Stocking Conference Report

Summary of the 19 presentations given across two days on the pros and cons of stocking from almost every angle conceivable.

Day One

Talk 1 – Why Stock?
David Soloman

This presentation was focused on why fisheries managers might want to begin a stocking programme and postulated 7 main reasons why stocking might or might not be needed and whether stocking was likely be effective in each case. The presentation then moves on to look at restoration rather than just stocking based on some of the points raised previously. The reasons and associated points are listed below:

1. No salmon in the catchment and I want there to be.
    - It's important in the 1st instance to find out why there are no salmon – is it because there are barriers or no spawning grounds?
        - Bypassing the barriers may be more effective than stocking – stocking will likely have to become permanent ranching as there would be no chance of natural spawning.

2. Not as many salmon in the catchment as I want there to be/ as there could be.
    - Again why? What factors are limiting the numbers of fish? – If these issues are fixed then you may even see natural regeneration.
        - Low level stocking might be considered to encourage recovery.

3. A human influence has impacted the catchment e.g. impassable dam/ destruction of spawning grounds.
    - Without removing/ bypassing the obstruction you're looking at creating a permanent ranching programme/ commitment.
        - Generally the justification for such a programme will be the revenue generated by angling.
        - Might become a nursery programme by stocking above any of the obstructions.

4. To enhance a trait or change genetic material (e.g. improve the spring fish run).
    - It is known/ believed that sea age at return is under genetic control – selective breeding

5. To produce salmon for angling catch (ranching).
    - Risk of ranched stock spawning – increased chance of ranched fish becoming domesticated and therefore an increased risk that they may damage the population if allowed to breed. But increased domestication actually reduces the ability to breed.
        - Rainbow trout losses the ability to breed with wild trout in 3 generations.
    - Manage by having 100% catch and release of wilds and 0% catch and release of ranched.

Some evidence suggests that straying salmon are attracted to rivers with salmon already in them.

6. To use stocked fish to attract straying wild fish into the river (as “decoys”).
    - Following a pheromone trail?
    - To avoid farmed and wild fish interbreeding you don’t need to release the stocked fish as long as the pheromones can reach the river course and move down to the estuary.

Salmon rivers and works on them are better viewed as restoration projects rather than just looking at stocking – points 1, 2 and 3 all focus on issues that stocking alone will not correct/ overcome. Any good restoration programme should follow a few key principles:

1. Have a clear statement of the problem.
2. Have a set of defined objectives.
3. Note all of the factors limiting salmon numbers/ population.
4. How will the proposed actions overcome the limiting factors?

Any [good] programme will also include a means of evaluating the success or failure of the programme and this requires that the stocked fish be identifiable vs. wild, especially if used as a decoy.

Talk 2 – How salmon populations work
Ken Whelan

This talk covered much that everyone already knows but really tried to get the audience to pay attention to how much variation there is in salmon populations and how many external factors can impact on salmon populations:

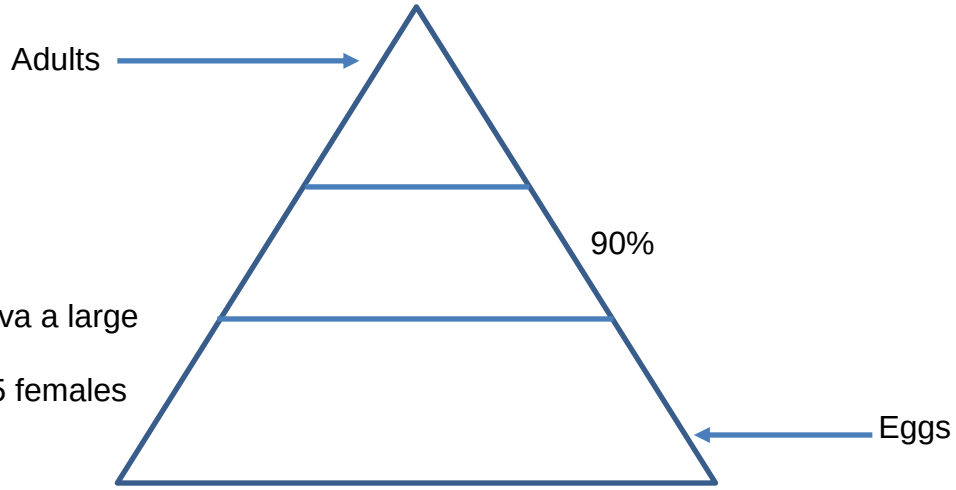
1. Salmon populations are:
    - Complex
    - Highly vulnerable
    - Highly structured
    - Specific adaptations for each life history
    - Discrete, self-sustaining populations
    - No matter how good a model is it’s only as good as last year’s data

2. Modern Salmon trace their ancestry back to approximately 50 million years ago.
    - Smolts 1-7 years, sea age 1-5 years, spring/ summer/ autumn and even winter runs.
        - Great variation in returns gives a “safety valve” to spawning events
    - On average ~1% of populations are smolts.
    - ~3 million fish in the sea (previously 7.5 – 8 million).
    - Grilse runs are usually higher than M.S.W. fish runs – 5 – 10% returns vs. 1 – 5%.
    - High temperatures in an estuary can have an impact on fish populations – mortality rates of up to 50% have been recorded.

3. Possible freshwater impacts on salmon populations:
    - Geology and the chemistry of the water
    - Vegetation

- Quality and quantity of water
- Temperature

4. Stocking is often used to address the concern that natural rates of reproduction are insufficient and that help is required to maintain healthy population:
   - In fact:
     - Natural fertilisation rates are very efficient – Precocious Parr are key to this with up to 7 spawners per red.
     - Very high numbers of eggs – adult populations have to be very low before juvenile populations drop too low to sustain a viable population.
     - A salmon population can be sustained (biologically) even if the number of adults is well below what is needed to sustain fisheries on the river (rod or net).



Is 100,000 ova a large number?
Only = 20-25 females

5. Possible marine impacts on salmon populations:
   - Salinity
   - Currents
   - By-catch

6. In the 1960's 30-40% of smolts survived at sea – now it's more like 5-10%
   - Different areas have different survival rates, however.

Talk 3 – The importance of genetics
Eric Verspoor

"Genetics" as a term covers a wide area of study which can be focused at the molecular or population level, or at a husbandry level.

1. Genetics has a role in and can help to give insights into:
   - Trait inheritance
   - The control of reproduction
   - Biodiversity = genetic diversity
   - Domestication and selective improvement
   - DNA

In order to successfully study the contributions of genetics it is generally taken to operate at a number of functional levels:

- Individuals
- Breeding populations
  - Determining this can be difficult with salmon as there may be more than one in any river
- Species

2. The individual

- Operates at a very small (molecular/ intracellular) scale.
- 100,000 of hard to define interacting DNA units

3. The population

- Interactions within individuals, between individuals, within between populations, between populations, between DNA and the environment and so on… Studies of population genetics often include:
  - Breeding studies
  - Characterising the traits and breeding success of parents and offspring
  - Analysis of DNA variation
  - Mathematical modelling

4. Issues:

- Genetic variation
- Genotype/ environment interactions

5. All individuals are genetically different and all breeding populations are genetically different.

- Fitness deviation – the difference between the genetic fitness (population or individual) and the environment (niche)
  - A big fitness deviation can lead to extinction
  - A small fitness deviation = good chances of survival

6. Populations of American and European Atlantic salmon are very different and there are also regional differences seen too e.g. Ireland.

- These differences are based on a set of molecular markers.
  - The use of markers must be treated with caution as the choice of markers/ loci is arbitrary and which markers/ loci are picked can give different levels of difference (or none)

7. Population “choices” were made/ adapted to 1000’s of years ago.

- In Newfoundland there are populations of salmon that never go to sea – they don’t migrate out to sea because 10,000 years ago the sea temperature was unsuitable and over time they lost the “instinct” and never got it back.
- Oykel eggs are resistant to acid flushes in the river, while eggs from the nearby (relatively) Shin are not (there are no acid flushes in the Shin).
  - Shin eggs stocked into the Oykel would show a very high mortality.

8. Populations can demonstrate both inbreeding and OUTBREEDING depression.
   - Most salmon populations are so well adapted to their specific environment (river) that by cross breeding them you create hybrids which are less well adapted as you've brought in less "fit" genes.

Talk 4 – Case study – Connecticut River Restoration Project – Management NOT Research Steve Gephard

1. The native salmon from the river were gone by 1810 – no native salmon at all.
   – Objective of the stocking was to create a run where no run existed at the time.

2. Started with 2 year smolts but went to a 1 year programme for costs (1year were cheaper) and there was no noticeable difference between the return rates of 1 and 2 year smolts.

3. Where do you get your stock?
   - Nearest river? – couldn't because there just weren't any.
   - Use eggs from a wide variety of locations and hope/ allow natural selection to occur.
     - Using Canadian eggs they had 7 returns in one year.
     - After nearby eggs became available from the 1970's the returns went up to 90 in one year.

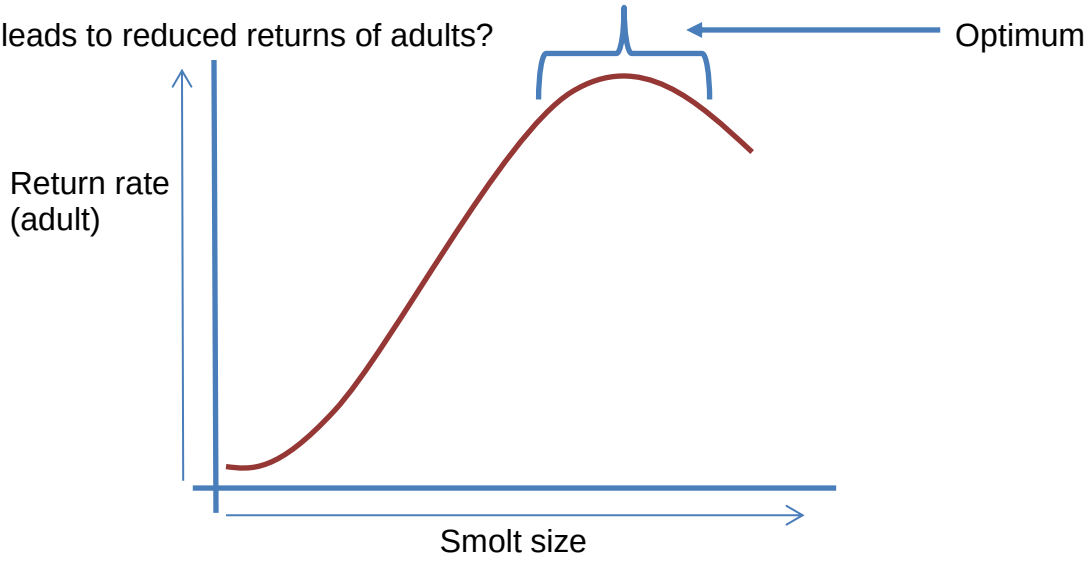
4. Down east rivers capture wild parr because the wild adult numbers are so low – these parr are then reared on to be broodstock.

5. Determining what's a smolt (McCormack et al 2006) – physiological assessment.
   - This showed that fish from well water hatcheries rather than surface water hatchery often look like smolts but aren't/ weren't.
     - Radio tagging showed that when released these fish went upstream not downstream.
   - High densities retarded smoltification

6. Night stocking results were inconclusive.

7. Hatchery stocked fish gave a peak return when released at the peak flow of the river – whereas wild smolts gave a peak return when they smolted later e.g. at a lower flow.

8. V. large smolts leads to reduced returns of adults?



9. A relationship was observed between fin condition (fatal fin condition) and sea survival/ returns.

10. Salmon home very effectively even spawning in sub-optimal locations, if that's where they were hatched.

- Need to put smolts out where you want them to spawn.

11. Study shows time spent in free flowing water may be beneficial to smolts.

12. Chose to move on to putting out fry to establish a parr population in the unused habitat to try and avoid the reduction in return rate associated with continued smolt release.

13. This project (and most US rivers) found that parr stocking (rather than fry or smolt) was not an effective way of establishing a returning population of adults.

14. In the end the project never created a self-sustaining population.

- Habitat issues never addressed? – lots of dams (with fish breaks) and many areas of poor habitat.
- Project knew that dams were the problem and part of the process/ project was getting fish ways mandated and getting fish bypasses etc. built to allow the fish to get to the sea.

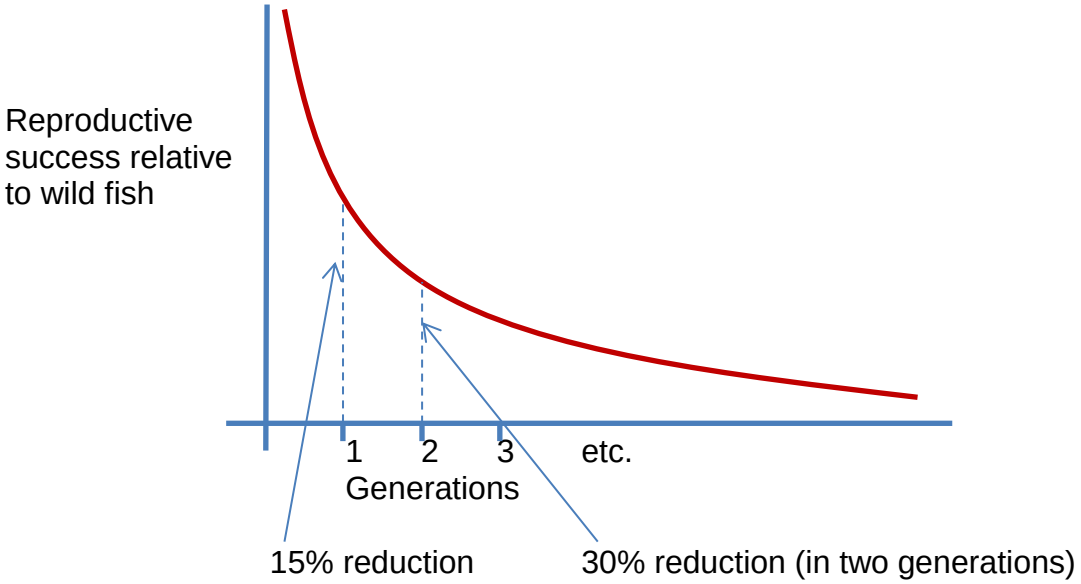
Talk 5 – Stocking versus catches
Kyle Young

1. Stocking has been going on since the time of Darwin.

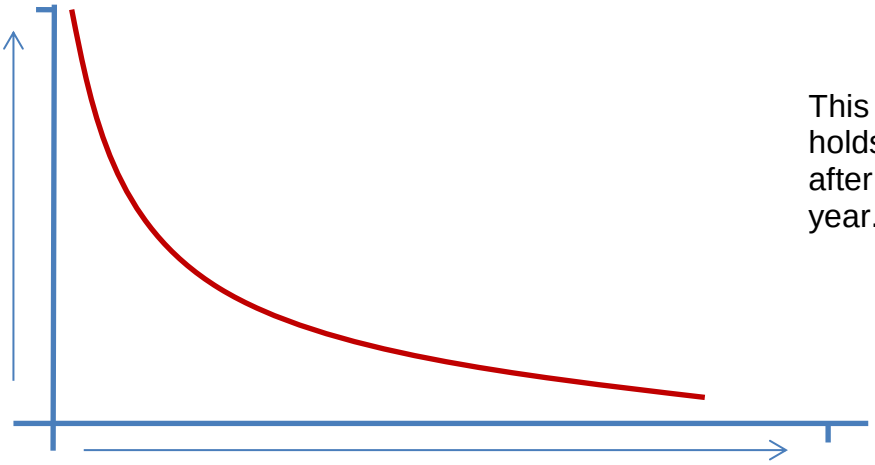
2. Hatchery changes the ratio of fitness and phenotype.

- For example: Peppered Moth – taking a white bark moth and raising it in a black bark environment and then releasing it back into a white bark environment.

3. Cumulative fitness decline when salmon are held in hatchery facilities for several generations.



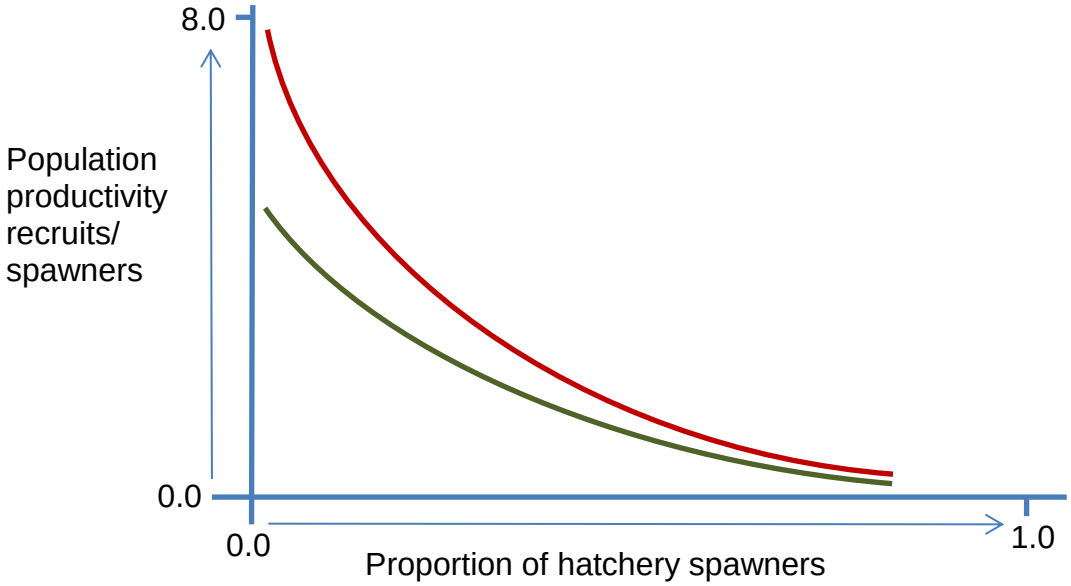
Average # of adults produced by their offspring breeding in the wild



This relationship holds up year after year after year.

Adults produced by wild broodstock bred in the hatchery

4. The “Catch-22” of stocking



5. The impact of hatchery fish is to push down the productivity of the population.
   - ☐ So why stock? – Angling
   - ☐ Does mean catch go up with mean stocking?
     - No. Stocked catchments do not have higher rod catches
   - ☐ Does annual stocking effort affect annual rod catch
     - No. Annual stocking effort is not related to annual catch.

6. Damage from stocking doesn’t appear to be balanced by detectable fishery benefits.
   - ☐ When do the benefits of stocking balance the damage?

Talk 6 – Effectiveness of stocking as a means of restoring salmon populations. Jamie Stevens

1. This talk focused on:
   - ☐ The natural re-colonisation of the Thames river
   - ☐ The natural re-colonisation of the Mersey river
   - ☐ The natural re-colonisation of the Tweed river
   - ☐ The impact of supportive breeding in the Dart river

2. What happen to stocked fish:
    - If they persist?
        - Displace wild populations
        - Interbreed with wild populations
    - Don't persist?
        - Stocking becomes a waste of time/ effort/ money

3. Thames stocked with fry, parr and smolts from 1975/ 78 through to 2010
    - Stocked (due to cost) with low quality Shannon and Delphi fish.
    - Analysed 10 tagged and 16 untagged fish caught between 2003 & 2008.
    - Used a base marker and found that the tagged fish came from Ireland and that the 16 untagged fish were coming from chalk streams in southern England (near the Isle of Wight) – these fish now seem to be dominating the Thames.
    - Restoration of the river's environment allows fish to return naturally (maybe acting as decoys?)

4. The Mersey showed restoration from close by rivers to the north of Liverpool.
    - Again river environment restoration appears to be the key to the natural restoration.

5. River Dart salmon numbers dropped.
    - Dart had been stocked for a long time.
        - three river stocks used in 1960's but need to see what happened
        - Using scales from the 1960's they found that:
            - 2-9% had Scottish ancestry
            - 1-5% had Icelandic ancestry
        - Definitive conclusion that there was no displacement by incomers
        - No hybridisation
        - Native stock now holds most of the numbers – 86-97% of the population.

6. "Get the river right and the fish will come back".

7. Clyde suggests introgression of Norwegian genes into the Clyde population, will it last or not?

Talk 7 – River Carron Restoration Project (so far…)
Eric Verspoor

This talk was a general summary of the RCRP to date and contained no real data or conclusions as the project is still ongoing and unfolding – for more details see the RCRP website.

1. Assessment of historical data and collection of new data to see there is a recovery or not?

Talk 8 – Smoltpro – Sustainable smolt production; an integrated approach.
Jörgen Johnsson

1. Hydroelectric dams put onto almost every dam in Sweden, in law they had to compensate by releasing smolts. In 1960's, 70's etc. the return rates were high but recent years have seen a drop (no longer cost effective). Smoltpro set up to develop a more cost effective and ecologically sound way to produce the required smolts.

2. Projects works as five working groups, each with a different area of responsibility e.g. economic WG, in hatchery WG, post release WG.

3. Paper released on "structural environment" Nësland et al (2013):
   - Reduces stress and fin damage, increases shelter-seeking behaviour in pre-smolt Atlantic salmon

4. Feed reduction and starvation has no or negative effects on one year smolts but increases migration speed in two year old Atlantic salmon smolts.

5. Reduced rearing density enhances seaward migration in one year old smolts.

6. Reduced rearing density increases spawning returns after one sea winter (one year old smolts)
   - 37 low density versus 19 high density so far.

7. Reduced rearing density generally increases the performance of one year old smolts.
   - Decreases fin damage.
   - Increased resistance to infection (due to improved intestinal barrier).
   - Increased migration.
   - Increased return rates (preliminary).
   - All of the above make the process more cost effective.

Talk 9 – The Lochy Smolt Programme
Jon Gibb

1. Fishing brings in ~£500,000 PA to the local economy

2. 1998 had a collapse in fishing from a peak at 2000 PA to ~32.

3. 3 Mile zone infringement from inshore fishing (act?) from 1984 onwards?

4. Do salmon follow pheromones trails to fish farms rather than to spawning grounds?

5. Lice data for the Lochy supports the two year cycle for lice infestation on trout.

6. Started to stock with fed fry but decided that this was not solving the problem e.g. lice.

7. Swapped to smolts
   - Less time spent in the river, can be marked (adipose fin clip), treated with SLICE to combat sea lice.
   - Always use indigenous fish

- Smolts from 2009

8. Allow killing of fin-clipped fish to attract anglers.

Talk 10 – River Bush, Northern Ireland; A case study.
Richard Kennedy.

1. Salmon station set up in 1973/ 4

2. Set up around a set of traps for smolts and adults

3. Pressures on salmon include:
   - Arterial drainage schemes
   - Excessive weed growth – weed is blocking the creation of redds
   - Degradation of the riparian zone
   - Reduction in habitat quality in the 1980's and 1990's
   - Predation

4. Smolt run has dropped to a low in 1995.
   - In the 1990's the conservation limit was not reached by natural deposition of ova.

5. Set targets to keep production above the conservation limit

Conservation Limit (CL)
The number of individuals required to successfully spawn – to maintain a "healthy" population this number of fish must be left in the river after the fishery has removed the fish it requires.

6. Bush monitors smolt production.
   - Suggests that when unfed and fed fry were put into the river the smolts through the trap outstripped the predictions in every year.

7. Estimated a fed fry survival rate of 4% - actually got (after careful stocking out) 5.15%(ish)
   - Still failed to maintain conservation limits except for two years between 2000 and 2012.

8. Stocked smolts were less developed, younger and ran earlier.

9. As said previously – abundance is <u>not</u> key, <u>quality is</u>.

10. Fix habitat issues

11. Maximise wild spawning and wild smolts which are better suited.

Talk 11 – What works: A workshop on wild Atlantic salmon recovery programmes.
Jon Carr

1. There have been declining stocks in Atlantic Salmon.
   - A near complete collapse in 1990's.

2. Southern range of US/ Canada rivers have threatened populations.

3. Salmon recovery?
   - □ Habitat restoration
   - □ Habitat restriction/ control
   - □ Hatcheries and captive breeding
     - Started in Germany in 1773

4.

Wild	Hatchery
▪ High mortality ▪ High selective pressures ▪ "On their own" ▪ Natural adaptation	▪ Low mortality ▪ Low selective pressures ▪ "Constant care" ▪ Low/ no natural adaptation

5. Difference in early life?
   - □ Eggs split ½ in a natural environment - heavier, better condition
     ½ in an incubator - enhanced feeding and more risk adverse
     - No difference in brain size in either environment - Higher survival and faster growth in semi-natural river/ streams

6. Reproductive success of wild exposed (freshwater juvenile stage) versus fully captive.
   - □ 76.1% ♀ 76.9% ♂ versus 23.9% ♀ 23.1% ♂

7. Transgenerational effects – offspring fitness of wild exposed vs. fully captive
   - □ Wild exposed can improve short (reproductive success) and long term (transgenerational) fitness of captive bred population.

8. Morphology – Who's from the hatchery?

Tanks	Semi-natural
X	✓ More similar in shape to wild
X	✓ Better fins on substrate
X	✓ Flow gives better fins and behaviour

9. Incubator environment impacts on growth/ phenotype

10. "Captive breeding as a temporary tool – must work to eliminate problems rather than relying only on stocking and don't make stocking your 1st resort."

Day two

Talk 1 – Overview of potential genetic impacts.
Phil McGinnity

1. Consideration
   Potential effects
   Literature

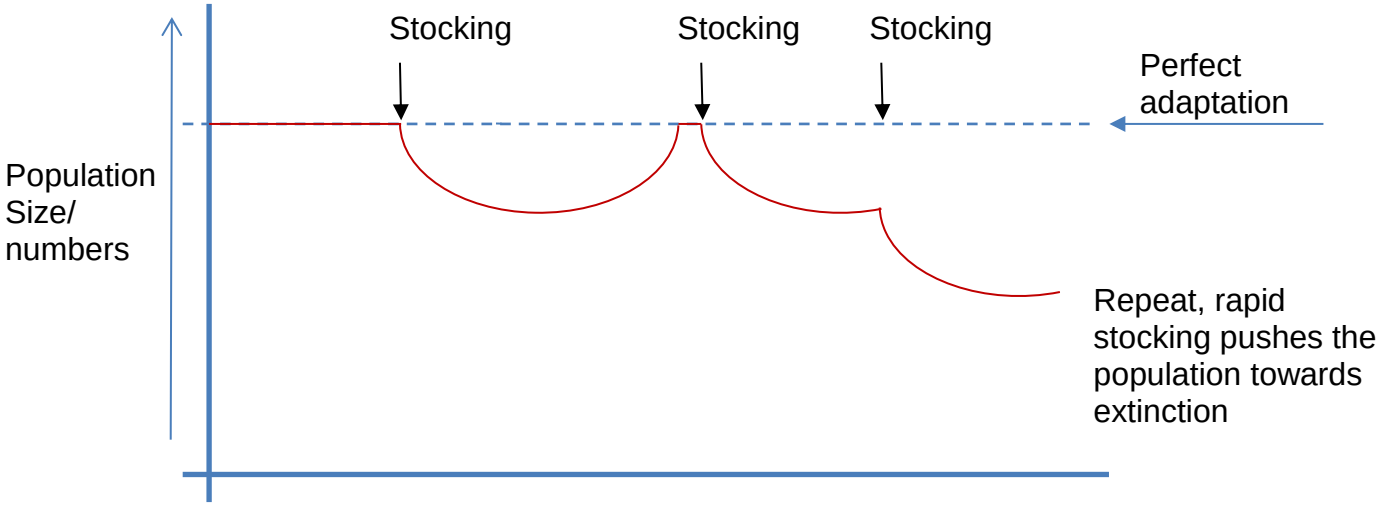
Present results
Summary
Context and protecting wildlife

2. Different populations in salmon
   Genetic structure in these is finely tuned
   Introduction from other populations will upset that adaptation

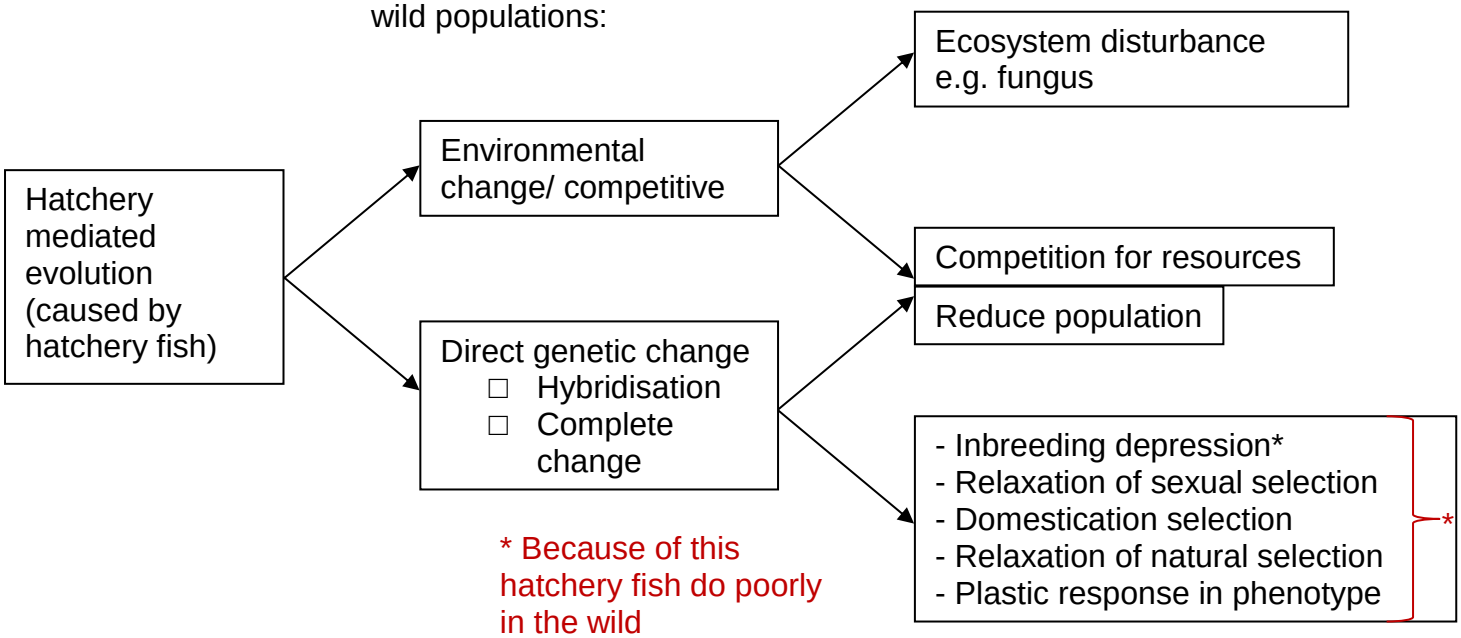
3. Local adaptation.
   - Phenotypic traits are heritable and provide best match for a given environment – freshwater, estuarine etc.
   - Includes things like timing of return – fish from different tributaries return at different times.

4. When there is a mismatch between genetics and environment you get a loss of numbers in a population but evolution occurs and ultimately population numbers go back up.

However:



5. Maladaptation leads to a reduction in population.
   - Get depression before you get adaptation
   - Some of the ways in which hatchery fish can impact on the genetics of wild populations:

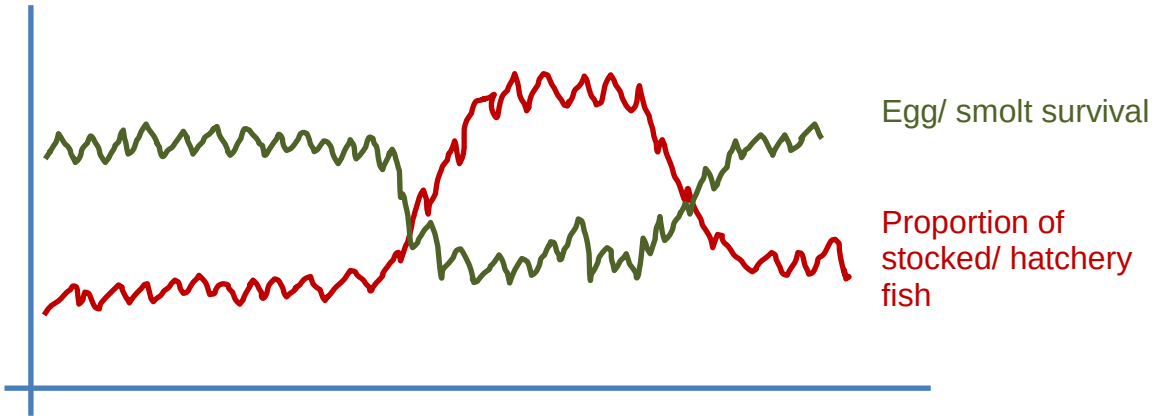


* A single event of close inbreeding = 78% reduction in the marine survival rate but almost no effect on the freshwater survival.

6. One generation of captive breeding:
   - Increases in-hatchery fitness
   - Decreases in-wild fitness
     - ~50% reduction in Atlantic salmon

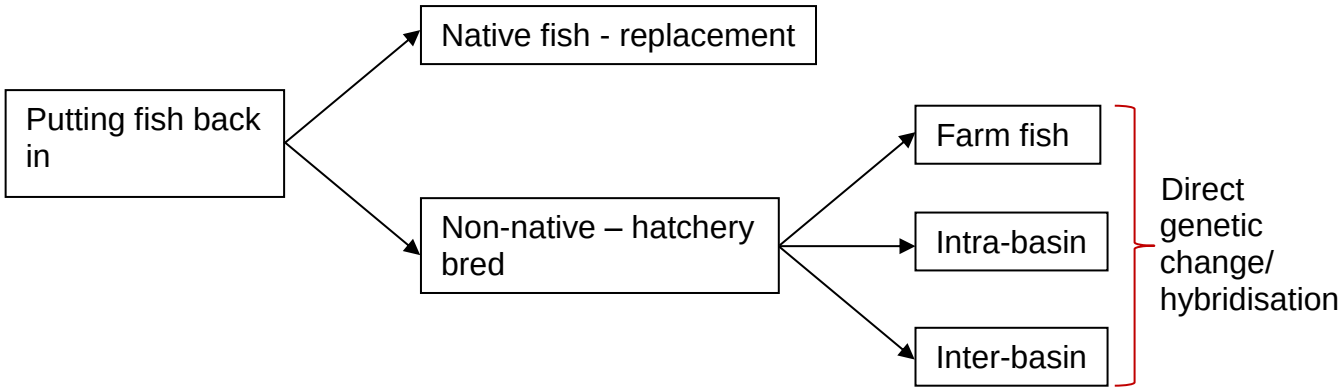
7. Characteristics affected – risk taking, aggressiveness (in mating) etc.

8.

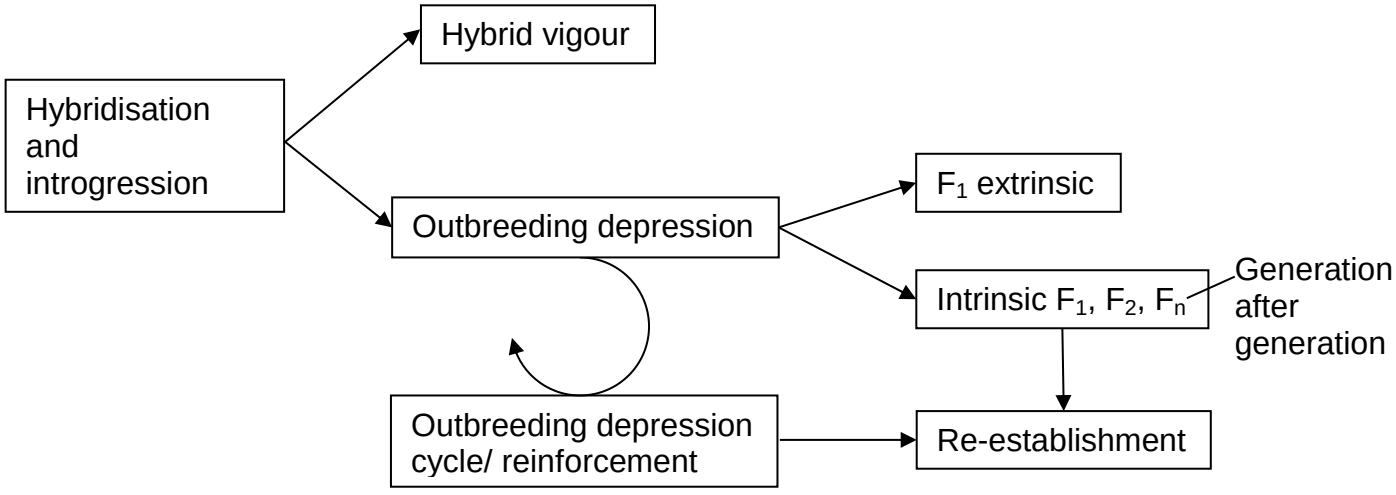


"Increasing proportions of stocked fish depress the survival of eggs and smolts"

9. Possible sources of stock and their possible impacts.



10. Hybridisation and introgression



11. The more you mix up the genes in a genotype the less fit (more maladapted) the hybrids are likely to be.

12. Little evidence of heterosis (hybrid vigour) – not when taken over the whole life cycle including estuary, sea etc.

13. Comparisons of survival:
- If natural = 1.00 (100%)
- If farmed = 0.02
- F1 (1st generation hybrid) = 0.42

Fitness/ survival measure

14. Occurs even at the scale of local fish populations.
- In the Burrishoole river – wild = 1.00
- The Owenmore (same river different tributary 50km distant) = 0.17
  - The main penalty is in the marine phase

15. 7/8 markers studied are intermediate in performance (outbreeding depression)

16. Considerations/ summary:
- Any impacts will be relative to the size of the introduction.
- Origin of introduced material.
- Behaviour – sexual selection.
- Behaviour – freshwater experience (life history, stage of release.
  - Smolts often less good at breeding than fry).
- Status of wild population.
  - Healthier population can resist introgression better than a weak population.
- Environmental factors
- Mature male parr – better at facilitating gene flow
- Carrying capacity

Talk 2 – Genetic parentage analysis to assess hatchery efficacy on the Spey.
Mark Coulson

1. Why stock?

2. Genotyping of broodstock.
- Evaluation of study success
- Identification of siblings

3. Used stock from as near to the river as possible.
- Objective – to boost natural smolt output.

4. Kept very careful records of who was mated with whom (fish).

5. What proportion of the rod-caught fish can be traced back to the hatchery?
- DNA – Fingerprints

– Paternity – looking at parentage (both parents) rather than paternity
– Relatedness
– Forensics

6. Look at a marker a marker and look to see what is shared between offspring and parents.
   - To get a good measure you use 17 markers as this is considered enough to exclude most potential parents.

7. 4,183 individuals were screened
   - 36 cases (0.8%) of identical genotypes – removed as experimental errors
   - Leaving 4,155 distinct genotypes
     - 114 (2.7%) removed due to insufficient profiles – tissue damage/ sample degradation, experimental error
   - 4,041 used for analysis
   - Compared with the "stud books" from the hatchery

8. 2008 catches to 2012 catches looked at to see what proportion were from the hatchery.
   - 1,958 individuals from rod catches

1,931	10	17
Not hatchery stock	1 hatchery parent ↓ 7 = ♂ 3 = ♀ ↓ Matched as a precocious parr and we've sampled it's early mating rather than it's mating in the hatchery	2 hatchery parents ↓ - 16/17 crosses occurred in the hatchery - Both parents caught same year and same area - Very small percentage of returns (0 to 1.8%)

9. >98% accuracy for study.

10. Possible issues/ errors in analysis.
   - Human error
   - False positives
   - Close relatives to true parentage e.g. "uncles" and "aunts" being picked up

11. 0% are returning to the Spey dam where there is a lot of stocking – re-capture electrofishing shows that the stocked juveniles are persisting above the dam.

Talk 3 – Ranga experience – Icelandic river(s)
Jóhannes Hinriksson

1. The west Ranga – one of the biggest spring water rivers in Iceland – 2 waterfalls, both have fish ladders.

2. The East Ranga is smaller and get darker during rains.

3. Low catches in 1972 – 89 of salmon (trout and Charr where okay).
   - Locals released parr in 1970's and 1980's.
   - No research done so far.

4. Local angling club put 48,000 smolts in to the river in 1989.
   - Put four ponds along the river by diverting the river, kept it going for a few months before release and the next year they got over 1000 salmon back.

5. The river association continued.
   - At this time the money earned from the fishery only just covers the cost of producing the smolts.

6. In 2002 a hatchery came up for sale and the Ranga people brought the hatchery.
   - Made up to 500,000 smolts
   - Returns are up to ~4% - no funding only paid for by fishing licences.
     - Cheapest licence is £80 up to £4,000 per rod per day.

7. In the last five years 50-55% of the licence income has covered the cost of the programme the rest has been used for re-investment and dividends.

8. 14,315 fish caught by 20 rods in 2008

9. From 2006 decided to hold smolts back as long as possible with positive results.

10. From 2009 they have used a natural release by just opening the ponds and letting the smolts leave naturally – have seen some drop in returns.

11. In 2012 decided to again hold the smolts back and catch went up from 4,353 to 5,461.

12. £43.00 average cost per fish.

13. Smolt release ponds are 20m x 10m by 1-1.5m deep.
   - Pond water is warmed by 1-3^{O}Cin a lake above the ponds – this helps to cause earlier smolting.

14. Hold the smolts until they are ready to go straight out to sea from the ponds – long, thin with loose scales is the best stage (17-23 cm, 14 grams are best size for release).

15. Use two year smolts (no success with one year smolts).
   - Feed twice a day for 30 – 60 days (rarely less than 40 days)

16. Broodstock – Use cages and get anglers to sell their 2SW fish to programme these are then retained for broodstock.

- Checked for disease/ infection – if present then not used for broodstock

17. Last year got 180 2SW ♀.

- Use three year males for mating.
- 80-85% of returns grilse still but seeing an increase in MSW catch since they started to select for 2SW ♀ in the broodstock.

18. Income from the licences has given money for the building of better facilities.

19. Trout and Charr are persisting but trout will be protected from next year.

- Trout fishing has gone because there are more fishermen? – Overfishing in the last few years?

20. Needs some research doing to see if there are any wild fish left.

Talk 4 – Delphi and Burrishoole
Ken Whelan

Burrishoole:

- From 1964 bred/ ranched some fish for tagging and releasing.
- The ranched strain was "designed" to do well at sea.
  - 10-15% return to the coast/ netting stations (sometimes up to 20%)
- Smolts are designed to go straight to sea.
  - 1 year (avoids fungus), reduce feed, change flow – this gets them ready to go to sea – released en masse.

Delphi:

- Introduced the Burrishoole line-bred strain and get good grille results.
- Started to line-breed MSW fish which worked when no-one thought that it would.
- Haven't had much success line-breeding a Delphi grilse so may have to re-introduce the Burrishoole strain again.
- In the 1990's the hatchery was losing in the order of £100,000 but the accommodation etc. balanced these losses out.

Most/ ALL of the ranched fish are removed at the end of the season to try and prevent them spawning and therefore affecting the natural population.

Talk 5 – Salmon stocking and climate change.
Tom Reed

1. Physical damage to the environment:

- CO_2 levels increasing.
- Oceans getting more acidic.
- Average temperature is increasing – the temperature has been higher in the Earth's past but the <u>rate</u> of warming is the current issue.

- Regional effects – continents warming more than water.
- North more than the equator.

2. Organisms can either: Move… → Individuals or populations Adapt… → Phenotype, physiological Or die!

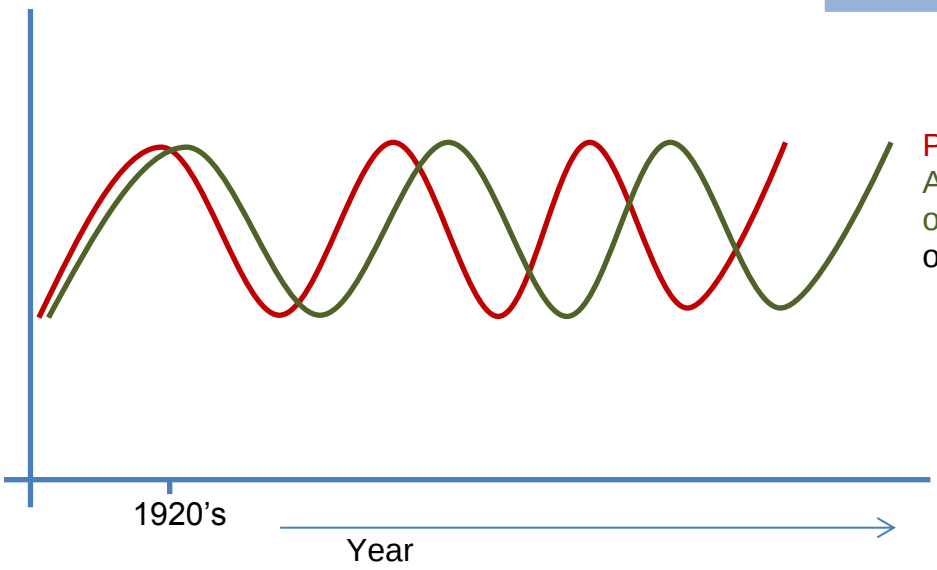
3. El Niño and La Niña (and other events) are getting more extreme (not necessarily more frequent).

Atlantic Decadal (or Multidecadal) Oscillation Is a series of long-duration changes in sea surface temperature of the Atlantic Ocean. It comprises both cool and warm phases, with phases lasting between 20 and 40 years.

4. Biotic and <u>abiotic</u> effects change in both salt and fresh water environments.

e.g.
Increased temperature
Migration costs

5.



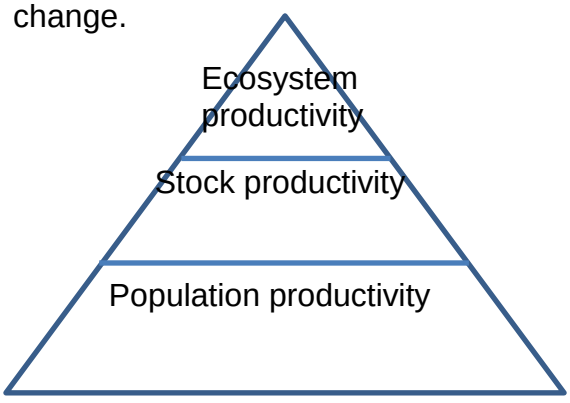
Productivity and Atlantic-decadal oscillation are now out of phase

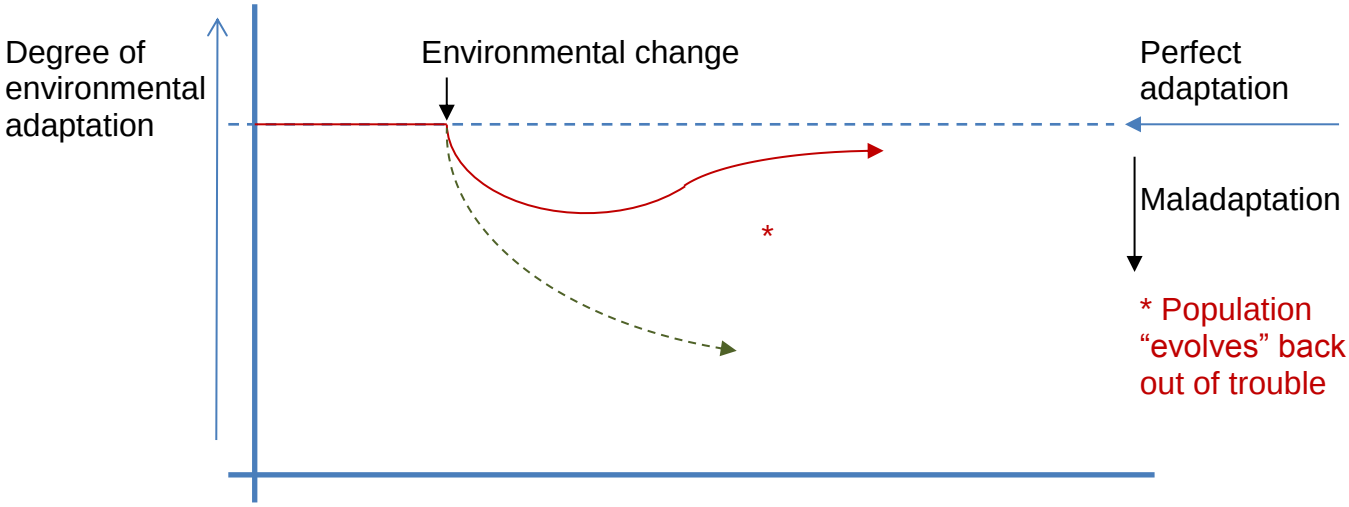
<u>Freshwater impacts</u>

6. Management of salmon in the face of climate change will be about minimising impacts in freshwater, estuary etc. – any pint in the cycle that we can take some kind of control.

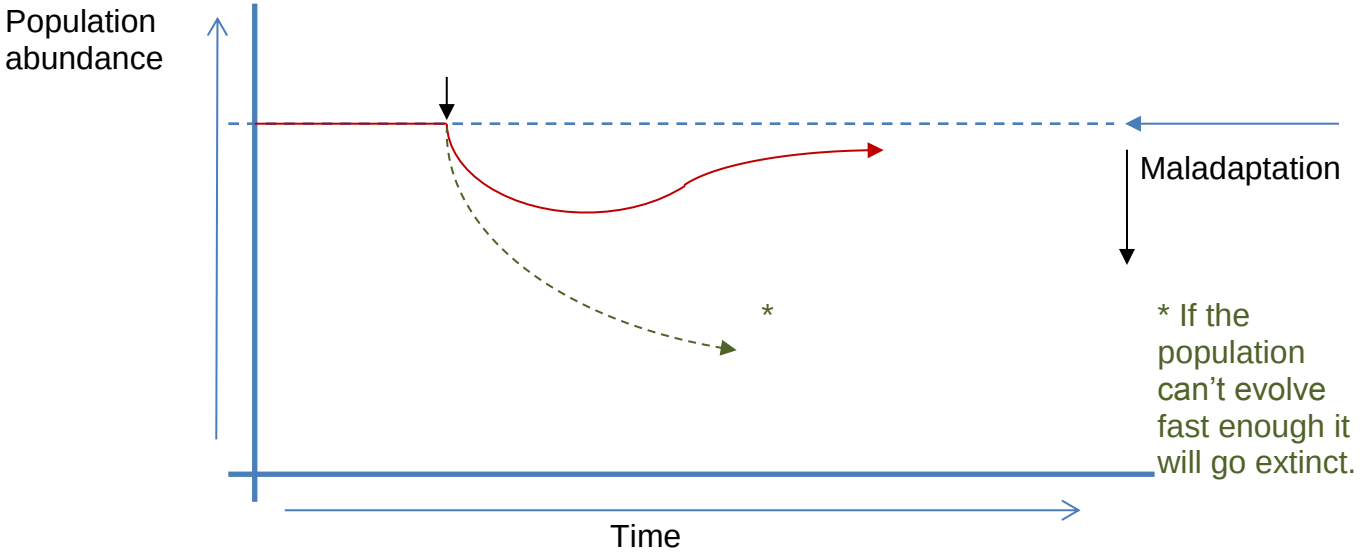
7. Can stocking help?

- ☐ Resilience = <u>sustained</u> productivity despite major environmental change.



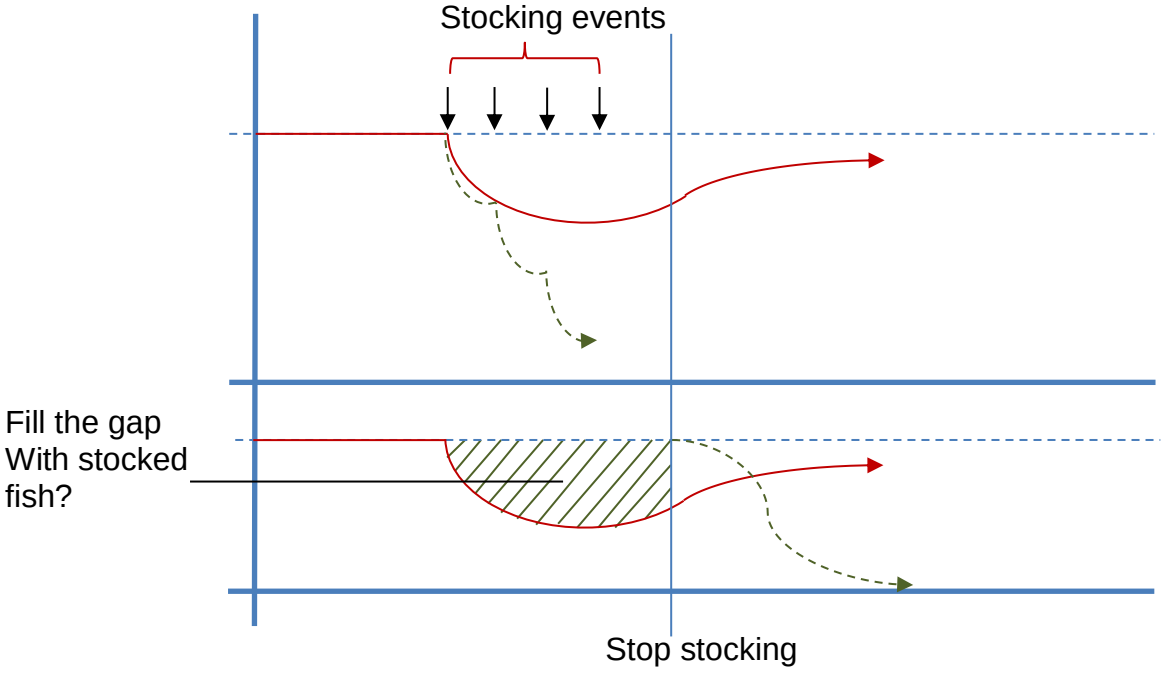


Same relationship for abundance

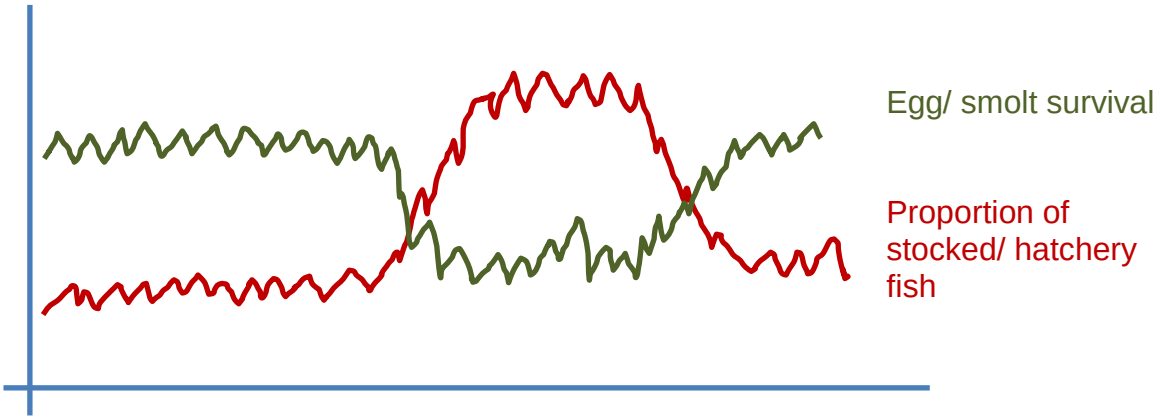


So, if populations are collapsing, what do you do?

- Stock?



Burrishoole case study



- % Hatching rate in spawning cohort (negative survival effect).
- Winter temperature for eggs/ fry (negative survival effect).
- Winter Temperature for parr (negative survival effect).
- Winter for smolts (positive effect).
- Winter temperature for hatchery eggs (VERY negative survival effect).

8. With climate change:
   - Low % of escapes shows little change in egg to smolt survival.
   - High % of escapes shows a decrease in egg to smolt survival.

9. Resilience of stocks is complex. – Look at/ compare oscillations in the Atlantic and Pacific.

10. Different populations in rivers (different tributaries) can respond to the oscillations differently giving resilience to any changes.
   - In Bristol Bay have only had to close fishing due to low numbers 4 times in a century.
   - Models show that if some of the complexity was lost then the fisheries would/ could be closed 40 times in the next century.

- If stocking leads to a decrease in local adaptation (population complexity) will this reduce the resilience of the populations?

11. Moving and adapting the population via stocking to try and map a population onto its favoured environment to try and help them to move with the climate change – could this be done?

Talk 6 – Costs and Benefits of stocking – Spey (making the best use of resources) Roger Knight

1. Two hatcheries between 2004 and 2010 producing up to 2.2 million eggs – now have one hatchery producing 230,000.

2. Genetics says that 150 fish from the hatchery contributing only ~2% of a catch of 8,000 – 10,000.

3. Spey catchment = ~3,800km^2.

4. Hatchery ran 24/ 7/ 365 at £120,000 PA for one hatchery (at peak) – 2nd hatchery added ~£40,000 – £50,000.

- □ £5,000 for running costs + staff wages, vehicles, fuel etc.
- □ Broodstock capture licence (and appropriate assessment).
- □ Hatchery now costs ~£55,000 – £60,000 PA).

5. Started stocking for enhancement.

- □ Extreme care taken to avoid doing harm to the natural population.

6. FASMOP.

- □ Assign mixed caught fish to tributaries.
- □ To see if any sub-populations exist in the river population.
- □ Identify whether the hatchery fish appear in the rod catch?
  - See Mark Coulson's data in previous talk.
    - Markers used couldn't resolve sub-population query.
    - Moved on to SNP's (Single Nucleotide Polymorphisms) – 3 times increase in differentiating samples.

7. Results of SNP's showed that some areas do have sub-populations.

8. Samples taken from across the river catchment and assessed against broodstock/ parent from previous years.

9. 2 from 558 came from the hatchery ~0.4%

- □ ∴ out of 10,000 fish caught – gives ~50 fish to the rod from the hatchery.
- → Had to extend the study to more years.
  - 0.5 – 1.8% (as per Mark Coulson's previous talk)
  - = ~150 rod catches (hatchery) versus 8,000 – 10,000 rod catches (yearly totals).
    - Balance this against how many the broodstock would have naturally put into the population if they hadn't been removed and put in the hatchery?...

10. £120,000 ÷ 150 fish?! (£800 per fish)

11. Stocking arguments need to go out into the public domain in a communicated manor suitable to the audience – so that calls for stocking and hatcheries are not the first thing that people do.

- □ Study has allowed the reallocation of resources.
  - Reduced, mitigating hatchery.
  - Bailiffs are now doing habitat restoration rather than catching broodstock.

12. Spey = £15 million PA to the local economy.
= 367 FT equivalent jobs.
= Conservation value (SAC).
- Balance to maintain the economic value of fishery and conservation.

Talk 7 – Is stocking the answer – Wye and Usk.
Stephen Marsh-Smith

1. The Wye and Usk Federation were started in 1995 and became a registered charity in 2000.

2. Both rivers are Sac classified.

3. 1973 – 1995:
- Barriers built with no fish passes.
- Poaching out of control.
- Other problems:
  - Acidification – due to pine plantations.
  - Sheep dip.
  - Agricultural intensification (sheep # increased by 4x)
  - Abstraction (climate change)
    - Hatchery closed.

4. 1995 – decision made to:
- Sort barriers.
- Sort habitat degradation.
- Sort population.
- Sort out exploitation.

5. Actually. A new hatchery was opened!

<u>So federation took matters into their own hands…</u>

6. To mitigate the forestry.
- Drainage system was blocked as the trees were removed; this re-established the original wetland habitat and improved the flow of the river.
- Acidification – limestone sand used to control the pH to between 5.5 and 7 – sand liming improved the pH significantly.

7. Barriers.
- Plan A
  - Remove the barriers with JCBs and hammers!...
- Plan B
  - Improvements on barriers that can't be removed.
  - Improvements have opened up >800km of habitat to fish.

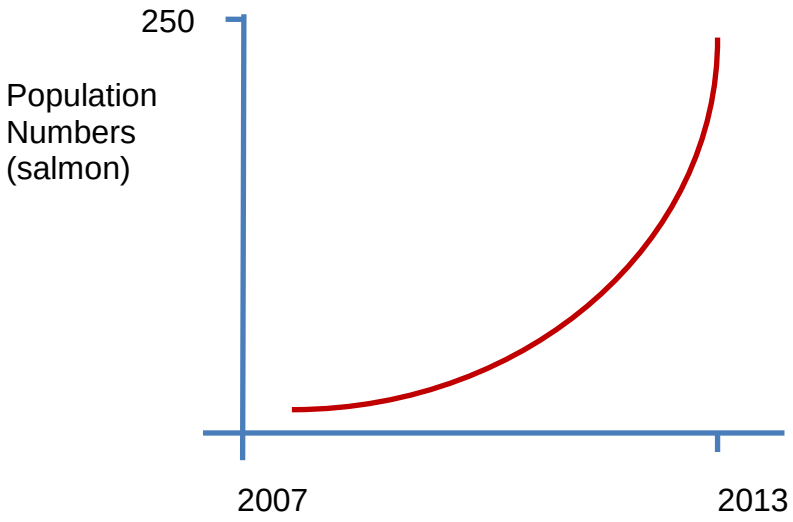
If a barrier exists then it will reduce the carrying capacity (or K) of the river. Putting fish in will only push numbers up to & against K without going past K (K will remain a constant). Need to remove the barrier to raise/ alter K.

- So far on the Wye:
  - 62 fish passes installed.
  - 19 Weirs removed.
  - >700 km of habitat opened up.
- So far on the Usk:
  - 16 fish passes installed.
  - 5 Weirs removed.
  - >155 km of habitat opened up.

8. Eroding banks.
   - ☐ Fenced off – allows recovery and tree growth for cover.
   - ☐ Produced a massive increase in fish.

9. Pollution.
   - ☐ Phosphate.
   - ☐ Sediment.
   - ☐ Pesticide.
   - ☐ Abstraction (agricultural).
   - ☐ Flooding – caused by soil compaction.
     - E.g. sewage fungus – solved the problem by putting new floors into silage clamps.

10. Have seen some very convincing results so far.



11. Hatcheries require no proper understanding of the issues, causes or scale of the problem.
   - ☐ Disproportionately expensive.
   - ☐ Treat the symptoms of the problem, not the problem itself.

Talk 8 – Ulster Angling Federation – Stocking, an angling perspective
Jim Haughey

The aim of this talk was to discuss the methods, scale and purpose of stocking from an angler's perspective through the use of an unnamed case study from Northern Ireland.

1. An example of an apparently successful hatchery/ stocking programme for the general boosting of fish numbers for angling but also for the general health of the stock.

- ~30 years of hatchery.

2. This stocking has been used as part of a programme of measures not as an isolated alternative/ cure-all.

3. Hatchery trout seemed to bring in salmon in the early days(?)

4. Stock into areas not being naturally spawned.

- River specific broodstock – lifted each year and only retained for a few months, stripped and then returned.
- Low cost – done on a volunteer basis.
- Low impact – no feeding of juveniles.
- Mitigation of local disasters e.g. floods.

5. Problems:

- Genetic variation?
- Broodstock not spawning naturally.

6. Benefits:

- Ownership and education.
- Incentives for bailiffs catch and release.
- Low impact, cost etc.

7. In Northern Ireland there are few, if any, wild rivers anymore.

- So why depend on “natural spawning” if it’s not there anymore?
- Conservation limits based on a “perfect distribution” of spawners throughout the river.
- Habitat conservation and improvement is a key element.
- Whole river restoration would be ideal.

8. In Northern Ireland - Adult returns seem to be below conservation limits.
- Juveniles surveys also seem to indicate low numbers.

<u>Discussion of whole conference and next steps.</u>

Wild stocks.

- Primacy of wild stocks; their conservation and protection should be of paramount importance.
- Stocks under pressure or below the Conservation Limit should be the focus.
- Approach, decision/ structure?
- Assessment guidance – who/ where?
- Restoration advice/ support.
- Research gaps?
- Planning for mitigation against climate change.
- Aims and objectives.
- Who should prioritise these?

- Who should fund these and why?

How do you begin to decide on what is causing the problem? – Is there a pro forma that will guide the decision?

1. Releases **not** done in areas with **viable** populations.
2. Fin clipping mandatory.
3. Conservation generic rules for rearing and releasing.
4. Monitor.
5. More research.
6. The need for conservation action to protect and save weak salmon.
7. Conservation action plans on a whole river basis are urgently needed.

Consensus that the process might be better in reverse with the emphasis moved to whole river planning first and releasing only as a final resort.

Conservation releases can be used to support a weak population.

<u>Final questions?</u>

1. How do we define what a healthy river is?
2. What is maximal abundance?