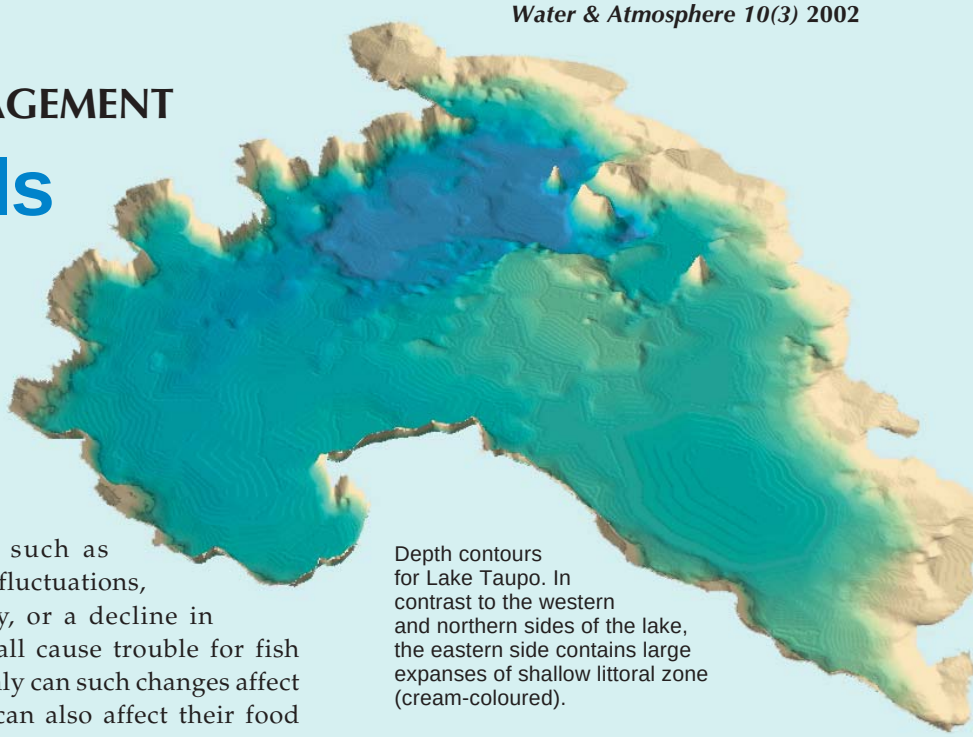
LAKES / RESOURCE MANAGEMENT

High-tech tools for tackling fisheries problems in lakes



Depth contours for Lake Taupo. In contrast to the western and northern sides of the lake, the eastern side contains large expanses of shallow littoral zone (cream-coloured).

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Management of lakes to protect fish can be improved by the use of GIS methods and new echo-sounding techniques.

Changes to lakes such as greater water-level fluctuations, increased turbidity, or a decline in water quality can all cause trouble for fish populations. Not only can such changes affect fish directly, they can also affect their food supplies and habitats. The problem for fisheries scientists has been how to measure and predict these effects.

Two new additions to the fisheries toolbox – GIS habitat modelling and high-frequency, split-beam echo-sounders – are helping to resolve such problems.

GIS habitat models

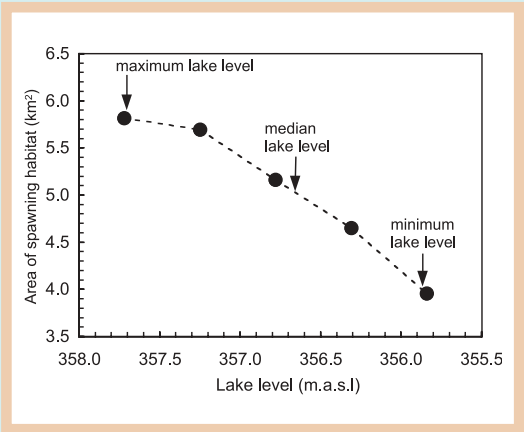
In many lakes the littoral zone – the shallow area at the lake edge – provides different types of habitat for fish and can easily be affected by changes in the lake environment. A challenge for scientists is to predict changes in littoral zone habitats and how these changes might affect fish populations. Three-dimensional GIS models of the littoral zone can provide some answers. However, we first need to know which features of these habitats are important for fish.

In Lake Taupo, we used GIS habitat modelling to examine the effect of lake-level changes on smelt spawning. Smelt in Lake Taupo drop their eggs on sandy substrates over a depth range of 0.5–2.5 m. Very few eggs are found on rocky or weedy substrates, or on sandy substrates outside this depth range. If the lake level falls, the 0.5–2.5 m depth range descends and the area of sandy substrate available for smelt spawning will change.

We used an extensive survey of approximately 300 transects along the littoral zone of Lake Taupo to build a three-dimensional, computer-based bathymetric map of the lake's margin. The main areas of sand, rock and weed were determined by aerial photography and direct observations, then superimposed onto the bathymetric map. The GIS model was used to calculate the area of sand lying between 0.5 and 2.5 m deep at each of five different lake levels. The lake levels tested ranged from the highest to the lowest levels currently allowed for the lake.

The results showed that the total area of smelt spawning habitat did not decline much as the lake level dropped from its maximum level to 50 cm below this, but after that it declined steadily, and at the minimum lake level was reduced by about 30%.

The Taupo GIS model can be readily used to calculate changes in the areas of other types of littoral zone habitat (such as rock substrates, or plant beds). We can also improve its predictive ability by adding more detail to the bathymetric and substrate maps which underpin it.



Change in the total area of smelt spawning habitat with lake level for Lake Taupo.

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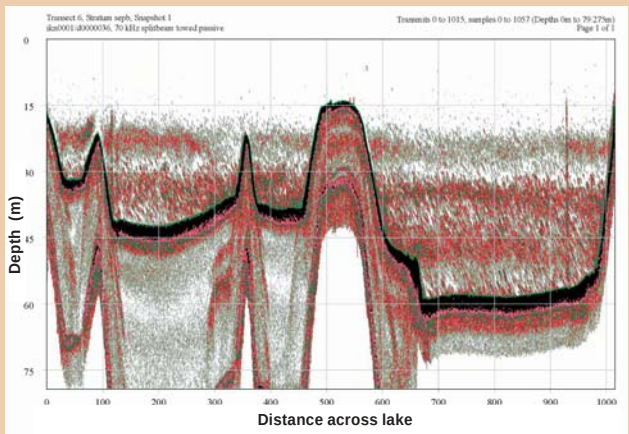
Where the habitat requirements of invertebrates, plants and fish are known, this approach can be used to assess the potential effects of physical changes in lakes on a wide range of communities. Such modelling is therefore likely to prove a powerful tool for lake managers in the future. However, we need to know which habitats in lakes are important for fish and invertebrates before this potential can be fully developed. Identifying these habitats is a key part of NIWA's Lake Ecosystems research programme.

Echo-sounding

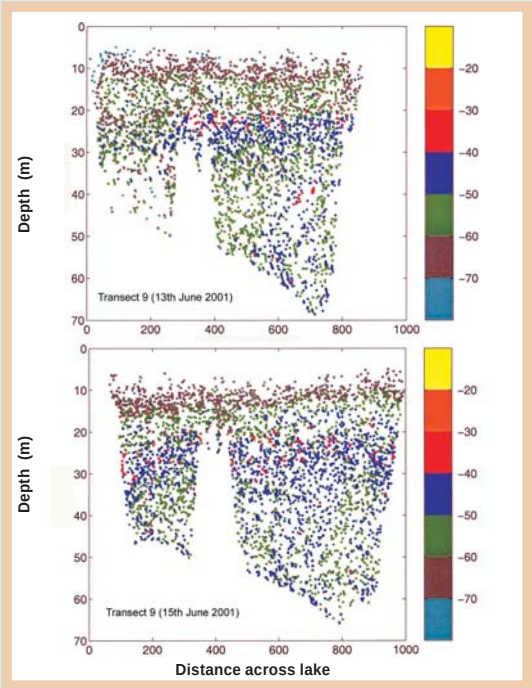
To date, measuring changes in fish populations in lakes has been constrained by the high mobility of fish. Echo-sounding has long been used to *locate* fish in lakes, but *counting* fish is not so easy. It is difficult to tell what species or size of fish produces the echo and, because fish move rapidly and often, sampling needs to cover all fish habitats throughout the lake, which is not always possible.



Typical echogram across Lake Rotoiti showing the lake bottom (thick black line) and up to four layers of fish between 15 and 60 m.

New echo-sounding technologies (both hardware and software) can now provide reliable measures of fish size. The large size difference between salmonids (trout and salmon), smelt, and larval bullies in New Zealand lakes means that it is generally possible to distinguish the echoes from these three types of fish.

We used CREST, a high-frequency, split-beam, echo-sounder and computer-based data acquisition system (see *Water & Atmosphere 4(1)*: 13–17) to sample fish populations in several North and South Island lakes during 2000/01. The CREST data – and our knowledge of the depth distributions of trout, smelt and bullies in Lake Rotoiti – allowed us to estimate the target strength for these three fish species so that we could discriminate between them. (Target strength is an acoustic measure of fish size.) From the distributions of the fish and how fast they changed, we could then decide if it would be feasible to assess their population size by using acoustic transects to cover the entire lake in a day.



Profiles from one side of Lake Rotoiti to the other showing changes in the distribution and density of adult rainbow trout (red dots) and large smelt (blue dots) over 3 days. The coloured bar indicates the target strength range for each dot (i.e., individual fish).

The sounder was sensitive enough to determine the density of zooplankton in the lake. It could also distinguish between larval bullies and smelt and it provided comparable data on their abundance and distribution in the open water of the lake. However, trout proved too mobile for reliable population assessment. Although trout may remain at certain depths and in particular regions of the lake for a day or so, over several days or more they can move rapidly from one side of the lake to the other. They can also move quickly from deep to shallow waters, where they cannot be detected.

In the South Island lakes – Coleridge, Tekapo, Hawea and Wanaka – we were not able to relate acoustic estimates of trout and salmon density to fish estimates based on netting studies. Therefore we still need a better understanding of the factors responsible for trout distribution and movement in lakes before echo-sounding can be reliably used to count trout and salmon. ■

Further reading

Rowe, D.K.; Shankar, U.; James, M.; Waugh, B. (2002). Use of GIS to predict effects of water level on the spawning area for smelt, *Retropinna retropinna* (Richardson), in Lake Taupo, New Zealand. *Fisheries Management and Ecology 9*: 205-216.

The GIS modelling in Lake Taupo was carried out for Mighty River Power Ltd. The echo-sounding work described in this article was undertaken for the New Zealand Fish & Game Council.