

NATIVE FISH

The ones that got away: determining whitebait movements and rates of escape

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Experiments aimed at understanding the migratory behaviour of whitebait may help to ensure that the traditional New Zealand pastime of whitebaiting does not become a thing of the past.

WHITEBAITING is a major pastime for many New Zealanders. Over the years much has been said about the decline of the fishery and there has been considerable speculation about the possible causes. Deforestation, diversion and pollution of rivers, and the introduction of exotic species have without doubt been contributing factors. It has also been suggested that over-fishing may have played a part. What we don't know is the relative impact of each of these effects, and there is continuing lively debate on this issue among scientists, resource managers and fishermen.

Many rivers have been so modified that it is unrealistic to aim for a return of the whitebait fishery to its former state. Nevertheless, it may be possible to manage the fishery to maintain or even enhance what remains. But fishery managers face two difficult questions, the answers to which should allow decisions about the sustainability of the fishery and might also assist in investigations into the possibilities for enhancement.

- How can the rate of escapement of whitebait – the numbers of fish that escape being caught – in a fishery be assessed?
- What is the level of escapement required to ensure that enough adults survive to produce next year's whitebait?

There is still some way to go before these questions can be answered with certainty. In the meantime, research has yielded much useful information about catch rates, whitebait movement and escapement.

below:

Brown- and red-stained whitebait immediately after staining. For comparison there is a single unstained whitebait (its head nearest the top of the picture).



Limited escape mechanisms

Findings in the 1980s showed that obvious escape mechanisms for whitebait are limited. McDowall and Eldon (1980) reported that migrating whitebait don't appear to move at night. Whitebait fishing regulations restrict the hours of fishing to the period between 5 am and 8 pm, most of the hours of daylight. The enforced break in fishing overnight therefore is likely to do little to increase whitebait escapement because the fish are not migrating. In another

study, Stancliff *et al.* (1988) showed that whitebait migrate only in surface waters (≤ 1.0 m). This means that, as they move upstream against the flow, migrating whitebait must locate water velocities low enough to swim against. Often this entails swimming in the low velocity areas along bank sides – the very places where many whitebaiters set their nets.

Mark-recapture experiments

More recently, we have attempted to estimate catch rates, escapement and movement of whitebait using a dye-marking technique in two North Island rivers, the Mokau and the Awakino. The rivers are adjacent catchments on the west coast of North Island with popular recreational whitebait fisheries in their lower reaches. Whitebaiting in the Awakino River occurs in the 10 km between the river mouth and the Awakino Gorge. In this area, 59 fishing stands were registered when the trials were carried out in 1991. In the Mokau River whitebaiting occurs in the lowest 20 km of the river, with 245 registered stands during the 1998 trials.

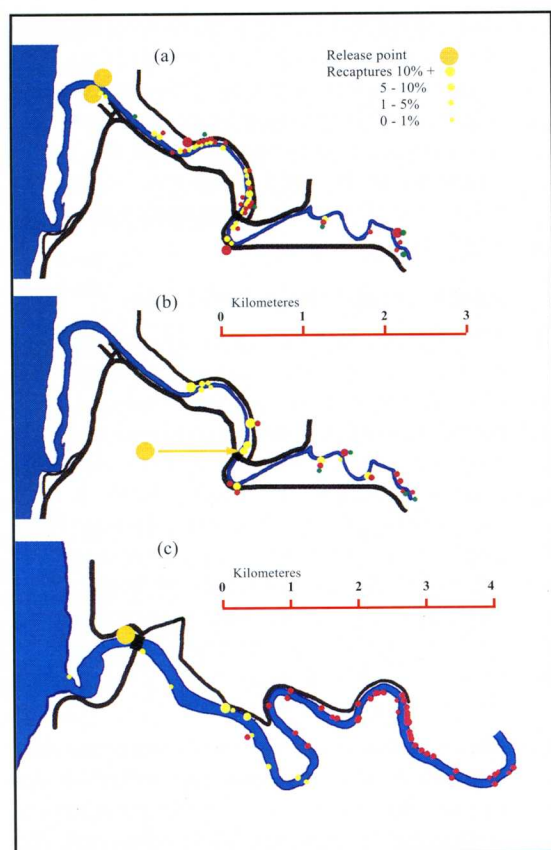
The experiments were based on the mark-recapture technique in which organisms are "marked" so that they can be distinguished from the population in general. Known numbers are then released. The proportion of marked individuals recaptured and the locations and timing of recaptures provide information about catch rates and movements of the population.

We obtained live whitebait from whitebaiters. The fish were kept in fish traps suspended in the river until required. Fish were stained by immersion in fresh solutions of Bismark Brown R (brown-coloured fish in photograph) or Neutral Red (red-coloured fish in photograph). Stained whitebait were released into the river and subsamples were retained in a live box so that we could monitor how long the stain lasted and the mortality rate of the fish.

To investigate their migration, stained whitebait were released into the Mokau and Awakino Rivers during two whitebait seasons.

- Eight releases into the Awakino River were made during three visits in 1991 at different sites and tidal stages.
- Two releases into the Mokau River were made during 1998 from the same point and at the same time in the tidal cycle.

After the releases each whitebaiter on the river was visited to record recaptures. The percentage of fish escaping the whitebaiters was calculated from the number of stained fish released and later recaptured. Movement rates for the recaptured whitebait were determined when whitebaiters provided the time of recapture. Distance travelled was estimated by measuring the river distance between the release and recapture sites.



Distributions of recaptured whitebait. Two releases in the Awakino River, (a) 9 September 1991 and (b) 23 October 1991; (c) one release in the Mokau River on 23 September 1998. Recaptures for day 1 (yellow), day 2 (red) and day 3 (green). The percentage of total whitebait recaptures at a site is indicated by circle size.

Most whitebaiters on both the rivers supported the work and diligently separated and recorded their catch. The greatest problem with the study was the difficulty recognising stained fish that had been in the river for some time. (Three days for Bismark Brown R and two days for Neutral Red were the maximum for a trained eye.) This was particularly the case once the fish had been dead for some time. For this reason we made a special effort to examine catches personally whenever possible. We restricted our analysis of the data to recordings made during the above-mentioned three-day and two-day periods.

Tides and migration

In most cases, when released, stained fish quickly orientated to the current and swam against it. This behaviour

meant that in the lower part of the river, where a strong incoming tidal flow occurred, some released whitebait would head downstream against the current. For example, one of the releases was made close to the Awakino River mouth on an incoming tide and most of the fish caught from that release were almost immediately collected downstream by scoopers (whitebaiters using hand-held nets rather than nets at

whitebait stands) who had just commenced fishing. Similarly, at the Mokau River mouth stained whitebait were caught in the surf zone by scoopers some 9 h after release, even though the fish were released on an incoming tide 2 km upstream of the mouth.

The diagrams (left) show that the capture sites were very widely distributed and the degree of escapement also varied considerably. This can be attributed to three main factors: the stain used, the ability of whitebaiters to recognise stained fish, and the state of tide at the release position.

The stain used affected how long fish remained identifiable while the state of the tide determined the direction of migration and how long the migration took. The position and number of whitebaiters in the immediate direction of fish movement also affected the chance of capture. Since whitebaiters tended to fish the tide, released fish were invariably subjected to varying levels of fishing pressure.

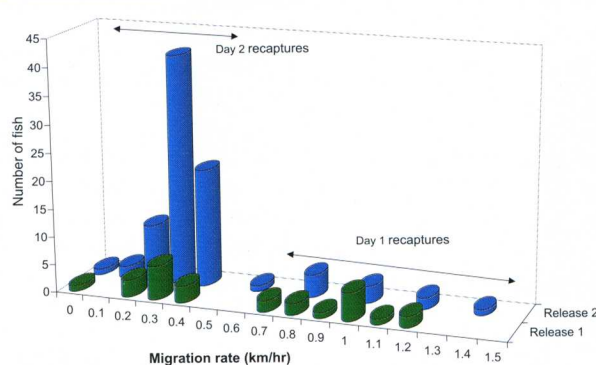
The migration rate of whitebait is not constant and is greatly influenced by the tide. As noted above, sometimes large numbers of stained fish headed downstream. We even had reports, during both years, of the capture of stained whitebait in neighbouring rivers. One was from as far as the Marokopa River, some 40 km north of the Awakino River! Observations by whitebaiters of shoals of whitebait swimming downstream during tidal pushes also suggest that in the lower parts of the river at least, a significant number of whitebait moved back downstream. If this represents a standard behaviour of migrating whitebait then this

Migration rate in whitebait

MIGRATION RATE is distinct from swimming speed. Swimming speed is the speed the fish can achieve under the conditions prevailing at the time. The migration rate includes swimming speed but also accounts for behavioural factors and river conditions. As whitebait do not migrate at night, upstream movement halts for the hours of darkness. This leads to reduced migration rates when comparing fish captured on day 1 of a release with those from subsequent days. Furthermore, any downstream movement by the fish as tidal flows change will decrease the migration rate. Obviously the higher the migration rate the less time the fish are available for capture in the whitebait fishery. Using the time from release to recapture, we calculated that on the first days after release the rate of upstream migration ranged from 0.06 to 1.42 km/h. The large variation in migration rate for day 1 recaptures was due to the differences in behaviour of

fish upon release. Some fish moved upstream rapidly with the tidal push. Conversely, other fish swam against the tidal current attempting to swim downstream, and hence when recaptured these fish could be relative close to the initial release point. The upstream migration rate calculated over the first two days after a release, though, was generally much lower, ranging from 0.15 to 0.51 km/h. By the end of day 2, most or all of the released fish have made nett inland movements, and the differences in distance

covered by individual fish becomes less pronounced. Migration rates that are determined for fish on day 3 after a release are likely to be relatively low. This is because the faster moving individuals will have ascended past the fishing areas and the recaptures are biased towards the slower moving individuals.



Migration rate plots of stained whitebait recaptured in the Mokau River during releases made on incoming tides in September 1998.

exposes the whitebait to much greater fishing pressure than if they migrated up-river continuously.

At the fastest migration rate recorded, a fresh run of whitebait entering the Awakino River could reach the Manganui Road bridge (approximately 5 km upstream from the Awakino River mouth) in about 3.5 hours. In the Mokau River, the two releases penetrated rapidly up river with the tidal push, moving at approximately 1 km per hour. However, even at the highest migration rates recorded, fresh runs of whitebait would not get past the main fishing area in either the Awakino or Mokau Rivers on a single tidal push. Furthermore, given that night-time movements of whitebait are thought to be small, the bulk of the fish will take at least two to three days to move out of the main fishing areas. These fish will of course be susceptible to capture whenever the strong flows of the centre of the river force the migrating fish to move upstream close to the river banks. (See panel for more on whitebait migration rates.)

Recapture rates

The percentage of stained whitebait recaptured ranged from 1.3 to 44.6%, with a mean for the eight releases in the Awakino River of about 19% (Table 1). For the two releases in the Mokau River the recapture rates were 5% and 12%. Recaptures were lower for Neutral Red stained fish (1.3 to 20.6% recaptures) as the duration of time they could be recognised was shorter than the Bismark Brown R stained fish (7.4 to 44.6% recaptures). Fishing pressure and position of the fishers relative to the release point also influenced capture rates.

Note that the recorded recapture rates also represent the *minimum* capture rates of whitebait. Factors that increase the real catch rate include: deaths of stained fish, unrecognised or unreported captures of stained fish and captures of stained fish once the dye has faded.

Interestingly, catch rates were not always greatest during the initial fishing period after releases. Peak capture rates were often on the second fishing tide after releases. This often coincided with increased fishing pressure in the mid tidal reaches of the rivers and channel forms forcing whitebait to swim closer to banks and therefore being more vulnerable to capture. Also of interest was that recaptures of stained whitebait occurred at stands on both sides of the rivers, not just the bank from which releases were made (see figure, above left). This indicates that whitebait regularly crossed the river channel during migration movements.

Factors affecting catch

Migrating whitebait swimming upstream will avoid the whitebaiters when current velocities in the centre of the river are suitably low. In higher flows the fish will tend to stick to bank-side regions, where

Stained whitebait releases and recaptures in the Awakino and Mokau Rivers

River	Release Date	Numbers Released	Tide	Colour	Recapture %	Recaptures in first 24h
Awakino	09/09/91	4300	Near full	Brown	44.6	608
	10/09/91	4800	Near full	Red	17.9	834
	26/09/91	5625	Falling	Brown	29.8	1374
	27/09/91	2600	Rising	Red	20.6	483
	28/09/91	7225	Rising	Red	1.6	115
	23/10/91	1500	Rising	Brown	30.4	362
	24/10/91	1700	Rising	Red	1.3	23
	25/10/91	2500	Falling	Brown	7.4	172
Mokau	22/09/98	1600	Rising	Red	5.0	36
	23/09/98	1600	Rising	Brown	12.0	54

most fishing takes place. Regular whitebaiters indicated that catches varied at different areas of the river depending on the interaction of river water levels and the tide. Therefore no single spot on a river is optimal for fishing during varying water flows. However, in the Awakino River, the section 7–8 km from the mouth produced the greatest catch per unit effort. This section of the river is deep and narrow, making whitebait migrate closer to the bank, in the narrow zone of lower velocity water. Other areas of the Awakino River were lightly fished if at all. Road access and difficulty of terrain appeared to be a significant factors in the distribution of the whitebaiters.

In the Mokau River, catch records provided by whitebaiters indicated that no single area dominated the catch, but access to stands is often by boat, therefore the distribution of fishing stands is not limited by access. There are indications that best catches were made when there were few whitebaiters on the river and that at any one time the amount of whitebait present is simply shared between the whitebaiters.

From the above observations and discussions with whitebaiters we concluded that daily catch by any whitebaiter was affected by the following factors.

- Tide timing and conditions. Since whitebait migrate only during daylight and possibly enter the river with the incoming tide, the timing of tide will influence the number of fish able to enter the river. The size of the tide and its interaction with river flows will also influence the distribution of water velocities suitable for migration.
- Weather conditions, particularly the effect this has on river flow and water clarity which both affect fishing efficiency, migration rate and whether the whitebait swim in the centre of the river or closer to the banks.
- The number of whitebaiters on the river, particularly the number immediately downstream on any fishing site. ■

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Further reading

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