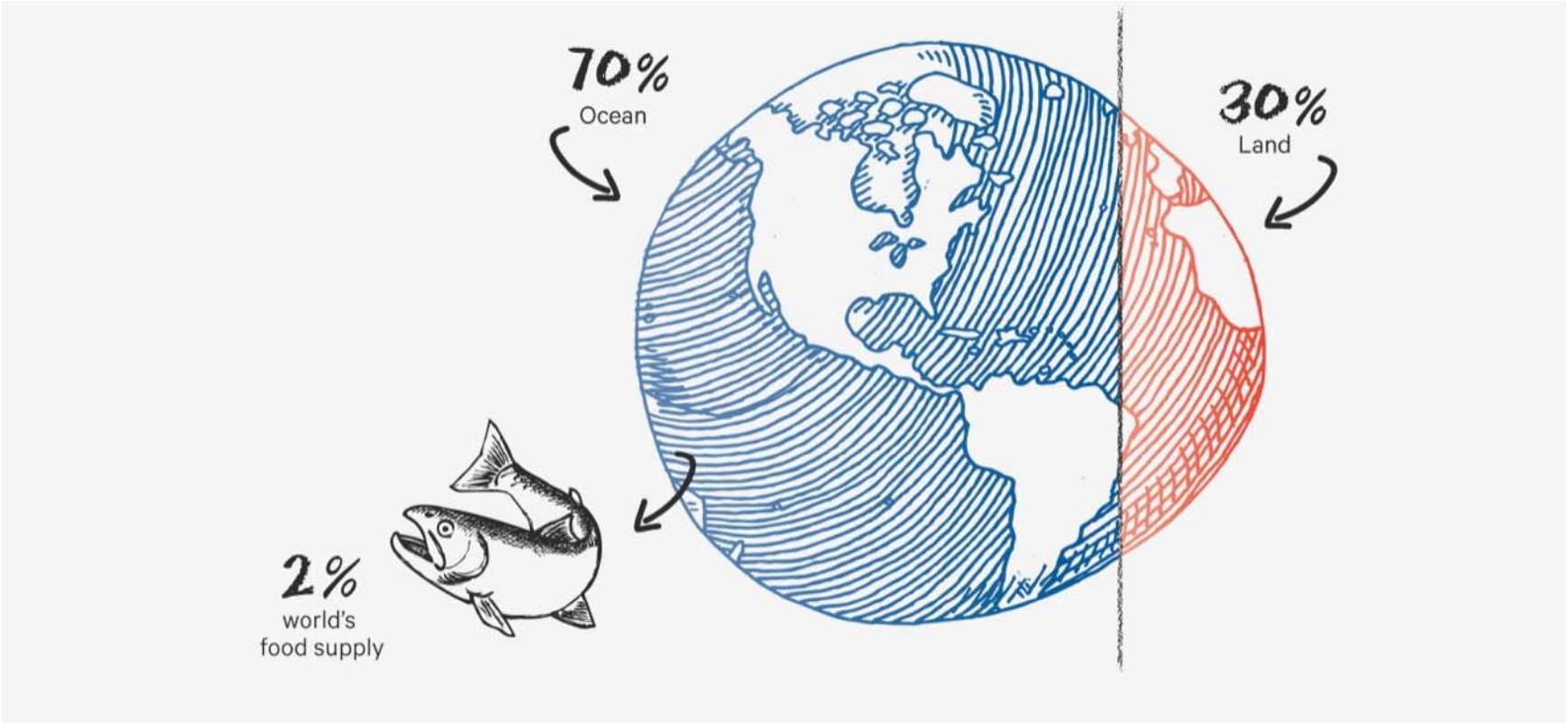
Breeding and reproduction in livestock systems in 2030 and beyond: How will science bring us there?

The salmon aquaculture sector and new breeding technologies

Ashie Norris. EAAP Belfast 2016

Oceans of opportunity! Seafood becoming more important in food security



marineharvest

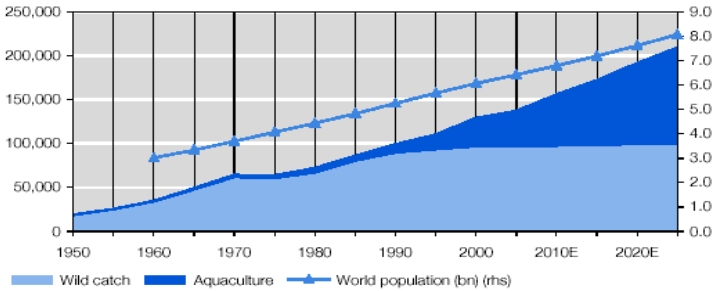
Global trends & Fish Farming

Food and Agriculture Organization of the United Nations

”Given the projected population growth, it is estimated that at least an additional 40 million tonnes of aquatic food will be required by 2030.”

- Rohana Subasinghe, FAO

Human population is increasing: 9,6 billion in 2050



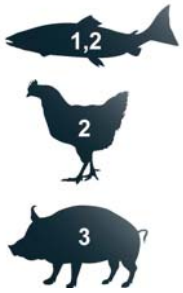
Wild fisheries cannot grow: 90% of fish stocks are fully exploited (FAO, 2012)

Highest seafood consumption ever (20kg/capita, FAO 2015)

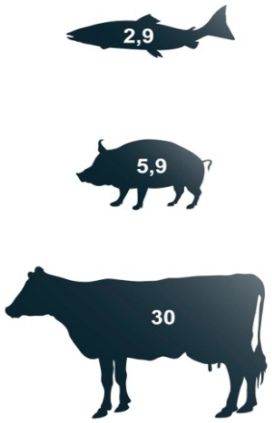
Growth in food supply must come from aquaculture

Sources: OECED-FAO Agricultural Outlook 2013, Kontali Analyse

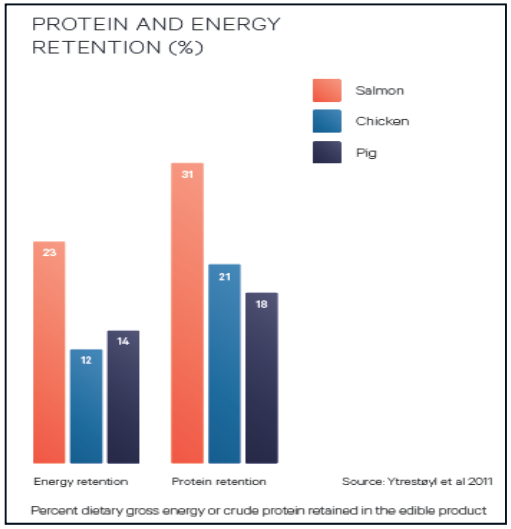
Salmon - Resource effective production



Uniquely low Feed Conversion Rates
(kg feed/ kg meat)

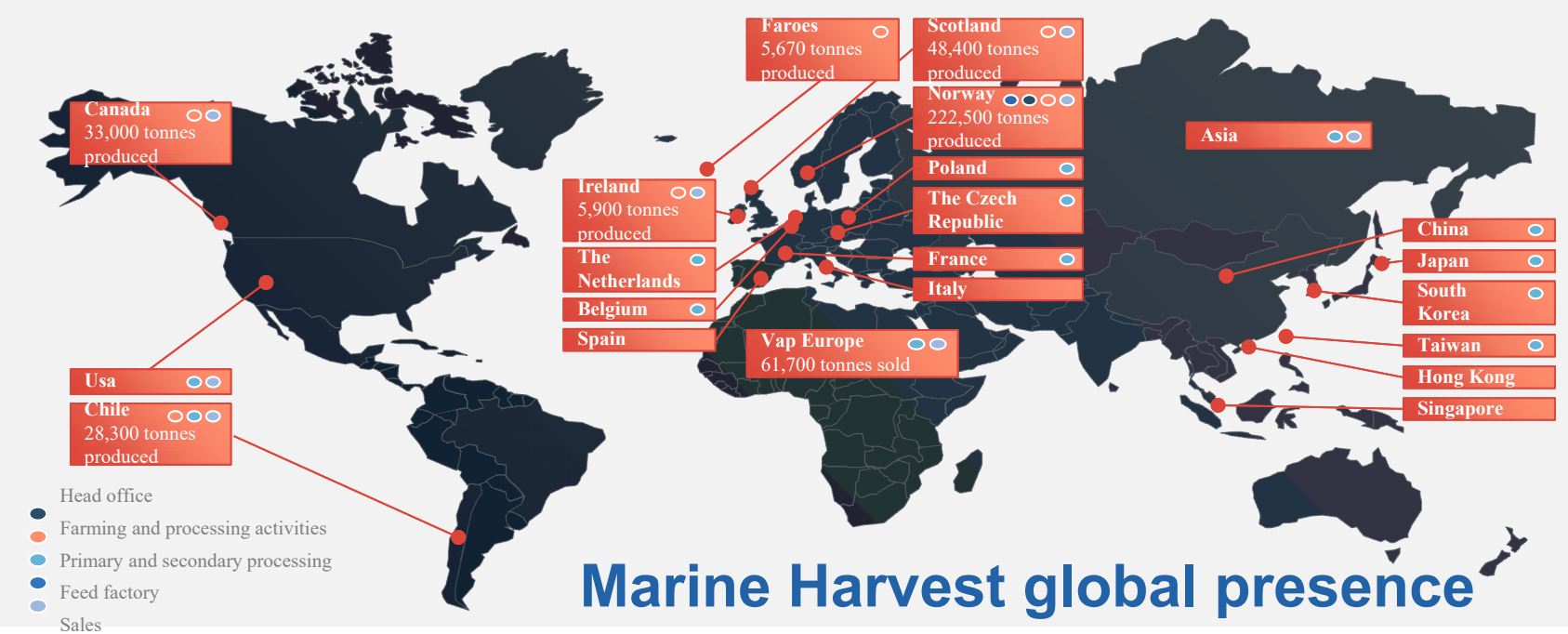


Uniquely low carbon footprint
(kg CO_2 eq/kg)



Uniquely high energy and protein retention in edible product

Both energy- and protein utilisation (feed to edible meat) gives salmon an advantage



Volume produced 2015:
392,300 tonnes

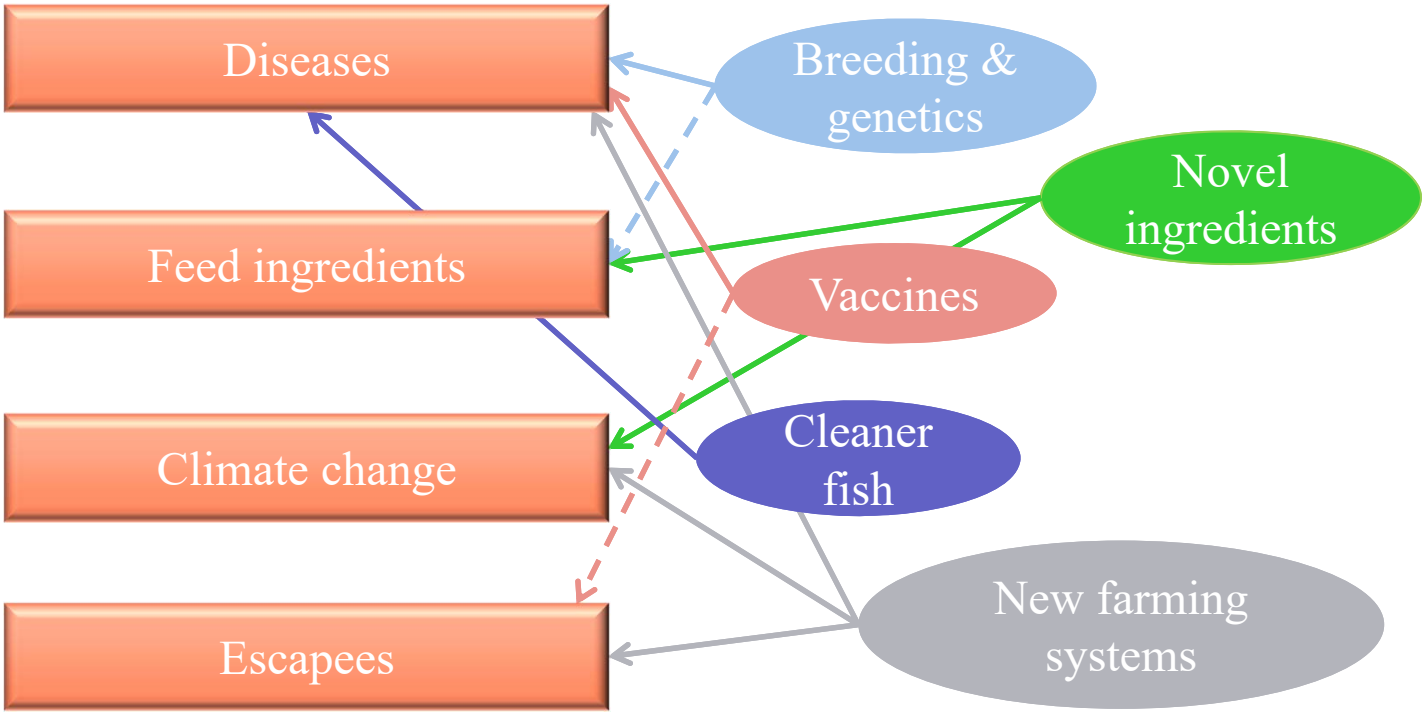
Salmon meals each day:
5.2 million

Sales 2015:
NOK 27 billion

Salmon breeding some basic facts….

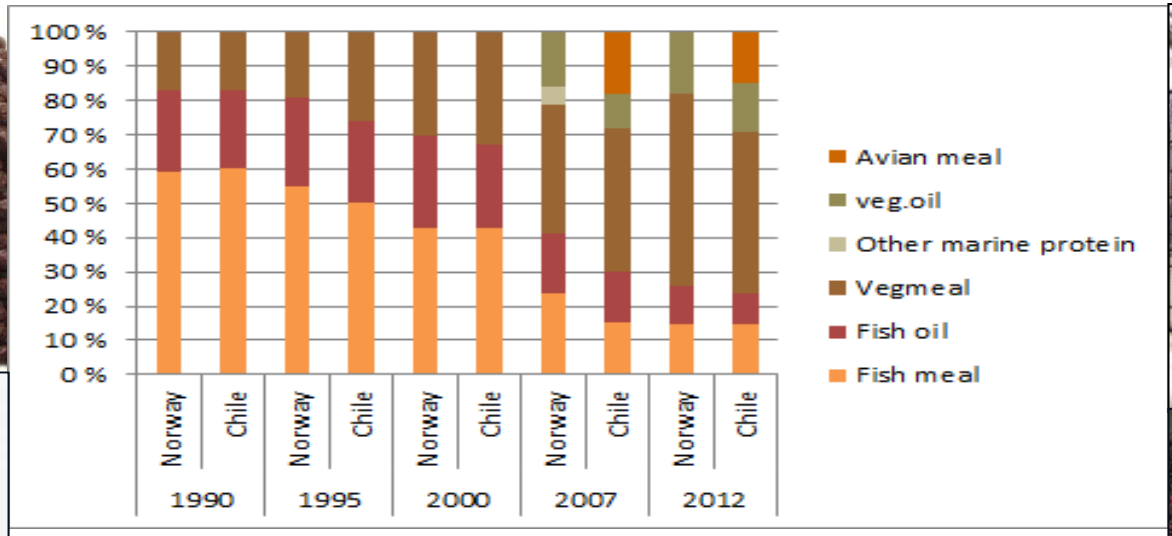
- Nucleus centrally controlled
- Large population but small Ne
- Long generation interval (3-4 years)

Biological challenges and solutions …



Feed ingredients

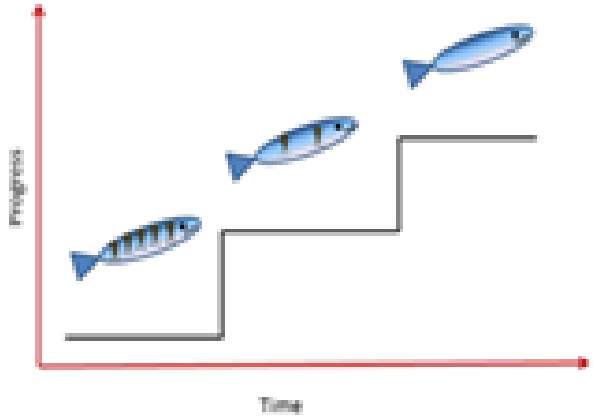
Farming environment changing dramatically – diet



The use of marine raw materials have come down from 80% to ca 25% of the diet

Diseases – sea lice

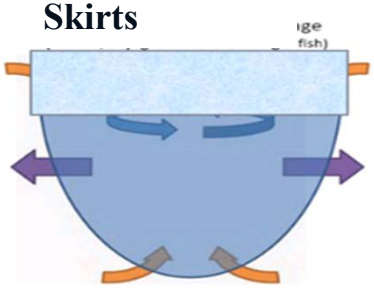
- Biggest production issue in salmon aquaculture-2015 cost 5 billion NOK (not including mortality from treatments, forced slaughter…)
- h^2 for resistance to sea lice low but consistent and repeatable.
- Underlying causes of resistance not well understood.
- Genomics approach will almost double accuracy of selection.



Diseases

Non-medicinal strategies for sea lice control

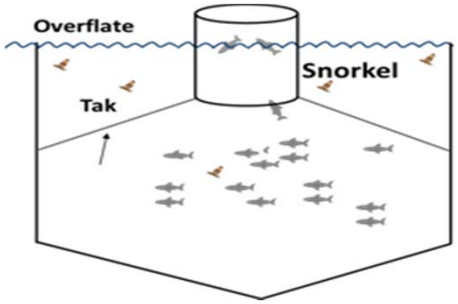
Skirts



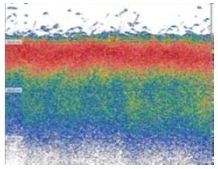
Lice flusher

Cleanerfish

Snorkel



Deep lights



Laser

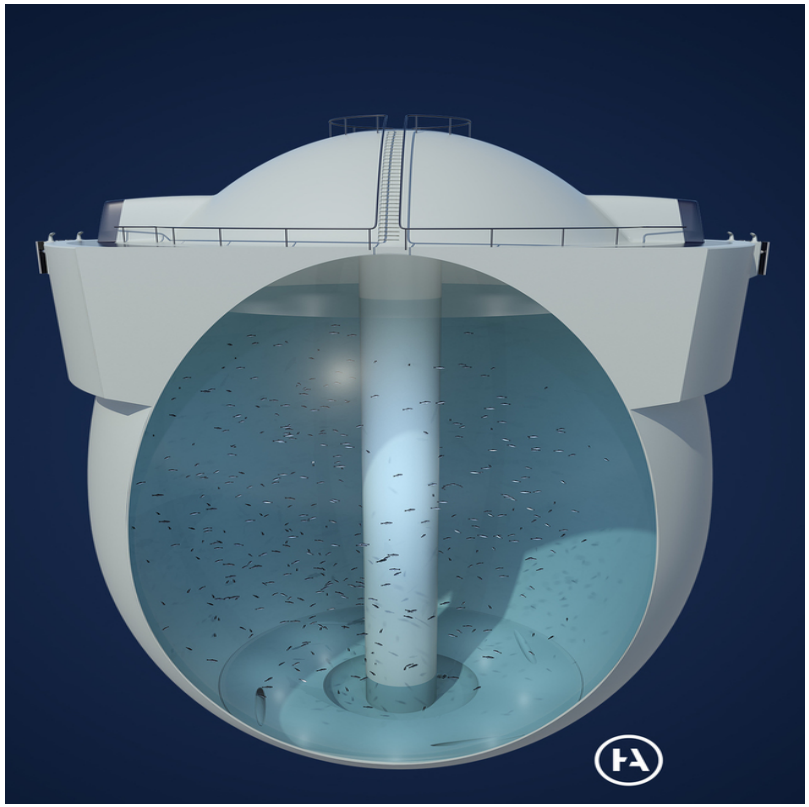
Climate change

Escapees

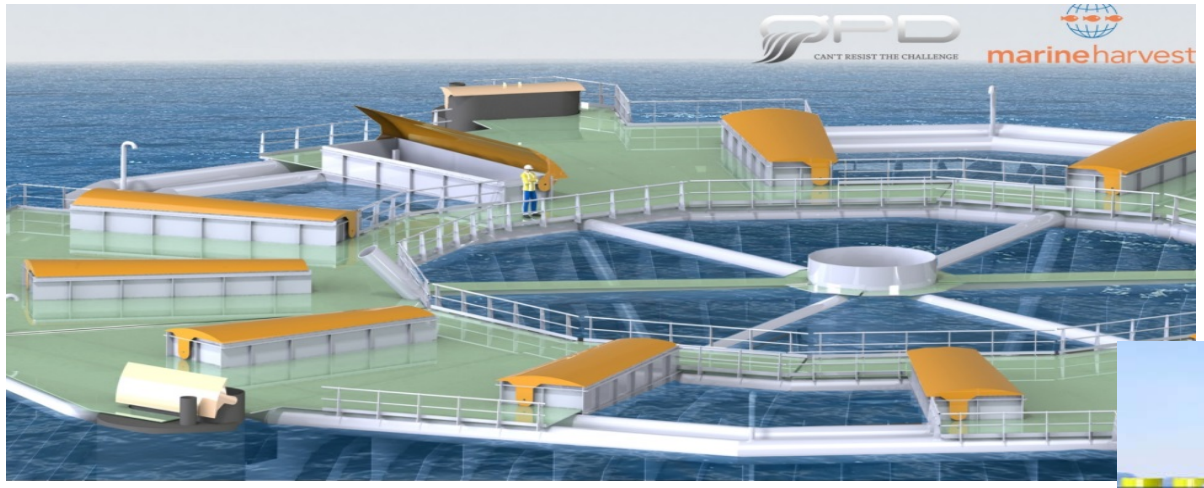
Farming environment is changing dramatically

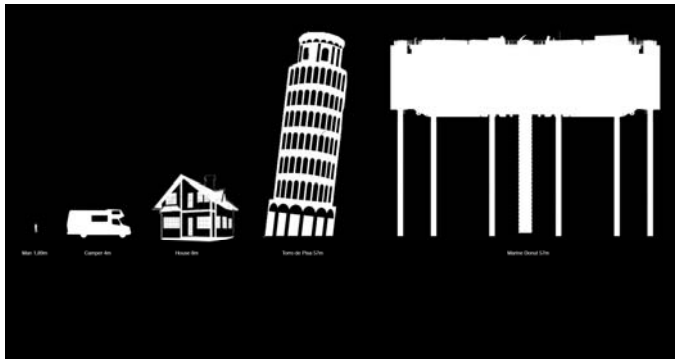
- Major changes in FW rearing systems (RAS systems)
- Traditional sea pen rearing has barely changed in past 50 years
- Possibility now of new sea rearing environment

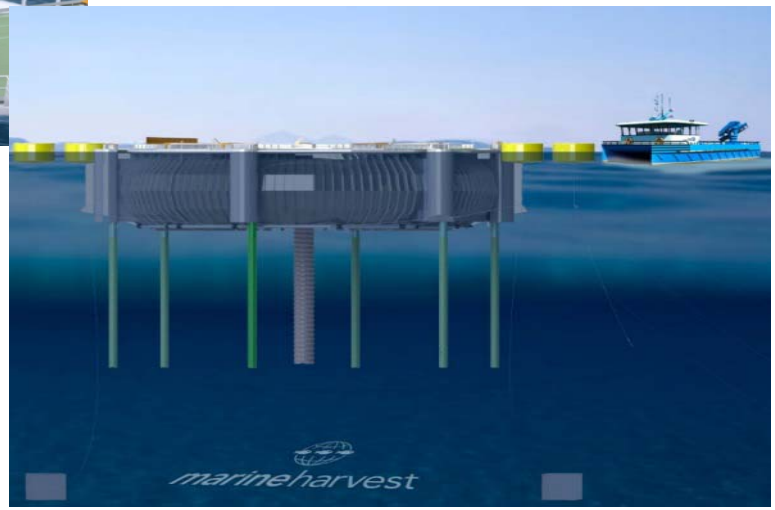
The Egg – semiclosed farming system



The Donut – semiclosed farming system







Future environment for salmon farming

- More intense, higher temperature FW rearing systems
- Larger smolt going to sea
- Shorter time at sea in enclosed or semiclosed rearing system
- Interacting with cleaner fish in open pens to stay lice-free
- More handling due non-medicinal lice treatments
- Vegetarian diets

What role will new genetic technologies play in responding to these changes?

An interesting 15 years….

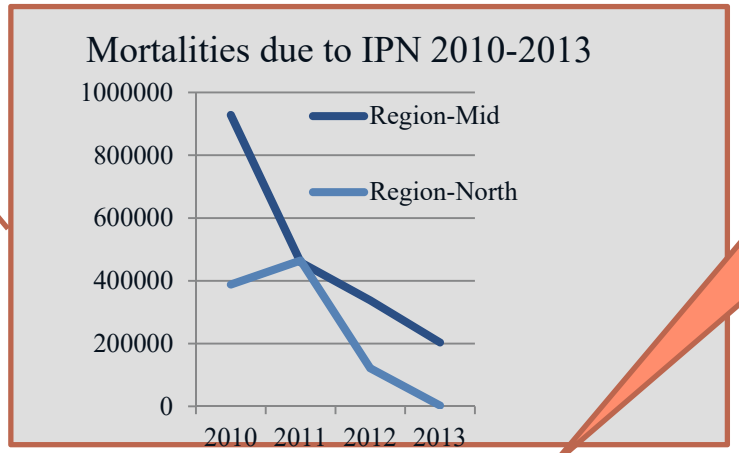
Implementation of GS for Pancreas disease (PD) resistance

QTL

First selection for QTL influencing resistance to IPN

Implementation of GS for PD, AGD, sea lice resistance

Family based breeding programs focused on growth and quality traits



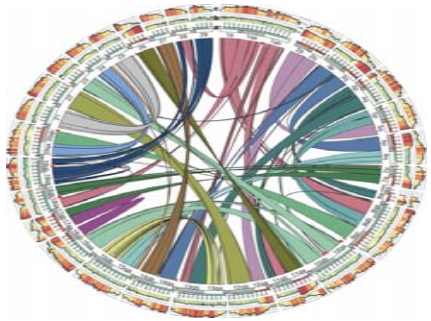
Annotated salmon genome released

2000 2010 2014 2015

Marine Harvest breeding timeline

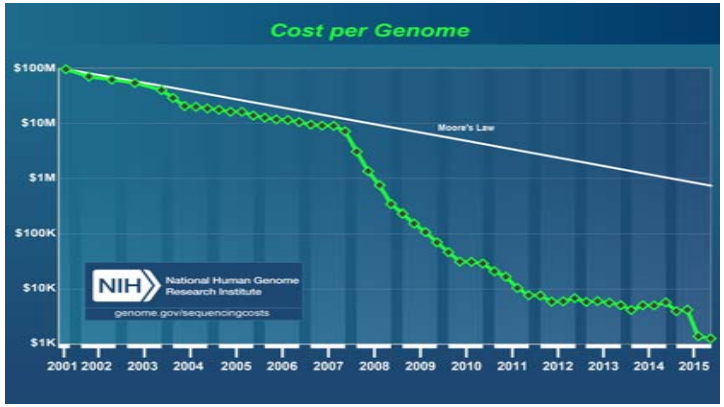
Genomic selection

- Main application in salmon > accuracy of selection for low h^2 traits.
- Most salmon breeding companies now using GS/GWAS to some extent.



- Salmon sequence completed 2014.
- Duplicated genome-low recombination

- Preselection of candidates, imputation, pooling of test sibs, cost of genotyping/sequencing will all influence application of GS.



Genome editing/CRISPR/CAS9

- CRSIPR/CAS9 potential for immediate use in salmon aquaculture
  - First demonstration of principal using pigmentation gene –albino salmon
  - Maturation gene knock out – targeting a ‘sterility vaccine’.

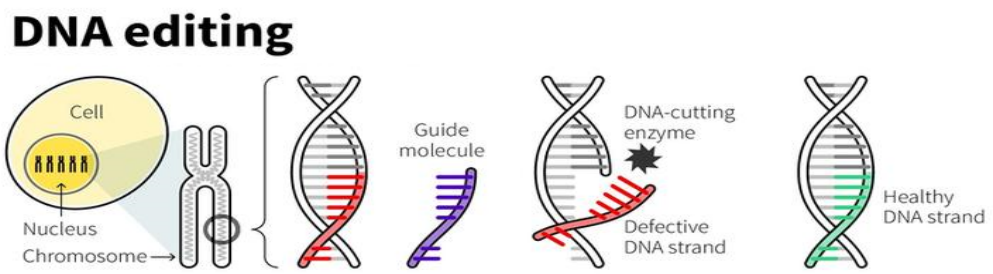
Progress in science depends on new techniques, new discoveries and new ideas, probably in that order.
Sydney Brenner

Targeted Mutagenesis in Atlantic Salmon (*Salmo salar* L.) Using the CRISPR/Cas9 System Induces Complete Knockout Individuals in the F0 Generation

Rolf B. Edvardsen, Sven Leininger, Lene Kleppe, Kai Ove Skaftnesmo, Anna Wargelius

FUNCTIONAL STUDIES IN ATLANTIC SALMON REVEAL GENETICS BEHIND REPRODUCTIVE TRAITS (*Salmo salar L.*)

***Wargelius, A.**, Kleppe, L., Skaftnesmo, K., Leininger, S., Furmanek, T., Tveiten, H., Slanchev, K., Taranger, G., Schulz, R., Andersson, E., Edvardsen, R.*
Institute of Marine Research, Norway



Next 30 years….

Implementation of GS for PD, AGD, sea lice resistance

Genomics

Program design

Gene editing

Annotated salmon genome released

Robust, wrasse friendly, ambient salmon

RAS/large smolt/,faster growth, strong heart

2016

2046

Marine Harvest breeding timeline

Thank you!

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