Environment Waikato Technical Report 2007/11

The Freshwater Fish Spawning and Migration Calendar Report

www.ew.govt.nz
ISSN 1172-4005 (Print)
ISSN 1177-9284 (Online)

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April 2007

Document #: 1105573

Acknowledgement

This report is the result of numerous peoples input. A big thank you goes out to David Speirs, Kevin Collier, Michelle Gibbs and Viv Smith from Environment Waikato. Glenn Maclean, Chris Annandale, Michael Lake and Sjaan Charteris from the Department of Conservation. David Rowe and Jacques Boubee from NIWA and Ben Wilson from Fish and Game for their input and comments on the calendar.

Environment Waikato staff members Kelly Taylor produced the calendar tables, Howard Ettema produced the maps of indigenous and trout habitat, and Janice Stokes corrected the layout and formatting.

Thank you to Environment Bay of Plenty for allowing the use of their freshwater fish calendar especially the text to be the basis for this calendar.

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Executive Summary

- The spawning periods of various fish species in the Environment Waikato region are shown.
- Migration definitions and migration periods for native fish and trout in the Environment Waikato region are shown.
- This report outlines how to use the freshwater fish migration and spawning calendar and its limitations.
- Outlines potential effects of instream works on fish migration and spawning.
- Outlines upstream migration rates of various fish species.
- The instream works restrictions align well with the spawning and migration times of the species they are designed to protect.

1 Introduction

The purpose of this calendar is to enable people (i.e. property developers, contractors, river engineers, farmers, resource managers, etc) to identify if a certain activity may adversely affect the life cycle of native fish and trout present in a stream or river in the Environment Waikato region. Knowledge of what native fish are migrating through or potentially spawning in an area and when is important so that human impacts on those native fish species can be minimised. This calendar is intended as a guide and there is no substitute for an in depth study of a specific site or sites.

If works are to be carried out in or near a stream or river the potential adverse effects of these on the instream community need to be considered. A development in which the streambed or bankside vegetation is to be disturbed needs to determine what the adverse effects of this activity will be. If the affects are physical disturbance of the stream bed or riparian areas then fish that spawn in that reach could be adversely affected. The activity should then to be timed when the important fish present are not spawning and the eggs have developed and hatched, therefore, mitigating any potential adverse effects on those species. For instance, if a development involves the vegetation disturbance of a lowland river bank in the tidal zone during February to July then it is likely that inanga spawning grounds would be affected, but at other times of year this activity would be more suitable.

The majority of New Zealand's native freshwater fish are 'diadromous' or 'sea run', meaning they migrate between freshwater and saltwater during some part of their life cycle (McDowall 1990). This can vary with some species living in freshwater but migrating to spawn at sea (catadromous), while others spend the majority of their lives at sea then migrate upstream from the sea to spawn in freshwater (anadromous). There are also others that spend part of their life at sea, but this marine stage is not directly related to spawning (amphidromous). Usually this is due to larvae being carried out to sea by river flow, this is then followed by an upstream migration of juveniles back into freshwater a few months later where the fish will develop into adults and spawn (McDowall 1990; 1995).

The migration calendar (Fig. 1 and Appendix 4), covers the migration of juveniles to adult habitats (Wilding et al. 2000) and migration of spawning adults to spawning habitat. Times are also shown for larvae being passively carried out to sea (Fig. 3). Migration activity will often occur throughout the whole year (Wilding et al. 2000; G Maclean *pers. comm.*); however, the majority of migration activity will occur during certain periods outlined in the calendar.

The migration times shown in the calendar relate to coastal streams and river mouths (except for the Taupo portion of the calendar) and it will take some time for fish to migrate upstream to sites further inland. This needs to be taken into account; for instance, glass eels (juvenile eel marine stage) enter estuaries and coastal streams in the times outlined on the calendar. Then there is a period of development in estuaries from glass eels to elver (juvenile eel freshwater stage), before the elver migrate upstream.

Spawning and migration events are often related to climatic conditions like rainfall / river flow and tides (Wilding et al. 2000). Therefore, peak spawning and migration periods vary from year to year depending on the occurrence of these phenomena. It is expected that this variation will be within the ranges given in the calendar, but there may be exceptions in some years and for less well studied species.

Some native fish are non-migratory (non-diadromous) and do not disperse far from their natal reaches let alone to sea. These fish spawn in suitable locations near their natural habitat. These fish were not included in the migration calendar as they do not undertake migrations of any significance, but are included in the spawning calendar. If

these species are found to be present at a site, it is likely that they will spawn in the vicinity of their home range within the dates outlined in the calendar.

A section of the calendar is included for Lake Taupo and its tributaries. The reason for this is that the lake effectively takes the place of the sea for diadromous species. Diadromous species such as koaro and smelt can migrate between the lake and streams for various parts of their life cycle, as do trout.

Table 1: Diadromy status of fish species included in the fish migration and spawning calendar

Relevant fish species present in the region		diadromous / non-diadromous
Lamprey	*Geotria australis*	anadromous
Longfinned eel	*Anguilla dieffenbachii*	catadromous
Shortfinned eel	*Anguilla australis*	catadromous
Common smelt	*Retropinna retropinna*	anadromous
Inanga	*Galaxias maculatus*	'marginally' catadromous [1]
Giant kokopu	*Galaxias argenteus*	amphidromous
Banded kokopu	*Galaxias fasciatus*	amphidromous
Shortjawed kokopu	*Galaxias postvectis*	amphidromous
Koaro	*Galaxias brevipinnis*	amphidromous
Torrentfish	*Cheimarrichthys fosteri*	amphidromous
Red finned bully	*Gobiomorphus huttoni*	amphidromous
Common bully	*Gobiomorphus cotidianus*	amphidromous
Bluegilled bully	*Gobiomorphus hubbsi*	amphidromous
Giant bully	*Gobiomorphus gobioides*	amphidromous
Cran's bully	*Gobiomorphus breviceps*	non-diadromous
Upland bully	*Gobiomorphus basalis*	non-diadromous
Black mudfish	*Neochanna diversus*	non-diadromous
Dwarf galaxias	*Galaxias divergens*	non-diadromous
Rainbow trout	*Oncorhynchus mykiss*	non-diadromous
Brown trout	*Salmo trutta*	non-diadromous and amphidromous[2]

[1] Spawns in the tidal zone in or near estuaries so is considered marginally catadromous, but not entirely catadromous (McDowall 1990).
[2] The majority are non-diadromous, but some brown trout are known to be 'sea run' spending time at sea and returning to different river systems.

Knowledge of what fish are present in the reach is not enough, you must be aware of the life cycles and spawning times of the various species to affectively assess potential adverse affects on a fish community.

If works are to be carried out in, or near, a waterway the potential adverse affects of the work needs to be considered. Will the removal of plants reduce fish cover, raise water temperatures or cause erosion? Will excessive sedimentation occur affecting fish food, migration paths and developing fish eggs? Will structures cause changes in velocity or be perched with overhangs that fish cannot move upstream past? Will the stream bed be disturbed affecting habitat or spawning grounds? Will the pool / riffle sequences be adversely affected?

Before the calendar can be used fish species present in the reach where the works are proposed to take place must be identified. There are various methods to determine this and they are discussed later in section 3 of this report.

Once the fish species present are identified the calendar can be used to determine the important times of year for carrying out their life cycle. An assessment can then be made on the likely impacts on the fish species present. Work should then be planned so that it is undertaken at times that are likely to have the least impact on fish reproductive cycles. Precedence should be given to threatened species and "significant" populations of fish.

2 Methods

A review of the available literature was made and the migration times (both upstream and downstream) were noted along with periods of spawning activity.

From the literature the peak periods of fish migration and spawning activity were included in the calendar (Fig. 1, 2, 3 and Appendix 4, marked in dark blue). Where appropriate, literature that also reported less intense activity or the entire range over which activity took place was included in the calendar (the light shade of blue). Light blue shading was also used instead of dark blue for species that the spawning or migration is not extensively studied or well known.

Where more than one article, book, or report covered the migration or spawning activity of a particular fish species, priority was given to data obtained from the Environment Waikato (EW) region. The peak and range given in the local study were used. If data from studies outside of the EW region differed from the local study the timing was incorporated into the calendar if necessary. When the peak or main period of activity of a study from outside the region did not overlap with the local study the peak in the calendar was extended if appropriate. Although, generally the period was added to the calendar as the range, to extend the possible period of migration or spawning activity. Where the range of activity did not match up with a local study this would be added to the calendar's range only if deemed appropriate. If no data was available from the EW region then any available data was used.

A draft of the calendar was then sent to various fish biologists in the Waikato region for their comments on the migration and spawning timings. Their comments and recommendations based on local knowledge were incorporated into the calendar where appropriate.

The conservation status of the native fish represented in the calendar was obtained from the New Zealand Threat Classification System lists (Hitchmough 2002) from the Department of Conservation (DoC) website. The conservation status of trout, the only introduced fish included in the calendar, is given as 'sportsfish' rather than 'not threatened' to reflect that it is an introduced fish, but still recognised as an important sports fish.

The description of the spawning habitat site is derived from the source referenced as a footnote to the calendar (the spawning period reference) although in some cases spawning habitat will also be mentioned in the migration reference or in McDowall (1990).

The light orange shading outlines the period at which no increase is allowed in the suspended sediment load caused by instream works as defined in Section 4.2.21 of the Proposed Waikato Regional Plan (Appendix 1. Suspended Solids Discharge Standards for Permitted Activity Rules in Chapters 4.2 and 4.3). The proposed Waikato Regional Plan has restrictions for activities in water bodies classed as Significant Indigenous Fisheries and Fish Habitat Class waters during August to December inclusive and also for Significant Trout Fisheries and Trout Habitat class waters during May to September

inclusive. Suspended solids standards were developed to enable migration of juvenile native fish upstream and to allow for successful trout spawning and egg development. The time period covered by this section of the plan is most appropriate to protect the majority of migrating juvenile native fish and trout spawning activity in this region.

The location of Significant Indigenous Fisheries and Significant Trout Fisheries are outlined in appendix 2 and 3. They are also available on the EW internal GIS system "Smartmaps". Works cannot be carried out that will cause an increase of suspended sediment above ambient levels during the period outlined in light orange on the calendar.

3 How to use the Calendar

The first step is to find out what fish species are present in the area and whether these fish spawn in the reach affected by the works. Use the calendar to find out when these spawning activities occur in the reach of interest. Determine how important these species are (are they threatened or protected? Do they provide a food resource? Are they classed as significant?) and if the proposed activity might affect any of the fish life cycle recruitment activities? If so, time the proposed activity to minimise any potential for adverse effects on fish spawning and migration patterns.

What fish species are present in the reach where the works are to take place? There are various methods to undertake a fish survey ranging from, electro-fishing, sweep or seine netting and setting fish traps to spotlighting at night. Broader scale information can also be found on the New Zealand Freshwater Fish Database (NIWA) www.niwascience.co.nz/services/nzffd/ or the EW website where there is various information including a fish presence predictive model and a report on fish distributions www.ew.govt.nz/publications/technicalreports/tr0111.htm.

Fish identification guides are available in McDowall (1990; 2000) and Ling (2001) the NIWA www.niwascience.co.nz/rc/freshwater/fishatlas/key and DoC www.doc.govt.nz/Explore/Hunting-and-Fishing/Whitebait-identification.asp websites. Be aware a permit may be needed from DoC for low impact collecting and research of fish species.

The reach of interest may not have habitat suitable to some species; however, a survey of different habitat types upstream may show other migratory species are present and therefore must pass through the reach of interest at some stage during their life cycle.

Use the calendar to estimate when spawning or migration through the reach of interest occurs.
For the species you have determined are present in the affected reach find the common name in the species list. Determine the conservation status (T = threatened, NT = not threatened, S = sportsfish) of the fish species. Also note that just because a species is not classed as nationally threatened does not mean that isn't locally important. Further reading should be undertaken on the fish present to determine their importance to the local ecosystem.

On the migration calendar (Figure 1), the migration direction column shows mostly upstream migration, but there are important downstream migrations of adult eels, inanga, lamprey and trout. For a calendar of both upstream and downstream movement timings see Figure 3. The life stage column details whether the fish are adult, juvenile or larvae at the time of migration. Glass eels are the marine juvenile stage of eels, the form the juveniles take for their migration from the spawning grounds in the ocean back to freshwater. Elver is the name given to juvenile eels that have developed pigmentation in freshwater (McDowall 1990). The calendar then represents the four seasons and abbreviations of each of the months to show when the migrations

occur. Remember that these timings are for locations close to the coast so caution needs to be used when estimating migration times further from the coast.

The spawning calendar gives a brief description of the habitat that the various fish species use to spawn instead of showing migration direction and life stage at the time of migration.

The light orange shading outlines the time of year when no increase in suspended solids above ambient levels is allowed effectively eliminating instream works. This applies to waterways classed as significant indigenous fisheries or fish habitat class waters identified in the Waikato Regional Plan so that upstream native fish migration is not impacted. There is a different time period for waterways classed as significant trout fisheries and trout habitat class waters to protect trout spawning activity and egg development.

Observe on the calendar when the migrations or spawning events occur for the fish species found to be present. If there are gaps when no life cycle aspects for the species present are affected (taking into account the time taken to migrate upstream from the coast), then that is the most appropriate time to undertake the works to have minimal impact on the fish community.

How do you assess the importance of this fish community? Some species that are locally abundant are uncommon on a national scale and vice versa. In terms of this calendar the importance of individual fish species has been derived from the Department of Conservation threat classification system list (Hitchmough 2002); however, this alludes to the importance of a particular species, but not necessarily the fish community present. Some fish species are considered to indicate healthy ecosystems and others may be found in impacted waterways. Obviously precedence should be given to threatened species and significant populations of fish.

Key

Peak Range Instream works restriction for peak sensitivity period of indigenous fish migration under Regional Plan section 4.2.21.

T = threatened NT = not threatened S= sportsfish

Migration – Environment Waikato region

Species	Status	Direction	Life stage	Summer		Autumn			Winter			Spring			Summer
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Lamprey [1, 22]	T	upstream	adult												
Long and shortfinned eel [1, 2]	T/NT	to estuary	glass eel												
Long and shortfinned eel [22]	T/NT	upstream	juvenile												
Common Smelt (sea run) [3]	NT	upstream	juvenile												
Inanga [3, 5, 23]	NT	upstream	juvenile												
Giant Kokopu [3, 1, 22, 4]	T	upstream	juvenile												
Banded Kokopu [3, 1, 22]	NT	upstream	juvenile												
Shortjawed Kokopu [5]	T	upstream	juvenile												
Koaro [6, 1]	NT	upstream	juvenile												
Torrentfish [22]	NT	upstream	juvenile												
Redfinned Bully [1, 22]	NT	upstream	juvenile												
Common Bully [1, 22]	NT	upstream	juvenile												
Bluegilled Bully [1]	NT	upstream	juvenile												
Giant Bully [1]	NT	upstream	juvenile												
Lake Taupo and tributaries															
Rainbow Trout (North Taupo) [7, 5]	S	upstream	adult												
Rainbow Trout (South Taupo) [7, 8, 9, 5]	S	upstream	adult												
Brown Trout (Taupo) [7]	S	upstream	adult												
Juvenile Trout (Taupo) [7]	S	down	juvenile												
Koaro (Taupo) [8, 10]	NT	up/down	adult												
Koaro (Taupo/Rotoaira) [10]	NT	down	larvae												
Koaro (Taupo) [10]	NT	upstream	juvenile												

1 McDowall 1995
2 Jellyman et al 1999
3 Stancliff et al 1988
4 McDowall and Kelly 1999
5 McDowall 1990
6 Wilding et al 2000 (and references therein).
7 G. Maclean (pers. comm.)
8 Rowe and Graynoth (MfE) 2002
9 Dedual and Jowett 1999
10 Rowe et al 2002
11 Ward et al 2005 (and references therein)
12 Mitchell and Penlington 1982
13 Charteris et al 2003
14 Allibone and Caskey 2000
15 Scrimgeour and Eldon 1989
16 Jellyman et al 2000
17 Staples 1975 (peak)
18 McDowall and Eldon 1997 (Captive breeding, range)
19 Barrier and Hicks 1994
20 Thompson 1987
21 Hopkins 1971
22 Boubee et al 2000
23 Chris Annandale (pers. comm.)
24 Ben Wilson (pers. comm)

Figure 1: Fish migration calendar for the Environment Waikato (EW) region showing the peak and range periods for migration activity, conservation status, migration direction, life stage at time of migration and instream works restriction period relating to indigenous fish habitat waterways under the EW regional plan.

Key

Peak Range

Instream works restriction for peak sensitivity period of trout spawning under Regional Plan section 4.2.21.

T = threatened
NT = not threatened
S = sportsfish

Spawning Habits – Environment Waikato region

Species	Status	Spawning habitat	Summer		Autumn			Winter			Spring			Summer
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Lamprey [5]	T	upper catchment (unconfirmed)												
Longfinned eel	T	Pacific ocean												
Shortfinned eel	NT	Pacific ocean												
Common Smelt (sea run) [3, 5, 11]	NT	sand banks of rivers												
Inanga [6]	NT	tidal esturary edge vegetation												
Giant Kokopu [4, 6]	T	mid-low reaches (unconfirmed)												
Banded Kokopu [12, 6, 13]	NT	stream margins at flood among vegetation and debris												
Shortjawed Kokopu [13]	T	stream bank rocks, debris and vegetation during flood												
Koaro [14, 13, 5]	NT	cobbles at stream edge												
Torrentfish [15, 1]	NT	lowland rivers/estuaries												
Redfinned Bully [1]	NT	flowing water under rocks												
Common Bully [5, 1]	NT	under firm flat surfaces												
Bluegilled Bully [5, 1]	NT	similar to other bullies												
Giant Bully [16]	NT	estuaries (unconfirmed)												
Cran's Bully [5]	NT	under large rocks												
Upland Bully [17, 18]	NT	under large flat rocks												
Black Mudfish [19, 20]	T	wetlands												
Dwarf Galaxias [21, 5]	T	small stones instreams												
Rainbow Trout (Waikato)[5, 24]	S	gravel bed in flowing water												
Brown Trout (Waikato)[5, 24]	S	gravel bed in flowing water												
Lake Taupo and tributaries														
Rainbow Trout (North Taupo)[17, 8, 7]	S	gravel bed in flowing water												
Rainbow Trout (South Taupo)[7, 8]	S	gravel bed in flowing water												
Brown Trout (Taupo)[7, 5, 8]	S	gravel bed in flowing water												
Common Smelt [5, 11]	NT	sandy lakeshore/slow flowing streams												
Koaro (Taupo)[8]	NT	cobbles at stream edge												
Common Bully [8, 7]	NT	hard substrates												

1 McDowall 1995
2 Jellyman et al 1999
3 Stancliff et al 1988
4 McDowall and Kelly 1999
5 McDowall 1990
6 Wilding et al 2000 (and references therein).
7 G. Maclean (pers. comm.)
8 Rowe and Graynoth (MfE) 2002
9 Dedual and Jowett 1999
10 Rowe et al 2002
11 Ward et al 2005 (and references therein)
12 Mitchell and Penlington 1982
13 Charteris et al 2003
14 Allibone and Caskey 2000
15 Scrimgeour and Eldon 1989
16 Jellyman et al 2000
17 Staples 1975 (peak)
18 McDowall and Eldon 1997 (Captive breeding, range)
19 Barrier and Hicks 1994
20 Thompson 1987
21 Hopkins 1971
22 Boubee et al 2000
23 Chris Annandale (pers. comm.)
24 Ben Wilson (pers. comm)

Figure 2: Fish spawning calendar for the Environment Waikato (EW) region showing the peak and range periods of spawning activity, conservation status spawning habitat and instream works restriction period relating to trout habitat waterways under the EW regional plan.

Key

Peak ■ Range ■ Instream works restriction for peak sensitivity period of indigenous fish migration under Regional Plan section 4.2.21

Migration Environment Waikato region

Species	Conservation status	Direction	Life stage	Summer Jan	Feb	Autumn Mar	Apr	May	Winter Jun	Jul	Aug	Spring Sept	Oct	Nov	Summer Dec
Lamprey [1, 22]	threatened	upstream	adult						■	■	■	■			
[1, 22]		down	juvenile				■	■	■	■	■				
Longfinned eel [22]	threatened	to estuary	glass eel							■	■	■	■	■	
[2, 1, 22]		upstream	juvenile	■	■	■	■							■	■
[1]		down	adult				■	■							
Shortfinned eel [22]	not threatened	to estuary	glass eel								■	■	■	■	■
[2, 1]		upstream	juvenile	■	■	■	■							■	■
[1]		down	adult		■	■	■								
Common Smelt [3]	not threatened	upstream	juvenile								■	■	■	■	
[1]		down	larvae			■	■	■	■						
Inanga [5, 23]	not threatened	upstream	juvenile					■	■	■	■	■	■	■	
[1]		down	larvae	■	■	■	■	■	■			■	■	■	■
Giant Kokopu [3, 1, 4, 22]	threatened	upstream	juvenile										■	■	■
[1, 22]		down	larvae					■	■	■	■				
Banded Kokopu [3, 1, 22]	not threatened	upstream	juvenile								■	■	■	■	
[1, 22]		down	larvae					■	■	■					
Shortjawed Kokopu [5]	threatened	upstream	juvenile									■	■	■	
[13]		down	larvae						■	■	■				
Koaro [7, 1]	not threatened	upstream	juvenile									■	■	■	
[1, 13]		down	larvae				■	■	■						
Torrentfish [1]	not threatened	upstream	juvenile	■	■									■	■
[1]		down	larvae		■	■	■	■							
Redfinned Bully [1, 22]	not threatened	upstream	juvenile											■	■
[1, 22]		down	larvae								■	■	■	■	
Common Bully [1, 22]	not threatened	upstream	juvenile	■	■								■	■	■
[1]		down	larvae										■	■	
Bluegilled Bully [1]	not threatened	upstream	juvenile											■	■
[1]		down	larvae	■	■							■	■	■	■
Giant Bully [1]	not threatened	upstream	juvenile	■	■									■	■
[1]		down	larvae											■	■
Lake Taupo and tributaries															
Rainbow Trout (North Taupo) [5, 7]	sportsfish	upstream	adult			■	■	■	■	■	■	■			
[8, 7]		down	juvenile	■	■	■	■	■	■	■	■	■	■	■	■
Rainbow Trout (South Taupo) [8, 9, 5, 7]	sportsfish	upstream	adult					■	■	■	■	■	■	■	
[8, 7]		down	juvenile	■	■	■	■	■	■	■	■	■	■	■	■
Brown Trout (Taupo) [7]	sportsfish	upstream	adult	■	■	■	■	■	■						■
[8, 7]		down	juvenile	■	■	■	■	■	■	■	■	■	■	■	■
Koaro (Taupo) [8, 10]	not threatened	up/down	adult	■	■									■	■
Koaro (Taupo/Rotoaira) [10]	not threatened	down	larvae	■	■	■	■								
Koaro (Taupo) [10]	not threatened	upstream	juvenile											■	■

1 McDowall 1995
2 Jellyman et al 1999
3 Stancliff et al 1988
4 McDowall and Kelly 1999
5 McDowall 1990
6 Wilding et al 2000 (and references therein).
7 G. Maclean (pers. comm.)
8 Rowe and Graynoth (MfE) 2002
9 Dedual and Jowett 1999
10 Rowe et al 2002
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19 Barrier and Hicks 1994
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21 Hopkins 1971
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23 Chris Annandale (pers. comm.)
24 Ben Wilson (pers. comm)

Figure 3: Fish migration calendar for the Environment Waikato (EW) region showing the peak and range periods for migration activity for both upstream and downstream migrations, fish conservation status, migration direction, life stage at time of migration and instream works restriction period relating to indigenous fish habitat waterways under the EW regional plan.

4 Discussion

This calendar is intended to aid in determining when various fish species' life cycles are most susceptible to the adverse affects of an anthropogenic activity and therefore, the most appropriate time of year to undertake the activity to help in avoiding those adverse effects.

For instance, the calendar can be used so that the lower banks and stream side vegetation is not disturbed in small forested streams that contain kokopu and koaro during their spawning season. For inanga, disturbance and grazing of bankside vegetation should be avoided in reaches of the lower river affected by spring tides during the time period covered in the calendar. Consented wetland works should not be undertaken during winter and early spring when the threatened black mudfish spawns. Works on the bed of the river should be avoided during smelt and trout spawning.

The calendar showing both upstream and downstream migration direction and timings (Figure 3) outlines the passive larval migration out to sea of various migratory species. Threats to this life stage include water abstractions and barriers to flow like closed river mouths (McDowall 1995). Our knowledge on these timings is less robust and is usually worked out from spawning periods or juvenile return times (McDowall 1995).

Literature from the Environment Waikato (EW) region has been used as much as possible to develop this calendar; however, some species' migration and spawning timings may be based at least in part on research from other regions. The timings given in the migration calendar are for coastal streams and lowland rivers relatively close to the coast (or lake). Much of the literature available relates to the return of juvenile fish into river mouths and estuaries. So for sites in coastal streams and lowland rivers the calendar is expected to be accurate. However, with greater distance from the coast the greater the likely delay in any upstream migration reaching that point. There is limited information for many species and caution needs to be taken when using this calendar further inland.

Upstream migration rates have been determined for a number of native fish included in the whitebait catch. Juvenile Inanga which make up the majority of the whitebait catch migrate upstream at an approximate rate of 0.31 km/day during spring and at 1.36 km/day during summer (Stancliff et al. 1988). In the same study juvenile banded kokopu were found to migrate upstream from the sea at a constant rate of 1.96 km/day (Stancliff et al. 1988). Juvenile smelt are capable of moving upstream at 4.2 km/day although the majority of juvenile smelt migrate upstream at a slower rate (Stancliff et al. 1988). These rates were determined in the lower Waikato River where there are no barriers to fish migration, these rates may be slower for fish that encounter barriers to fish passage further up catchments. Elver (juvenile eels) move upstream at a rate of 1.5 – 2 km/day (McDowall 1990; Wilding et al. 2000).

Laboratory tests using flume tanks showed sustained swimming speeds of juvenile native fish to be much higher than the above migration rates. With shortfin eel elver showing average sustained / steady swimming speed over the 3 hour experiments equivalent to 17.3 – 32.8 km/day (Mitchell 1989). Inanga whitebait, smelt, common bullies and banded kokopu juveniles were found to be capable of sustained / steady swimming speeds of 16.4 – 31.1 km/day, 16.4 – 23.3 km/day, 20.7 – 24.2 km/day, 16.4 – 25.1 km/day respectively (Mitchell 1989). Obviously this is the maximum potential migration speed. The speed at which the fish actually move upstream and the distance they cover will depend on river and stream velocities, barriers to passage, fish habitat and cover.

Rainbow trout moving up the Tongariro River to spawn were found to be highly variable in their migration rates. These ranged from 1.075 km/day upstream to 1.142 km/day

downstream with a mean upstream movement rate of 0.312 km/day (Dedual and Jowett 1999).

In any case if distance to the sea (or lake) is known then an approximation of the timing of the migration passing the particular site can be made for some species. Remember to use juvenile eel/elver timing rather than glass eel to estimate eel migration times to inland sites.

Interestingly rainbow trout spawning migrations in the Lake Taupo catchment have become progressively later over the last 10 years (G. Maclean *pers. comm*.). This calendar therefore appears to be one of the most accurate references for rainbow trout migration at the time of going to print. It will be interesting to see if similar trends are found in other freshwater fish species in the future.

If a fish survey is being undertaken care needs to be taken not to transfer fish eggs (often on stones and aquatic plants), aquatic weeds and potentially didymo that can be transported on equipment between sites. Pest fish are not included in the calendar, but measures should be taken not to transfer pest fish (or any coarse fish) between waterways. Saltwater solution (soak in 1 part salt to 14 parts water for 2 hours) or a bleach solution (spray or dip in 0.4% or 4mls per litre) is sufficient to be effective against the above although any obvious plant material and other detritus should be removed onsite and left at the source location rather than transported.

5 Conclusion

Once the fish species present have been determined this calendar can be used to determine when and where they are likely to spawn and the timing and direction of the major migration events in this region.

The calendar can be used to plan projects and riverine work for times where it is likely to have the least impact on native fish communities and trout.

This calendar and the migration and spawning times within are based on peer reviewed literature and biologists personal observations. However, there may be migration and spawning activity outside of the times stipulated in the calendar. Therefore, caution should be taken at all times to avoid any unnecessary adverse effects on fish communities.

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Appendix 1. Proposed Waikato Regional Plan Appeals Version: River and Lake Bed Module

4.2 River and Lake Bed Structures

4.2.21 Suspended Solids Discharge Standards for Permitted Activity Rules in Chapters 4.2 and 4.3

a. In any river or stream (including Hydro Electricity Reservoirs): as a result of works associated with a structure the suspended solids concentrations in the stream downstream of the structure shall not exceed the suspended solids concentration as measured at the same time in the stream immediately upstream of the structure.

b. In any lake (excluding Hydro Electricity Reservoirs): as a result of works associated with a structure the suspended solids concentration in the lake shall not exceed the ambient lake concentration (i.e. as measured in the lake in areas unaffected by the discharge).

c. The restrictions in a) and b) shall not apply with regard to the erection, reconstruction, placement, alteration or removal of a structure within a water body within any 24 hour period within 30 days from commencement of the works, except in:

    i. Significant Indigenous Fisheries and Fish Habitat Class waters during August to December inclusive

    ii. Significant Trout Fisheries and Trout Habitat class waters during May to September inclusive.

    The point at which compliance with standards a) and b) shall be measured is:

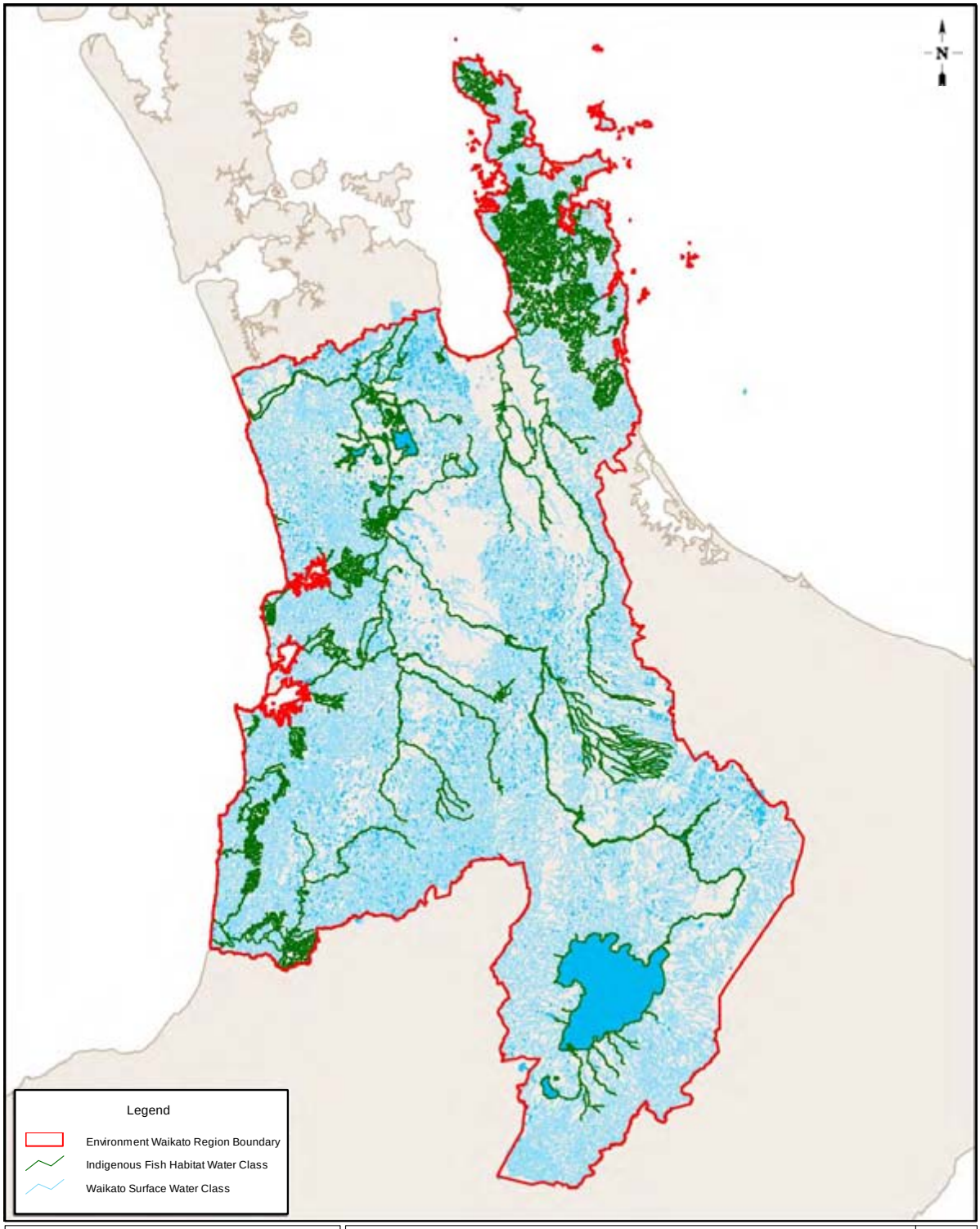
    iii. For rivers and streams (including Hydro Electricity Reservoirs): at a distance downstream of the discharge point (or site of the activity) which is three times the width of the river or stream and which in any instance does not exceed 200 metres from the point of discharge.

    iv. For lakes (other than Hydro Electricity Reservoirs): at a distance of 15 metres from the location of the discharge or the activity.

Advisory Notes:

- As Hydro Electricity Reservoirs have significant flows it is more appropriate to use the river compliance point (maximum of 200m from point of discharge), rather than one intended for lakes with very low current or flow velocities.

Appendix 2. Map of significant indigenous fisheries or fish habitat class waters



WRP Indigenous Fish Habitat

0 10 20 30 40 50
Kilometres

Scale - 1:1,430,000 @ A4

A4

Created by: HCE
Projection: NZTM
Date: 11th October 2006

Status: Final
Request No.: 14412
File name: S:GIS_JOBS/.....

1:50,000 Hydrological data Sourced from NZTopo Database.
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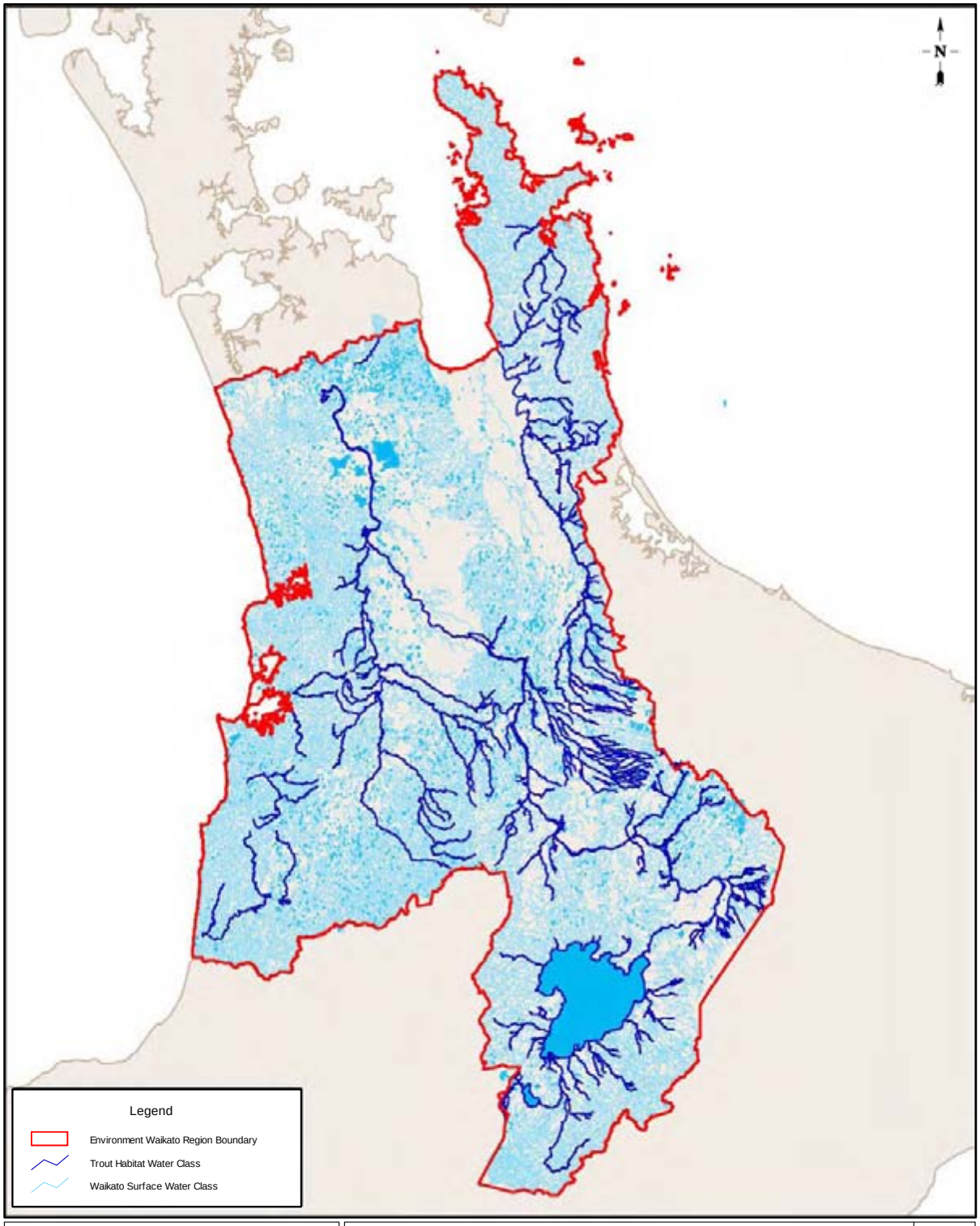
Appendix 3. Map of significant trout fisheries and trout habitat class waters.



WRP Trout Habitat

0 10 20 30 40 50
Kilometres

Scale - 1:1,430,000 @ A4

A4

1:50,000 Hydrological data Sourced from NZTopo Database.
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Created by: HCE
Projection: NZTM
Date: 11th October 2006

Status: Final
Request No.: 14412
File name: S:GIS_JOBS/.....

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Appendix 4. Environment Waikato Freshwater Fish Calendar Handout.

Environment Waikato Freshwater Fish Calendar

Introduction

Protecting spawning grounds, habitats and migration pathways are important to maintain the Waikato Region's freshwater fish populations. You can reduce the effects of stream work on fish by timing your works carefully. With proper planning, you can avoid seasons when fish are spawning or migrating without adding greatly to your project costs.

Life cycles

The spawning and migratory behaviour of New Zealand's freshwater fish is complex. Most native species require access to the sea to complete their life cycle. Inanga are a good example. They migrate to the lower reaches to spawn amongst the riverbank vegetation flooded by spring tides in Autumn. The larvae hatch when flooded by the next spring tide and are carried out to sea. Here they spend the winter months feeding and growing. Juvenile inanga, more commonly known as whitebait, come back into our rivers and streams in spring and gradually make their way upstream to suitable habitat.

Other species in the whitebait run are koaro, banded kokopu, giant kokopu, shortjawed kokopu and common smelt. Their spawning behaviour is less well understood. Adult eels migrate far out to sea to spawn, the glass eels (transparent sea going juveniles) migrate back to estuaries, then the elvers (young eels) return upstream to develop into adults. Lamprey and some bullies also migrate to sea and back.

Trout migrate from lakes and rivers into headwater streams where they spawn in shallow gravel areas (redds) during the winter months. The hatched fry remain in the gravel until their yolk sacs are absorbed and they emerge to feed and grow in the small streams.

Using the calendar

Whitebait runs, inanga spawning, elver migrations, downstream adult eel migrations and trout spawning represent some of the main parts of the life cycle. Development and river works are unlikely to affect more than one or two of these activities and so restrictions on work will often be short. We recommend that you identify the answers to the following questions when using the calendar:

1. Which fish are present in or pass through the affected reach? This might involve a fishing survey or reviewing existing records from the New Zealand Freshwater Fish Database (NIWA) www.niwascience.co.nz/rc/freshwater/fishatlas/fishFinder. For more detailed information read the report associated with this calendar on our website www.ew.govt.nz.
2. Do these fish spawn, live in or migrate through the affected reach? Which of these species, if any are threatened?
3. What times of year do spawning and migration take place? Use the calendar to identify this.

Whether the **peak or range** is used (light or dark shaded months) will depend on the significance of the fish species and population. Use the full range for significant populations.

The time of year given in the calendar for migratory fish (whitebait, elvers etc) applies to the arrival from the sea into coastal streams and rivers. The further inland you are, the less accurate the calendar will be.

More information

For more information on freshwater fish in the Waikato Region, call **Environment Waikato's Freephone 0800 800 401** or visit **www.ew.govt.nz.**

For more information on New Zealand's freshwater fish, visit **www.doc.govt.nz** and **www.niwascience.co.nz.**

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Key

Peak Range

Instream works restriction for peak sensitivity period of indigenous fish migration and trout spawning under Regional Plan section 4.2.21

T = threatened
NT = not threatened
S= sportsfish

Migration – Environment Waikato region

Species	Status	Direction	Life stage	Summer		Autumn			Winter			Spring			Summer
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Lamprey [1, 22]	T	upstream	adult												
Long and shortfinned eel [1, 2, 22]	T/NT	to estuary	glass eel												
Long and shortfinned eel [22]	T/NT	upstream	juvenile												
Common Smelt (sea run) [3]	NT	upstream	juvenile												
Inanga [3]	NT	upstream	juvenile												
Giant Kokopu [3, 1, 22]	T	upstream	juvenile												
Banded Kokopu [3, 1, 22]	NT	upstream	juvenile												
Shortjawed Kokopu [5]	T	upstream	juvenile												
Koaro [6]	NT	upstream	juvenile												
Torrentfish [22]	NT	upstream	juvenile												
Redfinned Bully [1, 22]	NT	upstream	juvenile												
Common Bully [1, 22]	NT	upstream	juvenile												
Bluegilled Bully [1]	NT	upstream	juvenile												
Giant Bully [1]	NT	upstream	juvenile												
Lake Taupo and tributaries															
Rainbow Trout (North Taupo) [7, 5]	S	upstream	adult												
Rainbow Trout (South Taupo) [7, 8, 9, 5]	S	upstream	adult												
Brown Trout (Taupo) [7]	S	upstream	adult												
Juvenile Trout (Taupo) [7]	S	down	juvenile												
Koaro (Taupo) [8]	NT	up/down	adult												
Koaro (Taupo/Rotoaira) [10]	NT	down	larvae												
Koaro (Taupo) [10]	NT	upstream	juvenile												

Spawning Habits – Environment Waikato region

Species	Status	Spawning habitat	Summer		Autumn			Winter			Spring			Summer
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Lamprey [5]	T	upper catchment (unconfirmed)												
Longfinned eel	T	Pacific ocean												
Shortfinned eel	NT	Pacific ocean												
Common Smelt (sea run) [3, 5, 11]	NT	sand banks of rivers												
Inanga [6]	NT	tidal esturary edge vegetation												
Giant Kokopu [4, 6]	T	mid-low reaches (unconfirmed)												
Banded Kokopu [12, 6, 13]	NT	stream margins at flood among vegetation and debris												
Shortjawed Kokopu [13]	T	stream bank rocks, debris and vegetation during flood												
Koaro [14, 13, 5]	NT	cobbles at stream edge												
Torrentfish [15, 1]	NT	lowland rivers/estuaries												
Redfinned Bully [1]	NT	flowing water under rocks												
Common Bully [5, 1]	NT	under firm flat surfaces												
Bluegilled Bully [5, 1]	NT	similar to other bullies												
Giant Bully [16]	NT	estuaries (unconfirmed)												
Cran's Bully [5]	NT	under large rocks												
Upland Bully [17, 18]	NT	under large flat rocks												
Black Mudfish [19, 20]	T	wetlands												
Dwarf Galaxias [21, 5]	T	small stones instreams												
Rainbow Trout (Waikato) [5, 24]	S	gravel bed in flowing water												
Brown Trout (Waikato) [5, 24]	S	gravel bed in flowing water												
Lake Taupo and tributaries														
Rainbow Trout (North Taupo) [17, 8, 7]	S	gravel bed in flowing water												
Rainbow Trout (South Taupo) [7, 8]	S	gravel bed in flowing water												
Brown Trout (Taupo) [7, 5, 8]	S	gravel bed in flowing water												
Common Smelt [5, 11]	NT	sandy lakeshore/slow flowing streams												
Koaro (Taupo) [8]	NT	cobbles at stream edge												
Common Bully [8, 7]	NT	hard substrates												

1 McDowall 1995
2 Jellyman et al 1999
3 Stancliff et al 1988
4 McDowall and Kelly 1999
5 McDowall 1990
6 Wilding et al 2000 (and references therein).
7 G. Maclean (pers. comm.)
8 Rowe and Graynoth (MfE) 2002
9 Dedual and Jowett 1999
10 Rowe et al 2002
11 Ward et al 2005 (and references therein)
12 Mitchell and Penlington 1982
13 Charteris et al 2003
14 Allibone and Caskey 2000
15 Scrimgeour and Eldon 1989
16 Jellyman et al 2000
17 Staples 1975 (peak)
18 McDowall and Eldon 1997 (Captive breeding, range)
19 Barrier and Hicks 1994
20 Thompson 1987
21 Hopkins 1971
22 Boubee et al 2000
23 Chris Annandale (pers. comm.)
24 Ben Wilson (pers. comm)

Please refer to the **Freshwater fish spawning and migration calendar report** for a full listing of references. www.ew.govt.nz/publications/technicalreports/tr0711.htm.