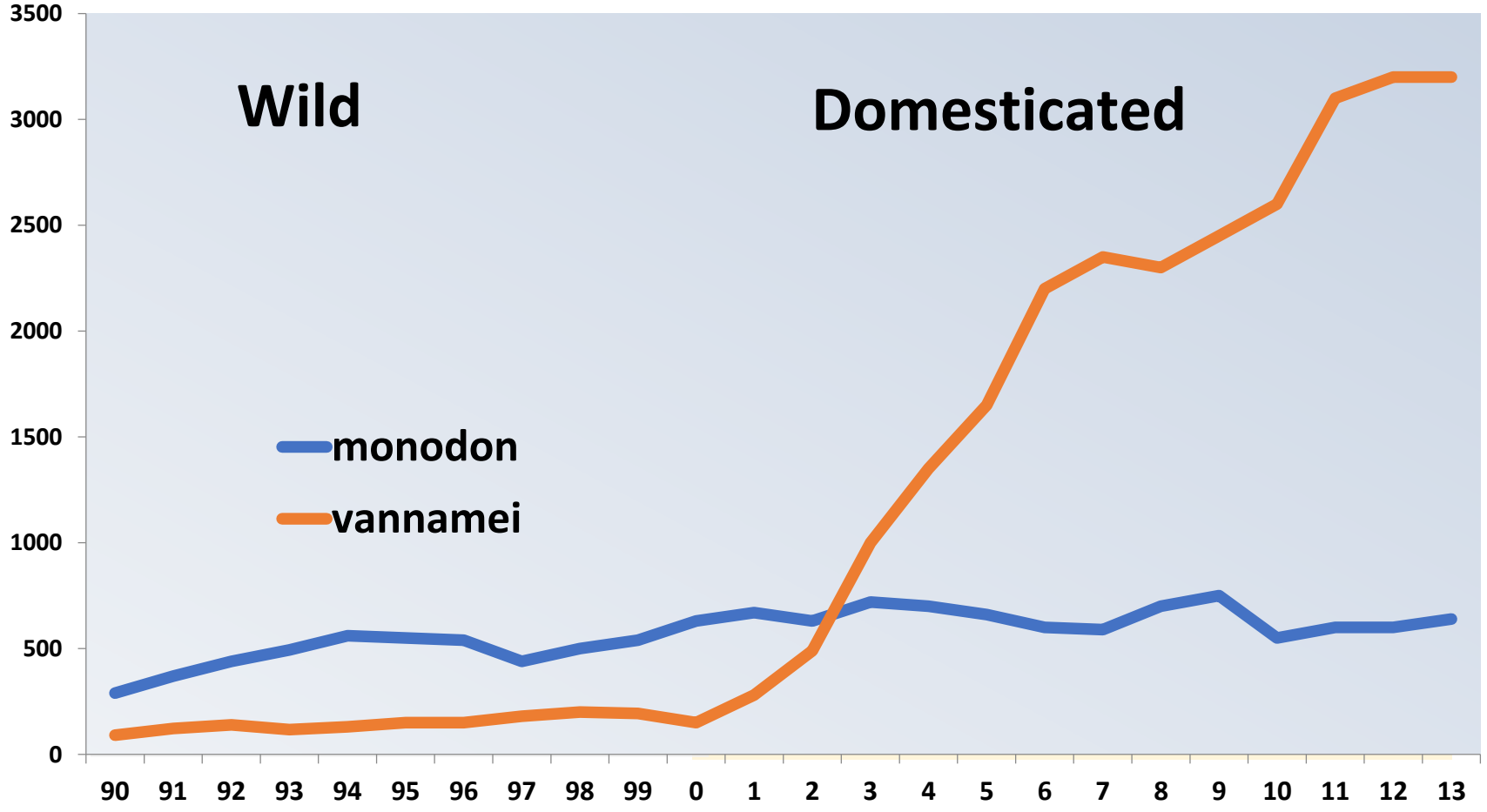
THE IMPORTANCE OF SHRIMP HEALTH AND BREEDING IN EVOLVING THE MODERN SHRIMP INDUSTRY

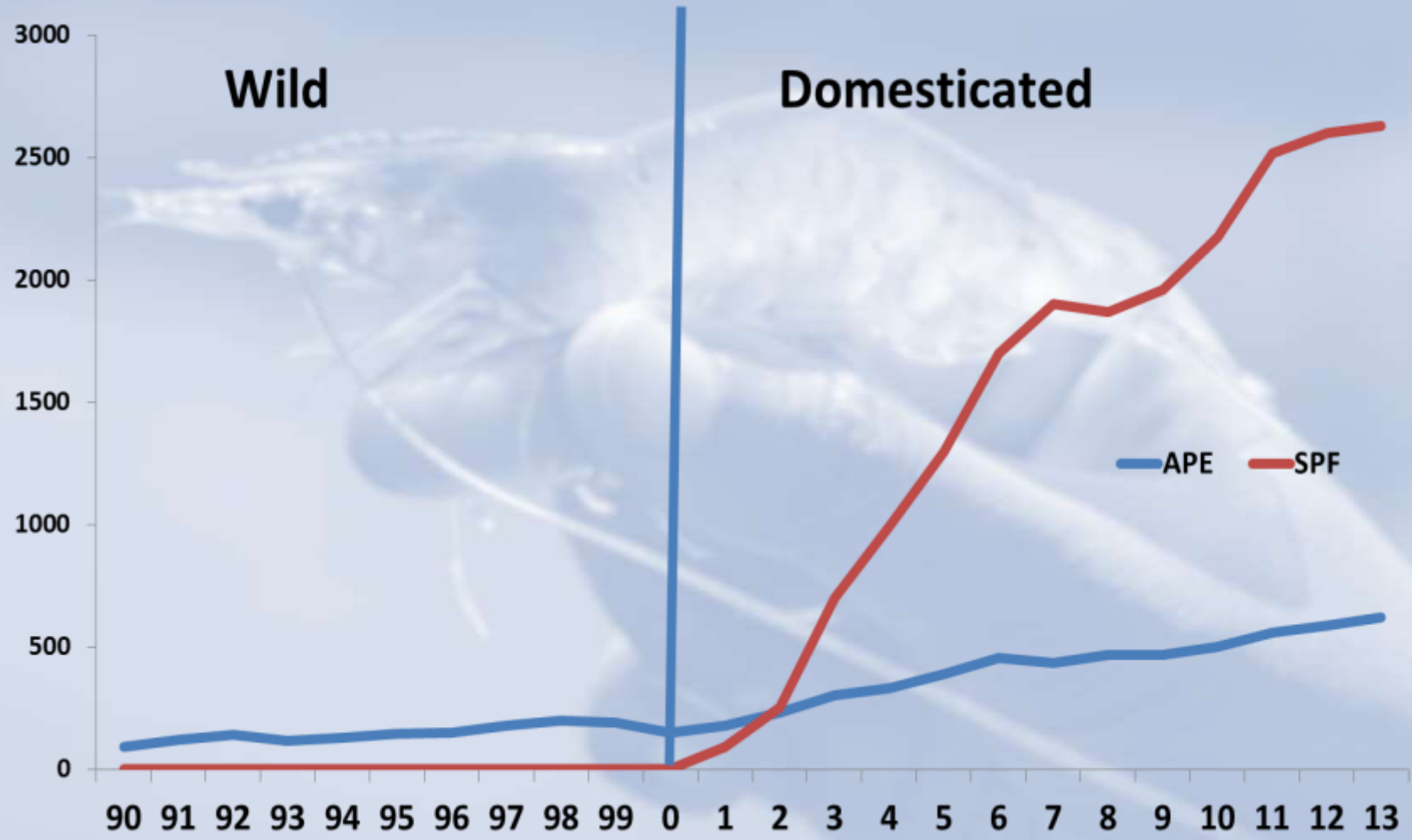
Robins McIntosh
Charoen Pokphand Foods
Bangkok Thailand

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



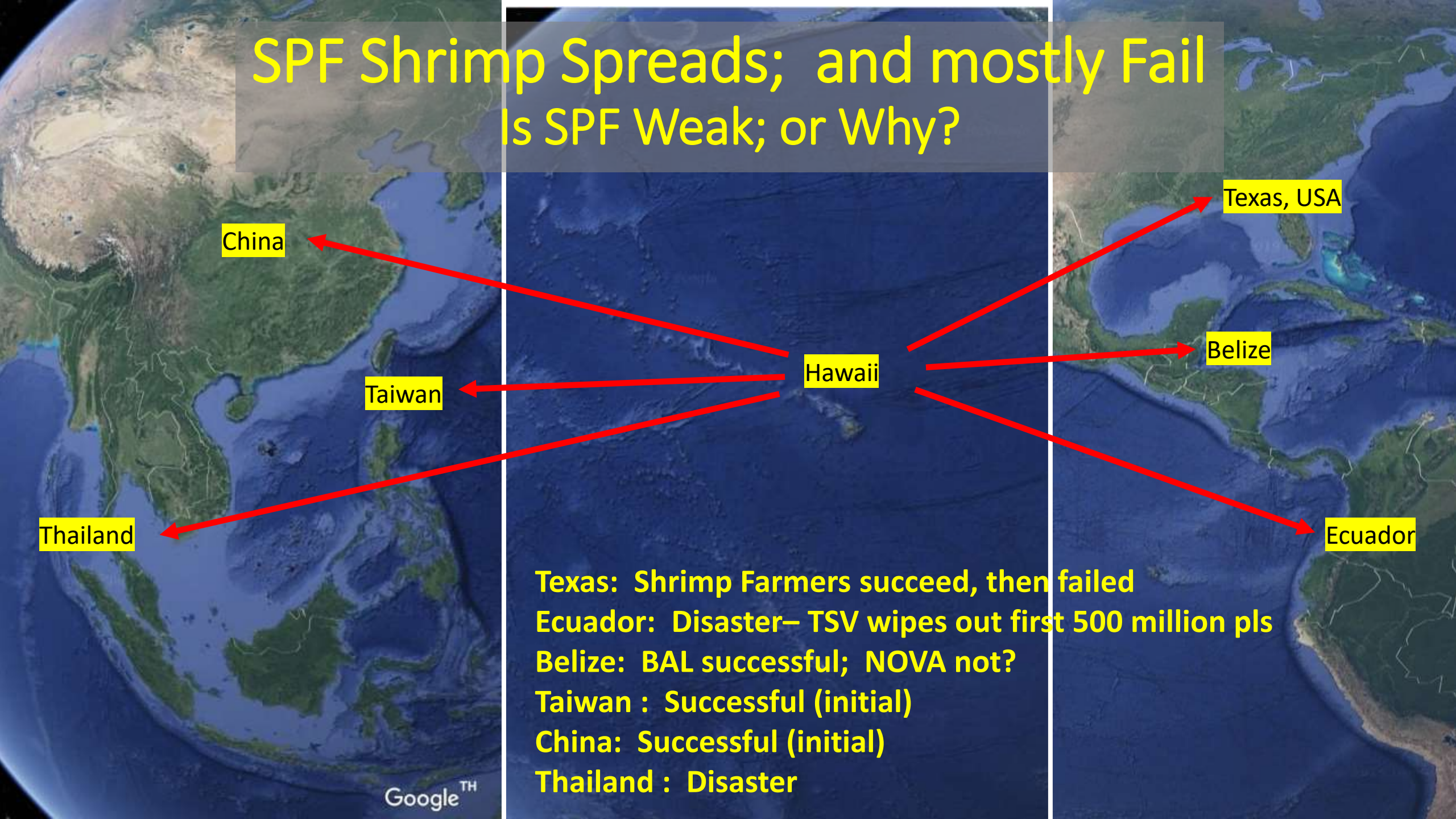
2000: The year where domestication became a dominant theme in Shrimp

And the most successful Domesticated Programs were SPF



SPF Shrimp Spreads; and mostly Fail

Is SPF Weak; or Why?



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

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

Biosecurity: Original SPF did not have viral Tolerance

Exclusion:
virus/microsporidea

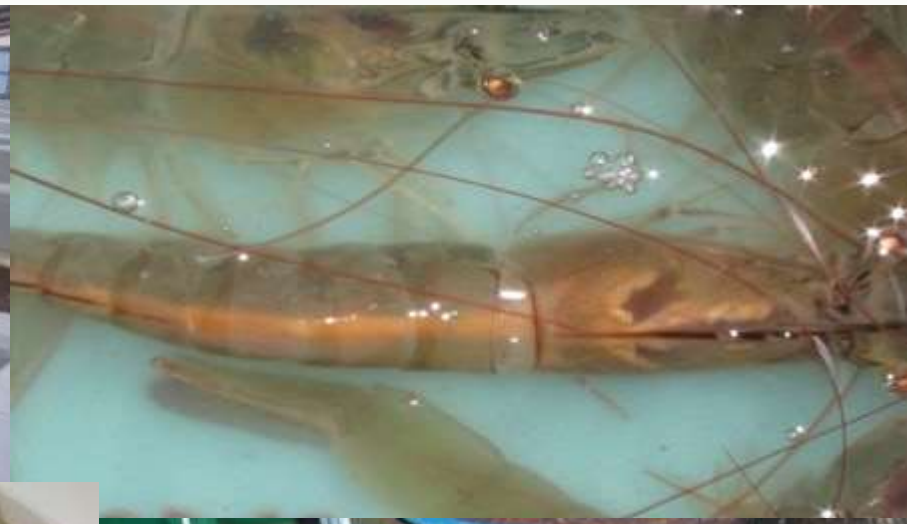
Limitation:
Bacteria/toxin

Shrimp Hatcheries had to be modernized to maintain disease free status

The Old

The New, Bio-secure, more efficient

Today Modernized Hatcheries: Modular, Sanitation Quality Control, Recycle, No Ablation, No Wild Feeds



Understanding SPF/SPR/SPT

Definition of SPF/SPR/SPT

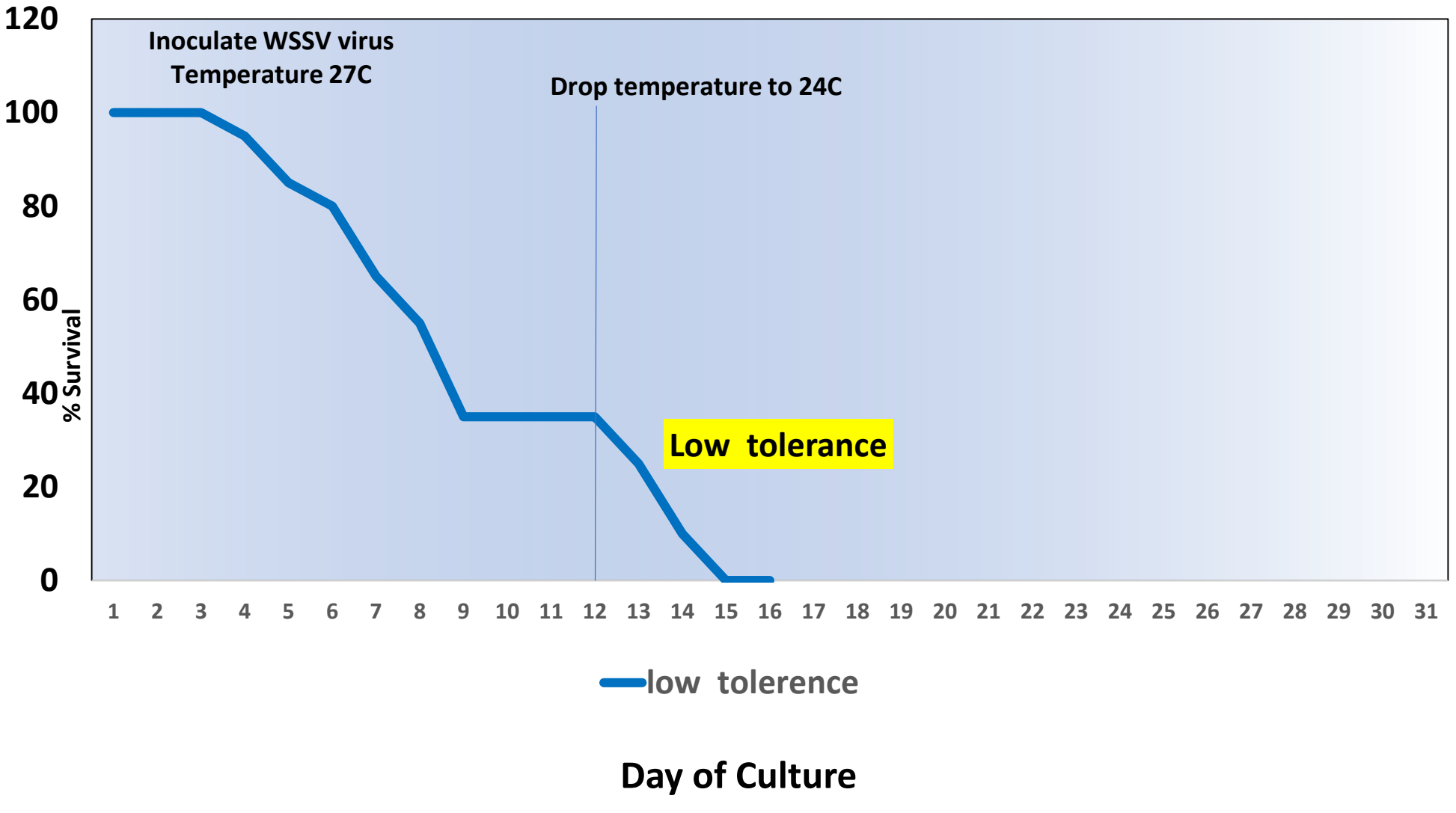
- **Specific Pathogen Free** Shrimp refers to the Health Status of a stock and not a genetic characteristic. To be SPF a shrimp should be free of all known shrimp virus (not only OIE listed pathogens).

- **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

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

Comparison of WSSV Tolerance and Resistance



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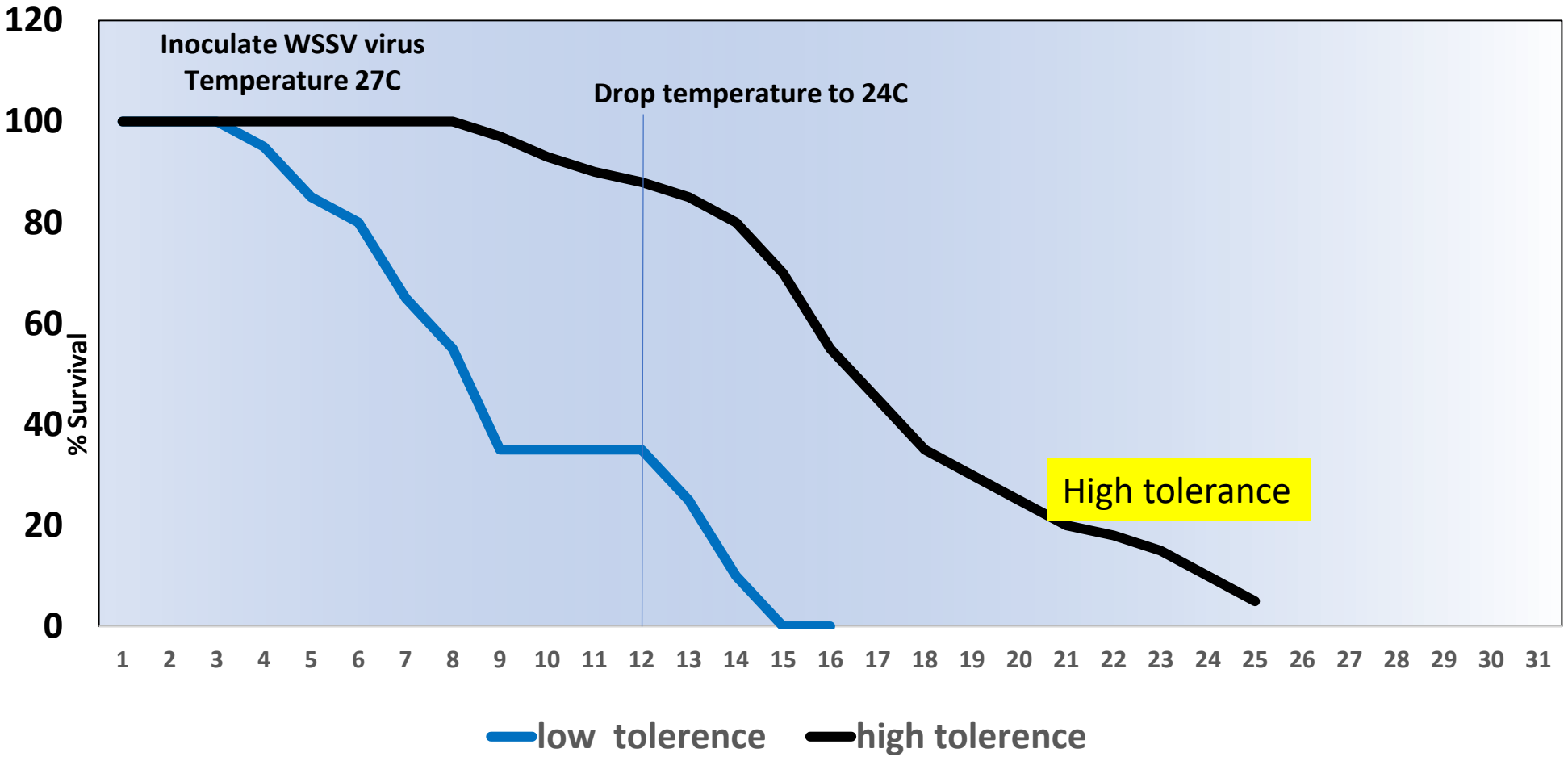

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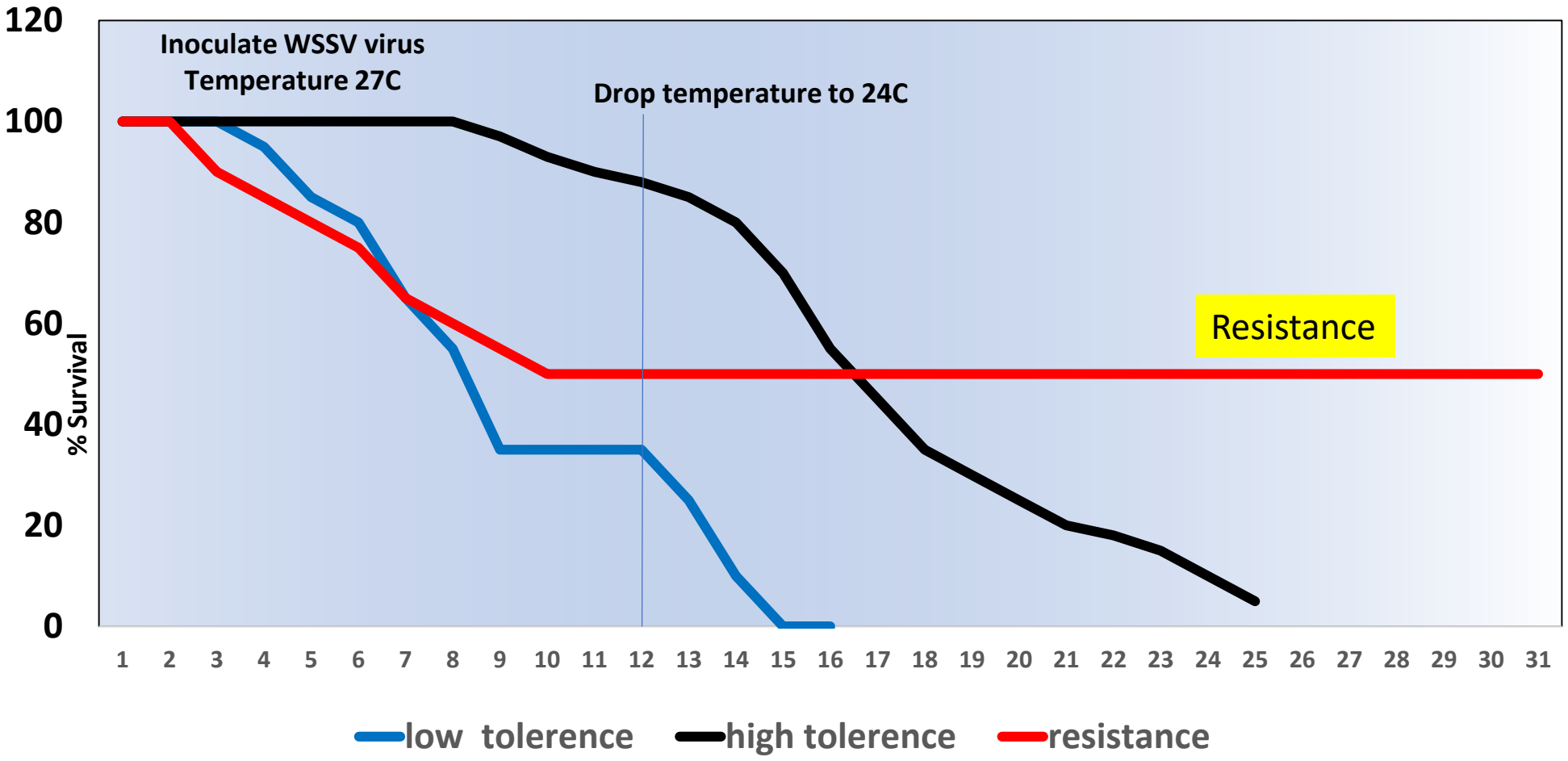
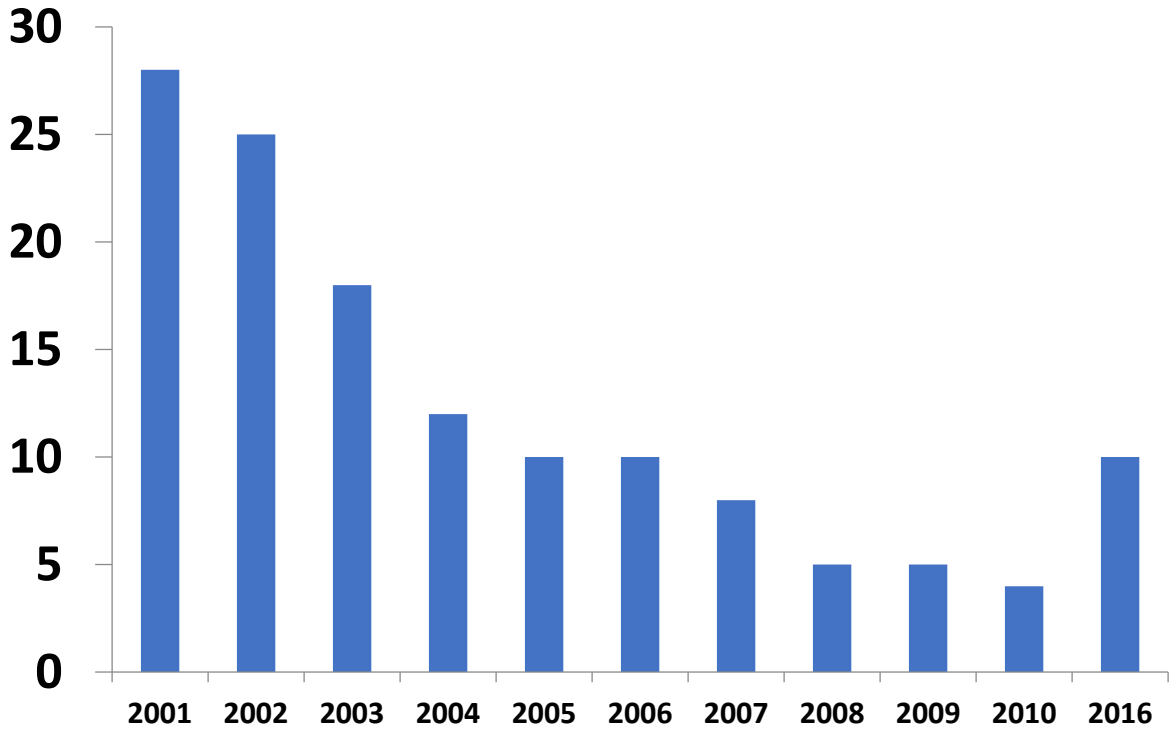


SPF was an essential tool in the success story of Asia

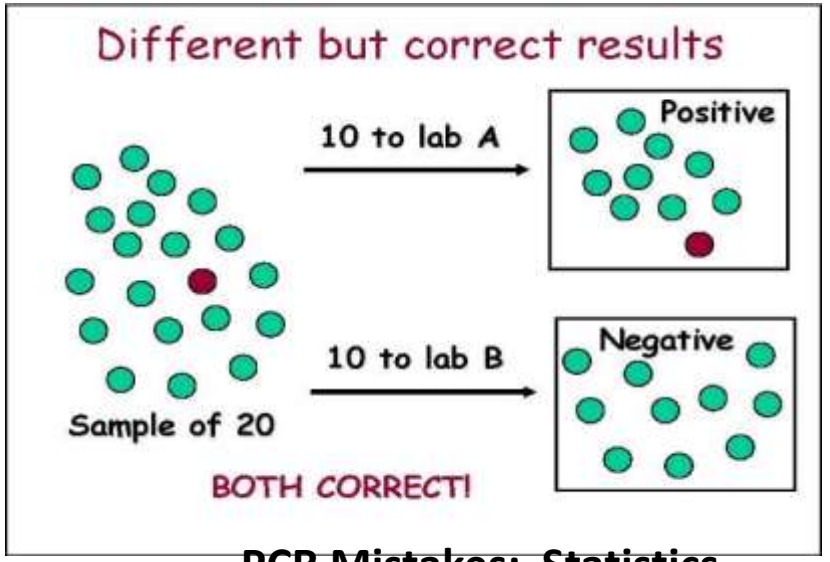
PCR and short-term quarantine cannot replace the SPF concept

Clean SPF shrimp reduced WSSV failure rate in Thailand



PCR makes mistakes

Results of "SPF by PCR testing":
Failure 2004 monodon



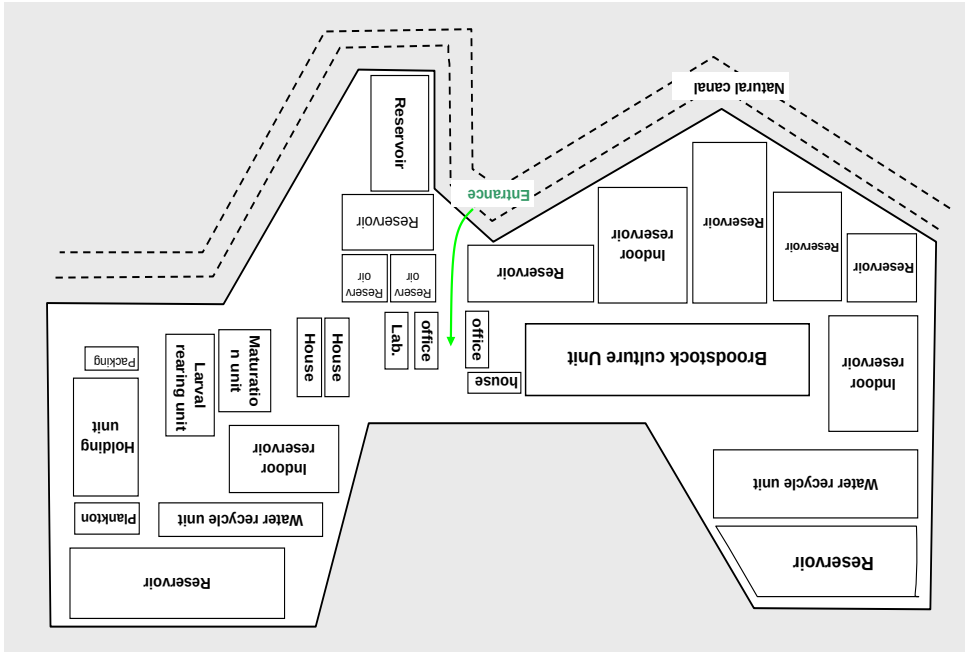
PCR Mistakes: Statistics

CPF decides on developing SPF Nucleus for SPF Vannamei and monodon in Thailand after successful introduction: 2002

CPF executives searching islands for nucleus breeding

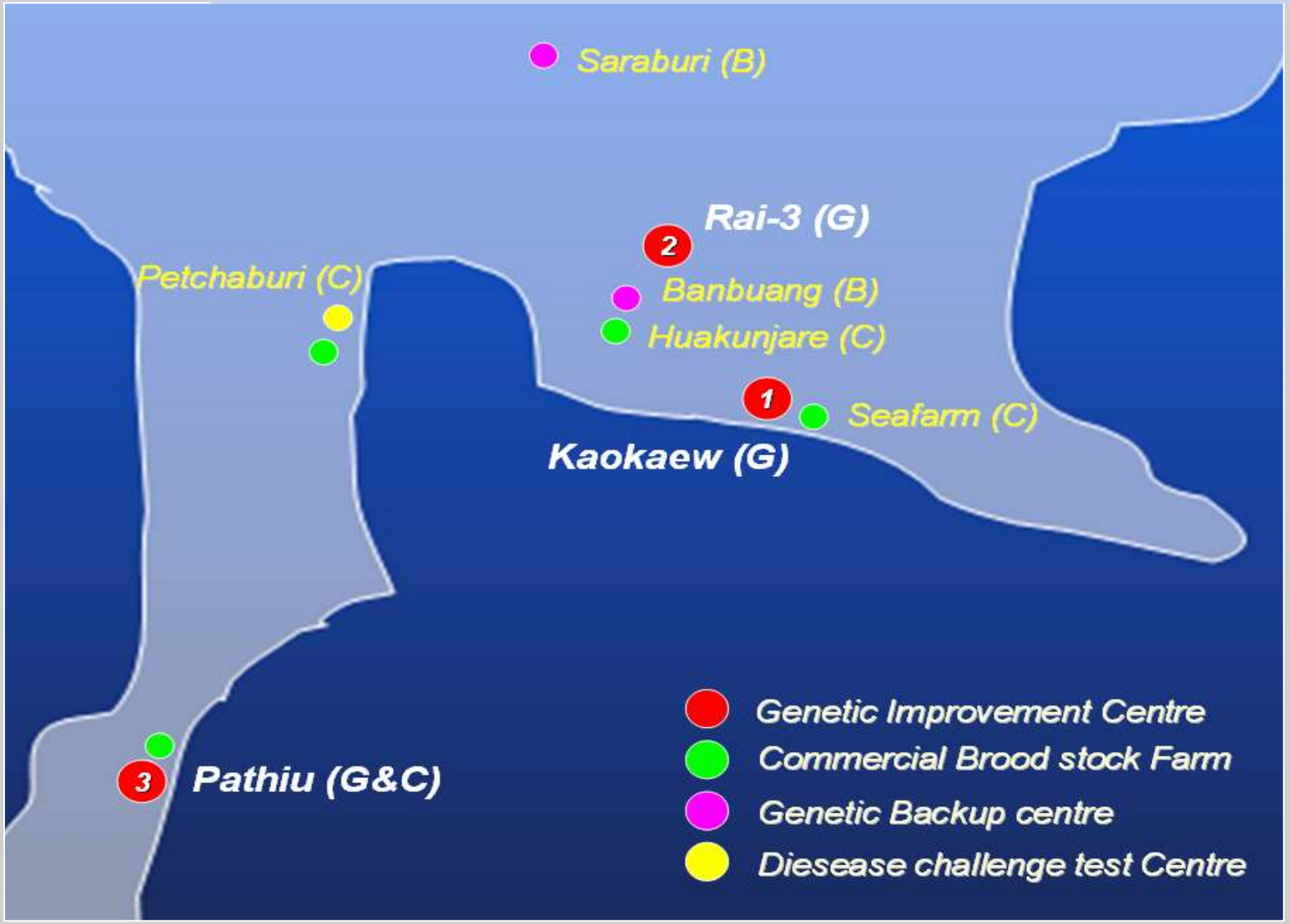
CPF Thailand develops first Nucleus Breeding Center 2003

Kao Kaew Nucleus Breeding Center



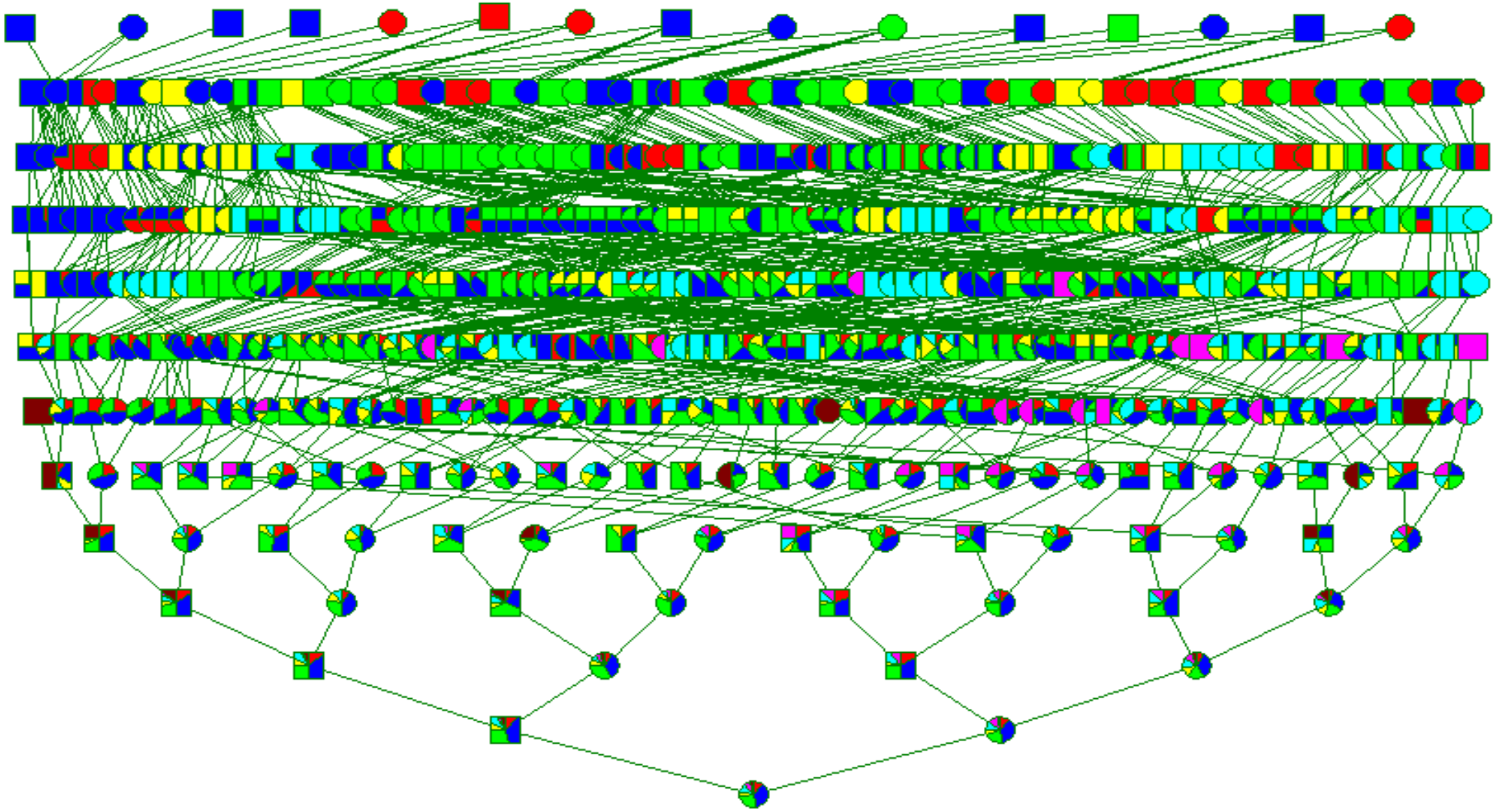
1. Strict Quarantine for Founders before entry
2. Nucleus Breeding Compartment; regular pathogen surveillance
3. List of pathogens being surveilled
4. Strictest of biosecurity;

CPF Marine Shrimp Broodstock Program Today:
Multiple facilities with Multiple functions



Vannamei and *Monodon* Program was initiated with highly variable collections of founding populations

CPF Pedigree: *Vannamei* Program A

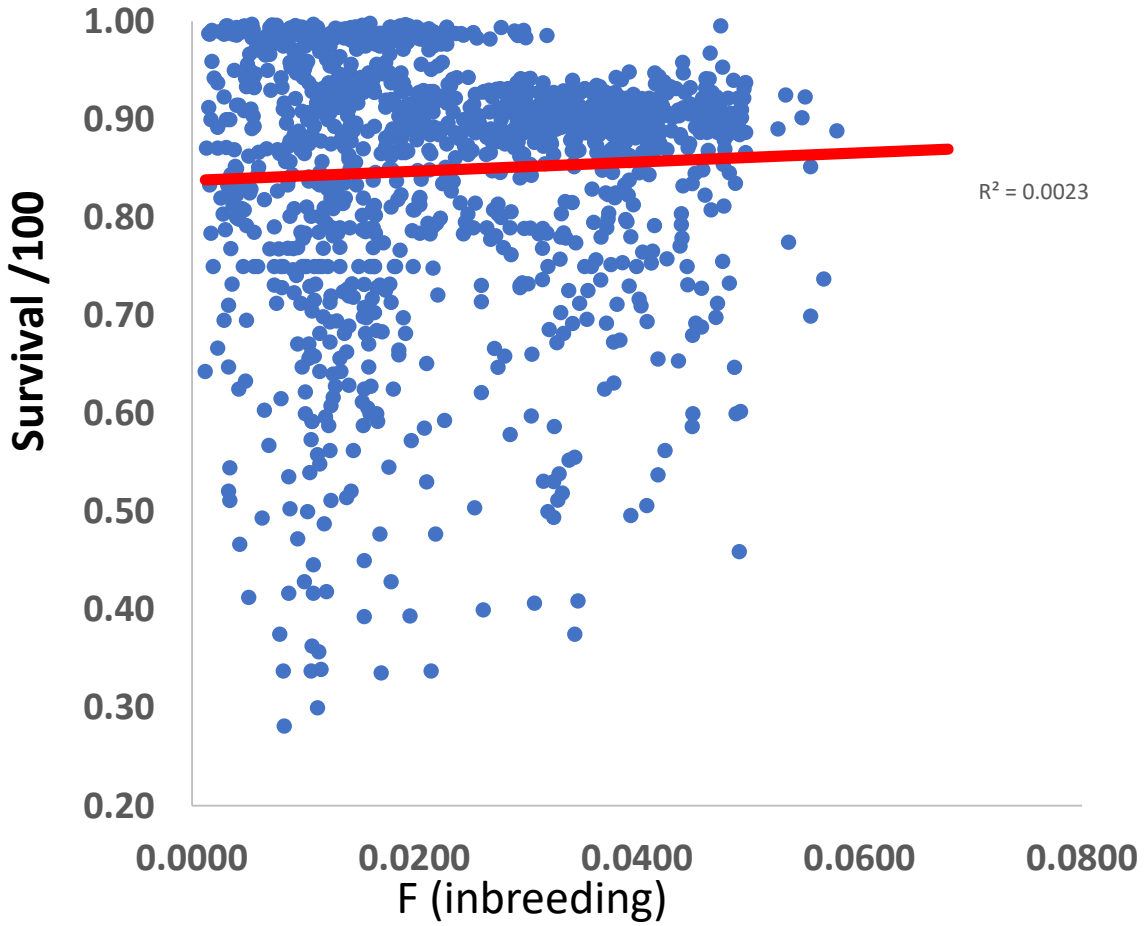


Selective genetics will result in “Inbreeding”

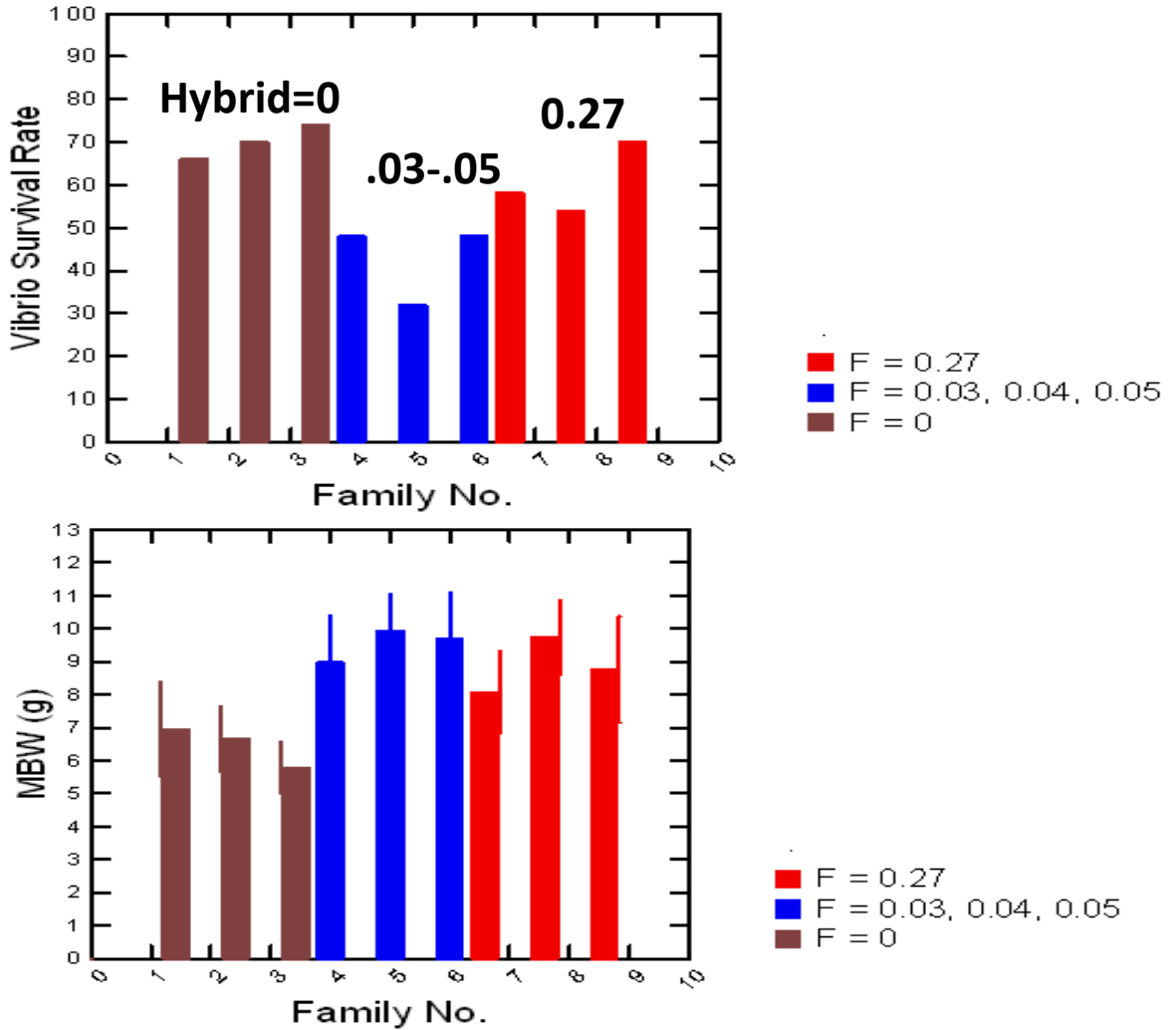
1)How significant is inbreeding effects in shrimp

2) What is a “maximum inbreeding level

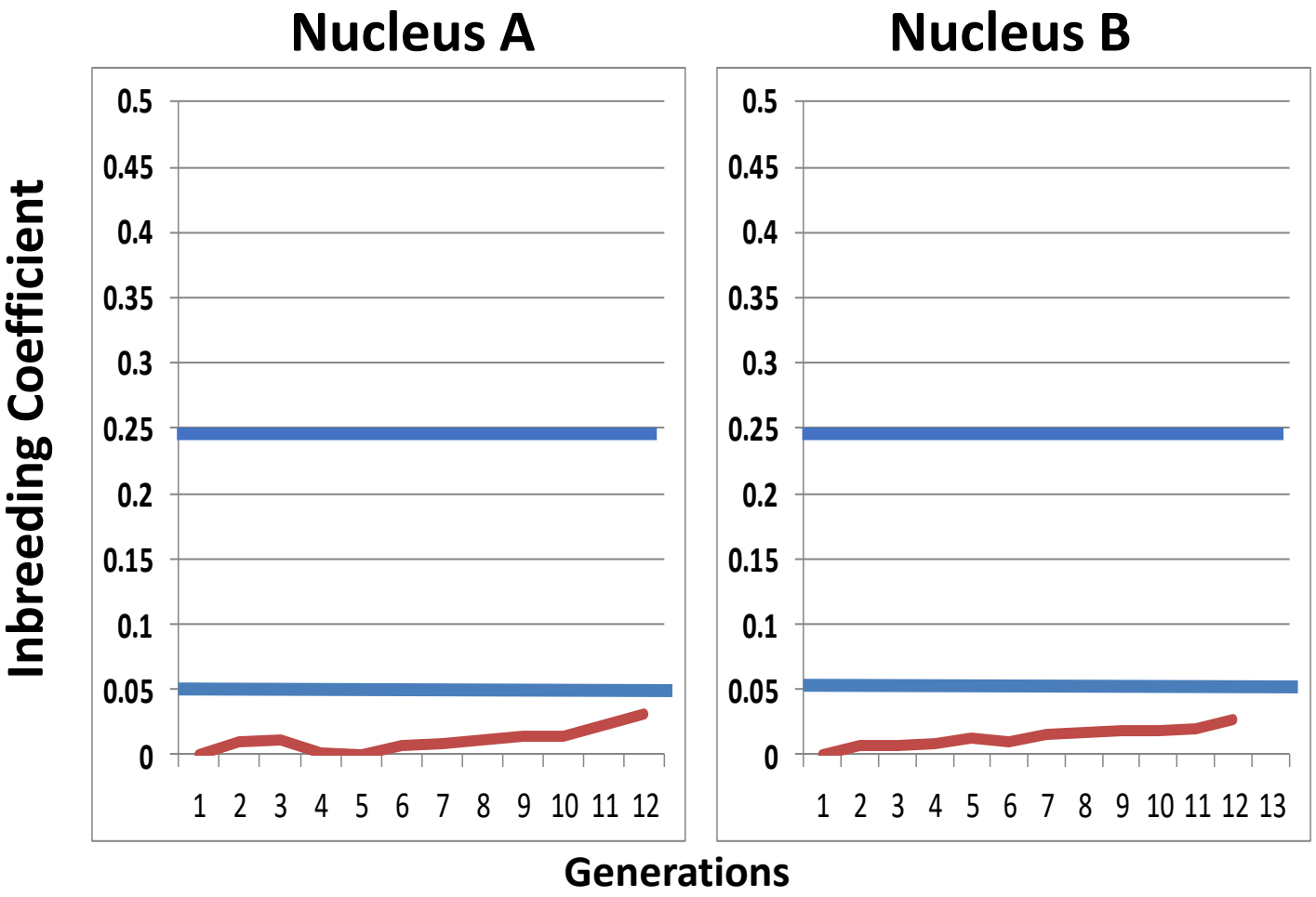
Larval rearing nauplii-pl12



Inbreeding effect on disease challenge and growth



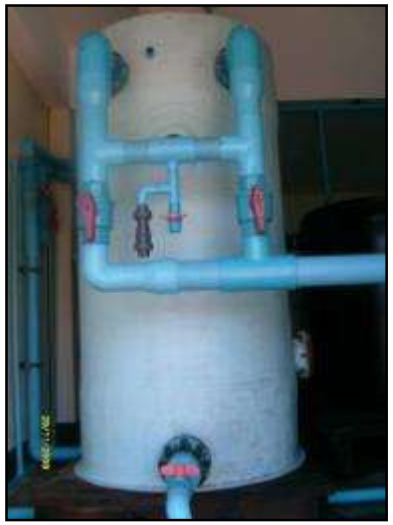
Three independent breeding programs for *Vannamei*
Three nucleus breeding sites



CP Breeds to Maximize Diversity- requires a large breeding populations
CPF maintains over 3000 families/year

Inland and Completely Closed Systems

Completely Closed RAS Maturation



Broodstock tanks

Recycle

No Fresh Feeds

Totally Closed : Phytoplankton

Larval Rearing : Individual Tanks for Family Development

Totally Enclosed: Growout of Broodstock
Zero Water exchange

SPF Broodstock Multiplication Centers (same biosecurity level as a Nucleus)

Continuous Surveillance of Nucleus and Multiplication Centers

MSBC-SPF

Disease Monitor (PCR)

update 31 may 2017

Year	No. of Sample												All Disease	
	WSSV	IHHNV	MBV	HPV	TSV	YHV/GAV	EHP	IMNV	LSNV	NHPB	MoV	AHPNS	No. of Samp.	% Negative
2008	695	695	352	352	1119	612							3825	100%
2009	234	234	234	234	234	234							1404	100%
2010	500	530	386	417	530	588							2951	100%
2011	478	478	369	369	466	466	273						2899	100%
2012	496	496	452	452	486	486	1229	23	23	23	23		4189	100%
2013	550	540	402	402	540	550	548	121	135	135	135	70	4128	100%
2014	602	602	547	547	580	580	550	192	192	192	200	650	5434	100%
2015	774	774	581	581	723	723	982	117	117	117	117	1280	6886	100%
2016	546	546	439	439	524	524	536	122	122	122	122	905	4947	100%
2017	525	525	337	337	507	507	611	142	142	142	142	639	4556	100%
Total	5,400	5,420	4,099	4,130	5,709	5,270	4,729	717	731	731	739	3,544	41,219	

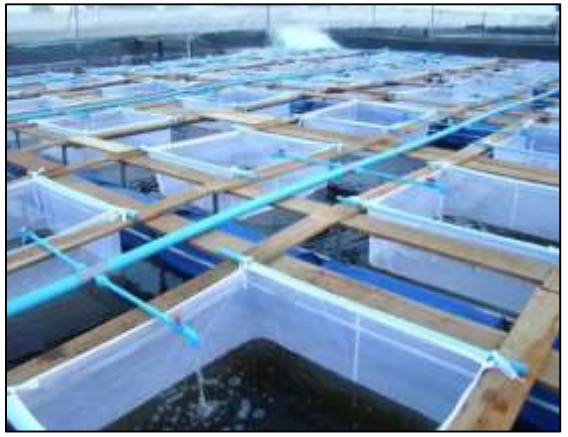
5000 tests per year x 4 sites= 20,000 PCR tests/year

No Green TCBS colonies

Shrimp Disease Challenge center

Purpose: to create challenge testing for trait development; on both a family and individual level

600 challenge tests/month (3x replication)



SPF is best platform for Phenotype selection

Successful Selection Phenotype depends on Heritability and control of E (Environment)

Both Family (weak) and Individual (strong)

G x E

To select phenotypes effectively need to maintain the same Environment

And SPF has a nearly constant internal environment

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	+++		++	++++	++++	+

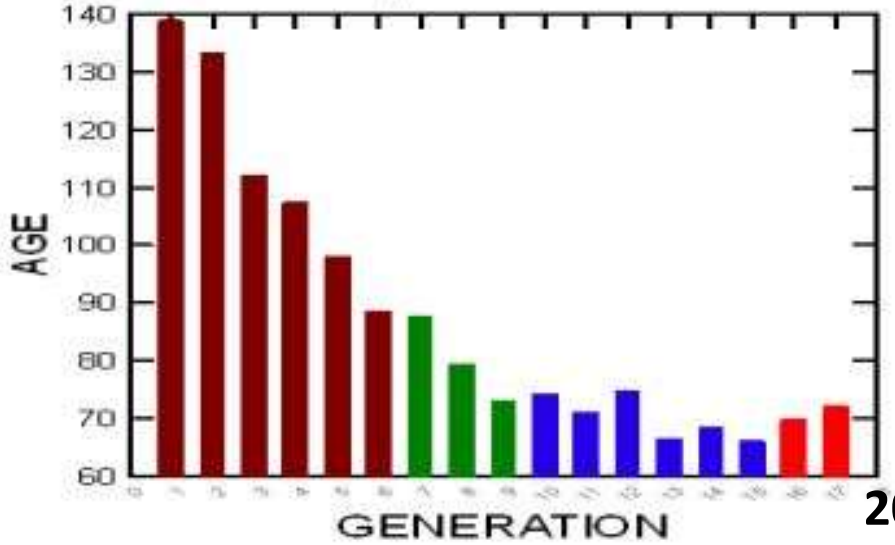
Turbo Pl was Born: 2008

"DEAD SHRIMP NEVER GROW FAST"

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

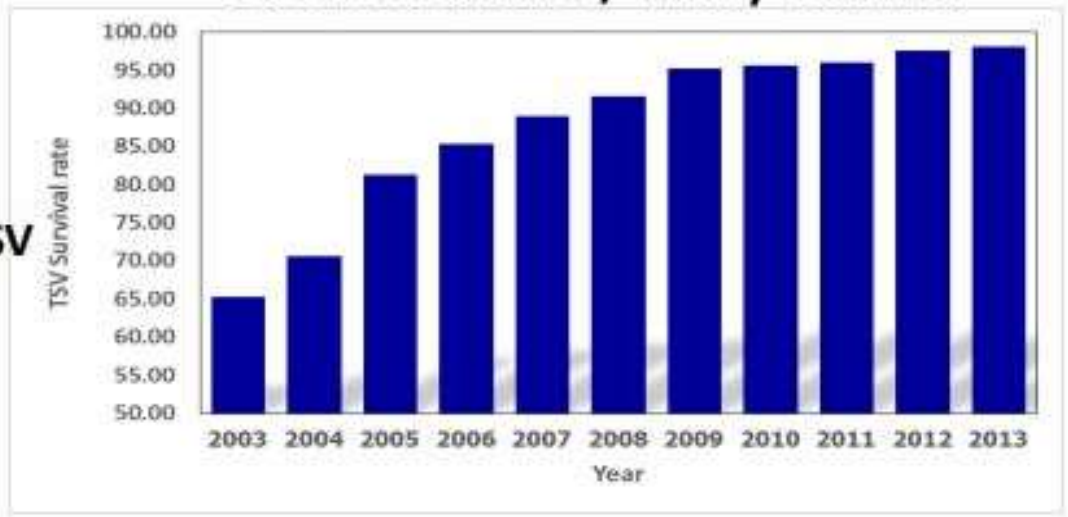
(all data from CPF *vannamei* Program/Hawaiian Concept)

Growth Rates/ Individual Selection

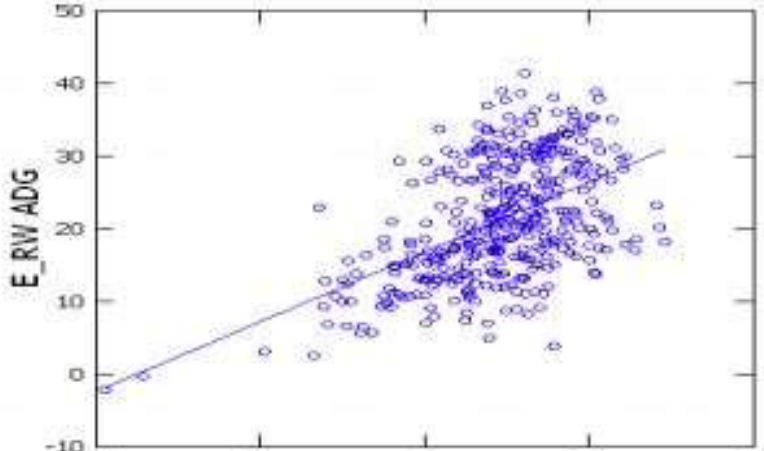


20 gen

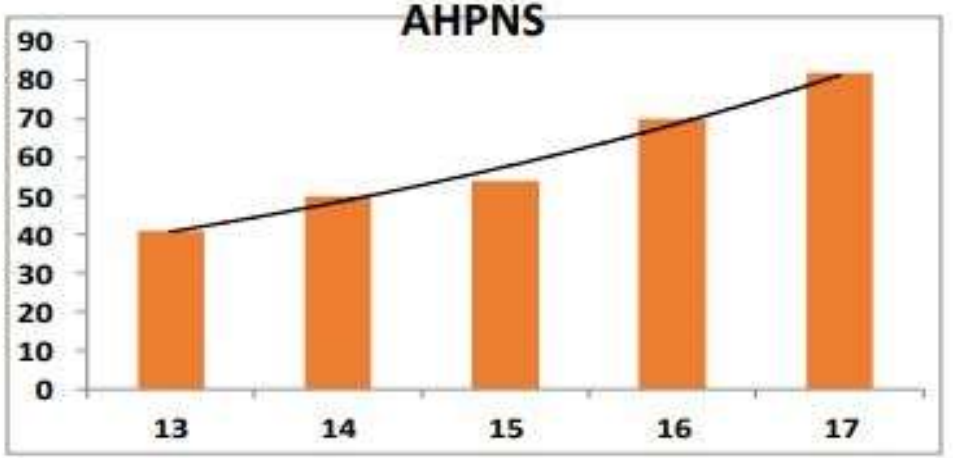
Disease Tolerance/ Family Selection



No negative correlation; growth and tolerance



AHPNS



Turbo (SPF-fast growth) cited as cause of EMS (AHPNS)?

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

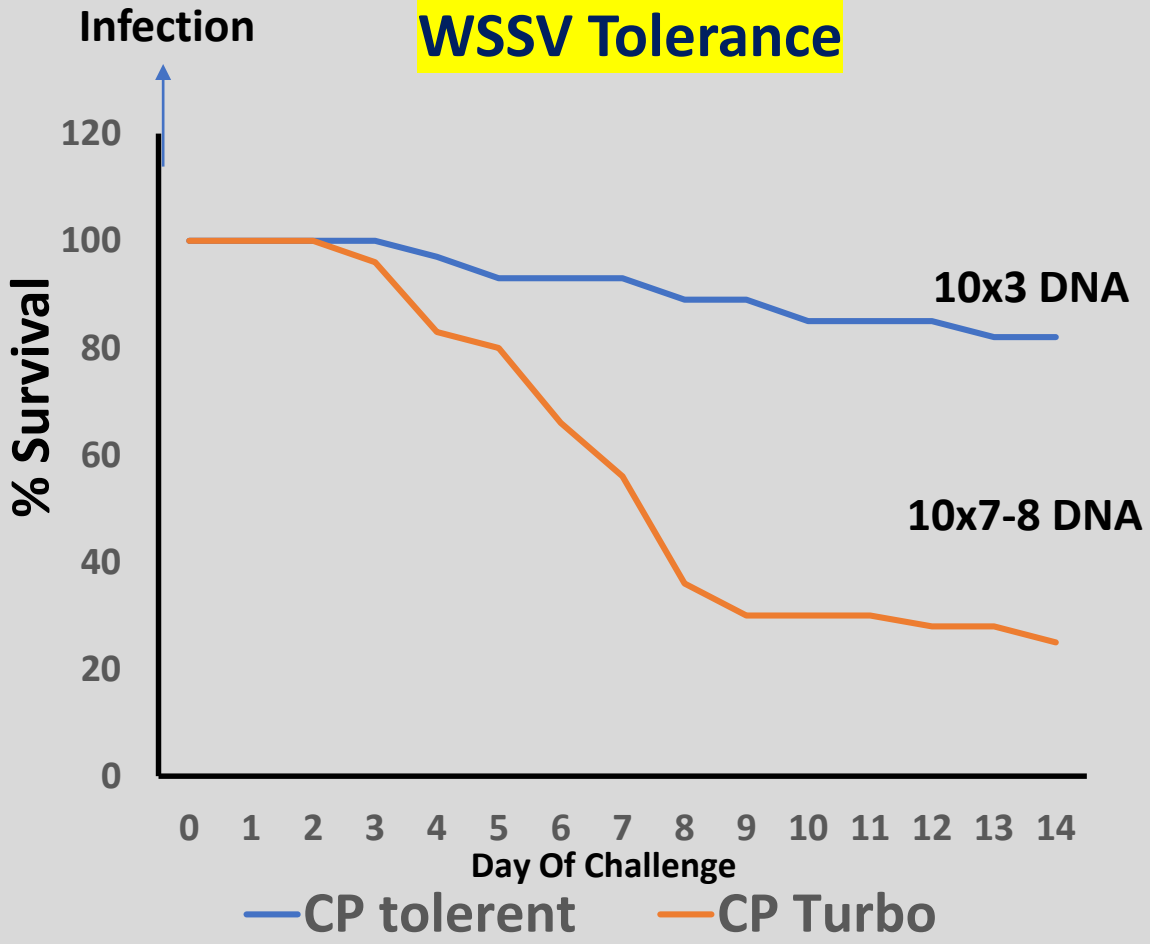
Parameter	APE I	APE II	APE III	SPF	SPF +
AHPNS CHALLENGE	21	60	55	62	78
MBW (DOC 35)	3.6	2.5	2.2	4.8	4.8
MBW (DOC 80)	17.5	15.5	13.5	29.6	29.6

+ =immune primed

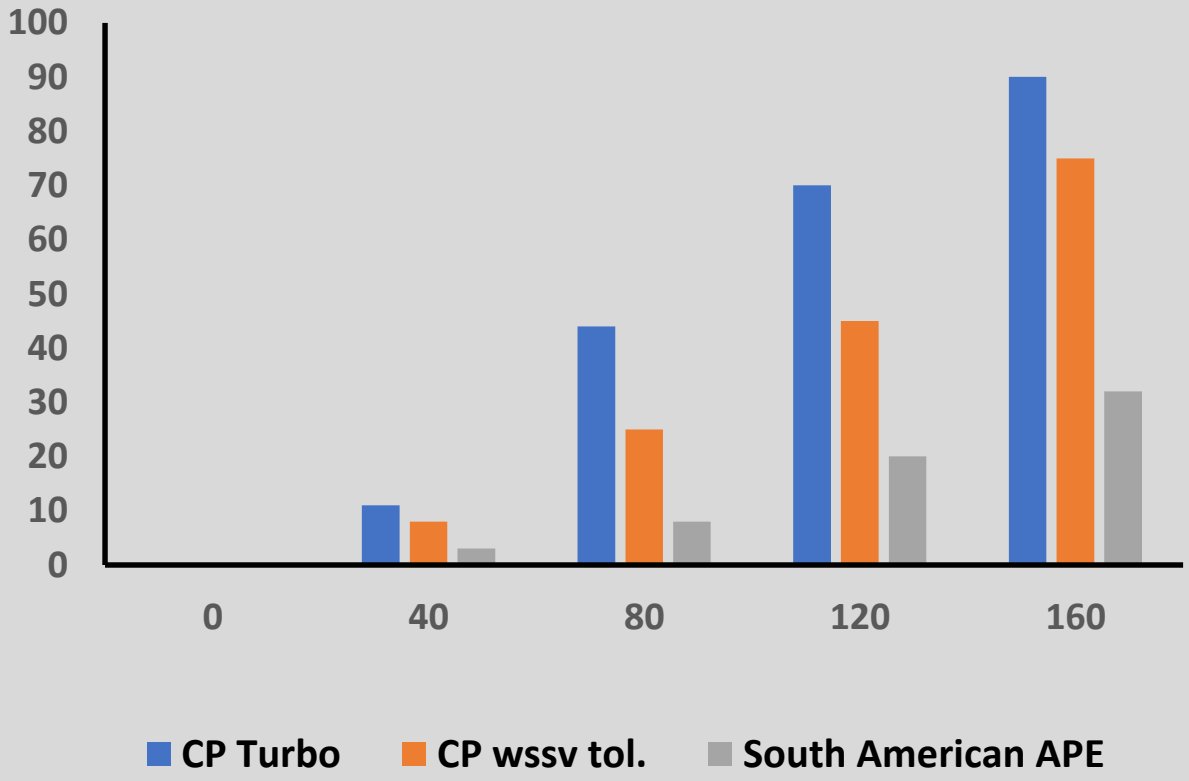
Must balance Growth with Tolerance
" Dead shrimp never grow fast"

Combining APE tolerance with SPF Health and Growth

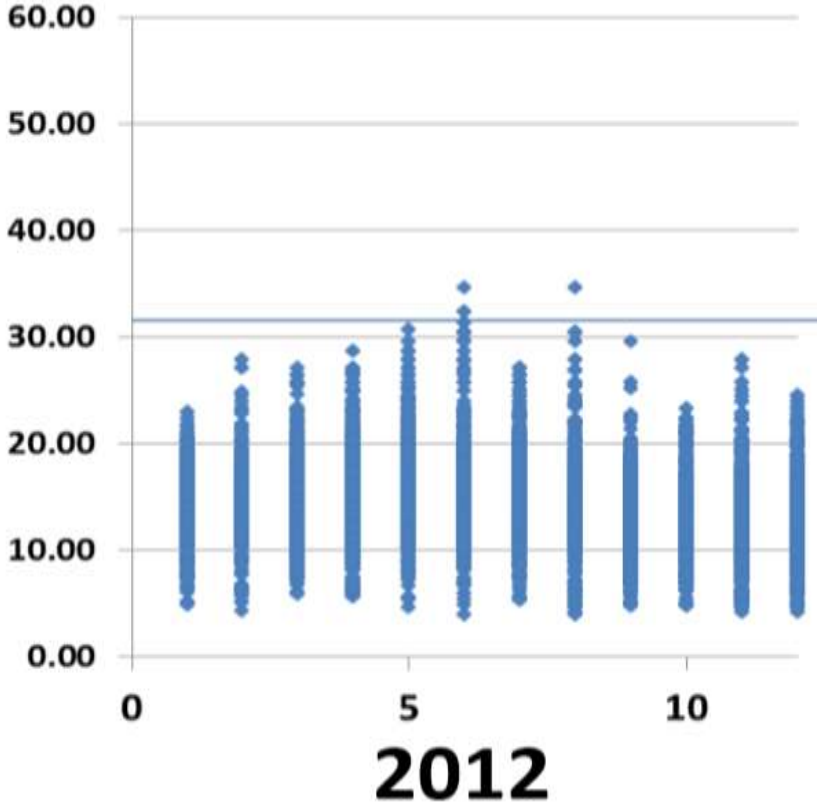
WSSV Tolerance



Growth Rates

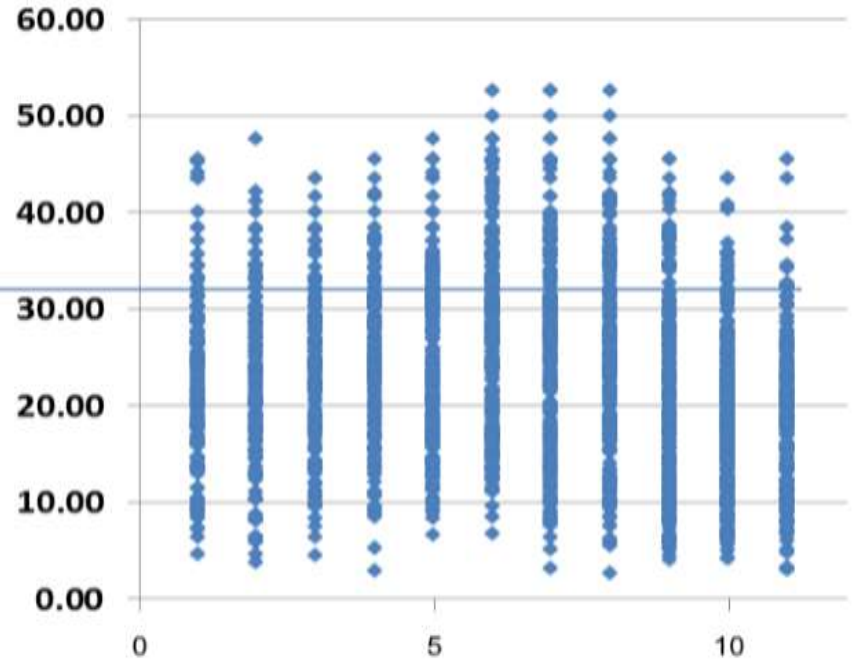


After EMS outbreaks;
Program re-indexed to APHNS tolerance + Robustness



2012

MBW: 14.5 GMS
YIELD: 10,400 KGS/HA
ADG: 0.18 GMS/DAY



2016

MBW: 24.1 GMS
YIELD: 21,300 KGS/HA
ADG: 0.31 GMS/DAY

The future is now: Utilize Marker Assisted Selection

Makes individual and low heritable selection possible

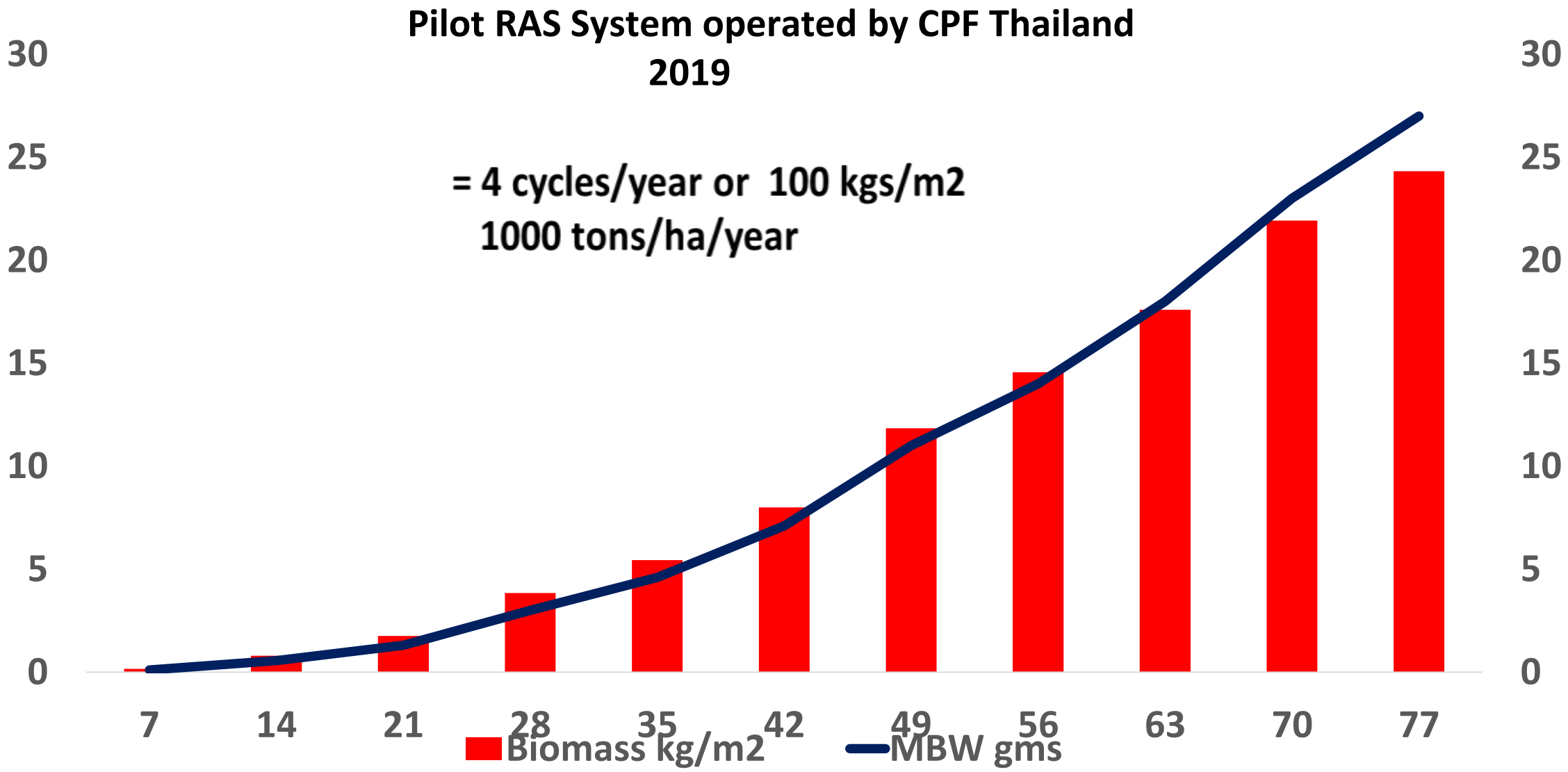
USE of Microarrays to select individual:

- **Robustness**
- **WSSV tolerance**
- **EHP tolerance**
- **Color**

CPF genome collection: every shrimp from Pedigree

CARMEN: Genome sequenced and annotated

The Future will be consistent of Systems with control Requires Robust + Fast Growth + Feeds



Genetic Improvement has made a Difference

2002

350/ gram

2016

200/gram

2004

14 grams
90 Days

2017

38 grams
85 Days

And changed Body Sizes

160 grams Female in 165 days Culture
5 Tons/Ha

SPF applies to Monodon as Well!!!

Before: 2001 **After: 2011**

The Turbo goes Full Renegade

Introducing CPKong- July 2020

Proud to be SPF

Watch out Pond Disease and Stress: CPKong is gunning for you