NATIONAL SEA RUN SALMON COMMITTEE WORKSHOP CHRISTCHURCH, 9 MAY 2019

RASMUS GABRIELSSON

- POPULATION GENOMICS:
  WILD SALMON DNA STUDY WITH FISH & GAME
- REVIEW OF HISTORICAL HATCHERY RELEASES OF CHINOOK SALMON IN NEW ZEALAND

JANE SYMONDS ET AL.
MARTIN UNWIN

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Fish & Game NEW ZEALAND

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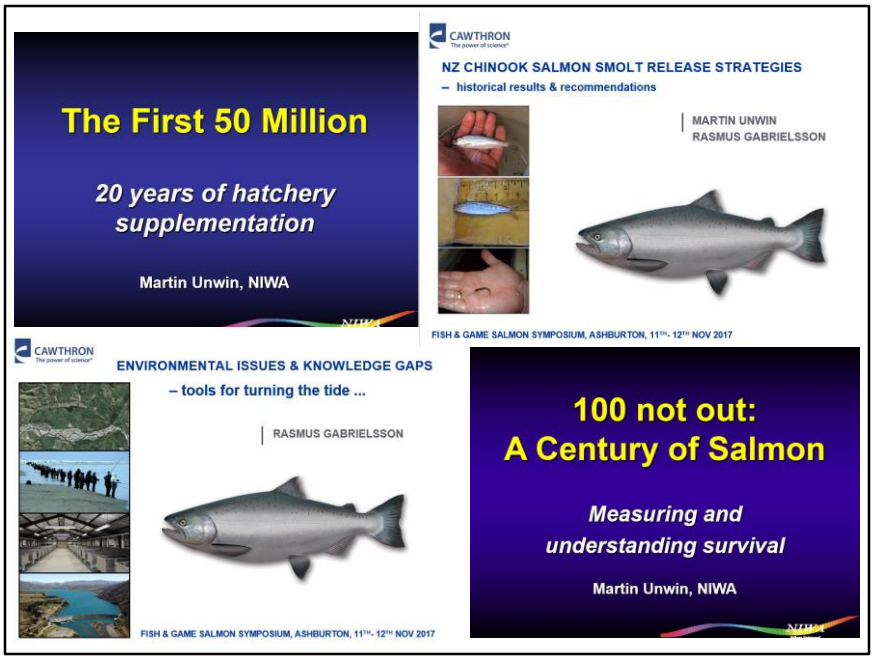
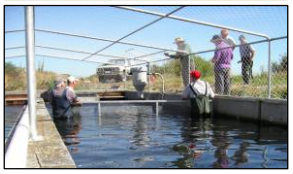
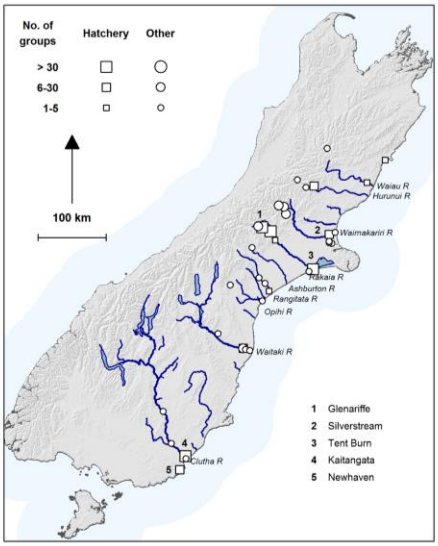


This presentation combines information presented by R Gabrielsson during the 2017 Salmon Symposium with information presented by M Unwin at the previous Salmon Symposium in the early 2000s.

HISTORICAL RELEASES OF CHINOOK SALMON

– hatchery releases for ocean ranching

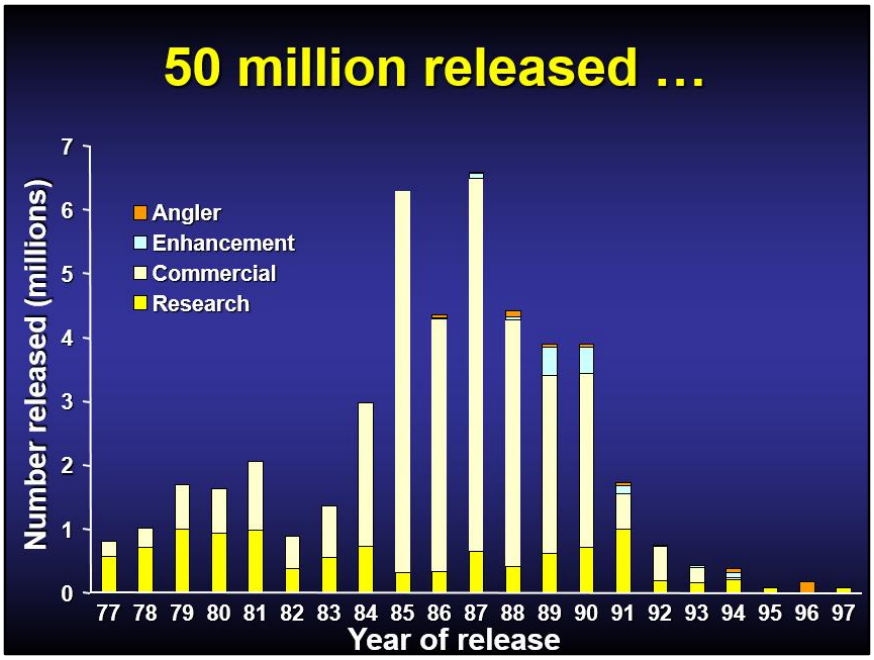




- In the late 1970s considerable effort went into developing a commercial ocean ranching industry in NZ, based on Chinook salmon. Between 1977 and 1997 over 46 million hatchery-reared Chinook salmon smolt were released into South Island rivers, peaking at ca. 6.5 million in 1987.

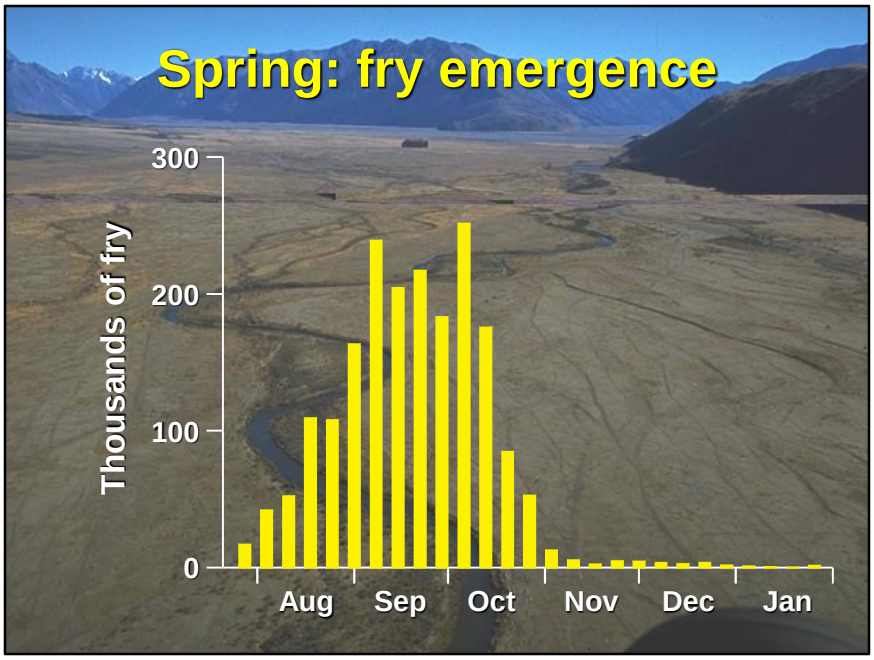
- Most of these releases (>70%) were from commercial salmon farms, but ~25% came from a government funded research program, while angler and enhancement funded releases accounted for <5%.

- Data from 540 releases of salmon (~4.5 million fish) all tagged with coded wire tags released from all major east coast salmon rivers over 14 years were used to evaluate the effects of different rearing and release strategies on survival to adulthood (see review report by Unwin and Gabrielsson 2018).

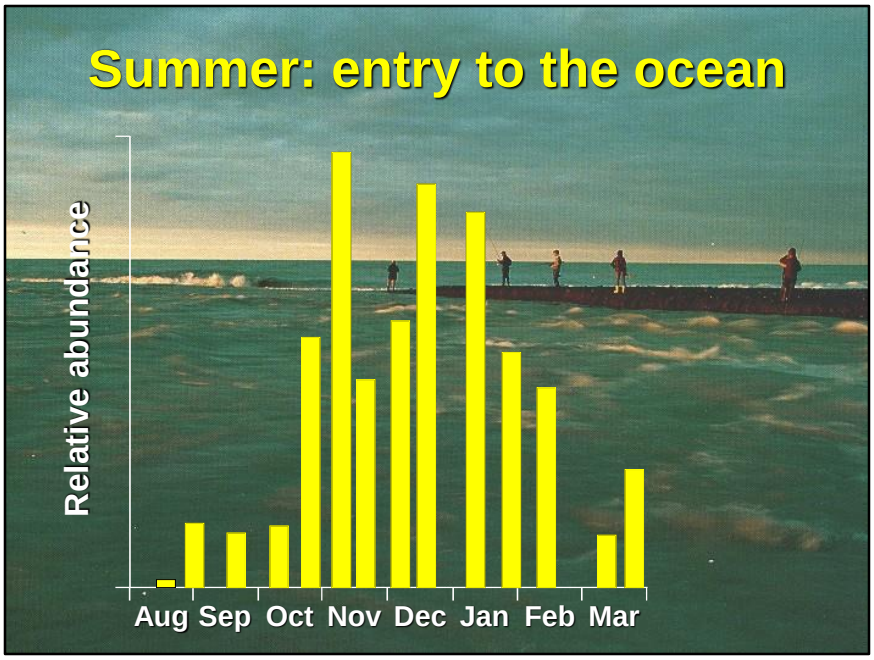


Commercial	72.5%
Research	23.6%
Enhancement	2.7%
Angler	1.2%

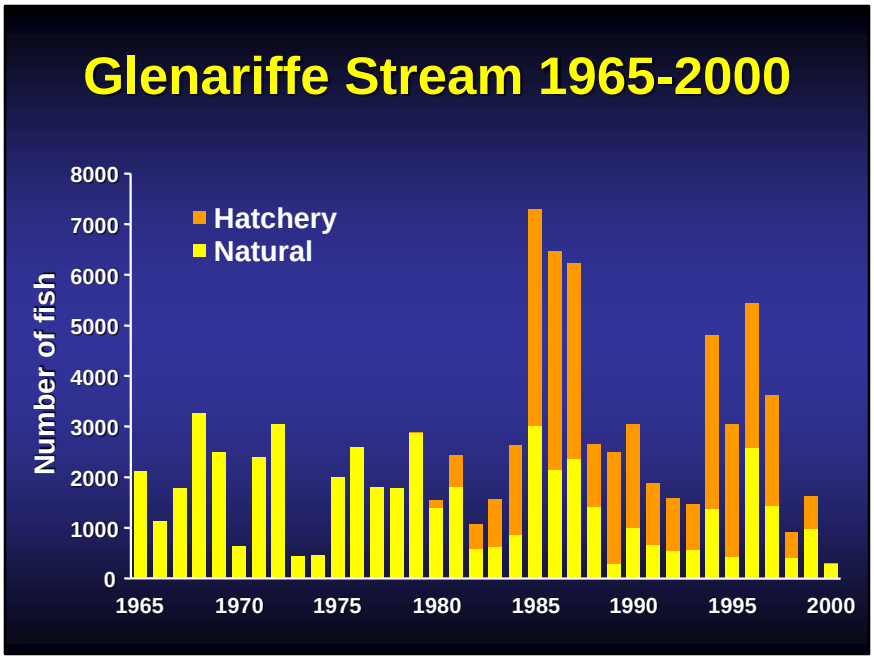
Large scale smolt releases associated with ocean ranching ventures in the late 1970s to early 1990s built unrealistic expectations among salmon anglers. Similar levels of enhancement releases of hatchery raised smolt actions are both totally unaffordable, and most likely very detrimental to locally adapted wild salmon populations.



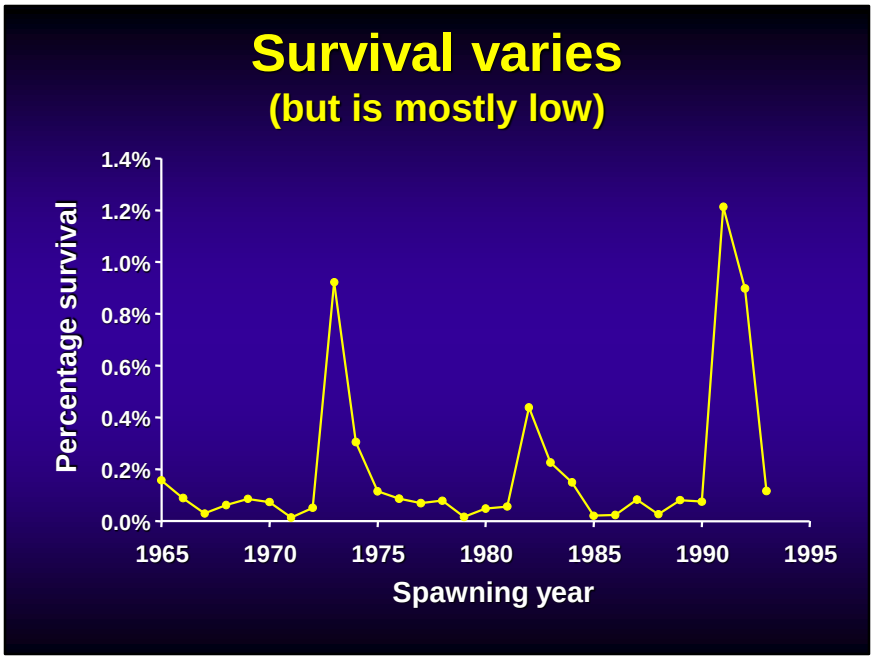
However, the research releases and other studies conducted during this period provided many insights into salmon ecology and populations structure. Much of this information is still applicable today. For example information of emergence (Glenariffe data from Rakaia River illustrating the behaviour of salmon with predominantly a ocean type life history).



Or information of time (or size) at ocean entry emergence, again Rakaia River data from salmon displaying a ocean type life history (i.e. ocean entry at 3-6 months of age)



Separating the Glenariffe run into hatchery and wild (natural) salmon indicate that large scale releases of hatchery reared smolt appear to overtime have largely replaced wild fish. Subsequent monitoring records have not yet shown a recovery of wild population, indicating that if wild population are repeatedly 'swamped' by hatchery returns it may eventually have a destabilised effect on population resilience.



Again Rakaia / Glenariffe data

Impacts of Hatchery Releases

- More fish returning to Glenariffe
  - and more to Rakaia (probably)
- More 2-year-old fish
  - hence smaller
- Increased straying
- Earlier spawning
- Genetic effects (unknown)

Hatchery Guidelines: 1. Don't mix populations (maintain genetic oversight), 2. Must have monitoring programme (marking programme/monitor adult returns), 3. Budget accordingly!

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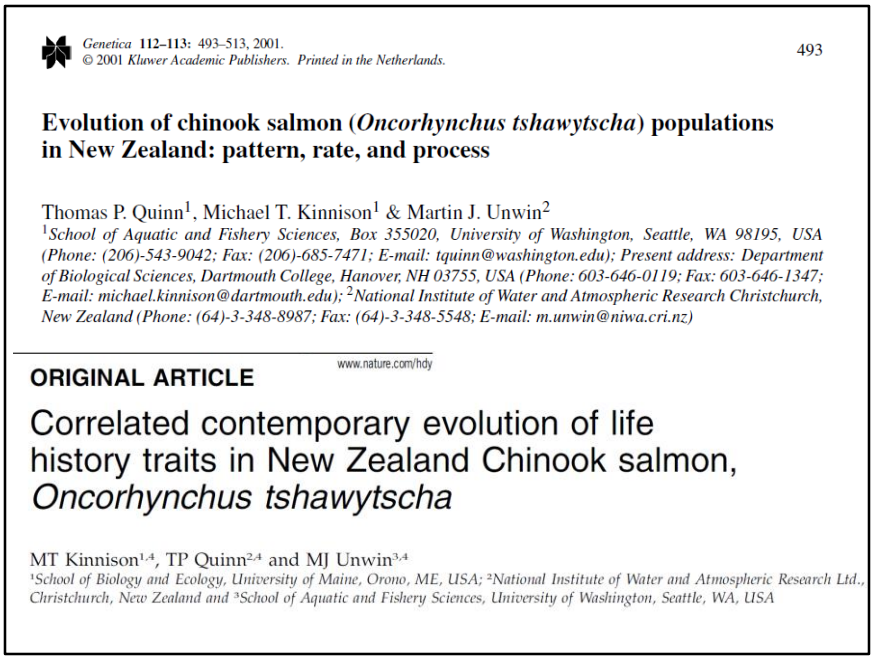

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Evolution of chinook salmon (*Oncorhynchus tshawytscha*) populations in New Zealand: pattern, rate, and process

Thomas P. Quinn[1], Michael T. Kinnison[1] & Martin J. Unwin[2]
[1]*School of Aquatic and Fishery Sciences, Box 355020, University of Washington, Seattle, WA 98195, USA (Phone: (206)-543-9042; Fax: (206)-685-7471; E-mail: tquinn@washington.edu); Present address: Department of Biological Sciences, Dartmouth College, Hanover, NH 03755, USA (Phone: 603-646-0119; Fax: 603-646-1347; E-mail: michael.kinnison@dartmouth.edu);* [2]*National Institute of Water and Atmospheric Research Christchurch, New Zealand (Phone: (64)-3-348-8987; Fax: (64)-3-348-5548; E-mail: m.unwin@niwa.cri.nz)*

www.nature.com/hdy

ORIGINAL ARTICLE

Correlated contemporary evolution of life history traits in New Zealand Chinook salmon, *Oncorhynchus tshawytscha*

MT Kinnison[1,4], TP Quinn[2,4] and MJ Unwin[3,4]
[1]*School of Biology and Ecology, University of Maine, Orono, ME, USA;* [2]*National Institute of Water and Atmospheric Research Ltd., Christchurch, New Zealand and* [3]*School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA, USA*

Research by Tom Quinn and Martin Unwin et al. found **consistent evidence** of **heritable differences among populations** in both size at **age and age at maturity**, often **corresponding to patterns observed in** the **wild**.

In total over 60 scientific paper and technical report have been published on research relating to NZ Chinook salmon populations. It would greatly benefit fishery managers and salmon conservation effort if this information was summaries and collated

Population structure in the 1990s

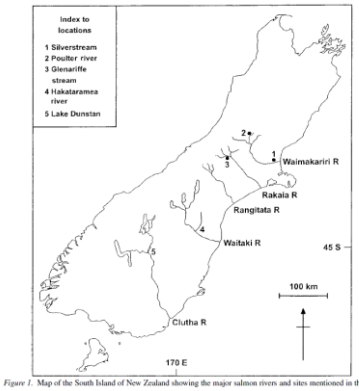


Figure 1. Map of the South Island of New Zealand showing the major salmon rivers and sites mentioned in the text.

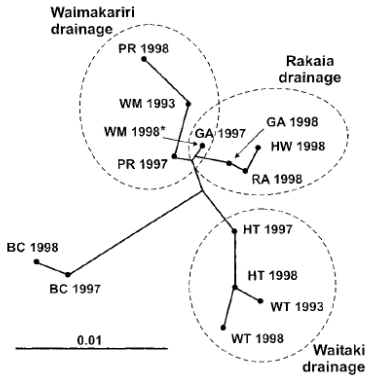
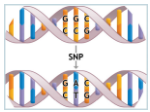


Figure 7. Neighbor-joining tree of θ values for temporal and spatial samples from three major NZ salmon drainages and their nearest North American relatives. Dashed lines indicate the subsets of samples derived from each of the drainages. Samples are abbreviated by letter code and year: Battle Creek, California – BC; Waitaki mainstem – WT; Hakataramea – HT; Rakaia mainstem – RA; Glenariffe stream – GA; Hydra waters – HW; Waimakariri mainstem – WM; Poulter river – PR. Note that WM 1998 (which coincides with the Glenariffe 1997 node) was the only sample that failed to cluster inside the 'true' drainage.

Research show that within 30 generations after Chinook salmon were introduced from the Sacramento River in California (represented by Battle Creek genetics in the figure above) NZ populations now vary both in phenotypic traits (e.g. growth in freshwater and at sea, age at ocean entry and maturity, dates of return to fresh water and reproduction,
morphology, and reproductive allocation etc.).

Importantly, work by Quinn, Kinnison & Unwin also demonstrated both a genetic basis for traits resulting in a higher survival, and hence improved the fitness. Take together this work provided ***strong evidence that locally adapted wild salmon populations in NZ have a 'home court advantage' compared to another population released from the same site.***

POPULATION GENOMICS:
SALMON DNA STUDY WITH FISH & GAME



400+ salmon

Sampling locations:

- Wairau River
- Waimakariri River
- Rakaia River (including Lake Heron)
- Rangitata River
- Waitaki River
- Clutha River (incl landlocked salmon from the Southern Lakes)
- Lake Paringa

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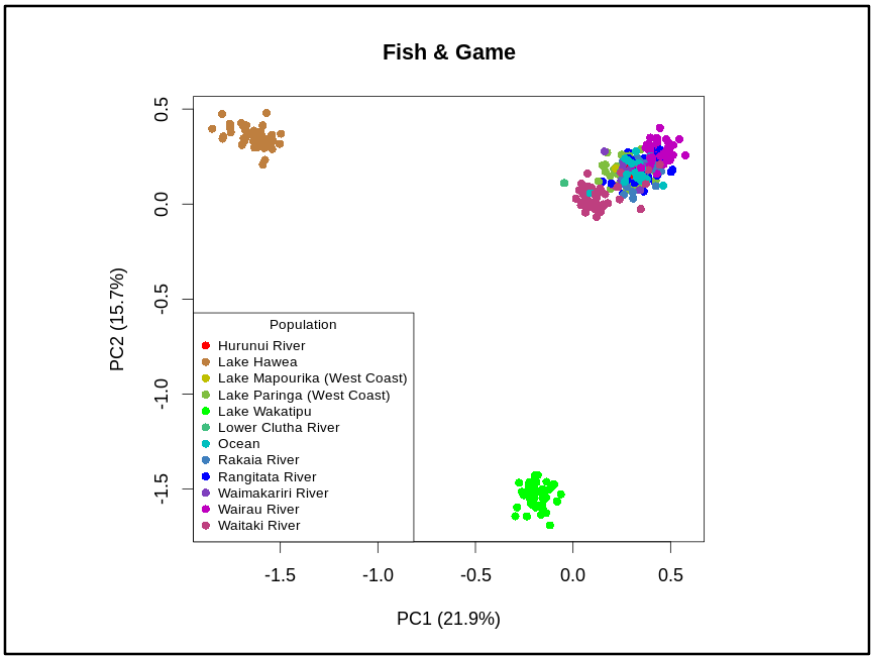
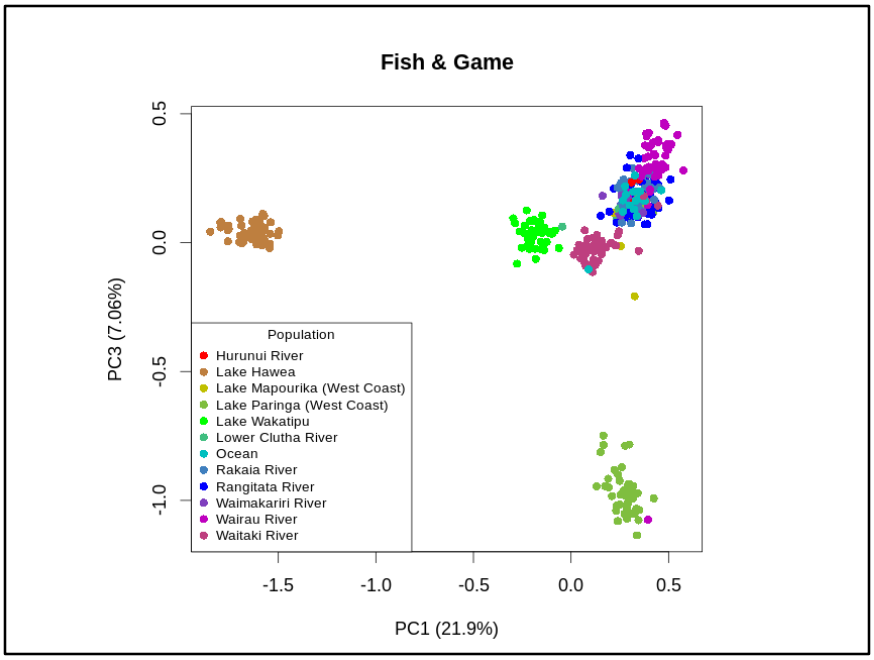
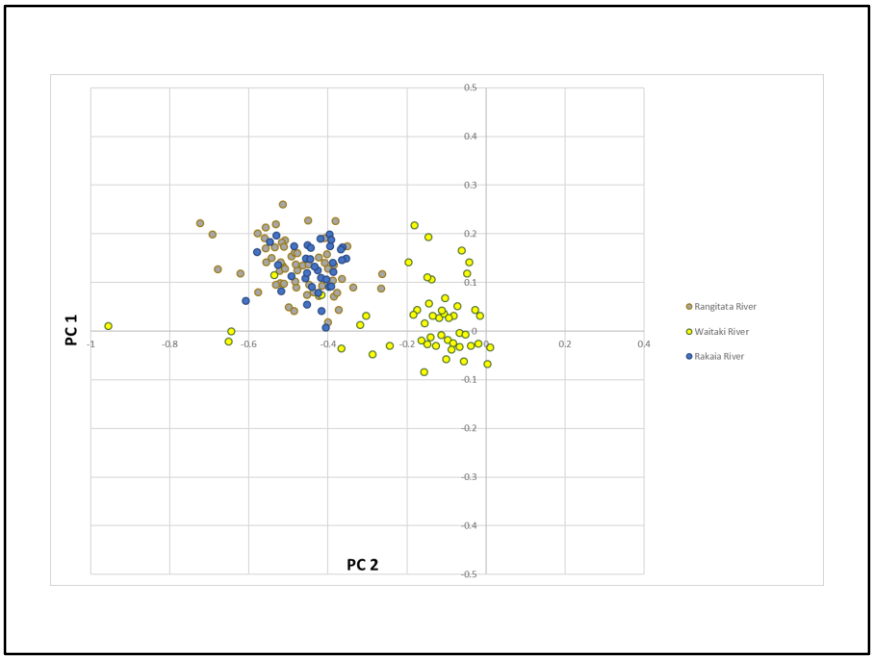
The following slides give an overview of a collaborative research project, involving Fish & Game, Cawthron and AgResearch, which is examining the population genetics of wild Chinook salmon populations in New Zealand. So far we have characterise the genetic structure and estimate the level of population divergence among seven different salmon populations, and aim to explore four more.



Preliminary results show that while several distinct genetic groups exists, not all key salmon fisheries form genetically unique populations. Highlighting that genetic analysis can be a cost effective and informative tool for fishery managers seeking to improve their understanding of the genetic structure behind local adaptations such as run time and life history differences, which have evolved among NZs wild salmon populations.


Fish & Game
PC3 (7.06%)
0.5
0.0
-0.5
-1.0
-1.5
-1.0
-0.5
0.0
0.5
PC1 (21.9%)
Population
Hurunui River
Lake Hawea
Lake Mapourika (West Coast)
Lake Paringa (West Coast)
Lake Wakatipu
Lower Clutha River
Ocean
Rakaia River
Rangitata River
Waimakariri River
Wairau River
Waitaki River


PC 1
PC 2
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-0.2
-0.3
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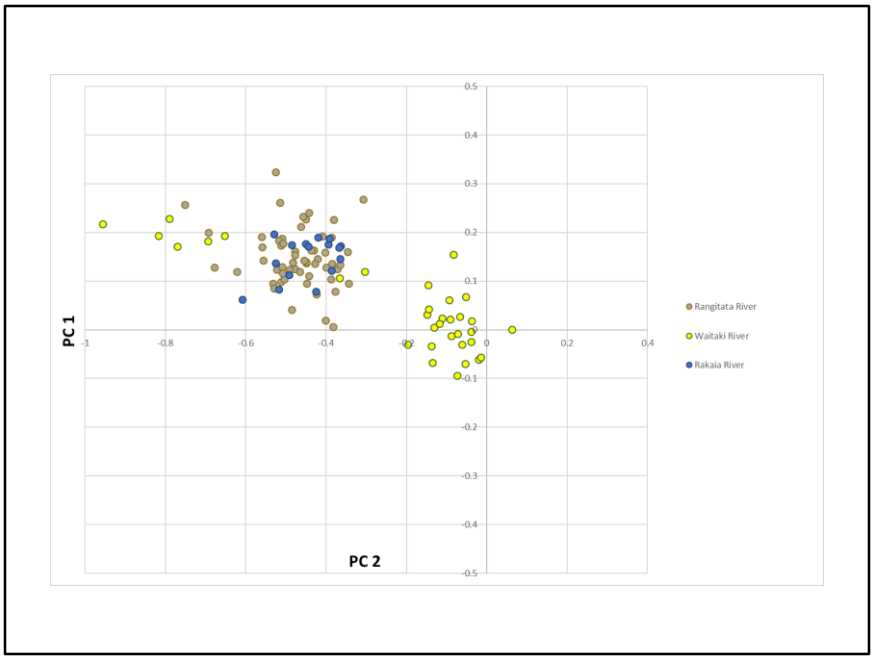
-0.5
-1
-0.8
-0.6
-0.4
-0.2
0.2
0.4
Rangitata River
Waitaki River
Rakaia River


PC 1
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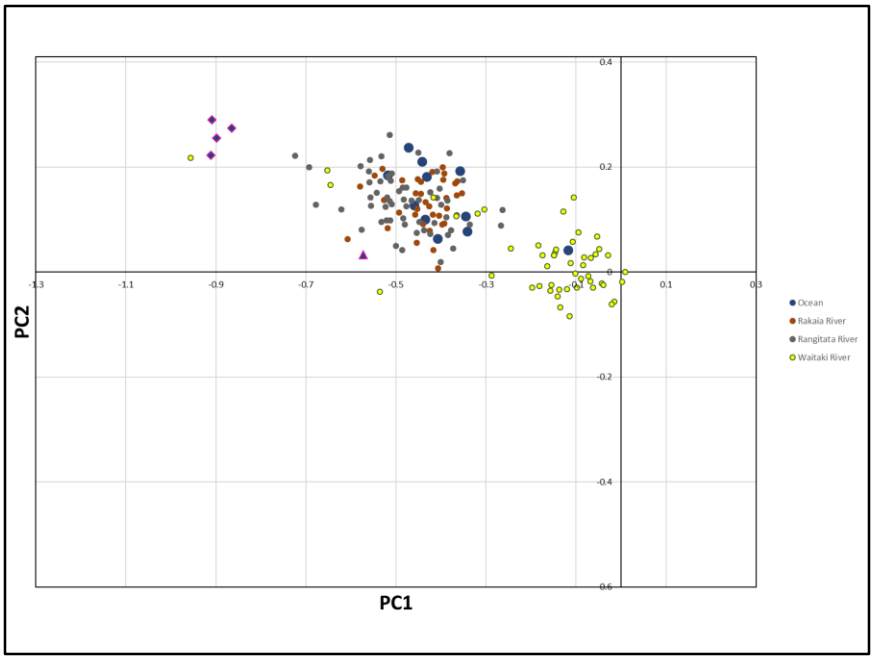
Rangitata River
Waitaki River
Rakaia River


PC2
PC1
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-0.5
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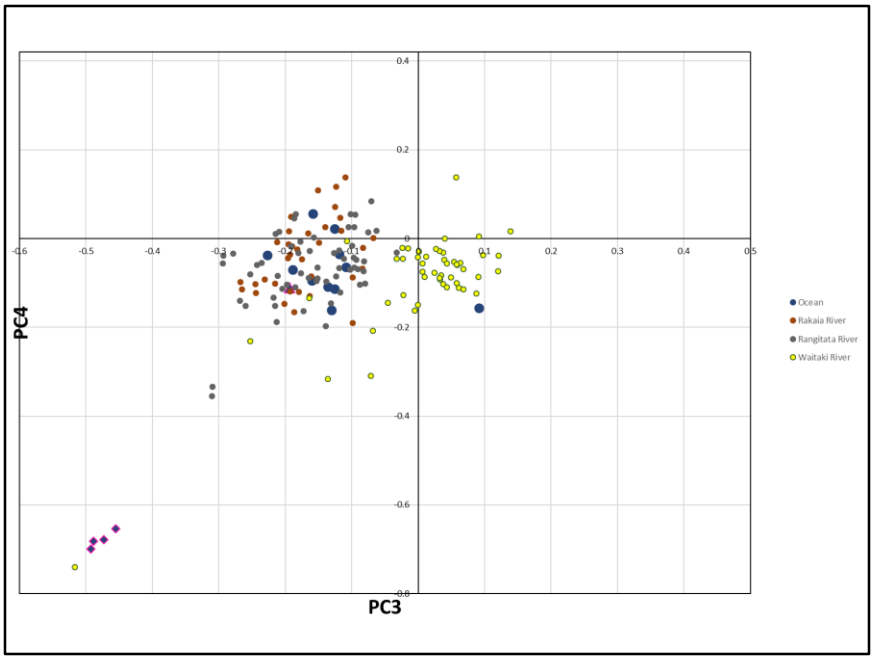
Ocean
Rakaia River
Rangitata River
Waitaki River


PC4
PC3
0.4
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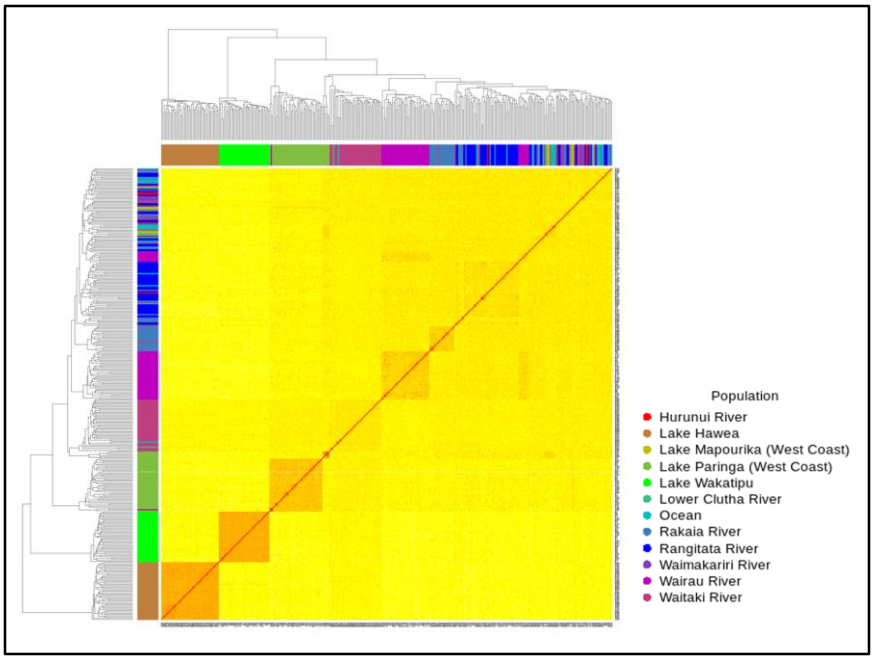
Ocean
Rakaia River
Rangitata River
Waitaki River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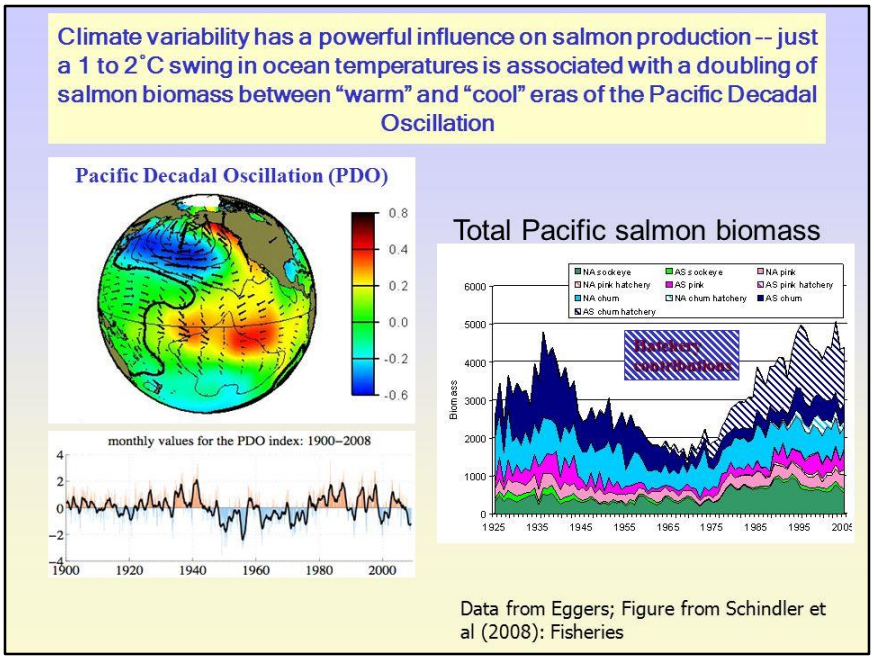
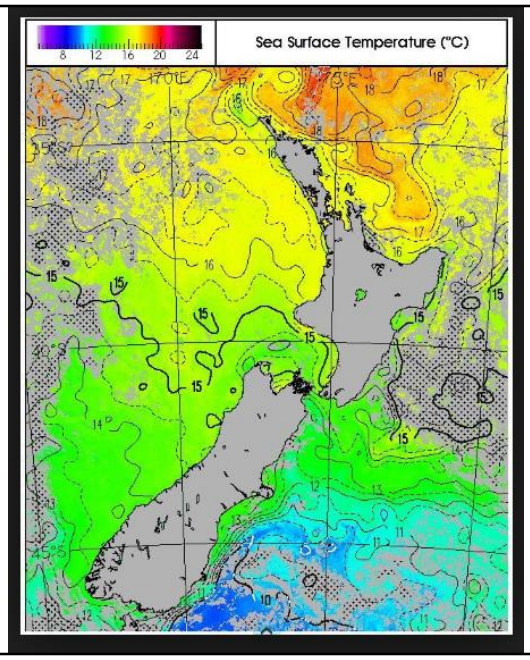
Lower Clutha River
Ocean
Rakaia River
Rangitata River
Waimakariri River
Wairau River
Waitaki River

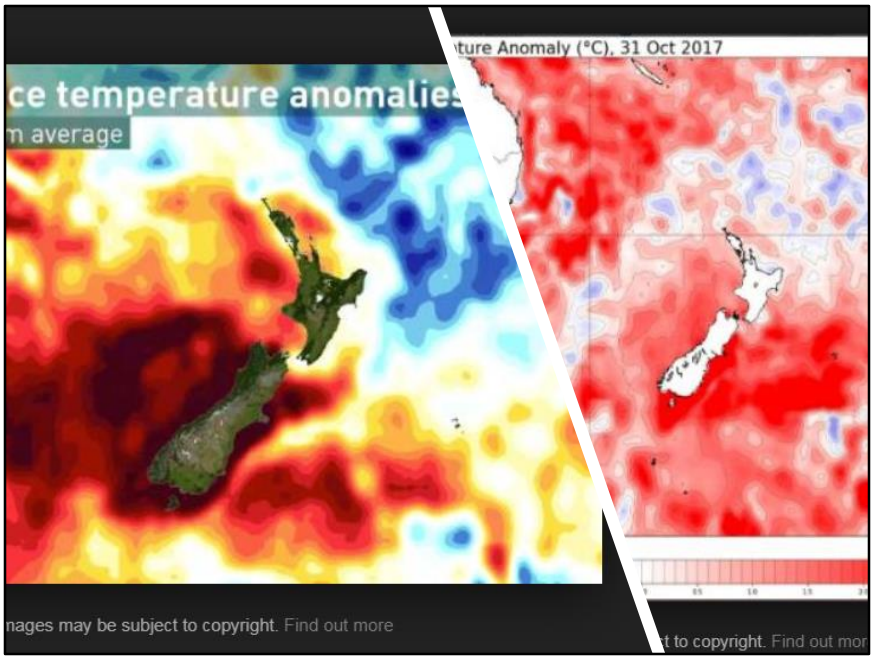
But what about the things that happen to salmon during their ocean phase (~2+ years) ????



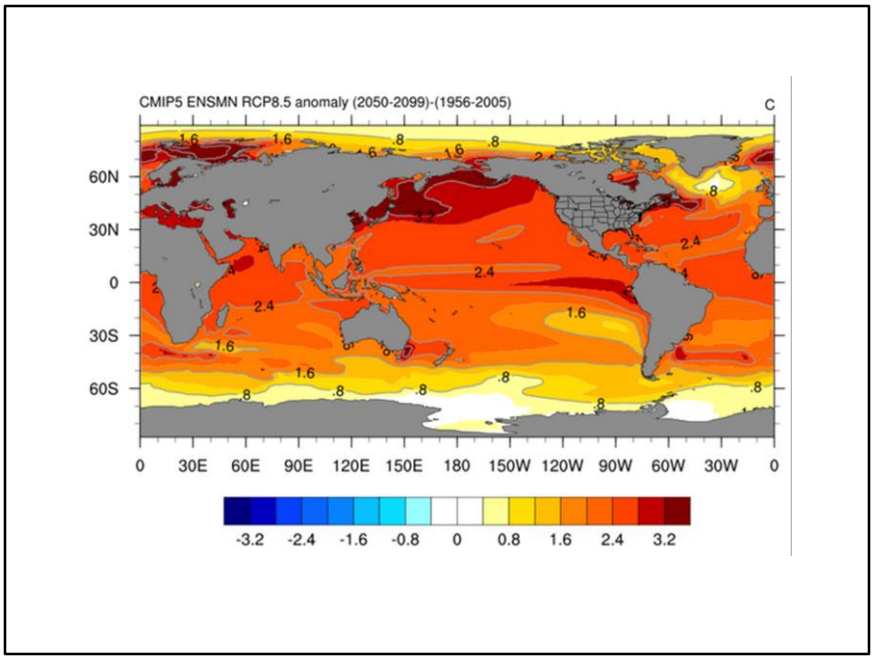
The oceans are warming all over the globe – and international studies show that cold blooded species like salmon do much worse during warmer years and periods...



Historically the marine environment around most of the NZ South Island has been suitable for Chinook salmon growth, as indicated by the mean sea surface temperature ranges shown in the figure above.



However, in recent years sea surface temperature anomalies have become a regular occurrence – as indicated by increasingly frequent catches of warm water species such as Snapper and Kingfish around the lower South Island.



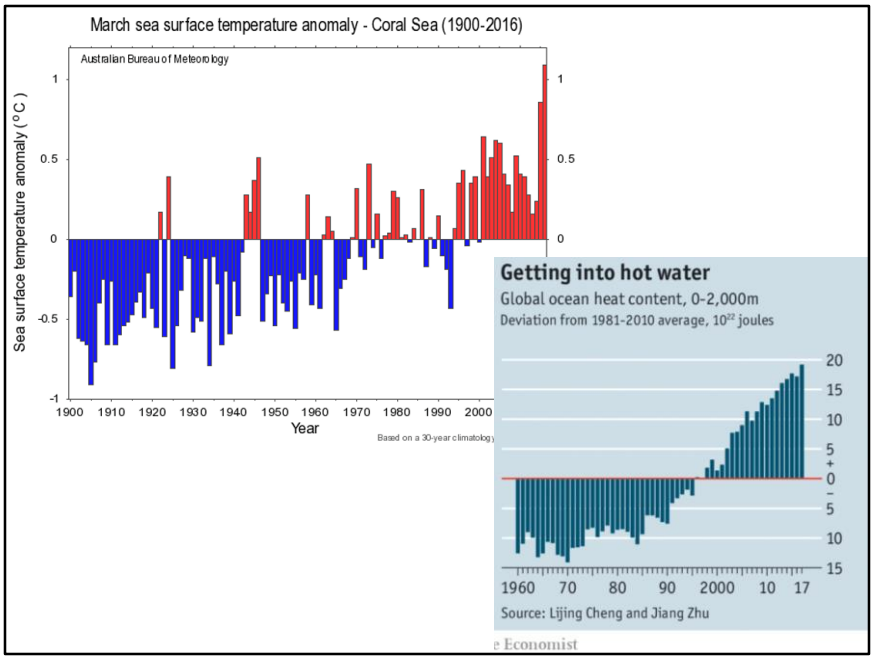
Recently, sea-surface temperatures in parts of the Tasman Sea have been much warmer than normal. In places sea-surface temperatures are about or over 2 degrees Celsius warmer than average, which rapidly changes environmental conditions – especially for cold water species like salmon.

<u>See these links for more information:</u>

https://www.stuff.co.nz/environment/climate-news/109134264/scientists-watching-rising-tasman-sea-temperatures--again

https://www.niwa.co.nz/news/scientists-confirm-warming-seas-around-new-Zealand

https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=12187629



Since the late 1990s global sea surface temperatures have been in a sustained period of heating (as illustrated by the temperature anomaly index in the two figures above).

However, when conditions are suitable even severely depleted salmon populations are capable of making a remarkable recovery. None exemplify this better then the remarkable resurgence of the Sockeye salmon populations across the upper Waitaki catchment. By the late 1990s / early 2000s Sockeye salmon were basically considered to be functionally extinct. Yet, 20 years on the annual spawning run is now estimate to range between 30, 000 – 40,000 individuals ....

GATHERING FW DATA FOR EVIDENCE-BASED DECISION MAKING

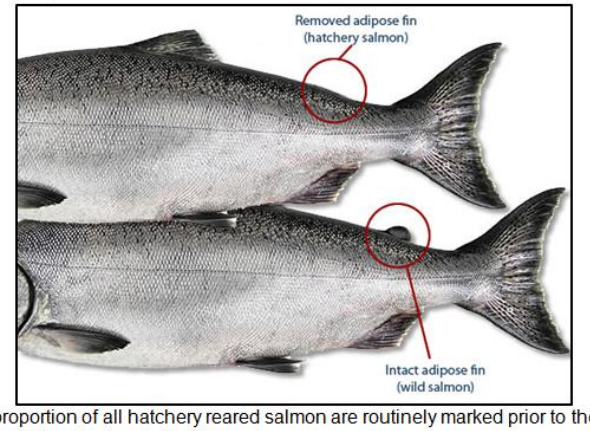
It is difficult to manage what you do not monitor…

- Adaptive improvements to enhancement programmes require some form of monitoring!
- Most hatcheries measure the "success" (*i.e. Smolt – Adult Survival, SAR*) of different release strategies (fish size/time/release location etc) in order to A) verify their contribution to harvest, B) ensure they are producing/stocking the right type/size of fish.

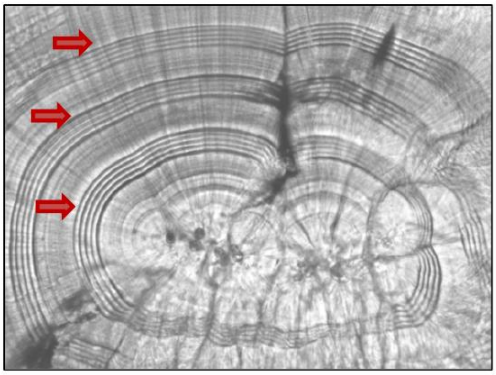
Salmon enhancement programmes and releases of hatchery reared smolt needs to be treated as a experiment ....

Hatchery Guidelines: 1. Don’t mix populations (maintain genetic oversight), 2. Must have monitoring programme (marking programme/monitor adult returns), 3. Budget accordingly!

Assess the proportion of Hatchery vs. Wild fish captured by anglers:



A proportion of all hatchery reared salmon are routinely marked prior to their release into the wild by clipping their adipose fin.



Example of a thermally marked Chinook salmon (*Oncorhynchus tshawytscha*) otolith. There are three distinct series (red arrows) of five marking events. Each marking event is caused by exposure to 8 hours of cool and 16 hours of background water temperature (from Volk *et al.* 2004).

WILD SALMON POPULATIONS ARE SHAPED BY THEIR ENVIRONMENTS ...

1. Natural scientists have known for years that a diverse ecosystem is always more resilient than a monoculture to disease.

2. Wild salmon populations are no different – a diverse range of spawning and nursery areas, and life history strategies (such as spawning date, size at ocean entry or age at maturity) increases the populations resilience to both natural and man made disturbances.

3. So to summaries the key message from researchers globally today is to focus efforts on looking after locally adapted wild populations, and their habitats, and prioritise evaluating how harvest rates and enhancement efforts may impact them.

QUESTIONS ? ...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