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Dear Andrew

DIDSON FISH SCREEN MONITORING TRIAL AT LEVELS PLAIN INTAKE

This letter presents a summary of a trial deployment of DIDSON sonar equipment to monitor fish screen efficacy and fish behaviour in front of the Levels Plain Irrigation Scheme water intake from the Opihi River (near Pleasant Point, South Canterbury). The experimental design was developed by the “project team”, comprising staff from Department of Conservation, Environment Canterbury, and Fish & Game New Zealand. Cawthron staff were engaged to operate the DIDSON and post-process the DIDSON data.

Experimental design:

Two species/size classes of fish were used in each of two experimental releases; salmon smolt (approximately 110 mm) and rainbow trout fry (approximately 25-30 mm). The two experiments involved:

1) Running the screen with the fish bypass blocked, and with reduced use of the automatic travelling screen cleaning brush mechanism;

2) Running the screen as normal, except with reduced use of the automatic travelling screen cleaning brush mechanism.

Prior to these experimental releases the forebay was dewatered as much as possible and electric-fished in an attempt to remove any wild fish from the area. The forebay was again dewatered and electric-fished between experiments 1 and 2 and at the end of experiment 2.

During each of these experiments a number of fish of each size class was released in separate batches immediately upstream of the screen, approximately 13 m upstream of the DIDSON. The DIDSON was deployed as close as practical to the screen (approximately 0.65 m from the screen face) and 7.5 m from the fish bypass entrance, looking sub-parallel down the screen toward the fish bypass entrance, with the ensonified field of view covering the entire water column for approximately 30% of the total screen length (overall screen length was approximately 16 m). In each case the DIDSON was operated from prior to the experimental releases, over night, until approximately 20 hours post-release (i.e. ~10:15 the following morning).

DIDSON footage was recorded at 7 frames per second.

DIDSON footage was played back at 100 frames per second in a darkened room and notes taken on fish size, location, behaviour and approximate numbers (summarized below). Files covering the first 2-3 hours following each experimental release were viewed in their entirety. However, to save processing time subsequent files were sub-sampled, with footage viewed in chunks of approximately 1-2 minutes per 5 minutes of footage, unless a change in the predominate pattern of activity/behaviour was observed, in which case footage was again viewed continuously until a new pattern of activity/behaviour became established.

Experiment 1:
500 rainbow trout released 13 m upstream of the DIDSON at 14:55 on 7 Dec 2010, followed by 1000 salmon in batches at approximately 17:45. Fish bypass entrance blocked.

Results:
From approximately 15:10 some small objects, possibly fish or floating debris, could be seen circulating in and immediately upstream of the fish bypass entrance bay. Circulation pattern was predominantly upstream on true left and downstream on true right, although the circulation pattern within the bypass entrance was more erratic. Occasionally one of these objects appeared to make contact with the screen face, predominantly within the first ~1m upstream of the bypass entrance bay. The fate of these objects after contacting the screen face was not clear.

Some similar objects occasionally appeared from the weed-beds on the true left of the forebay and moved diagonally downstream toward the screen face.

This type of activity continued through until the next fish release. The abundance of moving objects increased during periods when the screen cleaning brush mechanism was operating. Many of the larger moving objects are clearly floating debris (recognisable by their shape and tendency to deform).

By the time of the salmon release (17:45) quite a large amount of circulating debris had built up, making it impossible to discern any fish activity in the vicinity of the bypass entrance bay, including the first 1-2m upstream of this in the forebay.

From approximately 18:08 some obvious fish activity was visible, mainly centred between 3.5-5m downstream of the DIDSON. These fish were in the order of 100 mm long. There was no clear pattern to their movement. Individual fish held station for short periods and made forays upstream and downstream (perhaps drift feeding). Fish did not appear to be avoiding the screen face, but equally they did not appear to be actively exploring/investigating it. Fish did not appear to be actively shoaling.

Numbers of fish in the field of view built up over time, by 19:10 there were several tens of fish, at least, active in this area. Many were active within approximately 200mm of the screen face. By 19:50 the majority of these fish appeared to have moved upstream out of view of the DIDSON, although there were still occasional fish active in this area. By 20:25 almost no individual fish activity remained in the visible area of the forebay. Occasional shoals would come into view before moving back upstream.

These two types of activity pattern alternated through the night until about 05:00, although the possible drift feeding activity type appeared to dominate, in terms of time, over the active shoaling behaviour (perhaps ~90% c.f. 10% of the time, respectively).

From 05:00 there was a lot of active shoaling with very large shoals (100s of fish) moving up and down the forebay, sometimes as far as the bypass entrance and often out of view upstream. Size of shoals appeared to dwindle to a few tens of fish by about 07:00, and frequency of shoals being in view appeared to decline over time from then through to the end of this experiment (~10:16 on 7 Dec 2010).

Experiment 2:
903 rainbow trout released 13 m upstream of the DIDSON at 13:34 on 8 Dec 2010, followed by 300 salmon in three batches of 100 fish each between 14:02-14:10 hrs. Fish bypass entrance open.

Results:
It was not possible to distinguish individual rainbow trout fry in the DIDSON footage. Moving clusters, which may have been shoals of fry where seen from about 13:37 (i.e. ~2 minutes after the release). However, it was not possible to tell whether these were in fact fry or simply patches of floating debris (e.g. plant material). Some of these clusters contacted the screen face, although it was not possible to see if any passed through the screen. However, many (possibly most) appeared to ultimately exit via the bypass entrance (numbers unknown).

At about 14:05 (i.e. 3 minutes after first salmon released) some acoustic shadows of fish could be seen moving about and some exited via the bypass; about 14:10 smallish fish were seen in the true right corner of the bypass entrance bay, with many exiting via the bypass. These appeared to be relatively small fish and may have been residual rainbow trout exiting in response to the release of salmon smolt upstream. However, this is purely conjecture, as they could not be conclusively identified to species level.

By 14:20 some individual salmon sized fish (i.e. ~100 mm) visible ~4 m downstream of DIDSON.

The screen cleaner began operating again at about 14:25 until ~ 15:50.

From about 14:30 shoals of salmon (10s of fish) could be seen moving both upstream and downstream, with most activity centred about 3-5 m downstream of the DIDSON. These shoals may have been moving in an attempt to evade the screen cleaner, since they seemed to be most active when the screen cleaner was moving, or about to move, through the field of view. Many of these fish appeared to be avoiding the screen face, moving predominantly on the true left of the forebay. However, some small shoals approached the screen occasionally. Shoals would often approach the bypass, often entering the entrance bay, before swimming back upstream again. Sometimes it even appeared that some of the shoal may have entered the bypass opening, but some fish always returned upstream. However, it was not possible to distinguish if all of the fish in the original shoal had moved upstream (i.e. whether some had carried on down the bypass).

After an initial period of quite consistent shoaling activity, there was very little activity visible from about 15:50 until after 19:00, with just occasional sporadic movements of individual fish.

About 19:20 some shoaling activity, moving up and down the true left of forebay. At ~19:25 a shoal of about 20-30 fish appeared to exit via the bypass. Still sporadic shoals and individual fish moving up and down the forebay, mostly out of view upstream. At about 20:20 another small shoal of about 10-15 fish also entered the bypass, they went in and out a few times before disappearing.

Less fish movement apparent after about 21:00, only very sporadic, mainly individual fish moving about. No clear pattern to their movement.

An eel (~450 mm long) moved into view near the screen face ~2 m downstream of DIDSON at 02:15, moved diagonally downstream and into weed-beds on true left bank ~4 m downstream of DIDSON. More eel activity (about same size eel) immediately upstream of the bypass entrance bay at about 02:56, and moving about further upstream in the forebay ~03:04.

From about 05:00 there appeared to be an increase in activity of individual fish and small shoals (~10-20 fish) moving about, including forays into the bypass entrance bay. Some individuals and small shoals appear to move in and out of the bypass. Difficult to ascertain on balance how many stay in the bypass (i.e. exit downstream via the bypass).

Between 05:50-06:00 there was a flurry of activity, where several small shoals appeared to exit via the bypass (total about 30-60 fish). Then there was very little activity until the end of the monitoring period (~10:15).

Conclusions:

The DIDSON was not effective for monitoring fish of ~30 mm in length, as these fish could not be distinguished individually, although possible shoals could be seen. We have been able to distinguish whitebait of ~50-60 mm in other studies elsewhere. However, these were upstream migrating fish and consequently not easily confused with floating debris, e.g. leaves. Identification and enumeration of such small fish moving in a downstream direction, or milling around, below a screen would be contingent on having no confusing debris passing through the monitored area. Orientation of the fish relative to the DIDSON is also important, since fish present a much smaller target area for sonar detection when oriented directly toward the transponder, than when oriented across the sonar beams (i.e. perpendicular to the DIDSON). In this study we were not able to detect a dead 60 mm long bully suspended oriented head-on toward the DIDSON, about 3 m downstream. However, in other studies we have been able to see fish in the 35-55 mm size range oriented across the sonar beams, but in the absence of potentially confusing floating debris.

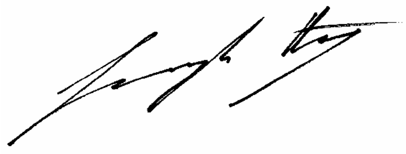
It was possible to distinguish the ~110 mm salmon smolt in the DIDSON footage, and their behaviour in the forebay could be observed. Aside from the first hour or two following release the salmon smolt appeared to be most active around dawn (~05:00-06:30) in both experiments. When the fish bypass was blocked (i.e. there was no exit available) the smolt spent much of their time apparently drift feeding, as well as moving about the forebay in shoals.

When the fish bypass was open there was less activity overall (although there were also less than 1/3 as many fish released in this second experiment). Some fish did exit via the bypass, but they often made exploratory forays into the bypass several times before remaining in it, suggesting that the bypass velocity was insufficient to ensure fish were flushed back to the Opihi River. Low water velocity in bypasses can allow predatory fish to lurk in wait for fish attempting to use the bypass.

To investigate efficacy of the screen (i.e. fish exclusion from the irrigation race) the DIDSON would arguably have been better set up downstream of the screen to observe any fish that made it through the screen. However, very small fish (~30 mm) would still be unlikely to have been distinguishable.

Set nets would likely provide a more efficient and cost effective method for enumerating numbers of fish passing through a screen, or a bypass. However, the strength of DIDSON technology is in observing fish behaviour, around screens and bypass entrances, for example, under dark and turbid conditions. The clear water conditions at the Levels Plain Intake may have made video with infrared flood lighting a viable alternative for monitoring fish behaviour during the night. Conversely, at locations, or times (e.g. during floods and freshes), when turbid conditions prevail the DIDSON may be the only viable option for monitoring fish behaviour. However, successful monitoring using DIDSON is contingent on fish size, with ~40-60 mm likely to be an absolute minimum with current technology, and can be hampered by large amounts of floating debris or obstacles that cast acoustic shadows as well as fish orientation relative to the sonar beams.

Yours sincerely



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