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Tutaekuri River Instream Flow Assessment

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Environmental Management Group Technical Report

Hydrology Section

Tutaekuri River Instream Flow Assessment

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EXECUTIVE SUMMARY

An instream flow assessment has been completed in response to increasing pressure on the water resources in the Tutaekuri catchment to provide scientifically robust and peer-reviewed data for setting minimum flows for this catchment. This report provides scientific data to inform the process of setting the minimum flow for the upper and lower reaches of the Tutaekuri River. Minimum flows are a vital component of water management in the Hawke's Bay Regional Council Regional Resource Management Plan (RRMP).

Field work began in the upper Tutaekuri during the summer of 2008/2009 and data collected were input into the software package Rhyabsim (River Hydraulics and Habitat Simulation) for analysis. Habitat suitability criteria (HSC) for species present in the Tutaekuri catchment were used to calculate the quantity of habitat over a range of flows.

Those species with the highest flow requirements were identified as critical species and their habitat assessed against the mean annual low flow (MALF).

The flows required to retain 90% of habitat at the MALF for rainbow trout and torrentfish (most flow demanding sport fish and native fish, respectively) for the Tutaekuri River at Ngaroto Road are:

- 2400 l/s for rainbow trout
- 2100 l/s for torrentfish

The minimum flow requirement for equal protection of rainbow trout and torrentfish habitat based on 85% of the MALF for the Tutaekuri River at Puketapu is 3200 l/s.

Allocation limits (in conjunction with minimum flows) are a vital component of water management regimes. These limits define the total amount of abstraction that can occur above the minimum flow and limit the impact of water abstraction on flow variability, including the frequency of occurrence and duration of the minimum flow. Allocation limits for the Tutaekuri catchment will be addressed in subsequent HBRC publications, presenting various allocation scenarios and their respective impact on the flow regime.

There are many considerations to be made in the water management process, the most important of which is defining the values that the community wishes to maintain or enhance. It is not the intention of this report to define those values as that process involves all stakeholders in the Tutaekuri catchment as part of a full assessment of RMA Section II, which addresses economic, cultural, social, and environmental matters. However, there are many National and Regional examples to guide minimum flow selection for instream habitat, which have been incorporated in this report.

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1.0 INTRODUCTION

1.1 Purpose

This investigation has been completed in response to increasing irrigation demand and necessity for scientifically supported water management policy in the Hawke's Bay Regional Council Regional Resource Management Plan (RRMP). To address the effect of flow changes on instream habitat, the River Hydraulics and Habitat Simulation (Rhyhabsim) model was applied. The results of the model are presented here to inform the process of setting a minimum flow which balances the needs of instream and out of stream users.

1.2 Instream Habitat Modelling

The focus of river management in New Zealand and overseas often aims to balance water needs for maintaining instream ecology while providing for out-of-stream water use. One-dimensional hydraulic habitat models like Rhyhabsim (Jowett 2004), allow water managers to identify the relationship between instream habitat and river flow which can be used to evaluate various management regimes.

Rhyhabsim uses the combination of a hydraulic simulation model to predict flow conditions (depth, velocity) and biological models of habitat use or preference to show how predicted flow conditions change the amount of available habitat for a range of species. The available habitat predictions are presented by an index called Weighted Usable Area (WUA), which is often expressed as an area per length of river, or m^2/m . WUA is actually a dimensionless parameter that provides an indication of the relative quantity and quality of available habitat at a given flow (Hay 2008¹).

An important consideration is that the WUA metric provides a relative measure of how predicted habitat changes with flow and that the shape or slope of the WUA curve is more important than its magnitude (Hay 2008¹). Using the slope of the WUA curve gives an indication of the rate of change of predicted habitat, which can be used to identify the species most sensitive to changes in flow.

The total effect of a proposed management regime can then be seen in context of its relative effects on different fish species.

2.0 TUTAEKURI HYDROLOGY

2.1 Catchment Overview

The Tutaekuri River catchment covers an area of approximately 840 square kilometres, stretching from the Kaweka Range to the coast at Awatoto (Figure 1). Tributary watersheds for the Manatutu Stream and Mangaone River comprise a large portion of the Tutaekuri catchment. In the upper reaches, the Mangatutu Stream is an important tributary that provides significant flow (up to half the total flow in the Tutaekuri during low-flow periods) and supports a significant rainbow trout fishery. The Otakarara Stream is a relatively small tributary in the upper catchment but is sustained by spring flow during summer, providing consistent discharge and cool temperatures. The Mangaone River is the largest tributary of the Tutaekuri and supports a viable trout fishery.

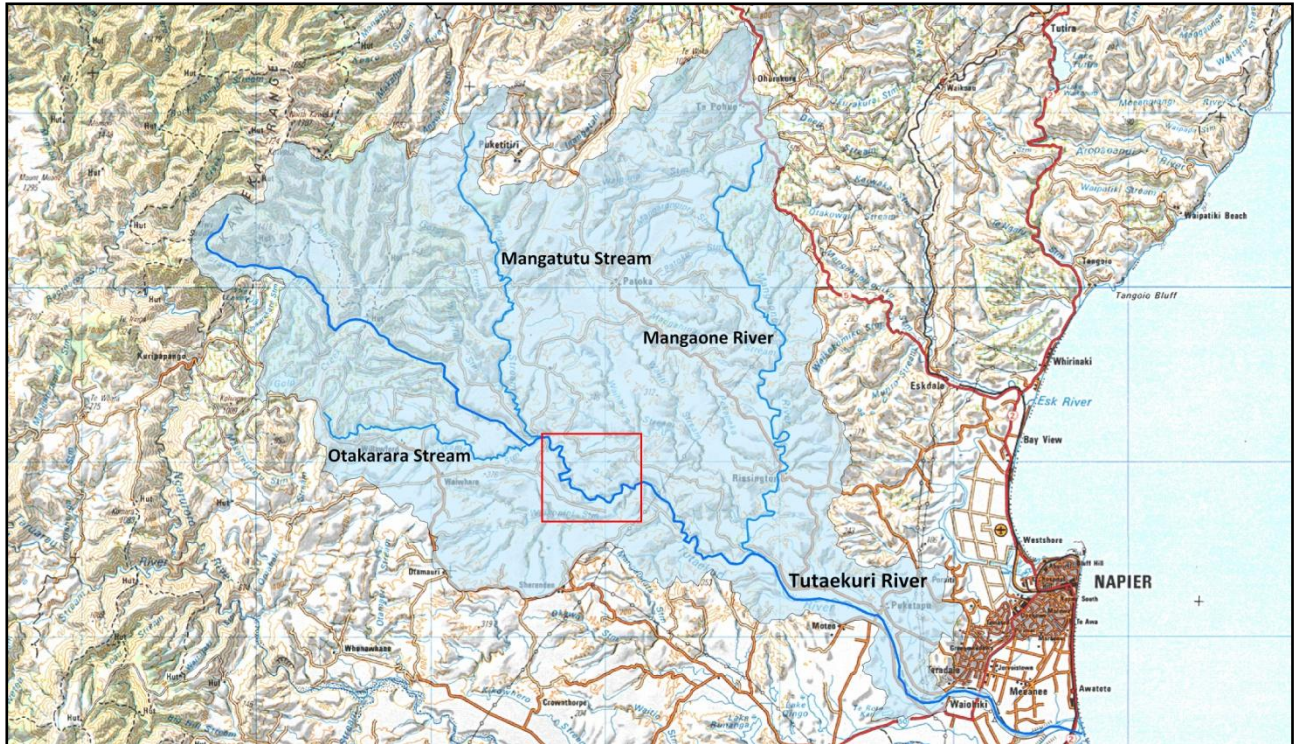


Figure 1: The Tutaekuri River catchment and 2009 instream habitat modelling study reach framed in red.

2.2 Naturalised Flows

Naturalised flow data were first calculated for the Tutaekuri River as part of the report “Flow Naturalisation for Six Hawke’s Bay Rivers” (Lew et al. 1997). The latest iteration of this work has used actual water usage records to refine the naturalised flow series (Harkness 2010).

The naturalised mean annual low flow has been calculated as a moving mean of the lowest 7-day consecutive flows for each full water year (July to June) for the record 1969 to 2008.

A series of flow statistics including the mean annual low flow have been calculated for the Tutaekuri River at the Puketapu minimum flow site using the naturalised flow series (Table 1). Naturalised flow statistics were also calculated for Ngaroto Road using a correlation of measured flows between the two sites.

Table 1: Naturalised flow statistics (l/s) for the Tutaekuri River at Puketapu and correlated flow for Ngaroto Road.

Site	7-day July to June Statistics		
	Mean	Median	MALF
Tutaekuri @ Puketapu	14460	8460	3800
Tutaekuri @ Ngaroto Rd	10166	6027	2800

3.0 REACH SELECTION AND HABITAT MODELLING METHODOLOGY

3.1 Stakeholder Consultation

The habitat modelling process for the Tutaekuri River began with consultation of stakeholders from the Department of Conservation (DOC), Fish and Game New Zealand, and local Iwi representatives. Scientists from National Institute for Water and Atmospheric Sciences (NIWA) and the Cawthron Institute were also consulted for their technical expertise in minimum flow investigations.

A brief discussion memo was circulated to stakeholders to aid understanding of the issues to be addressed in the modelling exercise (Johnson, 2009). This document included information describing the general trends in river gradient, hydrology, and geomorphology along with information on the modelling process and important considerations with using Rhyabsim. Further stakeholder involvement was included in the habitat mapping field work, described in Section 3.3.

3.2 Reach Selection

Reach selection is the process of selecting the river reach that is the most appropriate for addressing the objectives of the study. The upper Tutaekuri survey was initiated to specifically address increasing abstraction pressure in the upper reaches and tributaries and establish robust flow setting rules for this part of the catchment. Further work was completed to relate the results of the upper catchment study to the lower reaches.

There are three major factors as a part of the habitat modelling process that determine the reach(s) to be sampled to provide adequate data for 1D hydraulic habitat models:

- **Stream gradient:** stream gradient is a primary control on channel morphology and distribution of habitat types.
- **Morphology:** includes bank confinement, sediment supply and stream flow patterns. In braided systems, the extent of braiding can vary widely between reaches.
- **Hydrology:** survey reaches should be in areas of uniform flow without significant inflows or outflows.

Benchmarked elevation surveys of the Tutaekuri river corridor have been completed from Ngaroto Road to Hawke Bay at Awatoto (Figure 2). The data show a relatively consistent gradient from Ngaroto Road to Hawke Bay, but with subtle breaks at the Mangaone River confluence and at Redclyffe Bridge.

In general, the Tutaekuri River exhibits various degrees of braiding along most of its length with the middle reaches exhibiting a greater degree of braiding than the lower reaches. Downstream of the Mangaone River confluence, the strongly braided stream pattern transitions to a mostly single channel flow. River management works are the major control on this transition, as stopbanks, beach raking, and gravel extraction constrict the channel. A slight change in gradient may also be a contributing factor in the morphology along this river section.

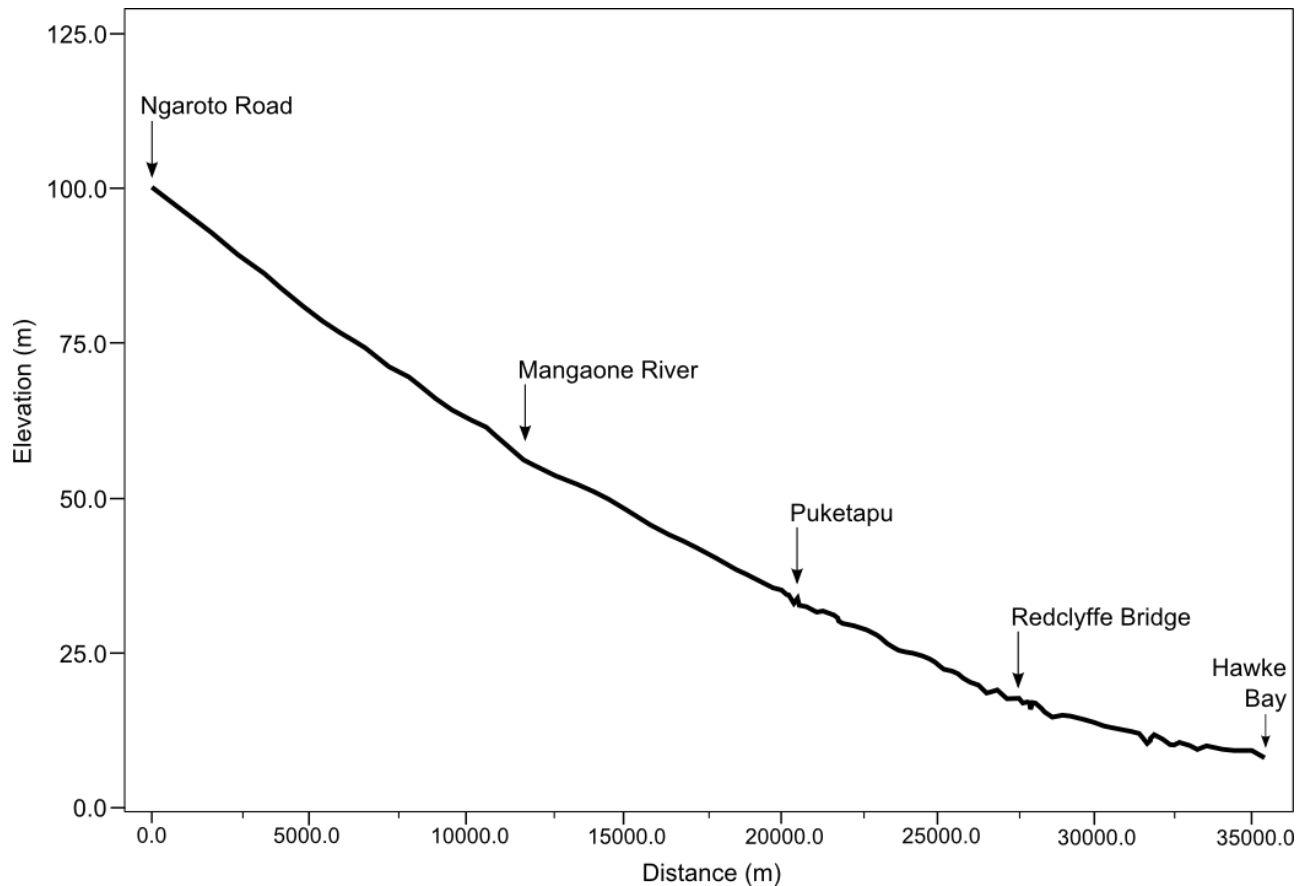


Figure 2: Stream gradient for the Tutaekuri River.

3.3 Habitat Mapping

Habitat mapping is a method for describing the character and distribution of flow types (meso-habitat units) within a river reach, which informs the final structure of the field survey and the weighting applied to individual transects in the model.

Habitat mapping was completed by HBRC staff and representatives from Fish and Game New Zealand for the 11 kilometer section of river from the Mangatutu confluence downstream to Ngaroto Road (Figure 3). The habitat mapping team walked the river, noting the beginning and end of each flow type, or meso-habitat unit, (runs, riffles, pools) and marking GPS waypoints at each location. The individual length, total flow type length, proportion by type, and proportion of total stream length was recorded. A consensus was reached among the survey team that the flow types encountered were sufficiently described as runs, riffles, and pools. The proportion of the total number of flow types and cumulative proportion of the total stream length of each habitat in the study section is shown in Table 2. Runs make up approximately half of the number of habitat units and account for over 60% of the stream length. Riffles comprise slightly less than 40% in both length and number. Pools make up 15% of the total number and only 3% of the total stream length. Initial field observations and subsequent review of GPS data indicated that the first third of the survey section (downstream of the Mangatutu confluence) exhibited a spatial distribution of habitat types representative of the total survey section. This upper river segment was chosen as the survey reach.

Table 2: Habitat mapping data for the Tutaekuri River including the total number of flow types and their length.

	Total No. Flow Types	Total Length (m)	%Total Flow Types	%Total Length	Final Survey Sections
Run	87	7770	47%	61%	12
Riffle	72	4464	39%	35%	8*
Pool	27	423	15%	03%	3

*two riffle flow types were excluded from the final model due to rating errors

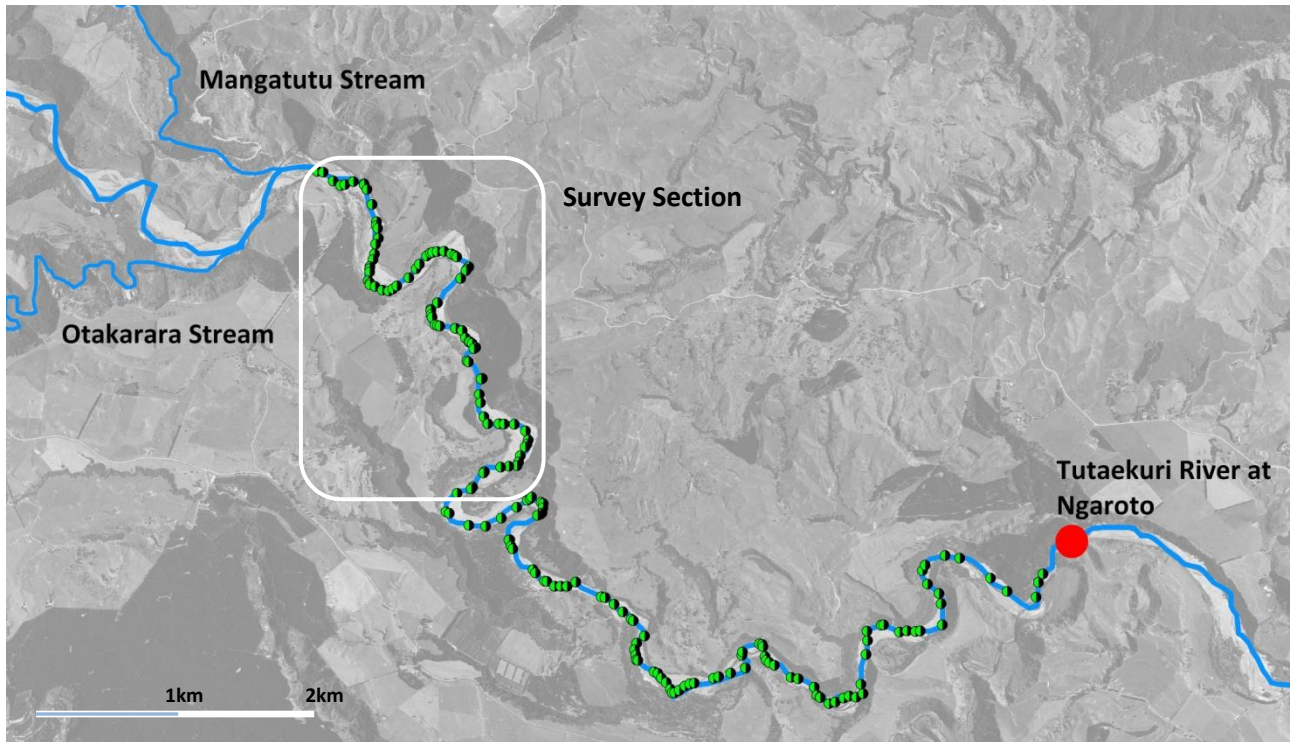


Figure 3: The study area focused on the reach between the Mangatutu Stream confluence and the flood warning site at Ngaroto Road. Green dots indicate the beginning of each mapped flow type (runs, riffles, and pools). Surveyed transects included in the model were taken from the mapped survey section (white box).

3.4 Data Collection

Transects were marked using steel “waratah” pegs. These steel pegs acted as benchmarks from which accurate water level measurements were taken. Water level and flow measurements were taken at each transect during successive gauging runs. Both water level and discharge measurements were used to formulate ratings during the model calibration process to allow predictions of flow conditions above and below the flows measured during the field exercise.

The gauging runs were conducted over a range of flows from slightly less than the MALF to approximately half the median flow. This provided a good range of flows for calibration of the model to allow robust habitat WUA predictions at low flows.

3.5 Data Checking

Field data were formatted and entered into Rhyabsim and checked for data quality. The first level of data checking used the built-in checking function in Rhyabsim to examine habitat weighting, stage at zero flow, and rating curve regression coefficient values. The checking output was reviewed to ensure that all transect weightings added to 100%, that stage at zero flows did not exceed the

maximum depth of the transect, and that rating curve regression coefficients were within an acceptable range, using the 95% threshold as a guide.

Cross-sections were then plotted and inspected for obvious errors in depth and velocity. The ratio of measured velocity to calculated velocity¹ at each measurement point along the channel cross-section is the Velocity Distribution Factor (VDF). VDFs are automatically fitted in Rhyhabsim. Unrealistic VDFs can impact the predicted velocities outside of the measured range, especially where assumed to be zero. VDFs were checked and edited as per Jowett (2004).

3.6 Ratings

The relationship between stage and flow is critical for model outputs to be considered representative of actual river conditions. These relationships, or ratings, are fitted in Rhyhabsim using stage and flow data gathered during field surveys. Three mathematical methods are used to generate ratings, each displayed in Rhyhabsim for a visual check. Transects with robust ratings have plots that are similar for each rating method used.

Two aspects regarding ratings need to be considered. One is that the three calculated rating curves for each individual transect plot similarly. The exponent of the rating used for each transect also needs to be consistent across the entire suite of transects. The recommended range of exponents for rating curves is from 1.5 to 3.5 (Jowett 2004).

For the Tutaekuri model, ratings for individual transects fit well between the three rating curve methods. Rating exponents from all but two transects (Riffles 12 and 13) fell within the recommended range and had a good degree of fit to gauging data (Figure 4). Riffles 12 and 13 were removed from the model.

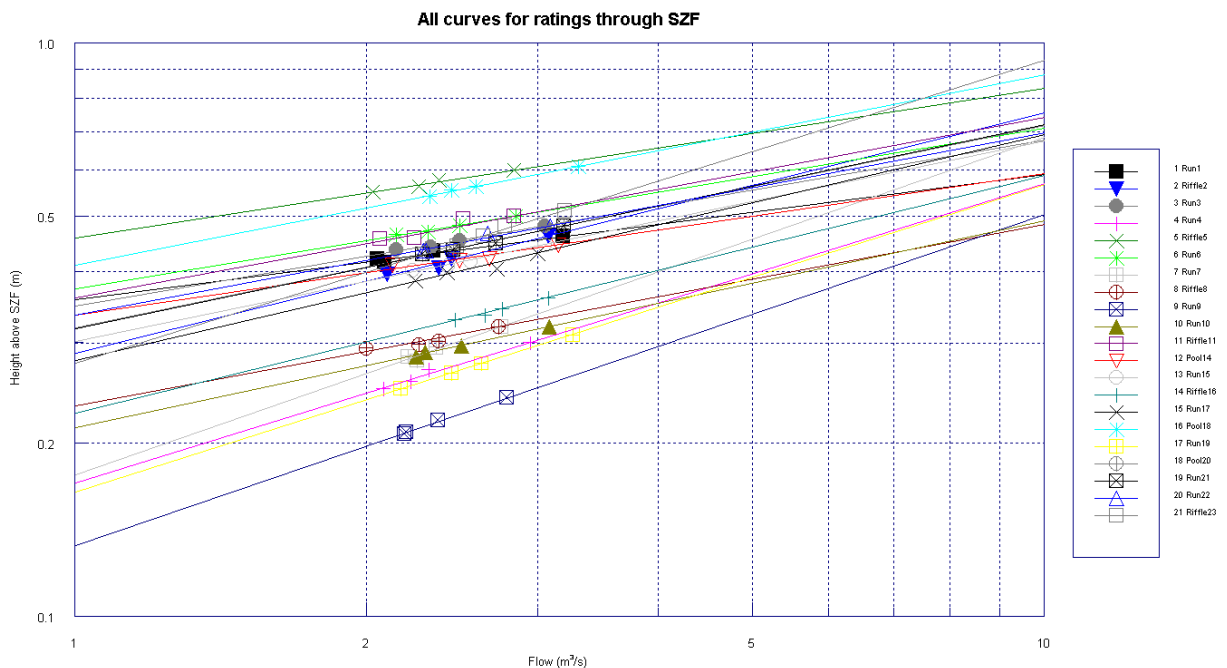


Figure 4: Ratings of transects in the Tutaekuri River, generated in the Rhyhabsim model (log-log scale). Transects 12 and 13 are excluded as their rating exponents fell outside of the recommended range.

¹ Calculated based on Manning's equation and assuming a uniform value of Manning's N across the transect. The velocity distribution factor (VDF) is a measure of how cell roughness varies across a transect.

3.7 Habitat Predictions

3.7.1 Suitability Criteria

One-dimensional hydraulic habitat model predictions are most sensitive to the habitat suitability criteria (HSC) applied (Jowett 2004). HSC should be chosen for species that occur in the study river, with special consideration made to the types of rivers which the HSC were developed and the type of observations used in developing the criteria.

A list of fish and macroinvertebrate species in the Tutaekuri catchment was compiled (Table 3). There are several species that may be considered as having high value, either as sport fish or because of their status as a rare or endangered species. The HSC applied in this report are shown in Appendix A.

Rainbow trout make up a significant sports fishery on in the Tutaekuri catchment. The Provisional HB Rainbow trout HSC were developed using data from the Ngaruroro and Tutaekuri Rivers, specifically targeting drift feeding fish >200mm length.

The Tutaekuri River is home to a number of native fish species. The Department of Conservation has released its latest appraisal of the threat classification status of native fish species (Allibone et al. 2010). The threat classification for several native fish species including torrentfish, koaro, and bluegill bully has been changed from “Not Threatened” to “At Risk - Declining”. Allibone et al. (2010) state “It is apparent that more serious effort is now required to reverse the decline in native freshwater fishes and to manage the instrumental causes of their decline that are ongoing, and in some cases increasing, if the extinction of further freshwater fish is to be prevented.” This suggests an increase in the conservation priority on a national level for these species. In addition to the threat classification being increased, these species inhabit areas that are sensitive to changes in flow, an important consideration for this modelling exercise.

Table 3: Fish species in the Tutaekuri catchment. Bold type indicates species with ‘At Risk – Declining’ threat classifications as per Allibone et al 2010.

	Common Name	Scientific Name	Habitat Modelled
Native Fish	Longfin eel	<i>Anguilla dieffenbachii</i>	Yes, two size classes
	Shortfin eel	<i>Anguilla australis</i>	Yes, two size classes
	Common bully	<i>Gobiomorphus cotidianus</i>	Yes
	Torrentfish	<i>Cheimarrichthys fosteri</i>	Yes
	Redfin bully	<i>Gobiomorphus huttoni</i>	Yes
	Inanga	<i>Galaxias maculatus</i>	Yes
	Crans bully	<i>Gobiomorphus basalís</i>	Yes
	Common smelt	<i>Retropinna retropinna</i>	Yes
	Koaro	<i>Galaxias brevipinnis</i>	Yes
	Bluegill bully	<i>Gobiomorphus hubbsi</i>	Yes
	Giant bully	<i>Gobiomorphus gobioides</i>	No HSC available
	Black flounder	<i>Rhombosolea retiaria</i>	No HSC available
	Yelloweyed mullet	<i>Aldrichetta forsteri</i>	No HSC available
	Grey mullet	<i>Mugil cephalus</i>	No HSC available
Sports Fish	Rainbow trout	<i>Oncorhynchus mykiss</i>	Yes, two size classes
Crustacea	Koura	<i>Paranephrops planiformis</i>	No HSC available
Insecta	Mayfly	<i>Deleatidium spp.</i>	Yes
	General Macroinvertebrate		Yes

3.7.2 Modelled Flow Range

The United States Geological Survey (USGS) Phabsim training document suggests that the Phabsim hydraulic model can be extrapolated up to 1.5 times the highest measured flow and down to 0.6 times the lowest calibration flow (Milhous et al. 1989). They state that the absolute maximum range for extrapolation is from 2.5 times the highest calibration flow and 0.4 times the lowest calibration flow. It is reported that the rating curve development functions of Rhyhabsim improve upon those found in Phabsim (Hay 2008²). The range of flows modelled in this report has been set within the USGS recommended limits at 1000 l/s to 5000 l/s.

4.0 RESULTS

The results of Rhyhabsim modelling on the Tutaekuri River have been compiled (Table 4). Flow levels have been presented for each modelled species which provide four levels of habitat WUA, ranging from the WUA optimum to 70% of habitat availability (either from the optimum or from the WUA at the MALF, whichever less). A selection of species have been highlighted which are likely to be of significant importance to regional stakeholders, thus forming pertinent management objectives for setting the minimum flow.

Table 4: Flows providing a range of habitat WUA retention levels for species modelled in the Tutaekuri River. HSC are from Jowett and Richardson (2008) unless otherwise noted.

TUTAEKURI RIVER		Retention levels for WUA at MALF or optimum WUA flow (whichever less)		
Habitat Suitability Criteria	Flow at WUA Optimum (l/s)	90%	80%	70%
Longfin eel <300mm (Jellyman et al 2003)	1300	**	**	**
Longfin eel >300mm (Jellyman et al 2003)	!	2300	1800	1400
Longfin eel <300mm	1200	800	600	500
Longfin eel >300mm	1100	700	500	**
Shortfin eel <300mm	900	600	**	**
Shortfin eel >300mm	900	**	**	**
Common bully	500	**	**	**
Torrentfish	!	2100	1800	1600
Redfin bully	700	**	**	**
Inanga feeding	**	**	**	**
Crans bully	**	**	**	**
Smelt	900	600	500	**
Koaro	2200	1300	1000	800
Bluegill bully	1900	1400	1200	1000
Rainbow trout <100mm	**	**	**	**
Rainbow trout >200mm (Provisional Hawke's Bay HSC)	!	2400	2000	1700
Mayfly (Jowett et al. 1991)	!	1800	1200	900
General Macroinvertebrate (Waters 1976)	3500	2100	1600	1300

!Flow at WUA optimum exceeds modelled range

**Flow at specified WUA value is less than modelled range

4.1 Trout Habitat

Rainbow trout are considered a high-priority management species in the Tutaekuri River. Several aspects of rainbow trout make them important species to consider, including their high flow requirements and sport fishing status. Recent work by the Cawthron Institute, Fish and Game New Zealand, and HBRC has been completed to develop habitat suitability criteria for rainbow trout in Hawke's Bay rivers.

Weighted usable area (WUA) response curves have been calculated in Rhyhabsim (Figure 5). WUA increases throughout the modelled range for adult trout, with a steep slope in the lower half of the range. This indicates that the natural low flow conditions in the Tutaekuri River are limiting for adult trout habitat and that reductions in flow below the MALF (2300 l/s) may incur a decline in available habitat. Juvenile trout habitat reflects the lower depth and velocity requirements of this life stage. Optimum habitat is provided at very low flows for juvenile rainbow trout.

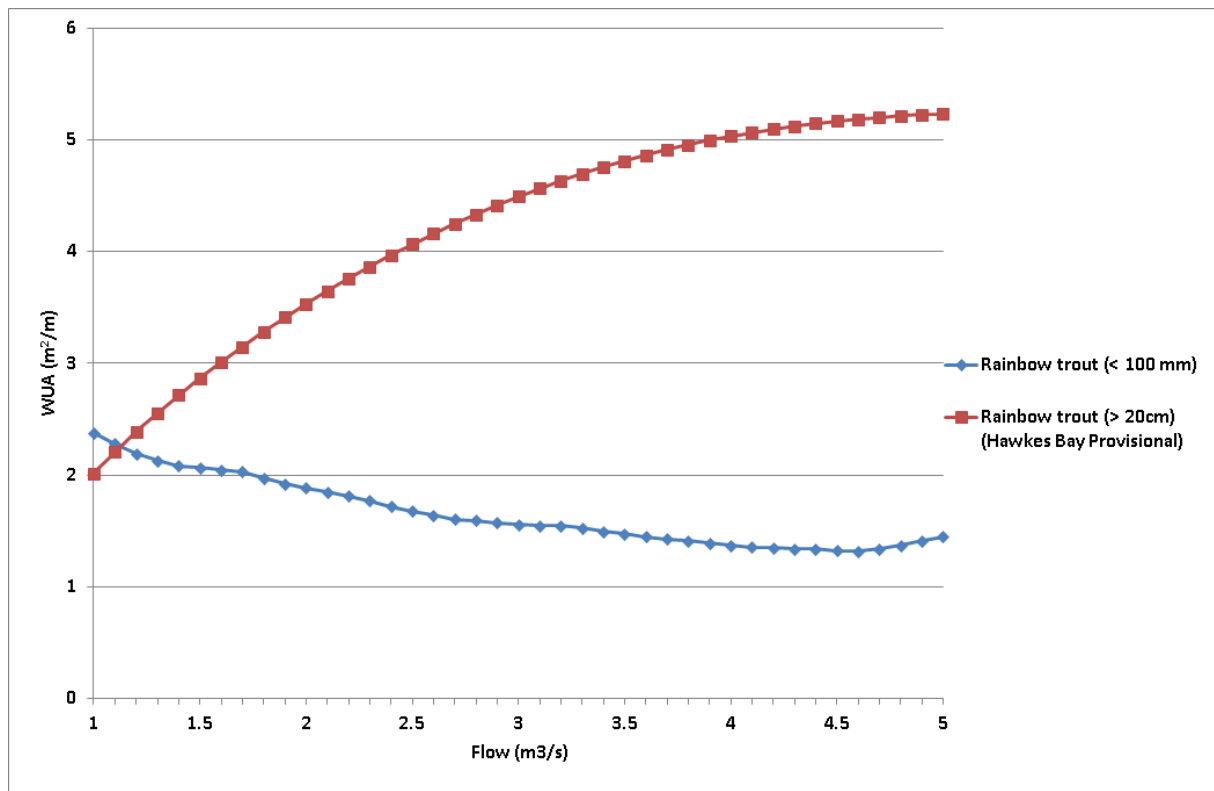


Figure 5: Rainbow trout habitat WUA responses.

4.2 Native Fish Habitat

Model results for longfin and shortfin eels are shown in Figure 6. The habitat suitability criteria used are from Jowett and Richardson (2008). These show that both size classes for both species have optimum habitat at flows below the MALF, with greater overall habitat for juvenile eels.

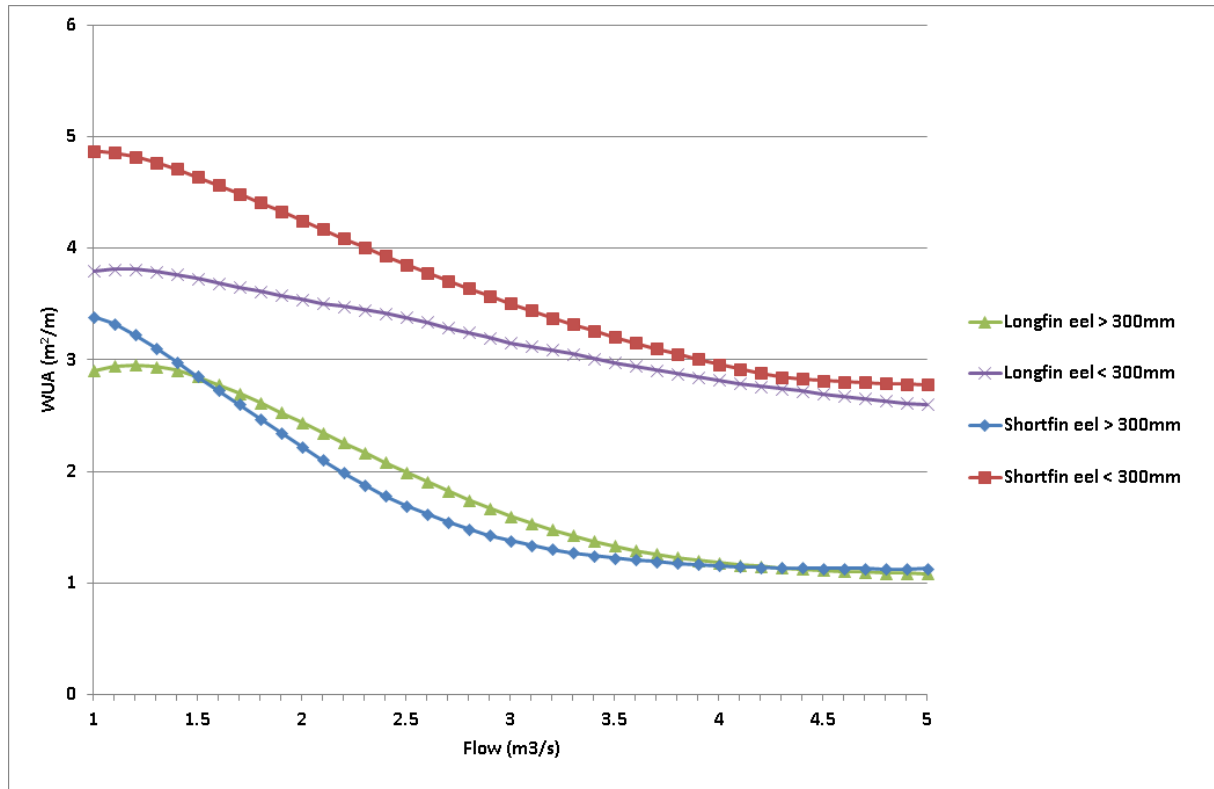


Figure 6: Longfin and shortfin eel habitat WUA responses.

The habitat WUA responses for native species with high flow requirements were compiled including bluegill bully, koaro, and torrentfish (Figure 7). Habitat for torrentfish and bluegill bullies is highly sensitive to reductions in flow below the optimum flow. The WUA response for koaro is less sensitive to reductions in flow below the optimum.

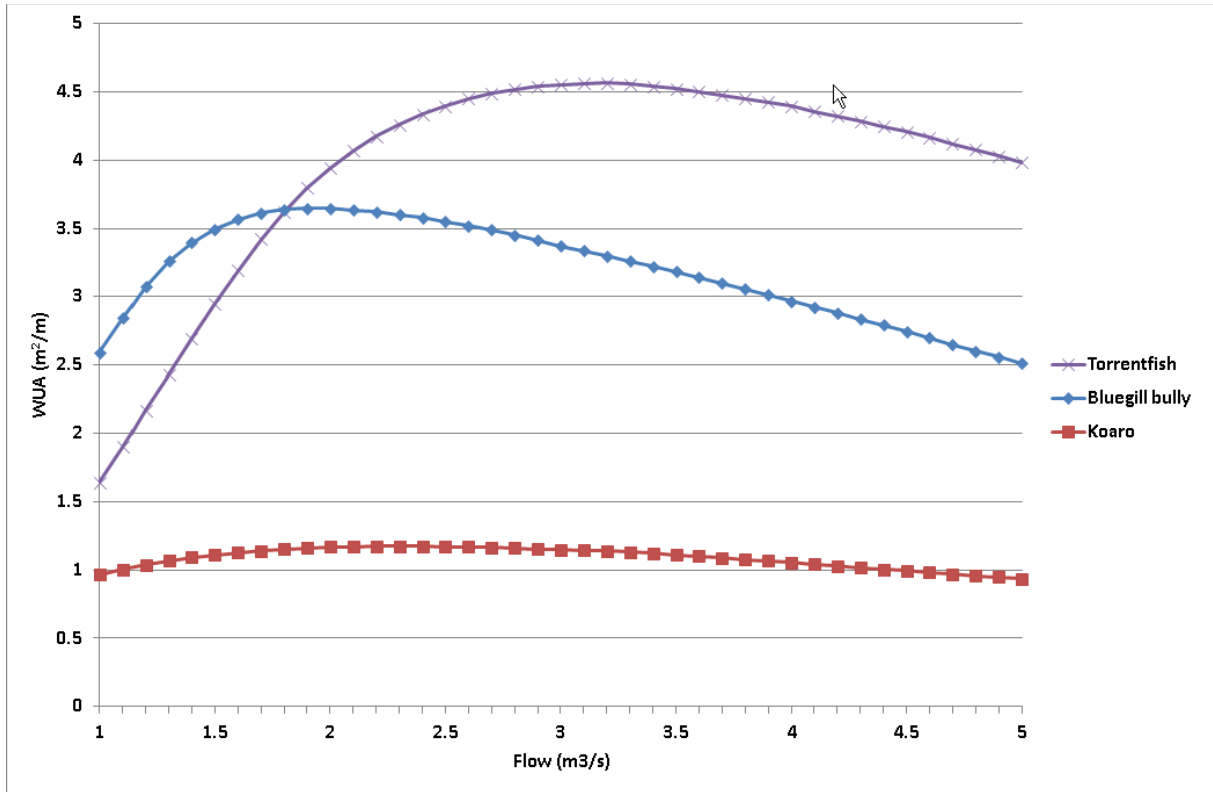


Figure 7: Habitat WUA responses for torrentfish, bluegill bully, and koaro.

Several native species in the Tutaekuri River seek out shallow, slow moving water as their preferred habitat. Those modelled include common bully, crans bully, redfin bully, and common smelt (Figure 8). All species show a similar WUA response with an optimum flow near the low end of the modelled range and a decline in habitat with increasing flows. Very slight increases in habitat are evident at the higher range, likely caused by inundation of shallower gradient river gravels on the channel margins.

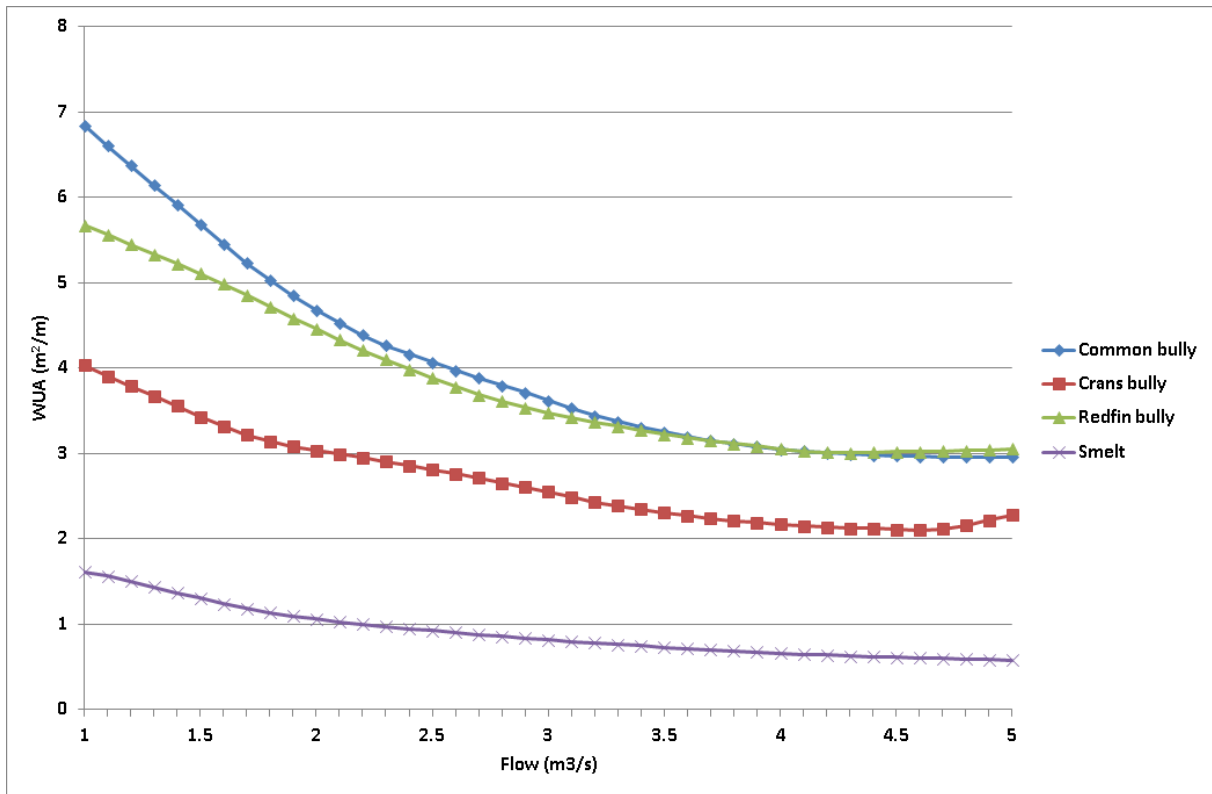


Figure 8: Habitat WUA responses for common bully, crans bully, redfin bully and smelt.

5.0 DISCUSSION

5.1 Ecological Relevance of the MALF

The mean annual low flow is an important hydrological parameter for long-lived fish and other river inhabitants with annual reproduction cycles (Jowett 1990, 2002, Clausen and Biggs 1997, Jowett et al. 2005, Booker et al. 2008^{1&2}). The lowest flow of each year acts as a bottleneck on instream habitat, thus affecting the living space of fish and other instream fauna. The mean annual low flow describes the magnitude of the expected low flow event for any given year, giving water resource managers a benchmark from which to make management decisions.

This relationship between MALF and fish habitat is often recognised in flow management. It has become common practice to interpret WUA curves in conjunction with the MALF. Where the optimum WUA for a given species is greater than the MALF, then it follows that MALF is a potential limiting factor for that species' habitat. Managers can attempt to mitigate the effect of water takes that constrain habitat by restricting the drawdown of rivers below MALF to maintain a percentage of WUA (habitat) available at the MALF.

5.2 Reconciling Flow Requirements of Multiple Instream Values

Typical instream habitat models include a range of species, each with its own unique life history, habits, and flow requirements. The process of flow management must reconcile these different and often conflicting flow requirements to provide protection for a range of instream values. Jowett and Hayes (2004) suggest identifying the critical instream values (fish species in this case) and managing for those values. Critical values may include rare or endangered fish species or highly valued sport fish with high flow requirements, under the assumption “that by providing sufficient flow to sustain the most flow sensitive, important value (species, life stage, or recreational activity), the other significant values will also be sustained” (Jowett & Hayes 2004, p. 8).

Habitat WUA can be used as the measurement tool for managing critical values by choosing a level of available habitat to be retained (based on either optimum WUA or WUA at the MALF, whichever is least). The level of habitat retention is ultimately an arbitrary value. The current scientific understanding of river ecosystems and fish populations is insufficient to identify levels of habitat below which detrimental effects will occur (Hay 2008²). The level of habitat retention is therefore based more on risk management (Jowett and Hayes 2004) with greater risk of detrimental effects on populations with increasing habitat loss. Where a range of values are present with varying importance, the level of habitat retention can then be varied according to the importance of the value. Suggested levels of habitat retention for a range of values were provided by Jowett and Hayes (2004) and have been included here (Table 5).

Table 5: Suggested significance ranking and levels of habitat retention of critical species values. From Jowett and Hayes 2004.

Critical Value	Fishery quality	Significance ranking	% habitat retention
Large adult trout – perennial fishery	High	1	90
Diadromous galaxiid	High	1	90
Non-diadromous galaxiid	-	2	80
Trout spawning/juvenile rearing	High	3	70
Large adult trout – perennial fishery	Low	3	70
Diadromous galaxiid	Low	3	70
Trout spawning/juvenile rearing	Low	5	60
Redfin/common bully	-	5	60

Weighted usable area expressed as a percentage (%WUA) was included in early version of Rhyhabsim to give an indication of relative habitat quality and to allow comparisons between hydrologically dissimilar catchments. On some occasions, the %WUA metric has historically been mistaken as a quantitative measure, leading to the metric being changed in newer versions of Rhyhabsim to a habitat suitability index (HSI, ranging from 0 to 1) in an attempt to reduce confusion around interpretation. Current methods of interpreting Rhyhabsim outputs for minimum flow setting focus on WUA as this metric is a quantitative measure which takes into account both habitat quality and quantity (Hay 2008²).

Most recent habitat modelling exercises in New Zealand have used the most sensitive species as the benchmark for setting minimum flows, assuming that all other species habitat will be provided for. Native fish habitat requirements have often been modelled to be less than those for trout (except some fast-water species). Recommendations for percent retention of native fish habitat WUA have often been less than that for trout. Explicit protection of native fish habitat is not commonly the

primary management objective in most minimum flow setting exercises. When applied, most cases have recommended retention of 60%-70% of the habitat WUA available at the MALF for native species (versus 80-90% for trout).

Jowett and Hayes (2004) raise two points regarding fast-water native fish, including torrentfish and bluegill bullies. The first suggests these species have relatively low instream value as they do not comprise sport or customary fisheries, although some customary fisheries for torrentfish have been documented (McDowall 2000). Further evidence is presented for their resilience to environmental changes, noting that most are diadromous and likely to be recruited from a regional gene pool. This would give them resilience to flow changes within a single river. This evidence supports the contention that lower habitat retention levels may be sufficient to support native fish populations. Significant flow reductions (below the naturalised MALF) on several rivers in the region may impact on regional native fish populations. The minimum flows of all rivers within the region should then be considered when addressing the habitat retention levels of diadromous native species. The current minimum flows relative to MALF for the major Hawke's Bay catchments show that there are considerable reductions below MALF on some of the major Hawke's Bay rivers (Table 6), with minimum flows on average 37% less than MALF.

The increase in threat status of native fish along with the current state of minimum flows relative to the MALF provides support for high levels of habitat retention for native fish species to mitigate risk to native fish populations through habitat loss.

Table 6: Percent difference between mean annual low flows and minimum flow levels for major catchments in Hawke's Bay.

River	MALF (l/s)	Minimum Flow (l/s)	Minimum Flow as % MALF
Wairoa	19,300	No minimum flow	-
Mohaka	23,000	No minimum flow	-
Esk	2,100	1,400	67%
Tutaekuri	*3,800	2,000	53%
Ngaruroro	*4,500	2,400	53%
Karamu	*1,300	1,100	85%
Tukituki	*6,400	3,500	55%
Maraetotara	350	220	63%
Porangahau	N/A	No minimum flow	-

*Naturalised 7-day July-June MALF

N/A: Data not available

6.0 LOWER TUTAEKURI

Supporting scientific investigations for minimum flow reviews have been completed for the Ngaruroro, upper and lower Tukituki, Tukipo, and Waipawa rivers. These investigations have all been for the development of instream habitat models for a range of species as described in this report. Given the flows which provide optimum habitat for these management species are considerably higher than the mean annual low flow (MALF), the preferred method to address this issue uses the MALF as the benchmark flow for the minimum flow setting process. It is understood that reductions in the minimum flow below the MALF incur an incremental risk to instream habitat.

Several iterations of this work throughout Hawke's Bay have shown a general trend in the relationship between habitat retention levels and reduction of flows below the MALF (Table 7).

Habitat models for all Hawke’s Bay rivers show that flow demanding species have optimum habitat levels at flows greater than the MALF. The methodology applied in these cases is to consider the amount of habitat relative to the MALF. This leads to minimum flows that are intrinsically linked to the MALF. It follows that given enough information about the flow requirements of flow demanding fish species for a particular river type in the same region, a pragmatic approach to addressing minimum flow requirements can be applied which does not require a habitat modelling approach.

Using evidence from models completed on Hawke’s Bay rivers, a pragmatic and conservative approach is recommended for minimum flow considerations which uses a percentage of MALF to estimate the impact on habitat for flow demanding fish species in gravel bed rivers (Table 8). The corresponding percentage of MALF required to meet the generalised habitat retention levels were derived by the mean and median of rainbow trout and torrentfish data from Table 7.

Table 7: Percentages of MALF required to meet habitat retention levels (H%) for rainbow trout and torrentfish in several Hawke's Bay rivers.

RAINBOW TROUT	MALF	90% Habitat Retention Level (H90)	80% Habitat Retention Level (H80)	70% Habitat Retention Level (H70)
Upper Tutaekuri	2800	86%	71%	61%
Ngaruroro	4500	87%	76%	60%
Upper Tukituki	2800	83%	67%	55%
Tukipo	186	79%	64%	57%
Waipawa	3000	94%	80%	67%
Lower Tukituki	6400	80%	67%	53%
TORRENTFISH				
Upper Tutaekuri	2800	75%	64%	57%
Ngaruroro	4500	93%	87%	76%
Upper Tukituki	2800	91%	80%	67%
Tukipo	186	68%	54%	46%
Waipawa	3000	100%	94%	94%
Lower Tukituki	6400	77%	63%	53%

Table 8: Percentages of MALF that meet generalised habitat retention levels (H%).

Approximate Level of Habitat Protection (H%)	H90	H80	H70
Corresponding % of MALF	85%	70%	60%
% MALF in l/s for the Lower Tutaekuri	3200	2700	2300

6.1 Minimum Flow Setting Process

There are many considerations to be made in the minimum flow setting process, the most important of which is defining the values that the community wishes to maintain or enhance. It is not the intention of this report to define those values as that process involves all stakeholders in the Tutaekuri catchment. However, there are many National and Regional examples to guide recommendations in this report, which have been incorporated.

One of the longstanding management objectives in the major Hawke’s Bay catchments is maintaining high quality rainbow trout fisheries. Rainbow trout have been a prominent management species for the Tutaekuri River in the past; however the importance of native fish habitat is becoming an

increasingly discussed topic. A report on the threat status of New Zealand native fish (Allibone et al. 2010) indicated a heightened importance on preserving habitat for a number of native species. It is recognised that for some rivers, the flows required to maintain 90% habitat retention for critical species are significantly higher than the current minimum flows in the Regional Resource Management Plan. It is recommended that a thorough consultation of regional stakeholders be held to discuss the goals for management of the Tutaekuri catchment, with clear outcomes defined for the maintenance of fish habitat. The results from this modelling exercise can then be used to determine the flow that best meets the needs of all stakeholders.

6.2 Allocation Limits

Minimum flows define the low flow limit below which water abstraction from rivers must cease. To ensure that detrimental ecological effects do not occur due to increases in the frequency and duration of the minimum flow, limits are placed on the amount of water allocated from a catchment. These allocation limits restrict the amount of total allocation, often in terms of both instantaneous rate of take and total volume. By placing limits on water allocation, flow variability within the natural hydrograph can be protected, in turn protecting ecological function related to flow variability (Berger 1998, Clausen and Biggs 1997, Duncan and Woods 2004, Jowett et al. 2005, MfE 2008, Richter et al. 1996, Richter et al. 1997, Richter et al. 1998, Smeltzer and Lassette 1999).

Allocation limits can be placed at different stages of the hydrograph to create “blocks” of water available for allocation, each with its own security of supply. The minimum flow and core allocation limit define the “core allocation” and additional higher minimum flows and high flow allocation limits define additional allocation blocks. This is a commonly used system for water allocation in New Zealand. An idealised schematic describes allocation limits as part of a water management regime (Figure 9).

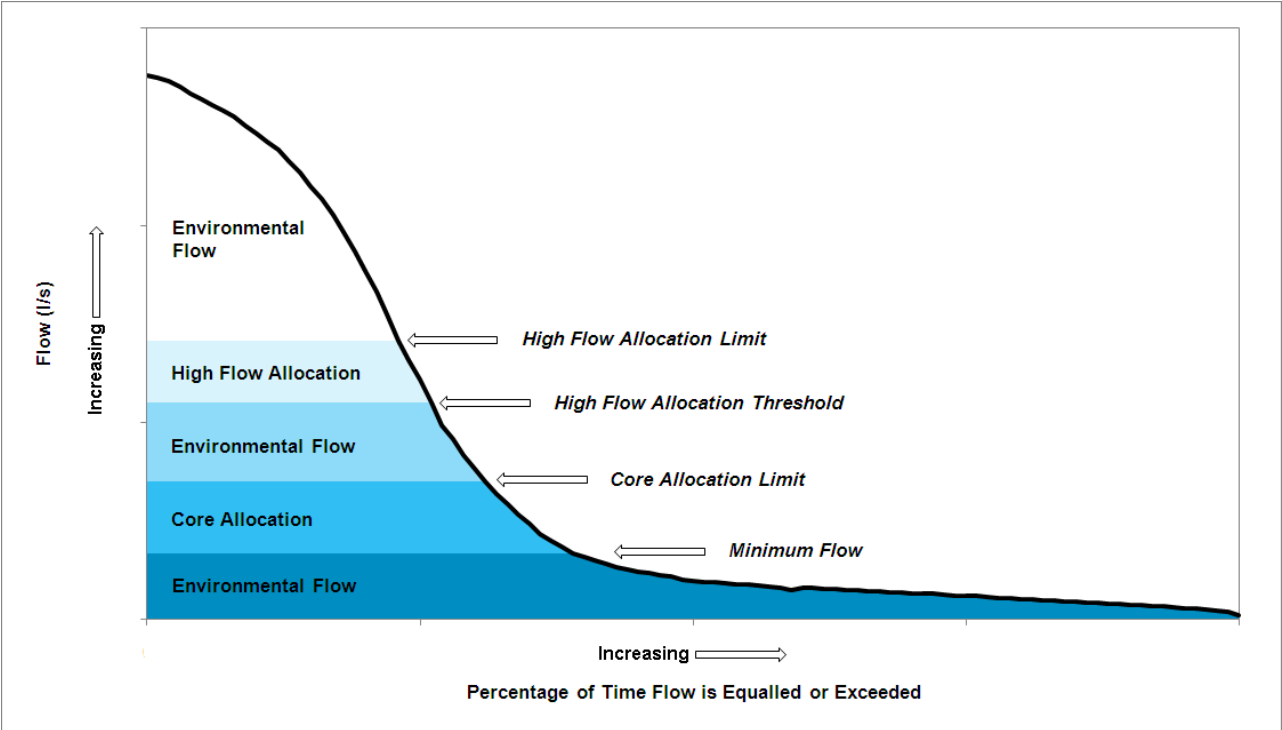


Figure 9: Schematic showing an idealised water allocation regime.

Allocation limits must be used in conjunction with minimum flows to account for a variety of instream habitat requirements. Allocation limits for the Tutaekuri catchment will be addressed in

subsequent HBRC publications, presenting various allocation scenarios and their respective impact on the flow regime.

7.0 CONCLUSIONS

This report describes the application of the Rhyabsim instream habitat model to assess the instream flow requirements for the upper Tutaekuri River. Habitat WUA versus flow relationships produced using Rhyabsim have been presented. The interpretation of the WUA versus flow relationships followed the process:

- Suggested critical values were identified as the species or life-stage that has the highest fishery or conservation value and/or the highest flow requirements. It is assumed that the minimum flow intended to protect habitat for these species will also accommodate species or life-stages with lower flow requirements.
- The habitat retention level for each critical value was referenced to the MALF or to the optimum flow, whichever was lowest
- A level of habitat retention was chosen which is likely to sustain the critical values

Potential minimum flows presented in this report are based on maintaining 90% of the habitat available at the MALF for sport fish (rainbow trout) and several native fish species. It is important that up-to-date stakeholder consultation is incorporated in identifying critical management targets for the Tutaekuri catchment. Where agreed targets are different from past management objectives, the full model outputs are available to define the flow that best achieves those targets.

The primary flow setting objective for many of the major Hawke's Bay rivers has been to provide sufficient physical habitat for the rainbow trout fishery. This has been successfully adopted because of the local support for recreational angling and the high flow requirements of trout, which have been accepted in many cases to provide ample flows for sustaining native species. It is anticipated that the rainbow trout fishery will continue to have a high standing in the list of management objectives for the Tutaekuri River.

Additional values including native fish have also been considered and model results provided accordingly. It is recommended that a full assessment of the values of the Tutaekuri be completed and considered in conjunction with the model results. Habitat WUA for a range of species can then be used as a currency for the setting of the minimum flow. The risk of habitat reduction for each valued species can be described by the rate of reduction of habitat WUA below the mean annual low flow. The importance of the relative values of the Tutaekuri can guide water managers to determine the best balance of habitat retention levels.

Evidence has also been presented to support a minimum flow for the lower Tutaekuri River at Puketapu based on the MALF statistic. Habitat modelling data in gravel bed rivers across Hawke's Bay has shown a consistent correlation between the MALF and habitat availability for flow demanding species. A series of flows based on percentages of MALF have been compiled as potential minimum flows with the understanding that reductions in flow below the MALF incur an increasing risk to the habitat of flow demanding fish like rainbow trout and torrentfish.

A summary table has been compiled with potential minimum flows for the upper and lower Tutaekuri River (Table 9).

Table 9: Required flows for rainbow trout and torrentfish for the upper and lower Tuktaekuri.

River section	Critical HSC	Environmental Objective	Required Minimum Flow (l/s)
Upper Tutaekuri	rainbow trout; torrentfish	90% Habitat Retention	2400
Lower Tutaekuri	rainbow trout; torrentfish	85% MALF	3200

Allocation limits (in conjunction with minimum flows) are a vital component of water management regimes. These limits define the total amount of abstraction that can occur above the minimum flow and limit the impact of water abstraction on flow variability, including the frequency of occurrence and duration of the minimum flow. Allocation limits for the Tutaekuri catchment will be addressed in subsequent HBRC publications, presenting various allocation scenarios and their respective impact on the flow regime.

There are many considerations to be made in the water management process, the most important of which is defining the values that the community wishes to maintain or enhance. It is not the intention of this report to define those values as that process involves all stakeholders in the Tutaekuri catchment as part of a full assessment of RMA Section II, which addresses economic, cultural, social, and environmental matters. However, there are many National and Regional examples to guide minimum flow selection for instream habitat, which have been incorporated in this report.

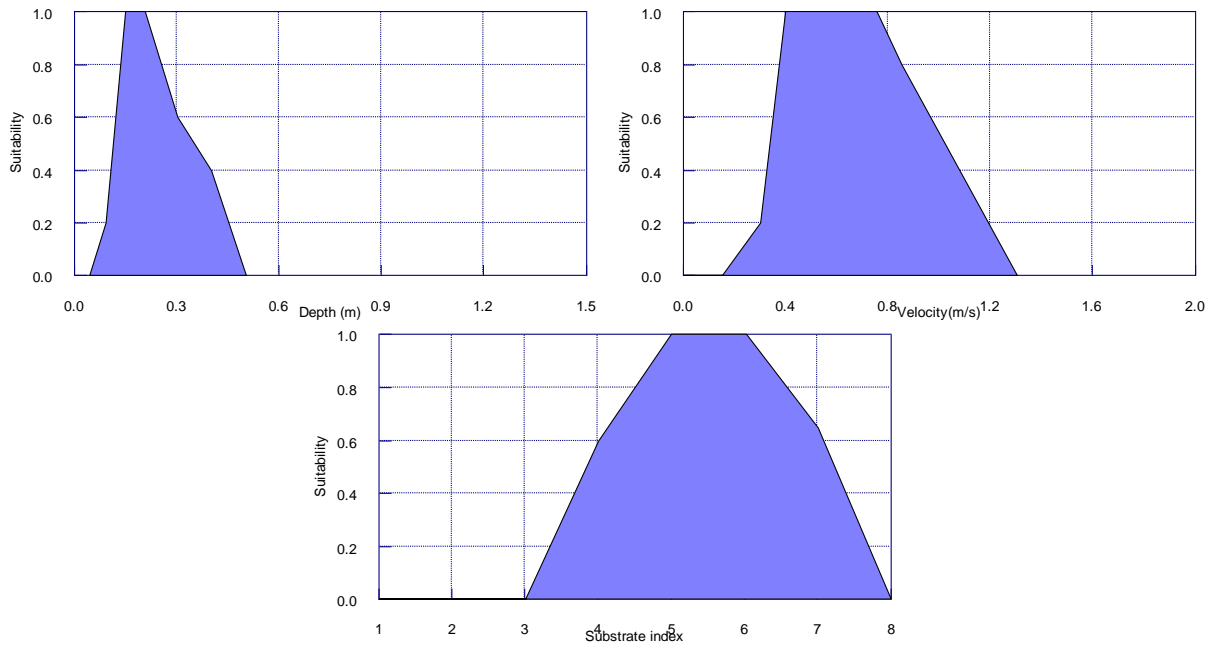
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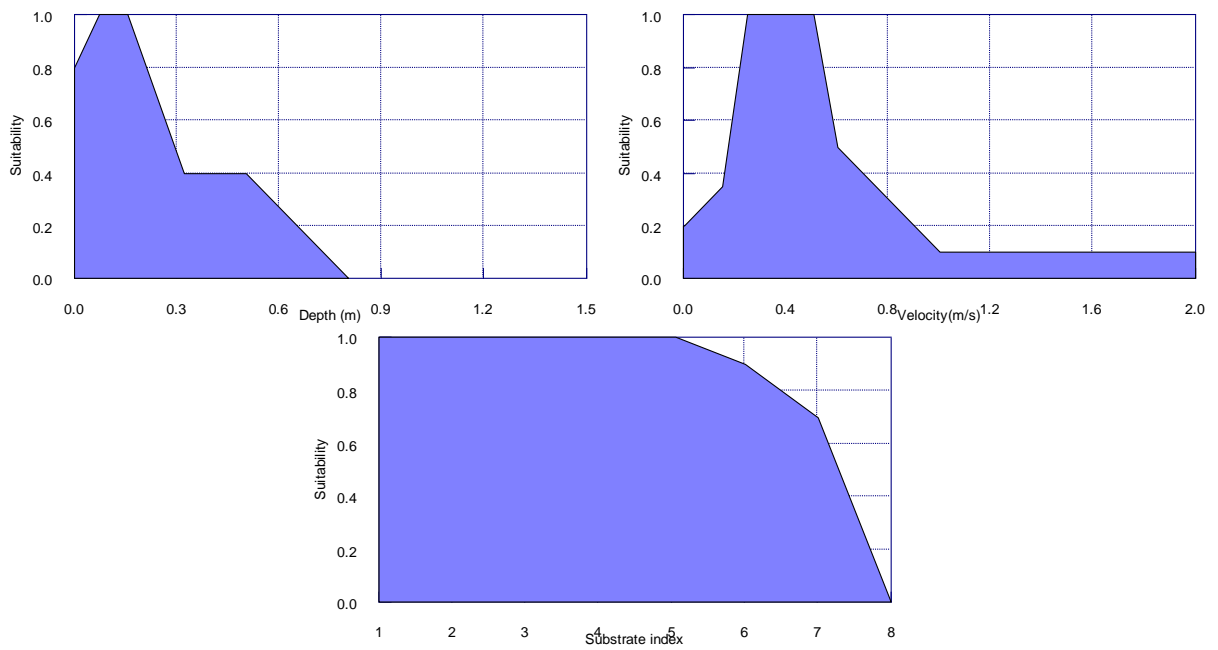
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APPENDIX A: HABITAT SUITABILITY CRITERIA

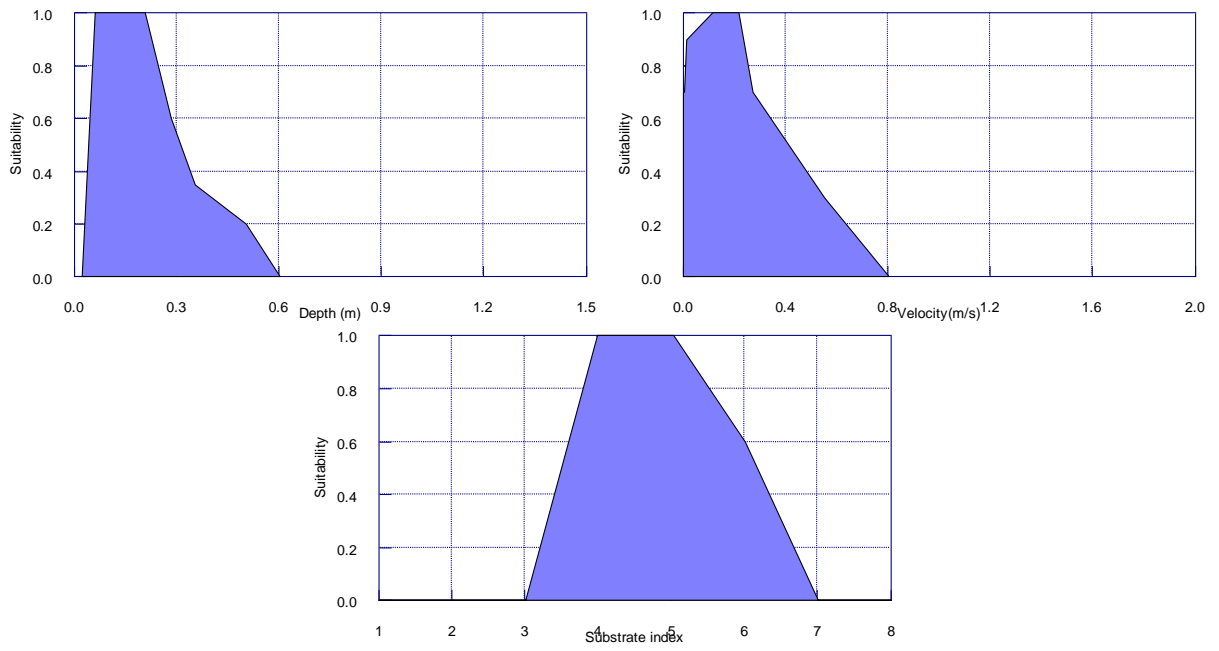
Bluegill bully (Jowett & Richardson 2008)



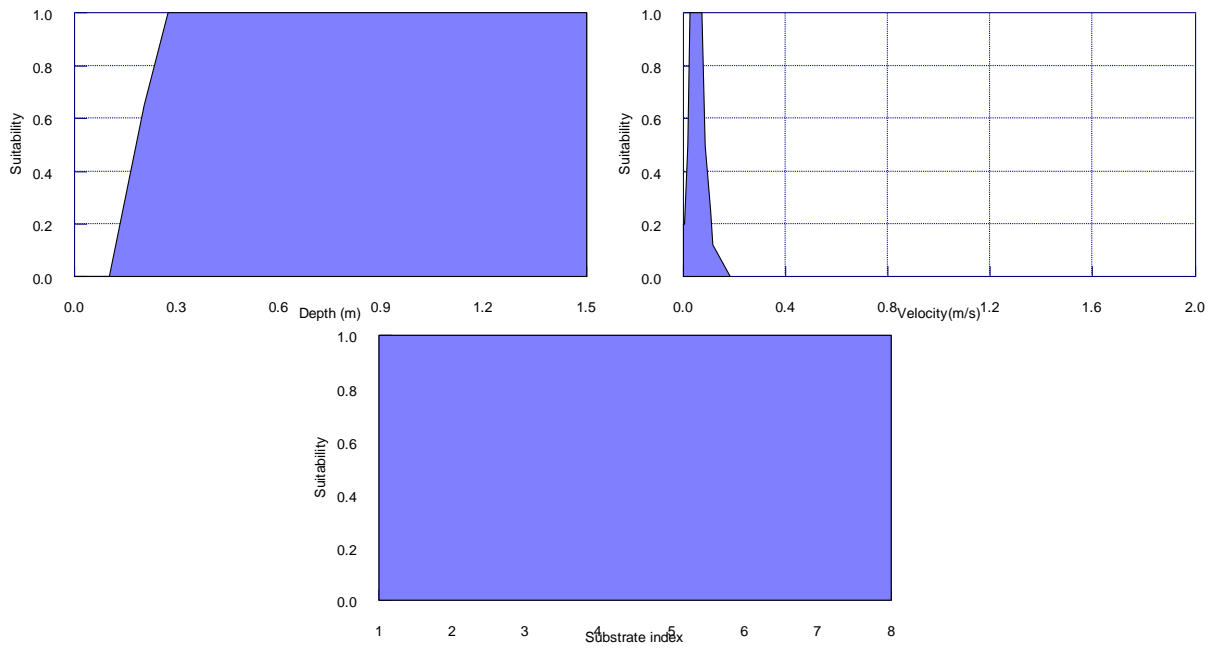
Common bully



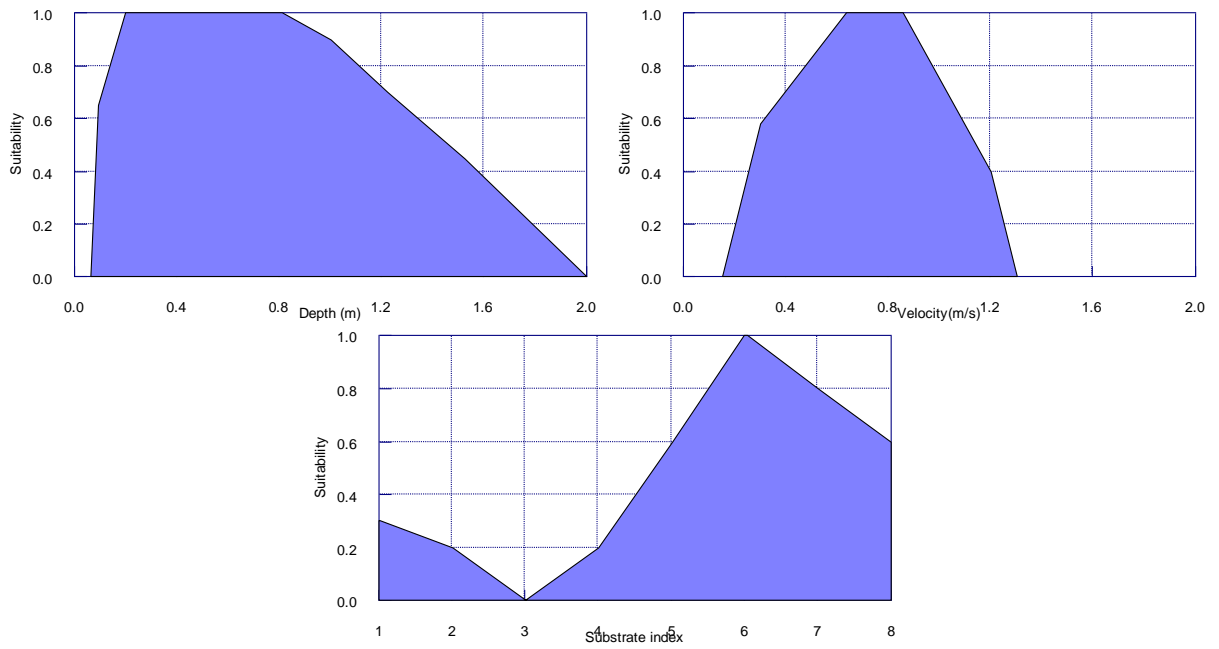
Crans bully (Jowett & Richardson 2008)



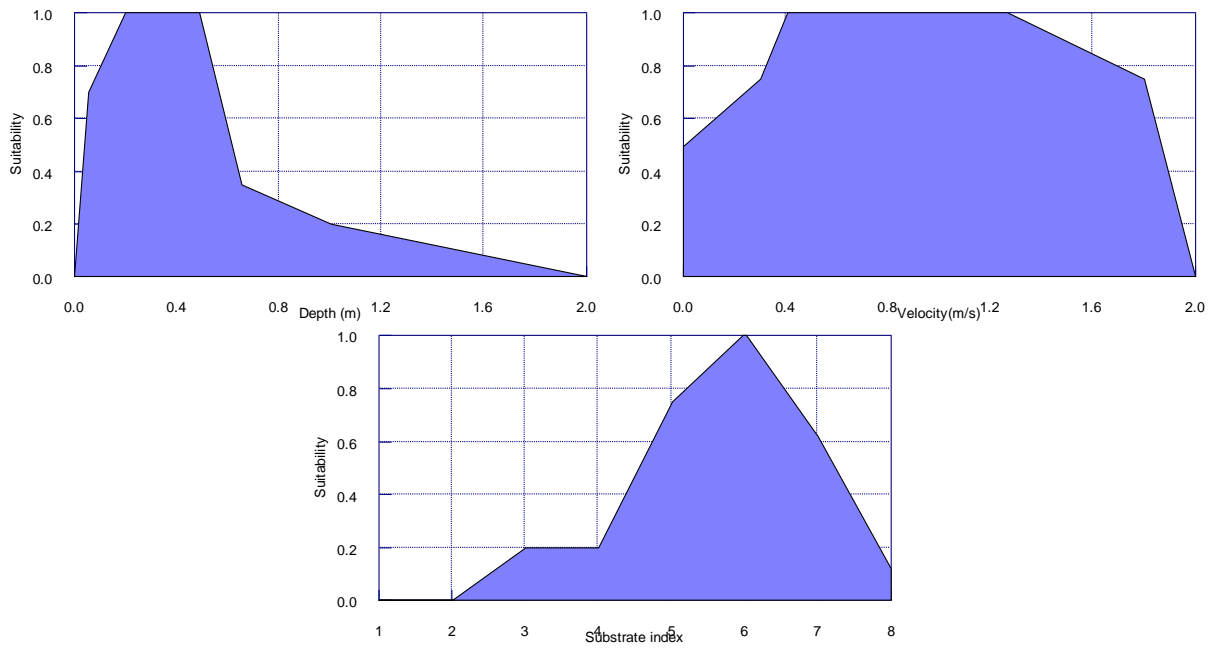
Inanga feeding



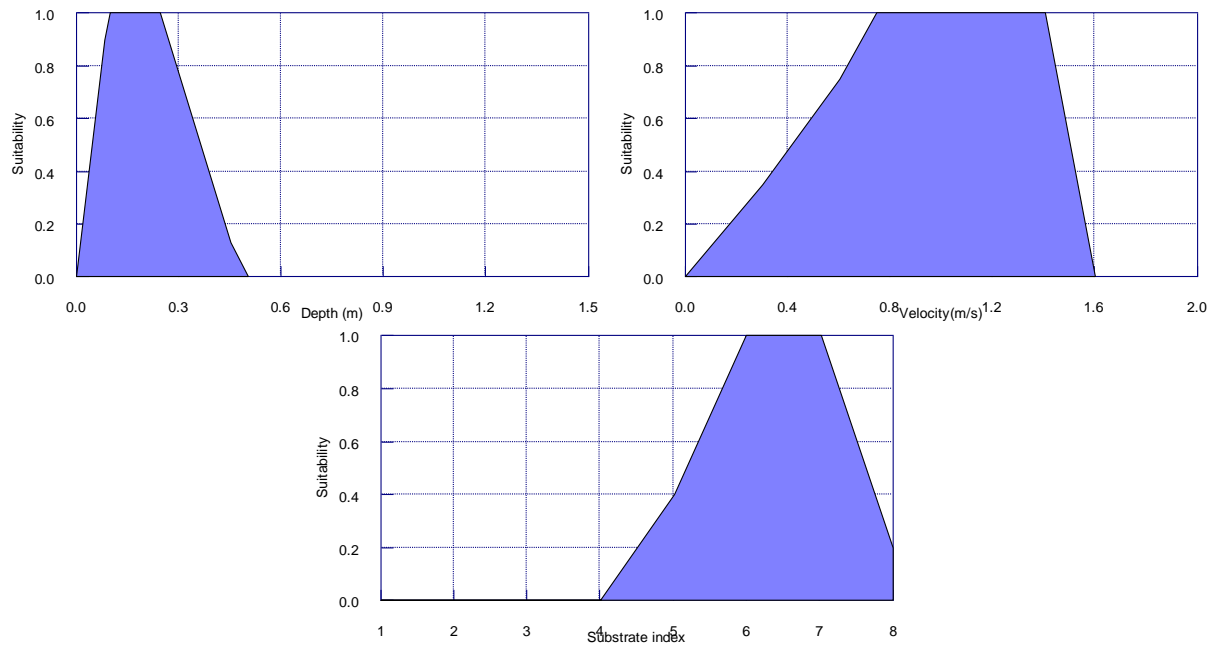
Food producing (Waters 1976)



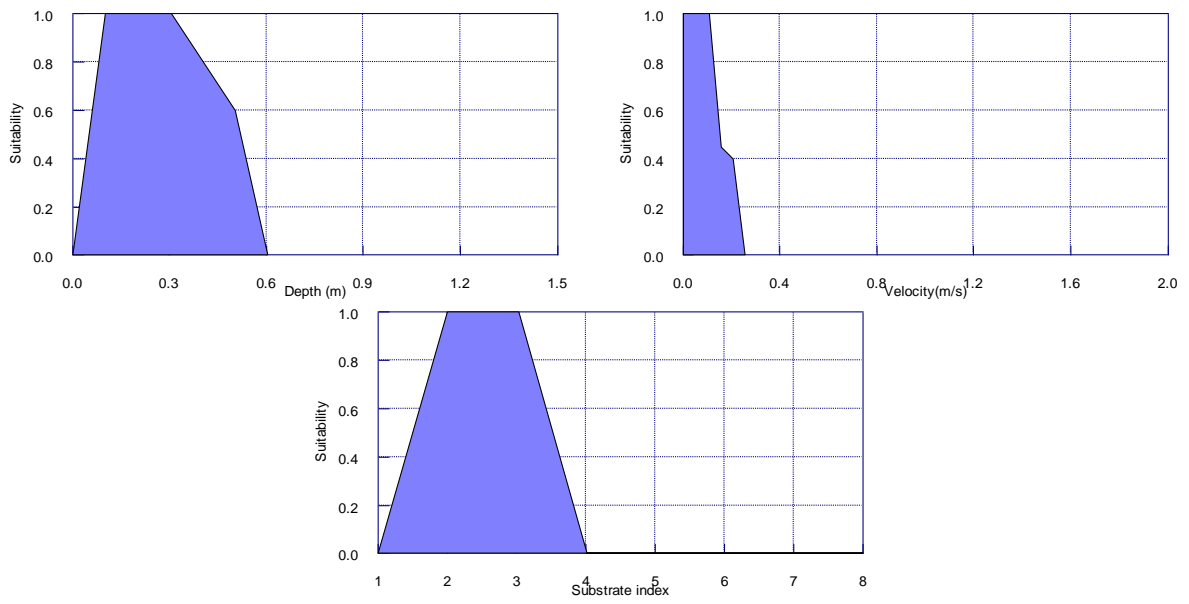
Deleatidium (mayfly)



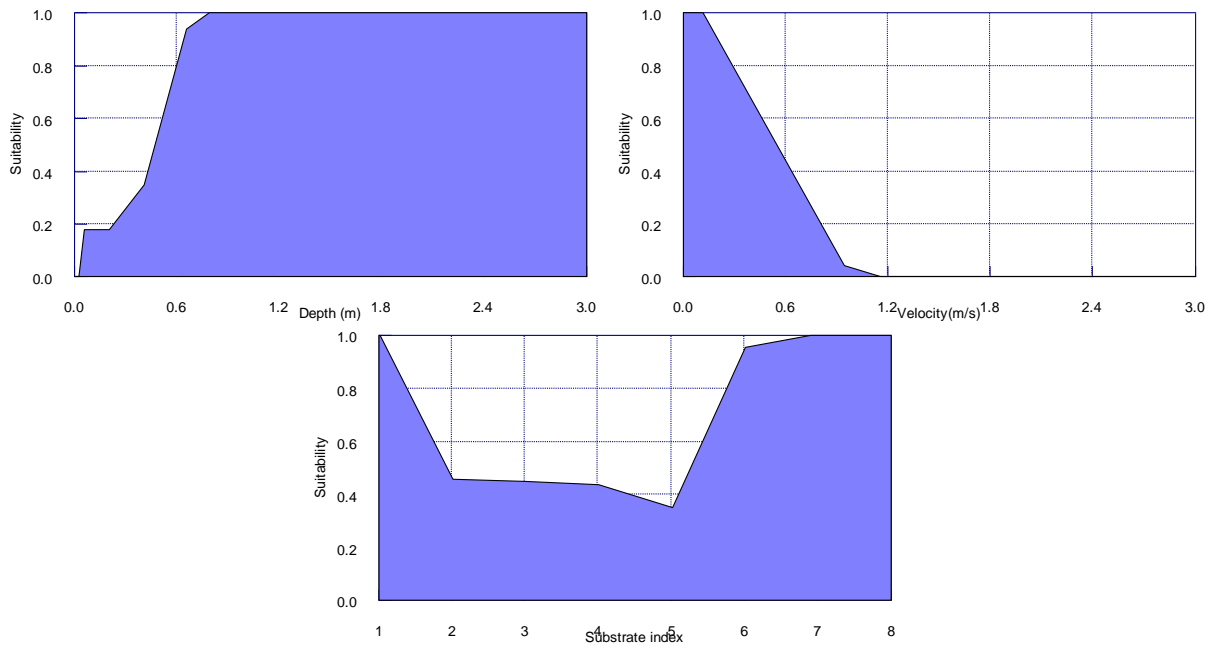
Koaro (Jowett & Richardson 2008)



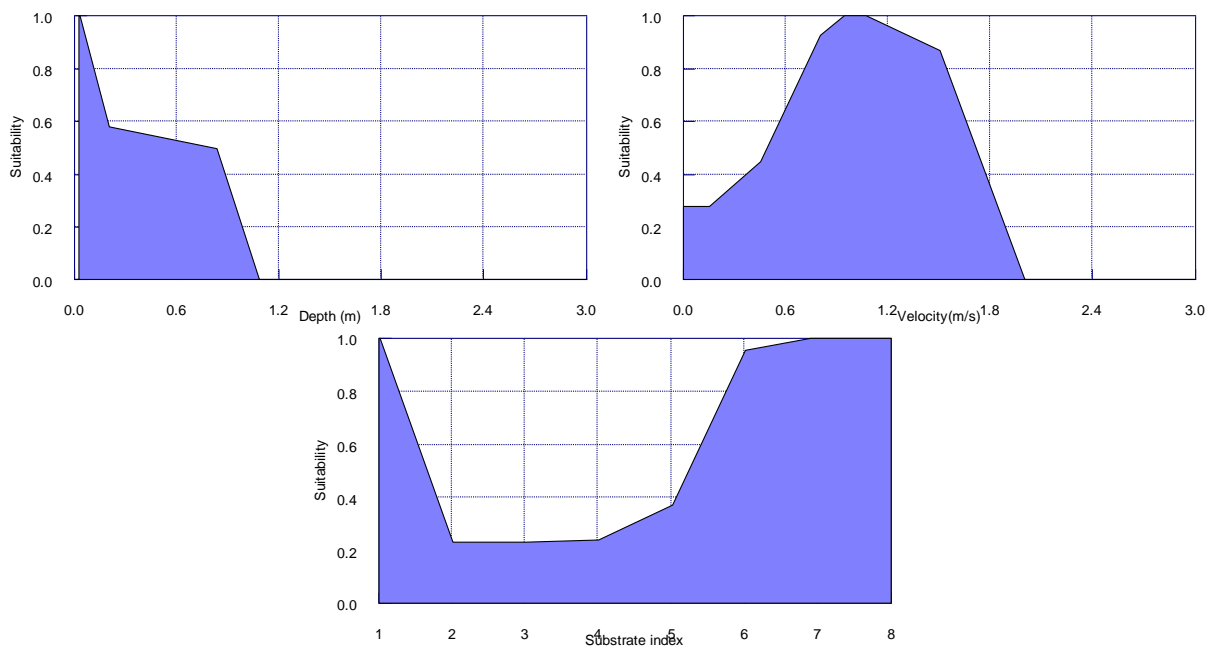
Lamprey (Jowett & Richardson 2008)



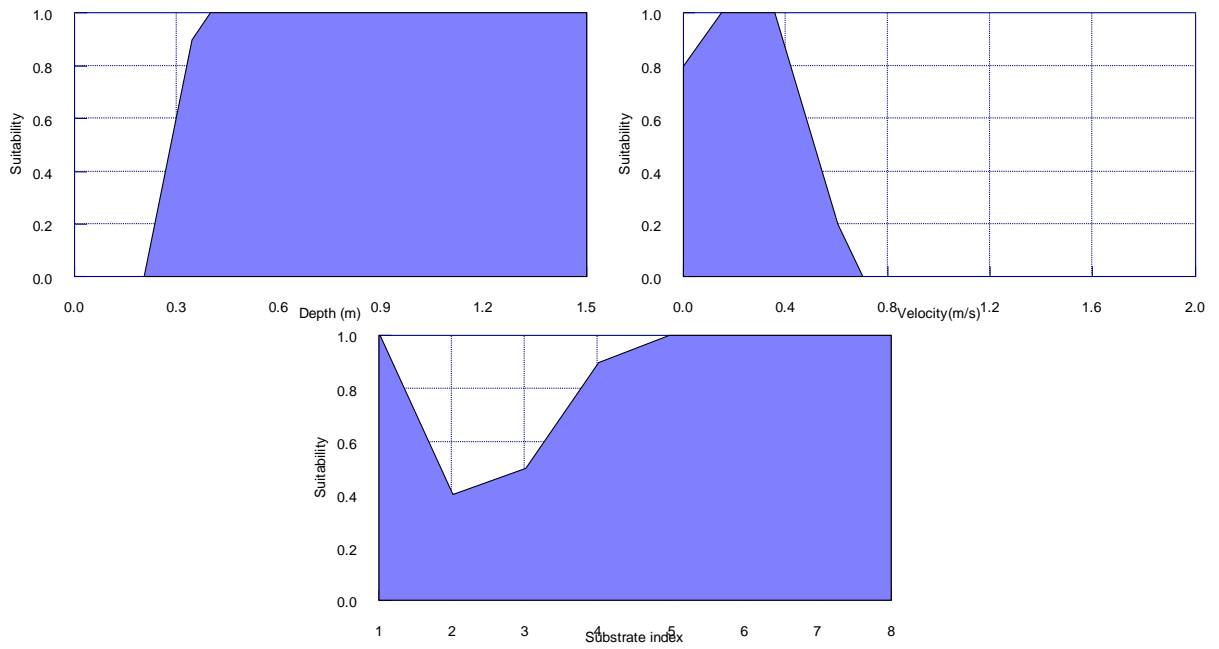
Longfin Eel > 300 mm (Jellyman)



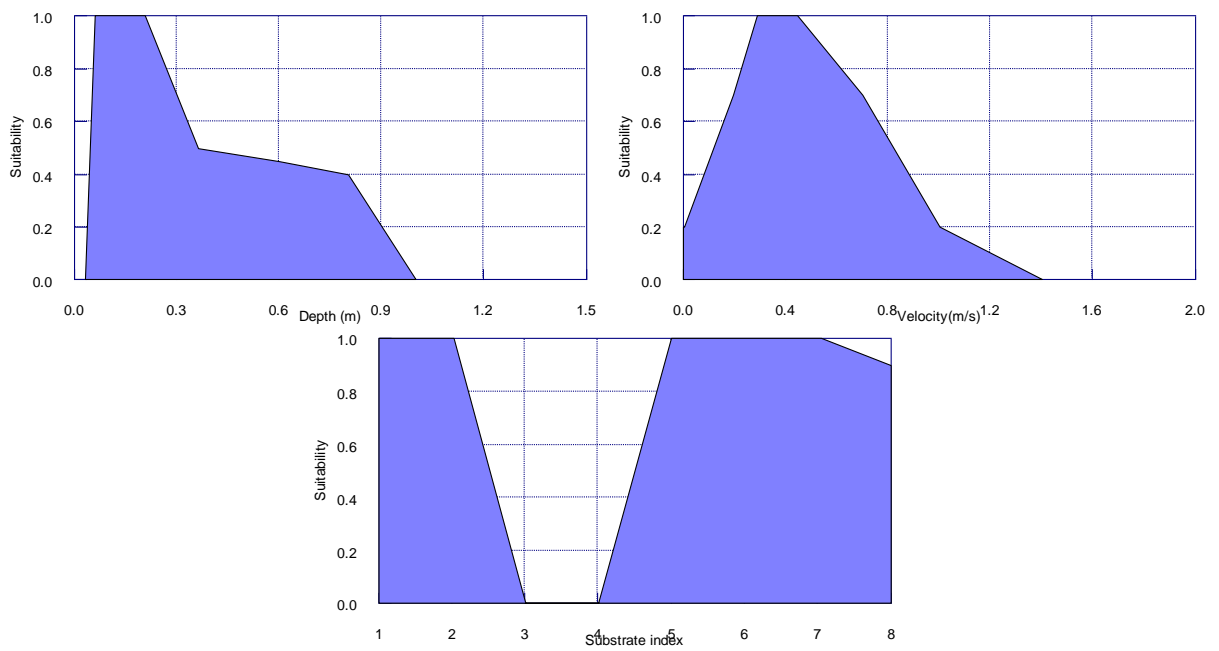
Longfin Eel < 300 mm (Jellyman)



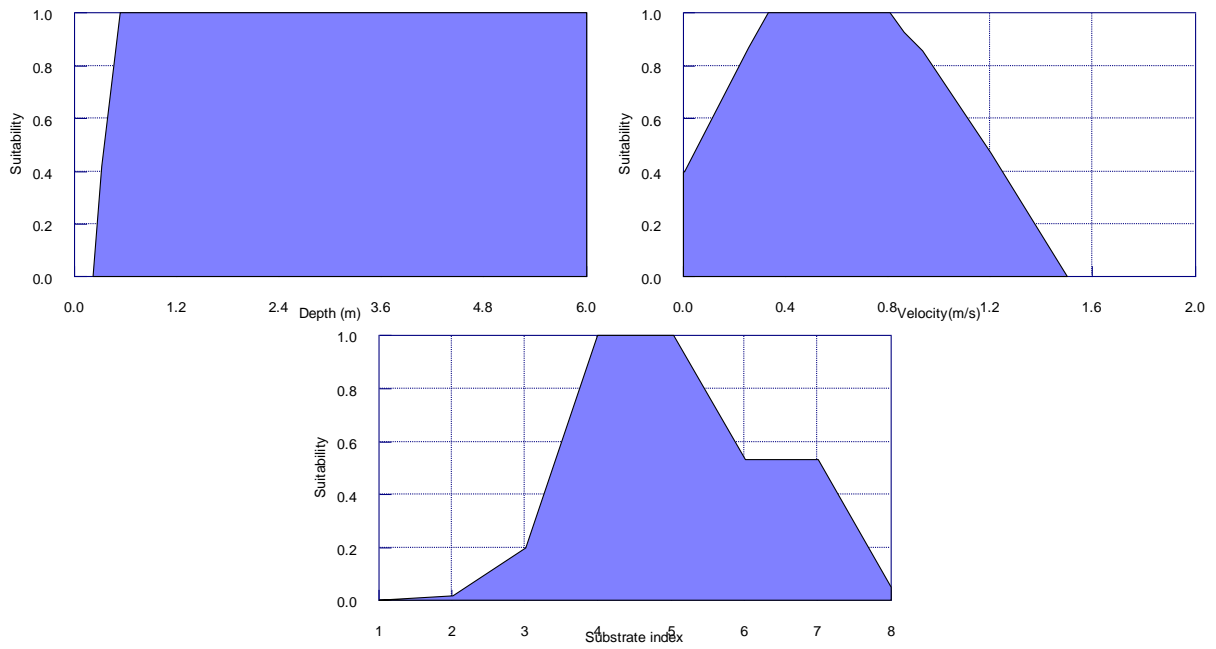
Longfin eel > 300mm (Jowett & Richardson 2008)



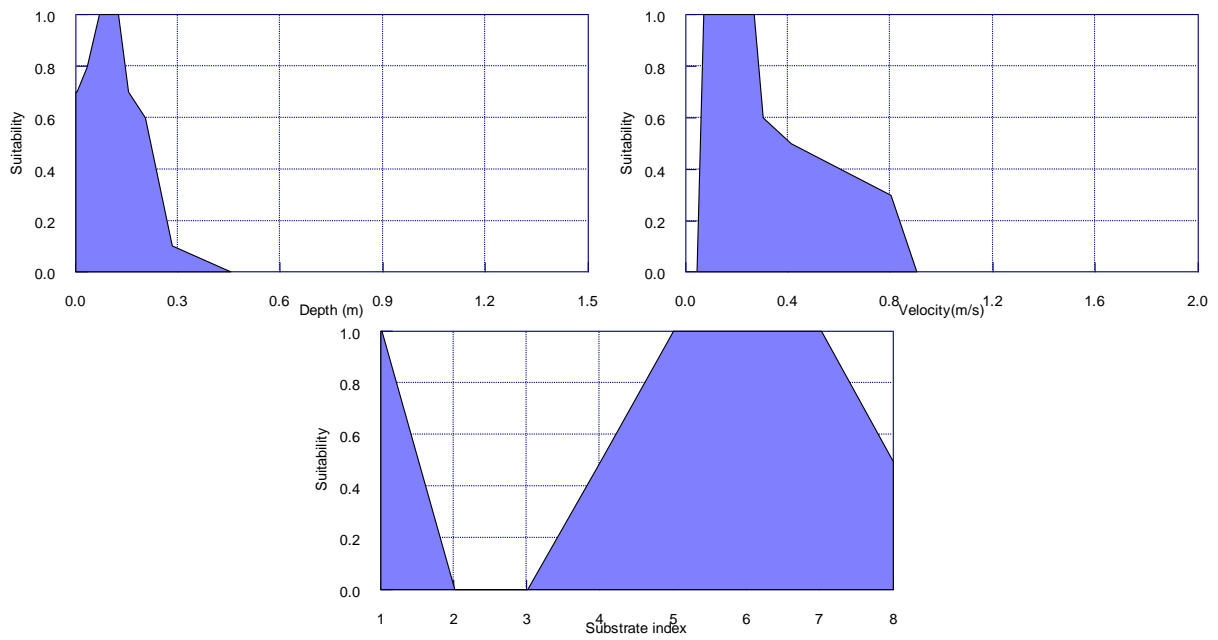
Longfin eel < 300mm (Jowett & Richardson 2008)



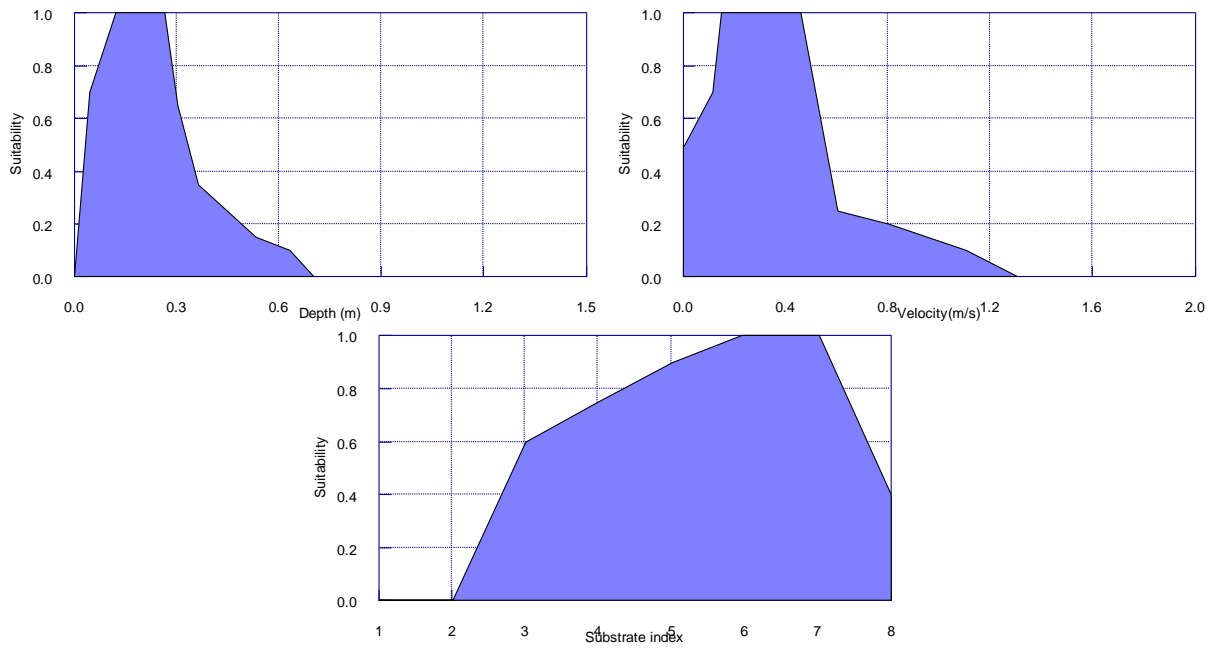
Rainbow trout (> 20cm) (Hawkes Bay Provisional)



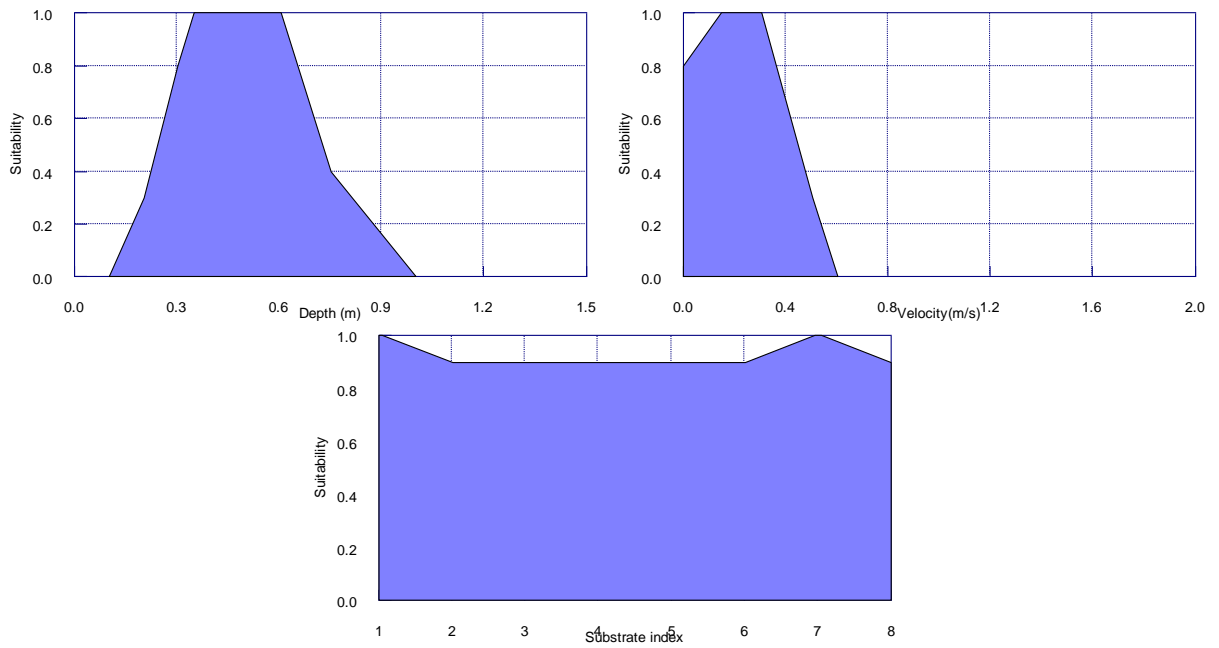
Rainbow trout (< 100 mm) (Jowett & Richardson 2008)



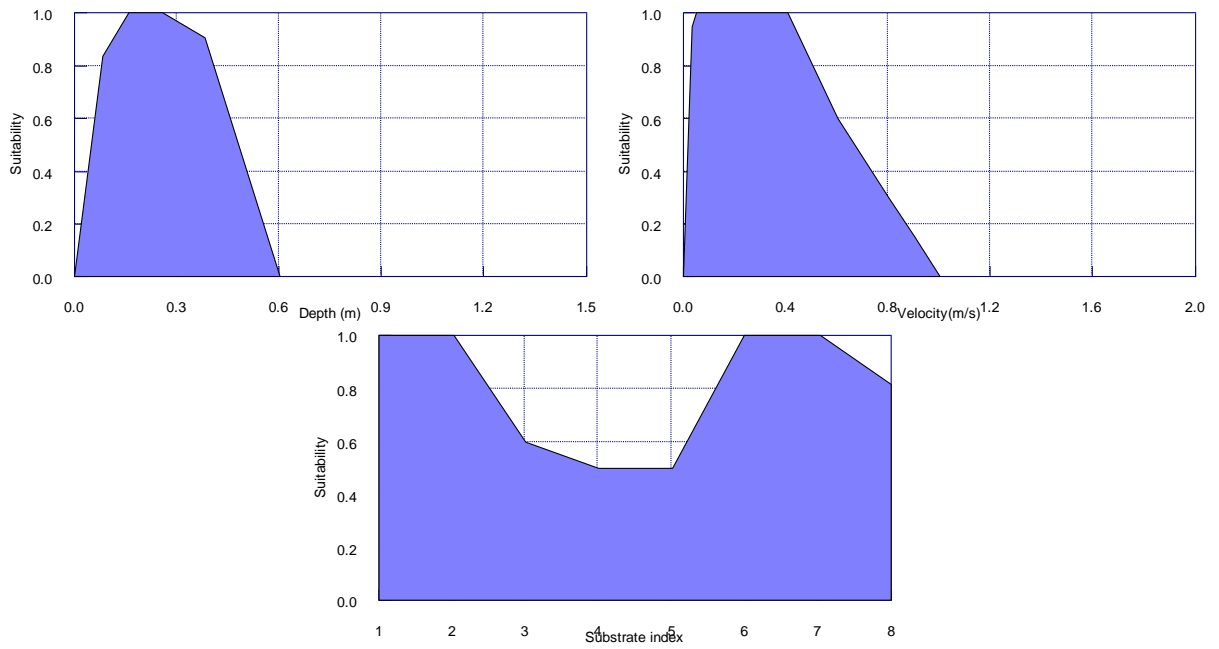
Redfin bully (Jowett & Richardson 2008)



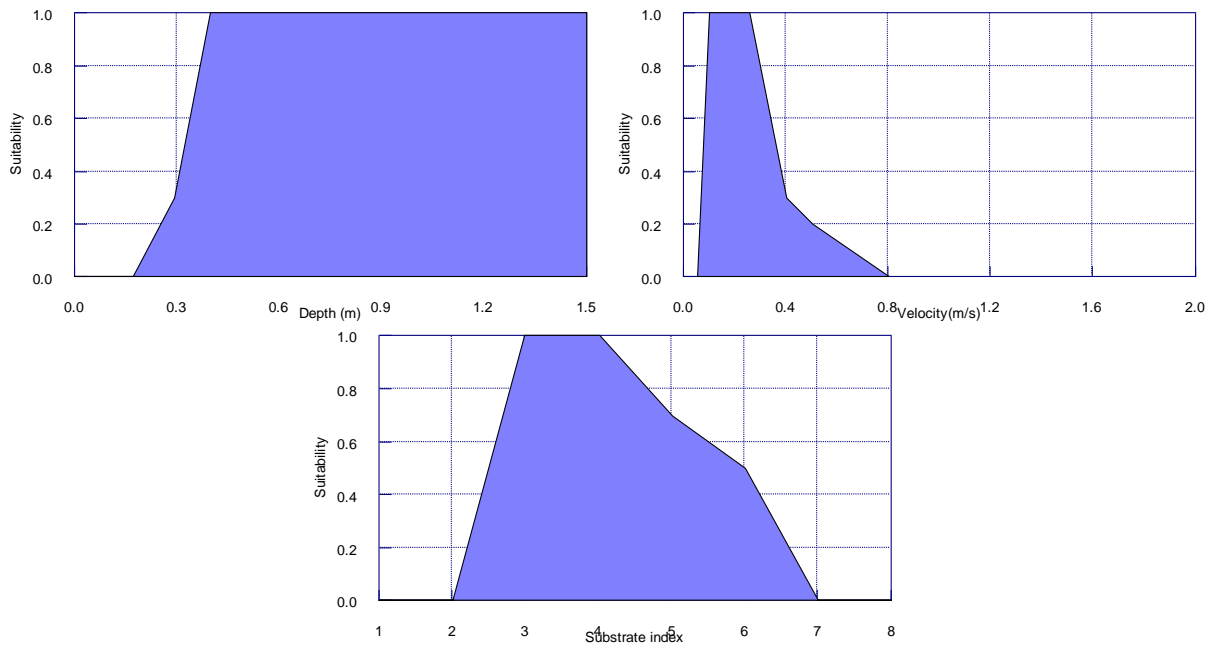
Shortfin eel > 300mm (Jowett & Richardson 2008)



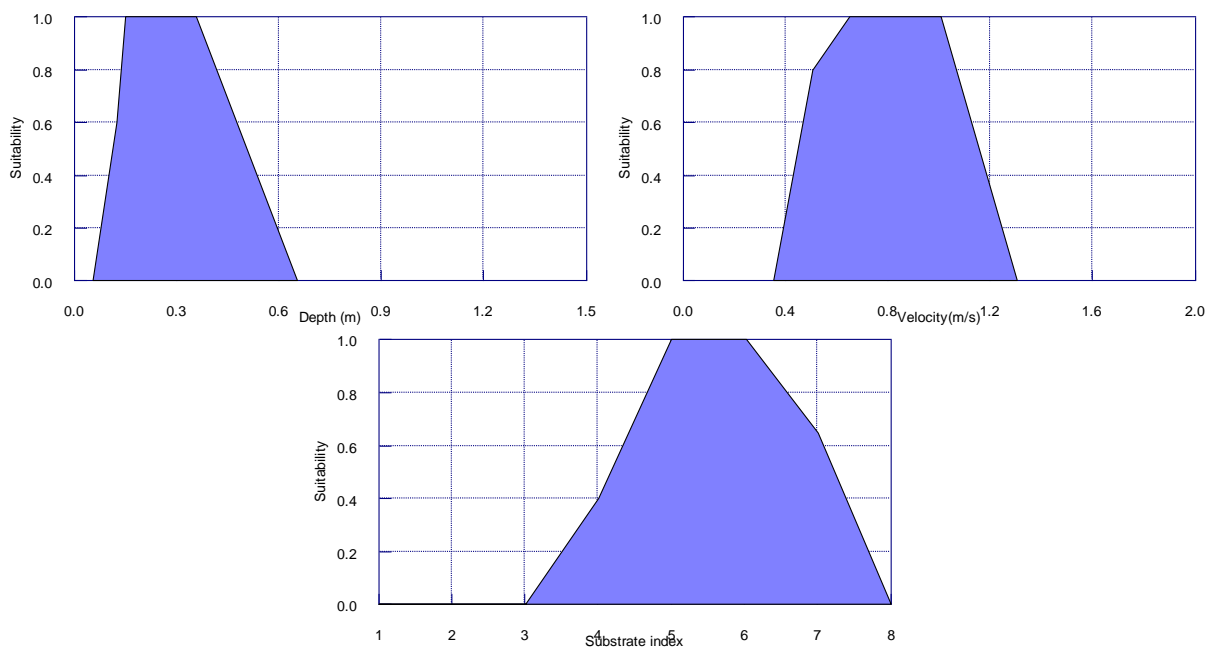
Shortfin eel < 300mm (Jowett & Richardson 2008)



Smelt (Jowett & Richardson 2008)



Torrentfish (Jowett & Richardson 2008)



Upland bully (Jowett & Richardson 2008)

