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ECHO SOUNDING FOR BATHYMETRIC CHARTS

The method employed in the present bathymetric survey was to steer a straight course at constant speed between fixed points on opposite shores of the lake while sounding, a method whose accuracy depends upon the accuracy with which points are fixed. Enlargements of aerial photographs to near the scale of the published bathymetric chart or larger were used to determine the fixed points on the lake shore.

On large lakes horizontal sextant angles and magnetic compass bearings were taken to ensure a straight course was maintained between the points. Times of fixes were noted on the echo sounder record, and tracks and positions of soundings corrected later, if necessary. Sounding traverses were made approximately one inch apart on the scale of the lake outline used and were made generally at right angles out from the shore and thus to the contours. On all lakes a number of cross traverses were run as check lines. Coverage even to this extent meant many kilometres of traverses particularly on the larger lakes.

Traversing was carried out using power driven boats run at constant speed on each traverse. Recording echo sounders were used. Because the traverses were covered at constant speed, the depth read from the echo sounding record at any one point could be related directly to the lake floor at the same proportional distance along the traverse line.

During each survey the calibration of the echo sounders was frequently checked by stopwatch; the recorded depth was checked by lead line observations and by comparisons of results from two echo sounders. Three of the lakes listed were surveyed without using echo sounders; Ngahewu because it is very small and Omapere and Rotokawau (east), both less than 2m deep, were spot sounded with lead line. The echo sounders used did not give satisfactory resolution in depths less than 2m.

PLOTTING OF DEPTHS

Accurate outlines of the lakes for plotting depths were obtained from Lands and Survey Department. Most of the outlines had been determined by aerial photography and the remainder by traversing. The scale of the final chart was selected to allow optimum presentation of data, consistent with lake size. The number of individual depths plotted for each traverse was determined in each case by the number that could be legibly written on the chart. Whereas Lucas (1904) used 200 soundings to establish his bathymetry of Lake Manapouri, the present survey used 4,348 soundings plotted from the continuous echo sounding records.

CORRECTIONS TO DEPTHS

At the time of each survey temperature observations were made throughout the water column over the whole area of the lake. The results obtained were used to calculate the temperature-dependent correction to the velocity of sound in the water using Matthews (1939) "Tables of velocity of sound in pure water and sea water". The mean horizontal velocity of sound was calculated for each water layer between the surface and lake bottom (5 metre layers for shallow and medium water depth lakes and 10 or 20 metre layers for deep lakes). The mean of these velocities was taken as the vertical sound velocity over the depth in question.

Dissolved salts were present in such low concentrations that no correction for the effect of salinity on the velocity of sound in water was necessary. A plot of conductivity ratio against distance from the sea for 12 lakes indicates a depletion of dissolved salts with distance. The effect of pressure on the velocity of sound in the water is small. Even in the deepest parts of the deep lakes sounded, pressure increases the velocity of sound by a maximum of 7 metres per second, the resulting depth correction required being less than 1 metre. No correction for pressure effect was made.

LAKE LEVELS

Lake level gauges which give continuous water level records and are related in some cases to official bench marks near lake shores were used to establish a water level datum for the surveys. At lakes without gauges the water level at time of survey was found by leveling from official bench marks near the shore. For many lakes, particularly the smaller ones with neither gauges nor nearby bench marks, the water level at time of survey was recorded in terms of a bench mark established adjacent to the lake. The bench marks were a square or triangular 6-inch block of concrete with a galvanised steel bolt or stainless steel mark placed near some fixed object such as a concrete floor of a pumphouse or a concrete culvert, and in some cases a mark on an existing structure was used as a bench mark.

Changes in lake level during surveys were usually very small, and if changes in level were recorded, soundings were reduced to a common datum. Datum levels recorded on the published charts are relative to the bench marks and where possible to mean sea level.

SOURCES OF ERROR IN SOUNDING

The accuracy of lines of soundings depends on the accuracy with which the end points are fixed, and in locating the soundings between the fixed end points.

Earlier Methods

One of these errors arises when the boat deviates from a straight line between the points. Both Lucas (1904) in his survey of New Zealand lakes and Murray and Pullar (l910) in the Survey of Scottish Freshwater Lochs used a device similar to a periscope with which an object on shore behind the surveyor is kept in line with an object on shore in front of the surveyor.

A further source of error arises in attempting to distribute the soundings evenly along the line between the points. Lucas (1904) used a modification of a ship's log which was attached to a brass screw 2 ft long which ran through a nut fitted to a trunnion so that it could turn horizontally through 180°. A sounding was taken when the screw had passed through the nut, the device turned through 180° and the next sounding was taken when the screw had again passed through the nut in the reverse direction.

After many trials Murray and Pullar (1910) found that these two errors were minimised by taking soundings as quickly as possible while the boat was being rowed across the lake at a constant speed, the soundings being taken at even numbers of oar strokes.

Cunningham *et al* (1953) towed a small paddle wheel through the water, geared to operate a buzzer at 1/2 or 1 chain intervals to indicate when soundings were to be taken.

In the surveys mentioned above, the soundings were taken by hand or with a sounding machine consisting of a wire wound on a drum and operated by hand.

Present Procedures

The present work was carried out using echo sounders which sounded continuously at rates from 77 to 265 echoes per minute (depending on the machine and scale used). The sounders produce a record on which individual bottom echoes appear on a constant time scale. Where lake traverses are covered at constant boat speed the echo sounding record is thus produced at a uniform geographic scale. The soundings are read off at equal intervals of time from the record and thus at equal intervals of distance along the traverse.

Keeping the boat on a straight line between the end points was much less a source of error in the present work than in earlier surveys. The boat was usually moving at about 3 knots or faster on larger lakes, and no stopping to take hand soundings was involved. The total elapsed time on each traverse was many times less than in earlier surveys and the absolute drift off the traverse line because of wind and waves was small. However, transits were used where possible to keep on line, and on large lakes horizontal sextant angles and compass bearings were taken to correct deviations.

References

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