# Review of Fish Screening Criteria or Attributes in Canterbury:

# Part 1: Approach velocity

## Issue

Recently there has been questioning or confusion over some Fish Screening criteria in Canterbury, particularly the criteria of approach velocity. This stems from subtle differences in the NIWA "Fish Screening: Good Practice Guidelines for Canterbury 2007" (NIWA FSGPGL), and the Fish Screening schedule (Schedule 2) in the Canterbury Land and Water Regional Plan 2011 (LWRP). This paper discusses and clarifies the reasoning behind these differences and the basis of the schedule 2. criteria.

## Summary

Confusion in the both the NIWA Guidelines and the Canterbury LWRP over "Approach velocity" and "through screen velocity" stem largely from multiple authors writing different parts of the two documents from different perspectives, rather than being a systematic error. There are distinct reasons why the FSWP process chose to implement "Through screen water velocity" as the approach velocity criteria rather than "Approach velocity a distance off the screen surface. This was because:

- through screen velocity is a design criterion that can be calculated from desk top parameters, so is consistent with the other desk top auditable design criteria
- Approach velocity was demonstrated as a very difficult and onerous measurement to reliably make and demonstrate
- Approach velocity is a concept most relevant to active pelagic swimming anadromous salmonid fish
- The through screen velocity is more relevant to the behaviour of many NZ native fish that often respond to water velocities by clinging or clamping to surfaces rather than swimming away

## Discussion

The NIWA FSGPGL was the resulting output of three years of work by the Canterbury Fish Screen Working Party (FSWP). It is therefore worth clarifying the rationale behind the process adopted by the FSWP, the process of capturing this in the NIWA FSGPGL, and subsequently condensing the (92 page) FSGPGL into a single page plan schedule (firstly as schedule WQN12 in the Natural Resources Regional Plan in 2008 (NRRP) and then to Schedule 2 in the LWRP in 2011).

The FSWP carefully examined fish screening requirements of both native fish (Charteris 2006) and sports fish (Bejacovich 2016) and then examined the current status of screening criteria approaches and guidelines from both North America and Europe. International approaches were consistent in requiring "Good Practice Design criteria" rather than requiring measurement of "Performance" or "Effectiveness" criteria via fisheries surveys. International experience noted the logistics of measuring operational screening effectiveness

performance of a fish screen was very onerous and very expensive (if achievable at all). In contrast, a process to achieve the development or agreement on key "Design criteria" was widely adopted internationally to produce screens that were agreed as effective screens that excluded all target fish species and life stages. This approach was therefore adopted near the end of the three-year FSWP process to address this issue. The three-pronged approach, examining native fish requirements, examining sports fish requirements, and then checking against international criteria, led to the development of the "seven key [design] criteria for Good Practice fish screening" in the NIWA FSGPGL.

Throughout this process, attempts to "measure" some of the "key criteria" reinforced the appropriateness of this chosen "design" approach. One of these was attempts to measure "approach velocity criteria" of water approaching a screen. A key member of the FSWP (Mr Kevin McFall (ECan)) was tasked with determining the feasibility of measuring "approach velocity", as described in North American anadromous salmonid criteria ("3 inches off the screen surface" - NMFS 1997). Using latest ADCP digital flow monitoring equipment he found this to be very difficult to measure or reproducibly measure (if achievable at all) following attempts at several existing Canterbury fish screens. Following his experience, the FSWP decided that requiring demonstration of approach velocities three inches off the face of screens was not feasible or not consistent with the other "design" approaches, and so decided to adopt the [calculated] "Through Screen velocity" as the "Approach velocity" criteria. This could be empirically measured and verified from desk top design, without onerous field measurement requirements and associated uncertainties.

Where measured approach velocity is required to be demonstrated in North America, it is generally defined as:

"*Confirmation of approach and sweeping velocities must consist of a series of velocity measurements encompassing the entire screen face, divided into a grid with each grid section representing no more than 5% of the total diverted flow through the screen (i.e. at least 20 points must be measured). The approach and sweeping velocity (parallel and perpendicular to the screen face) should be measured at the centre point of each grid section, as close as possible to the screen face without entering the boundary layer turbulence at the screen face. Uniformity of approach velocity is defined as being achieved when no individual approach velocity measurement exceeds 110% of the criteria*" (NMFS 2011).

As can be seen from this protocol, this measurement procedure is particularly onerous and requires demonstration of high precision (all values within 110% of the criteria). If that high precision cannot be achieved the screen is "non-compliant". If this were to be required in Canterbury, then compliance staff would be required to routinely carry ADCP flow measuring equipment and carry out a detailed series of measurements on screens, particularly where there was any doubt about this criterion.

It has also been suggested by others that "approach velocity" a distance off the screen surface can simply be considered a factor of "half" the calculated through screen velocity. This rationale is also somewhat naïve as the relationship between through-screen velocity and approach velocity will be determined by both the open-area ratio of the screening material, and the diameter off a cylindrical screen. The relationship between the two only

holds true for a large flat faced screen (with no edge effects) and a screen material with an open area ratio of exactly 50%. However, with differing mesh materials, and with cylindrical screen structures, this relation may deviate widely (much more-so than the NMFS measurement precision criteria above).

The North American "Approach velocity" criteria being measured "three increases off the screen surface" is widely presented in "Anadromous salmonid passage facility designs" (NFMS 1997, NFMS 2011, etc.). That is, it is a criterion specifically developed for anadromous salmonid fish. These are actively swimming/migrating pelagic fish species (trout, salmon, char, whitefish, shad etc.) that sense and respond to an accelerating water velocity, by turning away from and avoiding the water accelerating towards the screen surface. Their "world" is open water currents and they choose to not "touch" surfaces. We have no specific rationale on why the criteria is "three inches off the screen surface" other than that it is either at a distance that allows the smallest fish to turn and swim away without being damaged by touching the screen surface (i.e. twice its body length?) and/or that it should be measured "as close as possible to the screen face without entering the boundary layer of turbulence "(NFMS 2011). Three inches may therefore be a practical distance for both requirements. Despite a lack of distinct justification, this appears to be a distinct North American rationale for protecting actively swimming anadromous salmonid fish.

European criteria do not explicitly refer to such a distance off the screen surface, and as anadromous salmonid fish are not so prevalent or widespread in European waters, a wider range of valued fish forms are required to be protected. These fish (coarse fish species, eels, etc.) exhibit different behaviours and responses to water velocity/acceleration. There appears to be more recognition via legislation for protection of eel life stages in Europe. Likewise, New Zealand native fish species are not dominated by salmonids or salmonid-like growth forms and behaviours, and include a range of valued fish exhibiting anguilliform movement (eels and lamprey), benthic specialists (Torrentfish, bullies, galaxiids such as koaro), and species favouring backwaters and may even be 'gravel burrowers'. These fish species groups cannot therefore be expected to inherently respond to an accelerating velocity by instinctively swimming away, but may conversely exhibit "clamping, clinging, or climbing" like behaviours on the screen surface. For this reason, it became particularly important that critical screen velocities for NZ native fish may be associated with avoiding protracted "impingement" onto the screen surface, and enabling an ability for fish to release themselves from the screen surface to swim away undamaged. Lack of clear velocity requirements for native fish behaviours (other than generic swimming abilities) are therefore another strong reason to consider the through-screen velocity to be the appropriate "approach velocity" for NZ fish screens.

Mr Ben Curry has provided a review of guidelines, criteria, and rules for fish screens across [North American] National Jurisdictions, prepared by Dr Dana Schmidt of Golder Associates, Canada). This review concluded that the Environment Canterbury Schedule 2 of LWRP approach velocity criteria are in error as they deviate from accepted North American criteria. I would disagree with Dana Schmidt's review, as he believes that the NIWA FSGPGL was developed solely from North American guidelines, and he refers in many places in his review to those guidelines being developed to protect "anadromous salmonids" and/or "juvenile salmonids". I reiterate from the many points above, that the NIWA GPFSGL were developed from requirements for both native fish species, and sports fish species, and from

both European and North American criteria. Indeed, a widespread concern with Fish Screen decision making in Canterbury has been the excessive emphasis on protection of sports fish to the exclusion of native fish. Legislative and statuary emphasis in NZ is now more strongly on the protection of indigenous species and biodiversity. An excessive referral to North American criteria will only [again] reinforce a sports fish emphasis to the detriment of indigenous biodiversity. Careful consideration of the "seven criteria" of fish screening can therefore not unreasonably expect some reasoned divergence from the North American "anadromous salmonid" criteria.

For these reasons, the glossary of the NIWA FSGPG defined "Approach velocity: Speed of water through the screen". However, when a team of NIWA staff were preparing the bulk of the content of the guidelines, in error, they reverted to the approach velocity being consistent with North American anadromous salmonid criteria. In the text they also used a Canterbury [exotic] salmonid fish as the worked example justifying the criteria. This (and the ambiguity between the text and glossary) was not picked up in the editorial reviews of the guidelines document. However, when the guidelines were subsequently being transcribed into short and succinct statutory instruments (WQN12 and then Schedule 2) in 2008 for the NRRP and subsequently in 2011 for the LWRP, this error was identified and the schedule made consistent with the guideline glossary, as originally intended, as a "through screen velocity" criteria. I acknowledge that the LWRP apparently suffers from similar errors to the NIWA GPFSGL document in inconsistent quotes/advice between the plan text and the plan schedule. Again, this stems from different LWRP authors quoting from different parts of the NIWA GPFSGL. This is again unfortunate, and should be rectified in a subsequent plan review, but Schedule 2 stands alone as the statutory plan "rules", and as above, their reference to "through screen velocity" was carefully and deliberately chosen in plan development.

It remains that the NIWA FSGPGL are now over 10 years old, and the "approach velocity" error and confusion may not be the only criteria deserving further scrutiny, elaboration or reconsideration.