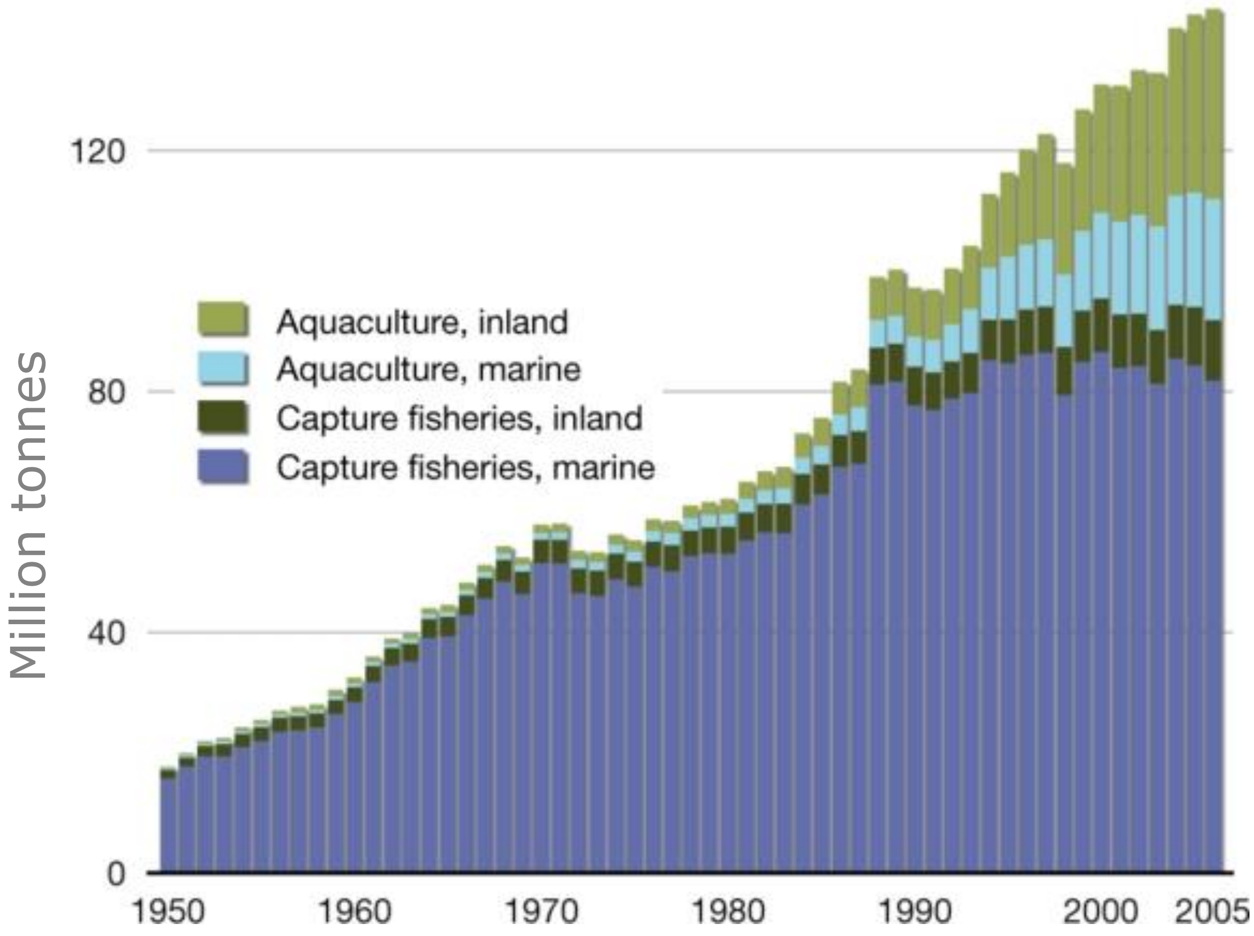
matís

Sjávarútvegsráðstefnan 2012 – Horft til framtíðar, Grand Hótel Reykjavík 8.-9. nóvember 2012.

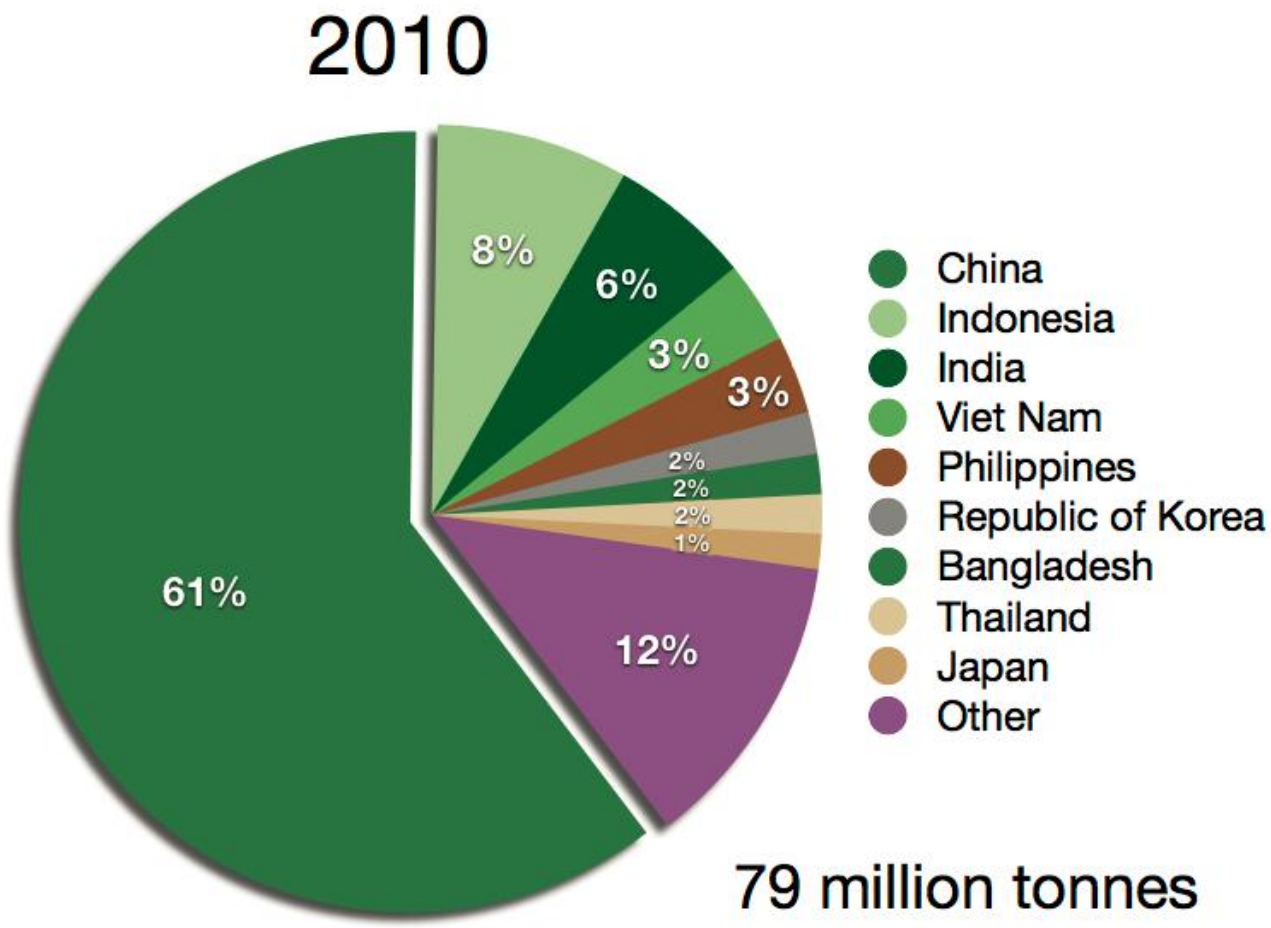
Application of Genetics in Aquaculture

Dr. Sarah Helyar

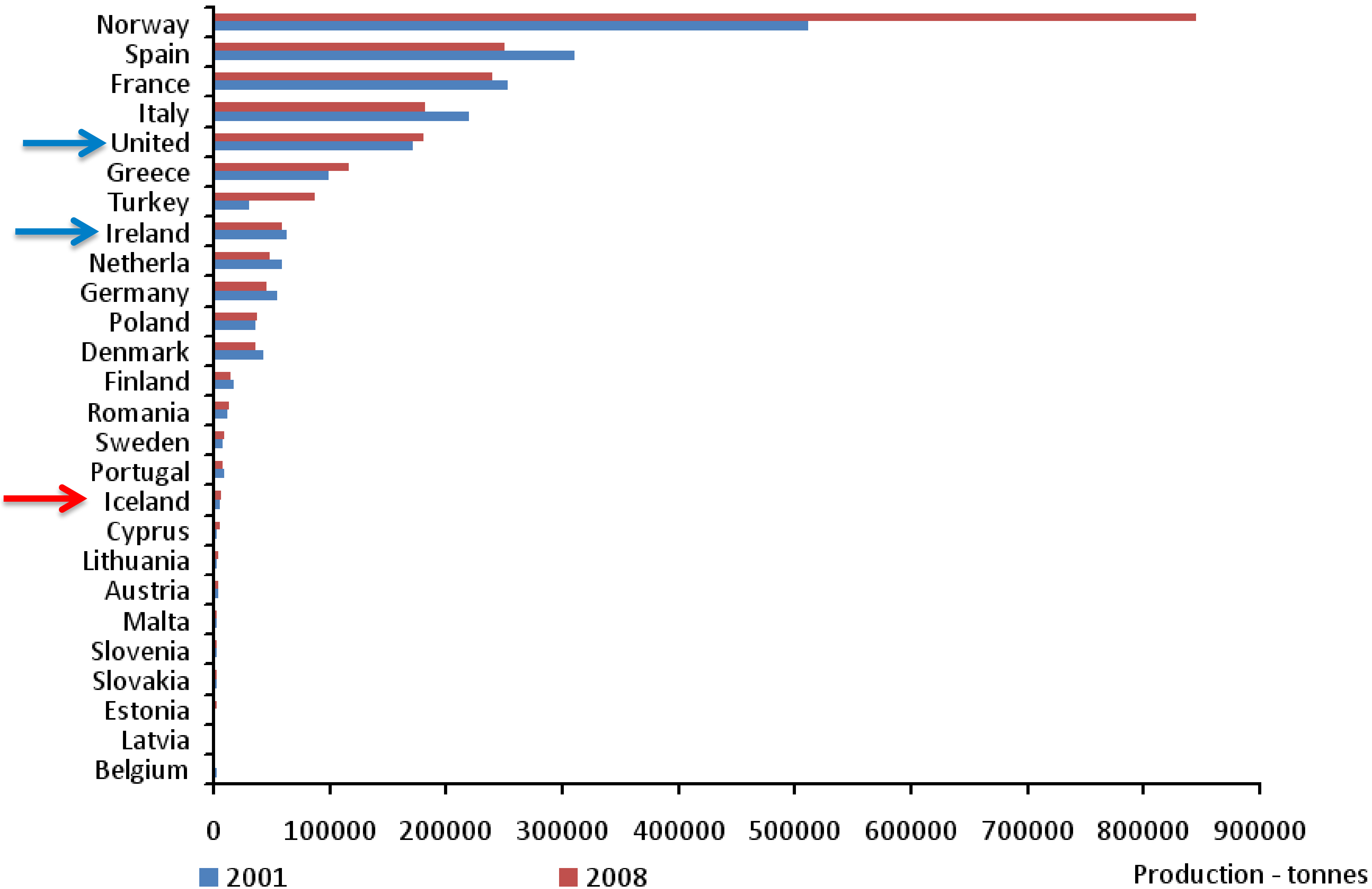
World fisheries and aquaculture production



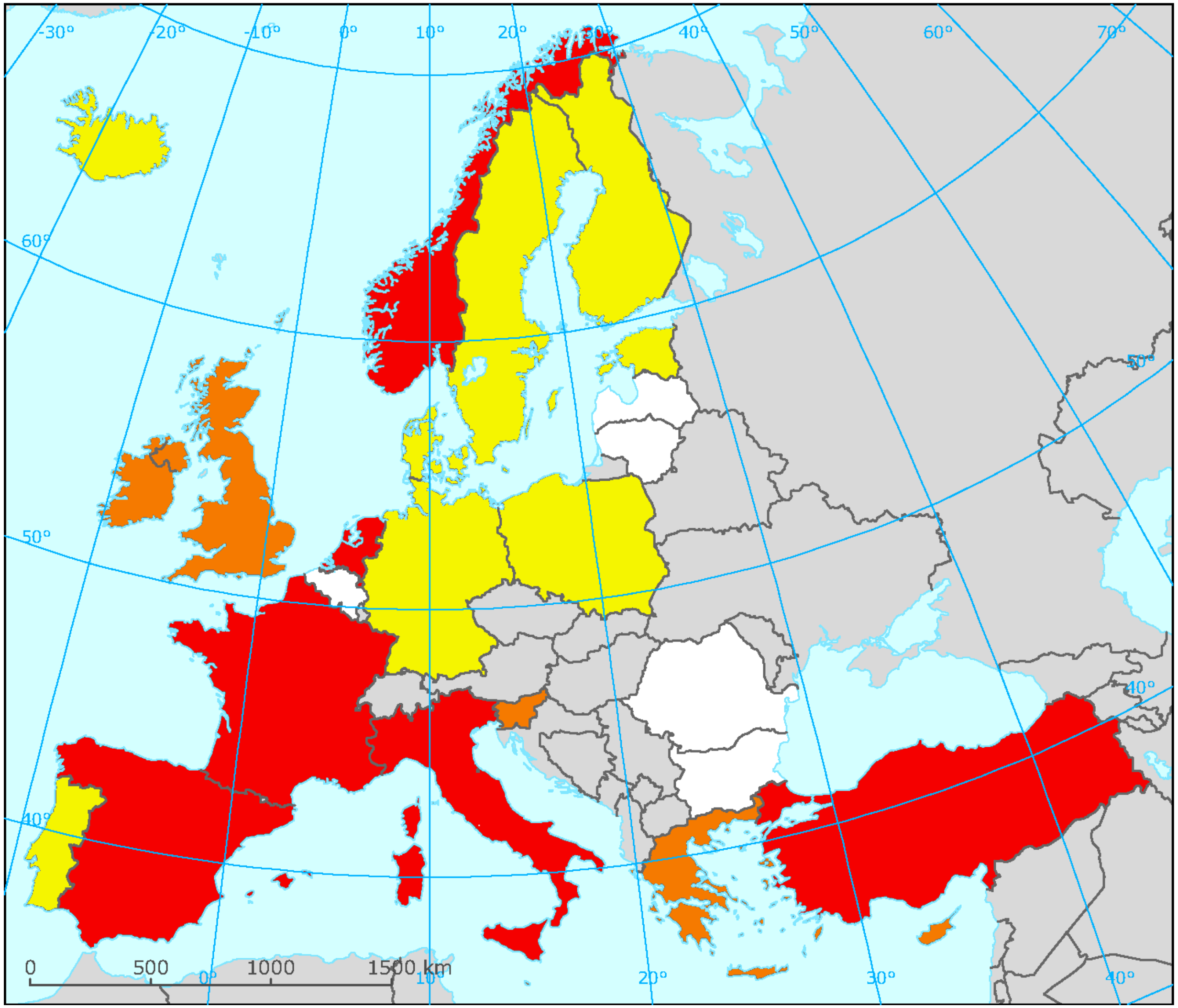
Aquaculture worldwide



Aquaculture within Europe



Aquaculture within Europe



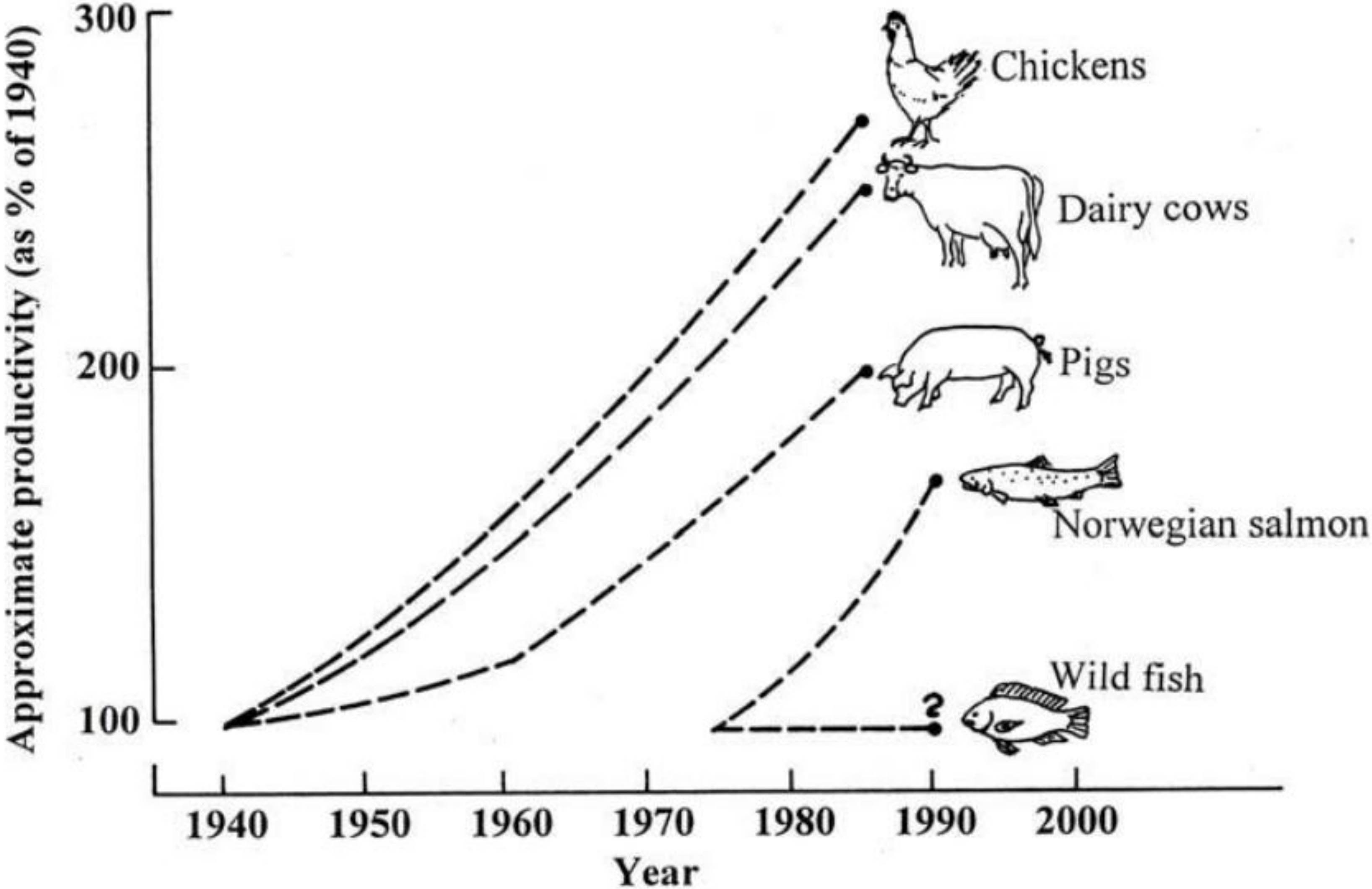
Marine aquaculture production relative to coastline length, 2008

Tonnes pr km

- 0–3
- > 3–10
- > 10–32
- No data
- Outside data coverage

The potential of genetics

The potential of genetics


Approximate productivity (as % of 1940)
300
200
100
Chickens
Dairy cows
Pigs
Norwegian salmon
Wild fish
?
1940
1950
1960
1970
1980
1990
2000
Year

The potential of genetics

selection for colour in carp and goldfish thought to have started in the 16th century.

"selective breeding does not work in fish, because fish are different from terrestrial farm animals."

1971, Colin Purdom, Lowestoft, England

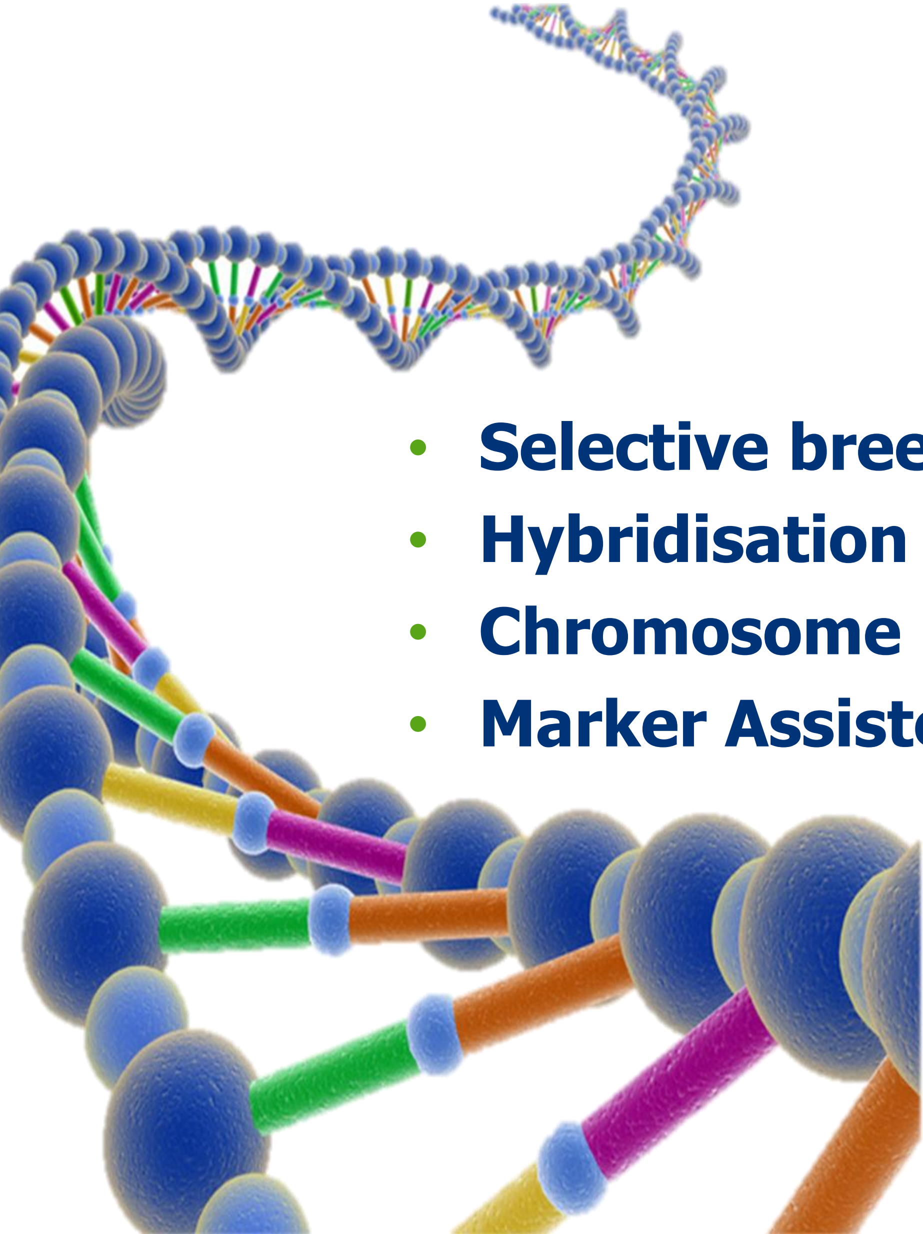
The potential of genetics

However, still not applied to aquaculture to the same extent that it has been in agriculture:

- **many species are still reliant on wild caught fry/broodstock**
- **traditional breeding programs degrade quality without replenishment**
- **Less than 5% of production from scientifically managed programs**

However, external fertilisation and high fecundity are advantages for targetting genetic improvement

Main techniques available:

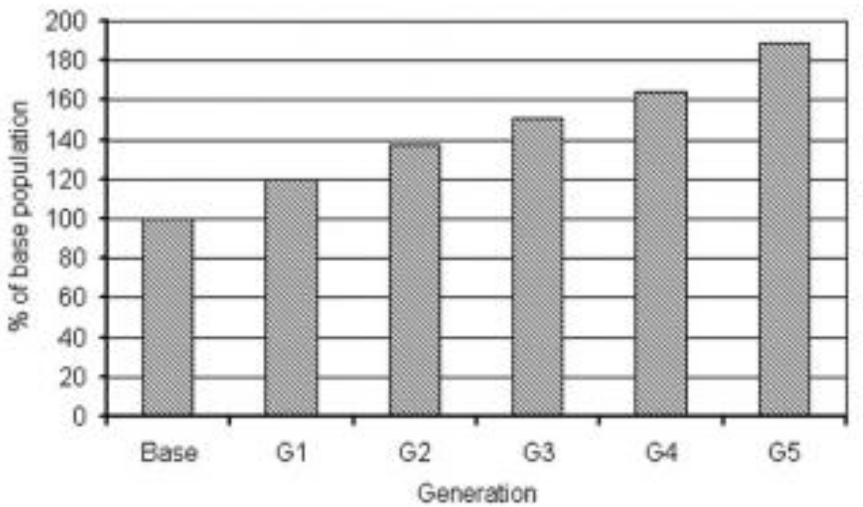


- Selective breeding
- Hybridisation
- Chromosome manipulation
- Marker Assisted Selection (MAS)

Selective breeding:

Nile Tilapia – the GIFT project

Through five generations of selection conducted during the life span of the GIFT project, the accumulated selection response for growth rate was 86% (corresponding to an average of 17% per generation)



Selection response in the GIFT project for increased bodyweight at harvest, measured as the percentage of the base population mean. For each generation, the response is calculated by comparing progeny of selected parents and progeny of parents with average breeding values (from Bentsen et al., 2003).

Selective breeding:

Nile Tilapia – the GIFT project

- increased from 127,000 tons to 2.3 million tons (1988-2008).
- highest increase in aquaculture production.
- potentially the most important aquaculture species in the world.
- 42% to 84% of total tilapia production (1988-2005).
- Frozen tilapia filets (mainly from Asia and Latin-America) are now exported world-wide.

Selective breeding:

Atlantic Salmon

Commercial selection programmes for several traits;

- **Growth**
- **Sexual maturation**
- **Body conformation**
- **Disease resitance (IPNV, ISA, etc)**

Most farmed salmon eggs now come form scientific breeding programmes, probably the species with most genomic information, allowing implemetation of QTL and MAS approaches.

Selective breeding:

Atlantic Salmon

Trait	Selected over wild (%)
Growth rate	+113*
Food consumption	+40*
Protein retention	+9
Energy retention	+14*
FCR[a]	−20*

[a] Feed conversion ratio or kg feed per kg body weight produced.

* $P<0.05$.

Genetic gain in Atlantic salmon over five years of selection (taken from Thodesen et al. 1999)

Hybridisation:

Tilapia:

Oreochromis aureus x O. niloticus
used in Israel, skewed male sex ratio and better cold tolerance.

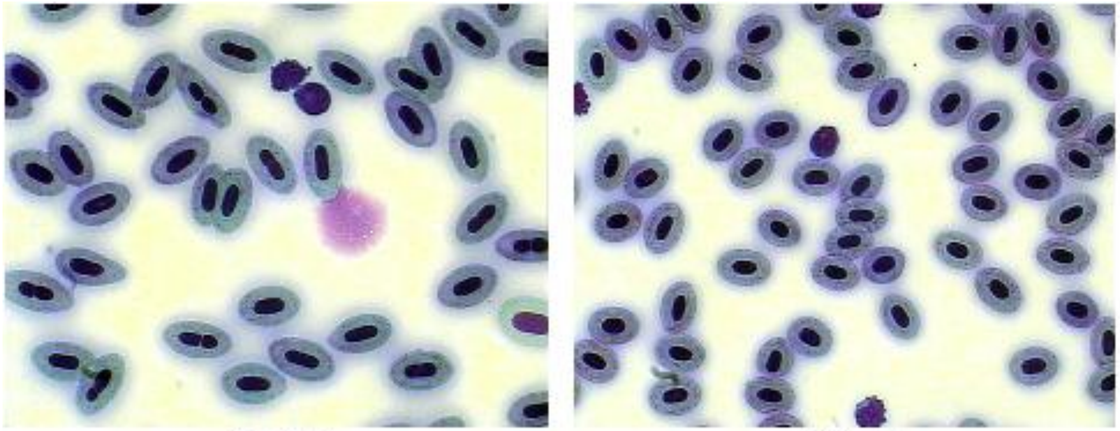
Striped bass:

Morone chrysops x M. Saxatilis
used in US, grows faster, better culture characteristics

Chromosome manipulation:

Advantages of producing sterile triploid animals:

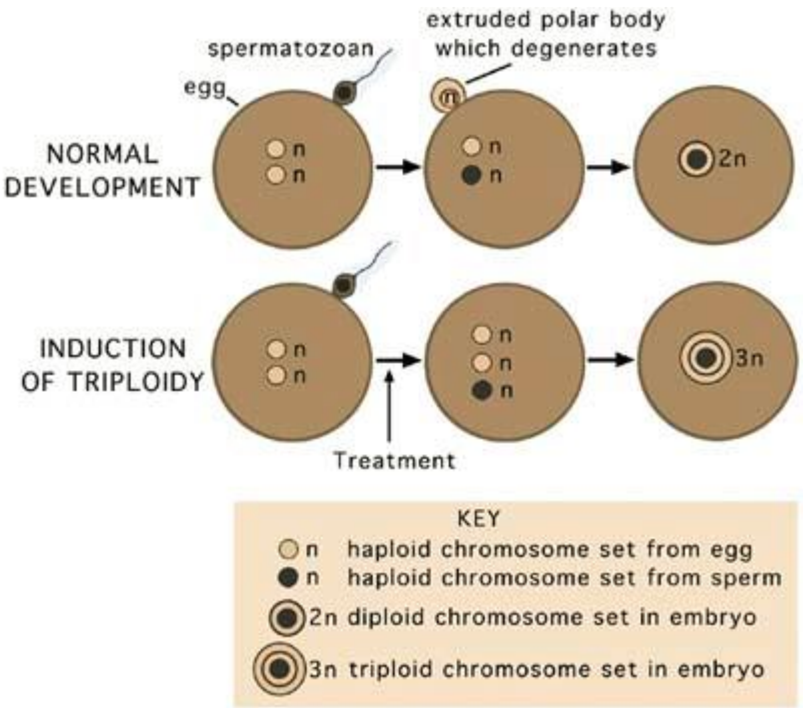
- **No maturation**



Triploid Diploid

Chromosome manipulation:

Sterility can be induced at the egg fertilisation stage by shocking eggs (heat/pressure/chemical) to produce offspring with an extra chromosome set (Triploid) and no gonadal development.



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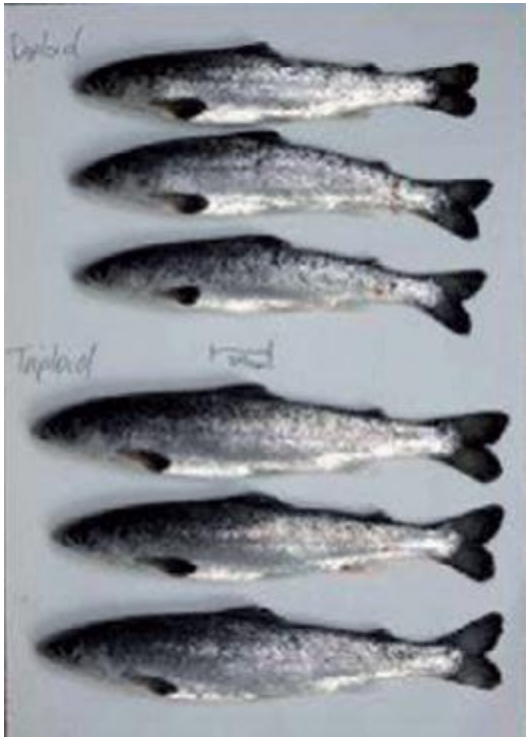
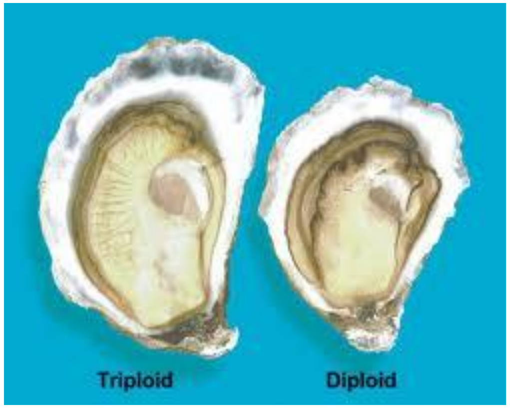


Brown trout



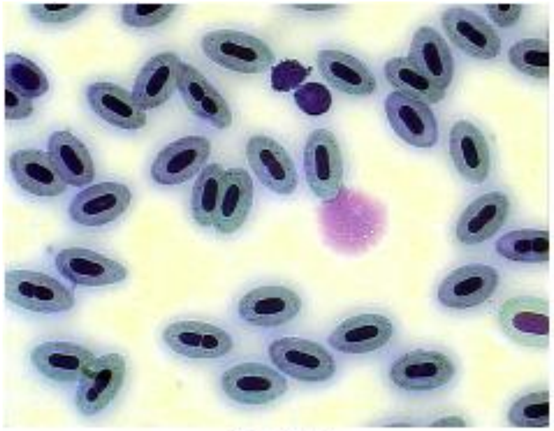
Pacific Oyster

Also production of tetraploid male boodstock

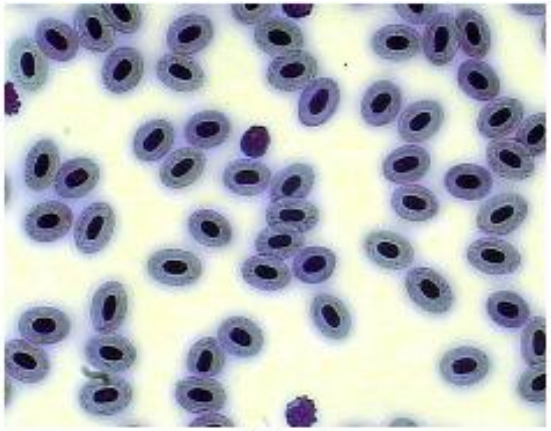
Chromosome manipulation:

Advantages of producing sterile triploid animals:

- Reduces the negative environmental impact of escapees
- no maturation, therefore
  - larger harvest windows,
  - lowered disease risk,
  - potentially reduced running costs
  - protection of IPR on selected strains
  - improved flesh quality at harvest,



Triploid



Diploid

Marker Assisted Selection (MAS):

Potential for very large improvements compared with conventional family-based breeding schemes:

- **Disease resistance**
- **Fillet quality traits**
- **Feed conversion efficiency**
- **Salinity and low temperature tolerance**

Marker Assisted Selection (MAS):

The main limitations are the number of species with sufficient genetic markers, and QTL maps.

Well established in agricultural species

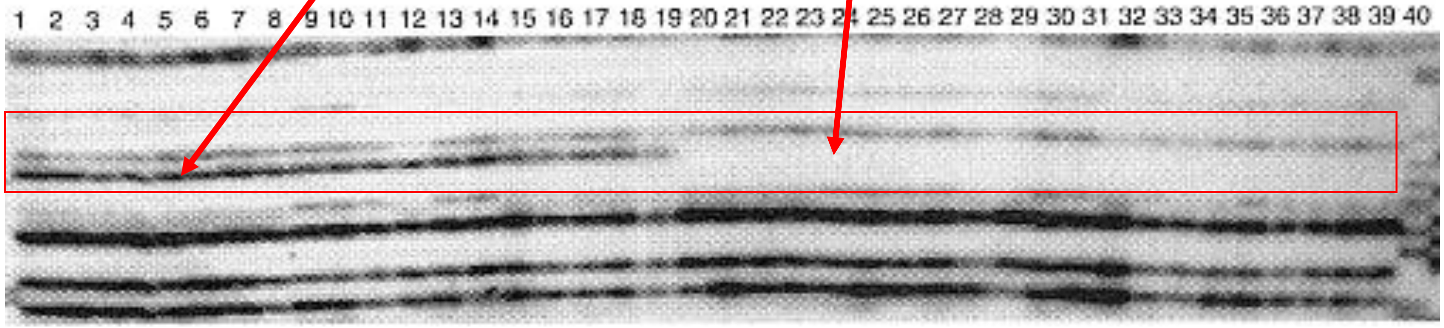
In aquaculture QTL known in salmon, tilapia, and common carp.

Eg resistance to infectious pancreatic necrosis (IPN) (Houston 2008)

Advances in sequencing technology now mean that dense genome maps are a real possibility for any commercially important species.

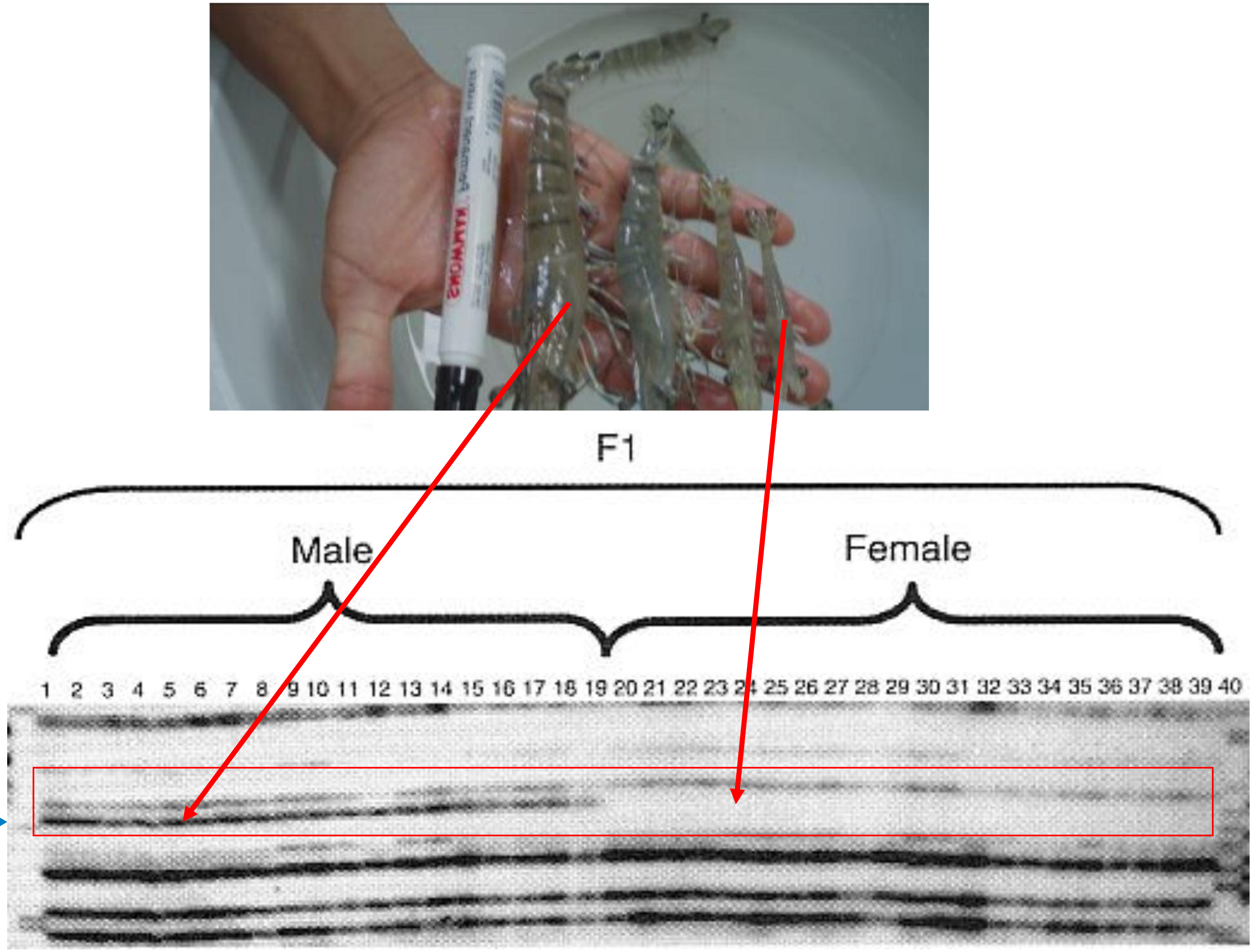
Work already underway for A. Salmon, tilapia, seabass, P. oyster.....

Not Marker Assisted Selection (MAS):



Marker linked to trait under selection

Not Marker Assisted Selection (MAS):



Marker linked to sex determination

The future?

Increased use of selective breeding, broodstock management and improvemnet programs;

Fish are ideal candidates, large numbers of progeny, high selection pressure per generation. Significant impact on sector performance.

Increased use of genomic technology

Will increase speed and accuracy of selection, costs reducing.

Transgenics?

Introducing genes from other species; Improved disease resistance, growth hormones, antifreeze protiens.... But issues with public acceptability, and environmental consequences.

Genetically engineered, plant based feeds?

A more immediate possibility, introduce omega-3 LC PUFAs, and reduce reliance on capture fisheries.