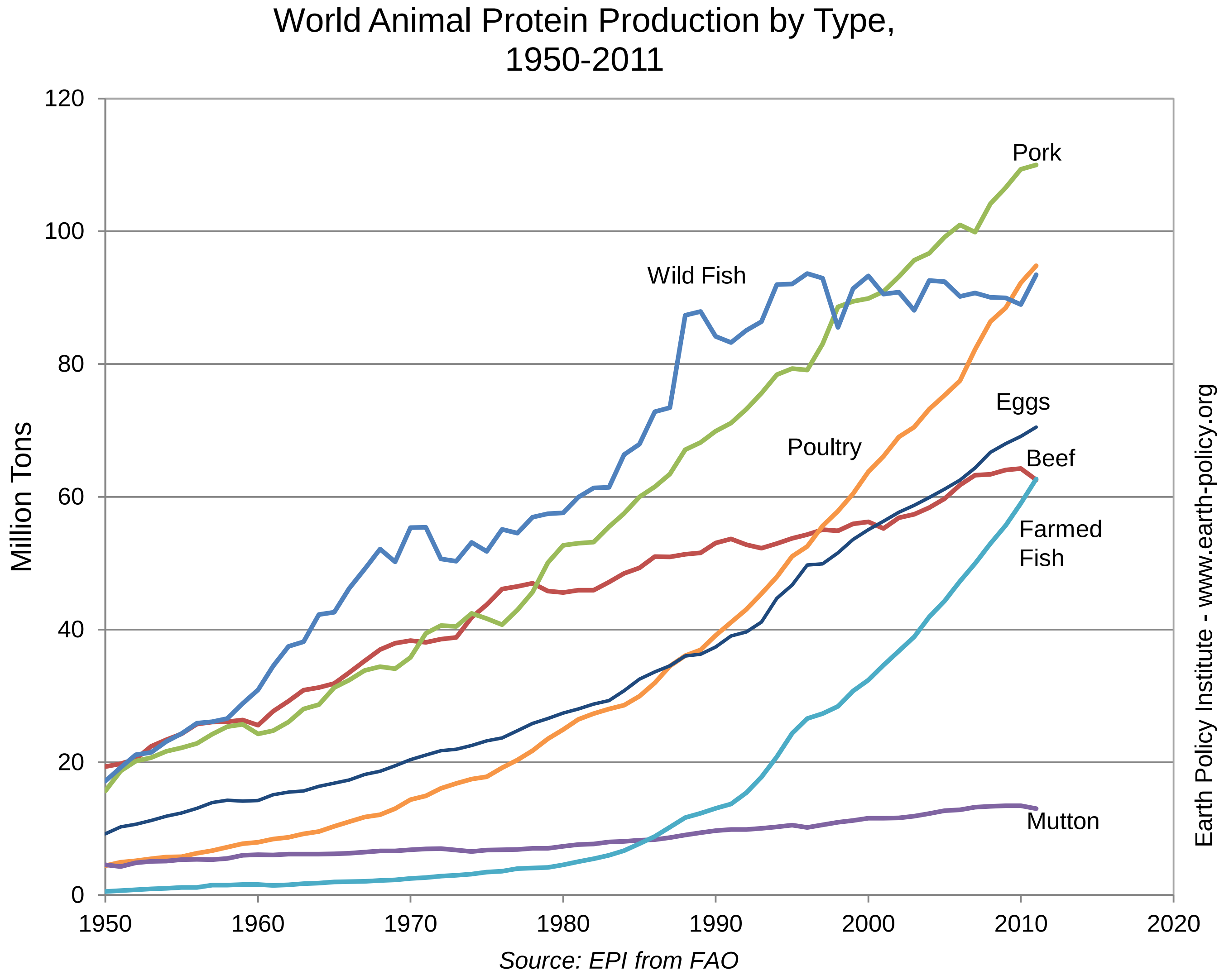
Short review:

BREEDING PROGRAMS IN FISH AQUACULTURE: HISTORICAL CONTEXT AND PERSPECTIVES

R. Neira, J.M. Yáñez, J.P. Lhorente

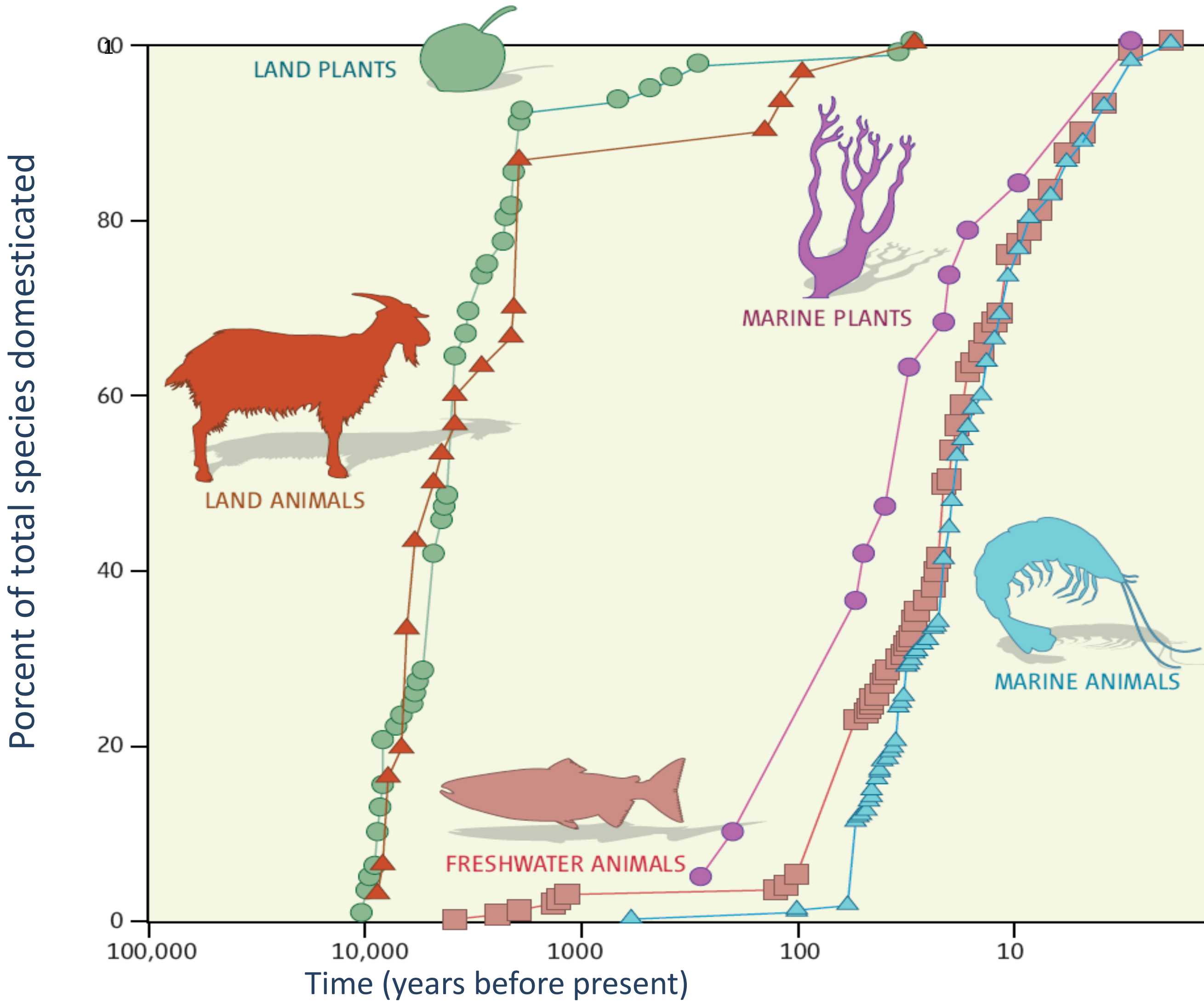
UNIVERSIDAD DE CHILE

AQUAINNOVO



World Animal Protein Production by Type,
1950-2011
Million Tons
120
100
80
60
40
20
0
1950
1960
1970
1980
1990
2000
2010
2020
Pork
Wild Fish
Eggs
Poultry
Beef
Farmed Fish
Mutton
Source: EPI from FAO
Earth Policy Institute - www.earth-policy.org

RAPID DOMESTICATION OF AQUATIC SPECIES



Most land species were domesticated earlier than aquatic species, but in the past 100 years, many more aquatic species than land species have been domesticated

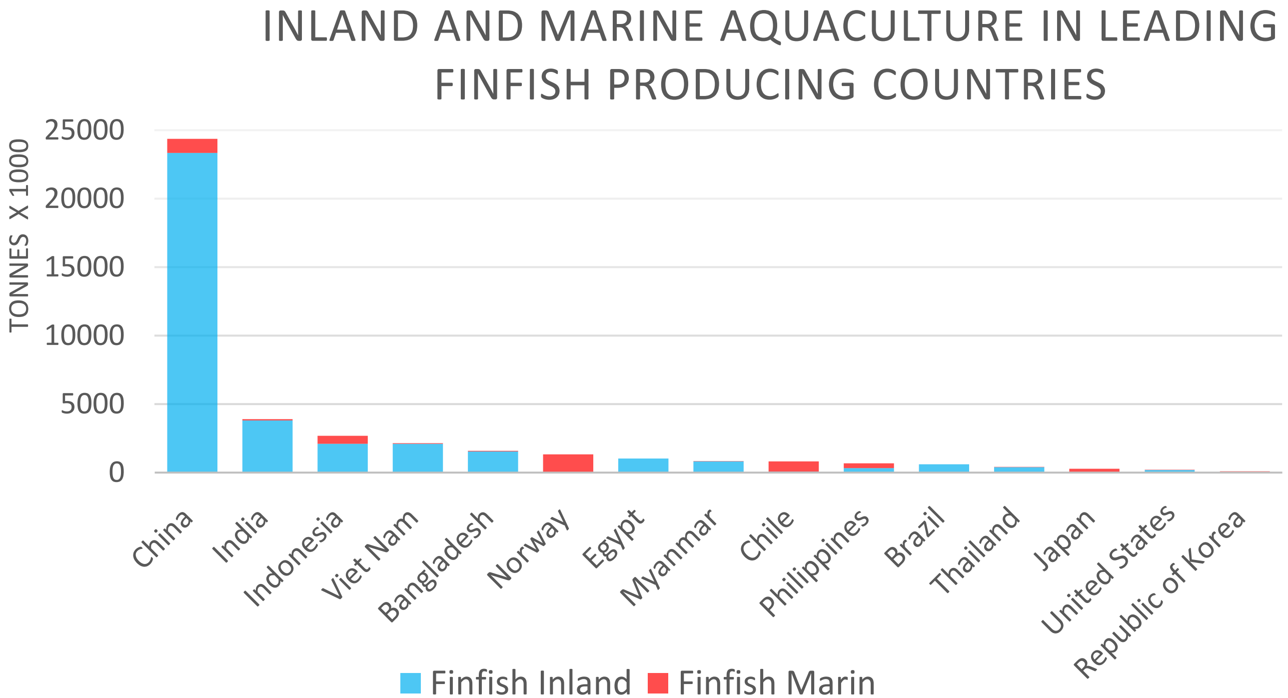
Duarte, Nuria y Holmer. (2007), Science, 316, 382-383.

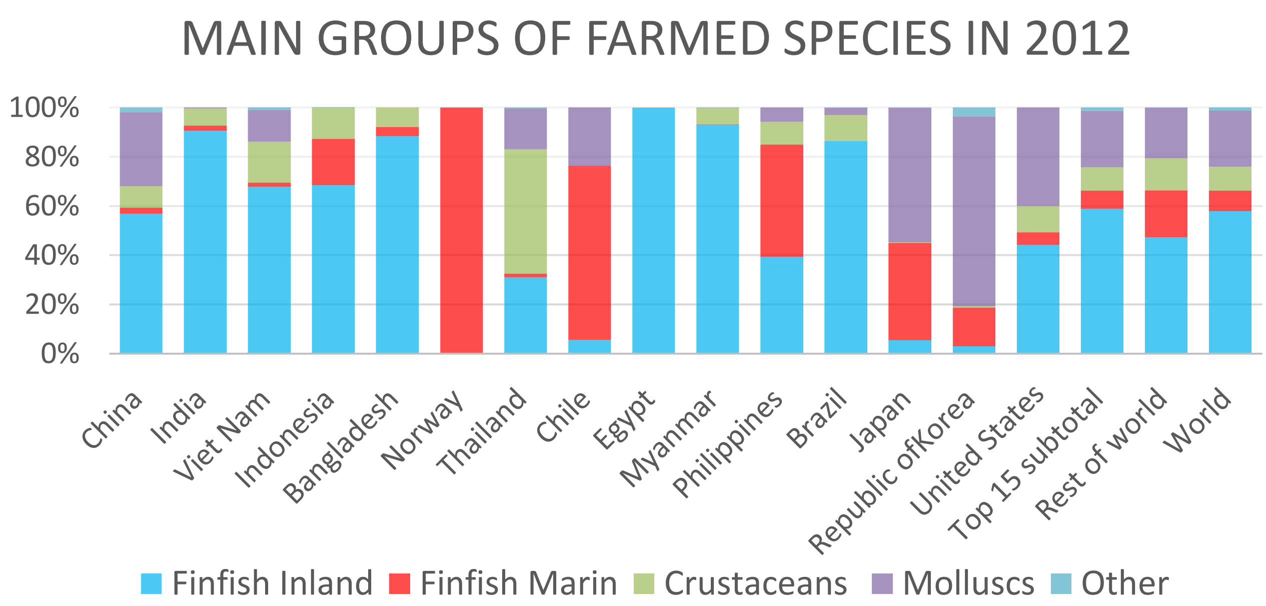
Consequences of the late origin of aquaculture

- As in animal breeding, the history of fish breeding shows that the principles of selection have been applied for thousands of years, long before the theoretical background was developed, with considerable success
- A further major consequence of the late origin of aquaculture is that there has been relatively little genetic selection for many species and this is compared with the highly selected plants and animals of agriculture.
- Modern agriculture is based on organisms that are vastly different from their wild ancestors, and in many cases their wild ancestors no longer exist.

Consequences of the late origin of aquaculture

- Modern agriculture would be totally uneconomic and the current world population would starve without these domesticated and genetically selected agricultural plants and animals
- Much of aquaculture, by contrast, is based on plants and animals that are still ‘wild’.
- There are, however, species that have been subject to strong selection, hybridisation, and molecular and genomic techniques, such as: • Atlantic salmon; • Rainbow trout; • Coho salmon • Tilapia species; • channel catfish. • Common carp … …



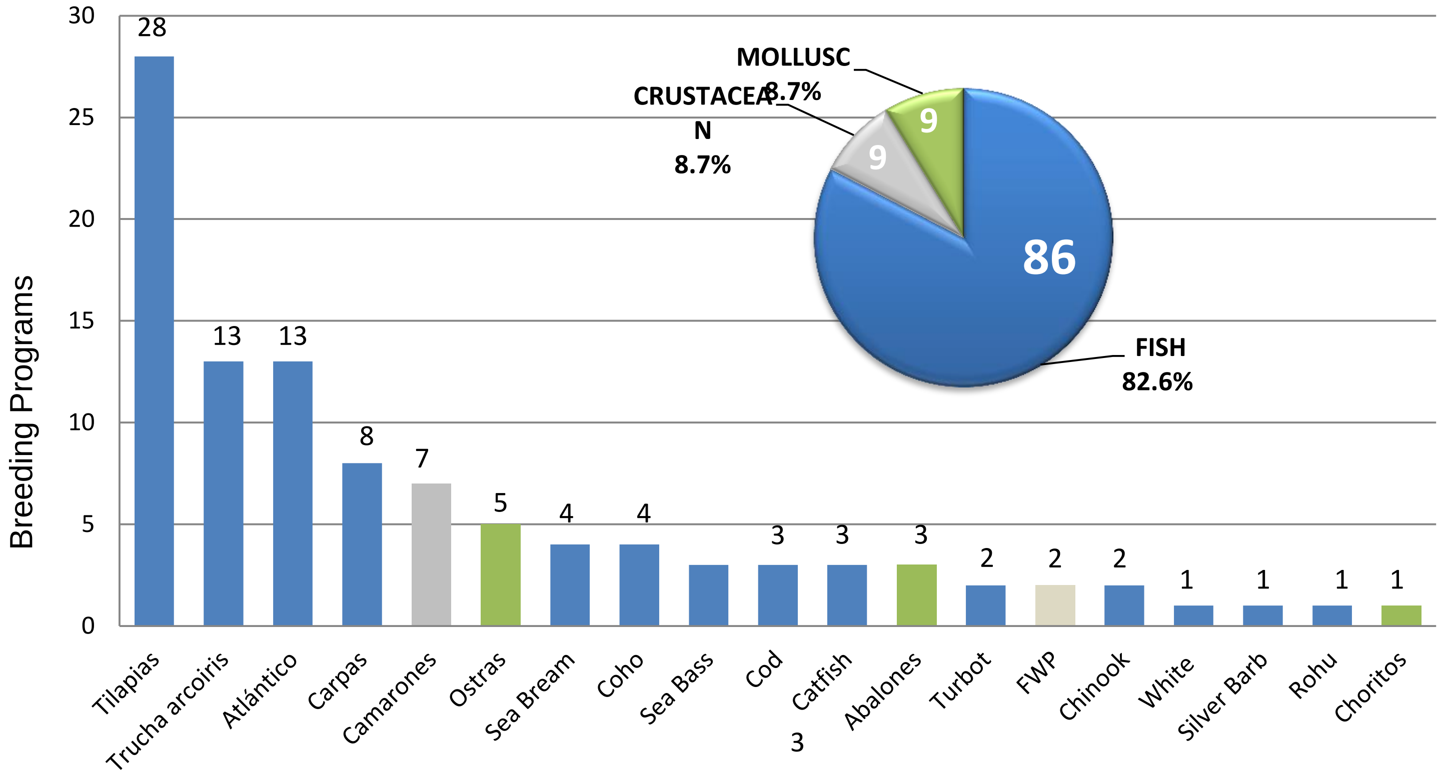


Of the 66.6 million tonnes of farmed food fish produced in 2012, two-thirds (44.2 million tonnes) were finfish species grown from inland aquaculture

Although finfish species grown from mariculture represent only 12.6 percent of the total farmed finfish production by volume, their value (US$23.5 billion) represents 26.9 percent of the total value of all farmed finfish species.

104 AQUACULTURE BREEDING PROGRAMS IN 2010 (86 finfish programs)

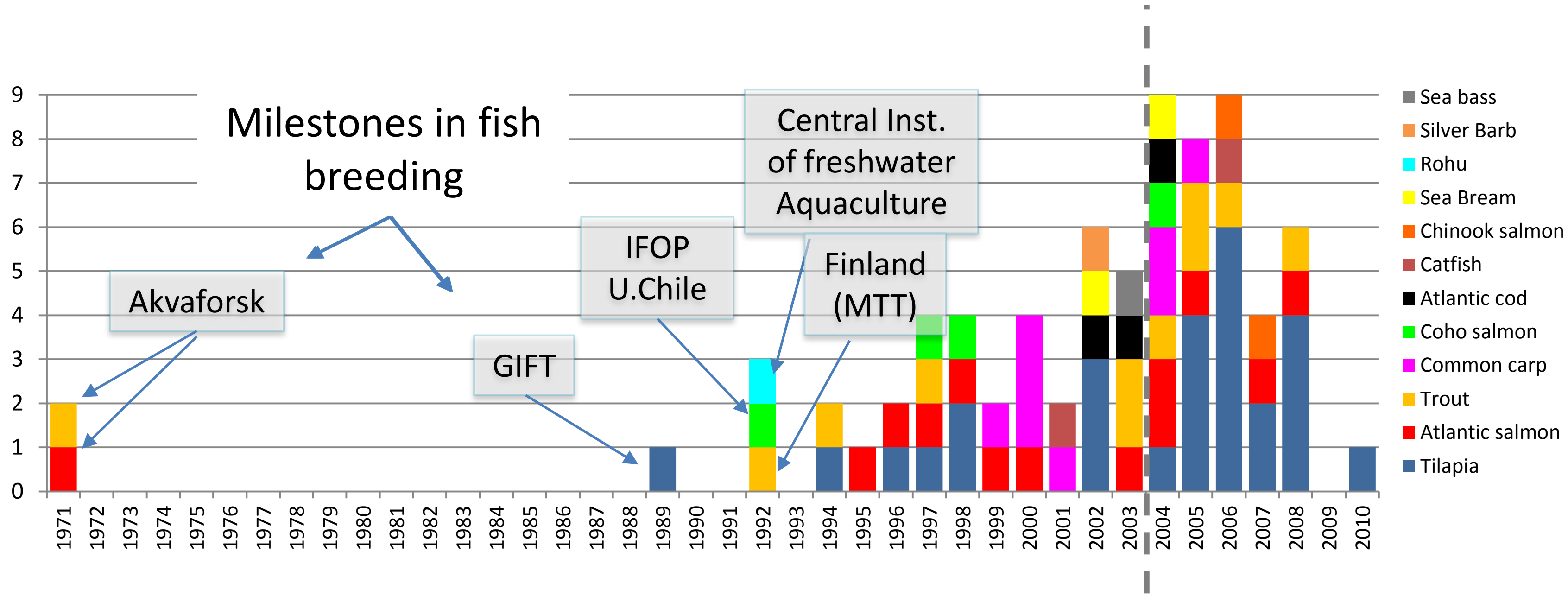
Rye et al (2010), Neira (2010)



Breeding Program defined as:

Having an impact on production or in people

YEAR STARTED OF FINFISH BREEDING PROGRAMS
(incomplete)

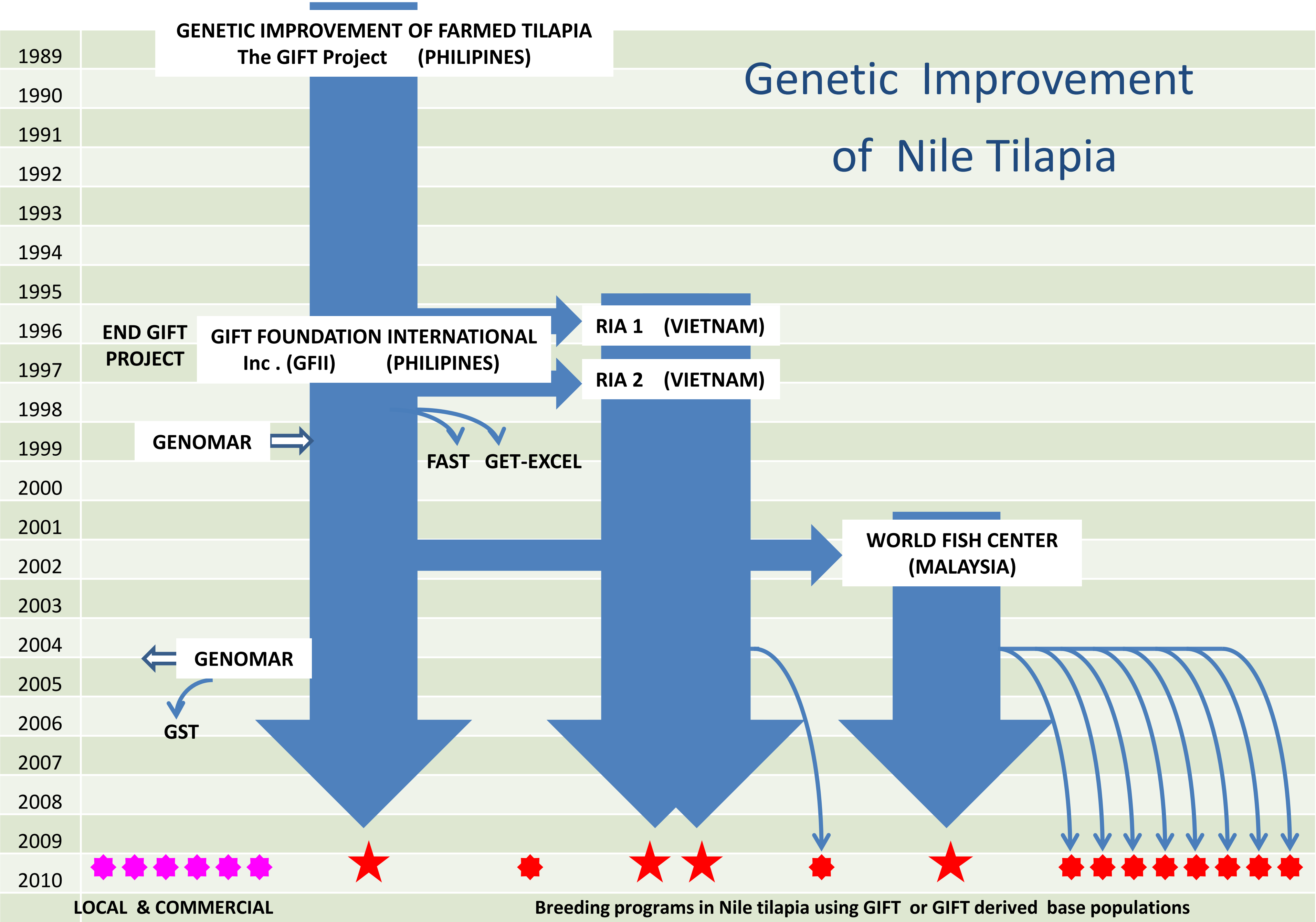


MORE THAN HALF OF FINFISH BREEDING PROGRAMS STARTED ON 2004 OR LATER

Objectives for genetic improvement

- Genetics to alleviate poverty
- Genetics to improve production efficiency

Genetic Improvement of Nile Tilapia



Desirable traits

- Growth rate is targeted for almost any genetic improvement program irrespective of species
- As growth rate is improved, the marginal economic importance of improving other traits such as age at first maturation, disease resistance, fillet yield or quality traits of the final product become important

86 FINFISH BREEDING PROGRAMS IN 2010

				Traits included in the breeding goal In addition to growth rate				
Species	# of programs	Average (range) # of families tested per generation	Average (range) # of traits in breeding goal	Disease resistance	Carcass quality	Age at sexual maturity	Cold or salinity tolerance	Other
Tilapia	28	105 (51-225)	1,9 (1-4)	3	7		5	4
Atlantic salmon	13	280(100-800)	5,4 (3-13)	10	9	1		2
Raibow trout	13	206 (100-400)	5,2 (2-11)	5	7	9		2
Common carp	8	125 (80-200)	2		1			
Coho salmon	4	133(40-300)	2,7 (1-6)	1	1	2		
Sea bream	4	100	6	1	1			1
Atlantic cod	3	110 (50-200)	4 (2-8)	2	1			1
Sea bass	3	100	5	1	1			1
Chinook salmon	2	100	1,5		1			
Turbot	2	60	1			2		
Catfish	2	140 (70-200)	1,5 (1-2)	1	1			
Channel catfish	1	200	4	1	1	1		
White fish	1	70	2		2			
Rohu	1	50	2	1				
Silver Barb	1	?	1					
Total	86	147	1,4					

8.2% Prod. based in improved stocks (Gjedrem et al., 2012)

Atlantic S	97
R. Trout	27
Coho S	22
Rest	1-2

Adapted from: Rye et al (2010) and Neira (2010)

Selection methods

- Individual (mass) selection.
- Individual selection with pair mating.
- Individual selection within cohorts and exchange of breeders
- Whithin family selection
- Combined selection index (individual + relatives info)
- Best Linear Unbiased Prediction (BLUP) and Restricted Maximum Likelihood (REML)

- *Response to Selection*






EPECIE	GENETIC GAIN PER GENERATION FOR GROWT TRAITS	AUTHORS
Atlantic salmon	10.6 - 14.2 %	Gjerde et al., 1986
rainbow trout	13.0 %	Gjerde et al., 1986
channel catfish	12 - 20 %	Dunham, 1987
Coho salmon	10.1 %	Hershberger et al., 1990
Coho salmon	9.9 - 10.5 %	Neira, et al., 2006
Tilapias	17.0 %	Eknath, 1997
Tilapias	7.2 %	Ponzoni, et al, 2008
Rohu carp	29.6 %	Mahapatra et al., 2004

Control of Breeding programs in Atlantic salmon

1970 · 1975 · 1980 · 1985 · 1990 · 1995 · 2000 · 2005 · 2010 · 2015

Research/Pilot scale	Linked to production	Ownership
1 AKVAFORSK Genetics Center AS		• Research Institutes
	1 NORSK LAKSEAVL NLA	• Private Association
	7 marineharvest, AquaChile, Landcatch, nutreco, AquaGen, Stofnfiskur, Invertec	• Salmon companies
	6 marineharvest, Pesquera Camanchaca, EW Group, AquaGen, AquaChile, Aquainnovo, Stofnfiskur, SalmoBreed, Benchmark Holdings, Landcatch A Hendrix Genetics Company, Super Salmon	• Salmon companies • Main Genetic providers (Livestock genetics Co)

Control of Breeding programs in Rainbow Trout

1970 – 1975 – 1980 – 1985 – 1990 – 1995 – 2000 – 2005 – 2010 – 2015

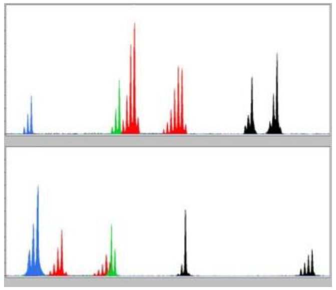
Research/Pilot scale	Linked to production	Ownership
2 AKVAFORSK Genetics Center AS; USDA	1 TROUTLODGE	• Research Institutes • Private Company
	1 NORSK LAKSEAVL NLA	• Private Association
1 MTT GAME AND FISHERIES RESEARCH	3 TROUTLODGE; INVERTEC; AQUACHILE	• Research Institute • Salmon companies
	5 EW GROUP; AQUACHILE; AQUAINNOVO; AquaGen; ova AquaSearch OUR EXPERTISE - YOUR VALUE; STOFNFISKUR SalmoBreed; TROUTLODGE; HENDRIX GENETICS; Benchmark Holdings	• Salmon companies • Main Genetic providers (Livestock genetics Co)

Control of Breeding programs in Coho salmon

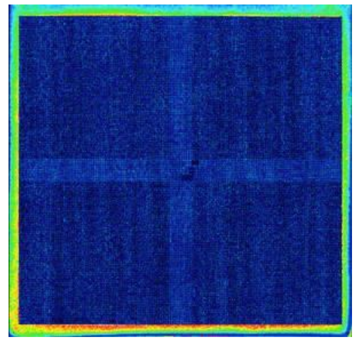
Period	Research/Pilot scale	Linked to production	Ownership
1970 – 1990	1 IFOP INSTITUTO DE FOMENTO PESQUERO		• Research Institute • University
1990 – 2002		3 AQUACHILE, nutreco, INVERTEC	• Salmon companies
2002 – 2015		marineharvest, Super Salmon, EW GROUP AquaGen, AQUACHILE AQUAINNOVO	• Salmon companies • Main Genetic providers (Livestock genetics Co)

1970 - - - - 1975 - - - - 1980 - - - - 1985 - - - - 1990 - - - - 1995 - - - - 2000 - - - - 2005 - - - - 2010 - - - - 2015

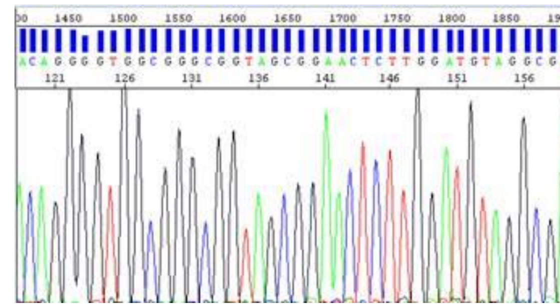
Evolution of genomics in Aquaculture improvement



RAPDs
AFLPs
RFLPs
Microsatellites



Single Nucleotide
Polymorphisms
(SNPs)



Whole genome
sequence data

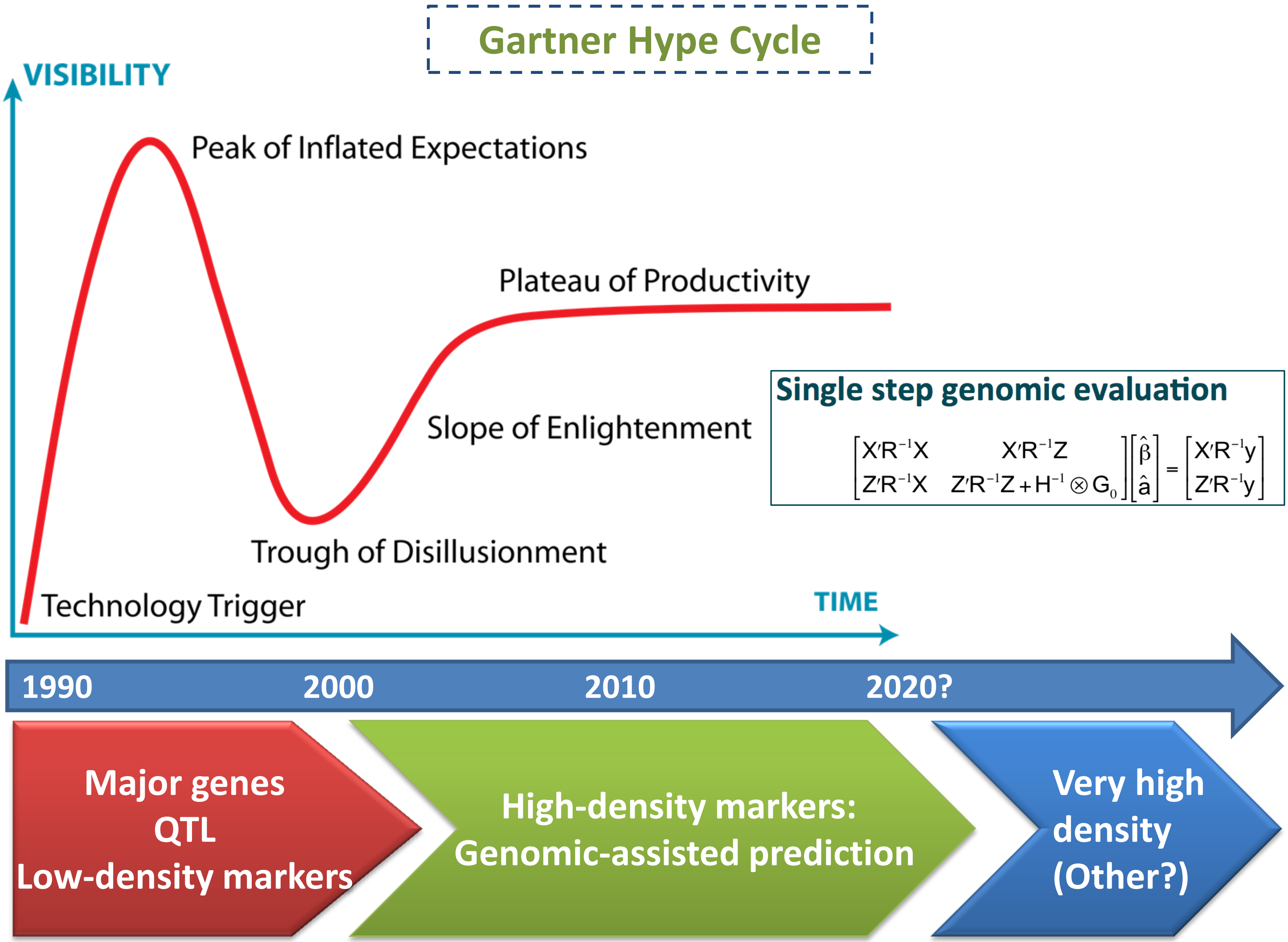
1990 | 2000 | 2010 | 2020?

Major genes
QTL
Low-density markers

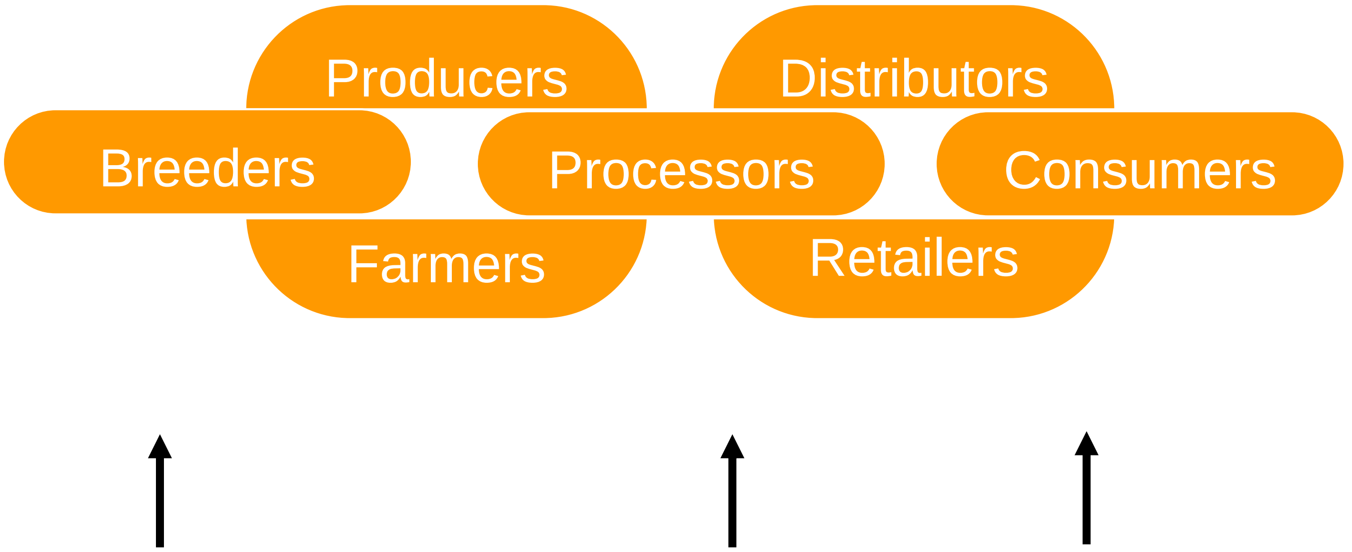
High-density markers:
Genomic-assisted prediction

Very high
density
(Other?)

Evolution of genomics in Aquaculture improvement



Global Supply Chain



Genetics, health, stress and sustainability improvements add value across the entire Global Supply Chain

Thank you