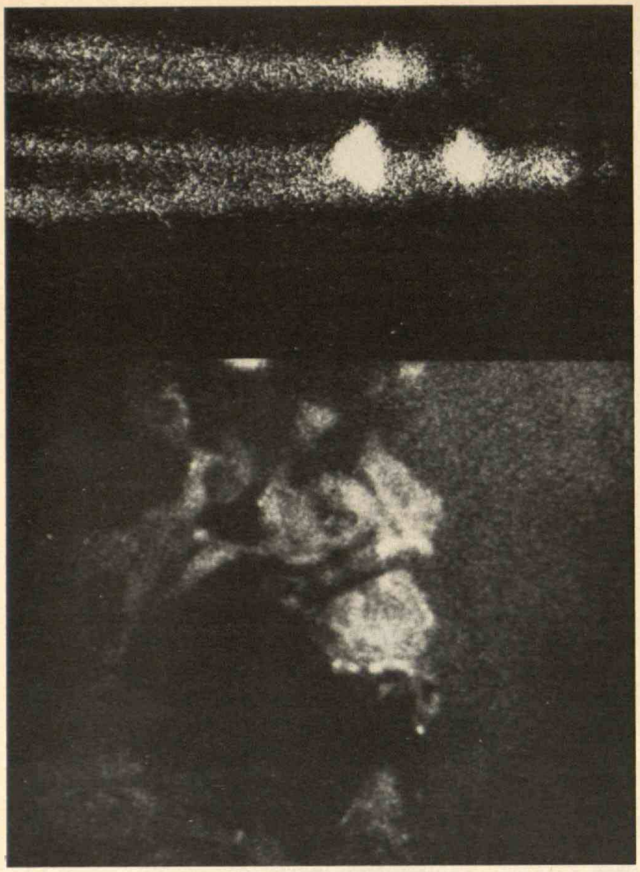
"One frame (the 'flipper') showed a fairly distinct, coloured object which I inferred was the animal or a portion of the animal. A final frame showed two objects, an interpretation which was consistent with the sonar record. One was much farther from the camera than the other, according to the sonar . . . the distant profile was about 12 feet long. The 'flippers' hanging down from it were about 4 feet long.

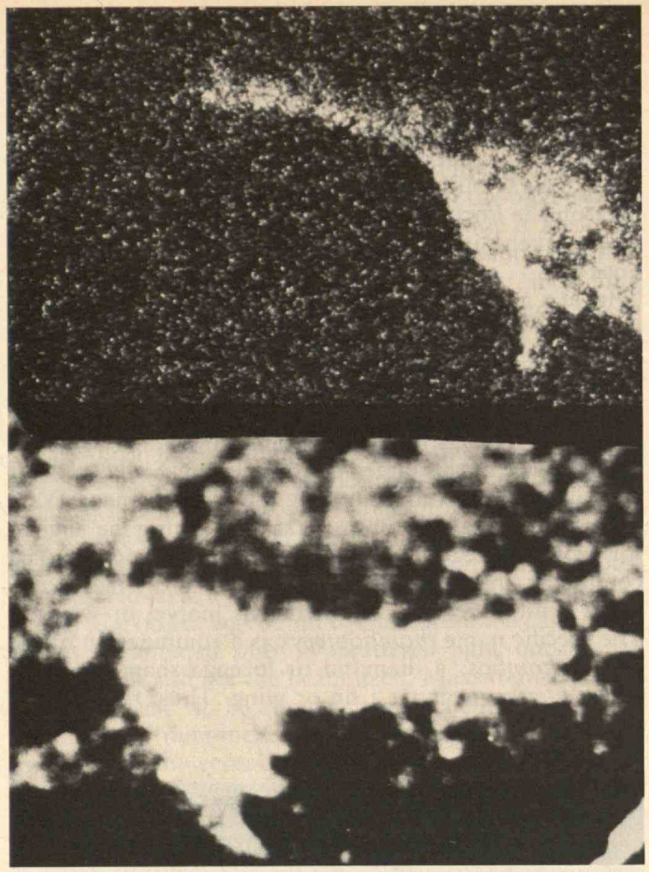
"1975: One picture showed a body with a long neck and two stubby appendages . . . the second frame appeared to show a neck and head, with the head closer to the camera than the body . . . the neck was reticulated. The head supported projections . . . I see no evidence that they are pictures of a model, toy . . . or whatever. I emphasize: I detect no evidence of a fraud. These objects are not patterns of algae, sediment or gas bubbles."





Top: The arrangement of equipment for the 1975 expedition. The sonar transducer, and sonar-activated camera were placed on a bottom ledge, and the backup system was suspended 40 feet from the bottom. The backup unit was the 1972 apparatus, with the camera and strobe separated by about five feet on a tubular frame. Bottom: Besides determining the distance of an object from the camera via light measurements, it was also possible in 1975 to use the geometry of the camera-strobe arrangement. Objects in the camera frame about ten feet away will be fully illuminated by the strobe beam, while objects framed at larger distances will have larger portions in shadow. The body-neck shot can be analyzed using this geometry, as shown. At a distance of 25 feet, the body of the creature would be fully illuminated on one side, and the head extending toward the camera and back into the light beam would also cast a shadow on the neck. (Academy of Applied Science)





Left: The top photo taken at a long range through a Questar telescope during the 1975 expedition shows twin wakes created by small projections moving down the loch. It was calculated that these wakes were about a foot apart, interestingly, agreeing well with the distance between the "horns" on the "head" shot (Academy of Applied Science photograph by Carol Rines) Right: A comparison of the photographs of large moving bodies taken in 1972 (bottom) and 1975 shows a resemblance. (Academy of Applied Science)

consistent with the data we have on the size of the animal and the shape of its flipper.

We are told that it is clearly unsatisfactory, from a zoological point of view, to base a name on photographs rather than on the remains of an animal, or at least some part of it. However, description from an illustration is permitted by the International Code of Zoological Nomenclature, and the procedure seems justified by the need to enact legislation to prevent decimation of what might well be a small population of animals.

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Robert H. Rines is Dean and Professor of Law at the Franklin Pierce Law Center, Concord, N.H. He holds an S.B. in physics from M.I.T., a J.D. from Georgetown University, and a Ph.D. from National Chiao Tung University. He holds patents for inventions in the field of sonar and radar, and has lectured at M.I.T. on patent law for the past ten years. **Charles W. Wyckoff,** M.I.T. '41, is the owner of Applied Photo Sciences, Needham, Mass., and was formerly with EG&G, Inc. He has invented wide-exposure-range films used to record nuclear test explosions, and to photograph the surface of the moon in the Apollo program. His experience in underwater photography dates from World War II, when he developed photographic instrumentation for underwater Explosions. **Harold E. "Doc" Edgerton,** Institute Professor Emeritus at M.I.T., is the "father" of strobe photography, having invented the strobe light in 1931. his most recent inventions include cameras and electronic gear for underwater exploration. His devices have been used in underwater scientific research, to locate sunken ships, and by such explorers as Jacques Cousteau to film underwater life. **Martin Klein** is President of Klein Associates, Inc. and holds an S.B. in electrical engineering from M.I.T. He has designed numerous sonar devices for use in oil exploration, underwater mapping, and to search for sunken ships.