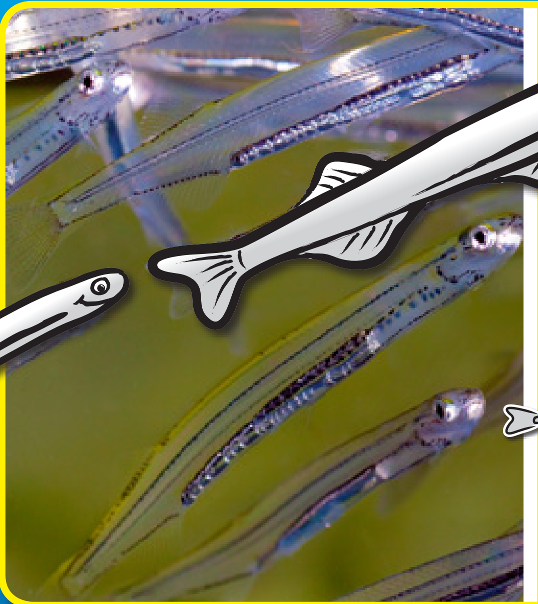


Inanga/Whitebait

National Inanga Spawning Education Programme

whitebait Connection
Xstream about freshwater life

eos ECOLOGY

The National Inanga Spawning Education Programme is supported by...

whitebait Connection – Xstream about freshwater life
Mountains-To-Sea Conservation Trust
CURIOUS MINDS – HE HIHIRI I TE MAHARA
Department of Conservation – Te Papa Atawhai
eos ECOLOGY – AQUATIC SCIENCE & VISUAL COMMUNICATION
WE ♥ WHITEBAIT – WHAKA INAKA : CAUSING WHITEBAIT
MARINE ECOLOGY RESEARCH GROUP – UNIVERSITY OF CANTERBURY, NZ

UPDATE 1 – SEPTEMBER 2017

www.whitebaitconnection.co.nz

Introduction

Overall, native fish populations in New Zealand are in decline. *Part of the problem is the damage we have done to the spawning habitat of īnanga, the species that makes up over 90% of the whitebait catch. Unfortunately, the habitat needed for their eggs to survive is often damaged or absent.* ***Less eggs = less īnanga!*** *Likewise, introduced predators (particularly trout) eat lots of the adults and change their behaviour, meaning the īnanga are not so successful at foraging for food. Why do we care? Inanga is an important food source for many creatures, including us!* ***High biodiversity = healthy ecosystem = everyone has lots to eat!*** *Furthermore, many of the simple actions that can be taken to improve things for īnanga, can also improve the overall quality of the water in our local environments, making it healthier for us to live by them and use them recreationally.*

Te Kaupapa Mātauranga Toene Inanga ā-Motu /The National Īnanga Spawning Programme (NISP) was created in 2016 by the Whitebait Connection (WBC) and offers opportunities for local decision-making, community involvement, freshwater research and monitoring, to give understanding and inspire and empower community into action. The NISP provides a comprehensive set of resources created to support teachers and students to learn more about īnanga and how to find, monitor and restore their spawning grounds. The NISP was designed to be delivered alongside the Whitebait Connection's Investigating Freshwater Inquiry Framework that has stages of learning and links to suggested teaching and learning experiences which support inquiry into freshwater environments. The NISP is designed to be used in all levels of the curriculum by teachers and environmental educators, but can also be offered as a stand-alone resource for groups wanting to get stuck in and needing expertise advice.

Background

The main reason for carrying out this project was that students and community members around NZ seemed to be becoming more and more aware that there were issues with their local waterways, but weren't often involved in the on-the-ground practical science that identifies, quantifies and remedies these issues. We saw that as an opportunity lost – an opportunity to engage the community in meaningful field work and involve them in the restoration planning and action. The result would be a more connected, aware and engaged public, improved whitebait spawning habitat and data on where the sites are, improved water quality and biodiversity corridors, and a set of comprehensive new supporting resources for iwi, educators, schools, community groups, Kura Māori and early childhood centres. We saw through delivery of our pilot project in 2016, that there was indeed a real need for this programme of work, due to the interest it sparked, and the demand we were experiencing in mentoring and supporting other groups to get involved. We acknowledge in an ideal world we could be mentoring and guiding groups through this whole process, but that we (and similar organisations) cannot be everywhere all the time, and if we can develop resources that meet the needs of these groups we can ensure long-term viability of this programme of work across a broader spectrum of community, especially those that are hard to reach and often not involved in science and technology.

This is a truly innovative project that uses best practice ground-breaking scientific techniques that are sure to excite and engage groups who have fewer opportunities to be involved with science and technology. The scope of the project broadens participants' abilities to engage with science and technology in both a local and national level thus promoting the relevance of it within their own lives, as well as others. This empowers them to take part in the societal debates around freshwater management issues facing NZ as well as directly take part in tackling the issues head on and be involved in the technology that will mitigate these issues moving forward.

The development of this resource has involved expert training sessions and collaborative input from and with Inanga spawning site experts such as Dr. Michael Hickford, Kim Jones and EOS Ecology.

Vision

A more connected, aware and engaged public, improved whitebait spawning habitat and data on where they are, improved water quality and biodiversity corridors, and a set of comprehensive new supporting resources in for iwi, educators, schools, community groups, Kura Māori and early childhood centres.

Goals

- *Empowered kaitiaki. Connected, aware and engaged public.*
- *Improved whitebait spawning and adult habitat.*
- *Improved water quality and biodiversity corridors*
- *WBC Coordinators will offer scientific vigour throughout the process and training will be provided to them by way of MTSCT's national wananga, training/evaluation visits, peer review forms and online training videos.*
- *Upload of all data onto our National Īnanga Spawning database (data on where the spawning sites and fish are as well as the groups engaged in the project).*
- *Ensure that a Māori worldview is incorporated into programme delivery, by working alongside Kaiako and iwi/hapu, and that all cultural considerations are addressed.*

Contributors

- *Dr. Michael Hickford – Marine Education Research Group (MERG), University of Canterbury (UOC)*
- *EOS Ecology – Kirsty Brennan, Bronwyn Gay, Shelley McMurtrie, Nick Hempston and Erron Henderson*
- *Mountains to Sea Wellington (MTSW) – Te Kawa Tangata Gordon Robb, Zoe Studd, Sarah Neighbours, Elizabeth Gibson*
- *Mountains to Sea Conservation Trust (MTSCT) – Kim Jones, Nicki Wakefield, Soozee McIntyre, Natalie Blandford, Jordan MacDonald, Sophie Tweddle*
- *Nga Mahi Te Taiao (NMTT) – Murray Palmer and Amy Hardy*

Acknowledgements

- *Department of Conservation (DOC)*
- *Auckland Council*
- *Landcare Trust*
- *Southern Trust*
- *Foundation North*

Feedback

We would love to hear your feedback on how you are using these resources! Please let us know and share your stories with us using the contacts below. It helps us to continually improve what we do and create more of what works!

Mobile phone:	*027 243 4818*
Email:	*info@whitebaitconnection.co.nz*
Website:	*www.whitebaitconnection.co.nz*
'Like' & follow WBC on Facebook:	*www.facebook.com/whitebaitconnection*

Ngā mihi

Kim Jones

WHITEBAIT CONNECTION NATIONAL COORDINATOR

National Inanga Spawning Education Programme from

PROGRAMME CONTENTS:

PART 1: Information (for use in the classroom)

PART 2: Experience (for use in the field)

PART 3: Action (for use in the field)

HOW TO USE THIS PPT:

Please curate your individual presentations from the slides following so it is appropriate for the age group and knowledge base of your audience.

In some places there are slides with more/less text for your to choose between… so delete the ones you don't want to use.

There are notes for your info in the 'notes' section.

If you don't want to use the 'building' habitat infographic just delete all except the last in the series.

There are some basic WBC 'master pages' which have been created just for you if you have any local content to add.

Use Myriad bold italic as the font, or Calibri bold italic if you don't have Myriad.

…and of course – remove this slide from the front before presenting :-)

- DELETE THIS SLIDE BEFORE PRESENTING


PART 1a: Information
National Inanga Spawning Education Programme
Inanga/Whitebait
What • Where • Why • How
Presented by:
whitebait Connection
Xstream about freshwater life
eos ECOLOGY
The National Inanga Spawning Education Programme is supported by...
CURIOUS MINDS
all photos & diagrams in this presentation are the © of EOS Ecology unless otherwise specified & cannot be used by any other party without written consent

TITLE SLIDE

- Things we are going to cover today

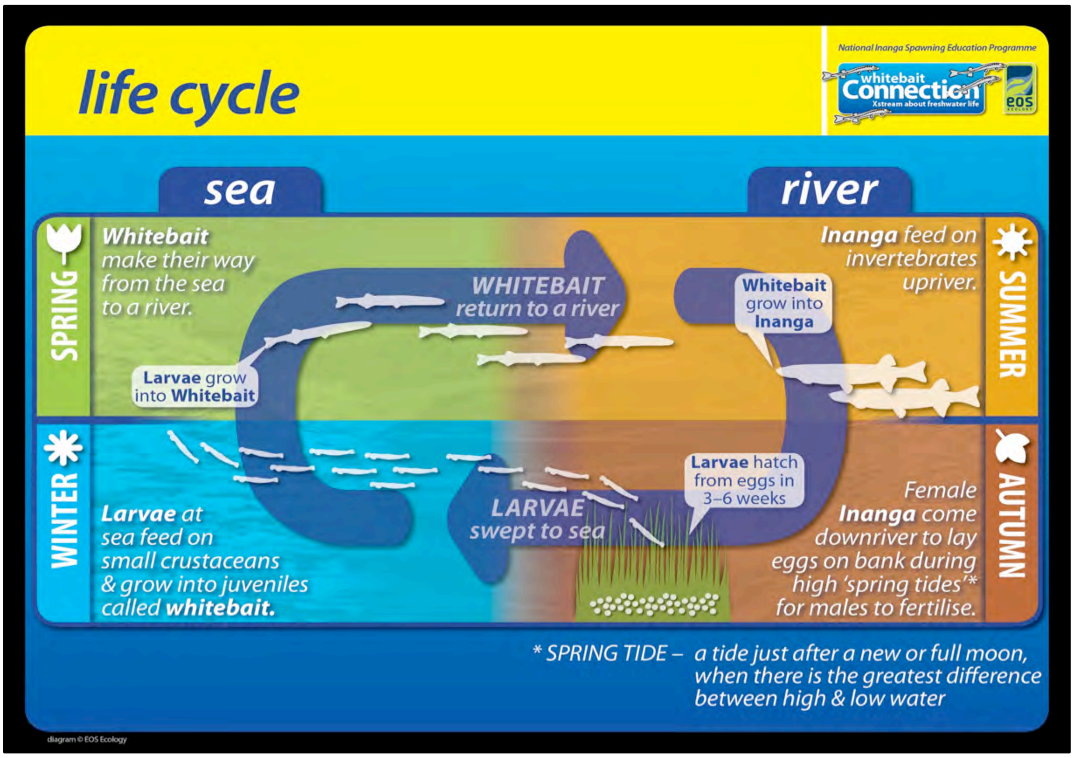
WHAT are whitebait/inanga

National Inanga Spawning Education Programme

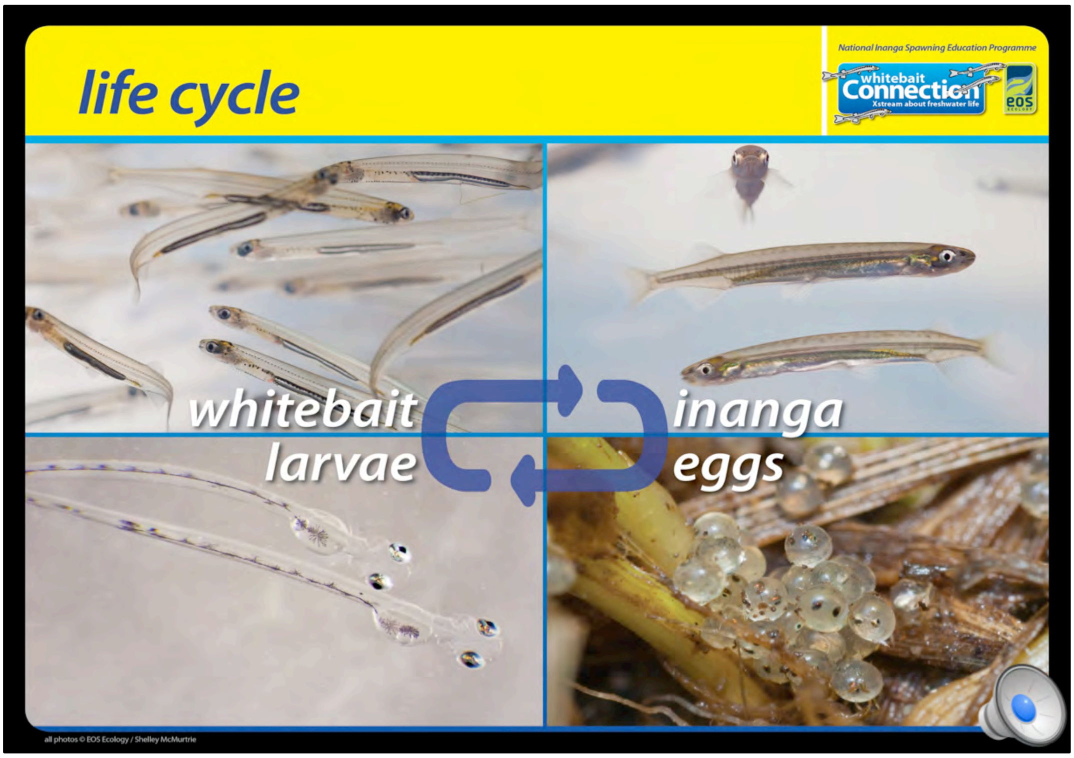
whitebait Connection
Xstream about freshwater life

- 'WHITEBAIT' = collective term for juvenile stage of 5 species of fish *(Galaxiidae)*
- 'INANGA' = adult stage of 1 of the 5 whitebait species *(Galaxias maculatus)*
- INANGA are the smallest, growing no longer than 110 mm


our 5 whitebait species
National Inanga Spawning Education Programme
whitebait Connection
Xstream about freshwater life
eos
extinct
nationally threatened
critical
endangered
vulnerable
at risk
declining
recovering
relict
naturally uncommon
not threatened
inanga
shortjaw kōkopu
kōaro
banded kōkopu
giant kōkopu
inanga CAN'T climb barriers... unlike the other 4 species
all photos © EOS Ecology / Shelley McMurtrie



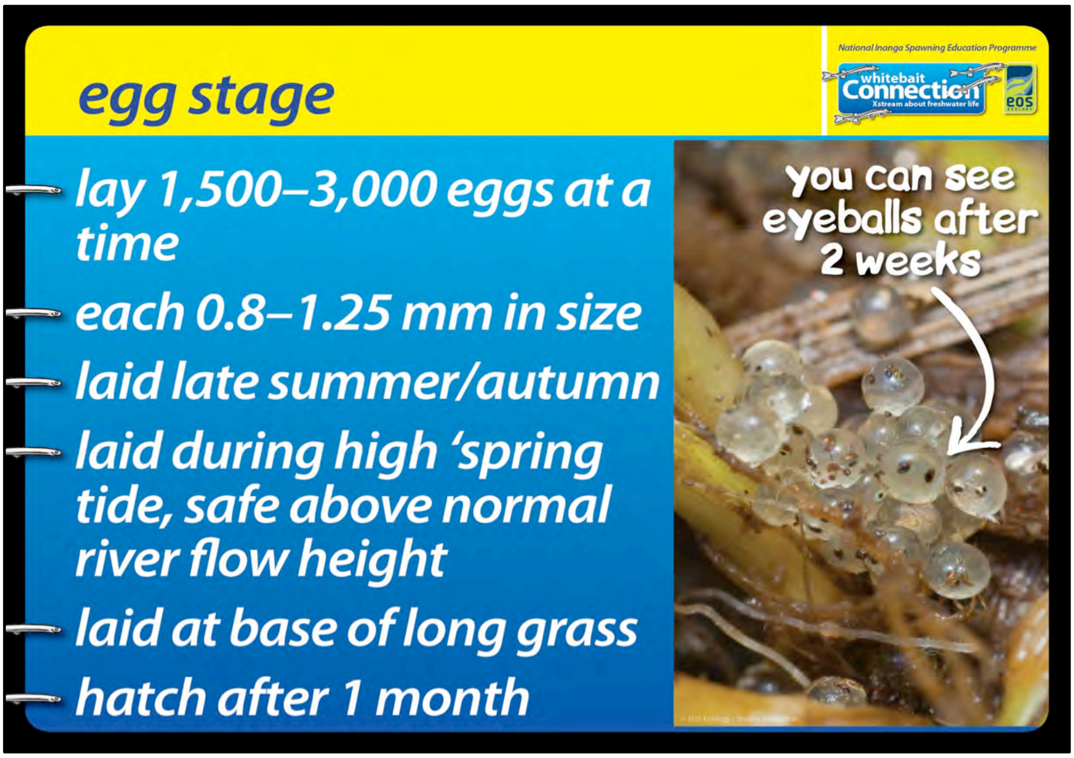
- Diadromous – live in both marine and freshwater
- There are some populations that go out into lakes instead of ocean
- Go to sea to get reliable food and disperse
- Marine dispersal ensures genetic mixing and ability to reinvade disturbed rivers
- Also risky – might get eaten, might starve and might get lost
- Adults feed a lot on detritus – bugs dropping into river – need overhanging vegetation for bugs to fall off and to keep water cooler
- Life cycle built around redundancy – most larvae and most whitebait can die but population persists
- Having lots of larvae and sending them to sea is "not putting all your eggs in the same basket" i.e. if bad things happen then they won't all be lost



- Audio track will automatically play once through then stop.

USE **EITHER** THIS SLIDE **OR** THE FOLLOWING

- lay 1,500–3,000 eggs at a time (depends on size of female)
- each 0.8–1.25 mm in size
- laid late summer/autumn
- laid during high ‘spring tide, safe above normal river flow height
- laid at base of long grass
- You can see eyeballs after 2 weeks
- hatch after 1 month
- Inanga are broadcast spawners – females lay eggs and males fertilise them externally
- Eggs swell-up after being laid – absorb water
- Inside each egg is a tiny embryo
- Embryos breath oxygen – eggs need to stay moist for oxygen to get inside
- Embryo has to go through a set of developmental stages – the warmer the eggs is, the faster it gets through these stages
- Eggs are laid high on the bank to protect them from aquatic predators e.g. other fish (including inanga – they are cannibals) and invertebrates



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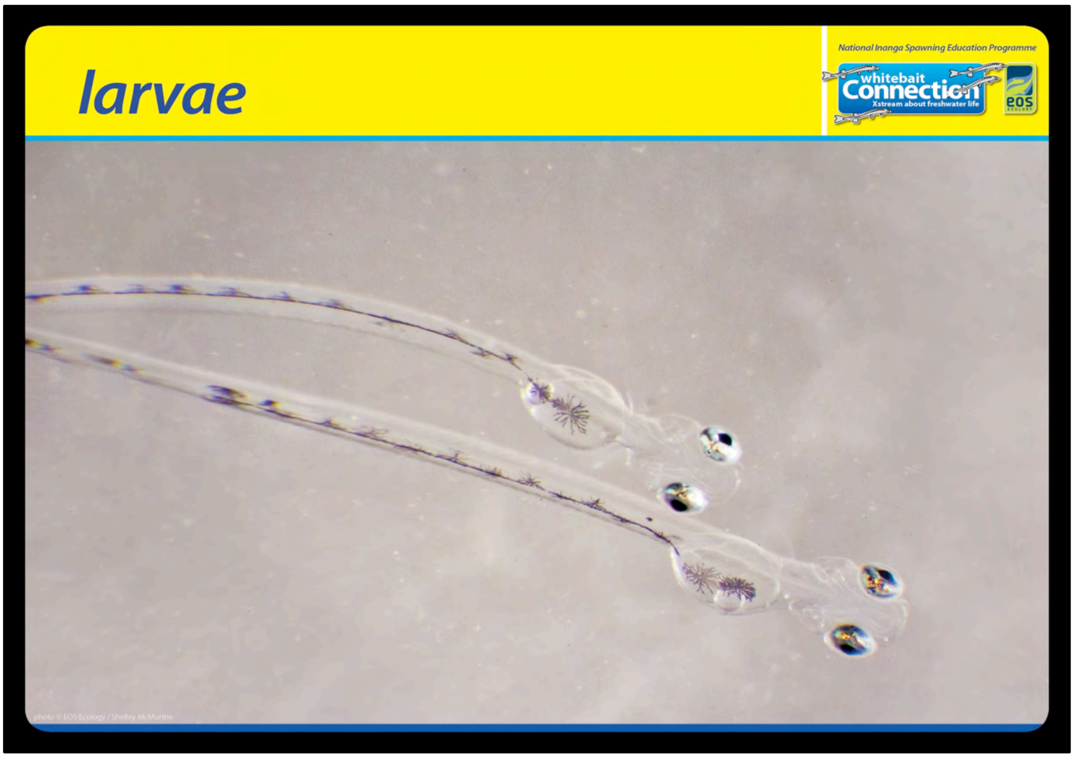
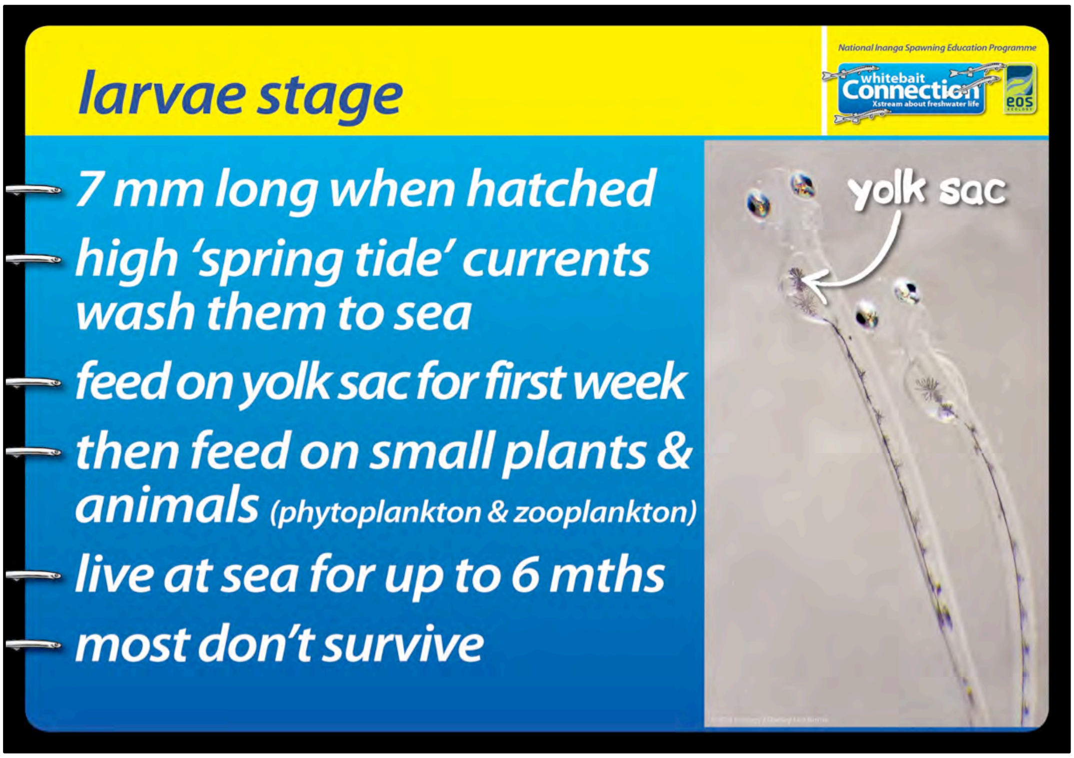


USE **EITHER** THIS SLIDE **OR** THE FOLLOWING

- 7 mm long when hatched
- high ‘spring tide’ currents wash them to sea
- feed on yolk sac for first week
- then feed on small plants & animals
- live at sea for up to 6 mths
- most don’t survive
- Newly hatched larvae are ‘positively phototaxic’ – just like moths they are drawn towards light = the surface
- Tidal currents are greatest at the surface so the larvae are carried out to seas quickly
- Need to develop eyesight and swimming ability first so have a yolk sac (a packed lunch) to feed them at first
- Their mouth size (gape) limits what they can eat – they don’t have hands so if they can’t swallow it whole then they can’t eat it – they can’t eat bigger animals until they get bigger
- We don’t know where they go
- Some have been found 100s of kilometres away from the coast line



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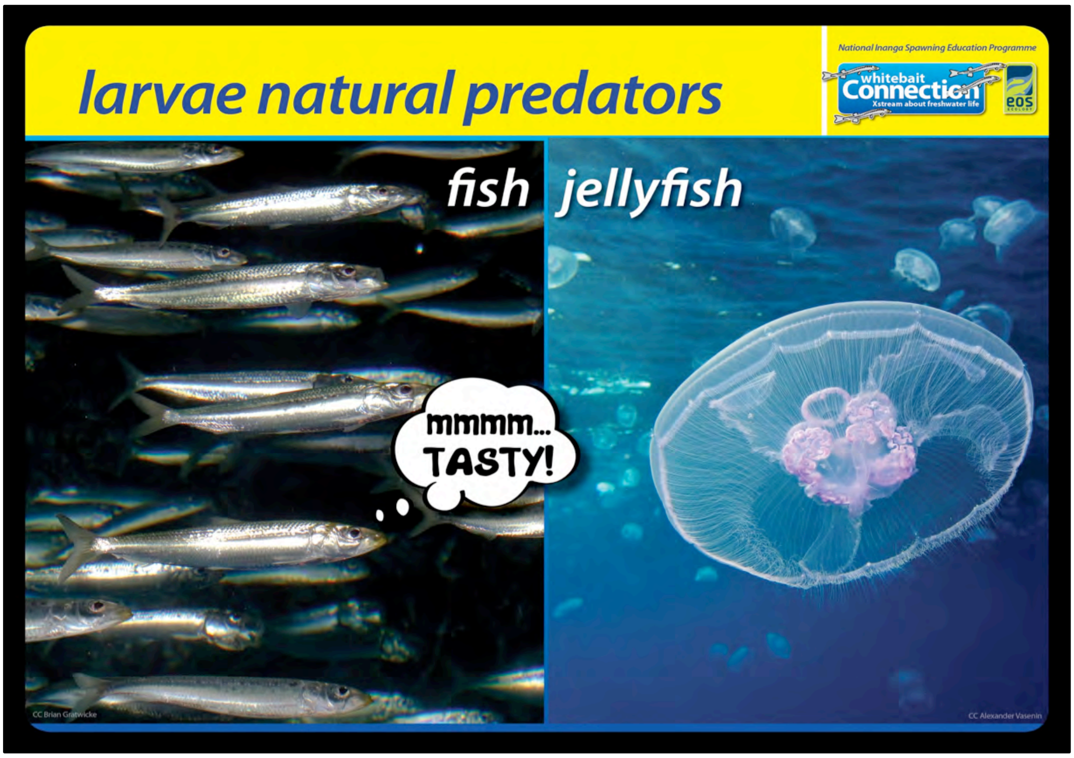

- There are lots of larvae initially because most of them will die
- There are many animals that make their living from eating plankton and larval fish
- The goal for larvae is to find food, grow quickly and get too big or too fast to be eaten by these predators

- USE **EITHER** THIS SLIDE **OR** THE NEXT

- 6-month old juveniles
- swim in large groups & with other species for safety
- find way to rivers by smelling the freshwater
- swim upriver, but weak swimmers – can't climb
- most don't survive
- Surviving larvae move back into coastal waters when they are around 6 months old
- They form large shoals in the ocean and we think they drift along the coast until they sense the plume of freshwater coming out of a river
- More whitebait enter rivers immediately after floods when presumably the plume was bigger
- They appear to stop feeding 2-3 days before they enter the river – whitebait's stomach are always empty when they enter a river
- Move from saltwater to freshwater is REALLY hard on a whitebait's body – all the salts that have built up in their tissues want to leave and be replaced with freshwater
- They swim up the middle of the river but move closer to the banks when the current is too strong
- They mostly live in the coastal reaches of rivers because they can't swim past rapids/waterfalls/weirs/culverts etc
- Again, most of the whitebait entering a river are going to die – some will be caught by whitebaiters, but most will starve or get eaten by predators

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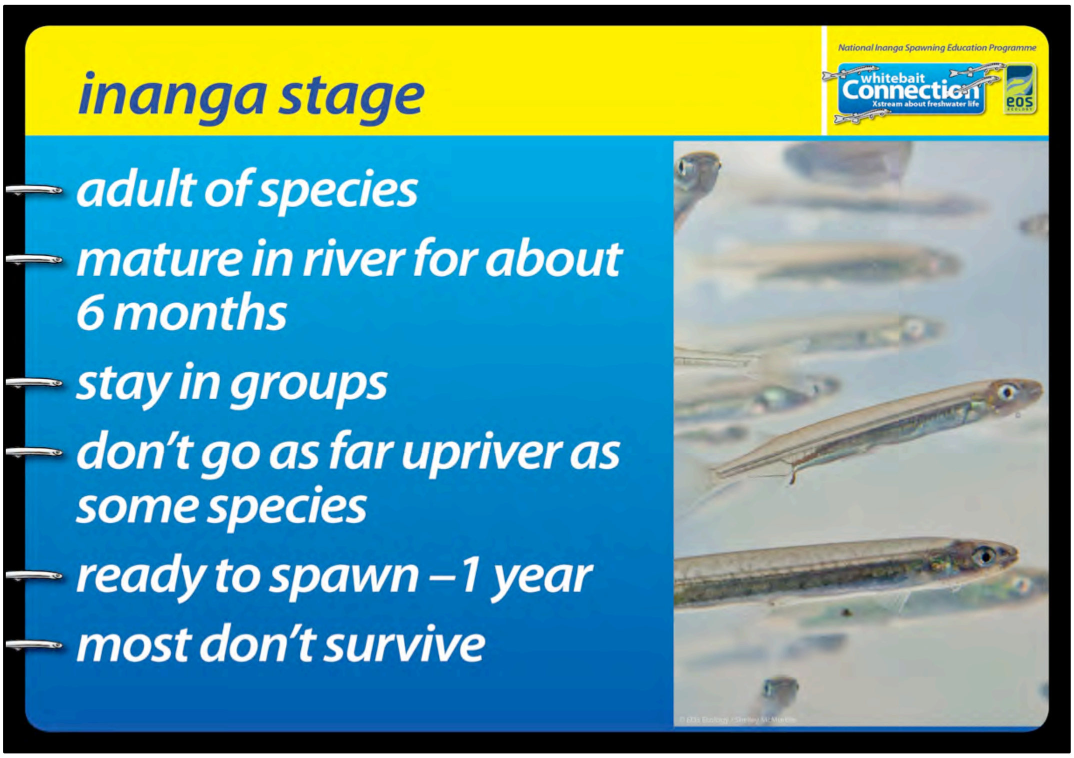
- Fish form shoals because there is safety in numbers
- Predators can’t eat all the fish in a shoal and get confused by the numbers present
- We’re not sure what happens in the ocean, but inanga are unusual among the galaxiids in that they stay in shoals from the whitebait stage through maturation to spawning – the other 4 whitebait species and non-migratory galaxiids are all solitary
- Large numbers of whitebait are consumed by predators at the river mouth (kahawai) in the river (trout) and nearer the banks (wading birds)

- USE **EITHER** THIS SLIDE **OR** THE NEXT

- adult of species
- mature in river for about 6 months
- stay in groups (shoals)
- don’t go as far upriver as some species
- ready to spawn – 1 year
- most don’t survive
- Adults take about 6 months to mature and be ready to spawn
- They mainly stay in coastal waterways because of their limited climbing ability
- Adult inanga migrate downstream to estuary to spawn
- Many 1 yr old fish appear to spawn once and then die
- Some fish don’t spawn until they are 2 or even 3 years old
- A few fish seem to be able to spawn in multiple years



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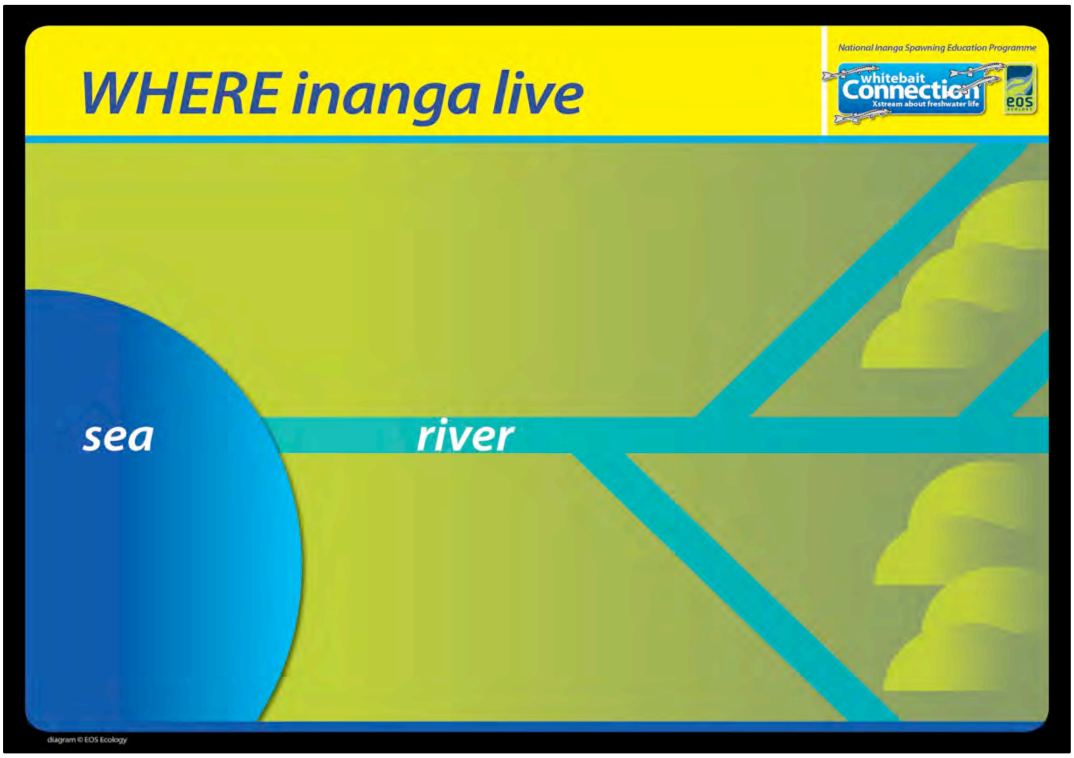
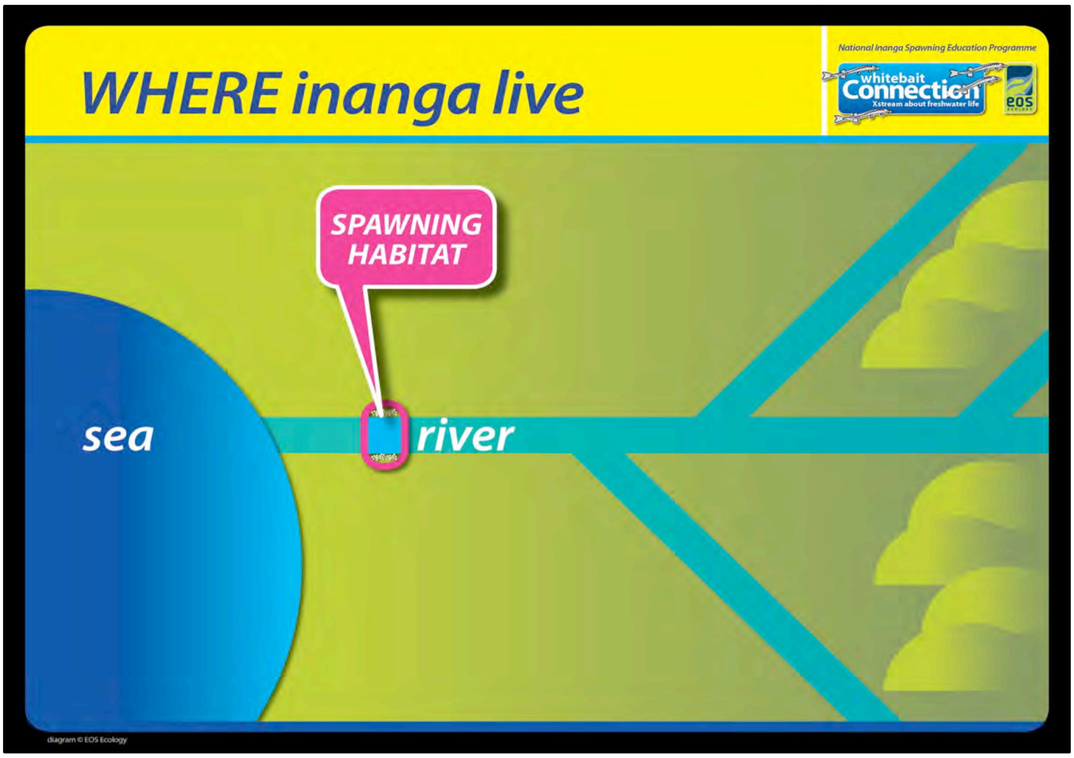
- Many adult inanga get eaten by predators (eels) while they are spawning
- The slurping sound of eels feeding while the inanga try to spawn is a useful tool to use to find spawning sites

- Video will automatically play through, full screen size

- After introducing diadromy, maybe also mention that there are populations of inanga that don't go out to sea (non-diadromous) and use lakes as their 'sea'



- Inanga populations can live over large length of river (10's of kms) and they need to be able to find other fish to be able to spawn – when they do they form 'spawning aggregations' – even bigger shoals
- Need tidal influence to make river bank spawning habitat available
- Also need tidal currents to wash larvae out to sea
- They use saltwater wedge as a road sign – "wait here for the others and when they arrive spawn here"
- Spawning aggregations show a searching behaviour before they spawn – they seem to swim into and 'test' the vegetation many times before they eventually spawn



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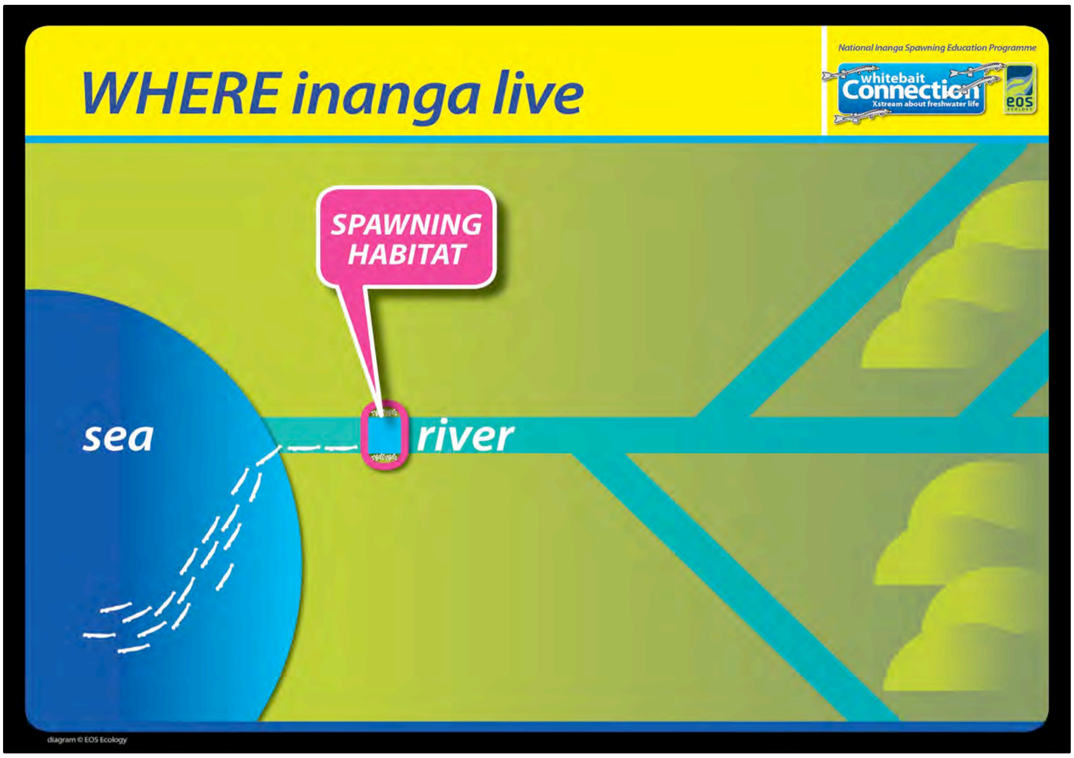

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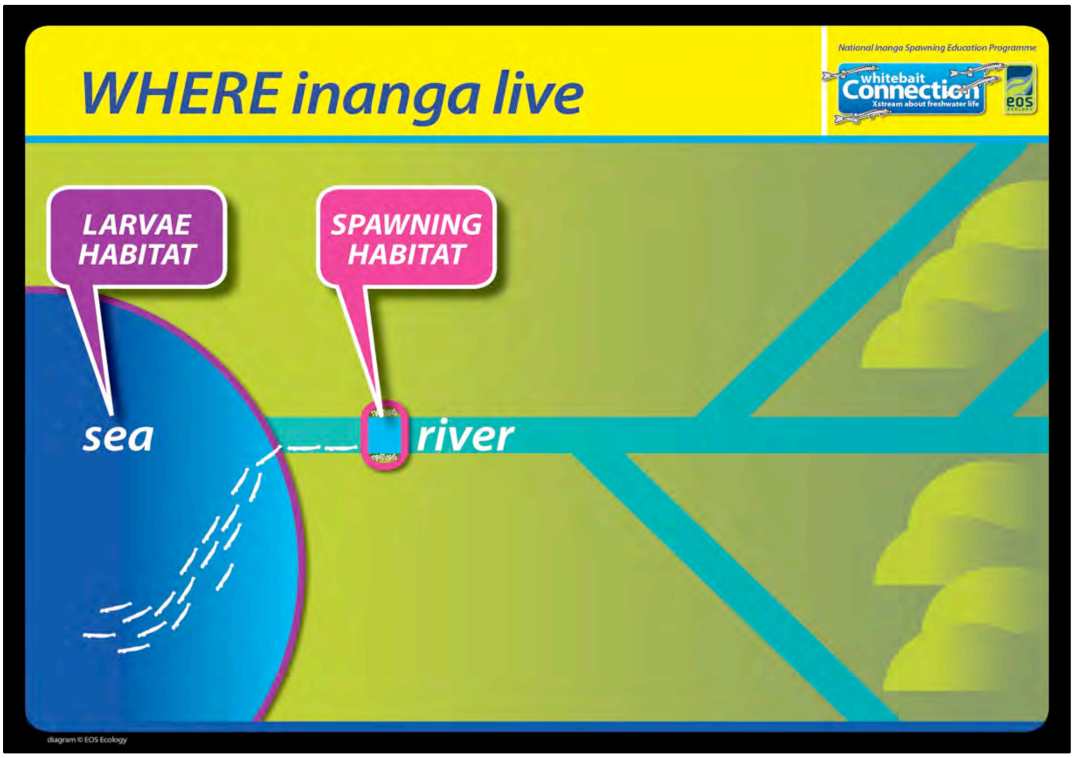

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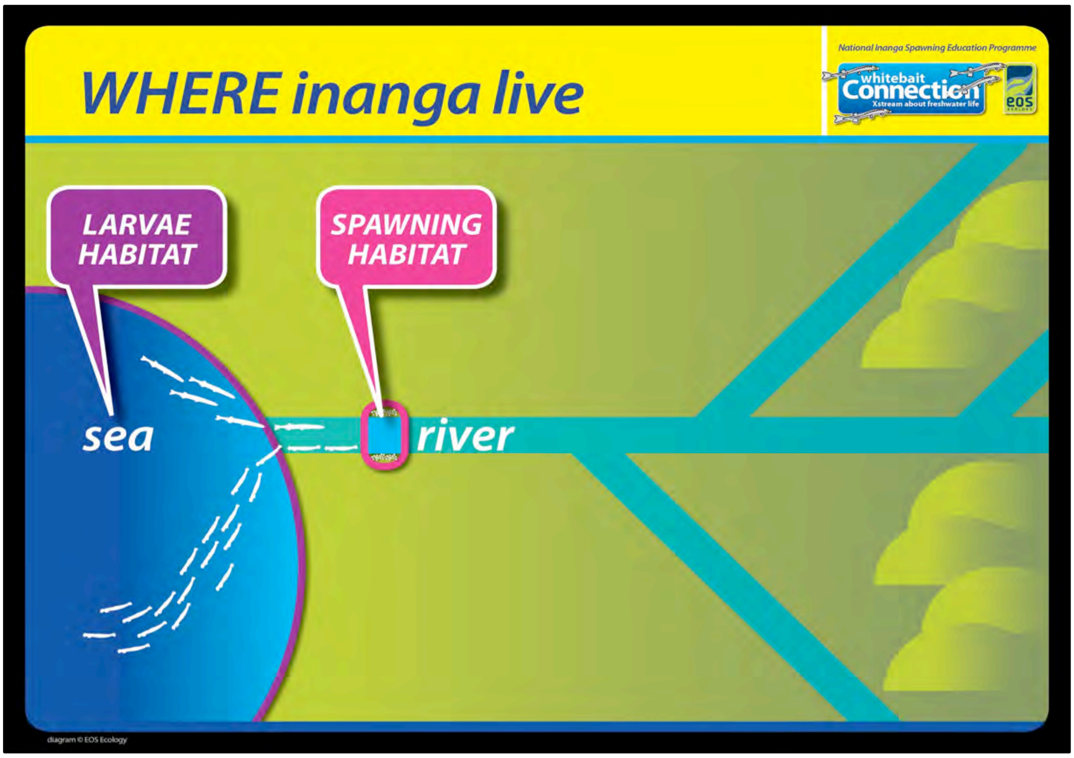

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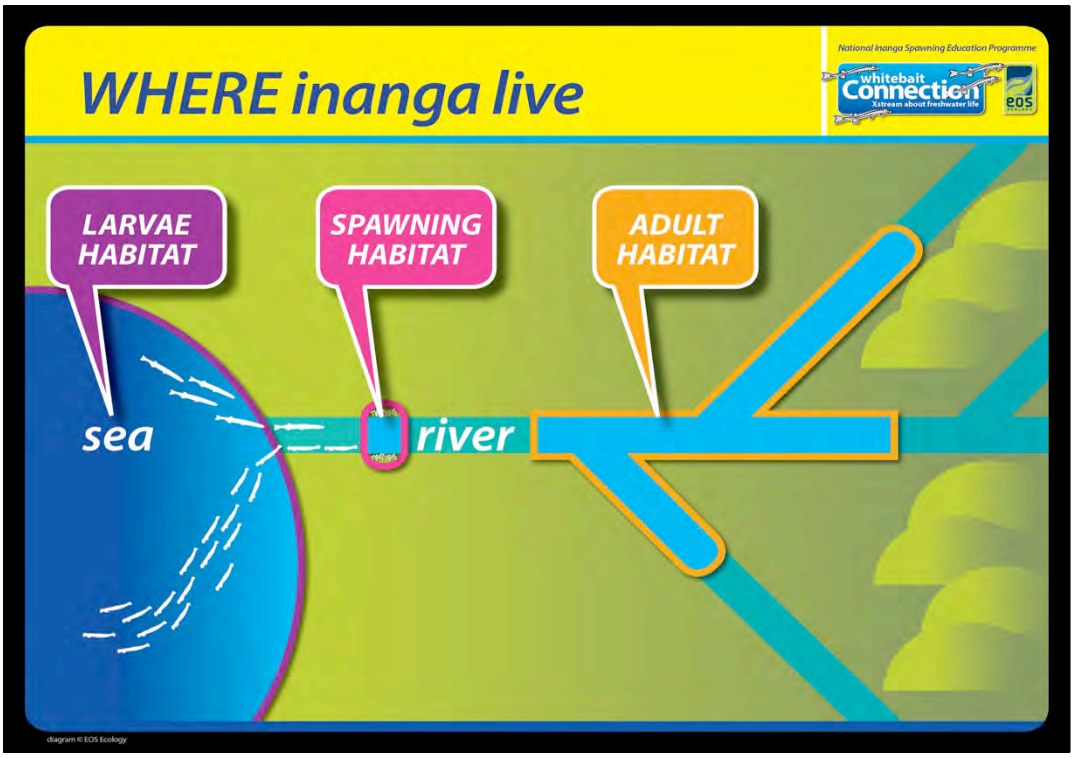

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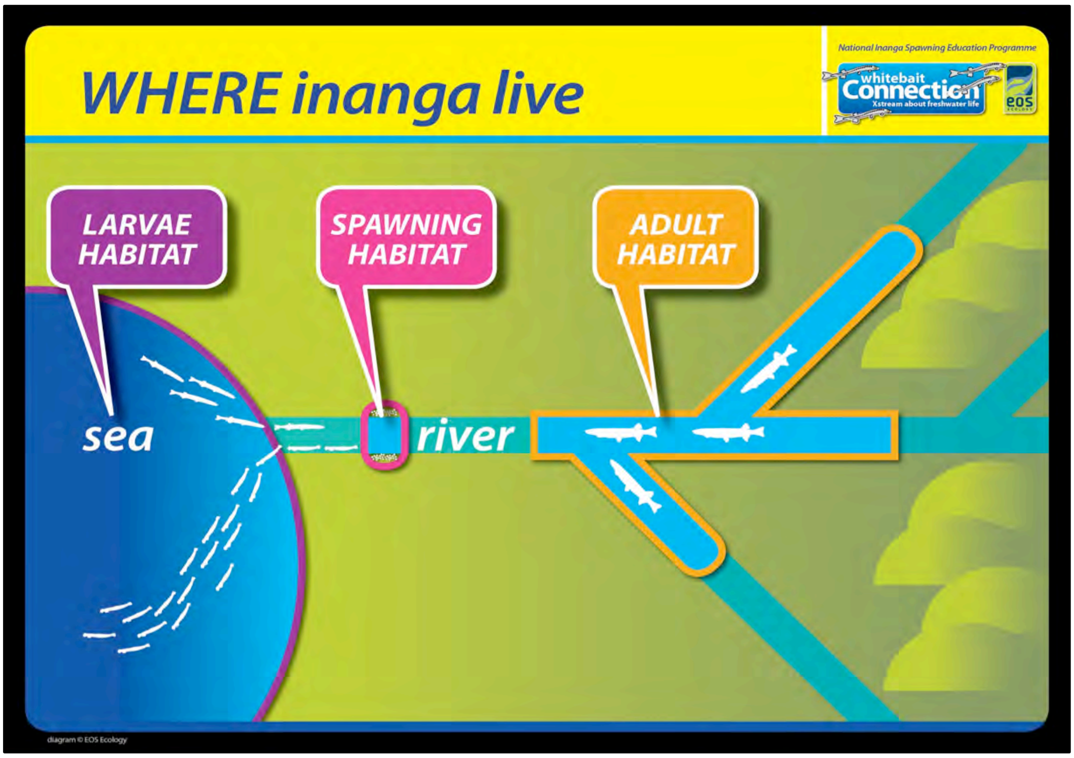

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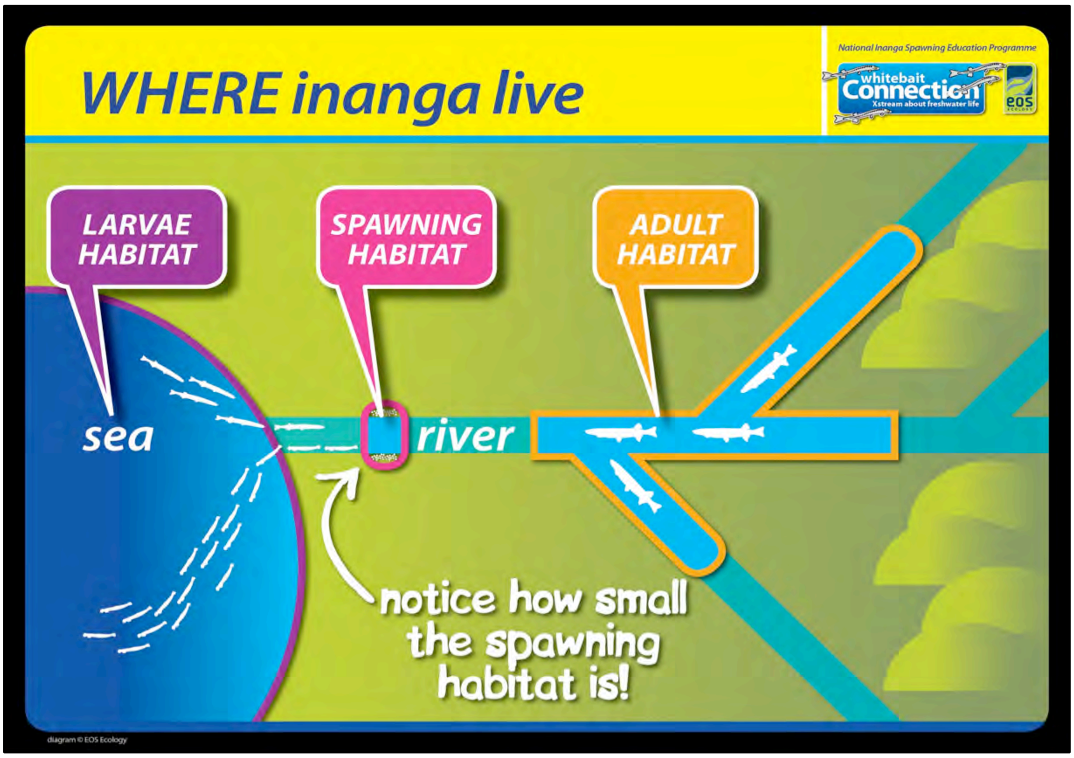

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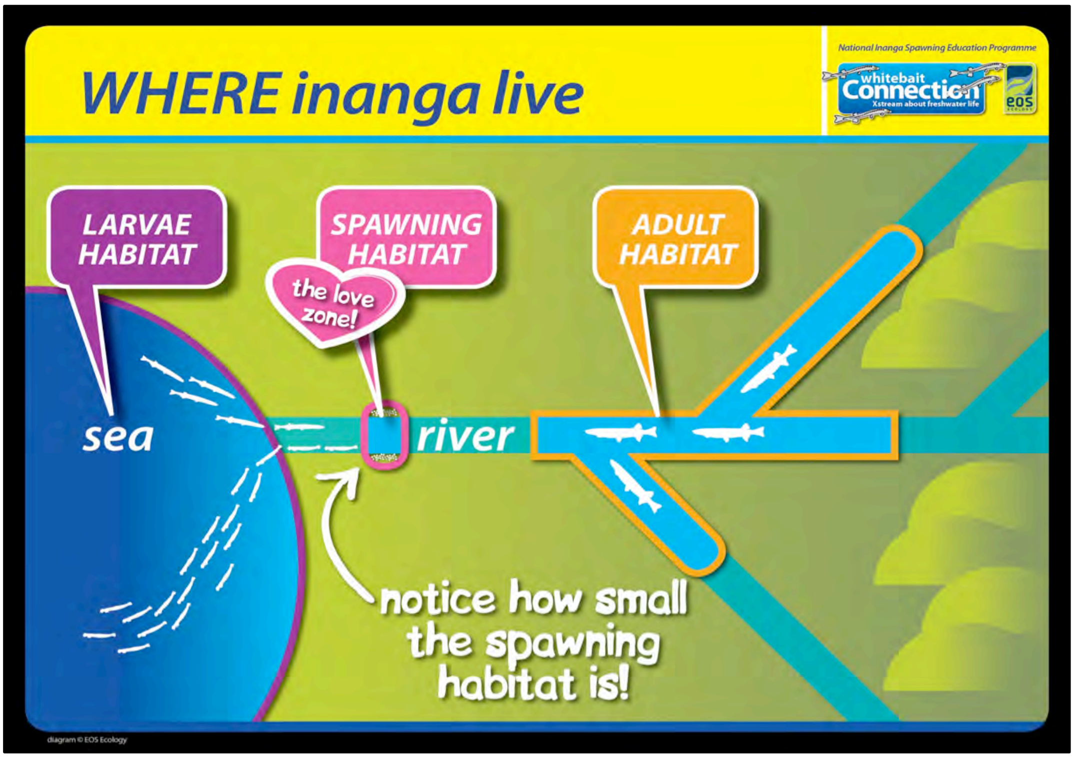

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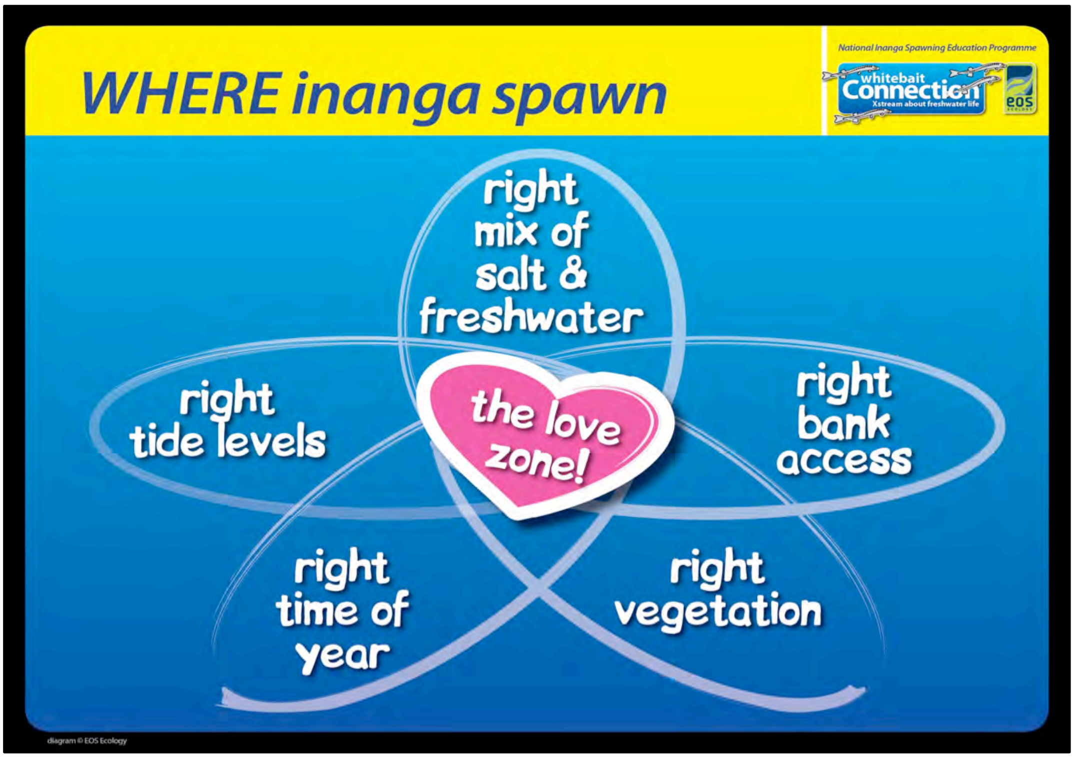

WHERE inanga spawn
National Inanga Spawning Education Programme
whitebait Connection
Xstream about freshwater life
eos ecology
right mix of salt & freshwater
right tide levels
the love zone!
right bank access
right time of year
right vegetation
diagram © EOS Ecology

WHERE inanga spawn

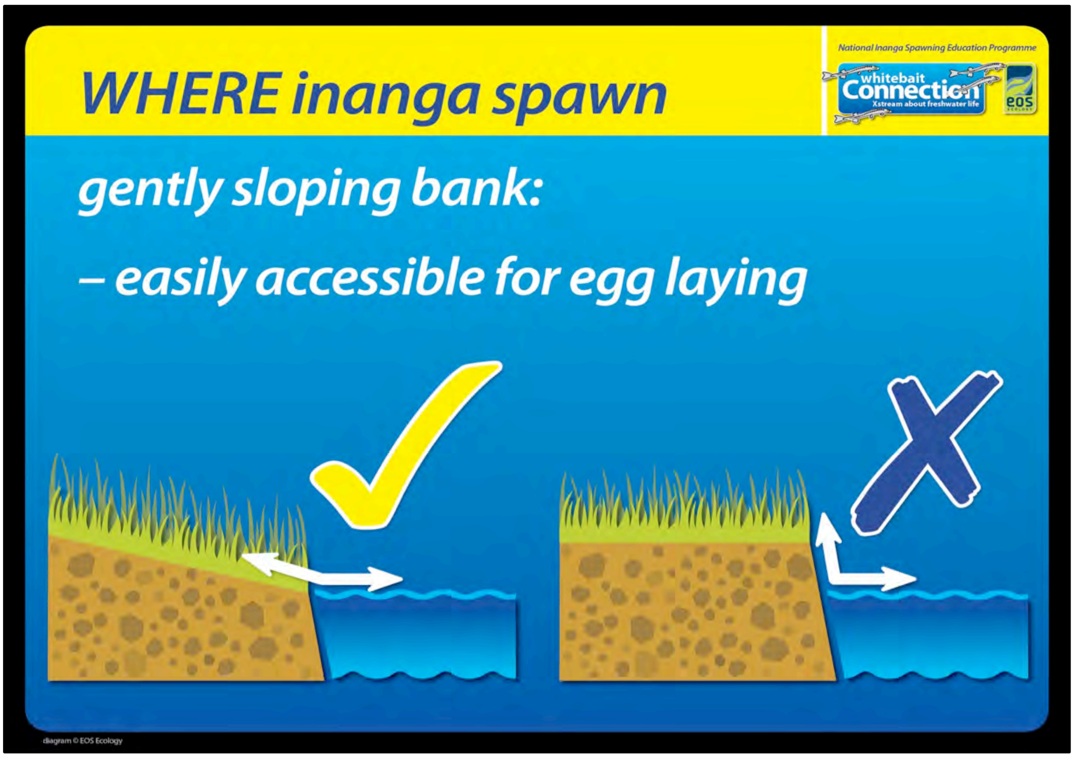
National Inanga Spawning Education Programme

right distance from the sea:

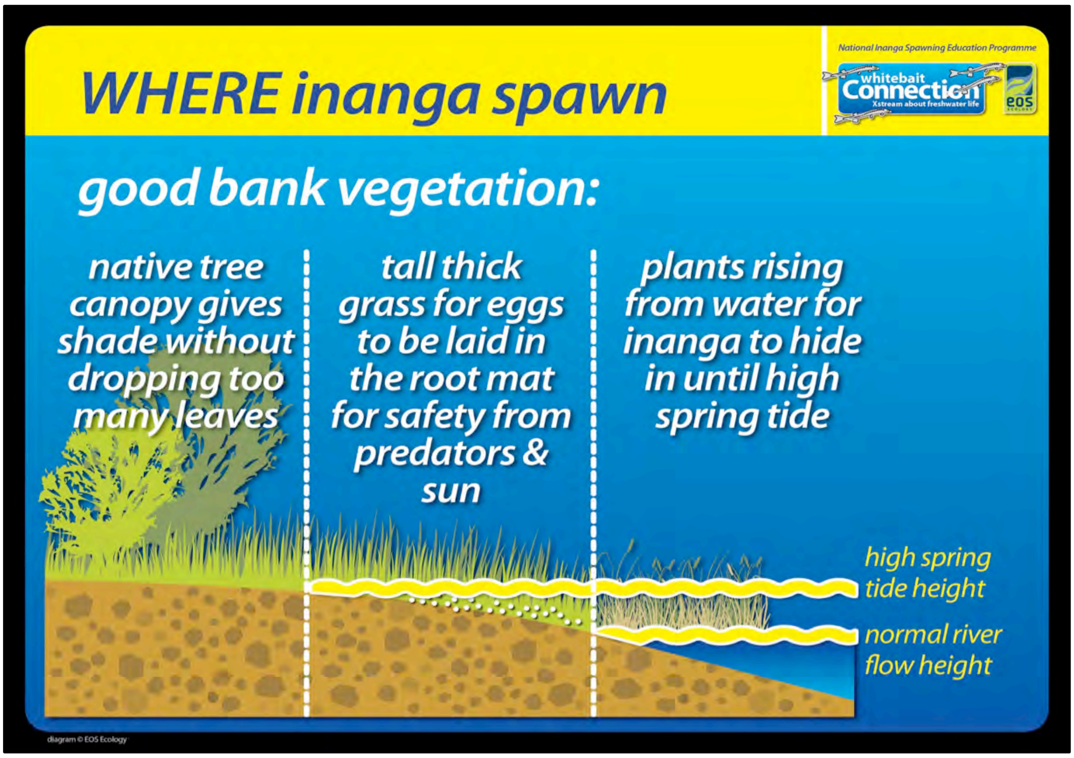
– where high spring tides reach

– water not too salty

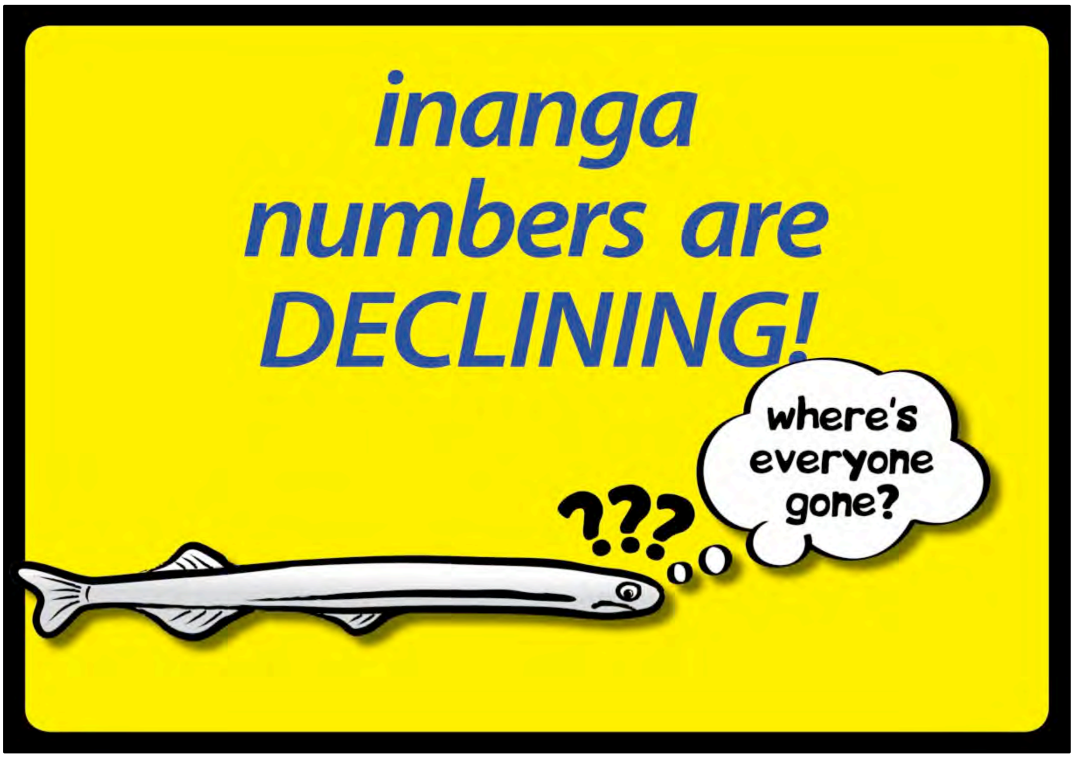
– usually within 200 m from salt water wedge



- Gently sloping banks have more area between the high tide and low tide mark for spawning



- Canopy vegetation and bankside vegetation acts like an umbrella during the day and a blanket at night
- Inanga eggs need to stay cool and damp while they are out of the water
- Adults are really vulnerable to predators when they swim into the very shallow water to spawn – they can't manoeuvre – so emergent vegetation gives them some protection from hungry eels and wading birds

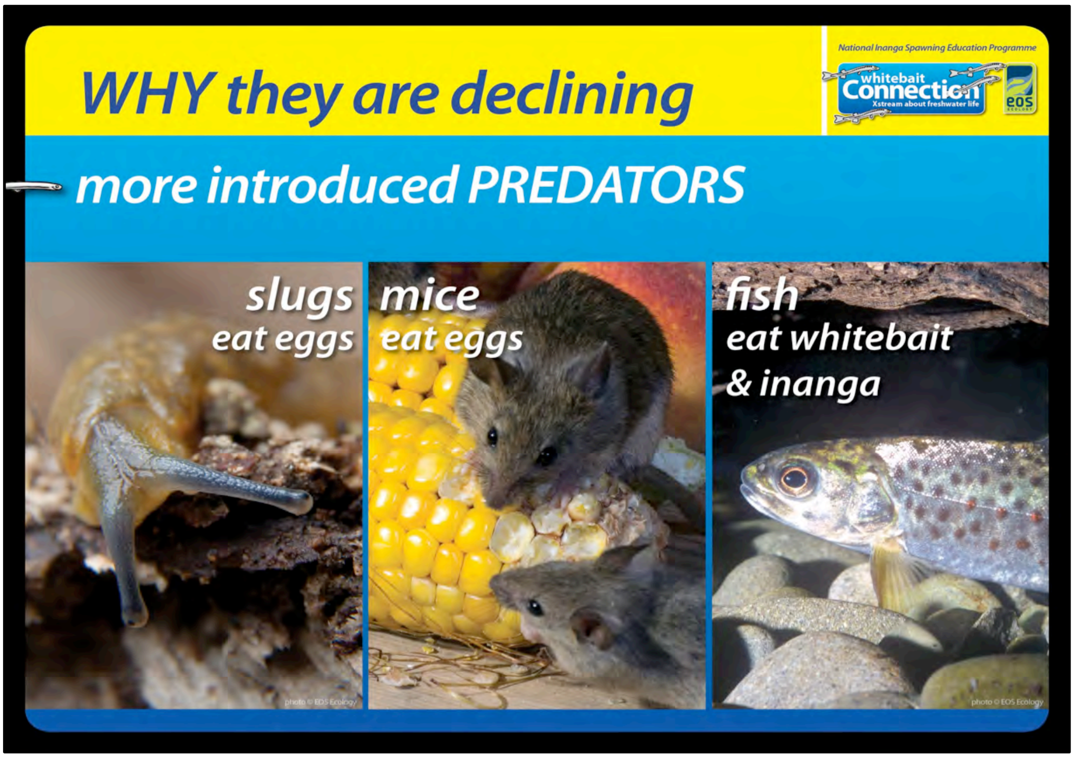


- Native fish populations in NZ are declining
- Inanga are doing better than most because they are generalists – the are flexible in where they live and what they eat

- New Zealanders love to catch and eat whitebait
- Unfortunately, the whitebait we all love may be disappearing
- Part of the problem is the damage we have done to the spawning habitat of the species that makes up over 90% of the whitebait catch.
- Unfortunately, the habitat needed for the eggs to survive is often damaged or absent.

- No eggs = no whitebait
- If we want to preserve the whitebait fishery, we need to preserve or restore their spawning habitat. Before we can do that, we need to find more inanga spawning sites.


WHY do we care!
National Inanga Spawning Education Programme
whitebait Connection
Xstream about freshwater life
eos
high biodiversity = healthy ecosystem
...everyone has lots to EAT!
this doesn't seem fair!?
inanga
yummy little fishies!!!
if it fits in my mouth I'm eating it!
all photos © EOS Ecology

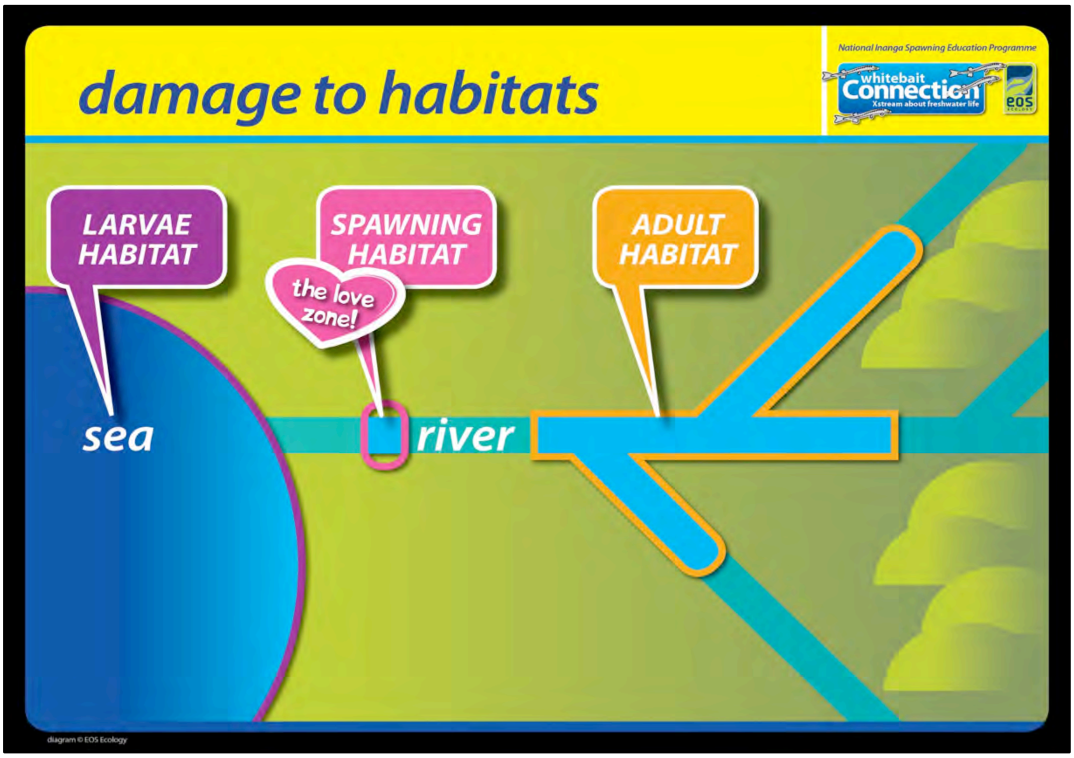


- Introduced predators (particularly trout) eat lots of adults and change their behaviour meaning they are not so successful at foraging for food (maybe for next slide)

WHY they are declining

National Inanga Spawning Education Programme

- damage to spawning HABITAT...including:
  - fewer 'good' banks
  - less overhanging plants = less safe places
- changes to whitebait & adult HABITAT... including:
  - less 'good' habitat
  - harder to move upriver – barriers



- They need to be able to move around the river easily and not be stopped by dams/culverts/weirs or other barriers

- Livestock will preferentially graze the vegetation closer to rivers because the grass is always more lush
- Grazing not only removes the protective vegetation canopy, it also damages the roots of vegetation, the bank shape and soil stability
- These changes increase erosion and steepen the banks which makes less area for spawning
- Cows are worse than sheep because of their size
- Riverbanks are difficult and expensive to fence and keep fenced

- maybe make the point that out of desperation inanga will spawn in sub-optimal habitat (e.g. shingle) but the eggs dry out and very few survive

- mowing of river banks obviously shortens the vegetation, but it also this out the aerial roots
- mowing isn't a problem if it happens at the right time, but vegetation can take 2-3 months to fully recover in late summer/early autumn

- direct effect of sediment burying eggs, but indirect effect of sediment clogging up bank vegetation and aerial roots
- clogging reduces the quantity and quality of the spawning habitat

- inanga are ok, but not great swimmers
- they struggle to swim against long straight sections of fast moving water
- the struggle to climb or jump up even small ‘waterfalls’
- tide gates slow down their progress – they have to wait for low tide for the gate to open
- predators hang around below tide gates and eat the inanga while they are waiting to get through

- They need to be able to move around the river easily and not be stopped by dams/culverts/weirs or other barriers

HOW we can help the inanga!

- riverbank vegetation and inanga spawning habitat can be slow to recover from damage
- inanga always come back to the same spot in the river to spawn so they will come back to damaged areas and try to spawn but their eggs will die
- we can give them a temporary helping hand by installing artificial habitats that mimic good quality natural spawning habitat
- the gap between straw bales is cool, shaded and damp – perfect for developing inanga eggs

- livestock do long-lasting damage to river banks and spawning sites
- fencing off the riverbanks (especially around the spawning site) will have huge positive effect on water quality, bank structure, vegetation, spawning and egg survival
- authorities have lots of different priorities when maintaining river banks
- often grooming and flood control are seen as more important than protecting habitats
- we can encourage the authorities to balance these priorities and use what we know about inanga spawning to work around any clashes in timing

Inanga/Whitebait
What • Where • Why • How

National Inanga Spawning Education Programme from whitebait Connection Xstream about freshwater life eos ecology

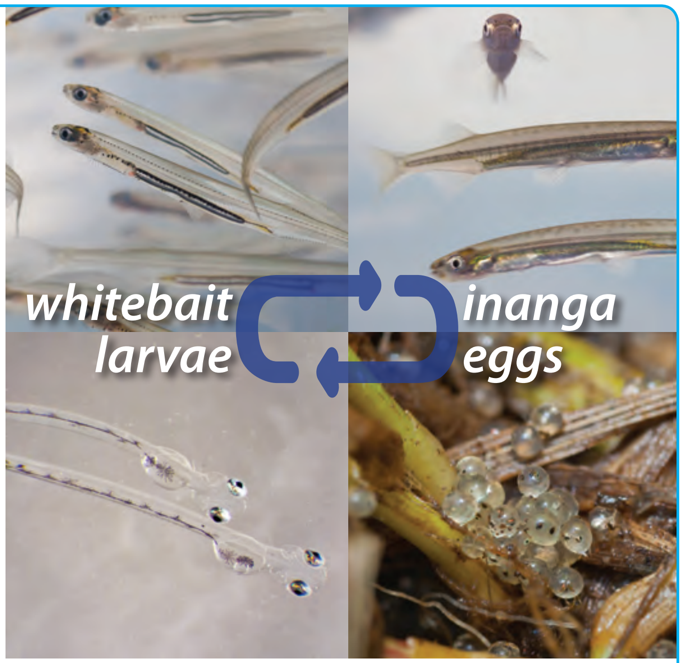
WHAT are inanga:

'Whitebait' is a collective term for the juvenile stage of the five New Zealand species of the fish family* Galaxiidae*. 'Inanga' is the name for the adult stage of one of these five whitebait species –* Galaxias maculatus*.

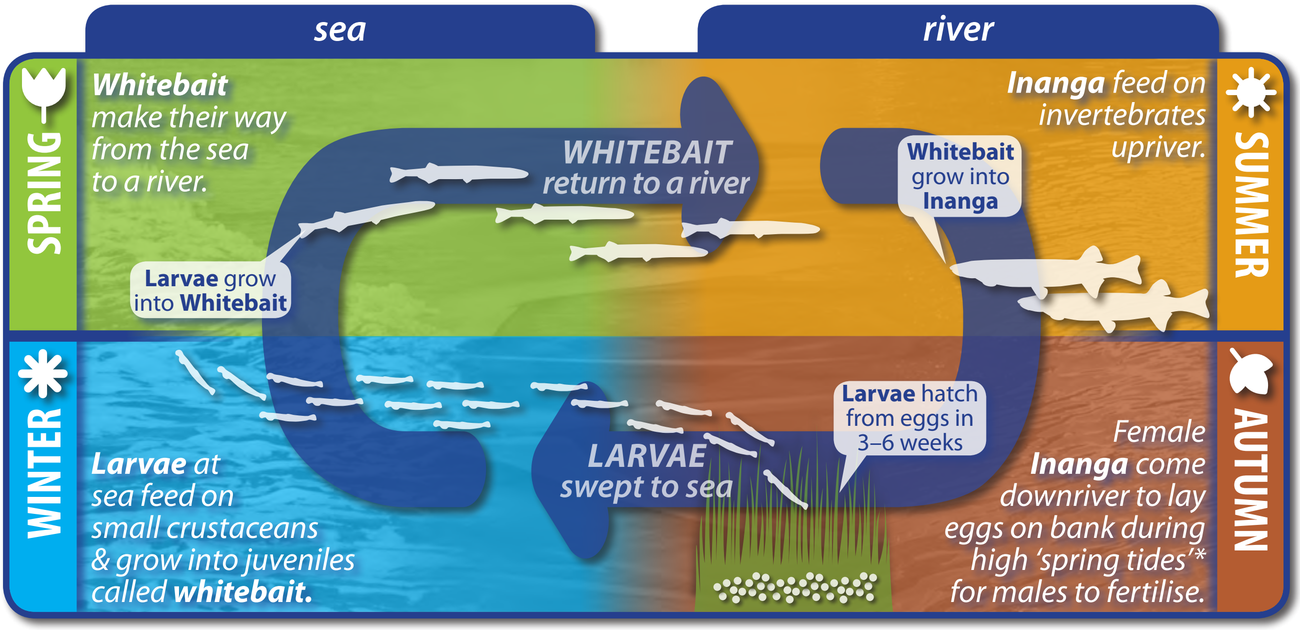
Inanga is the smallest of our whitebait species, growing no longer than 110 mm.

It's the only species that can't climb barriers – which means it has a unique set of requirements for survival.

They are diadromous – meaning they live in marine and freshwater environments.



Inanga lifecycle



* SPRING TIDE – a tide just after a new or full moon, when there is the greatest difference between high & low water

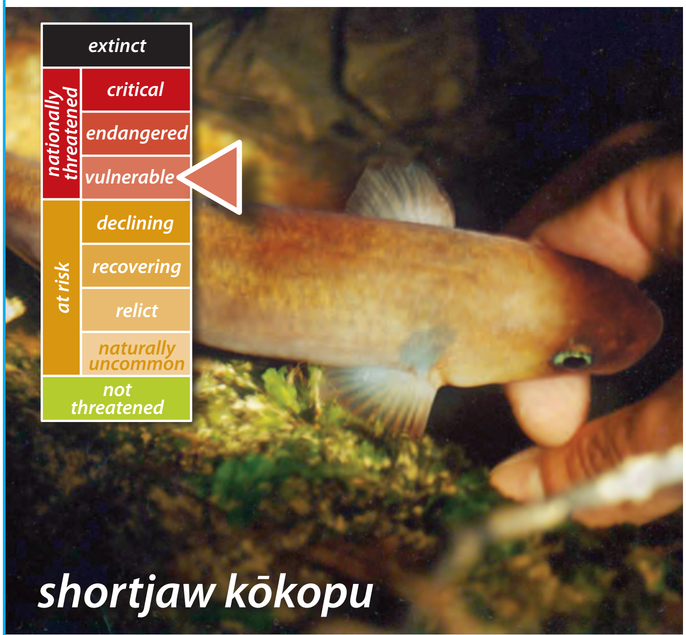
During their spawning season in late summer/autumn female inanga will lay 1,500–3,000 eggs. They are tiny – each egg being just 0.8–1.25 mm in size.

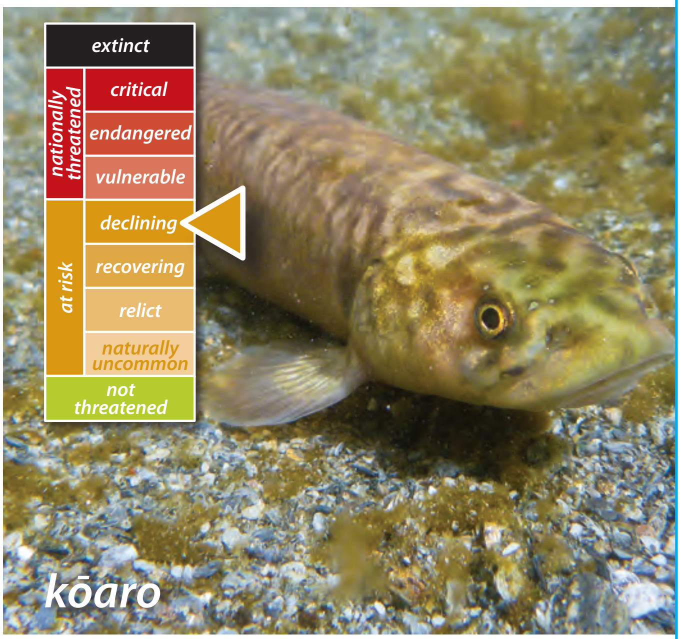
After a month they will hatch into 7 mm long larvae. For the first week they feed on their attached yolk sac, then they start to feed on small plants and animals. They head out to sea for up to six months. Having lots of larvae and sending them out to sea is the inanga version of "not putting all your eggs in one basket" i.e., if bad things happen then they won't all be lost.

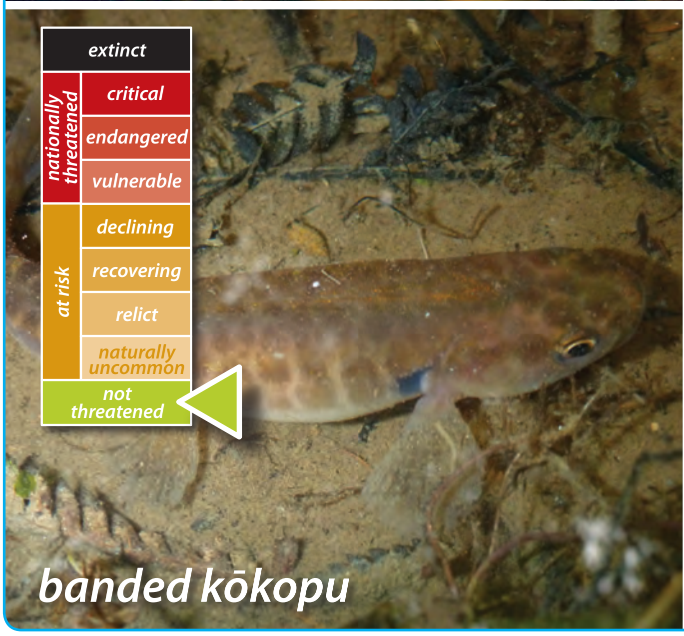
The six-month old juveniles (now called 'whitebait') find their way to rivers in large groups/shoals by smelling the freshwater. They swim upriver, but are weak swimmers and can't climb up barriers e.g., rapids, waterfalls/weirs/culverts etc. Most of the whitebait don't survive this journey as they starve, get eaten by predators or are caught by whitebaiters.

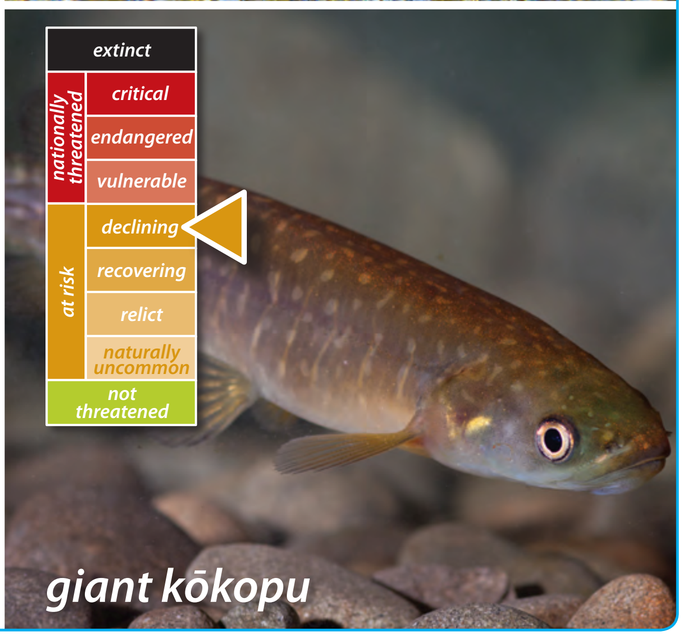
They mature into adults in the river for about six months. They are ready to head back downstream and lay their own eggs (spawn) after a year.

The 5 whitebait species in New Zealand

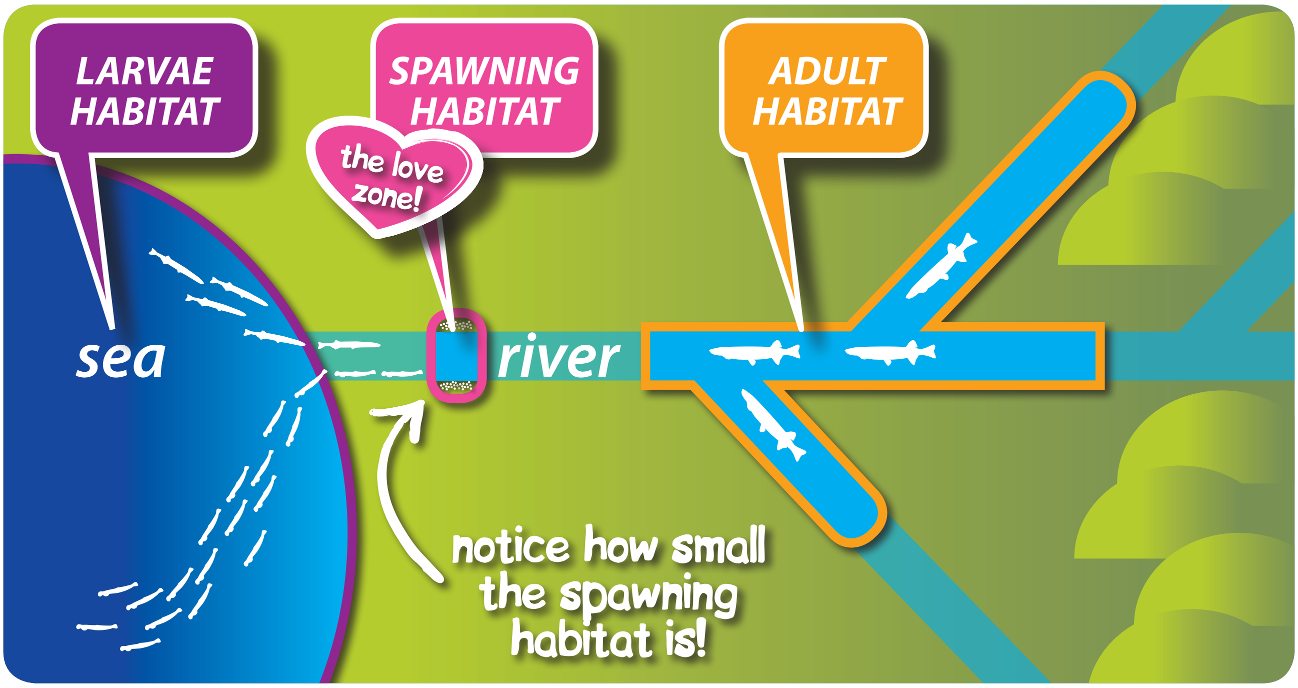






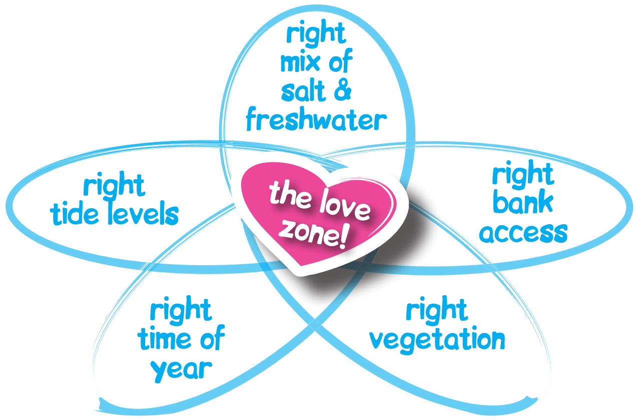


WHERE inanga live & like to lay their eggs:



Getting the right spawning habitat – 'the love zone' – is a delicate balance of a number of conditions.

Issues include adult inanga being vulnerable to predators when they swim into the shallow water to spawn – so emergent vegetation gives them some protection from hungry eels and wading birds. Inanga eggs need to stay cool and damp while they are out of the water. Canopy and bankside vegetation covering the eggs act like an umbrella during the day and a blanket at night.



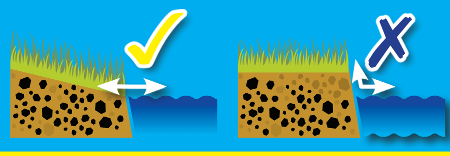
IDEAL INANGA SPAWNING HABITAT

Right distance from estuary/sea

Some stretches of this waterway are optimal for inanga spawning due to their location in relation to the sea. Spawning occurs in areas where high spring tides can reach, but the water isn't too salty. During spring tides inanga can lay their eggs in vegetation high up the riverbanks, above the normal river flow height.

Gently sloping bank

Ideally the riverbank will be a gentle slope rather than a steep edge. This means there is more accessible bank area for inanga to lay their eggs on during the high spring tide.

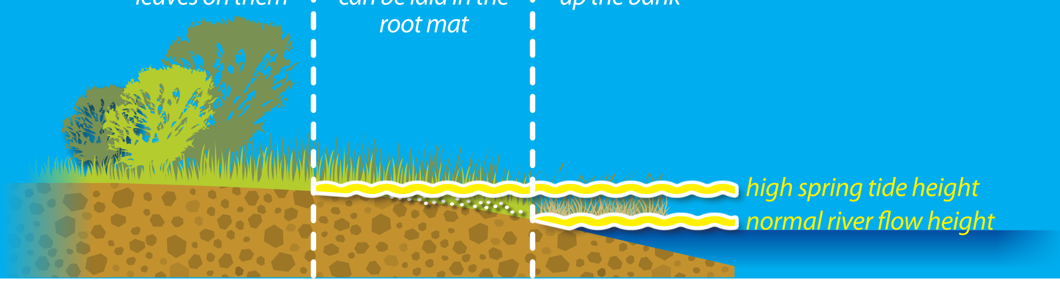


Good bank vegetation

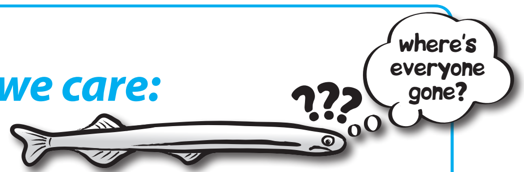
Canopy of native trees/shrubs *– provide shade for eggs while not dropping lots of leaves on them*

Tall thick grass *– so inanga eggs can be laid in the root mat*

Plants rising from water *– for inanga to hide in until high tide takes them up the bank*



WHY inanga numbers are declining, & why we care:



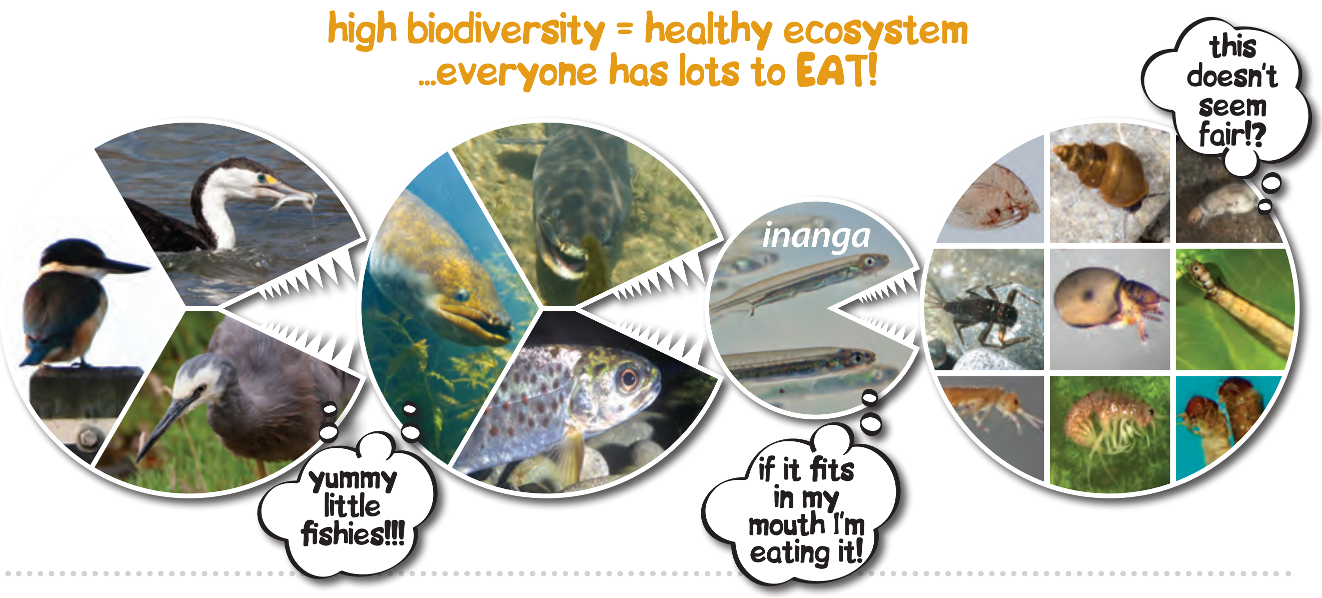
Overall native fish populations in New Zealand are in decline.

Inanga are doing better than most because they are generalists i.e., they are flexible in where they live and what they eat. Part of the problem is the damage we have done to the spawning habitat of the species that makes up over 90% of the whitebait catch.

Unfortunately, the habitat needed for the eggs to survive is often damaged or absent.

Less eggs = less inanga!

Also, introduced predators (particularly trout) eat lots of adults and change their behaviour meaning the inanga are not so successful at foraging for food.



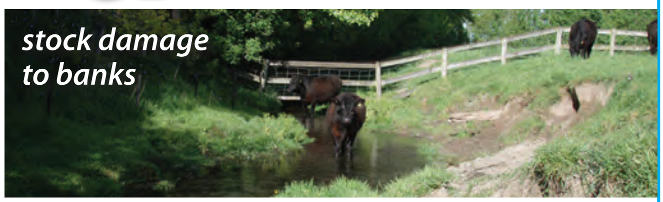
Damage to inanga habitats include, but are not limited to...

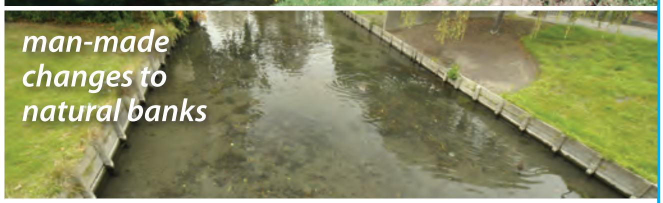
Spawning habitat:

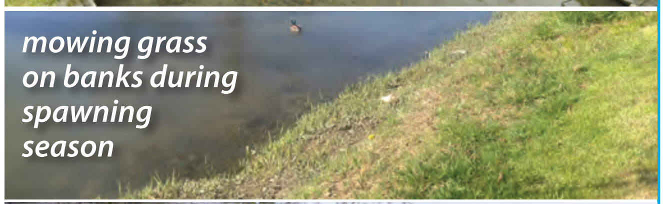
- *Farm stock damage.*
- *Man-made changes to natural bank structures.*
- *Mowing of the long vegetation on banks during spawning season.*
- *Excessive sediment on banks, smothering vegetation.*
- *Construction of barriers that prevent inanga entering spawning areas e.g., tide gates.*

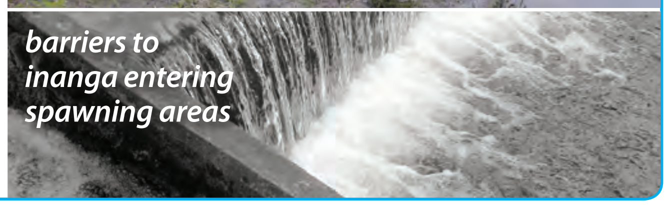
Adult habitat:

- *Construction of barriers that prevent inanga swimming upriver to feed e.g., tide gates, weirs, culverts etc.*









HOW we can help them:

Riverbank vegetation and inanga spawning habitat can be slow to recover from damage.

Inanga always come back to the same spot in the river to spawn, so they will come back to damaged areas and try to spawn...but their eggs will die. Therefore it is imperative that we look after their remaining good spawning areas, and look to improve/restore those already damaged.

Things we can do to help include...

In the short-term:

- *Install temporary straw bale spawning habitat. The moist, cool gap between the bales provides a great temporary place to spawn until longer-term solutions take effect.*

In the long-term:

- *Fence out stock.*
- *Implement riparian planting plan.*
- *Encourage authorities to review maintenance strategies for banks.*
- *Remove tide gates and other barriers to inanga getting upriver.*
- *Inanga eggs are very vulnerable. The only protection they have from being eaten by predators is the vegetation they are developing in. Tall, dense, vegetation hides the eggs and makes access difficult for predators. If you can maintain or restore the vegetation then pests will become less of a problem.*

FURTHER READING & RESOURCES:

- *McDowall, R. M. (1984). The New Zealand Whitebait Book. Wellington, Reed.*
- *Mitchell, C. P. and G. A. Eldon (1991). How to locate and protect whitebait spawning grounds. Rotorua, Freshwater Fisheries Centre.*
- *Richardson, J. and M. J. Taylor (2002). A guide to restoring inanga habitat. NIWA Science and Technology Series 50: 1–29.*

The National Inanga Spawning Education Programme is supported by...

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Inanga/Whitebait
Identifying adults & eggs

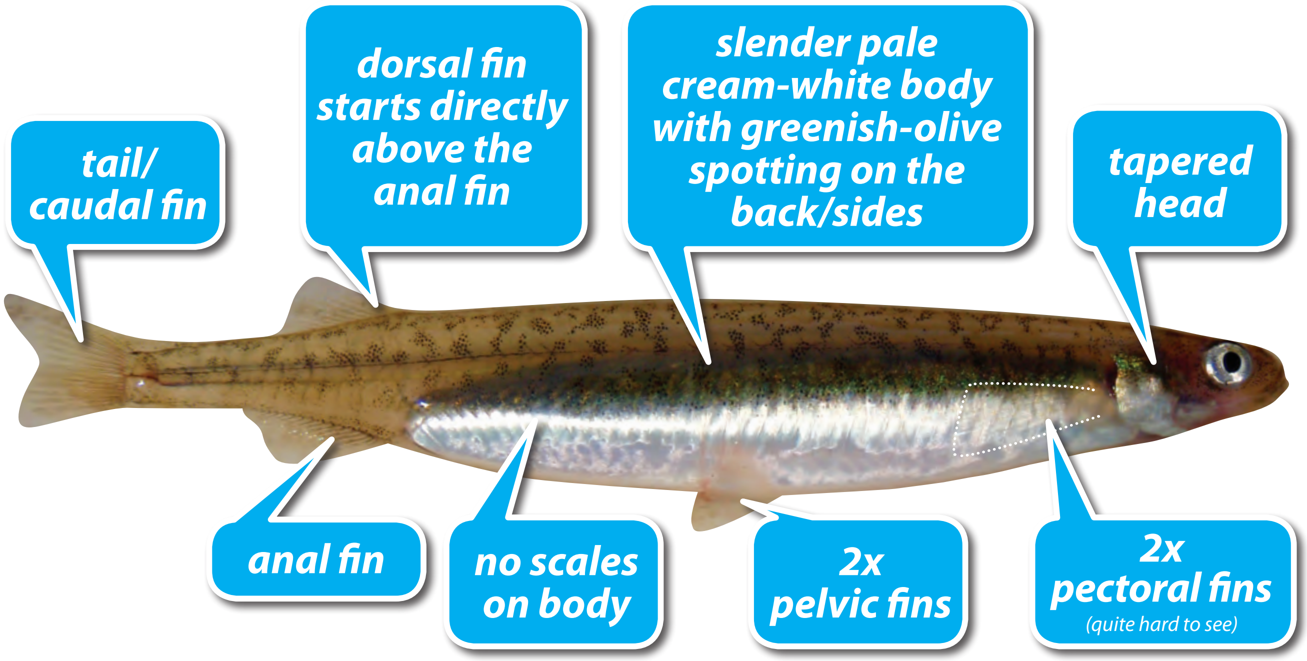
National Inanga Spawning Education Programme from whitebait Connection Xstream about freshwater life eos ECOLOGY

shoaling inanga © EOS Ecology

Adult inanga are easy to identify from other fish species as not many live in the same places, or behave in the same way.

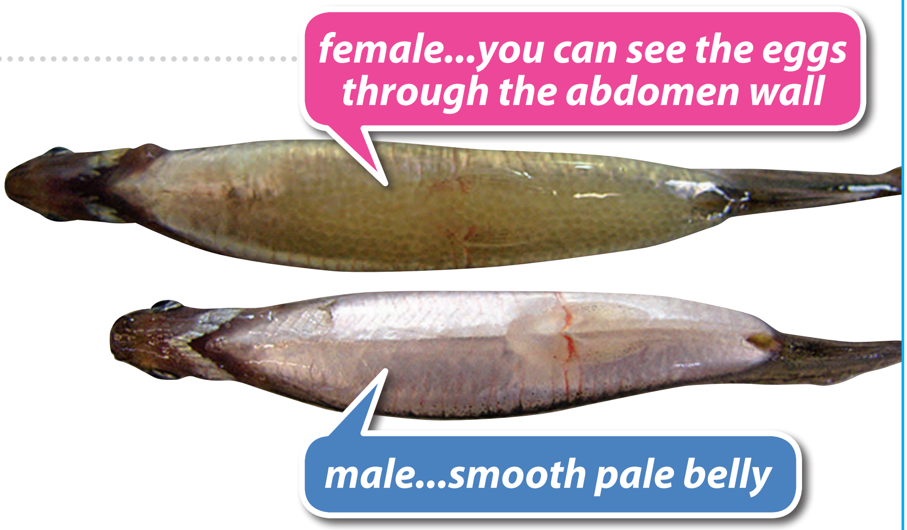
Inanga swim slowly in shoals (schools) in the lower reaches of waterways and are slower moving than smelt or yelloweyed mullet.

Inanga don't get very big. Females are usually bigger than males, but even the biggest females are usually less than 120 mm long.



Telling the sexes apart

Male and female inanga are usually difficult to tell apart externally, but it's easy when they are ready to spawn. You can see the large golden eggs in females through the wall of the abdomen while the males is smooth and pale white.



belly shots © Jess Stevens

Inanga egg ✔

Inanga/whitebait eggs are small (0.8–1.2 mm in diameter), transparent round balls. Once they are a couple of weeks old the inanga embryo eyes can be seen inside as two small black dots.

Slug egg ✖

Slug eggs, at 2–3 mm in diameter, are larger than inanga eggs. They are milky white in colour and more like chicken eggs in shape. Slugs lay their eggs in similar places to inanga and may eat small numbers of inanga eggs.

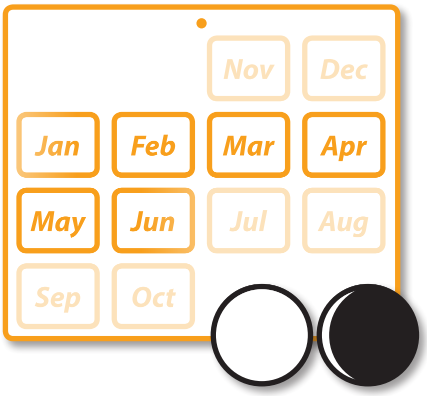
The National Inanga Spawning Education Programme is supported by...

PART 2a: Experience

Inanga/Whitebait

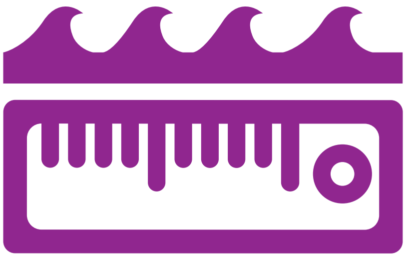
Finding natural spawning sites

National Inanga Spawning Education Programme from whitebait Connection Xstream about freshwater life



WHEN TO LOOK:

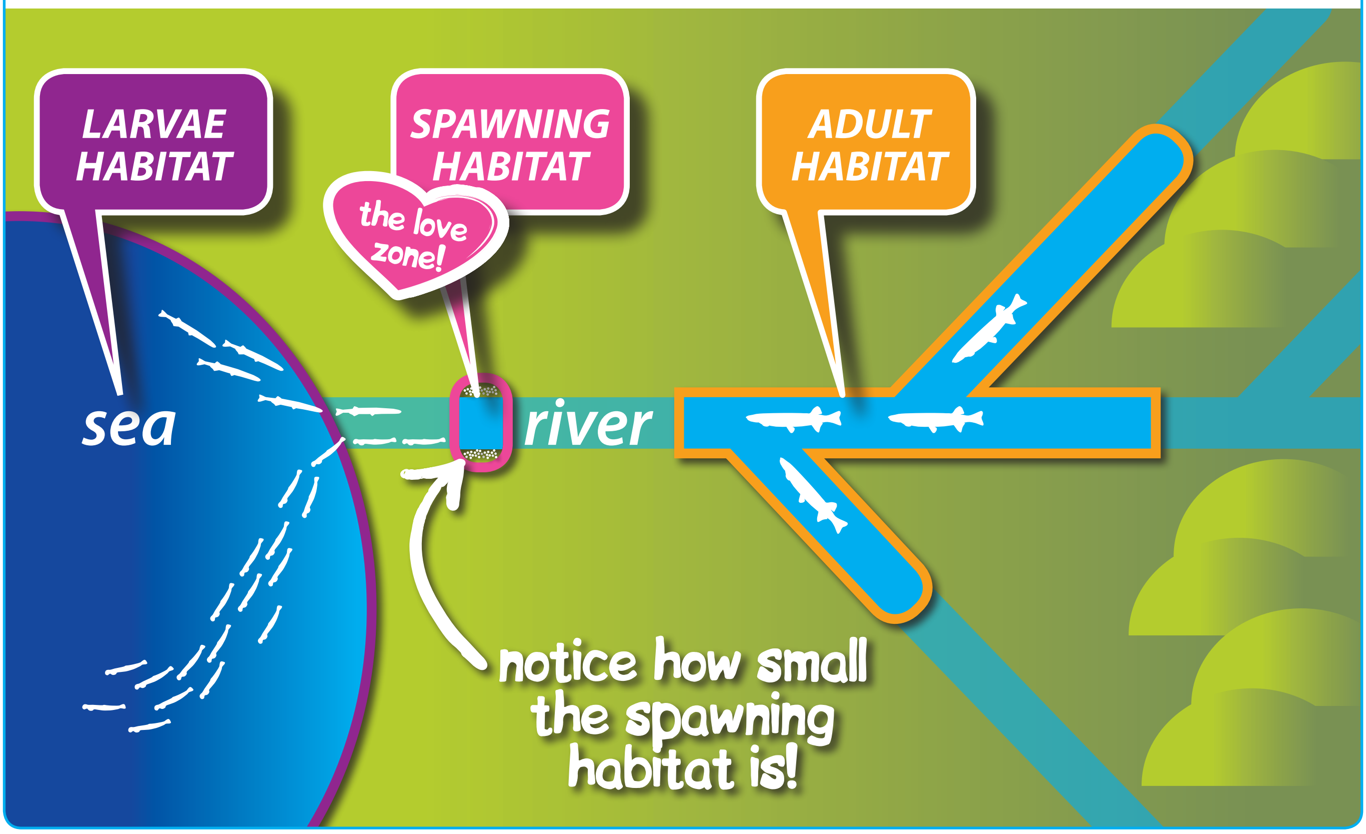
Inanga spawn mainly from late January–early June *(peak levels in April). Eggs are laid over several days just after the new or full moon (sometimes both). The tides are higher than normal at these times (they're called spring tides) and spawning occurs 2–3 days after the highest spring tides. You can use a moon phase calendar and local tide tables to determine when spawning should occur. Before you start looking for eggs, it's best to visit a stream during a spring high tide to mark the high tide water level on the river banks (it's often much higher than you imagine!) –* ***look for eggs at low tide****.*

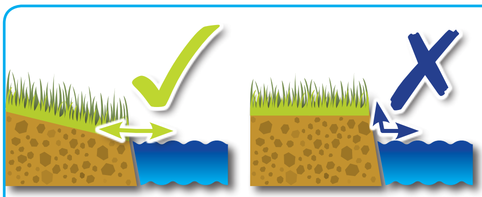


WHERE TO LOOK:

1. Distance from the sea

Inanga spawning often occurs close to the upstream limit of saltwater penetration *– this is usually quite different to the limit of the tide's influence. This can be determined by testing the bottom water in the deepest part of the stream channel at high tide with a salinity meter. Be aware that the extent of saltwater penetration can vary hugely from day to day, the bigger the tide, the further upriver the saltwater will go.*





2. Access to bank

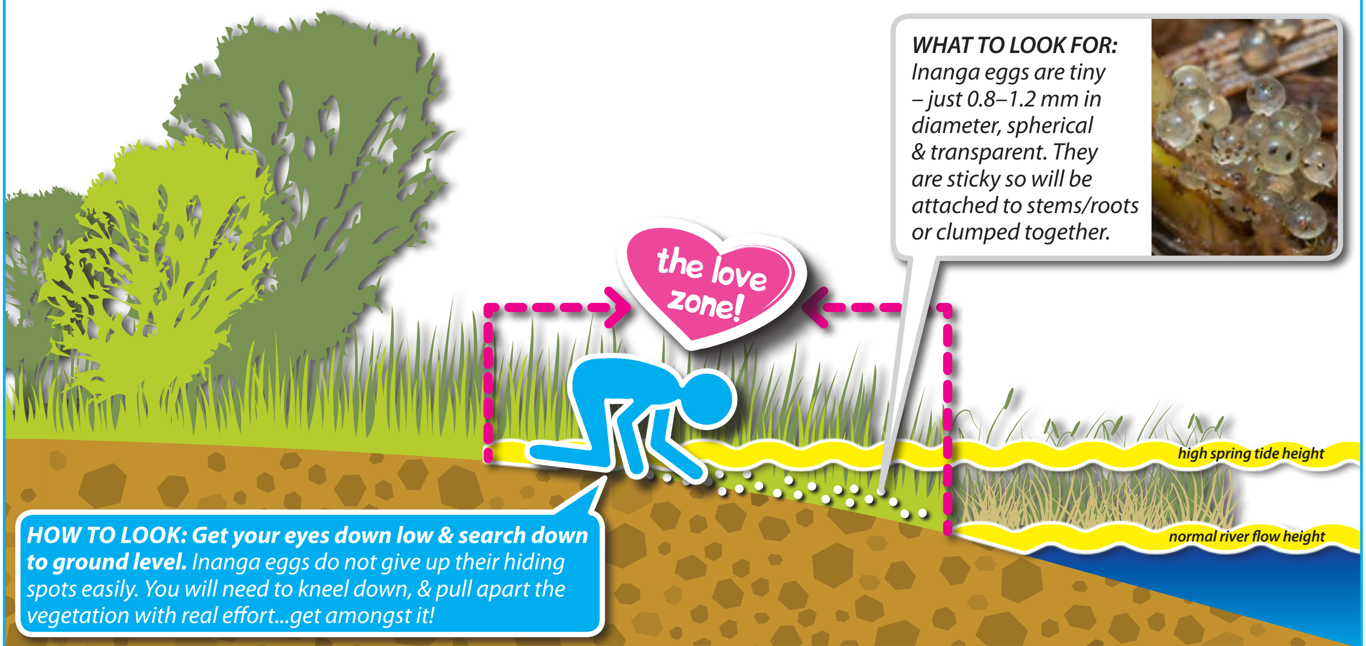
Look for gentle natural slopes that the spring tide can cover.

3. Bank vegetation

Find the upstream limit of salt-tolerant plants and search upstream of this point...*Vegetation also responds to saltwater penetration – the presence of some salt-tolerant plants is an indication that the site may be too salty. Eggs are very rarely found amongst* Cotula coronopifolia *(bachelor's button),* Juncus kraussii *(sea rush),* Apodasmia similis *(jointed wire rush) or* Schoenoplectus pungens *(three-square).*

Focus on the tallest, densest clumps of vegetation, these are the most likely to contain eggs...*Inanga eggs need to stay moist so that oxygen can permeate through the outer layer of the egg and the embryo inside can breathe. Adults prefer to spawn in tall, dense vegetation that buffers temperature and humidity variations and that protects the developing eggs from ultraviolet radiation. Because of their thick aerial root mat and/or dense stems, inanga eggs are* ***commonly*** *found among* Schedonorus phoenix *(tall fescue),* Agrostis stolonifera *(creeping bent) or* Juncus edgariae *(Edgar's rush).*

If the soil is dry or sandy you will not find inanga eggs...*Another clue for finding inanga eggs is moisture. Look on the most shaded bank of the stream first, the vegetation here will be lusher and the soil beneath will be moist.*



FURTHER READING & RESOURCES:

- *Find a moon phase calendar at* ***www.moonconnection.com***
- *Find local tide tables at* ***www.linz.govt.nz/hydro***

- *McDowall, R. M. (1984). The New Zealand Whitebait Book. Wellington, Reed.*
- *Mitchell, C. P. and G. A. Eldon (1991). How to locate and protect whitebait spawning grounds. Rotorua, Freshwater Fisheries Centre*
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Inanga/Whitebait
Find the saltwater wedge

National Inanga Spawning Education Programme from whitebait Connection – Xstream about freshwater life – eos ecology

Inanga spawning sites can be hard to find, but if you can find the ***upstream end of the saltwater wedge*** *it can help focus your search.*

The saltwater wedge is the found where saltwater from the sea merges with freshwater from the river. Saltwater is denser/heavier than freshwater due to its mineral content, so it stays on the riverbed while the freshwater floats over top. This leaves a wedge-shaped area of salty water underneath the fresh river water – called the saltwater wedge.

What is salinity?

- *Salinity tells you the mass of dissolved salts in the water – usually expressed as parts per thousand (ppt) – seawater around NZ has a salinity of about 35 ppt.*
- *About 90% of the dissolved salts are sodium chloride (table salt) the other salts are are made up of chlorine, sodium, magnesium, sulphur, calcium and potassium*
- *Freshwater has a salinity of less than 0.5 ppt.*

To find the upstream edge of the saltwater wedge we have to test the salinity of the water at the bottom (on the bed) of the river.

To do this you will need:

salinity meter *(a cable/pole for the unit, or a way of collecting water from deeper water may be useful)*

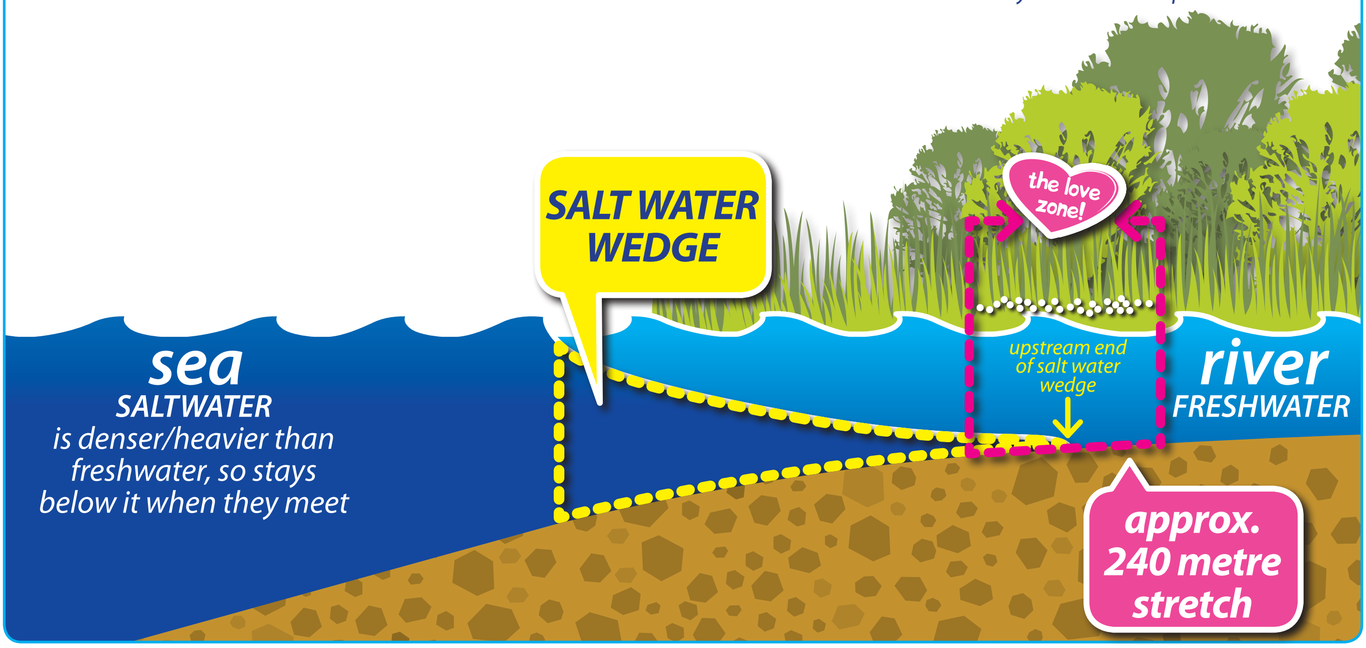
Salinity meters can be obtained from NIWA Instrument Systems, Envco or similar instrument suppliers. Or, you could contact your local City or Regional Council and see if they will assist you.

GPS unit

note-taking equipment *(or a data recording sheet, see next page for an example)*

kayak *(might be useful in deep/wide rivers)*

Ensure you follow best-practice health and safety protocols when using kayaks, e.g., using approved kayak instructors, ensuring there are at least two of you in case of capsize etc.



Procedure for TESTING SALINITY:

Step 1. Find when the next high spring tide is from your local tide table. This is when you'll need to do your testing.

Step 2. **DAY 1**
Head to the LOWER END of the waterway well before the predicted high spring tide time.

Step 3. LOWER the salinity meter probe to the bottom of the DEEPEST part of the river, wait until the reading stabilises and record the salinity/time/GPS location location – make sure you record this as the 'bottom' salinity.

Step 4. LIFT the salinity meter probe up to the surface at the same spot, wait until the reading stabilises then record the salinity/time/GPS location again – make sure you record this as 'surface' salinity.

Step 5. MOVE UPSTREAM slightly and repeat steps 3 & 4. If the readings are similar to your first location double the distance to the next location upstream and repeat stepts 3 & 4 again.

Step 6. Continue to REPEAT STEP 5 until the salinity readings start to lower, then lower the distance between locations again.

Step 7. Once the 'bottom' salinity drops below 0.5 ppt the PREVIOUS location tested downstream is then marked as todays 'upstream edge of the saltwater wedge'.

Step 8. **NEXT DAY/S**
REPEAT steps 1–7, but try and time your survey to arrive at your 'upstream edge of saltwater wedge' location from yesterday closer to high tide.

Other TIPS:

- Make sure the salinity meter is calibrated – put the probe in the ocean and it should read approximately 35 ppt, put it in a glass of tapwater and it should read less than 0.5 ppt.
- Use bridges to take readings in the middle of the river.
- Make sure you rinse the salinity probe under tapwater at the end of the day.
- Watch out for stuctures in the river (e.g. tide gates/weirs) that stop the upstream movement of saltwater.
- It takes time for the saltwater to make its way upstream. The saltwater wedge might keep moving upstream well after the time the tide was predicted to be high at the river mouth or a nearby port.
- The tide coming into a river acts like a dam and pushes against the flow of the river. The freshwater may be held back some distance further up from the upstream edge of the saltwater wedge.
- The position of the saltwater wedge is affected by how big the tide actually is THAT DAY (see next point) and the flow of the river THAT DAY – so you will probably need to average its position over several days.
- Tide tables tell you when and how big the high tide SHOULD be on that day, but the actual high tide is massively influenced by the weather and air pressure – high air pressure and offshore winds can make the actual tide much smaller than was predicted in tide timetables.

FURTHER READING & RESOURCES:

- Find a moon phase calendar at **www.moonconnection.com**
- Find local tide tables at **www.linz.govt.nz/hydro**

The National Inanga Spawning Education Programme is supported by...

Saltwater Limit Survey

METADATA	
Waterway name:	**Catchment name:**
Date (DD/MM/YY):	**Observers names:**
Nearest standard port:	**Predicted time of high tide (HH:MM):**
Current local atmospheric pressure (hPa):	**Observed time of high tide (HH:MM):**
Any impediments to tidal flow? (if yes, provide details) **Unknown / No / Yes:**	**Flow condition:** **Low / Normal / High / Unknown**

OBSERVATION DATA		
Did this survey include a search for evidence of inanga spawning: Yes / No		
What was observed? **Spawning / Eggs / Both / Neither**	**Any previous spawning records for this site?** **Yes / No / Unknown**	**Relative to the spawning site, the saltwater limit is** **Upstream / Downstream / Adjacent / Unknown**

SALINITY DATA

Observed location of saltwater limit:: **Easting (NZTM):** **Northing (NZTM):**

#	Waypoint	Time (HH:MM)	Easting (NZTM)	Northing (NZTM)	Channel TL/Centre/TR	Depth (m)	Salinity (ppt) Bottom	Mid-water	Surface
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

Supporting documents

Photo filenames:

Sketch of site

Sketch should include survey extent, spawning sites, impediments to flow/passage, saltwater limit, vegetation types, land use, photo points, GPS points

NOTES FOR OBSERVERS

METADATA

Waterway name: *name of the waterway that was surveyed*

Catchment name: *as published in Catchments of New Zealand (1956)*

Date: *date on which the field component of the survey was completed*

Observers names: *for verification of survey results*

Nearest Standard (or Secondary) port: *see www.linz.govt.nz for lists of Standard and associated Secondary ports*

Predicted time of high tides at nearest port: *see www.linz.govt.nz for tidal predictions at the nearest port*

Current local atmospheric pressure: *atmospheric air pressure can alter local tidal amplitude significantly*

Observed time of high water at survey site: *time that you observed water levels to peak at the survey site*

Any impediments to tidal flow: *is there a culvert, tide gate, sand bar etc that could impede tidal flow?*

Flow conditions*: is the waterway obviously above or below normal flow conditions?*

OBSERVATION DATA

Did this survey include a search for evidence of inanga spawning?

Did you actively search for eggs or see spawning?

What was observed?

Eggs found, spawning seen, both or neither

Has spawning been recorded in this waterway previously? *Is there any record of previous spawning in this waterway?*

SALINITY DATA

Observed location of saltwater limit:

from the data set collected, where is the upstream limit of saltwater

For each location that you measure the salinity, enter the following data:

Time:	*time that the measurement was taken*
Easting:	*longitude of the measurement site from GPS using the NZTM coordinate system*
Northing:	*latitude of the measurement site from GPS using the NZTM coordinate system*
Channel:	*indicate where in the channel the salinity measurement was taken - true left, centre or true right*
Depth:	*how deep was the water at the site where the salinity measurement was taken?*
Salinity:	*what was the salinity at the bottom, in mid-water and at the surface?*

PART 2c: Experience

Inanga/Whitebait
Assessing spawning habitat

National Inanga Spawning Education Programme from

Most females inanga only have one opportunity to spawn. If she finds good quality spawning habitat then about 80% of those eggs will survive to start their journey to becoming a whitebait – but if she doesn't find good quality habitat then all of those potential whitebait might be lost.

Historical spawning habitat

*At the time of European settlement of New Zealand, the tidally influenced riparian vegetation in inanga spawning areas likely comprised of tall overarching forest and scrub (e.g., kowhai (*Sophora *spp.), patē (*Schefflera digitate*), manatu (*Plagianthus regius*), kahikatea (*Podocarpus dacrydioides*), and ti kouka (*Cordyline australis*), and tall tussock species (e.g., harakeke (*Phormium tenax*), tussock sedges (*Carex secta, C. virgata*), and wiwi (*Juncus edgariae*)).*

This canopy shaded and sheltered the banks, and supported a loose undergrowth of sedges, herbs and mosses.

It was within the root masses of these sedges and herbs, and associated plant litter, that inanga spawned.

Contemporary spawning habitat

Most riparian zones in New Zealand, and their associated inanga spawning sites, are now dominated by a suite of exotic grasses.

*Inanga eggs are frequently attached to tall fescue (*Schedonorus phoenix*) with creeping bent (*Agrostis stolonifera*) and Yorkshire fog (*Holcus lanatus*) usually comprising much lower proportions.*

*Exotic herbs favoured at spawning sites include clover (*Trifolium *spp.), monkey musk (*Mimulus guttatus*) and buttercup (*Rununculus *sp.), but these plants rarely dominate the riparian plant community.*

HOW TO ASSESS GOOD HABITAT YOURSELF

If you are looking for natural spawning sites, or planning to put in some temporary spawning habitat, then knowing what you're looking at is vital.

*On the next two pages you'll find an '**Inanga spawning habitat assessment sheet**' that will help you with this. You will need one assessment sheet per site.*

Once you have filled out your location's particulars at the top, there are guidelines to help you assess your site. It covers off twelve different attribute criteria and helps you assign points for your sites current state.

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The National Inanga Spawning Education Programme is supported by...

Inanga spawning habitat assessment sheet

National Inanga Spawning Education Programme from whitebait Connection Xstream about freshwater life

*Date:*__________________ *Time:*__________________ *Person:*____________________________________

Organisation *(e.g. school name etc.)*: ____

*River name:*____ *River bank* *(circle one)*: ***true-right*** [1] ***/ true-left*** [1]

Site location on river: *(choose a permanent marker on the river as a site marker, e.g. a bridge)*

Upstream / downstream *(circle one)* *end of site is*____________*metres,* ***upstream / downstream*** *(circle one)*

of *(name the site marker)*____

Downstream GPS coords: *Northing:*__________________________ *Easting:*___________________________

Survey length (metres): ____

Pre-start check list:

- ☐ *I have assessed all site hazards & dealt with H&S matters*
- ☐ *I have checked for saltwater/fish access issues downstream*
- ☐ *I am in 'the love zone" (i.e., spawning reach) for this river* [2]
- ☐ *I know where the 'highwater mark' is at my site* [2]
- ☐ *I am assessing the site at the right time of year* [2] *(i.e., in spawning season)*

My site is within a *(circle one)*: ***natural area / rural area / urban area / other*** *(specify)*____________________

HABITAT ASSESSMENT *(tick ONE score per line item i.e., either 0, 5 or 10 points – then write the score in the righthand column)*

Score: → ***Attributes:*** ↓	***0 points*** ***= BAD*** *no good for spawning, or if spawning occurs none of the eggs will survive*	***5 points*** ***= OK*** *spawning will occur but improvement will increase spawning and egg survival*	***10 points*** ***= GOOD*** *good spawning and egg survival*	***Your points:*** *write each attributes points here* ↓
fish access *Check the river between your spawning site and the sea to find out if there is anything stopping the upstream movement of inanga.*	*tide gate, weir, or other significant barrier to upstream movement of inanga*	*small drop culvert, section of piped stream, or a partially open tide gate*	*no barriers*	
saltwater access *Check the river between your spawning site and the sea to find out if there is anything stopping the upstream movement of saltwater.*	*tide gate, weir, or other significant barrier to saltwater*	*small drop culvert, section of piped stream, or a partially open tide gate*	*no barriers*	
bank angle *Take the average bank angle over a 1 m band that spans the high spring tide mark. Lay a metre long ruler/pole over the ground (lying perpendicular to the water's edge) and measure your angle off that. Pick a location within your spawning site that is representative or take several measurements and then take an average of those.*	*less than 7˚ angle OR more than 35˚ angle*	*between 21–35˚ angle*	*between 7–20˚ angle*	

[1] *The left and right when looking downstream.*

[2] *See the 'Inanga/whitebait – Finding natural spawning sites' info sheet for more information.*

...continued over page...

HABITAT ASSESSMENT continued... *(tick ONE score per line item i.e., either 0, 5 or 10 points – then write the score in the righthand column)*

Score: → **Attributes:** ↓	***0 points*** **= BAD** *no good for spawning, or if spawning occurs none of the eggs will survive*	***5 points*** **= OK** *spawning will occur but improvement will increase spawning and egg survival*	***10 points*** **= GOOD** *good spawning and egg survival*	***Your points:*** *write each attributes points here* ↓
bank material *What is the DOMINANT material (inorganic) that forms the bank? Assess this over a 1m band that spans the high spring tide mark.*	*continuous bare rocks, rip-rap, gravel, sand, mud, concrete or wood*	*mainly patches of earth/loam (soil) but with other material mixed in*	*continuous earth/loam (soil)*	
vegetation cover *How much of the ground is covered by living vegetation (i.e., how much of the bare ground underneath is hidden by growing plants). Assess this over a 1m band that spans the high spring tide mark.*	*Less than 50%*	*between 50–75%*	*more than 75%*	
vegetation height *Take the average of the main/ DOMINANT vegetation in the area. Ignore smaller discrete clumps of larger vegetation. Assess over a 1 m band that spans the high spring tide mark. Measure to the top of where the growth starts to thin out i.e., ignore feathery taller tops.*	*less than 10 cm* *(plants are too short and won't be able to keep the ground moist)* *more than 50 cm* *(plants are likely too big to be any good as spawning habitat)*	*between 10–20 cm*	*between 21–50 cm*	
vegetation type *Select the DOMINANT vegetation type in that band. Assess this over a 1m band that spans the high spring tide mark.*	*large woody plants* *(trees, gorse, blackberry, shrubs), yellow-flag iris, herbs*	*raupo, flax, carex*	*pasture grasses/rushes* *better types for spawning are tall fescue (*Schedonorus phoenix*), creeping bent (*Agrostis stolonifera*), and Edgar's rush (*Juncus edgariae*)*	
root mat thickness *Use your hands to pull apart the vegetation until you can see the ground. How thick are the vegetation and roots at ground-level? Assess this over a 1m band that spans the high spring tide mark.*	*Vegetation is very easy to pull apart, no roots growing over the ground surface, low density of plant stems, can see bits of the ground even before you start pulling the plants.*	*When you pull apart the plant stems you can see areas of bare soil.* *(i.e., little coverage of root mats over the ground surface)*	*Vegetation is hard to pull apart. Lots of roots/stems at ground level.* *(i.e., it is hard to get to the soil below the root mats)*	
ground moisture *Check the ground at the base of the vegetation to see how damp it is. Assess this over a 1 m band that spans the high spring tide mark.*	*very dry and dusty*	*dry in some places*	*damp or wet*	
cover for fish *Adult fish congregate before spawning time and need lots of cover to protect them from natural predators. Look in the area between your 1m band and down into the water at the bank. Is there any vegetation growing there, or are any plants overhanging the banks, or large logs or boulders in the water that might provide cover for adult fish?*		*NO fish cover* ***OR*** *only ONE of the following:* *– tall plants that would be emergent at high tide* *– large plants closely over-hanging the water* *– submerged aquatic plants* *– logs or large boulders in the water*	*At least TWO of the following:* *– tall plants that would be emergent at high tide* *– large plants closely over-hanging the water* *– submerged aquatic plants* *– logs or large boulders in the water*	
bank maintenance *Are the banks mowed regularly so that the grass is always short at your spawning site?*	*banks regularly mowed and grass kept short*		*banks rarely mowed, or mowed more than 2 months before the inanga spawning season*	
livestock protection ***(for rural areas only)*** *Is your spawning site fenced to prevent livestock access?*	*No sign of any fence of any type; livestock can readily access the banks. There is sign of recent damage from livestock access.*	*There is a temporary fence installed, but no permanent one* *(i.e., an electric wire on temporary stakes)* *OR* *there is a fence but it is damaged or there is an open gate that allows livestock access to the site* *(meaning that livestock can get in)*	*There is a permanent fence that prevents livestock from accessing the site at all times. There is no sign of recent damage from livestock access.*	

TALLY UP ALL YOUR ATTRIBUTE POINTS FROM BOTH PAGES HERE →

- ***A score of 90–120 indicates that the spawning habitat is in good condition for spawning!***
- ***A score of 55–90 indicates that the spawning habitat is OK, but would be better with improvements.***
- ***If you a 0 score for ANY of the attributes then spawning is UNLIKELY to occur – needs improvements.***

Inanga/Whitebait
Counting eggs – assess spawning activity

National Inanga Spawning Education Programme from whitebait Connection Xstream about freshwater life

Counting how many inanga eggs are laid in 'the love zone' over a spawning season is a great way to assess spawning activity, and compare activity over time.

We use a simple scientific method called 'random stratified sampling' to 'quantify' the number of eggs per site. You don't have to try and count every single inanga egg on the bank or in the temporary straw bale habitat you've previously installed ! This makes the process faster and more consistent between sites.

Quantifying eggs in NATURAL HABITAT:

You've already found 'the Love Zone' * *(so you know the section of river where you're most likely to find eggs), it's low tide, and you're ready for an inanga egg hunt.*

First you need to define the AREA *of the 'patch' of eggs. An egg patch can be made up of lots of smaller 'clumps' of eggs. As long as clumps are less than 1 m apart they are considered to be part of the same patch.*

Once you've measured the length of your patch, and you know the average width of all egg clumps in the patch, then you can calculate the AREA of egg coverage with this equation:

AREA *(m^2 of the patch with eggs) =*
patch length × average clump width**

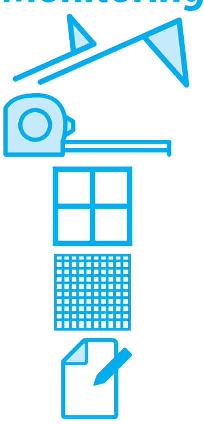
Next, estimate the NUMBER OF EGGS *in the whole patch by doing representative sample counts of individual eggs within a small space. We scale up these small sample numbers later.*

Within your egg patch RANDOMLY (don't purposefully look for eggs) place a 10×10 cm wire quadrat. If there are less than 200-odd eggs within the whole quadrat count them all – but, if there are more, use the 10×10 cm wire quadrat with 1 cm grid squares, and count all the eggs within only 5 random squares (so 5 out of 100 squares in the grid) then multiply by 20. If there's no eggs in a square just record zero.

DENSITY *(eggs per m^2 per patch) =*
average number of eggs in all quadrat counts**** ***× 100***

PRODUCTIVITY *(number of egg patch) =*
AREA × DENSITY

Monitoring equipment needed:



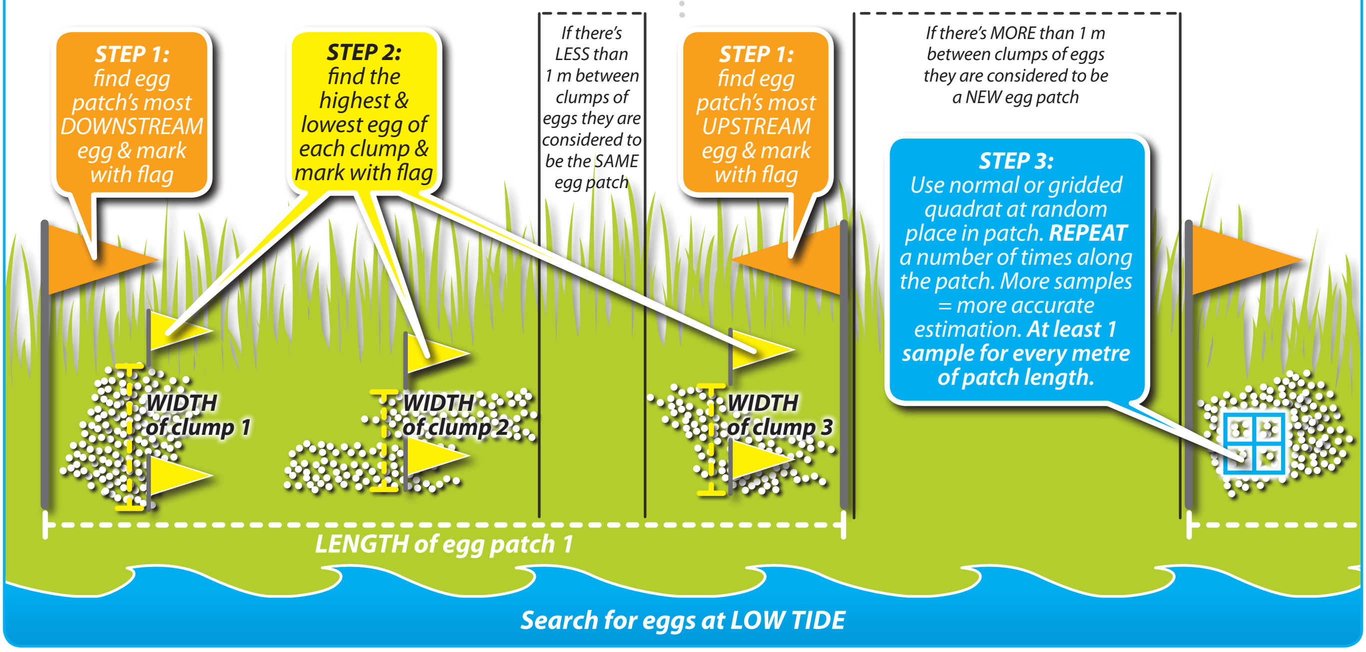
flags/flagging tape

tape measure

10×10 cm wire quadrat

10×10 cm wire quadrat with 1 cm grid squares

equipment to record data

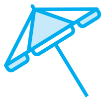


* see 'Further Reading & Resources' if you don't know what/where 'the Love Zone' is
** average clump width = all clump widths added together then divided by number of clumps
*** average number of eggs = all quadrat totals for that patch added together then divided by the number of quadrats counted

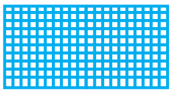
Quantifying eggs in TEMPORARY STRAW BALE HABITAT:

If you have previously installed temporary straw bale habitats on your waterway, use the same method for quantifying the AREA of egg coverage, and the DENSITY of egg coverage as you would in the natural environment – just with the systematic method explained here...

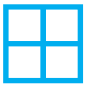
Monitoring equipment needed:



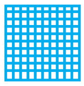
sun umbrella



1×0.5 m AREA grid with 5×5 cm grid squares



10×10 cm DENSITY quadrat



10×10 cm DENSITY quadrat with 1×1 cm grid squares

equipment to record data

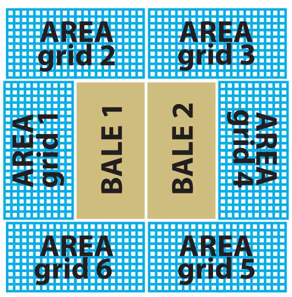
You will also need all the equipment to remove and replace the bales as needed. See 'Further Reading & Resources'.

SURVEY METHOD (the order to work in):

Before you start – ALWAYS ensure bales are shaded from the sun*. Eggs dry out and die very quickly in the sun.*

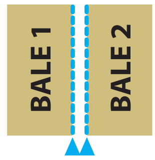
Using a sun umbrella to protect any eggs found while checking 0.5 m ground perimeter around bales.

***Surface 1:* First, check the 0.5 m perimeter of ground around the bales for eggs.**



- *IF YOU DON'T FIND EGGS just record a zero on your data sheet and continue to surface 2.*
- *IF YOU DO FIND EGGS – follow the 1) AREA, then 2) DENSITY count methods explained on the next page. This will involve you placing the large 1x0.5 m grid with 5x5 cm grid squares 6 times to cover the whole perimeter. Once you've done the area & density counts move to surface 2.*

***Surface 2:* Next, check the bale interior surfaces for eggs.** *The interior surfaces are the sides where the bales touch each other in the middle.*



2x bale interior surfaces

- *IF YOU DON'T FIND EGGS just record a zero on your data sheet and continue to surface 3.*
- *IF YOU DO FIND EGGS – follow the 1) AREA, then 2) DENSITY count methods explained on the next page. This will entail you placing the large 1x0.5 m grid with 5x5 cm grid squares twice – once on each bale.*

Checking the interior surface of a bale for eggs.

Be careful *when rolling the bales to ensure they don't fall apart/damage eggs.*

***Surface 3:* Lastly, check the ground underneath the bales for eggs.**

- *IF YOU DON'T FIND EGGS just record a zero on your data sheet and you are finished for this site.*
- *IF YOU DO FIND EGGS – follow the 1) AREA, then 2) DENSITY count methods explained on the next page. This will entail you placing the large 1x0.5 m grid with 5x5 cm grid squares twice – once on the ground underneath each bale. If it looks like the eggs have stuck/or been laid on the bottom of the bale instead of the ground, then use the bottom of the bale INSTEAD of the ground underneath the bale. Only count one of these – don't count both.*

Checking the ground under the bale for eggs.

AREA & DENSITY COUNTING METHODS FOR WHEN YOU DO FIND EGGS:

When eggs ARE found use your quadrats to do 1) AREA and 2) DENSITY counts. *These counts allow you to estimate:*

– ***AREA*** *of egg coverage = m² of the bale set with eggs*

– ***DENSITY*** *of eggs = eggs per m² per bale set*

– *egg* ***PRODUCTIVITY*** *= number of eggs per bale set*

Doing a DENSITY count with the 10×10 cm quadrat with 1×1 cm squares on the interior surface of a bale.

1) DEFINE AREA (counting grid squares): *1×0.5 m large area grid with 5×5 cm squares*

Using the large AREA grid on the ground around the bales.

Using the large AREA grid on an interior bale surface.

If you find eggs – apply the large AREA grid to the area you found them....1) grass around the bales, 2) the interior surfaces of the bales, and 3) the ground underneath the bales (as described in the Survey Method on previous page). Count the number of 5×5 cm grid squares that have eggs in them. You will repeat this 6 times on the grass (to cover the whole perimeter), once on each of the two bales interior surfaces, and once underneath each of the two bales. You can then calculate the...

AREA = number of grid squares with eggs × 0.0025

2) DEFINE DENSITY (counting eggs): *Use ONE of the following methods to do a representative egg count. Repeat up to 3 times per surface in different random spots. Record totals of all your quadrat counts. If there's no eggs in a quadrat/square just record a zero on your data sheet.*

if LESS than 200-odd eggs use the 10×10 cm quadrat

*Count **all** the eggs within the **whole** quadrat (i.e., all 4 squares). This gives you the total for this quadrat count.*

OR

if MORE than 200-odd eggs use the 10×10 cm quadrat with 1×1 cm squares

*Count **all** the eggs in only **5** random grid squares, then **multiply that number by 20**. This gives you the total for this quadrat count.*

Once you've completed all the appropriate small quadrat counts and found your averages you can then calculate the...*

DENSITY = average* number of eggs in all quadrat counts x 100
PRODUCTIVITY = AREA × DENSITY

** Average = all quadrat totals for that bale set added together then divided by the number of quadrats counted*

FURTHER READING & RESOURCES:

- *To find instructions on how to find 'the love zone' see Whitebait Connection (WBC) National Inanga Spawning Education Programme (NISP) resource 2a: Finding natural spawning sites.*
- *For list of equipment required when shifting bales see WBC NISP resource 3a: Install temporary spawning habitat.*
- *Find local tide tables at **www.linz.govt.nz/hydro***

The National Inanga Spawning Education Programme is supported by...

whitebait Connection Xstream about freshwater life · Mountains-To-Sea Conservation Trust · CURIOUS MINDS HE HIHIRI I TE MAHARA · Department of Conservation Te Papa Atawhai · EOS ECOLOGY AQUATIC SCIENCE & VISUAL COMMUNICATION · WE ♥ WHITEBAIT WHAKA INAKA : CAUSING WHITEBAIT · MARINE ECOLOGY RESEARCH GROUP

PART 3a: Action

Inanga/Whitebait

Install temporary spawning habitat

National Inanga Spawning Education Programme from whitebait Connection, Xstream about freshwater life, eos ecology

Inanga spawning and egg survival are closely linked to the availability of good quality spawning habitat. If natural riparian vegetation is damaged or still developing, then straw/hay bales make effective temporary spawning habitat for a season.

The basic concept is that when straw bales are placed (long-sides parallel) the crevice between them is:

- accessible to spawning inanga
- shaded from the sun
- moist & cool

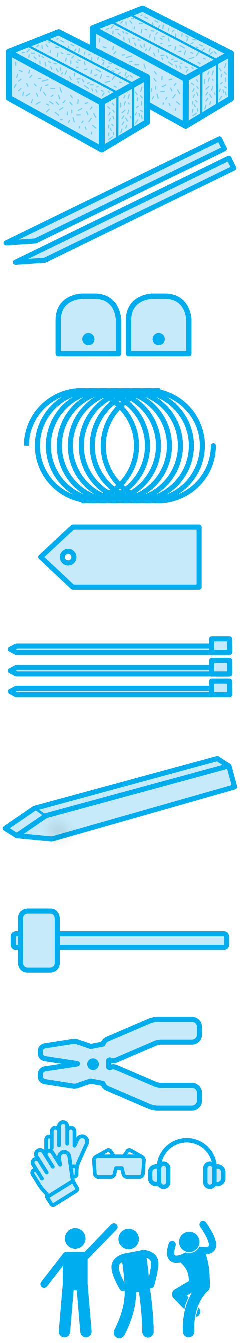
= GREAT TEMPORARY INANGA SPAWNING HABITAT!

Why straw/hay bales? Wheat straw, barley straw or hay bales are good because they are robust, biodegradable, cheap and an effective short-term substitute for native riparian vegetation. Ideally, several bale sets will be installed at multiple sites across the known/suspected spawning area. Seek some specialist advice on your programme before you start if required.

Before you start... it's important to know that you are in the right part of the river and at the right height up the bank for the spring tides. (see Further reading & resources section)

Also ensure you have the permission of the appropriate authorities and landowners for your project before you begin any work whatsoever.

Installation equipment needed:



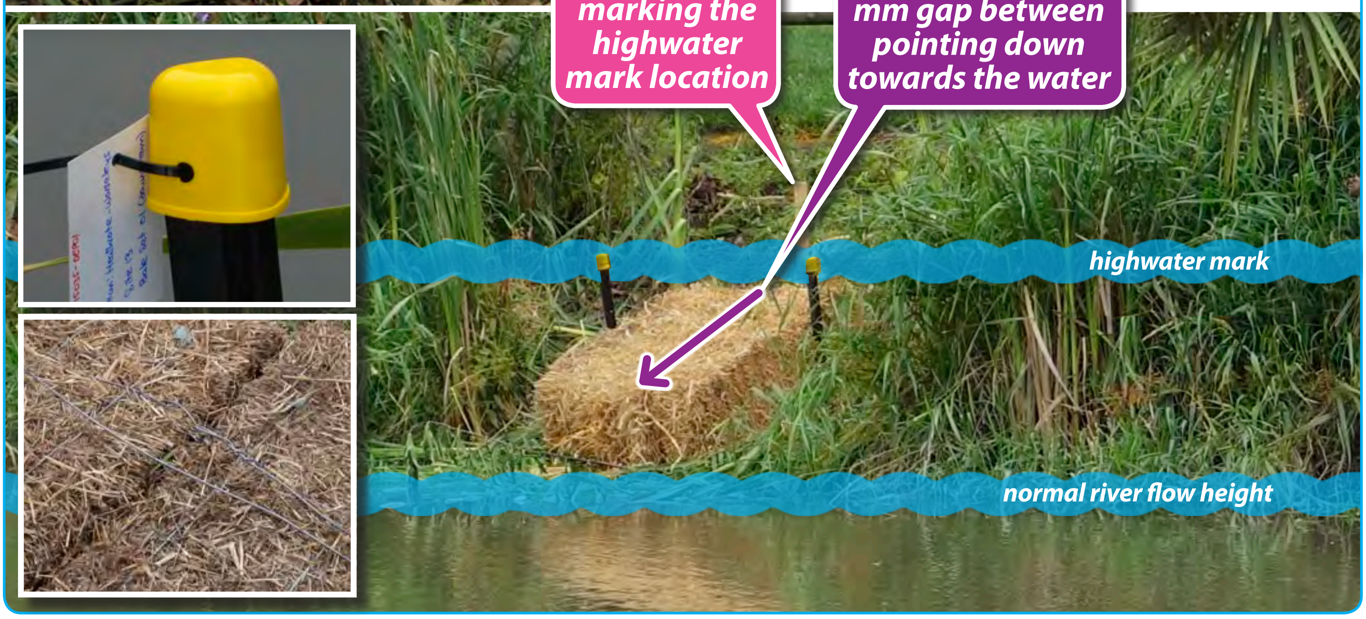
- 2x straw/hay bales per set
- 2x 1.5 m metal stakes (waratahs) per set
- 2x hi viz stake safety caps per set
- 3–4 m of 4 mm wire per set
- 1x site label per set
- 3x 30 cm cable ties per set
- 1x 45 cm wooden stake per set
- mallet/club hammer/post driver for metal stakes
- wirecutters/pliers for wire
- usual safety gear
- willing helpers!

The National Inanga Spawning Education Programme is supported by...

whitebait Connection – Xstream about freshwater life; Mountains-To-Sea Conservation Trust; Curious Minds – He Hihiri i te Mahara; Department of Conservation – Te Papa Atawhai; eos ecology – Aquatic Science & Visual Communication; We ♥ Whitebait – Whaka Inaka : Causing Whitebait; Marine Ecology Research Group – University of Canterbury

Installation method:

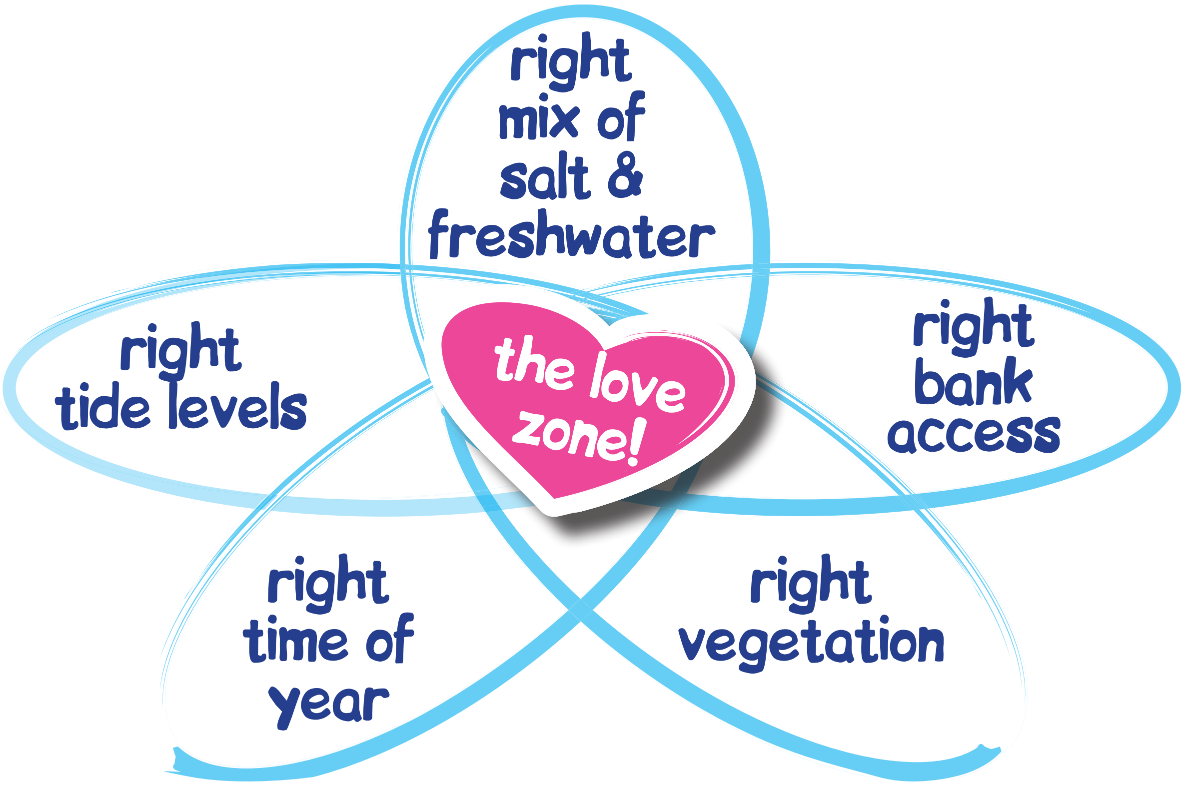
1. *Visit the site during several spring high tides and mark the highest point that the water gets to on the bank (**highwater mark**) with the **wooden stake**. Do this over several days as the water level may change a lot from one day to the next.*
2. *Once all the sites are marked, head out at **low tide** to install the bales. Make sure it is a **couple of weeks before** the spawning spring tide so the bales have time to 'season'.*
3. *Place the bales onto the bank just below the **highwater mark**, but above the **normal river flow height**. Lay them long sides next to each other, at right angles to the river (gap pointing down). Leave a 50 mm gap between the bales. This way the tide inundates the gap between the bales. TIP: Always carry bales by holding BOTH twines to stop them falling apart.*
4. *Place the metal stakes halfway down the length of the two bales so they are snug on the outside, and hammer in until firmly in place. Try and get a wire hole in the metal stake against each bale, and level with the top of the bale.*
5. *Cut a piece of wire that is 2.5 times as long as the distance between the two hammered metal stakes.*
6. *Make a secure loop in one end of the wire and thread the other straight end of the wire through the hole in the metal stake that is level with the top of the bales. Pull through until the loop sits in the middle between the two bales.*
7. *Bend the wire at the hole in the metal stake so it is firmly in place. Thread the straight end through the opposite metal stake and secure with a solid bend again, then thread it through the initial loop back at the centre.*
9. *Secure the final piece of wire through the loop back on itself, and push any left over ends safely into the bale.*
10. *Hammer the metal stakes deeper into the ground to tighten the wires and ensure the bales are firmly held against the ground for the when the spring tides arrive. They shouldn't move when you kick them.*
11. *Attach the hi viz safety caps & the site label to the top of the metal stakes with cable ties.*

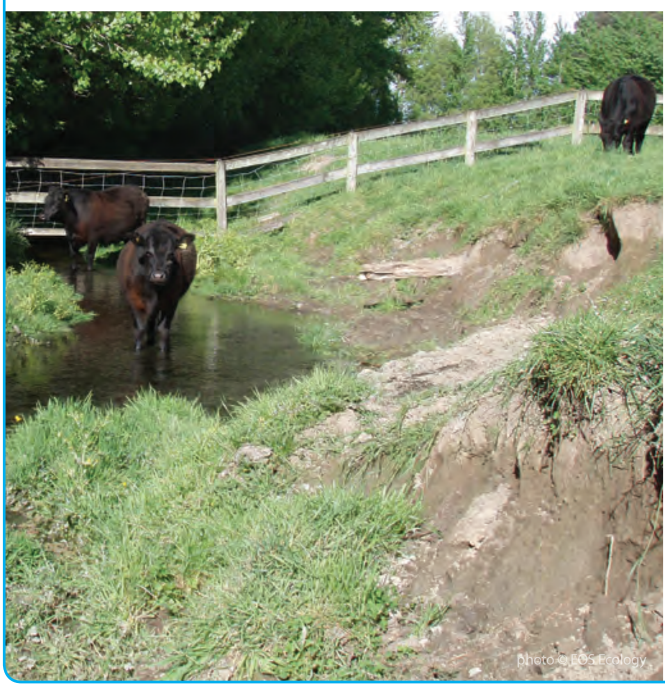


Inanga/Whitebait
Maintain/care for a spawning site

National Inanga Spawning Education Programme from whitebait Connection Xstream about freshwater life eos ecology

It takes a specific combination of conditions to create good spawning habitat for inanga. Once these conditions have been established it's important we do all we can to keep them. A change or reduction in any of the individual elements will mean reduced or absent spawning and egg survival.





WHAT HARMS SPAWNING SITES?

Livestock grazing

If they have access, livestock will preferentially graze on riparian vegetation because it has a higher moisture content than their paddock feed.

This leads to:

- ***thinning and shortening of riparian vegetation** which exposes the aerial roots causing them to die-back*
- ***pugging and compaction** – cattle weigh 400–500 kg, in wet soils their hooves remould the surface soil (pugging) and tear/bury riparian vegetation*

- *in drier soil the ground is **compacted by treading** – this increases the soil's susceptibility to waterlogging and anaerobic conditions which can restrict plant growth*
- *treading can also lead to **bank steepening/erosion**.*

Solution includes...

- *using **fencing** to exclude all large (cattle) livestock year-round*
- *grazing only **smaller livestock** (sheep) by waterways as this has fewer long-term effects, but needs to be stopped at least 3 months before the beginning of the spawning season to allow time for regrowth of riparian vegetation.*

Mowing grass at spawning sites

River bank maintenance – which includes mowing long grass – shortens/thins riparian vegetation.

This leads to:

- *in the short-term, **reduction in the density** of riparian vegetation (but in the long-term can encourage lush regrowth)*
- ***aerial roots are exposed** to direct sunlight and this causes die-back*
- ***reduced height/density** of vegetation which causes less spawning and poorer egg survival.*

Solution includes...

- *mowing at the right time of the year can help maintain good quality riparian vegetation, but the recovery time after mowing for vegetation density is much longer than for vegetation height.*

Sedimentation

Good inanga spawning habitat is tall dense vegetation – unfortunately tall dense vegetation traps and holds any sediment that may be in the waterway. Sediment tends to fall out of water around inanga spawning sites because of the damming effect of the tide i.e., the current slows down and the sediment is deposited on the banks.

This leads to:

- ***clogging** of the aerial roots/stems of the riparian vegetation*
- ***eggs being smothered** or microclimate changes so eggs do not survive.*

Solution includes...

- ***reduce** deforestation and **increase** riparian vegetation throughout catchment to filter out land-sourced sediment **before** it enters the river*
- ***develop a catchment-wide plan** to reduce sediment getting into the waterways to begin with.*

Predators

Inanga eggs are very vulnerable. The only protection they have from being eaten by predators is the vegetation they are developing in. Tall, dense, vegetation hides the eggs and makes access difficult for predators. If you can maintain or restore the vegetation then pests will become less of a problem.

The National Inanga Spawning Education Programme is supported by...

Inanga/Whitebait
Long-term habitat restoration

National Inanga Spawning Education Programme from whitebait Connection Xstream about freshwater life eos ecology

If you have assessed your local inanga spawning habitats and found them in less than ideal condition for spawning, here are some actions you can think about taking for future improvement.

If you have used our 'Inanga spawning habitat assessment sheet' you will already know there are twelve attributes required for a good spawning site. Here are some long-term restoration solutions you can look to implement for each of these attributes if you encounter spawning issues.

Fish access:

Inanga spend part of their lifecyle at sea and migrate into fresh water as whitebait. If there is a barrier to their upstream movement they will not be able to make their way into the waterway and reach adulthood.

Solution – *The barrier (e.g., drop culvert, weir) will need to be removed/mitigated to allow inanga.*

Saltwater access:

Inanga need saltwater present in the waterway to give them a cue to spawn. If it's not present, they don't know when or where to spawn.

Solution – *The saltwater barrier (e.g., tide gates/ barrages) will need to be removed/mitigated to allow spawning to take place.*

Bank angle:

The right bank slope means there is a good amount of native habitat on the bank that can be used for spawning. Banks that are too steep will not be used for spawning. Banks that are too flat are susceptible to tide height change (so if there is a lower or higher tide, the bank will either be under or out of the water).

Solution – *Get the bank regraded to a 7˚–25˚ slope.*


photos © EOS Ecology

Bank material:

The bank material needs to be able to support lush plant growth and retain moisture for eggs to survive.

Solution – *The bank will need to have artificial spawning habitat added, or the banks will need to be completely regraded and accessible.*

Vegetation cover:

There needs to be a good cover of vegetation on the bank to shelter and keep eggs moist. If the cover is too sparse inanga eggs will dry out and die.

Solution – *Work out why there isn't good plant growth and deal with that issue as appropriate.*

- *Maintenance issue i.e., vegetation is cut too often – **review maintenance strategy**.*
- *Livestock access issue i.e., livestock are eating the vegetation or damaging the banks – **fence out livestock**.*
- *Bank slope issue i.e., the banks are too steep and are eroding away – **regrade bank slope**.*
- *Shading issue i.e., direct shading is restricting plant growth – **maintain shading trees/plants**.*
- *Exotic trees smothering plant growth with leaf-fall – **remove exotics and replace with natives or ensure leaf litter removal before spawning season**.*

Vegetation height

Vegetation needs to be the right height to ensure eggs can survive for the month they are out of the water. If the vegetation is too short it won't be able to create a thick enough root mat, if the vegetation is too tall it will start to thin out at ground level and not provide the density needed for egg survival.

Solution – *If vegetation is too short or long then look at changing maintenance strategies to promote the best plant height.*

Vegetation type

Some vegetation types are good for spawning while others aren't. However, some diversity is always good (some patches of larger plants will give cover to fish while they are spawning etc.) – so don't remove all larger plants from a site unless they are a plant pest.

Solution – *Look to remove these pest/problem plants and replace with species more suitable for spawning. Yellow flag iris is a pest plant and is not good for spawning. It is very hard to get rid of so* ***must be controlled*** *as soon as you first notice it at your site!*

Root mat thickness

Inanga need plant root mats to be nice and dense at ground level in order for moisture to be retained by the vegetation and for the plants to shade the eggs. The ability for this to happen relates to maintenance – if the grass is cropped/cut too regularly it will not be able to build up this layer of root mat/debris/stems.

Solution – *Review maintenance strategy/remove livestock from the area.*

Ground moisture

Inanga eggs will dry out and die if they are not kept moist. The reasons for dry ground at a spawning site may be due to the bank material or the vegetation cover/type.

Solution – *Either look to change the bank material type (if it is not earth/soil) and/or look at your maintenance/livestock strategies as shorter grass will mean the ground will dry out more quickly.*

Cover for fish

Inanga adults congregate before spawning, so need lots of cover (e.g., overhanging/emergent plants, logs, rocks etc.) to protect themselves from predators.

Solution – *Depending on your stream you can add logs/rocks in the water to provide cover. Also look at planting some rushes in the water at low tide to provide some emergent cover.*

Bank maintenance

If banks are mown too regularly the vegetation will never grow to the height/thickness needed to protect the inanga eggs.

Solution – *Talk to the people/authorities that maintain the banks to see if they can change their maintenance strategy to help promote better spawning conditions. Refer to previous attributes to get further information on what the current maintenance strategy may be affecting.*

Livestock protection

If livestock access spawning habitat they can damage the banks and keep the grass too short to protect the inanga eggs. They can also squash eggs if they access the site during the spawning season.

Solution – *Talk to the landowner about putting in a permanent fence. Most Regional Councils have funding to help with this.*

Egg predators

Inanga eggs are very vulnerable. The only protection they have from being eaten by rodents and slugs etc. is the vegetation they are developing in.

Solution – *Tall, dense, vegetation hides the eggs and makes access difficult for predators. If you can maintain or restore the vegetation then pests will become less of a problem.*

The National Inanga Spawning Education Programme is supported by...

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These straw bales are part of a project helping to restore inanga/whitebait spawning.

Please leave the bales undisturbed.

National Inanga Spawning Education Programme from

Straw bales have been installed along the banks and will be monitored until the end of the spawning season. Along with improving spawning success they will also tell us exactly where inanga can spawn. This will help us identify the best places for long-term restoration of their spawning habitat. This is vital as whitebait numbers are declining and Inanga are currently listed as 'At Risk'.

Straw bales are good artificial spawning habitat for inanga. Adult inanga wriggle between the bales to lay their eggs during the high spring tides. The eggs are kept safe until the next spring tide when they hatch and the larvae are washed out to sea to grow into juvenile inanga, generically called 'whitebait'.*

** SPRING TIDE – a tide just after a new or full moon, when there is the greatest difference between high & low water*

The National Inanga Spawning Education Programme is supported by...

Locally supported by...

Find out more by going to the "Whitebait Connection" facebook page. *Please let us know if the bales look like they have been damaged.*

Contact us at:

info@whitebaitconnection.co.nz

Inanga/whitebait spawning restoration programme

National Inanga Spawning Education Programme from

whitebait Connection
Xstream about freshwater life

photo © EOS Ecology

photo © EOS Ecology

You may have seen the straw bales on the banks of this waterway over the summer/autumn months. These bales were part of a project aimed at halting the declining numbers of inanga/whitebait.

One of the main reasons for declining inanga numbers is the loss of suitable bank habitat for egg laying. The straw bales provided a temporary place for inanga to spawn in areas where the eggs wouldn't have survived otherwise. This has helped identify these areas that need long-term bank restoration/maintenance to restore spawning success for generations of inanga to come.

IDEAL INANGA SPAWNING HABITAT:

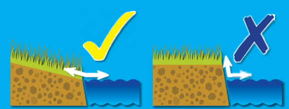
Right distance from estuary/sea

Some stretches of this waterway are optimal for inanga spawning due to their location in relation to the sea. Spawning occurs in areas where high spring tides can reach, but the water isn't too salty. During spring tides inanga can lay their eggs in vegetation high up the riverbanks, above the normal river flow height.*

** SPRING TIDE – a tide just after a new or full moon, when there is the greatest difference between high & low water*

Gently sloping bank

Ideally the riverbank will be a gentle slope rather than a steep edge. This means there is more accessible bank area for inanga to lay their eggs on during the high spring tide.

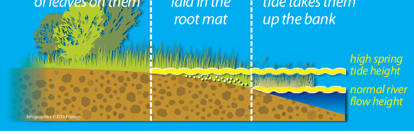


Good bank vegetation

Canopy of native trees/shrubs – provide shade for eggs while not dropping lots of leaves on them

Tall thick grass – so inanga eggs can be laid in the root mat

Plants rising from water – for inanga to hide in until high tide takes them up the bank



No predators

Inanga eggs are vulnerable to hungry pests.

No pollution

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PART 3e: Action

Inanga habitat

How to monitor pest activity

National Inanga Spawning Education Programme from whitebait Connection – Xstream about freshwater life – eos ecology

Small mammal pests can compromise native habitats and dramatically reduce native species populations. This is true for inanga – pests such as mice, rats and hedgehogs consider inanga eggs a tasty treat, especially when found in their thousands on riverbanks.

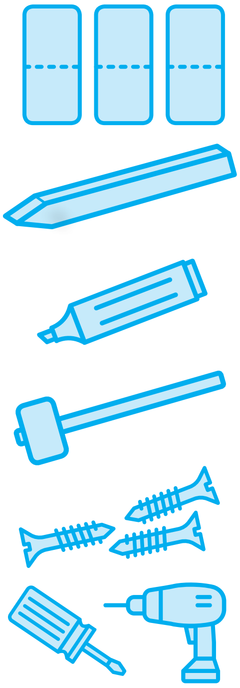
Before pest management/trapping can take place, it is important to understand which pests you have present, and what areas pests are visiting more frequently. This way you'll be able to use the best management/trapping method for the pests you actually have, and use them in the most effective locations – saving time and money. Even if you aren't planning on implementing a pest control programme in the near future, it's a great idea to know what is going on in your local inanga spawning area.

Implementing a pest monitoring programme allows the collection of data and generates awareness of the presence of pests in your local environment. (You should continue to monitor for pests during your management/trapping programme to assess its effectiveness.)

There are a number of methods for monitoring small mammal pest activity, but we recommend the use of pest detector chew cards as a non-invasive way to start the process. The good thing about this method is that it is simple, inexpensive and can be done by school groups, kindy kids, community groups or families. The detector cards work by using a non-toxic edible lure inside the card that the pests nibble on, leaving behind indentifiable chew marks.*

Example of a Goodnature pest detector card, filled with non-toxic peanut-buttery goodness.

Installation equipment needed:



- **pest detector cards**
- **1x wooden stake per detector card site**
- **permanent marker**
- **mallet** (for hammering in wooden stakes)
- **screws**
- **screwdriver/drill**

To install... *Choose where to put your detector cards in/around the inanga spawning habitat. Make sure you check for hazards. (Depending on funds/time, you are better off choosing fewer sites, then monitoring these over time to get a good representative sample of what's foraging in the area.)*

Follow the instructions provided with your detector cards. Generally this involves folding the card in half so the lure bait inside starts to squeeze out. Screw it to the wooden stake, then hammer the stake firmly into the ground in your chosen spot. (Note the final distance of the card above the ground. It's usually suggested to be about 8 cm so pests can reach.)

If you are doing a few locations, use the permanent marker to write a site number on the stake.

We suggest you leave each card out for 3–7 days, then check it and replace with a fresh one. (See full monitoring instructions over page.)

* *Other small mammal pest monitoring methods include: tracking tunnels, identifying poo pellets, spotlighting and motion detector cameras. See the 'Further Reading & Resources' over the page for supplier suggestions.*

If you are interested in getting a good representation of the pests around your local inanga habitat we suggest you monitor throughout the spawning season.

MONITORING METHOD

Step 1. ***On arriving at the site, check your surroundings for any hazards.***

Step 2. ***Take a photo of the detector card insitu on the stake.*** *Be sure to note the photo number/ time photo taken down so that you can link it back to the site when you get back. Make sure the photo is close up, but ensure that the writing on the wooden stake is in the photo as well as this tells you what site number it is.*

Step 3. ***Have a close look at the detector card before removing it from the stake.*** *Has it been chewed/eaten? If there were no markings, was there still lure mix hanging out the bottom?*

Step 4. ***Remove the pest detector card from the stake*** *using your screwdriver/drill. If the card has been chewed then also look for the bitten off bits and collect those as well.*

Step 5. ***Place your card and any chewed pieces into the plastic bag.*** *Use your permanent marker to write the site/date on the bag.*

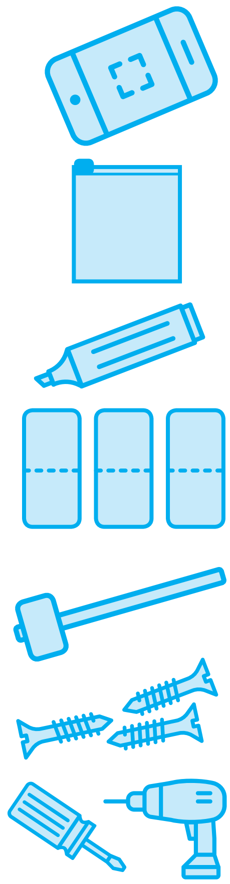
Step 6. ***Replace the pest detector card with a fresh one.*** *Screw it back into the same hole if able.*

Step 7. ***Identify your local pests*** *by comparing your chew-marked detector cards with the identification chart supplied by your card manufacturer.*

Step 8. ***Record your observations*** *if you are monitoring a number of sites for a few rounds of detector cards then. Keep your pest card/s in their plastic bag for future reference and comparison.*

Step 9. *Repeat for each round of monitoring.*

Monitoring equipment needed:



camera *(to photograph used detector card on stake, with site number in photo, if doing more than one round of monitoring)*

ziplock/snaplock plastic bag *(to store used pest detector cards in)*

permanent marker

replacement pest detector cards *(if doing more than one round of monitoring)*

mallet *(for hammering stakes back in if required)*

replacement screws incase needed

screwdriver/drill

Example of pest nibble identifications

FURTHER READING & RESOURCES:

- *www.goodnature.co.nz/products/accessories*
- *www.traps.co.nz/chew-card-unloaded*
- *www.connovation.co.nz/pest-monitoring*
- *www.eosecology.co.nz/files/2016_WhakaInaka_PestMonitoring_ReportCard.pdf*

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