The Importance of Shrimp Health and Breeding in Evolving the Modern Shrimp Industry

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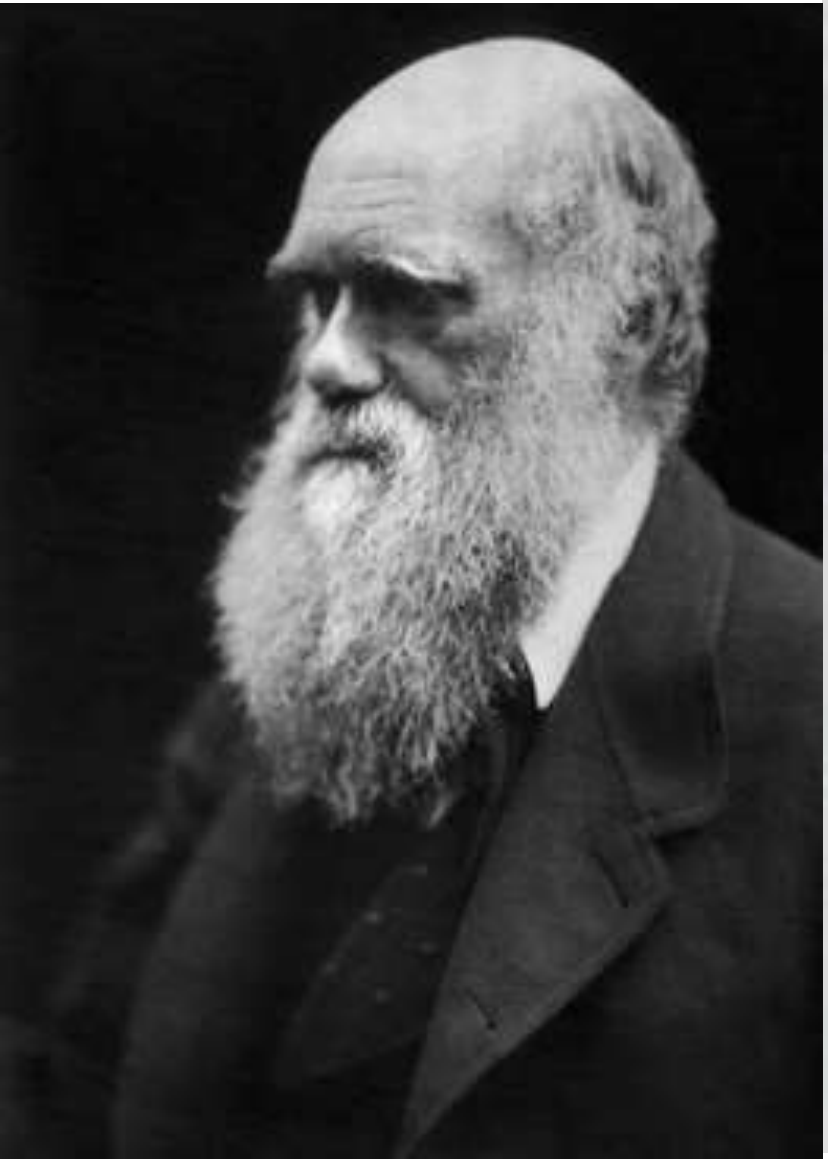
Re-Learning What Health Is and Is Not

Has Poor shrimp health been normalized?

- Not Healthy is not “only being dead”
- Lack of Healthy is not always inbreeding
- Lack of Healthy is not always feed issues
- Lack of Healthy is not always management issues

- **Consider Environment, Stresses, and Greed as reasons for declining shrimp health**

Myth: Low survival in a Hatchery results in your best post larvae (Darwinian Theory)



Bragging rights in Hatcheries

"Low Hatchery survival= Strong Pl's
Cheap cost and sales price"

"The strong survive."

Fellow Hatchery man circ 1994

Early Shrimp Culture technology in the Americas was based on Large Extensive and Semi-Intensive Farms with minimum controls and no biosecurity

Ecuadorian 20 Ha ponds

Central American 10 Ha Ponds

No aeration, high water exchange rates, few feed rate controls
And highly variable profitability

McIntosh goes to Belize 1996;
Advise from leading Ecuadorean Farmers – DON'T DO IT!!!!

Healthy Harvest of SPF from Belize

DYING SPF from TSV

- SPF is weak; has no disease resistance
- SPF grows fast and DIES fast
- Shrimp must have exposure to a wide array of pond pathogens and undergo pond selection pressures to succeed

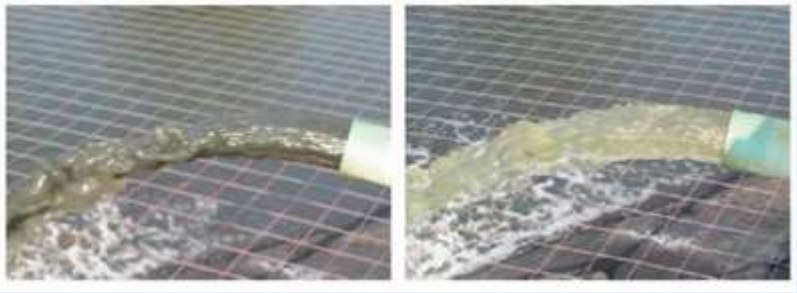
Needed Biosecurity and good culture conditions for “SPF” to Succeed

Exclusion:

virus/microsporidea

Limitation:

Bacteria/toxin



Prior to 2000: All post larvae were from wild pls and broodstock
Why did it need to change?


Collecting wild PLs

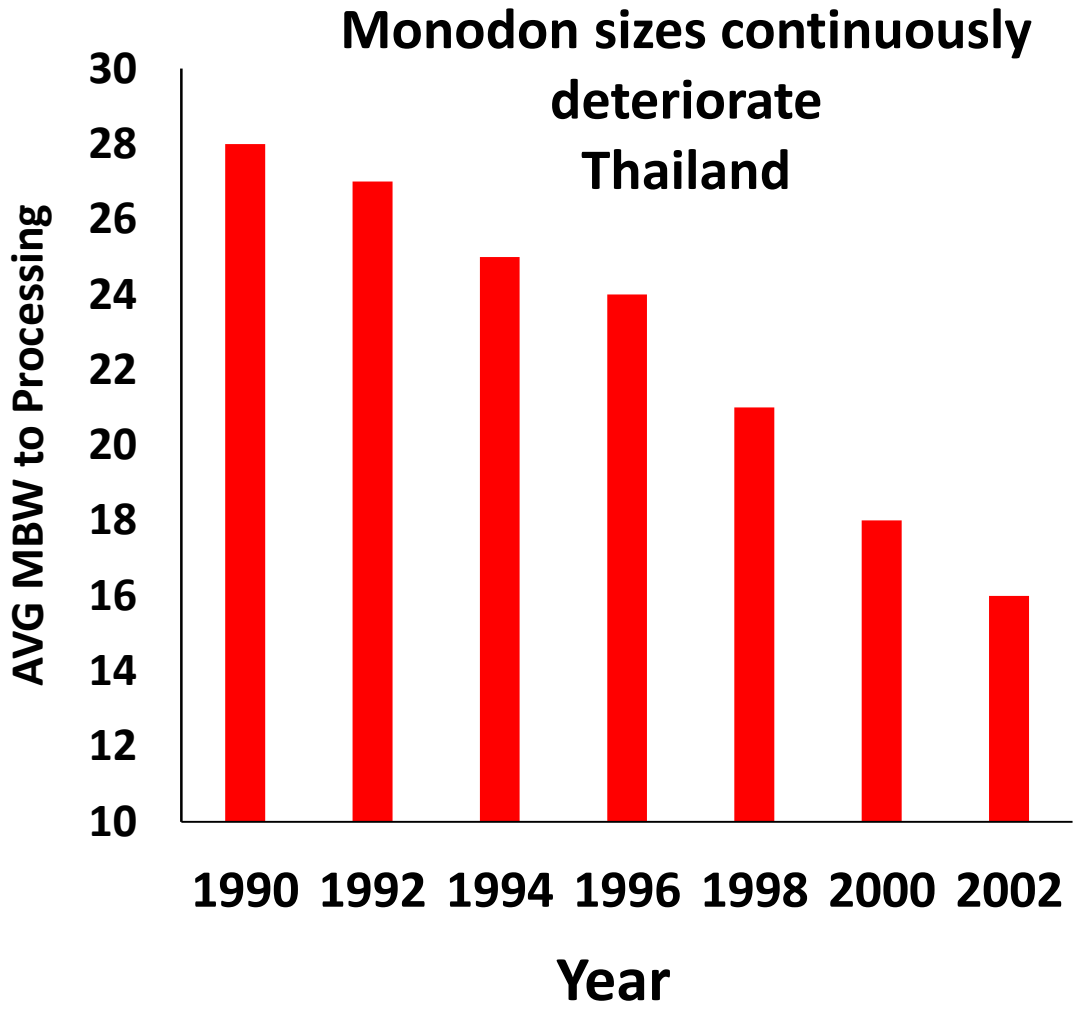

Collecting wild broodstock


Farmed shrimp were healthy

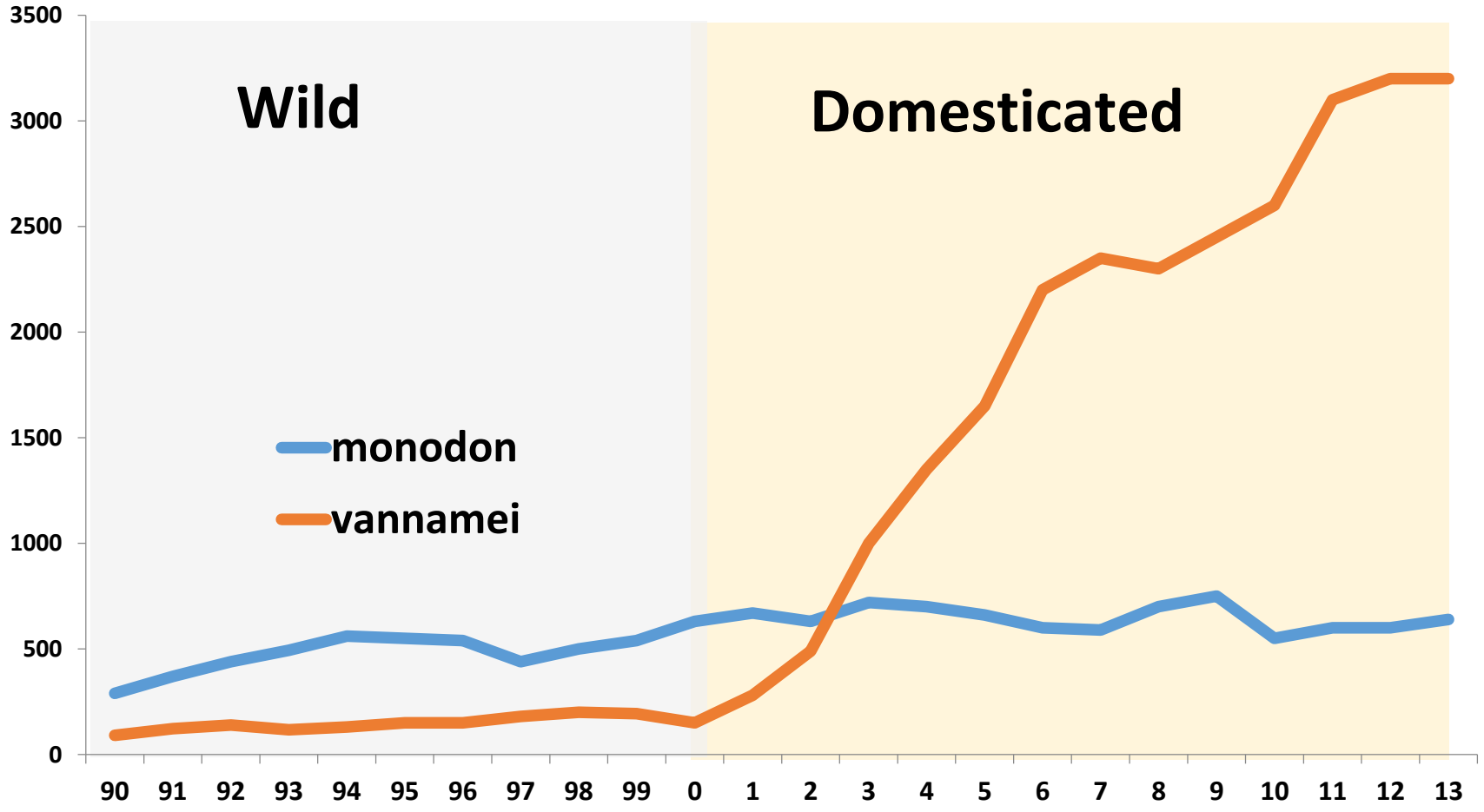
1989 Monodon

In 1998-1999:
America Died of WSSV (Vannamei)

In 1999-2000
Asia lost growth and survival (Monodon)

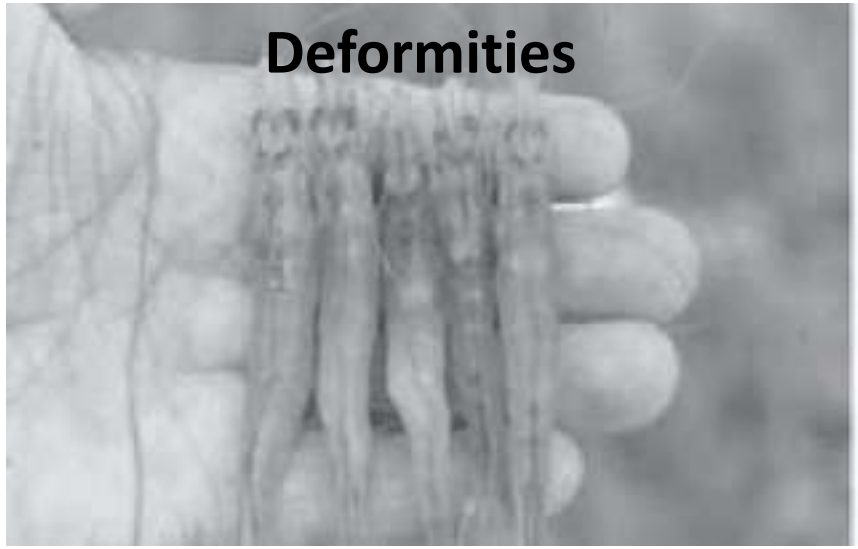


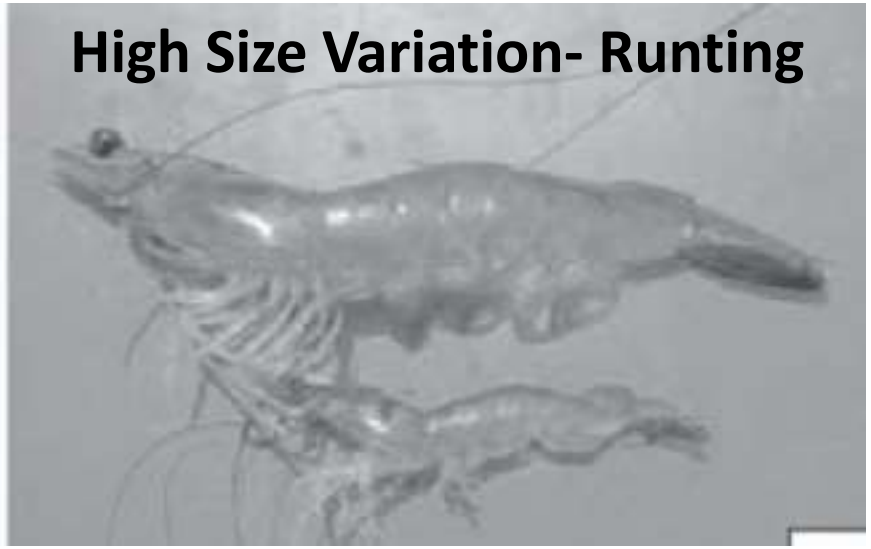
Adoption of Domestication results in surge in shrimp industry growth 2003-2010



2000: The year where domestication became a dominant theme in Shrimp

SPF Concept Developed(1990-1991) in Hawaii
Response to introduction of IHHNV



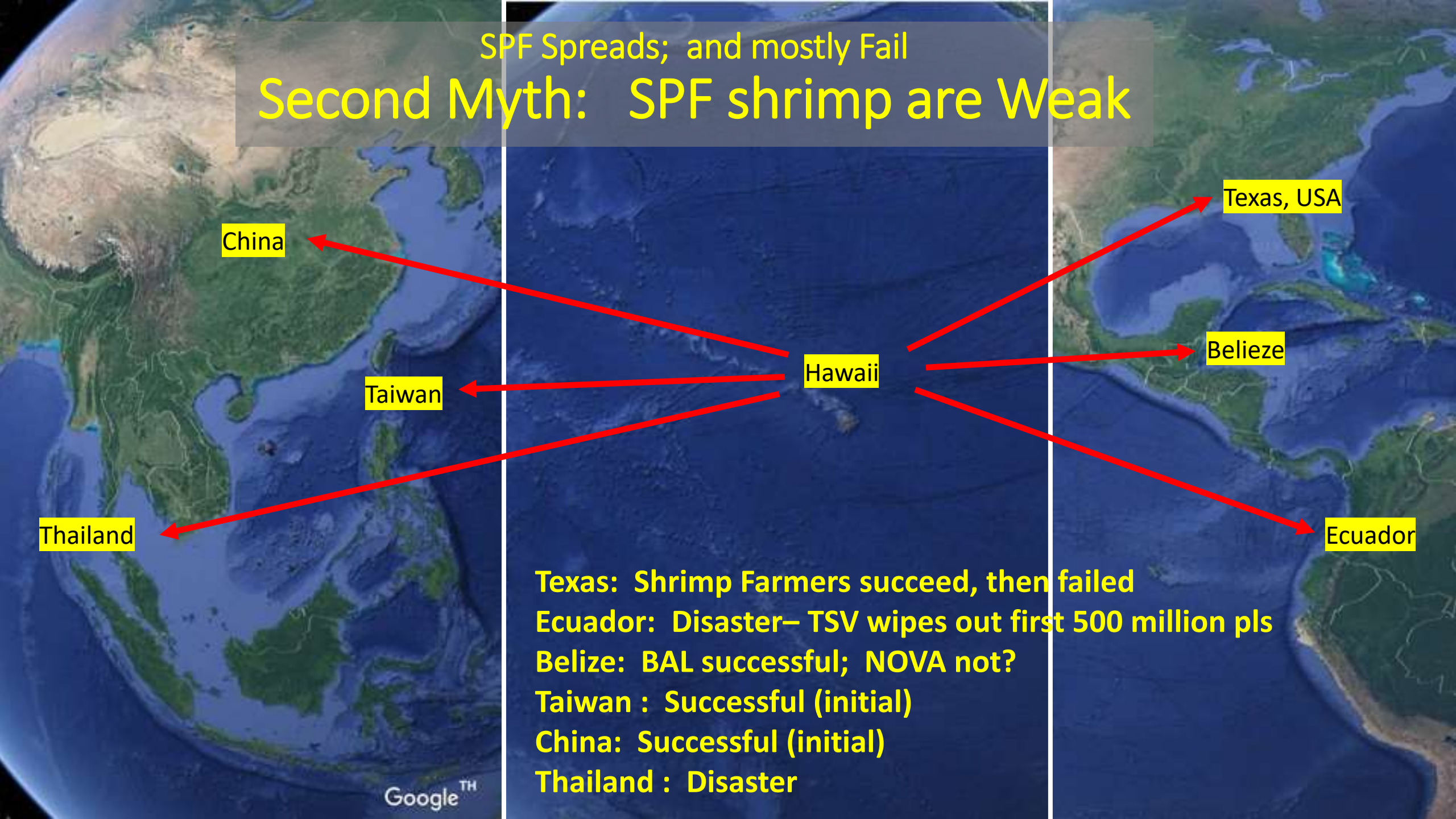


IHHNV introduced and infects post larvae
Hawaiian pond production declines

Myth I: Must have an island for SPF

SPF Spreads; and mostly Fail

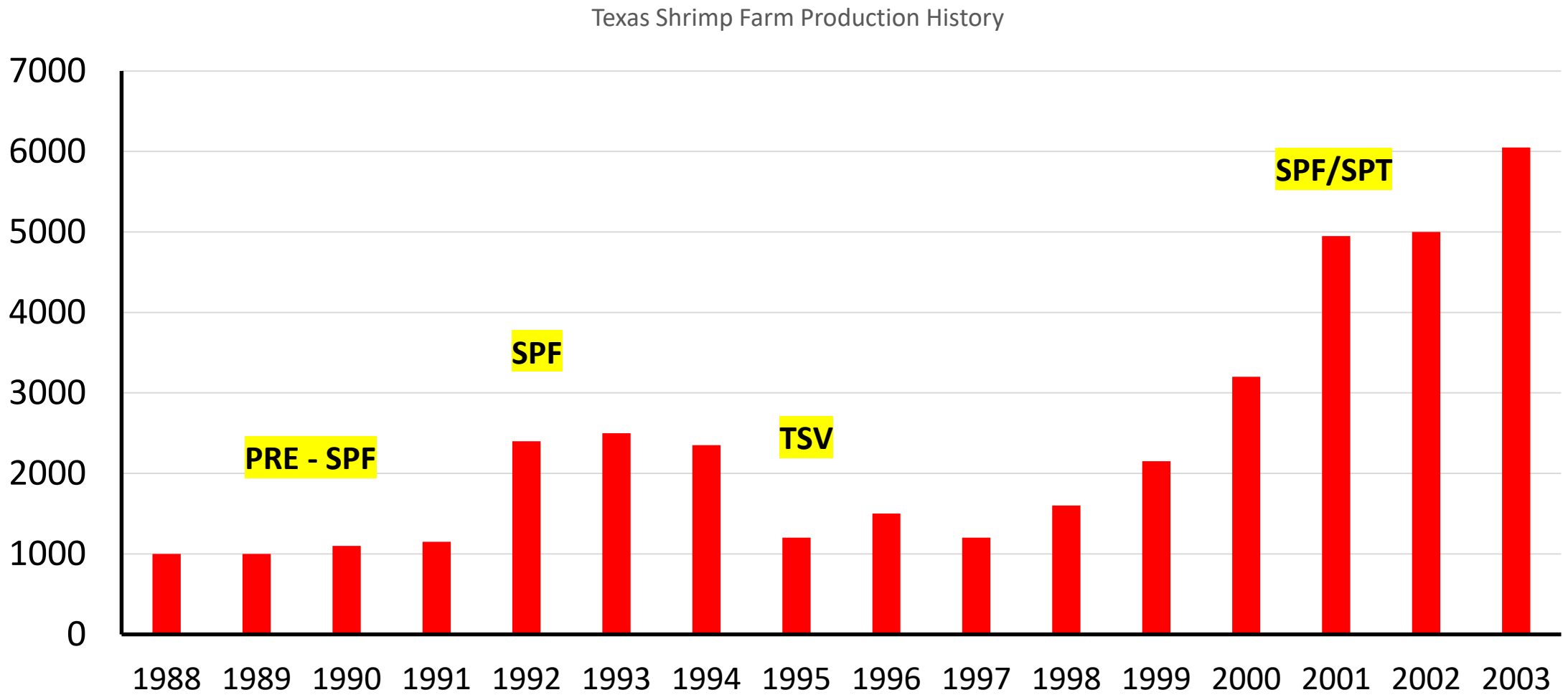
Second Myth: SPF shrimp are Weak



Texas: Shrimp Farmers succeed, then failed
Ecuador: Disaster– TSV wipes out first 500 million pls
Belize: BAL successful; NOVA not?
Taiwan : Successful (initial)
China: Successful (initial)
Thailand : Disaster

History of Texas Shrimp Production

Demonstrates the strengths and weakness of SPF shrimp model



Healthy Shrimp are not “just” Shrimp without disease BUT

Shrimp with a fully developed immune system to prevent disease

Understanding SPF/SPR/SPT

Definition of SPF/SPR/SPT

- **Specific Pathogen Free** Shrimp refers to the Health Status of a stock and not a genetic characteristic. To be SPF a shrimp should be free of all known shrimp virus (not only OIE listed pathogens).

- **Specific Pathogen Resistant** Shrimp refers to a Genetic characteristic- being resistant to infection of a specific pathogen; a shrimp may be SPF and SPR.

- **Specific Pathogen Tolerant** Shrimp refers to a Genetic Characteristic where the shrimp can get infected but does not express the disease

Important Lesson:

The description SPF refers to health Status only; The shrimp is free of specified pathogens

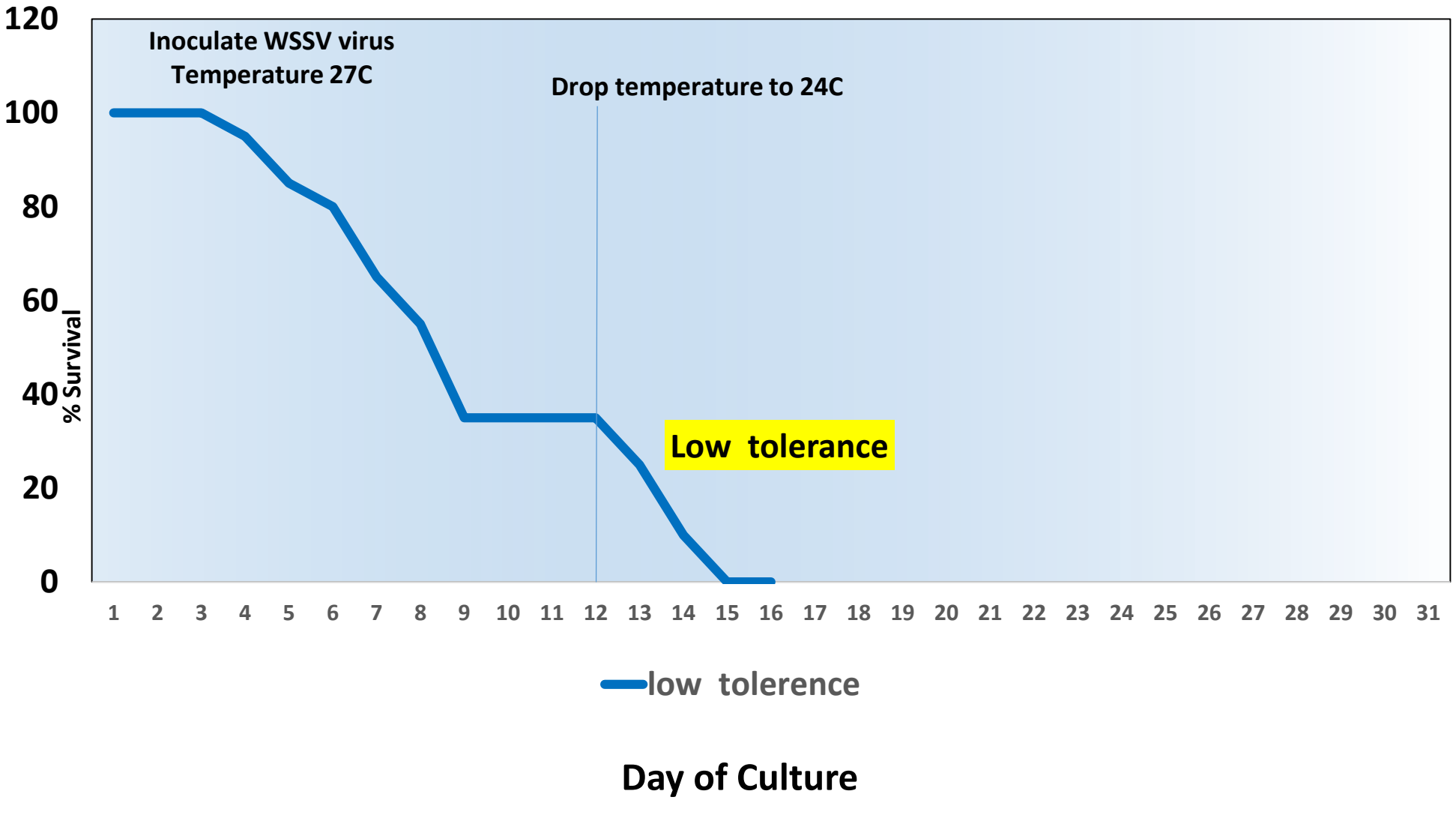
Tolerance to Disease (SPT) is Genetic and must be developed and selected

Both SPF and Tolerance being independent; can be in the same shrimp or not

There can be SPF only– original Hawaiian SPF
There can be SPF combined with SPT:
There can be SPT only –APE is an example

Tolerance is not Resistance
Either SPF or APE: but not Both

Comparison of WSSV Tolerance and Resistance



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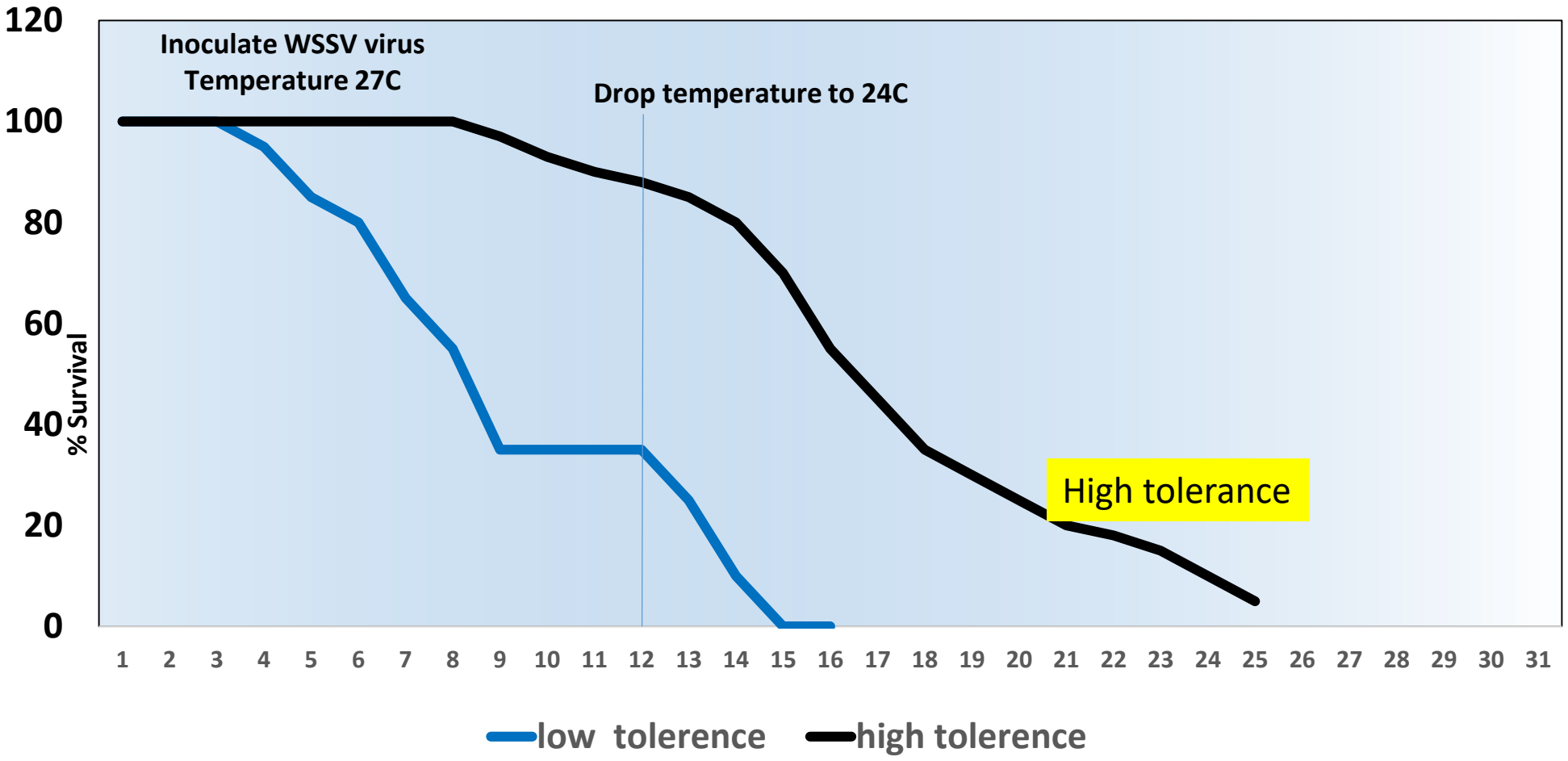

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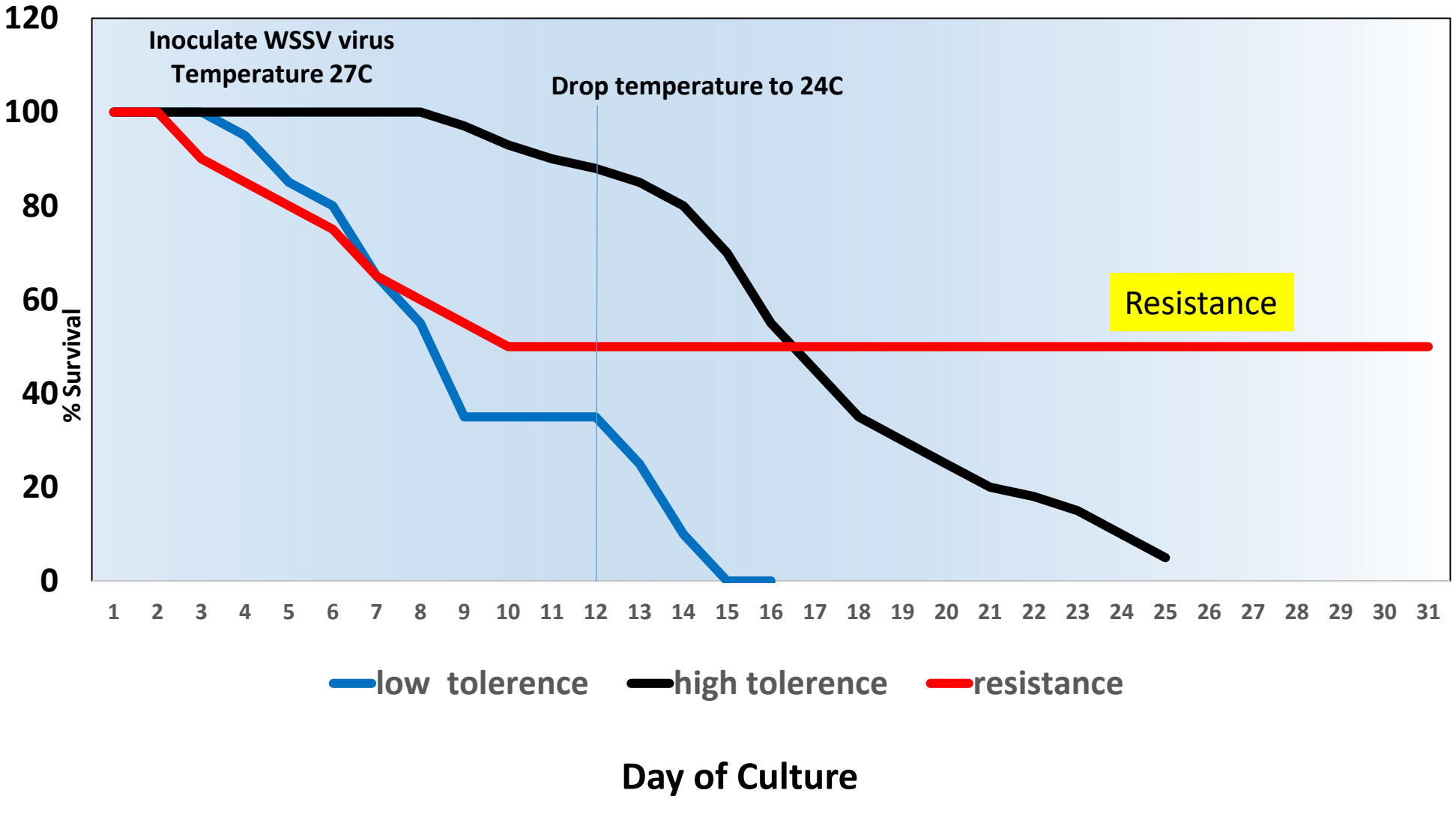
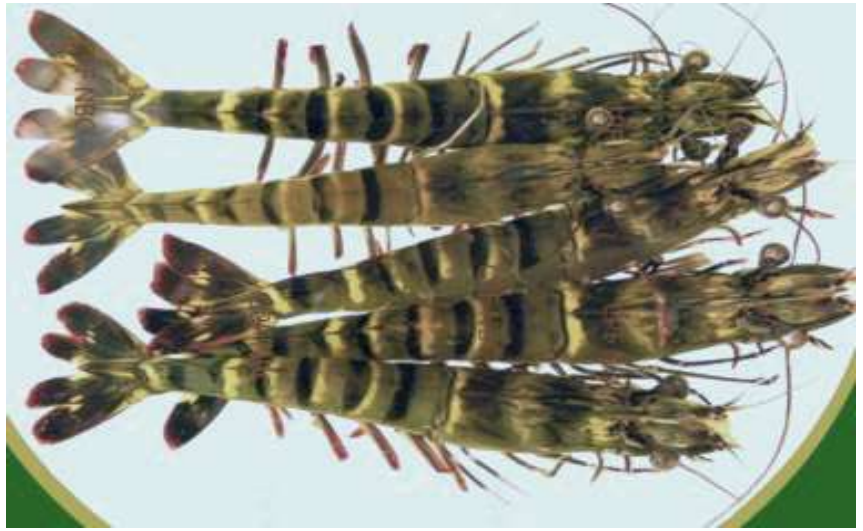


Domesticated Pathogen free shrimp stocks are essential for efficient genetic selections

Monodon

CV < 15%



35 grams in 105 days

Vannamei

CV <12%

42 grams in 100 days

SPF requires Nucleus Breeding Concepts certified disease free compartments

1. Strict Quarantine for Founders before entry
2. Nucleus Breeding Compartment; regularpathogen surveillance
3. List of pathogens being surveilled
4. Strictest of biosecurity;

Two contrasting methods of initiating SPF populations: Hawaiian and Reverse SPF

Screening from wild sea caught shrimp: quarantine
(original Hawaiian Protocol)

Must create tolerance from SPF

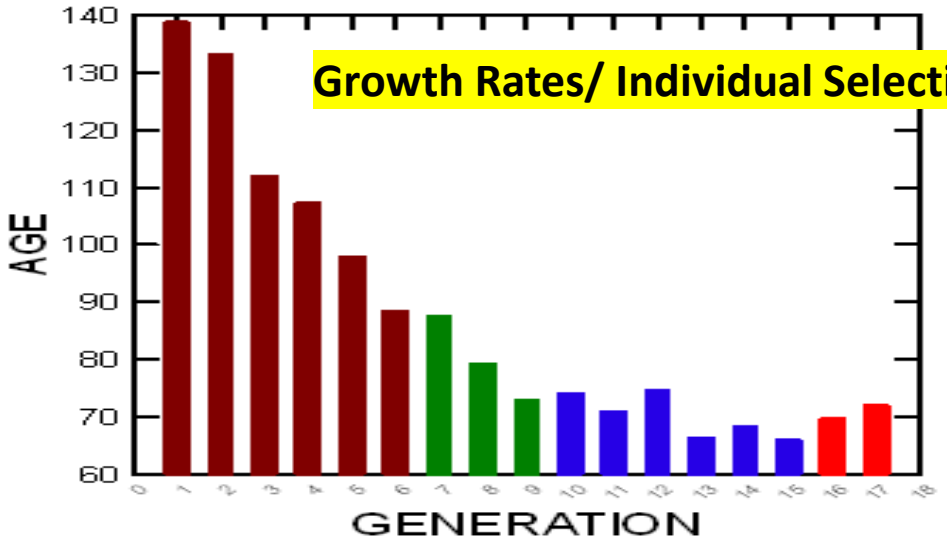
Screening from shrimp exposed to pathogens
Many generations: quarantine
(referred to as reverse SPF)

Must select spf from tolerant shrimp

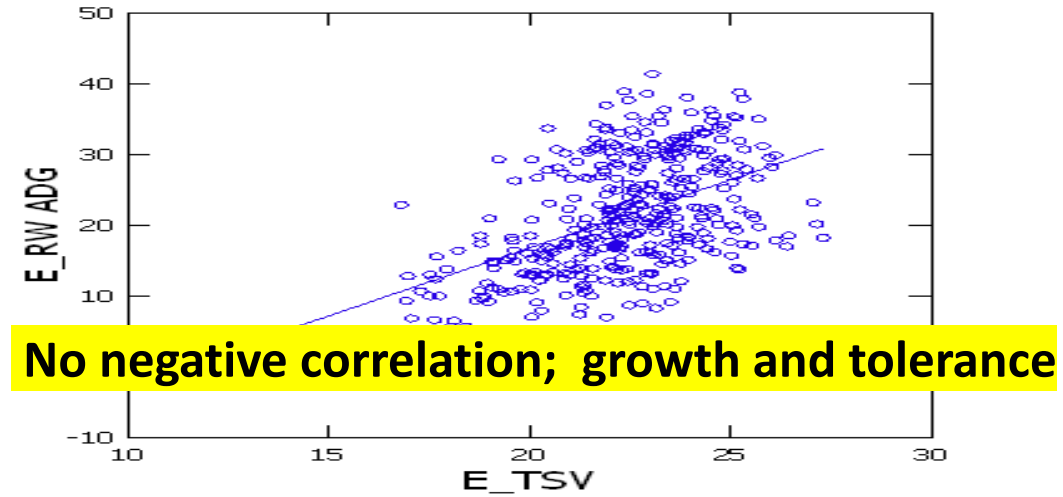
SPF is a good breeding platform: Growth and Tolerance (SPF/SPT)

(all data from CPF *vannamei* Program/Hawaiian Concept)

Growth Rates/ Individual Selection

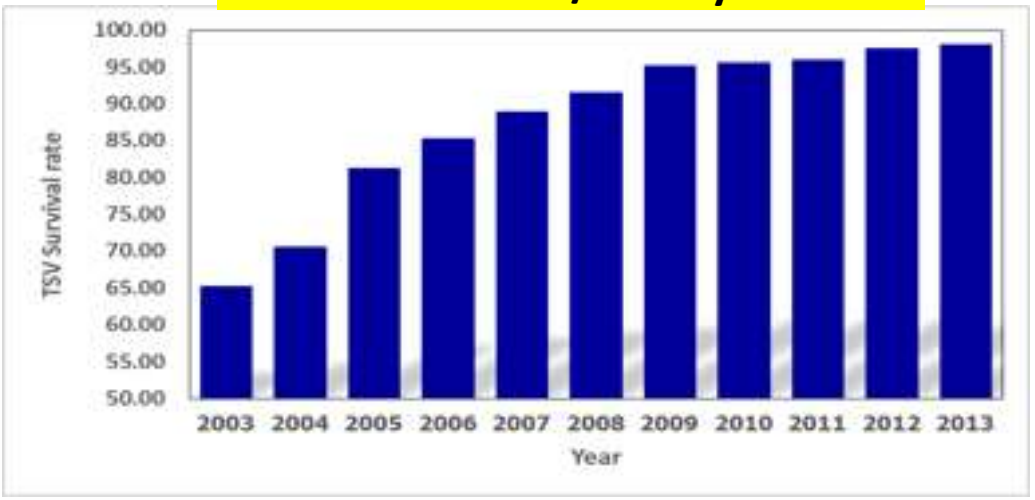


TSV

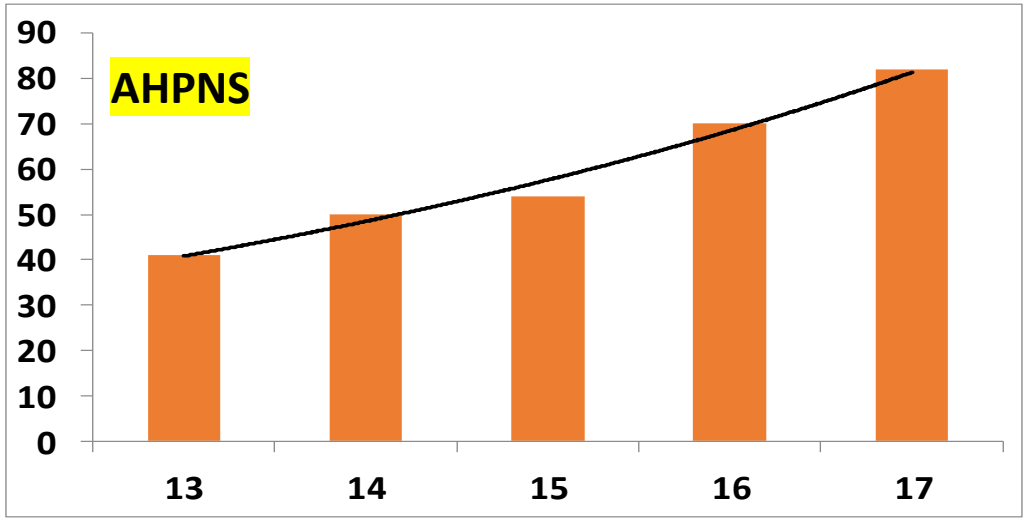


No negative correlation; growth and tolerance

Disease Tolerance/ Family Selection

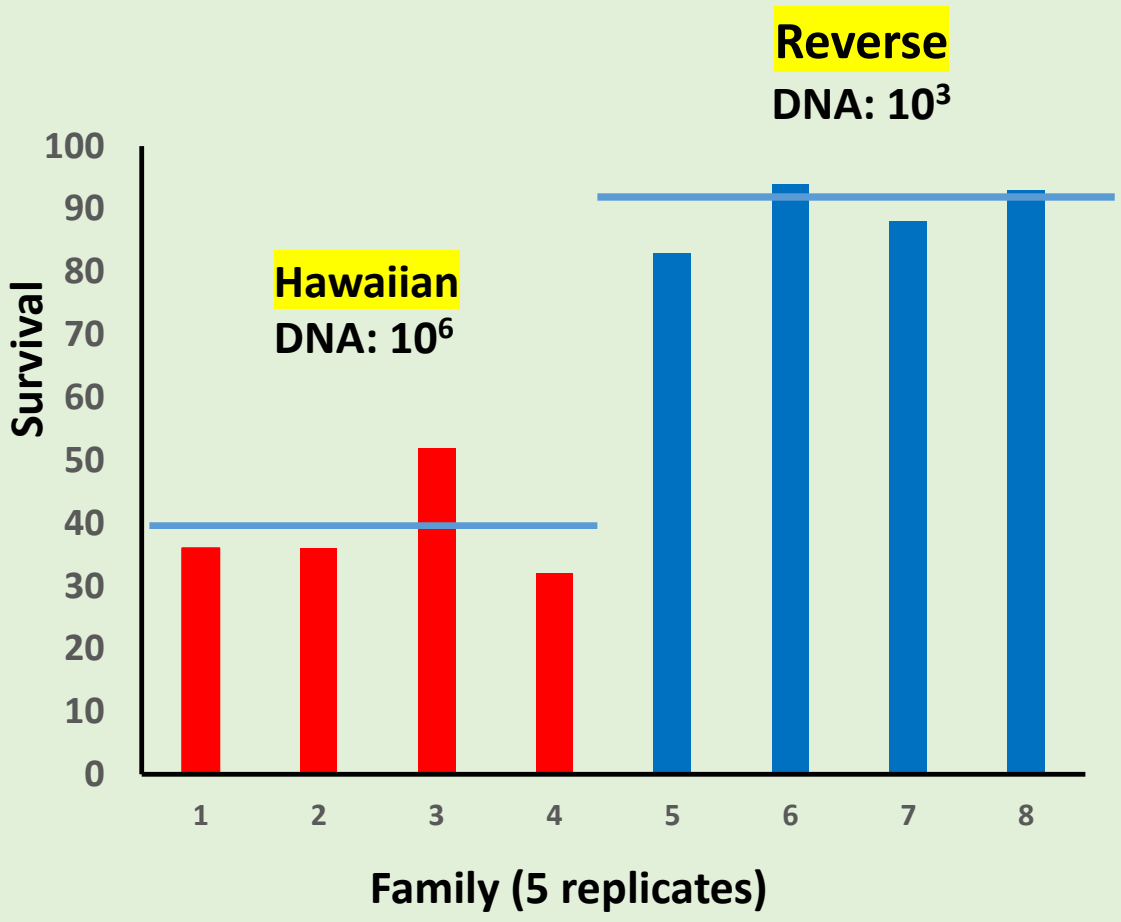


AHPNS

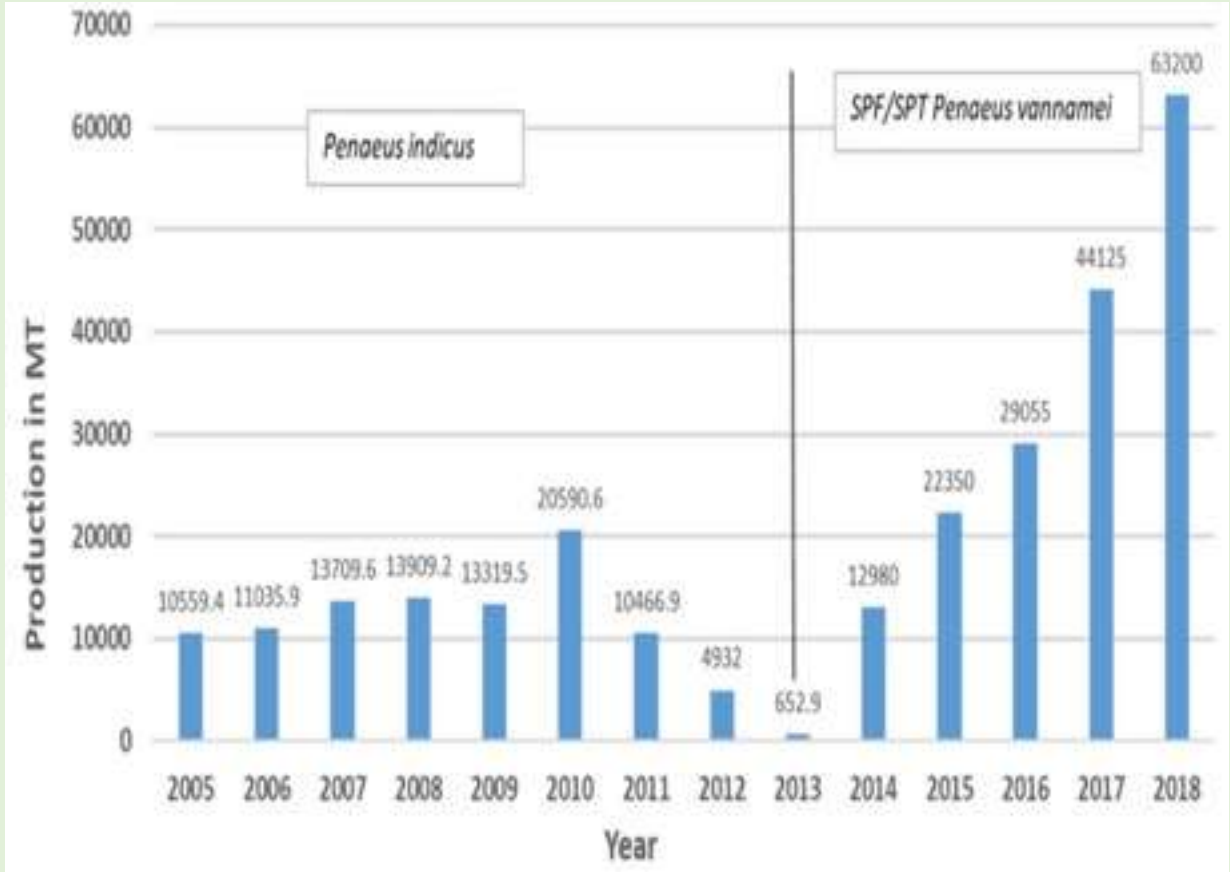


Reverse SPF proves to be an efficient way to create disease free/healthy + disease tolerant shrimp (SPF/SPT)

Thailand : WSSV Lab Challenge



Saudi Arabia: Real World Proof

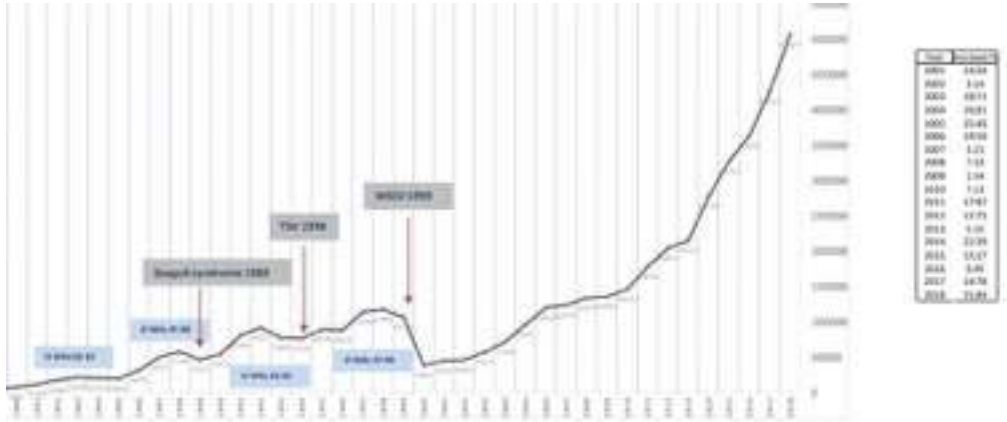


Specific Pathogen Resistant (SPR): Does it exist?

True resistance has been found as a homozygous trait in P. Monodon off Madagascar: but only individuals- entire families

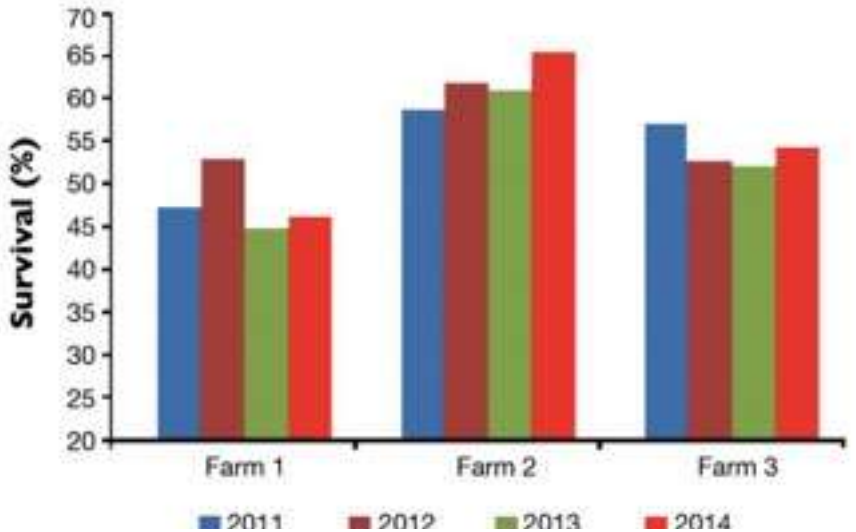
SPT/APE: Effective concept for Low Density (not secure for international Trade)

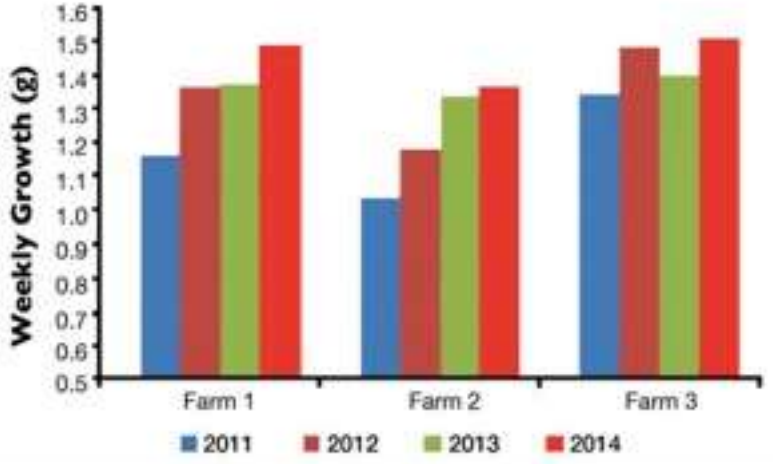
After the 2000 Industry collapse from WSSV Industry recovered using APE domestication



Birds on WSSV dying shrimp in Ecuadorian Pond (small percentage)

Selection from the Pond environment





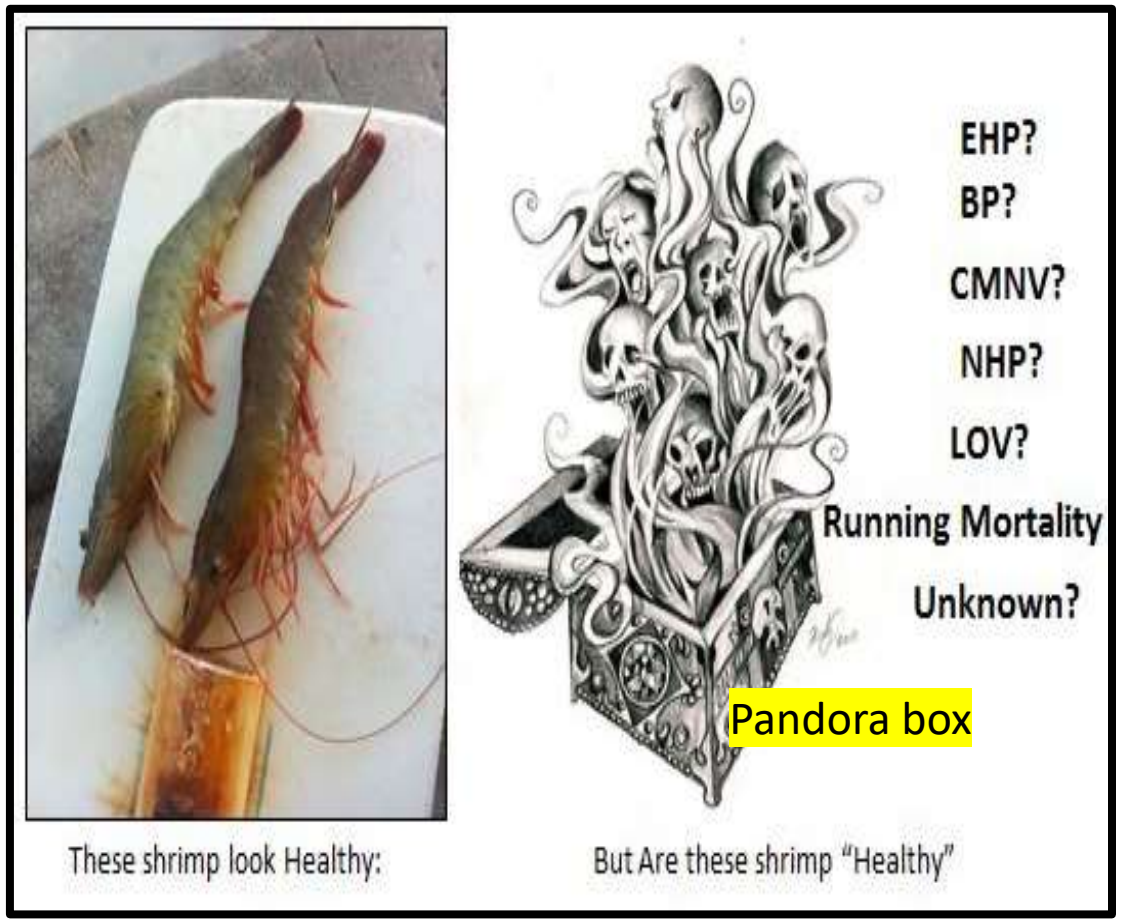
Disease (Health)
is a function of stress, genetics and the pathogen

No disease

IMNV; EHP Disease

Camanor Farms; Brazil using same non SPF post larvae

Why Does it Matter: SPF/SPT/SPR



- Only "genuine" SPF guarantees freedom of pathogens
- Shrimp marketed today as SPR; are not SPR– they are SPT and SPT carries pathogens if not also Genuine "SPF"
- The myth persists that SPF is weak and SPR is strong- this is a dangerous and wrong idea

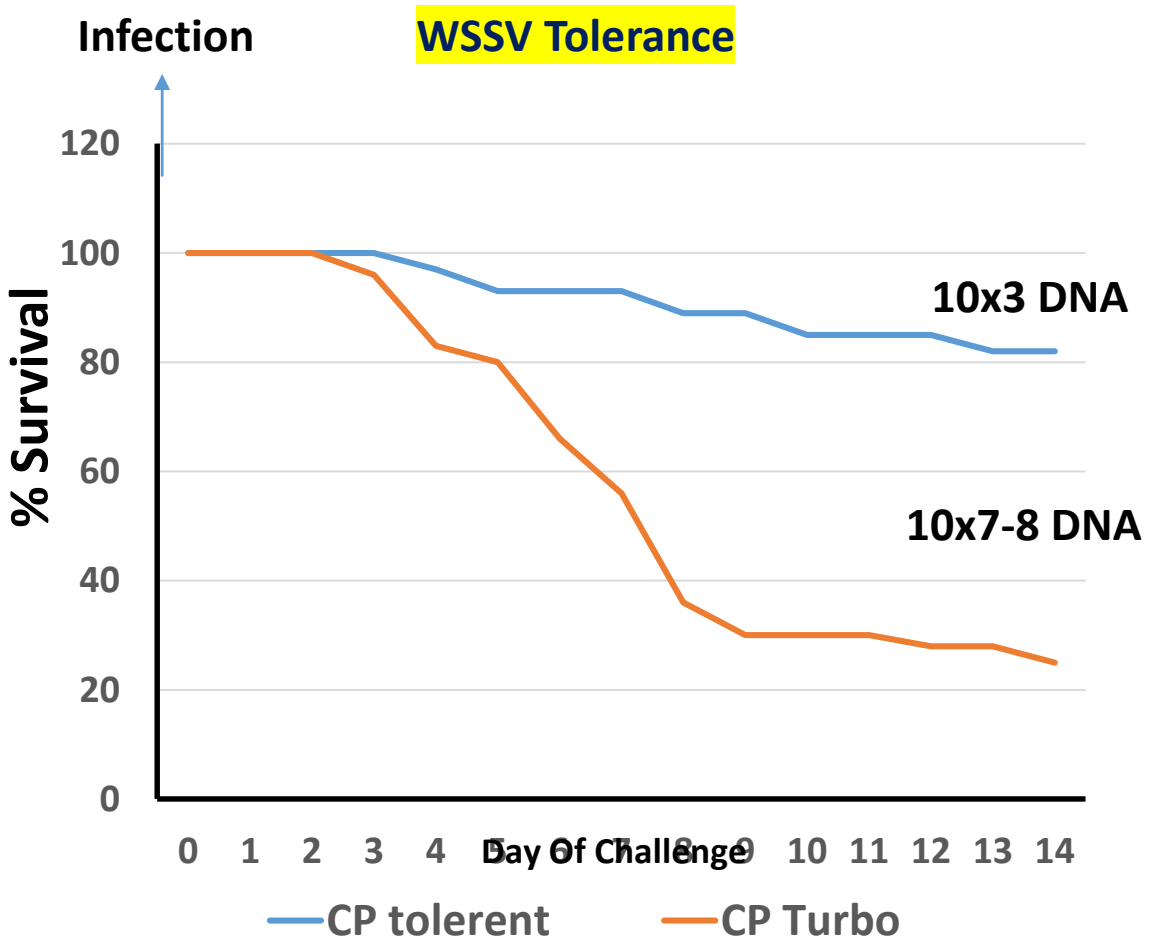
Is it True?

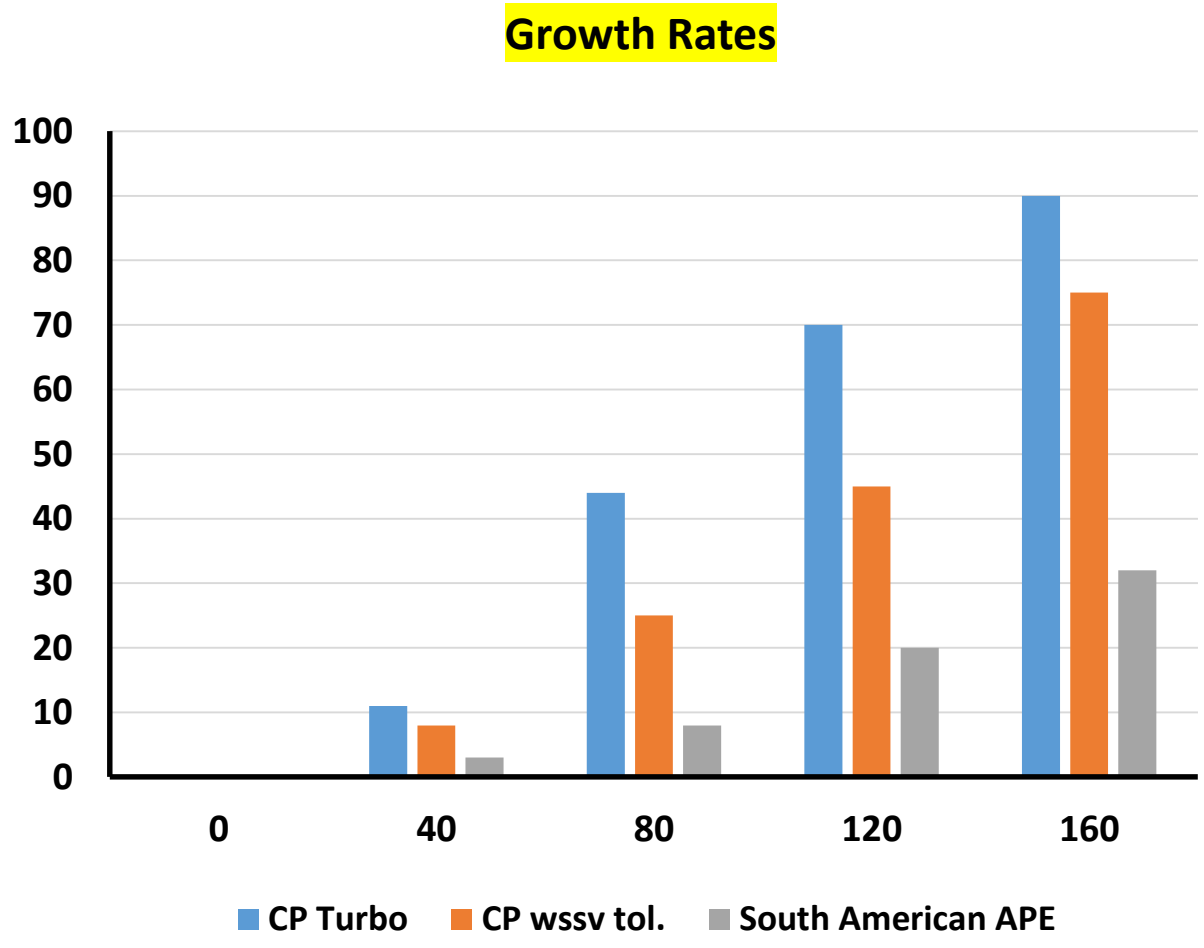
"APE" survives better against EMS - SPF dies much faster?

Parameter	APE I	APE II	APE III	SPF	SPF +
AHPNS CHALLENGE	21	60	55	**62**	**78**
MBW (DOC 35)	3.6	2.5	2.2	**4.8**	**4.8**
MBW (DOC 80)	17.5	15.5	13.5	**29.6**	**29.6**

+ =immune primed

Combining APE tolerance with SPF Health and Growth





SPF applies to Monodon as Well!!!

Before: 2001 **After: 2011**

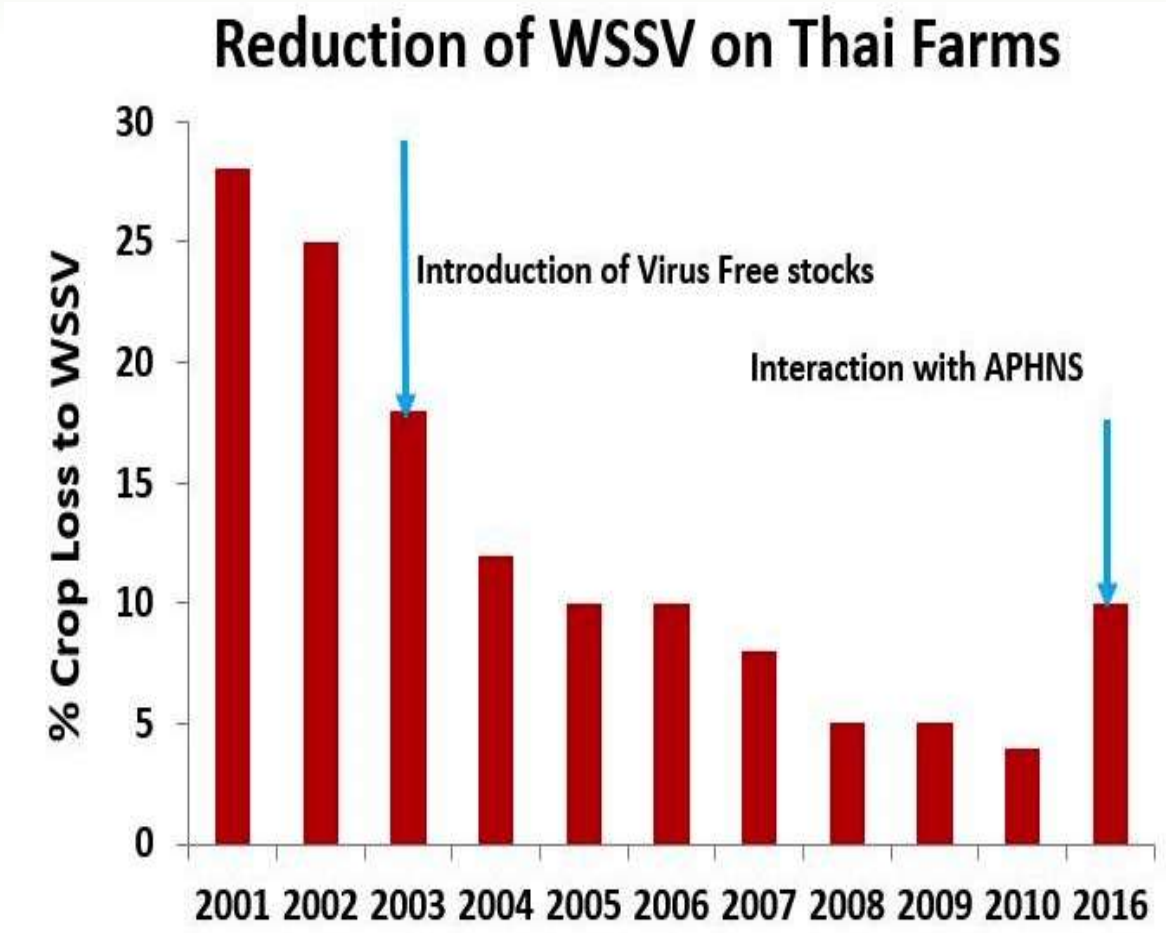
CPF thinking and Processes

CPF executives searching for Island to locate original SPF nucleus in Thailand (2002)

- Dead Shrimp don't grow
- Growth is important for lower costs (FCR, Capital,)
- Size Matters

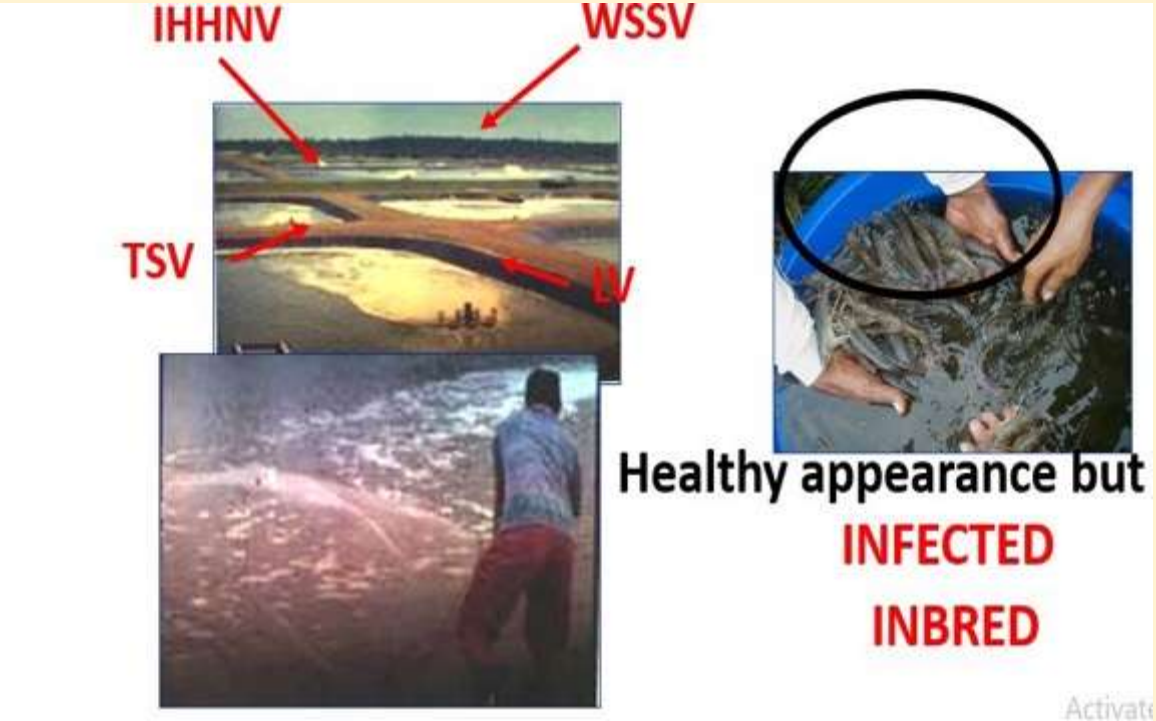
- Never Never Ever sell or give a shrimp to any farmer that contains a pathogen-
- Broodstock and post larvae are major responsibilities

Pathogen Free Animal STOCKS A MUST FOR Heathy shrimp and is the Basis of Biosecurity



Nucleus Breeding in disease free compartments is the Only WAY

Pond broodstock are not cheap



Pond Reared Appears to be CHEAP

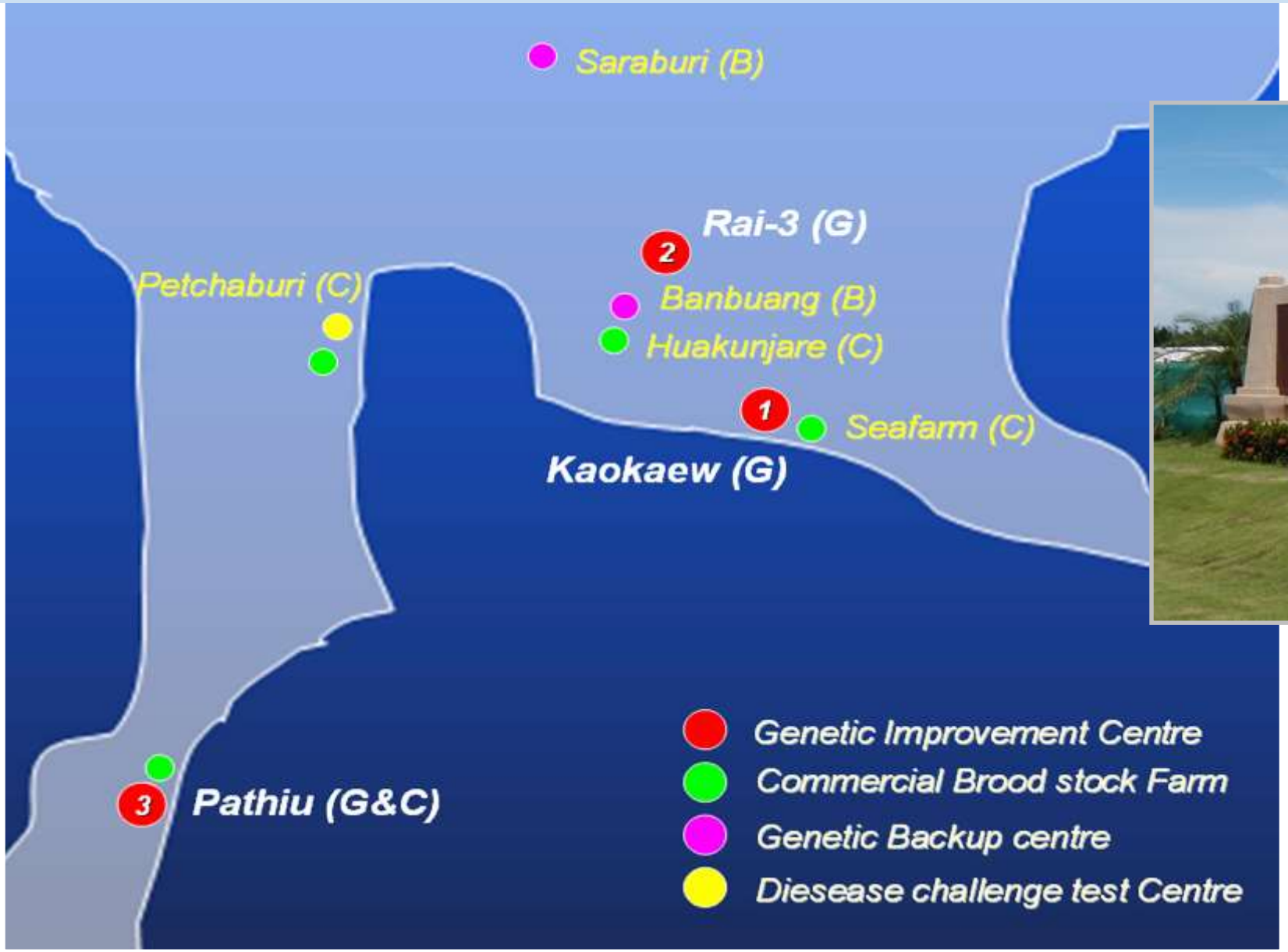
Nucleus SPF Broodstock are not Expensive

But for sustainable and “intensified “ systems only pathogen free will succeed

Thailand adopts Nucleus Breeding for SPF 2003

1. Strict Quarantine for Founders before entry
2. Nucleus Breeding Compartment; constant pathogen surveillance
3. List of pathogens being surveilled
4. Strictest level of biosecurity

Marine Shrimp Broodstock Program requires Multiple Facilities



Nucleus Breeding

Should have constant Surveillance of all known/possible pathogens

Not Just OIE pathogens

CHAROEN POKPHAND FOODS PUBLIC CO.,LTD

135/1 M.8, Nongkhanan, Mueang District, Phetchaburi 76000, Thailand

Establishment standard : Sor-Aor. 3 No: TH 7623160002

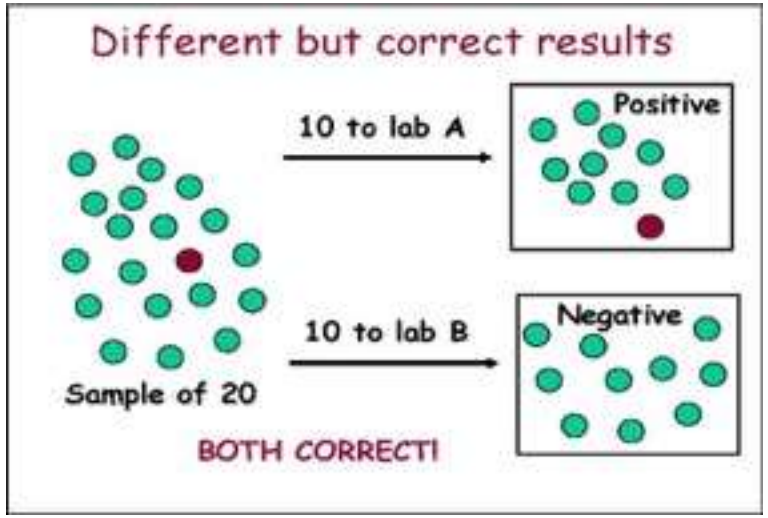
CERTIFICATE OF ANALYSIS

Year	No. of Sample														All Disease		
	IHHNV	IMNV	TSV	WSSV	YHV	EHP	AHPND	NHPB	DIV1	HPV	CMNV	BP	MBV	MrNV	No. of Sample	% Negative	% Positive
2013	604	604	604	604	604	6,113	60								9,193	100%	0%
2014	873	873	873	873	873	5,928	840								11,133	100%	0%
2015	654	654	654	654	654	3,955	900								8,125	100%	0%
2016	512	472	472	472	472	3,174	736								6,310	100%	0%
2017	457	432	433	434	435	4,607	1,326								8,124	100%	0%
2018	467	442	442	467	467	4,287	1,262	680	114	680					9,308	100%	0%
2019	2,613	1,156	1,156	2,984	2,613	5,439	3,780	2,306	688	2,642	19				25,396	100%	0%
2020	3,363	2,801	2,801	3,363	3,363	6,525	5,189	5,020	886	6,801	30	20			40,162	100%	0%
2021	1,510	1,510	1,510	1,510	1,510	4,119	2,469	2,591	268	3,934	40	50	40	40	21,101	100%	0%
Total	11,053	8,944	8,945	11,361	10,991	44,147	16,562	10,597	1,956	14,057	89	70	40	40	138,852		

This is certify that the processed white shrimp broodstock quality analysis which listed above has been analysed by CPF Central Laboratory

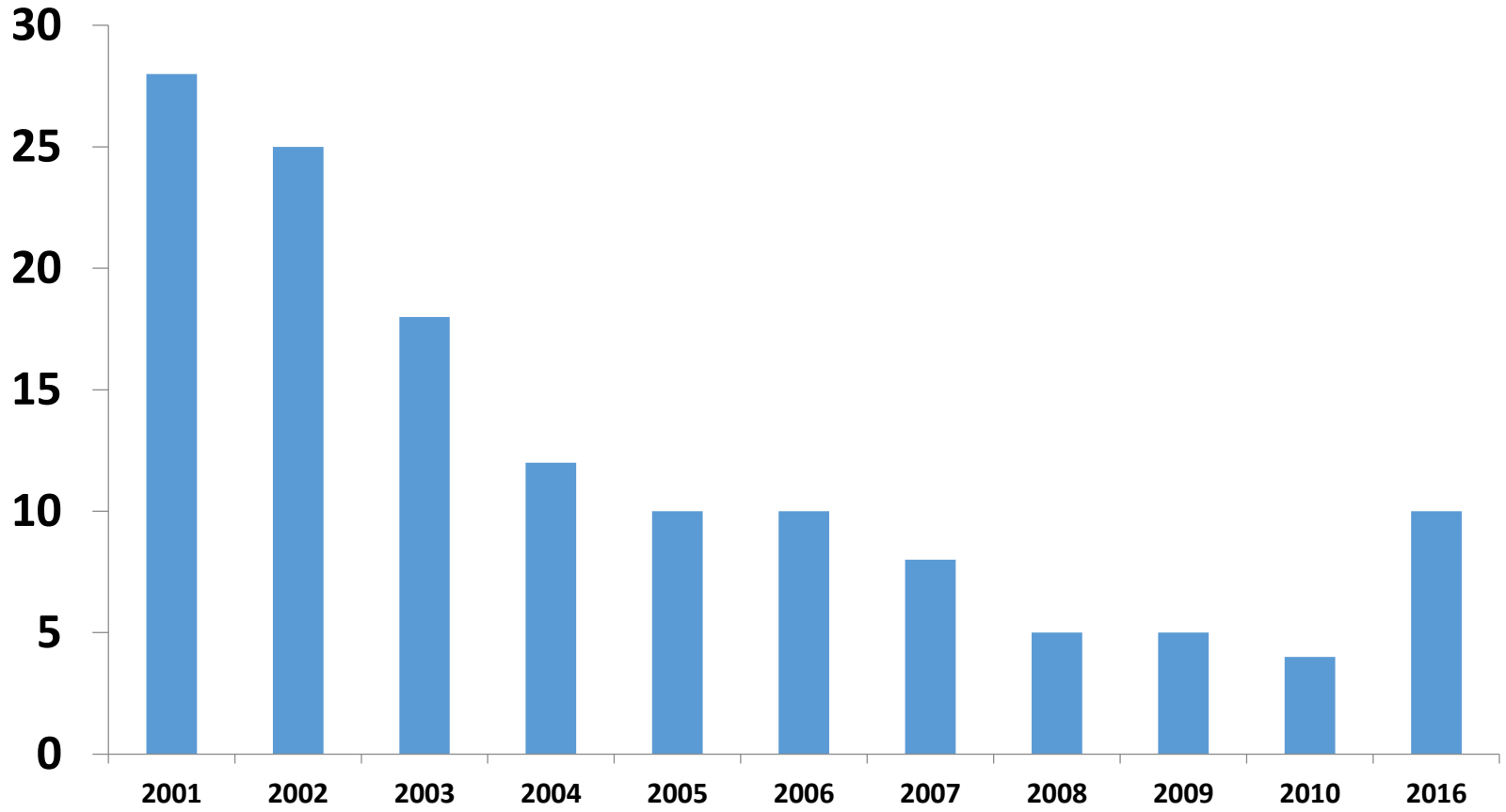
SPF is a process and not a PCR test result

PCR only + short term quarantine does not replace SPF shrimp



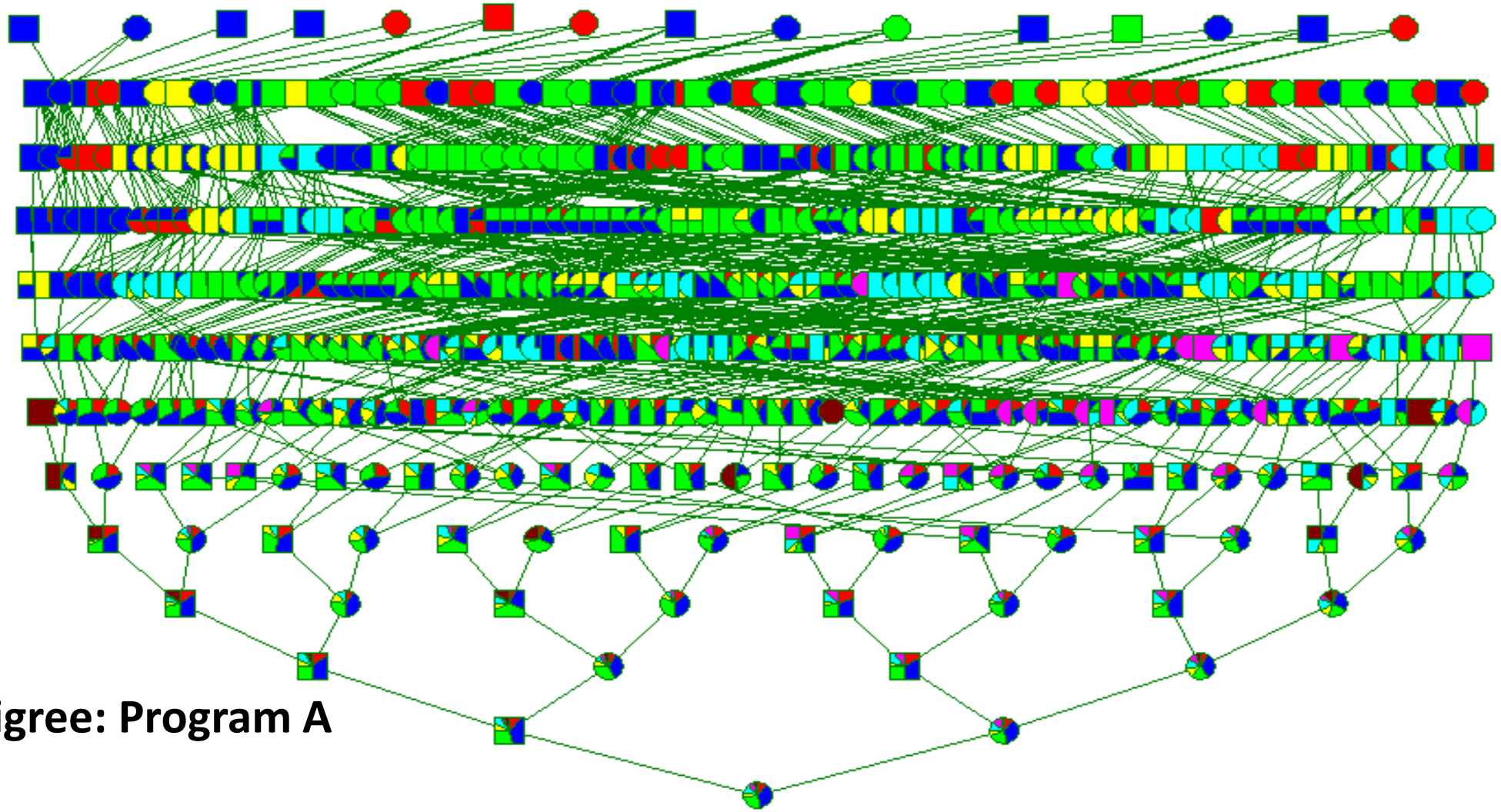
(8 known pathogens)

Clean SPF shrimp reduced WSSV failure rate in Thailand



Before PCR tested wild broodstock and post larvae

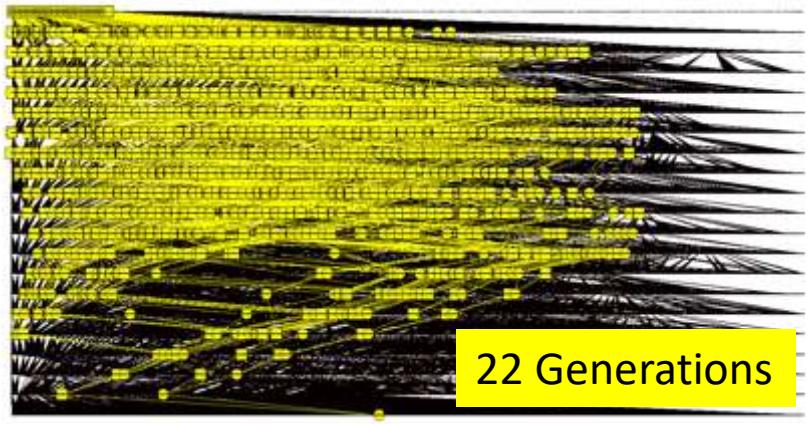
Pedigrees define a breeding program



CPF Pedigree: Program A

CPF Genetics breeding program

CPF was the first company in Asia to develop and operate SPF genetic centers and broodstock multiplication centers; starting operations in 2003. Since operations began CPF broodstock have been maintained disease free.



CP Family Pedigree

The Process

Broodstock — AI full-sib family

↓

Nauplii-PL45: 60 Families — Rearing in individual tanks

↓ Between Family selection

Best 2 Families for commercial

PL45-28g: 10-12 Families — Rearing in grow-out pond

↓ Within-family selection

Next Gen. Broodstocks

Family Based Breeding Strategy- Shrimp

How to breed for multiple characteristics: Use of Indexing

Indexing weight depends on the needs of Farmers

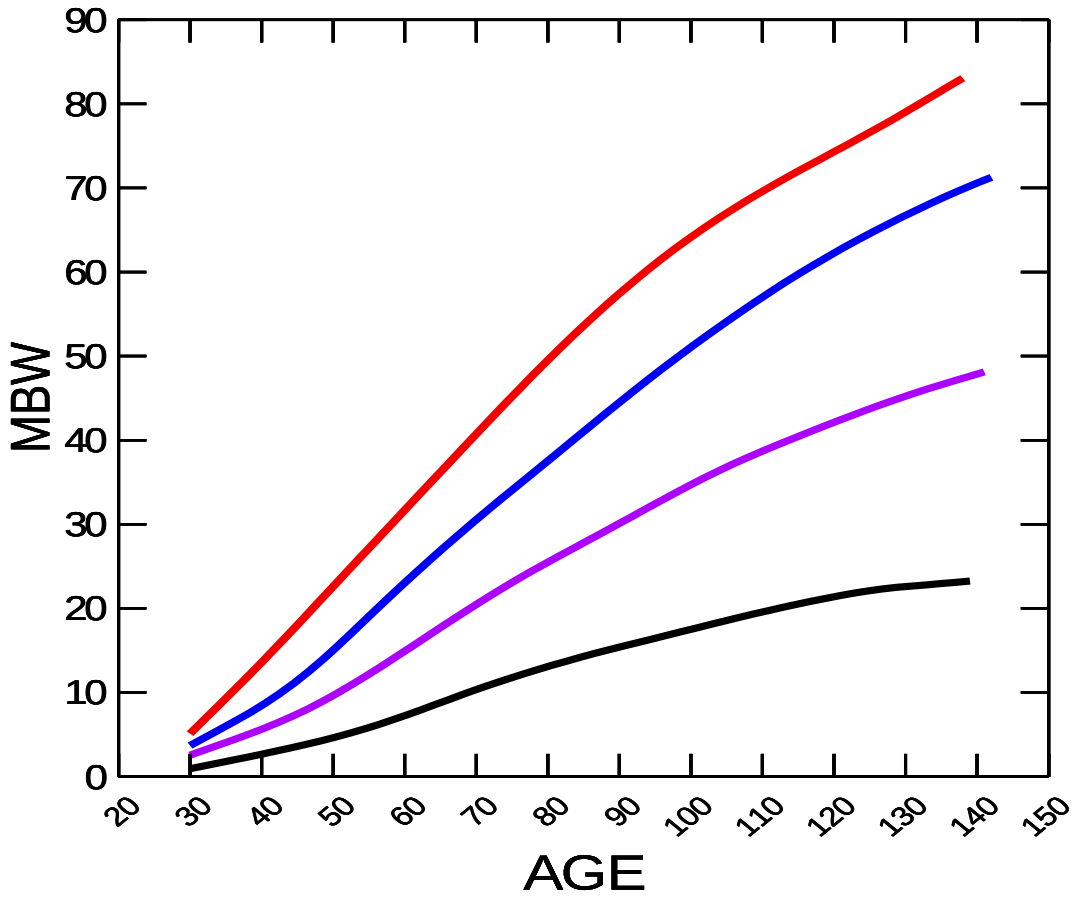
Years	Growth	TSV	APHNS	WSSV	Robustness	Reproduction
2004-2007	++	++++				+
2008-2012	++++	++			++	+
2013-2017	++		++++		+++	+
2018- present	+++		++	++++	++++	+

Turbo Pl was Born: 2008

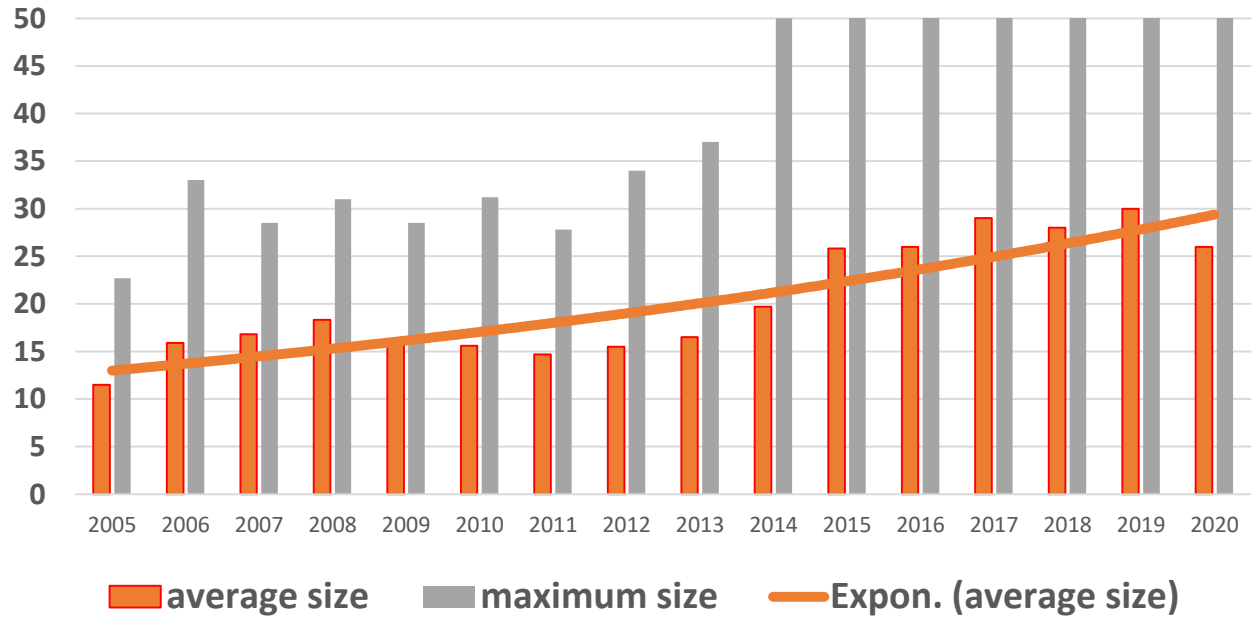
"DEAD SHRIMP NEVER GROW FAST"

Growth Improvement and Farm Performance

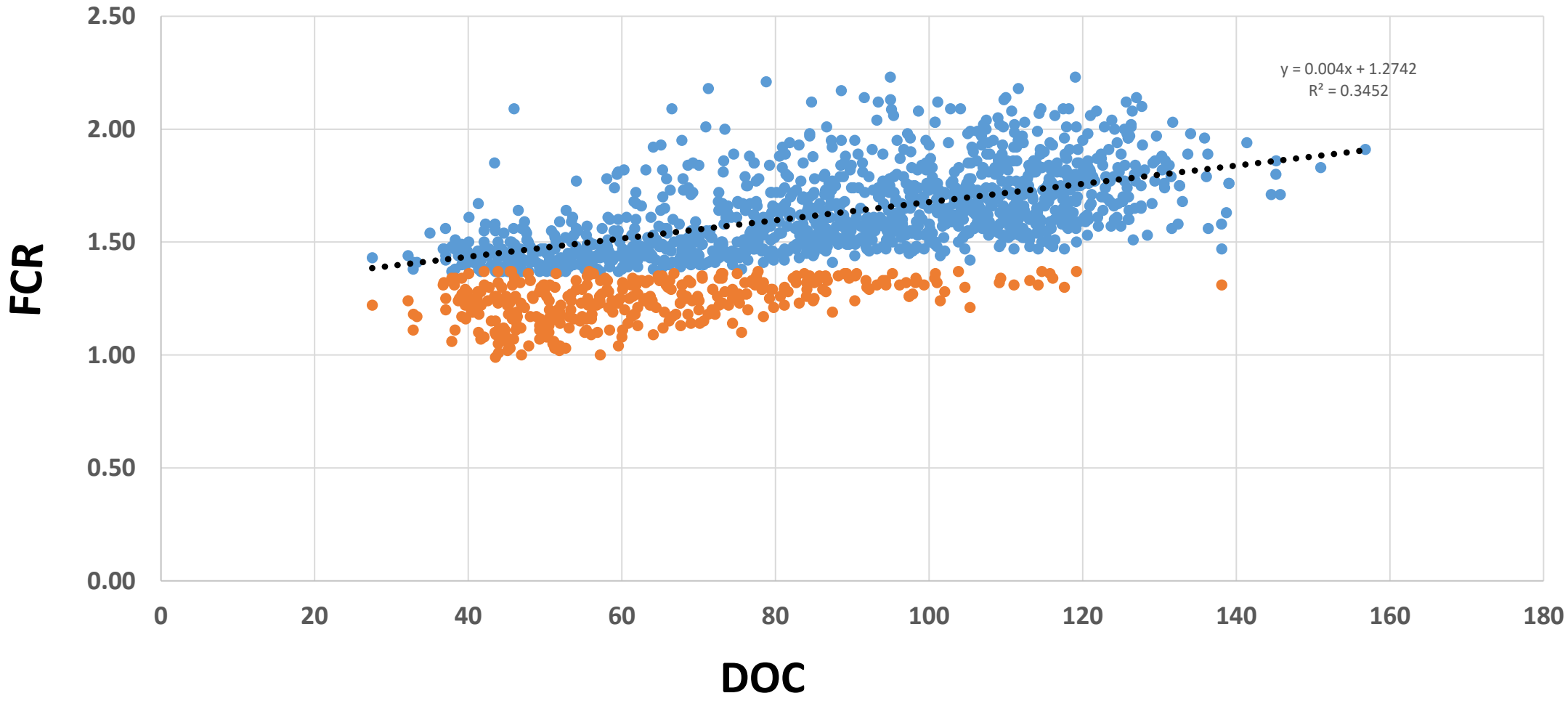
Genetic Raceway at 150/m2



Thailand Farm Performance

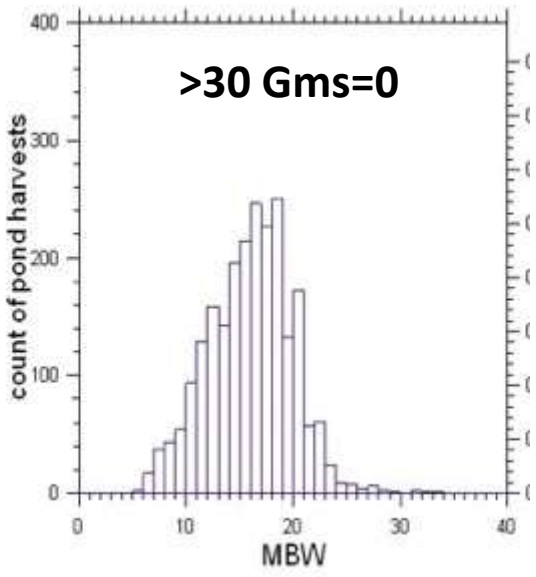


Growth Rate Improves FCR (assuming survival stays constant)



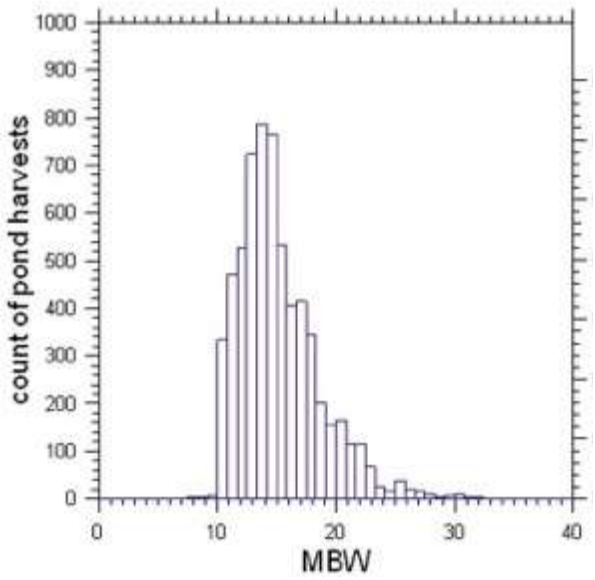
Harvest Sizes have increased over the time of the program providing higher farmer values

2006

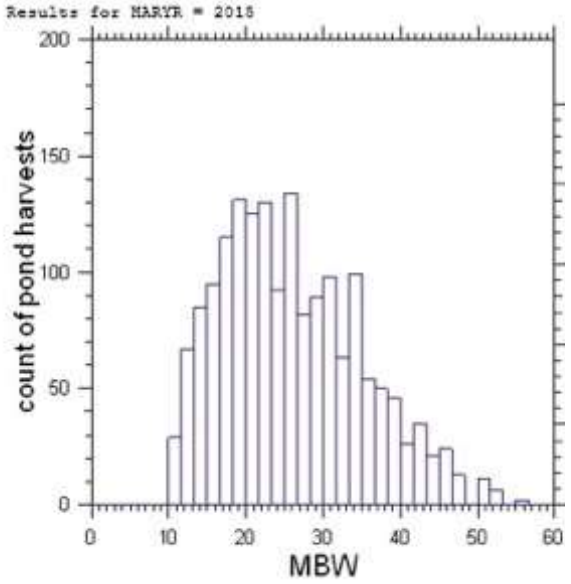


30 gms= 0 percent

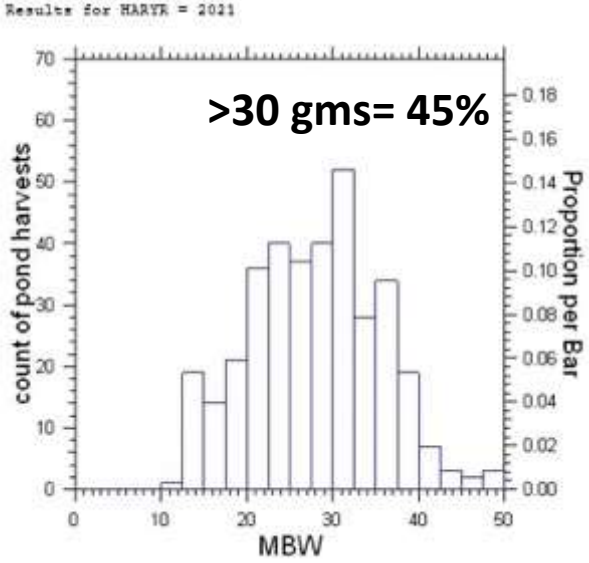
2012



2015



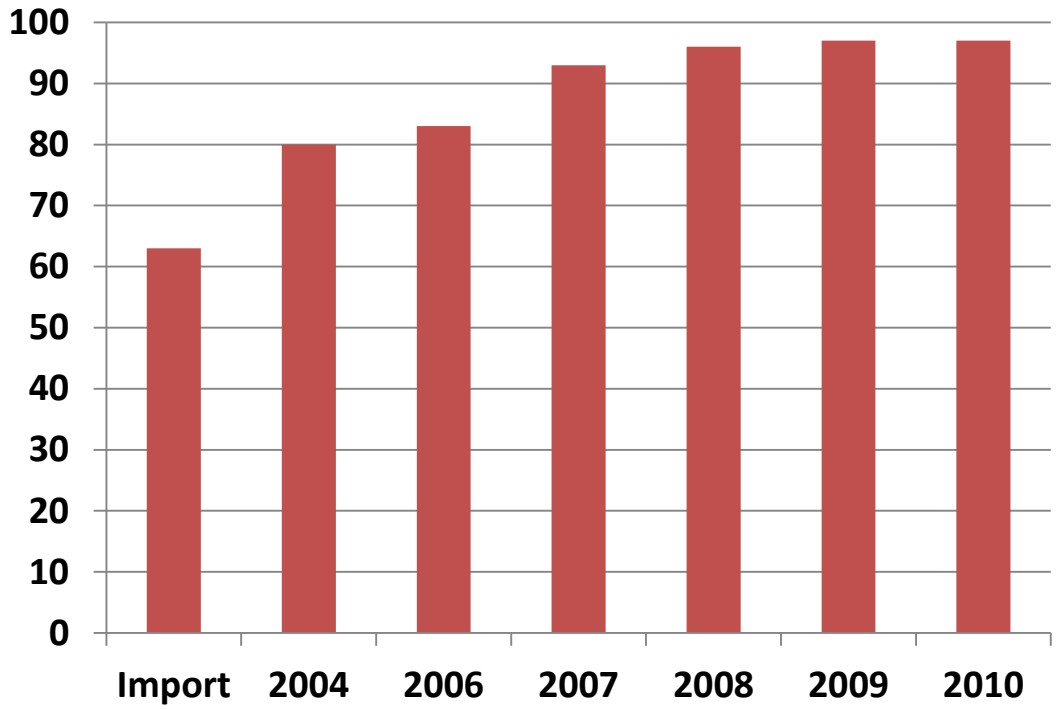
2021



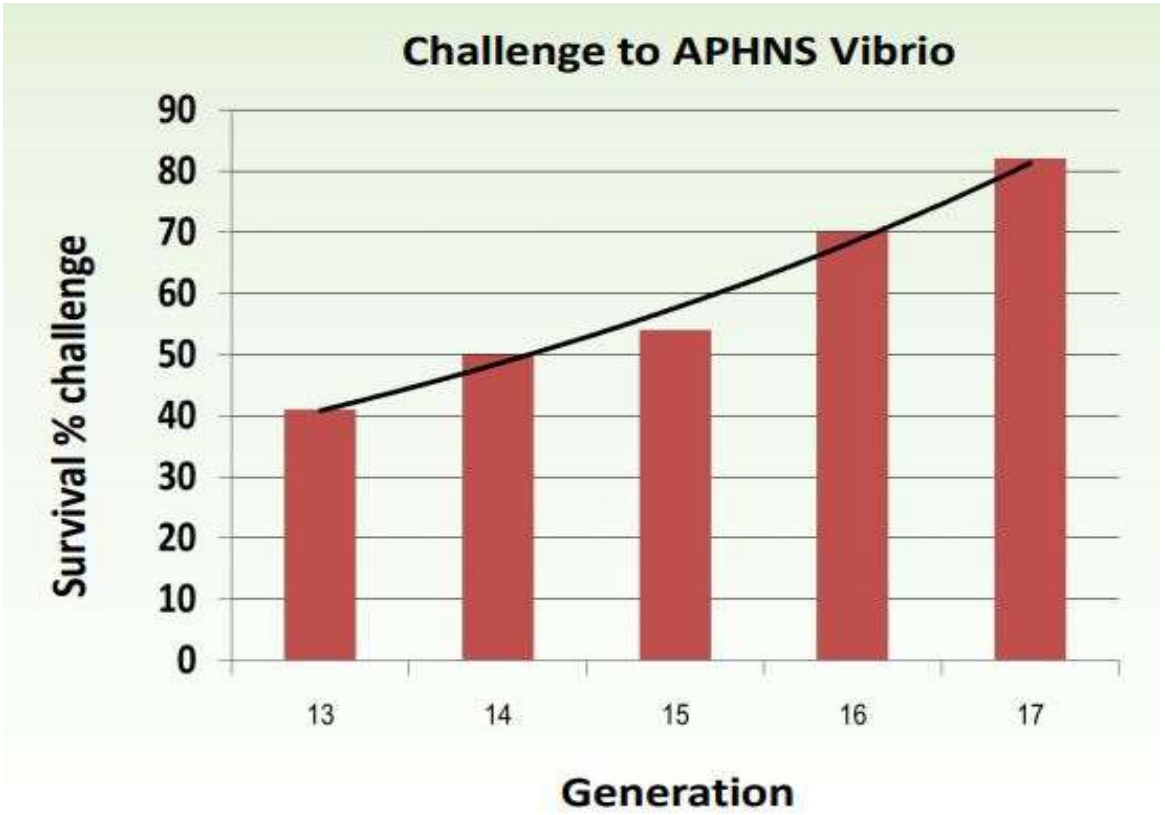
>30 gms= 40%percent

Disease Tolerance: Laboratory challenge

TSV >99%

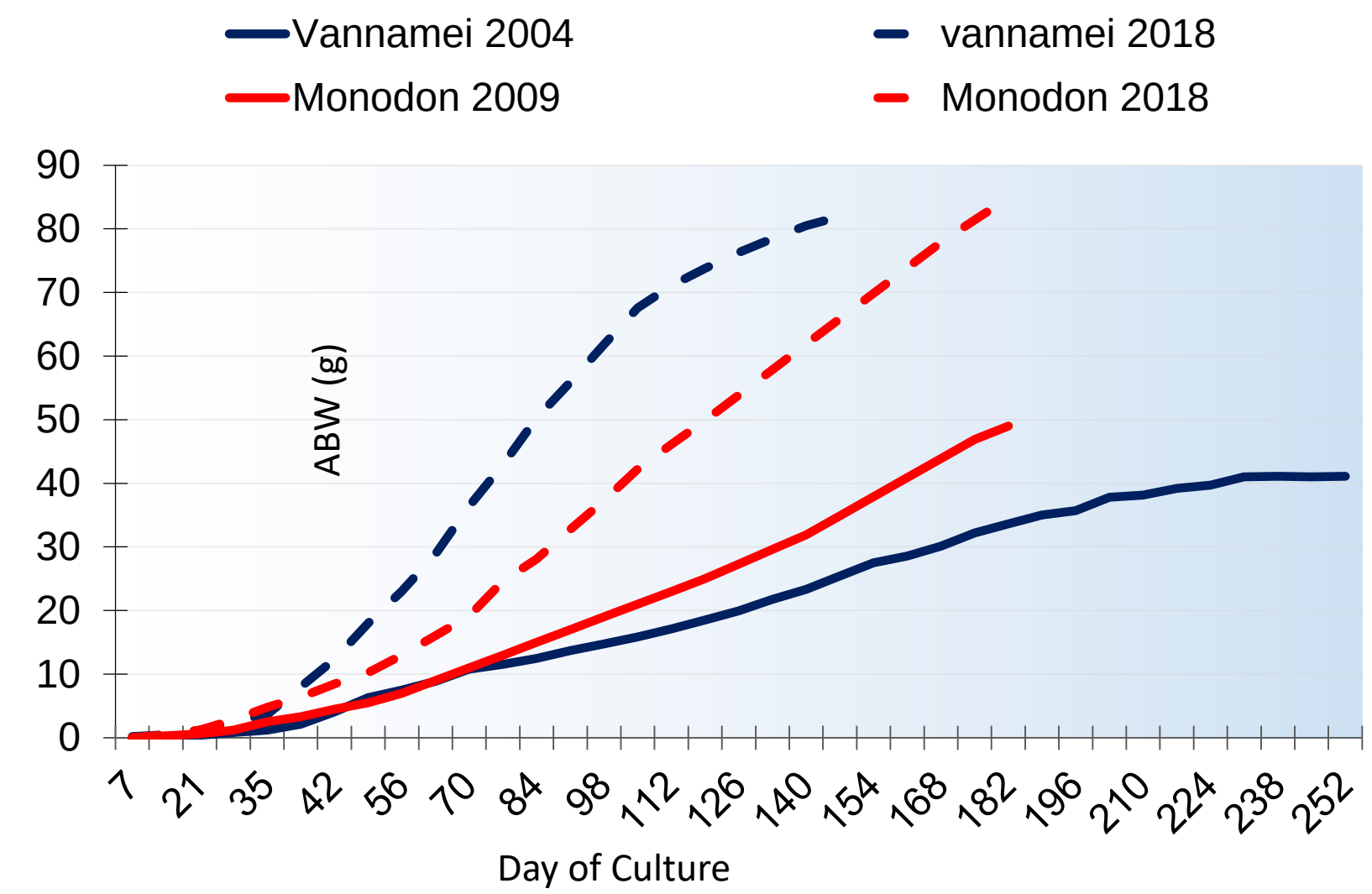


EMS> 80%



Changes in Turbo over the Years

Maximize Growth and Survival depends on the “E” in GxE.



GxE in Hatchery

Same larvae : grown in different conditions


CPF “Turbo” requires Pond Biosecurity, good pond Conditions
New Farm in Central America

Farmers do not buy Broodstock; Farmers buy Post Larvae

Modern hatchery is modularized:

Consistent operations and production

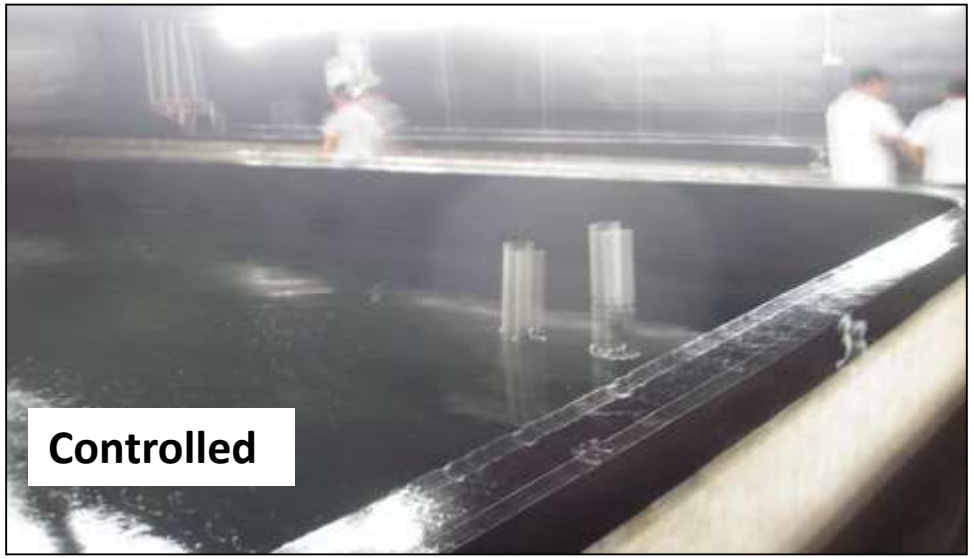
Disinfection of Water and Air become essential with todays environment





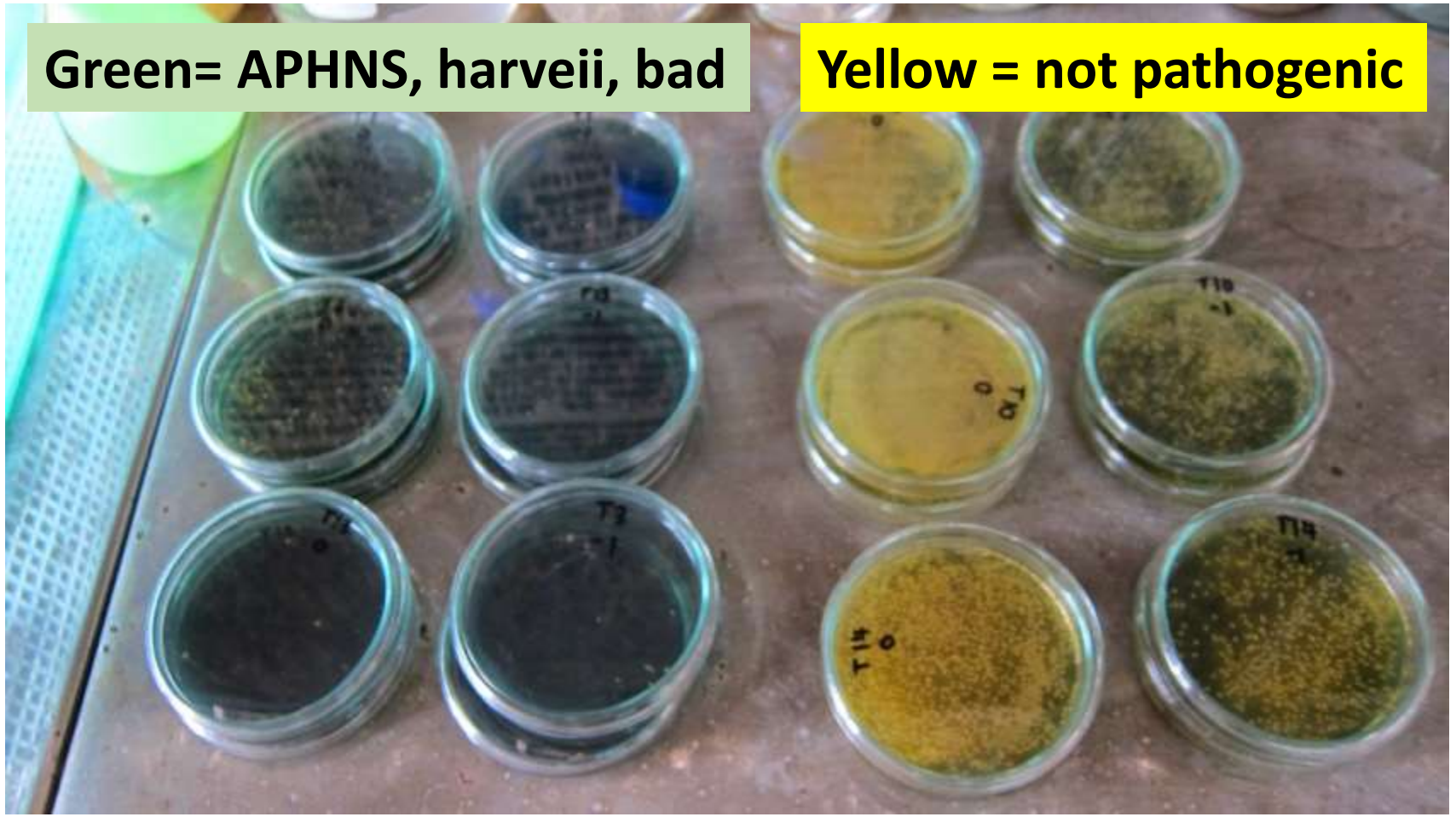
Today with the challenge of fungal and parasite spores; new cost effective technologies are required

Maturation Operations require pathogen free feeds



EFFICIENCY= 30-45 MILLION NAUPLII/1000 FEMALES/DAY

TCBS Monitoring is Good QC

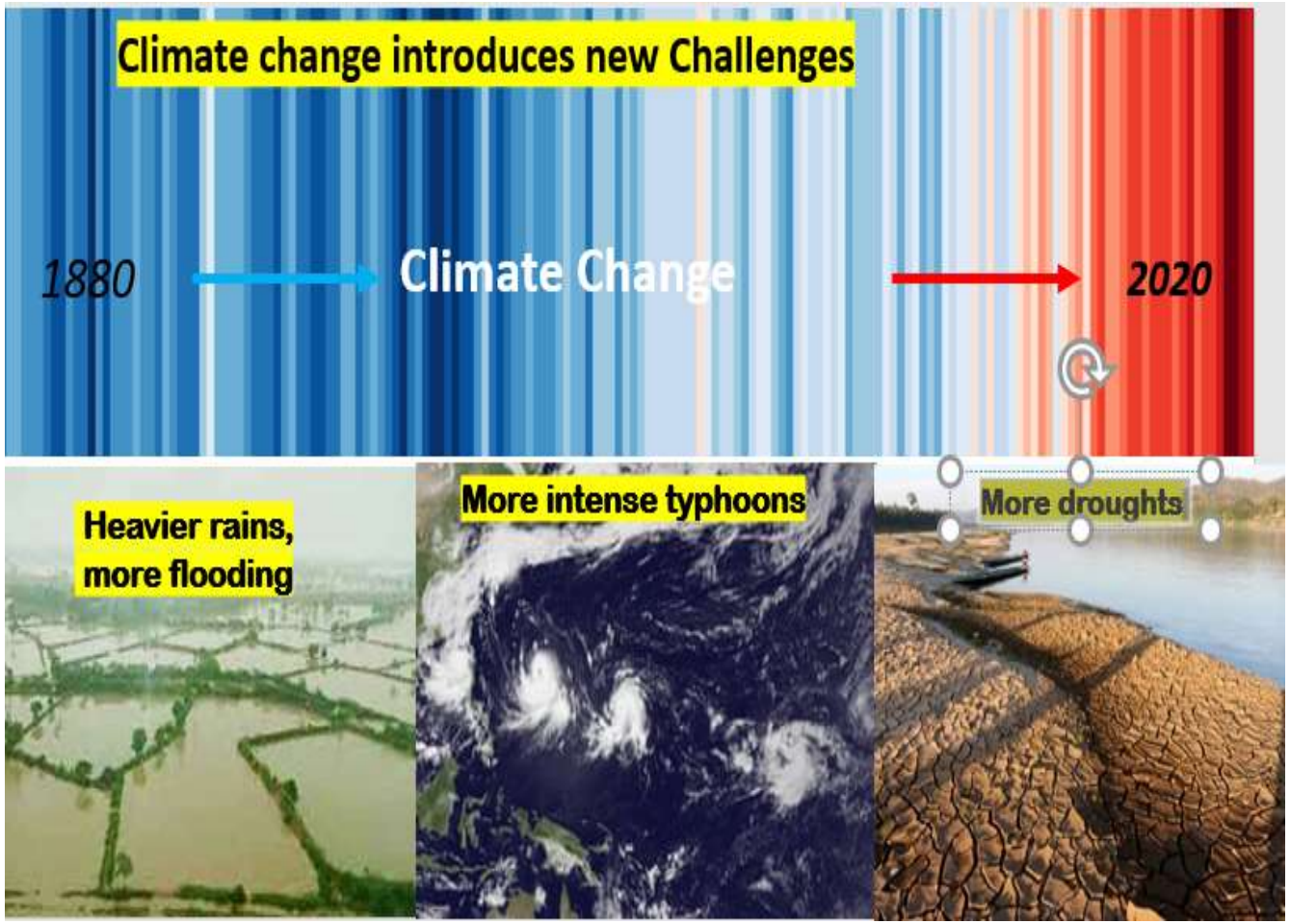


<10^3/gram pl

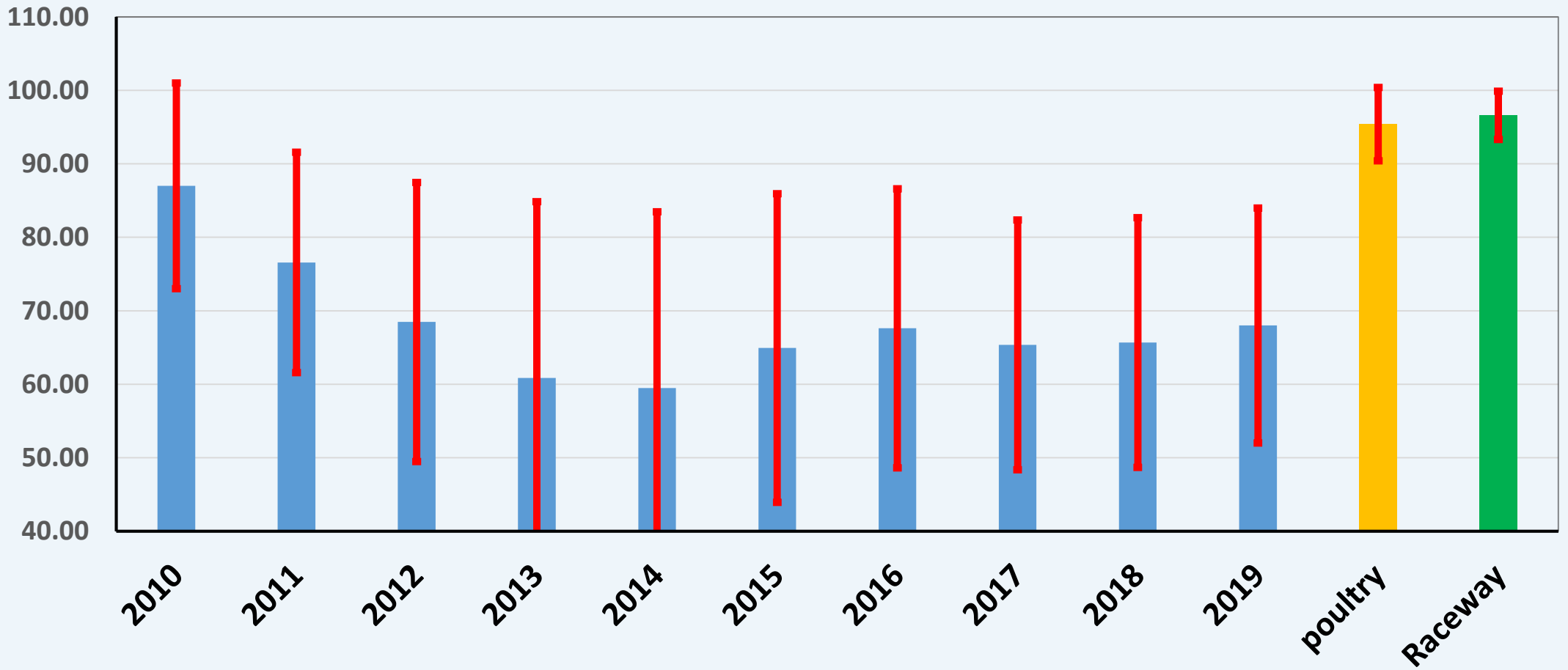
< 10^4/gram/pl

The FUTURE

- **Environmental and Climatic Change**
- **Increasing Prevalence of DISEASE**
- **Necessity for Efficiency**
- **Balance of Markets and Consumption**
- **New Technologies**



Survivals can be Improved:
Improving Immune and Culture systems

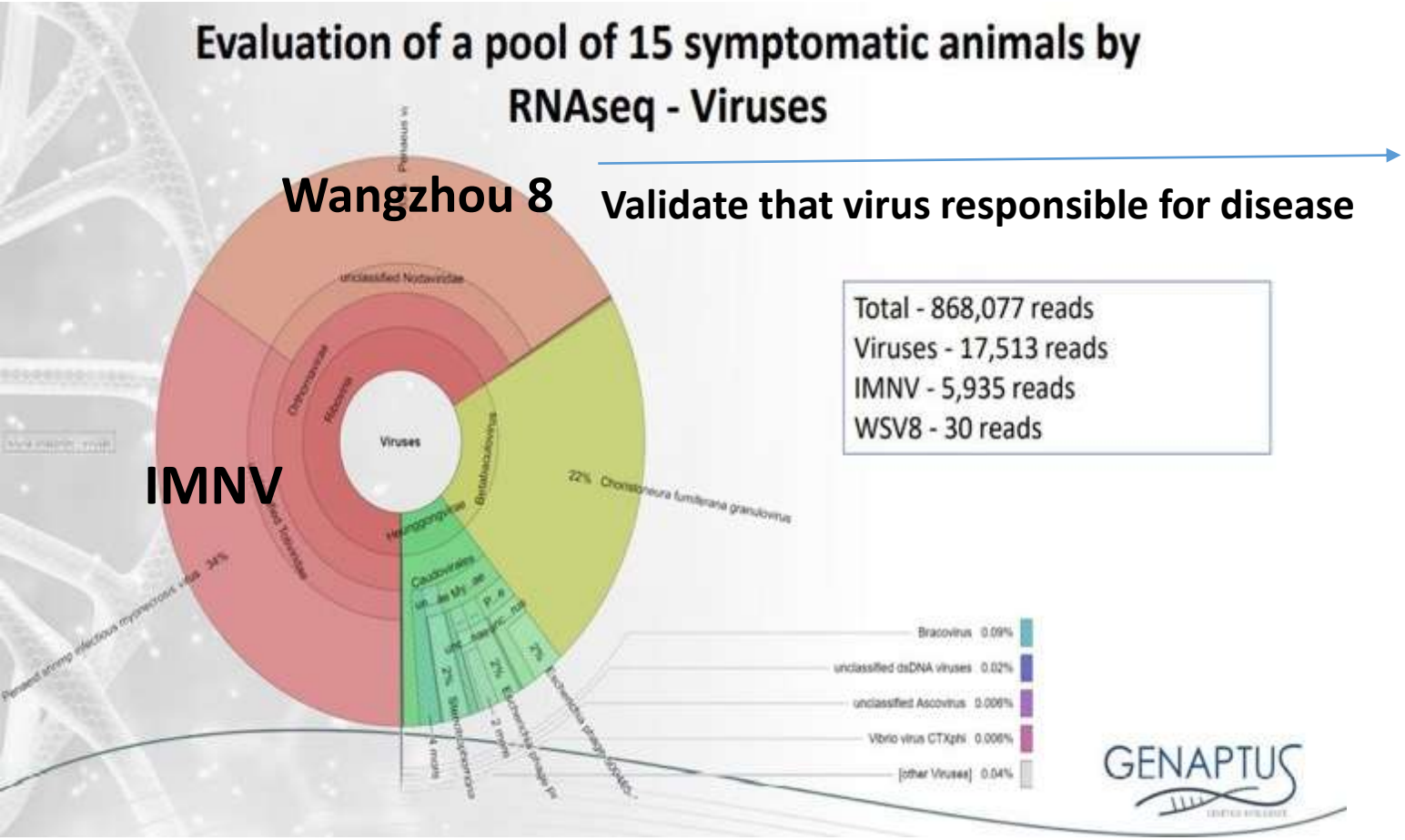


Increasing Environmental Stresses

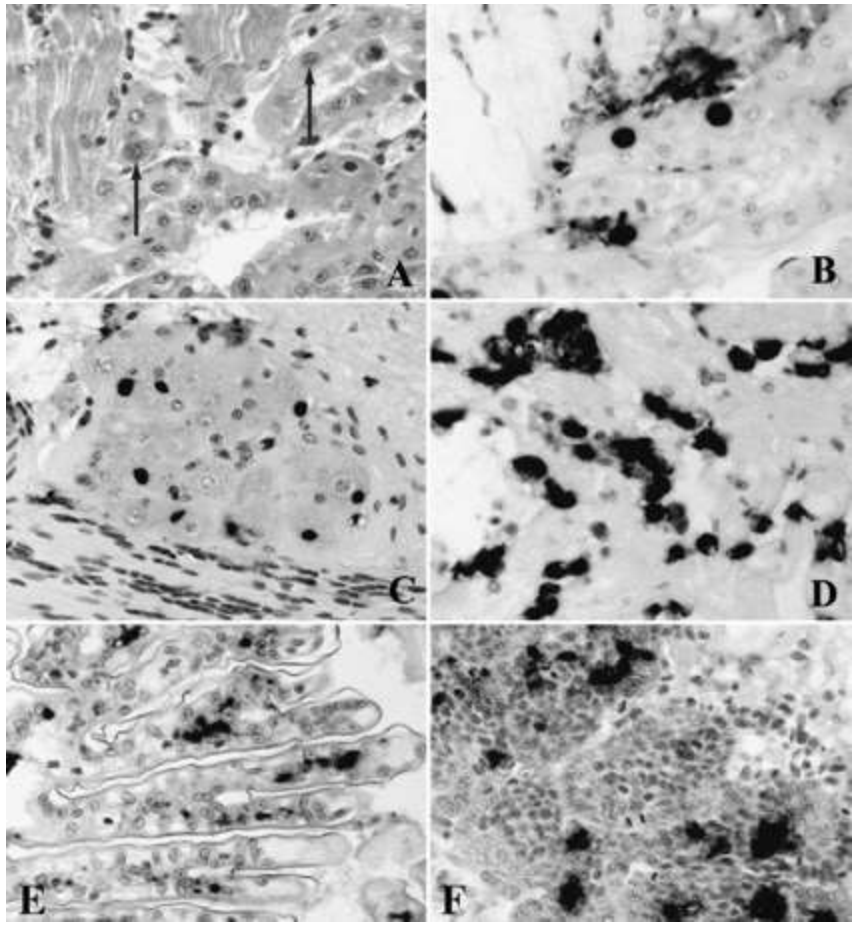
Trend to smaller, more intensive ponds for additional control (Vietnam, Thailand, China)

Metagenomics is changing the way we identify new emerging pathogens and define microbiology of "healthy environments"

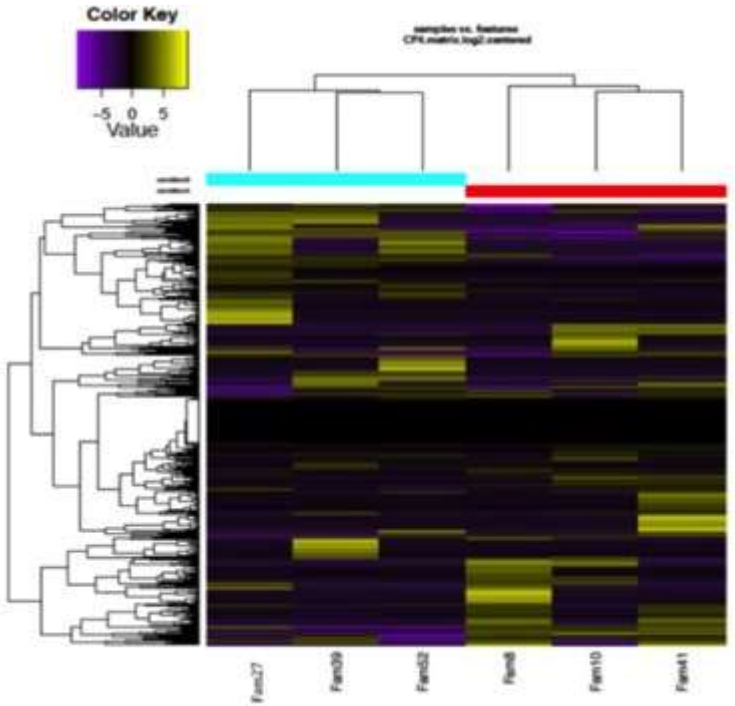
Metagenomic Taxonomy Blast

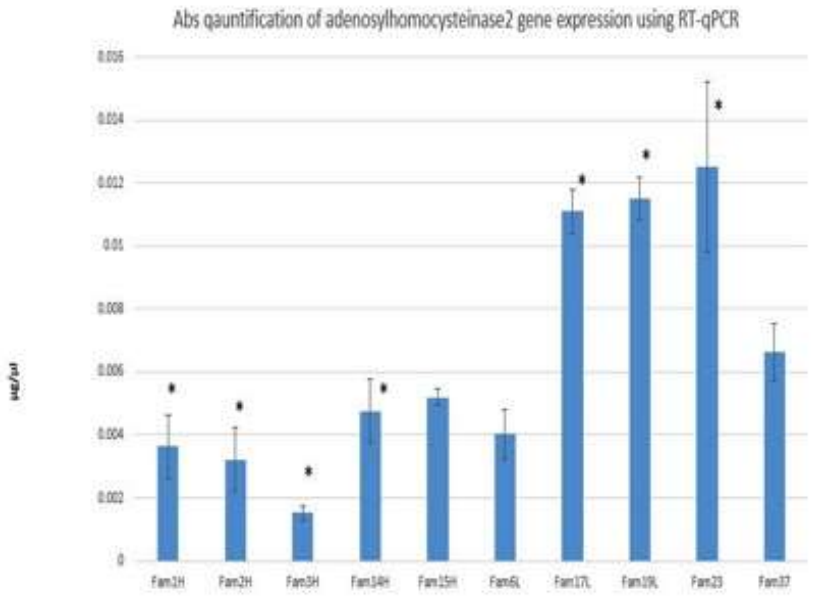


In-Situ Hybridization



Genomics will increase the speed and accuracy with which we apply genetics to low heritability traits (disease stress tolerance, and robustness)





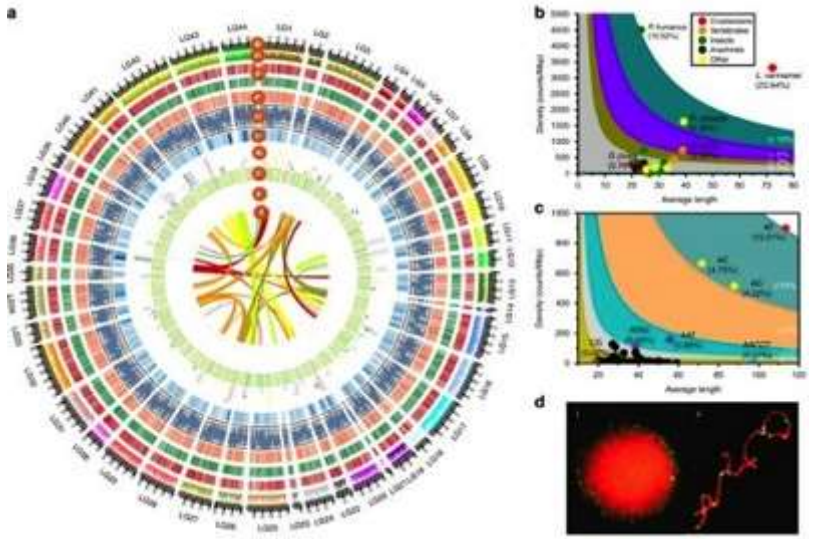
RNA seq data applied to APHND Tolerance expression

Dr. Anchalee Tassanakajon

Penaeid shrimp genome provides insights into benthic adaptation and frequent molting

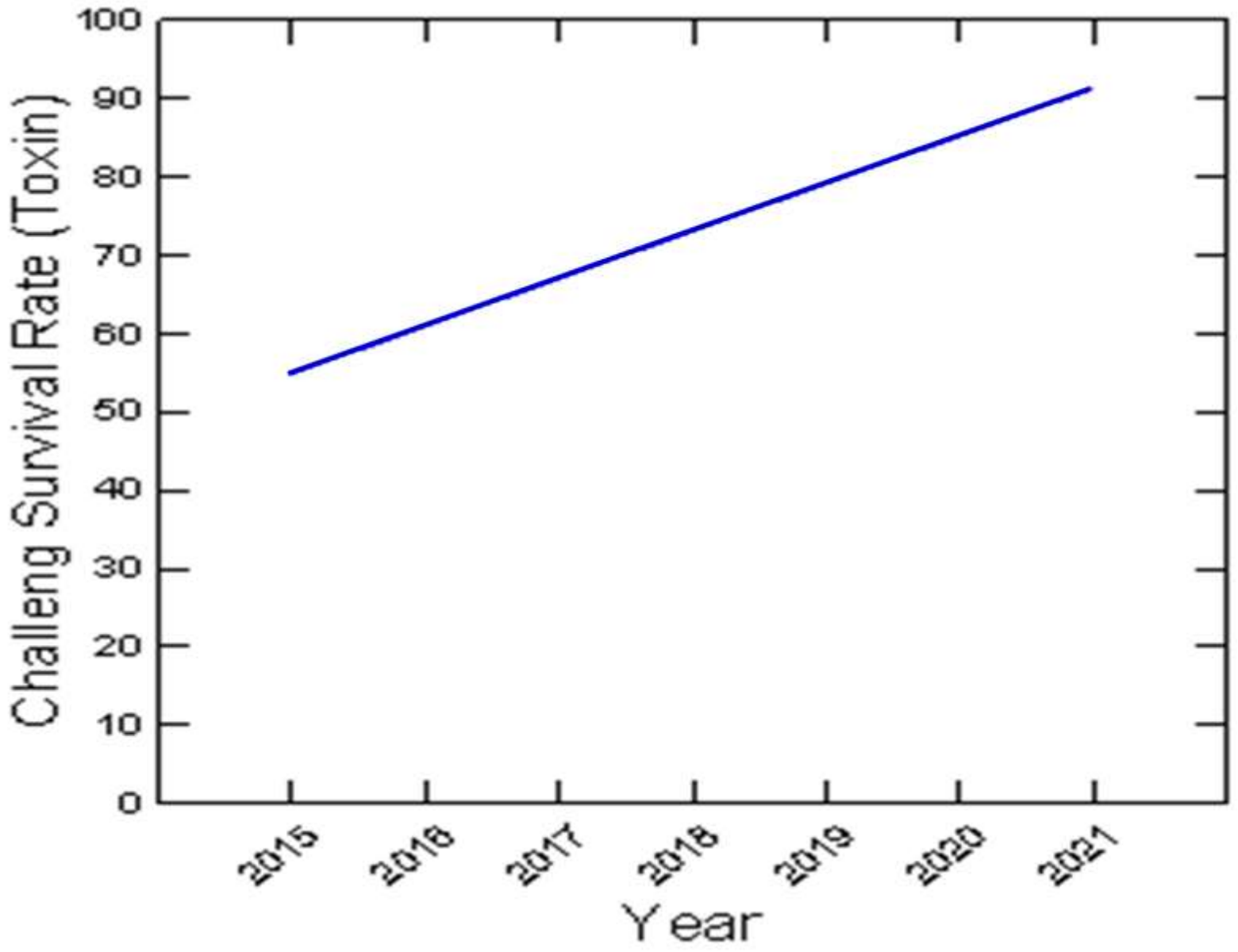
Xiaojun Zhang, Jianbo Yuan, [...] Jianhai Xiang

Jianhai Xiang



Genetic Epigenetic selection can increase survival (robustness) of shrimp under stress

Increased tolerance to APHNS toxins over generation of selective breeding in the presence of NO_2 stress

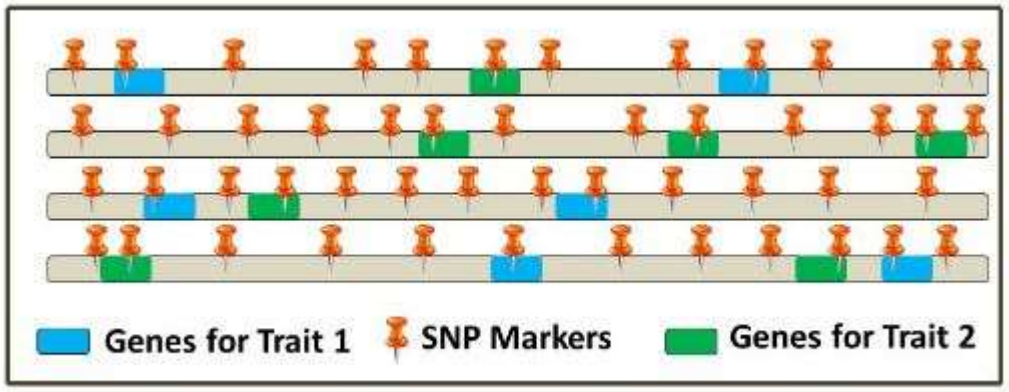


2022: Introducing CP KONG : more robust, wssv tolerence

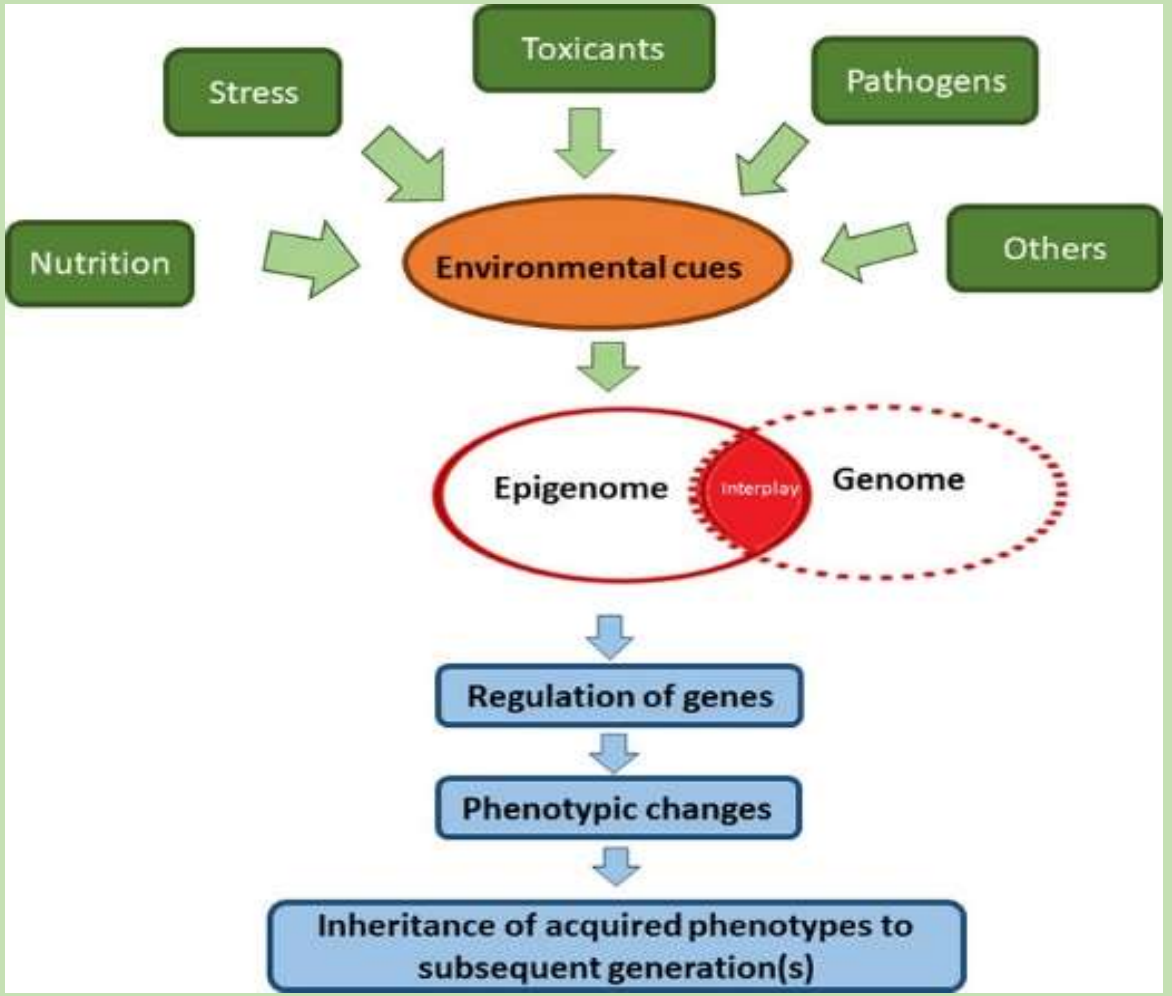
Increase robustness through selective

Genetics/ family and individuals

Classic challenge provides
Inputs to develop multi trait
SNP chips



Increase tolerance through manipulation of the genome (epigenetics)



C.P. KONG
WSSV tolerance with Greater Robustness

- **Growth Rate: 15 gms 0.17 (85)**
  30 gms 0.29 (105)

Requirements :

- **Less Biosecurity and Pond controls**
- **Oxygen> 5.0**
- **Best when stocked <40/m2**

Reminder: This is Healthy

Healthy Post Larvae

Survival > 60%

Healthy Shrimp

Survival > 85%

Holistic Approach for Success

Genetics

Feed

Seed

Management