CAWTHRON

Assessment of Affects on Fish Passage at Tide Gates Using DIDSON Technology

Cawthron Report No. 1260

March 2007

Assessment of Affects on Fish Passage at Tide Gates Using DIDSON Technology

Rowan Strickland

Aaron Quarterman

Prepared for

Tasman District Council

Cawthron Institute
98 Halifax Street East, Private Bag 2
Nelson, New Zealand
Ph. +64 3 548 2319
Fax. + 64 3 546 9464
www.cawthron.org.nz

Reviewed by: Roger Young

Approved for release by: Rowan Strickland

Recommended citation:
Strickland R, Quarterman A 2007. Assessment of Affects on Fish Passage at Tide Gates Using DIDSON Technology. Prepared for Tasman District Council. Cawthron Report No. 1260. 12 p.

TABLE OF CONTENTS

LIST OF FIGURES

1. INTRODUCTION

Methods to observe fish behaviour at structures in streams and the ability to count fish numbers passing these structures have been limited, particularly in low visibility conditions, either at night or in turbid water. Dual-Frequency Identification Sonar (DIDSON) is a very rapid method of ascertaining the presence of a target organism or object in water regardless of water clarity.

DIDSON was developed in the United States for naval use in harbour surveillance and underwater mine detection, but has more recently been used for assessing salmon behaviour near dams and to enumerate salmon runs and redds in low visibility conditions, demonstrating that it is a useful tool for fisheries applications.

The DIDSON system uses sound to produce near video-quality images of fish at ranges up to 15 m in high-frequency mode (1.8 MHz) and up to 40 m in low-frequency mode (1.2 MHz). The system is operated via a laptop computer to monitor and store images. Data is collected at about 1.5 GB per hour.

Two trials funded under FRST's Envirolink fund and the Motueka Integrated Catchment project were set up in the Tasman District Council (TDC) area to:

1. Trial DIDSON at several tide gate structures to test that the results are useful for the purposes of consent monitoring where fish passage has been a condition of the design structure.
2. Using the tide gate structure on Pearl Creek as one of the trial sites, propose management options for manipulating gate opening in order to enhance fish passage while continuing to ensure land protection.
3. Provide an on-site demonstration to TDC staff of DIDSON technology and its application for the above.

Our approach was to run DIDSON for approximately 24 hours at each of two sites, or as long as was required to cover several tide cycles, and to collect sufficient imagery to demonstrate the effectiveness of the method and the behaviour of fish in relation to tide gate operation to TDC staff. The two sites were at tide gates at an inlet in the Motueka estuary and Pearl Creek, a tributary of the Waimea estuary.

The purpose of this report is to document the findings of the two sets of 24 hour monitoring and to provide a discussion document for the on-site demonstration.

2. RESULTS

2.1. Motueka tide gate

The tide gate on one of the Motueka estuary tributaries, referred to in this report as the Motueka tide gate, cuts off tidal influence into a small modified wetland and drains system (Figure 1). There is a second control gate about 100 metres upstream of this tide gate that allows drainage of dairy pasture from behind a stop bank. The area immediately upstream of the Motueka tide gate (Figure 2) is leased from the Department of Conservation to graze dairy cows.

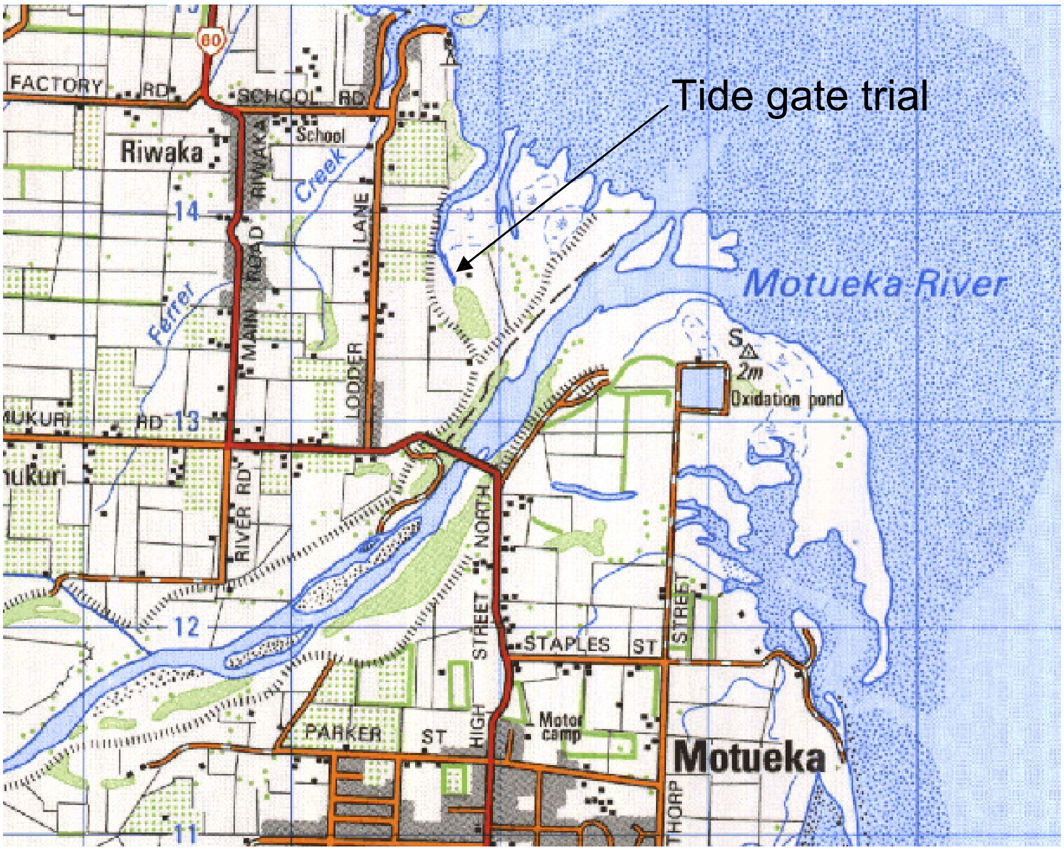

Figure 1. Location of tide gate trial in the Motueka Estuary.

Figure 2. Small tidal arm in the Motueka estuary draining DOC owned reserve. Whitebaiting was occurring within 20 metres of the tide gate.

During normal flows the Motueka tide gate holds back very little water from the upstream catchment so that on the dropping tide, gate opening is gradual and the gate remains in a partially open state for just over seven hours (Figure 3). During half tide conditions the flow through the culvert is slow as is the small stream draining the wetland.

Figure 3. Motueka tide gate remains open even at half tide height, allowing about four to six hours on every tide cycle for whitebait to negotiate the culvert.

The DIDSON was set up about two metres from the tide gate at an angle sufficient to allow monitoring of fish behaviour through one side of the gate (Figure 4).

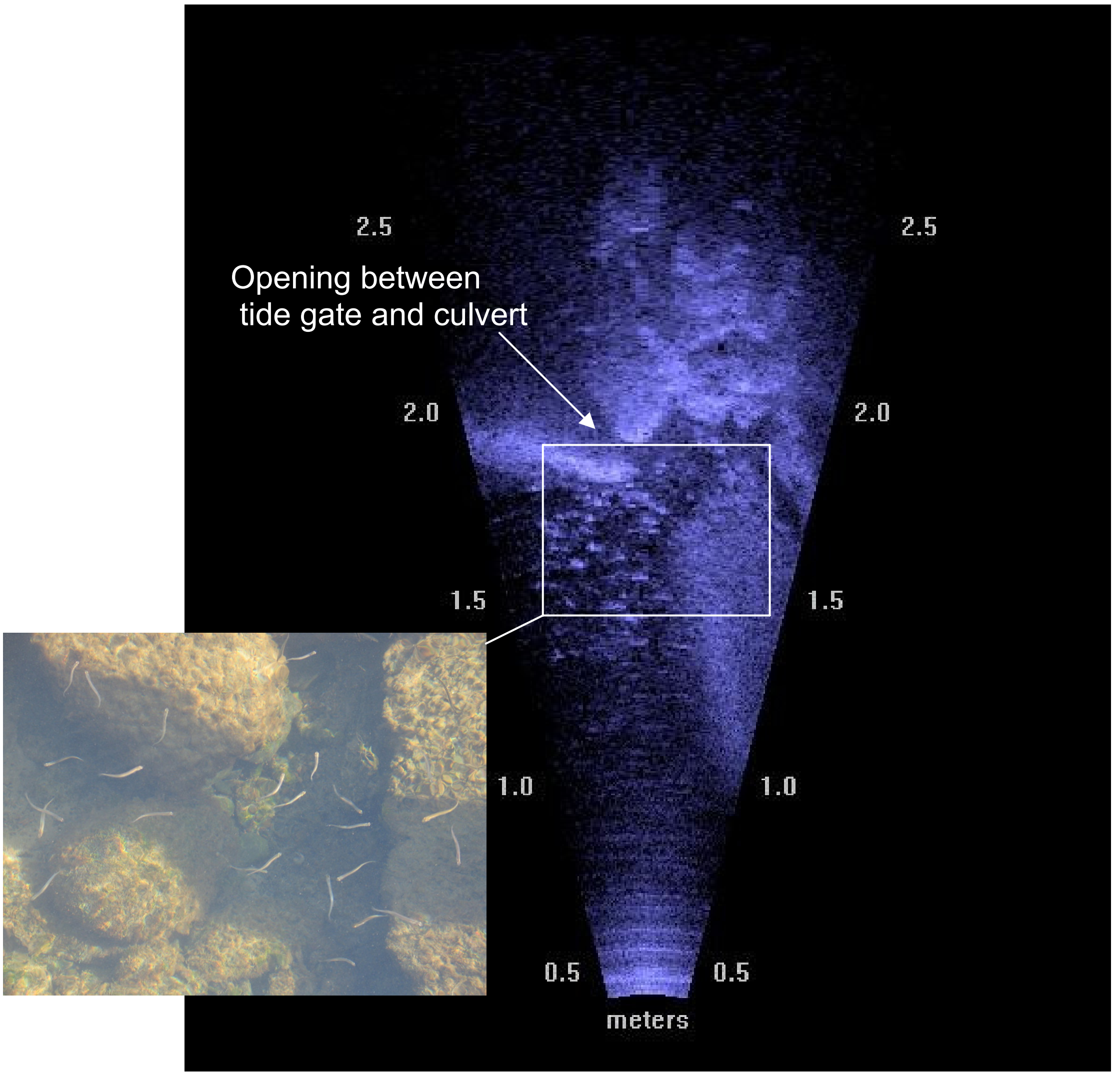

Figure 4. DIDSON underwater plan view of the Motueka tide gate taken of and at the same angle as the image in Figure 3. Inset is actual plan view photo of whitebait congregating at the tide gate entrance.

2.2. Pearl Creek tide gate

Pearl Creek discharges into the Waimea estuary through a tide gate that drains an important wetland (Figure 5) that is home to several whitebait species including the rare giant kokopu.

Figure 5. Wetland and backed up water created upstream of the Pearl Creek tide gate.

A substantial flow in the creek causes water to back up through the lower section of the wetland when the tide gate closes at high tide. The gate remains closed for about three and a half hours and open for about eight and a half hours on each tidal cycle (Figure 6). Due to the flow in the creek and the water that is impounded during gate closure, a steady velocity above 0.3 metres/sec is created through the gate and possibly persists through the culvert.

Figure 6. Pearl Creek tide gate open at low tide (left) and closed at high tide (right). DIDSON is mounted between three waratahs at left of frames. On the tide monitored, water eventually covered the top of the waratahs and the tide gate.

2.3. Discharge velocities

The discharge velocity at each of the flood gates was estimated from the travel time and distance of suspended particles recorded by DIDSON. While these velocities do not cover the full cross-section of the tide gate gap, they provide an indication of the relative change in discharge velocity over the tidal cycle. It is therefore possible that there are parts of the tide gate cross-section that provide lesser velocities than those estimated and are slow enough that whitebait can swim against them. Velocities and notes taken through the tidal cycle at each of the tide gates are shown in Figures 7 and 8.

Code	Hours	Comments
1	1421	Gate open, Some whitebait going through opening on DIDSON image and then observed coming out other end of culvert (shoal of approx 50-80).
2	1500	Velocity through opening appeared to have increased and bait attempting to go through the gap were being pushed back out. Velocity measurements from DIDSON unable to be measured until 1518 hours because not positioned properly.
3	1530	Velocity slowed enough to observe whitebait making it through the gap and small shoals observed exiting top end of culvert through until gates closed at 2218.
4	1830	Gate still open, water flowing out.
5	1905	Smaller numbers of whitebait still milling around gate, few getting through gate.
6	1911	Larger fish seen at gate (seem to be galaxiids).
7	2006	More larger fish seen at gate (DIDSON), gate still open, flow slowing (gap decreased), shoals of whitebait still seen at upstream end of culvert.
8	2030	Same as previous.
9	2100	600mm eel seen at TR side of tide gate (out of view of DIDSON), small shoal of whitebait at upstream end of culvert.
10	2200	Whitebait and small galaxiids still milling around gate, eel not seen since first observation, gate still open with reasonable flow.
	2215	Gate closed.

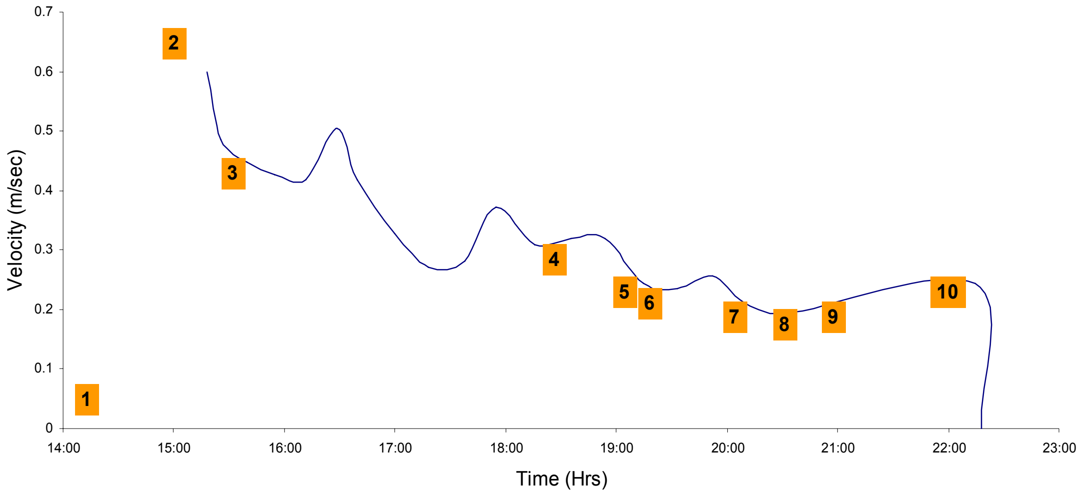

Figure 7. Velocities and observations at a Motueka tide gate during October 2006.

Code	Hours	Comments
1	1533	Gate opens, velocity steadily increasing. Whitebait accumulate in corner of culvert and occasionally attempt to head into the culvert but don't appear to cope with the velocity.
2	1543	Gate fully open.
3	1620	No whitebait appearing at the upstream end of culvert.
4	1700	Flow still too strong above and below culvert to allow whitebait passage upstream – still bundled up at downstream entrance.
5	1851	Dog in water near DIDSON.
6	1927	Whitebait seen 3 m downstream of gate, none observed above gate.
7	2023	Whitebait starting to accumulate around gate - flow still seems too strong for them to go through the gate.
8	2100	Eel passes through the gate (heading downstream).
9	2109	Still a lot of flow through gate, no fish seen in DIDSON.
10	2211	Gate still open, large fish splashing downstream approx 15-20 m.
11	2303	Large eel goes downstream through gate.
12	2331	Large eel goes upstream through gate.
13	2354	Gate beginning to close.
	0000	Gate closed.

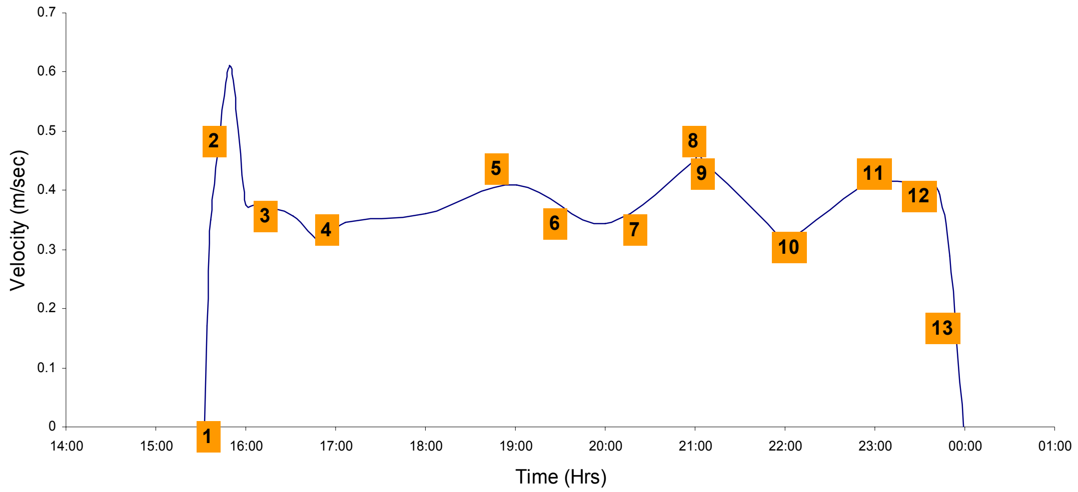

Figure 8. Velocities and observations at the Pearl Creek tide gate during October 2006.

2.4. Water velocity effects on fish passage

Swimming performances of some native fish were measured in a flume tank by Mitchell (1989). The conclusions of that study suggested that inanga whitebait would be able to negotiate velocities less than 0.3 m/sec over distances less than 10 metres, but would require velocities less than 0.25 m/sec for distances more than 15 metres.

Assuming that water velocity through each of the culverts does not exceed the velocity as it discharges from the tide gate and that each of the culverts is no longer than 10 metres, an indication of the period through the tidal cycle that upstream fish passage is most likely to occur can be calculated from each of the graphs. Based on this, the Motueka tide gate allowed about a four hour gap after 1900 hours until gate closure, though bank-side observation determined successful whitebait passage began at 1530 hours until closure. This was probably due to the slow velocity through the culvert.

There appears to be a lot less opportunity at Pearl Creek for successful passage. There was only about a minute at the opening of the gate when the discharge velocity was less than 0.3 m/sec. Neither DIDSON or bank-side observation was able to determine any successful passage past the tide gate, though about ten whitebait were observed at the top side of the culvert prior to monitoring.

2.5. Fish activity at night

The DIDSON allowed fish behaviour to also be observed at night.

Whitebait numbers at each of the tide gates diminished as night approached and were only observed occasionally up to and during gate closure. By comparison during daylight at both sites, shoals of whitebait congregated and steadily increased in number up to and during gate closure.

Fewer predatory fish visited the tide gates during gate closure at night. A single large fish briefly swam into view at the Motueka tide gate (Figure 9) and a small eel was active in the area for a short time but did not come into view on the DIDSON.

At Pearl Creek, neither whitebait or larger fish were active at night except a large eel went downstream through the gate and returned upstream about 30 minutes later just prior to gate closure.

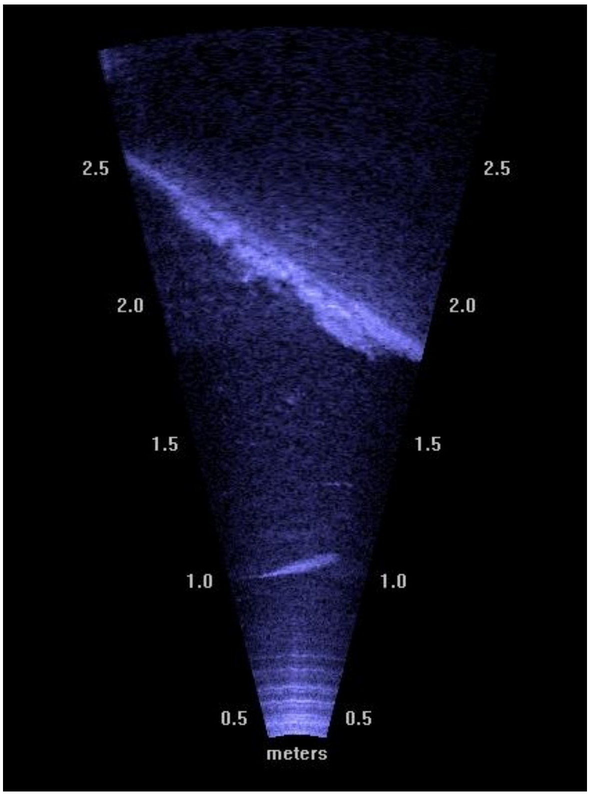

Figure 9. A 31 cm fish (either kahawai or trout) did several passes through the beam after dark at high water and during tide gate closure. Very few whitebait remained or were active in the beam after dark.

3. FISH PASSAGE AND HABITAT IMPROVEMENTS

3.1. Motueka tide gate

Water clarity allowed bank side observation of fish behaviour at this structure for most of the tidal cycle except high tide. DIDSON images enabled us to observe what took place during the high tide period when water became turbid and surface scum and debris obscured any chance of seeing into the water. Yelloweye mullet and possibly small kahawai exploited this increased depth as an opportunity to feed on the whitebait shoals accumulating at the closed tide gate. Once the gate opened and water level began dropping, the larger fish retreated from this arm of the estuary and for most of the time that the gate remained open, whitebait could be seen exiting the top end of the culvert and making their way upstream.

Apart from increasing whitebait vulnerability to predators, the tide gate appeared to have negligible effect on whitebait passage for most of the seven hours that the gate remained open, as there was a steady stream of whitebait exiting the top end of the culvert. Given the number of whitebait successfully reaching the remnant parcel of wetland above the culvert, there appeared to be insufficient habitat and protection for these fish to grow on to maturity. There is a lot of scope for improving the remnant wetland and increasing its potential as rearing habitat.

3.2. Pearl Creek tide gate

As was experienced at the Motueka tide gate, water clarity allowed bank side observation for most of the tidal cycle other than at full tide. DIDSON images allowed viewing of fish behaviour at full tide, when it was otherwise impossible to see what was happening below the surface. DIDSON images also allowed us to determine that whitebait were unsuccessfully attempting to enter the culvert.

From the images and measurements obtained with the DIDSON, combined with our observations above the culvert, it appears that water velocity generated through the culvert and the opening at the gate is more than whitebait can cope with. Despite this a small shoal of whitebait was observed on the upstream side of the culvert. However this small shoal pales beside the thousands of whitebait that were observed accumulating below the tide gate.

Upstream of the tide gate, Pearl Creek offers good rearing habitat for whitebait and other species, but needs better fish access into and through it to ensure it is fully utilised. The gate itself remains open for a sufficient amount of time during each tidal cycle to allow fish access. The main issue to deal with is the effect of velocity through the culvert and tide gate. There are several ways of overcoming this issue, but on-site discussion with an engineer to work through what is practical and feasible is required before recommendations can be made.

4. CONCLUSIONS

DIDSON images allowed observation of fish behaviour and measurement of water velocity that would otherwise have been difficult or impossible to obtain by any other means. We therefore conclude that it is a very good method for determining fish access issues at structures such as tide gates, even though for much of the time during this study water clarity allowed the basic question of whether fish were achieving passage past these structures to be determined by bank side observation.

At the two tide gates studied, the issue was not a case of needing to manipulate gate opening in order to enhance fish passage, but rather the water velocity created by the structure in one instance and lack of suitable upstream habitat at the other. No doubt the issues created by various tide gate designs and their locations will vary from site to site depending on gate design and purpose, upstream habitats and the species attempting to utilise these habitats. Dealing with the issues created by tide gates will therefore require case by case assessment and management. Dealing with these issues is probably best prioritised around the value of the habitats upstream of these structures.

5. REFERENCES

Mitchell CP 1989. Swimming performances of some native freshwater fishes. NZ Journal of Martine and Freshwater Research, Vol. 23: 181-187