



10th International Abalone Symposium

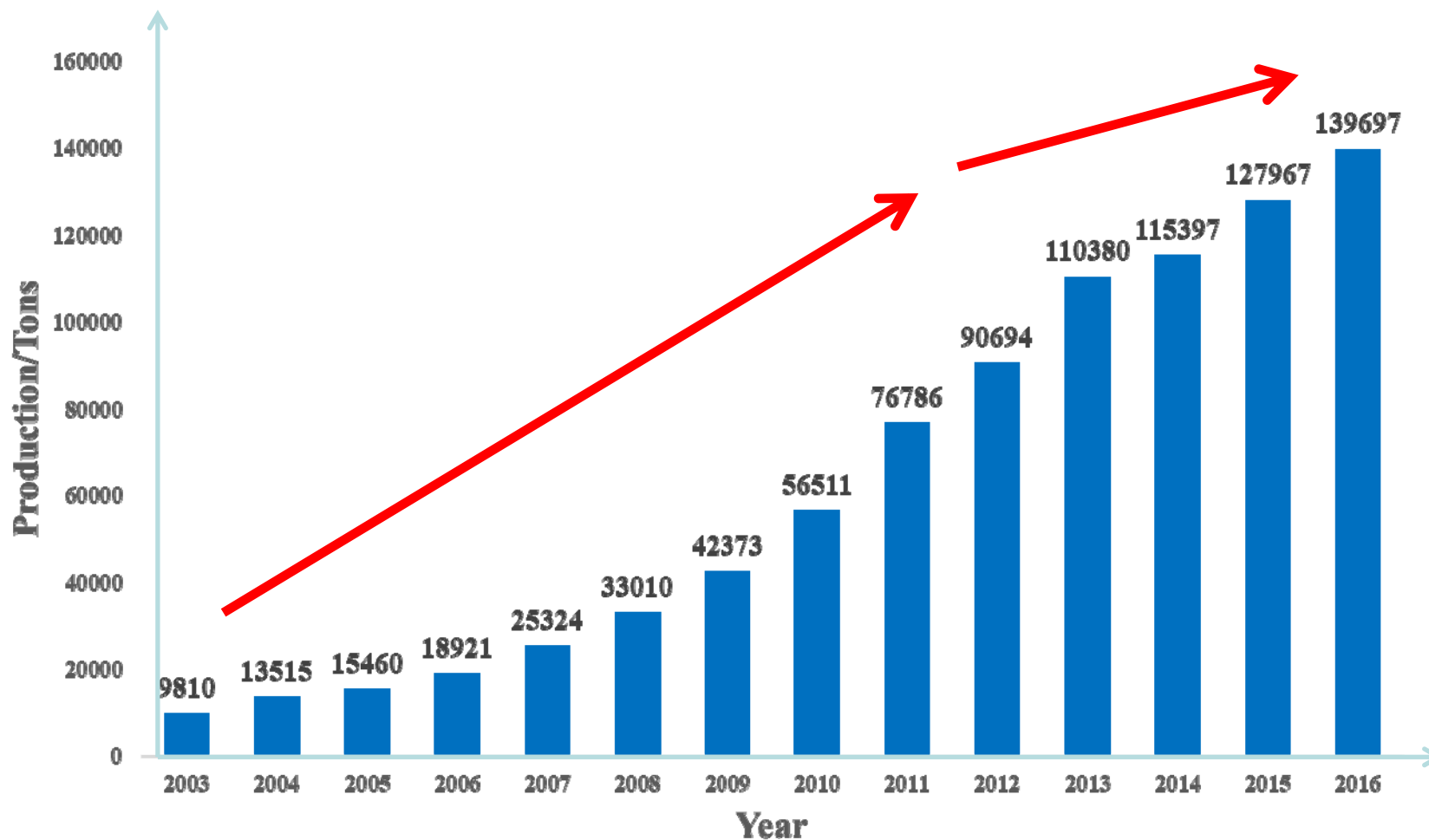
8-12th May 2018 | XIAMEN, China

PROGRESS AND PROSPECT FOR ABALONE RESEARCH AND INDUSTRY IN CHINA

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2018-5-8 Xiamen

Abalone aquaculture production in China

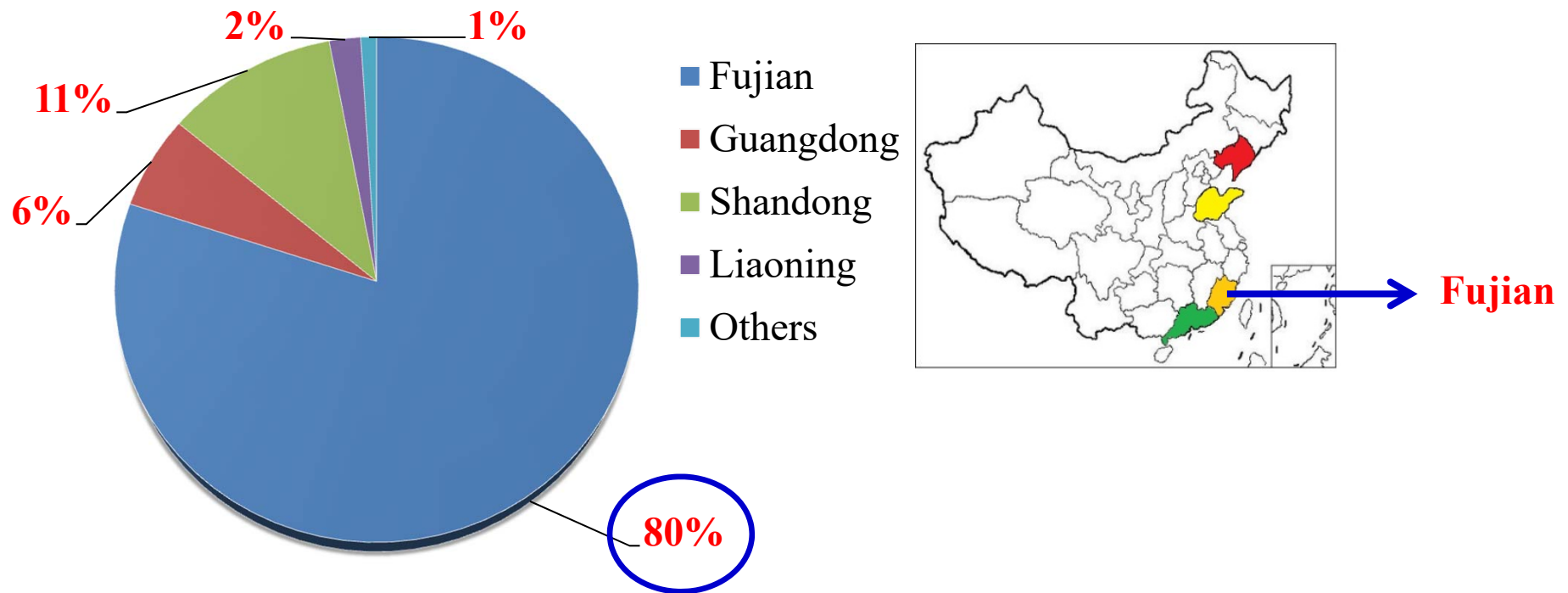


Data: China Fishery Statistical Yearbook

Abalone production in different provinces in 2016

Annual production $\approx$ 140,000 tons, value > 3 billion US Dollar each year.

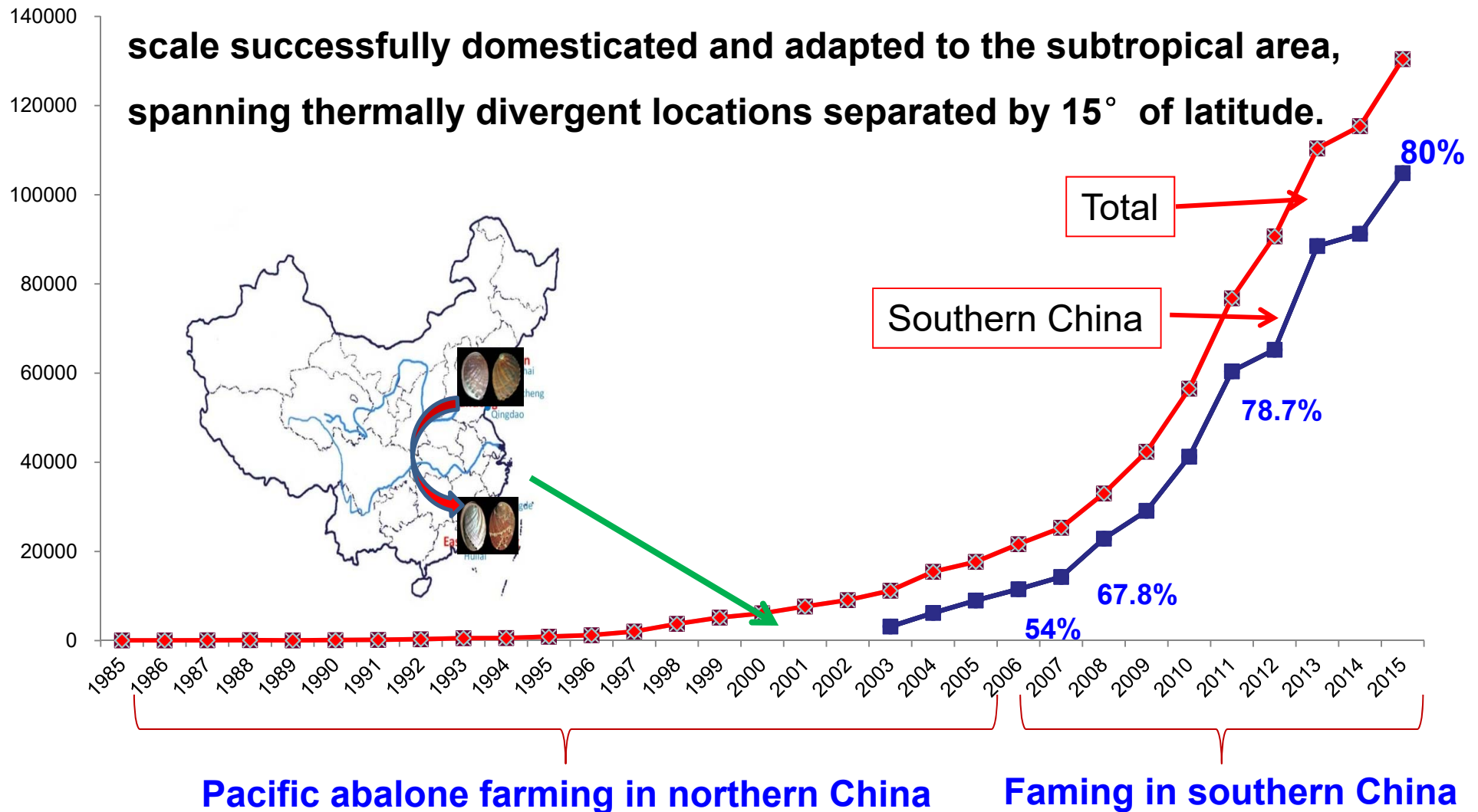
1% production vs 15% value in mollusc farming



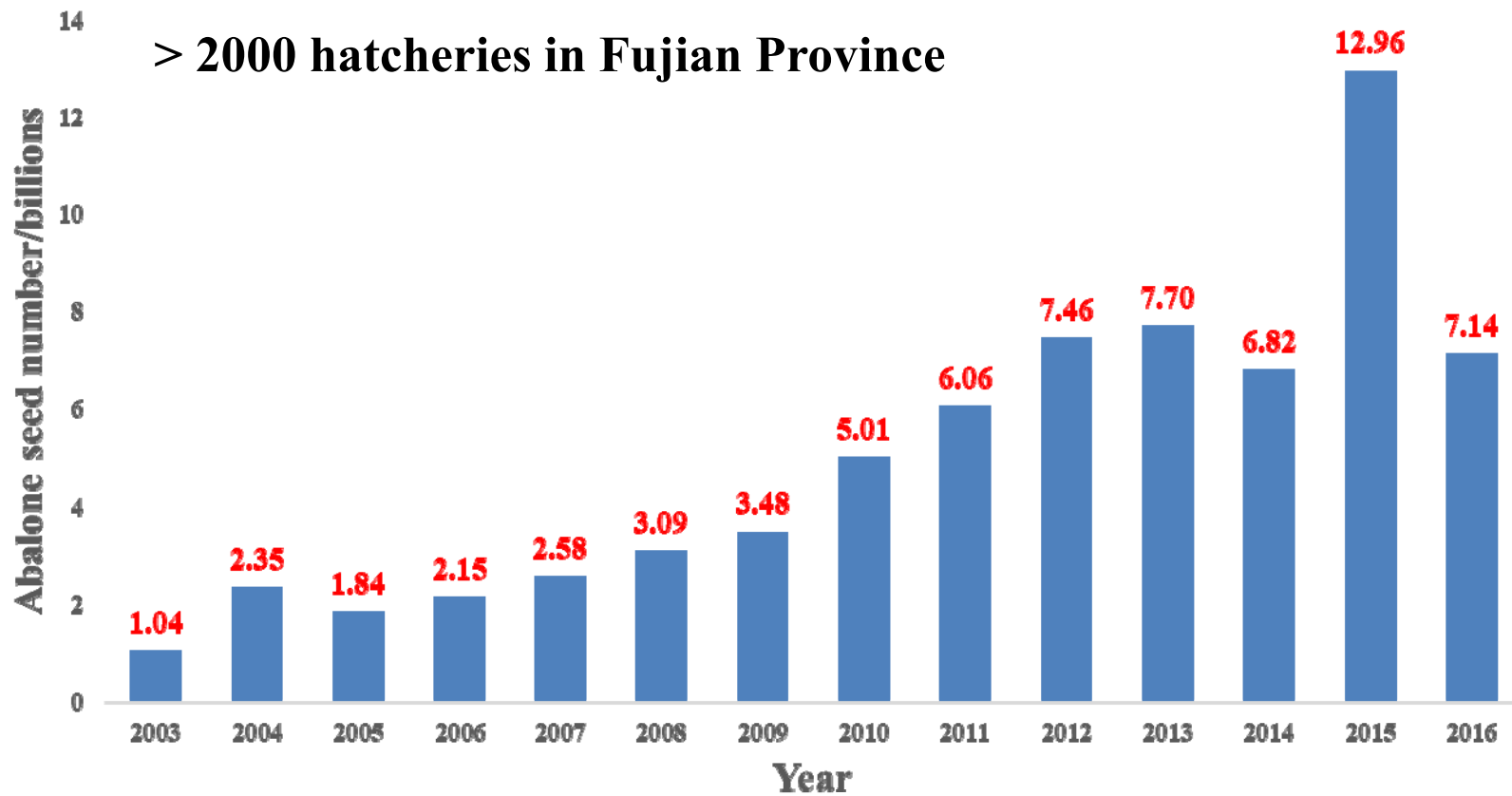
Data: China Fishery Statistical Yearbook 2017

Abalone farming in China

The temperate species Pacific abalone, *Haliotis discus hannai*, is large-scale successfully domesticated and adapted to the subtropical area, spanning thermally divergent locations separated by 15° of latitude.



Abalone seed number stabilized around 7 billions in last 5 years



Data: China Fishery Statistical Yearbook

Why Fujian develop so quickly in recent years?

1. Excellent natural conditions:

Convenient culture environment, etc.
temperature

Many bays are suitable for sea-based grow-out

2. Abundant Seaweed resources:

The productions for Kelp and *Gracilaria*
ranked 1st in China.

3. Genetic improvement and skillful culture techniques

Genetic improvement project supported by
government since 2000

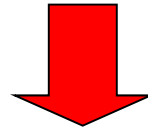
4. Skillful labors and update techniques

Low-cost seed production
Highly efficient sea-based culture systems

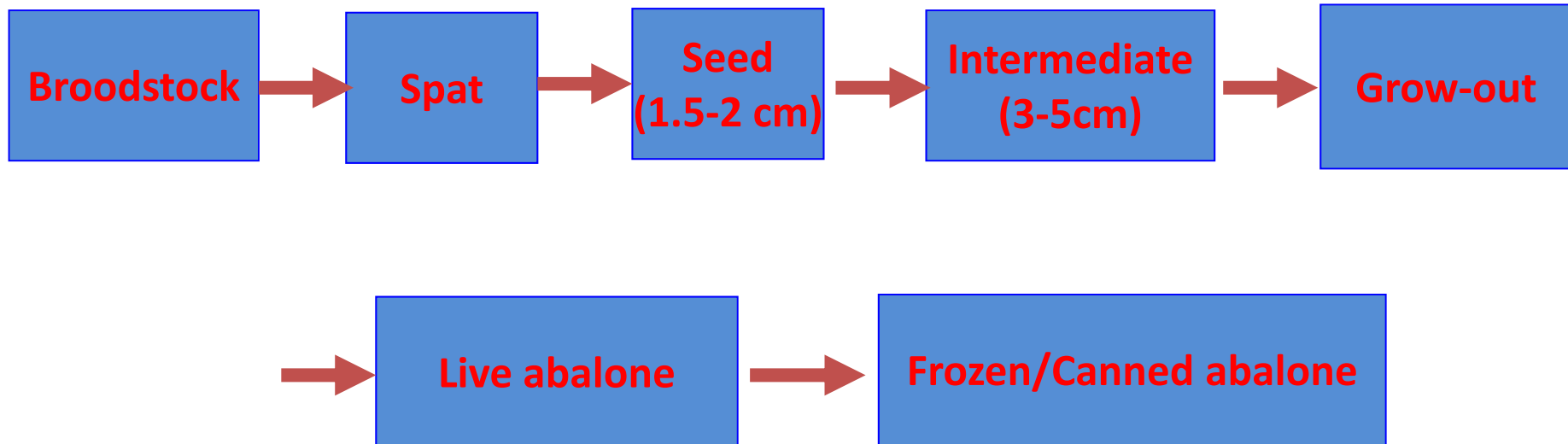


Update process: from 3 steps to 7 steps

Traditional
process



Update process



Seed culture technology

Step 1: Hatchery and early juvenile (0-4 mm, 35-45 days)



Polythene membrane



Plate with juveniles



Nursing pond



Peeling off early juvenile abalone

Step 2: Intermediate rearing (4 -18mm,4-5 months)



Rearing ponds



Cement brick



Seeds with shell length about 2cm



Grow-out System

System 1 Land-based intensive farming



Grow-out cages



Basket size: $40 \times 30 \times 30$ cm

Rearing density: 20-30 inds/basket

Grow-out ponds

System 2 Sea-based farming system





Qingdao

Rongcheng

Shandong

Qingdao



Shandong



Fujian



Fujian

Provided by Dr. Fucun Wu (IOCAS)

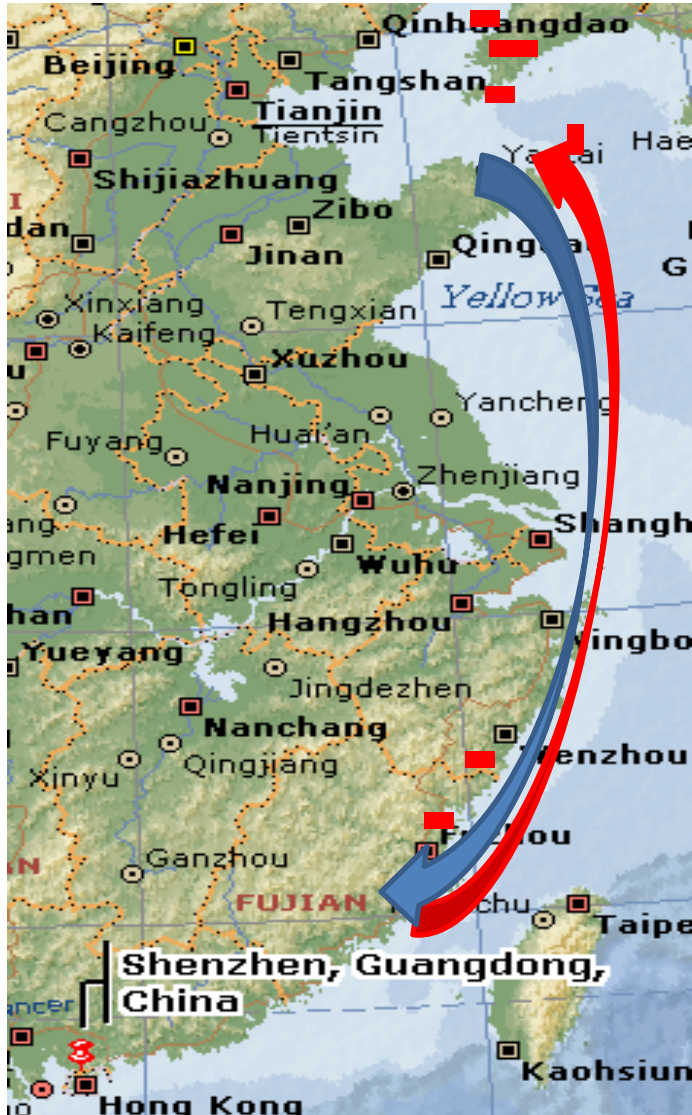
Diet of abalone



Diet for juvenile: **artificial
forage in serial**

Diet in grow-out : ***Gracilaria*
spp. and Kelp**

“South-North Relay” for Pacific abalone aquaculture



Winter: in Southern China (Fujian)

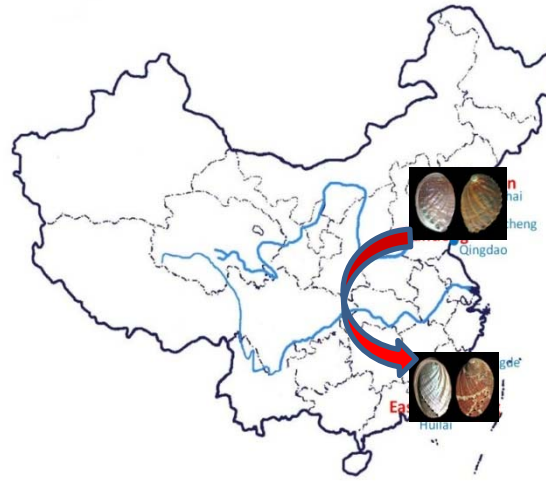
Summer: in Northern China (Shandong, Liaoning)

Advantages:

- Grow at comfortable temperature the whole year; Shorten the grow-out period
- High survival rate in summer, avoiding typhoon and high temperature

The further development of South-North relay mode

The South-north relay mode has been a common practice in China. The production was 9,000 tons in 2016 by this mode and it double in 2017.



Mode	Number of trips	Size	Starting time	Sales time	Purpose
S→N	1	large	spring	autumn	survival rate
S→N→S	2	medium	spring	next spring	large size abalone
S→N→S→N	3	small	spring	next autumn	survival rate and large size abalone
N→S→N	2	small	autumn	next autumn	growth

S: South; N: North; The red sign indicated the dominant mode.

IMTA for abalone, kelp and sea cucumber



a. **Kelp** longline culture

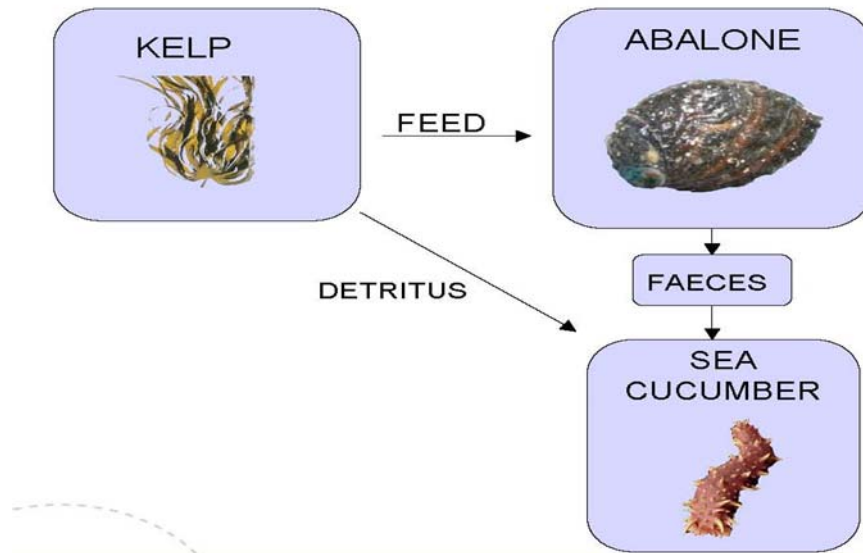
b. **Abalone** net cages hanging vertically from longlines

c. **Sea cucumber** *Apostichopus japonicus* added directly to the abalone cages

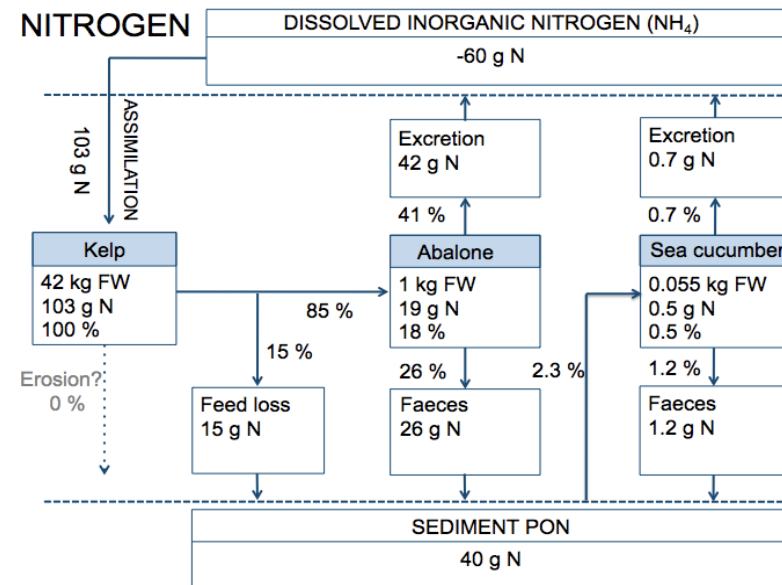
Provided by Prof. Jianguang Fang (YSFRI)

The advantages of IMTA system

IMTA system



The effective use of nutrient



- Advantage:**
1. It is beneficial to the environment, because it lowers emissions of faeces and detritus.
 2. It can increase profits, about \$ 14,000 per acre, from \$ 8,000 per acre for only kelp culture to \$ 22,000 per acre for the IMTA system.

Products forms and Sales

◇ Majority are sold live to market and many cuisines are developed



◇ Processed products are steadily increasing

◇ Utilization of by-products are sprouting



Frozen



Canned

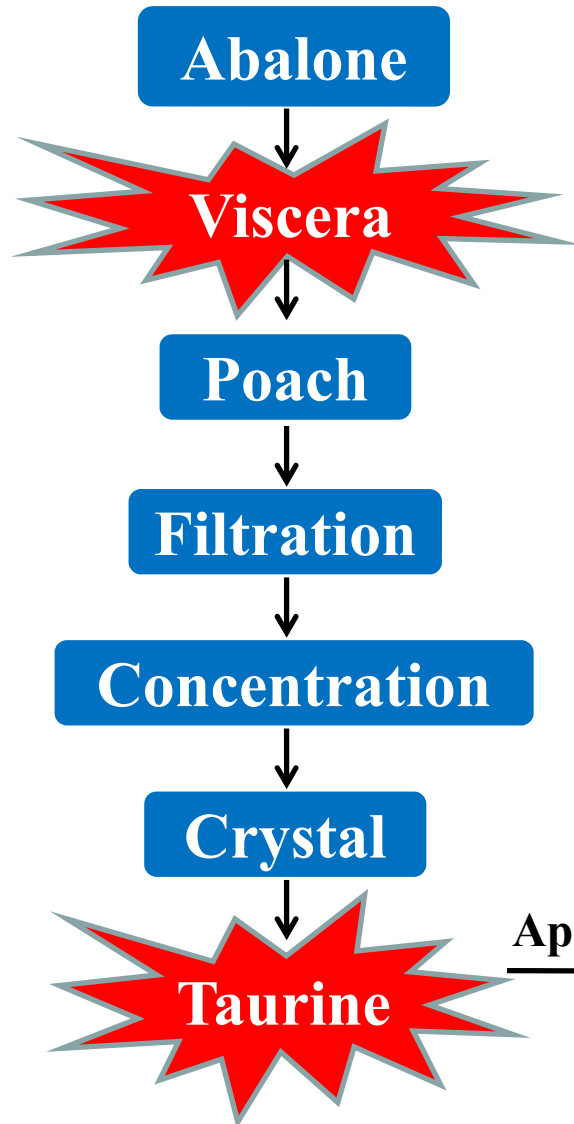


Artware



Taurine

Taurine



The content of taurine

Species		Content (g/kg)
Clam		7.21
Cuttlefish	viscera	5.86
	muscle	2.27
Sleeve-fish	viscera	2.99
	muscle	1.43
Oyster		5.49
Abalone	viscera	4.30

Application



Provided by Prof. Minjie Cao (Jimei University)

Problems and Challenges

- Deterioration of culture environment (stocking density, red tide et al.)
- Seed quality degeneration
- Decline of disease resistance
- Summer mortality
- Market

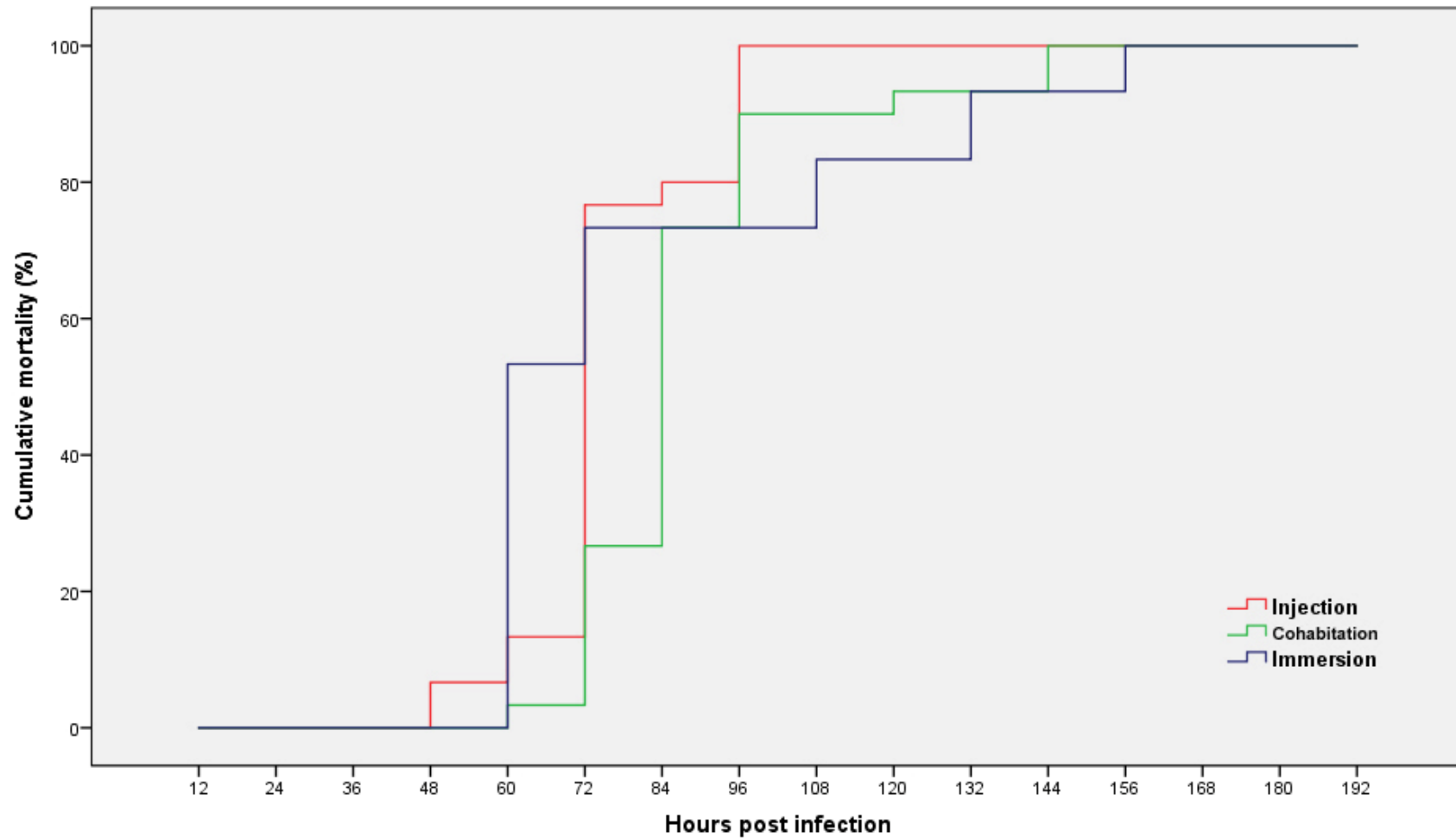


***H. diversicolor* and *H. discus hannai* showed disparate susceptibility to Haliotid herpesvirus 1 (HaHV-1)**

Experimental infection with three different methods (injection, immersion and cohabitation) showed similar results.

- *H. diversicolor* was highly susceptible to HaHV-1 infection, and suffered from 100% mortality with an acute process after challenge.
- *H. discus hannai* was resistant to HaHV-1 infection, and no clinical signs or mortalities were found after challenging with all three methods.

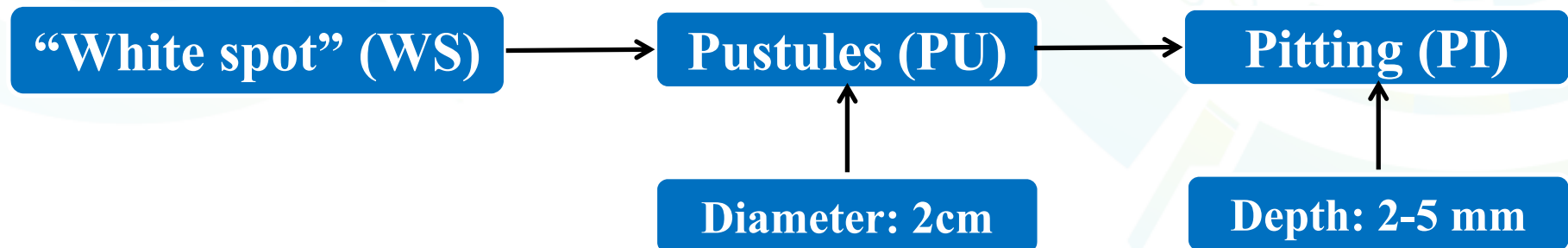
Mortality curve of *H. diversicolor* after challenge with different methods



Impetigo



The distribution of pustules on sick abalone

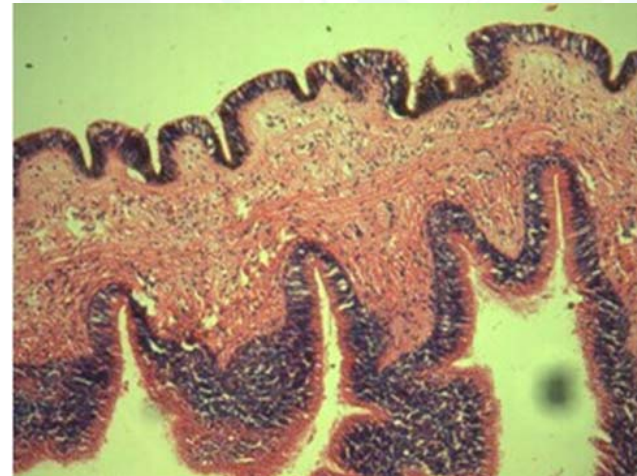
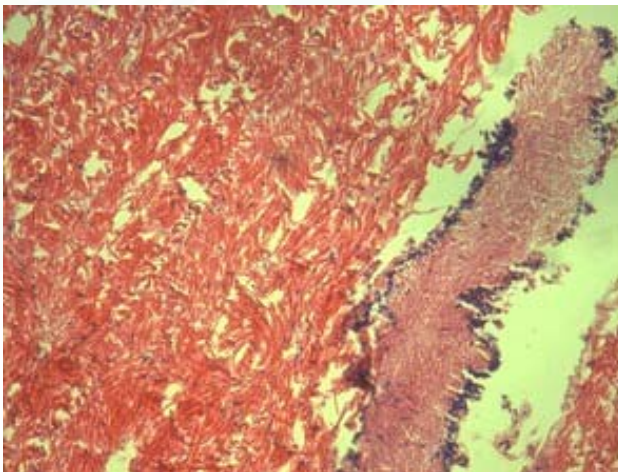


Provided by Prof. Jiangyong Wang

Toxicity with isolated dominant strain

BV2		Abalone		
	Concentration (CFU/mL)	Total	Death	Mortality rate (%)
1	8.7×10^3	20	12	60
2	8.7×10^4	20	15	75
3	8.7×10^5	20	17	85
4	8.7×10^6	20	18	90
5	8.7×10^7	20	20	100
control	0	20	0	0

$LD_{50} \approx 7.76 \times 10^5$ CFU/mL



The foot morphology of sick (left) and normal (right) abalone (HE staining)

Novel varieties

Three novel varieties were conferred by Ministry of Agriculture and now were large-scale cultured in China.

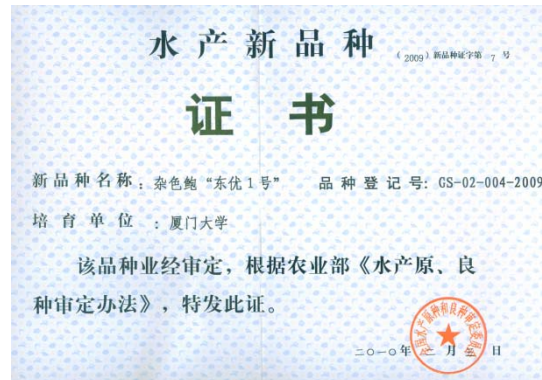


Haliotis discus hannai

“Dalian 1”

In 2005

Growth rate and
high temperature resistance



H. diversicolor

“Dongyou 1”

In 2010

Disease resistance



Hybrid

“Xipan abalone”

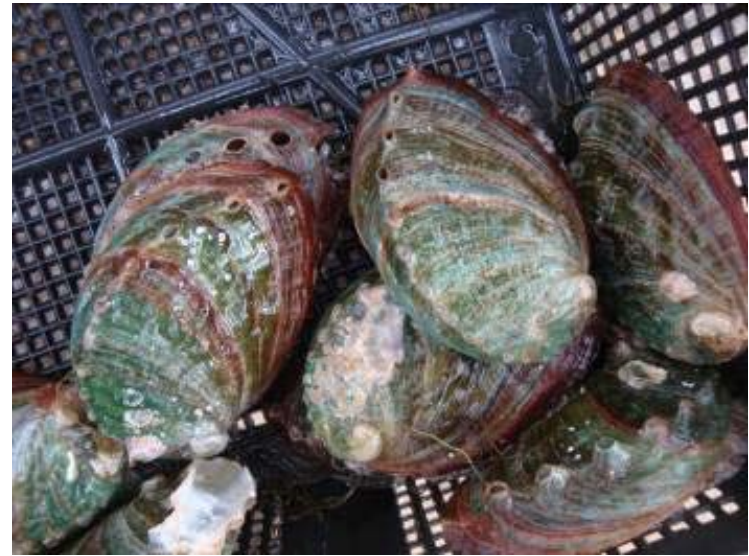
In 2014

High temperature resistance

Pacific abalone



JP population



KR population

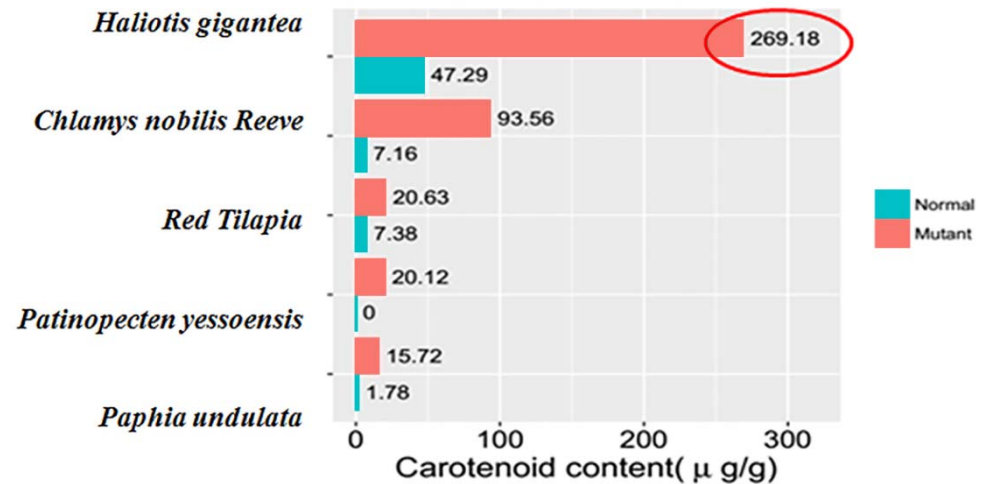
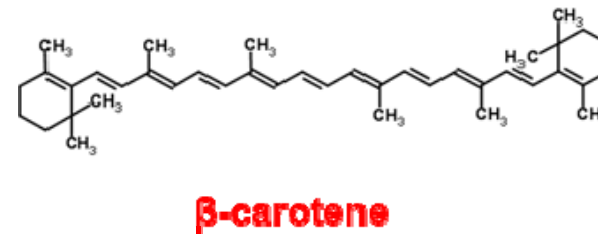
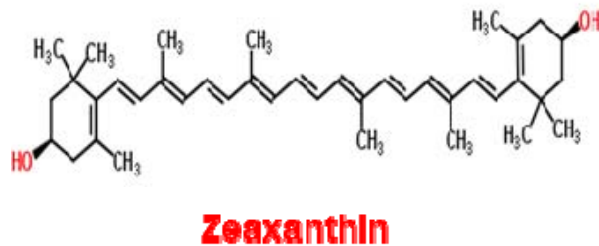
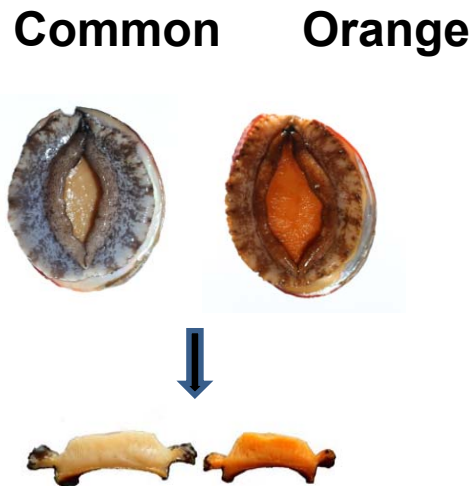


JJ line



Red shell line

Orange variety



Comparison of carotenoid content

We identified two major kinds of carotenoid in abalones (*Haliotis gigantea*) are **Zeaxanthin** and **β-carotene**.

The concentrations of zeaxanthin and β -Carotene for **orange-variety** were significantly higher than **normal abalones**.

Facilities



Family system



Hybrid system



Selection system



Parents improved system

Evaluation of stress tolerance



The lab for stress tolerance assessment



Sensor



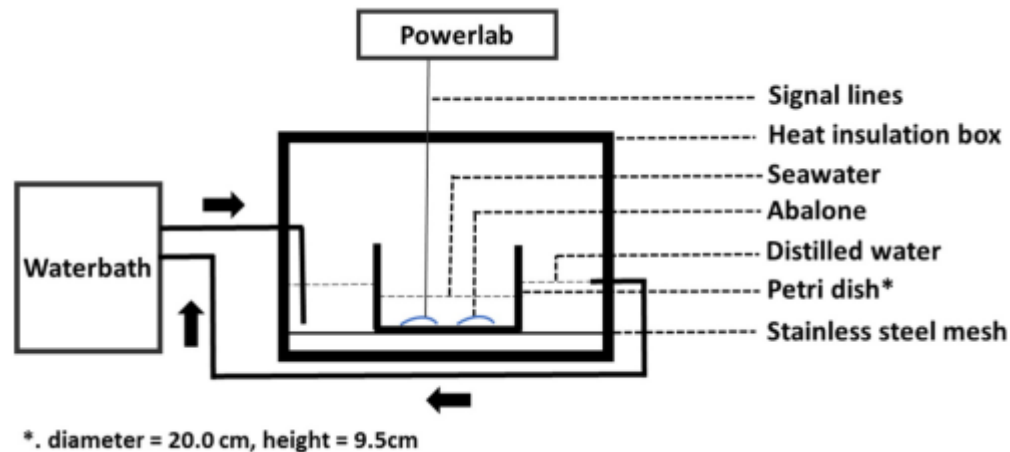
Amplifier



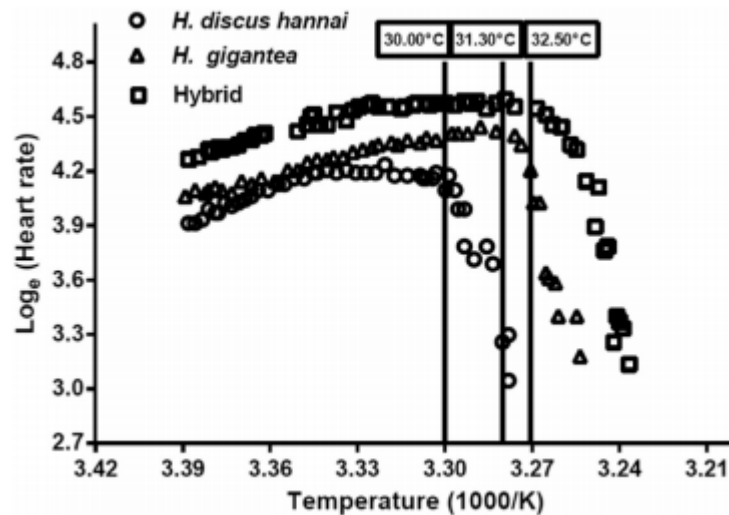
Powerlab

The non-invasive method to measure heart rate

Heart beat rate and thermal tolerance

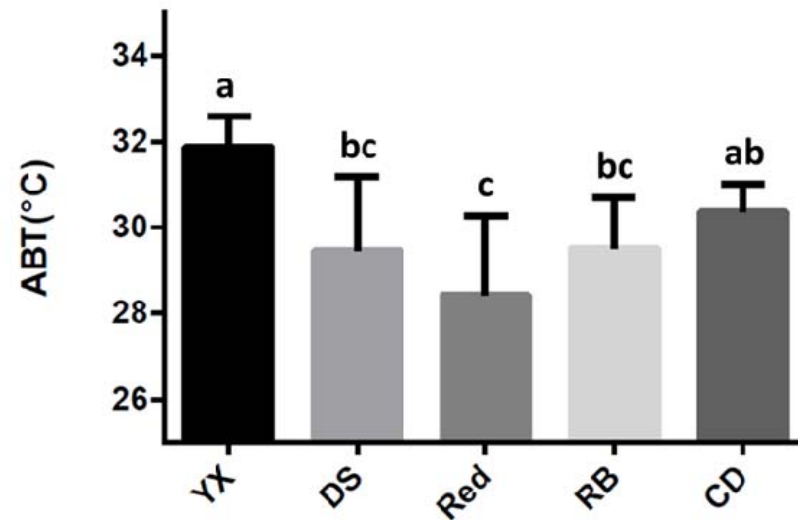


The schematic drawing for measurement of ABT



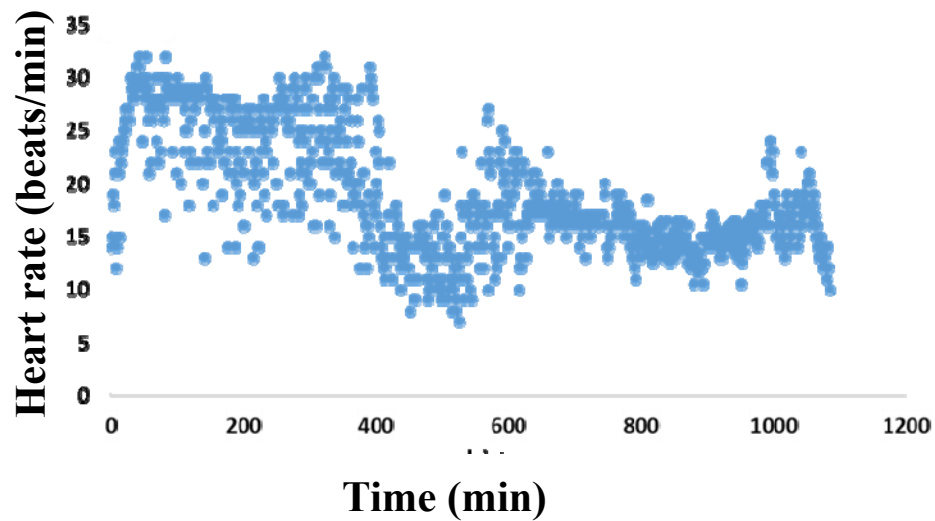
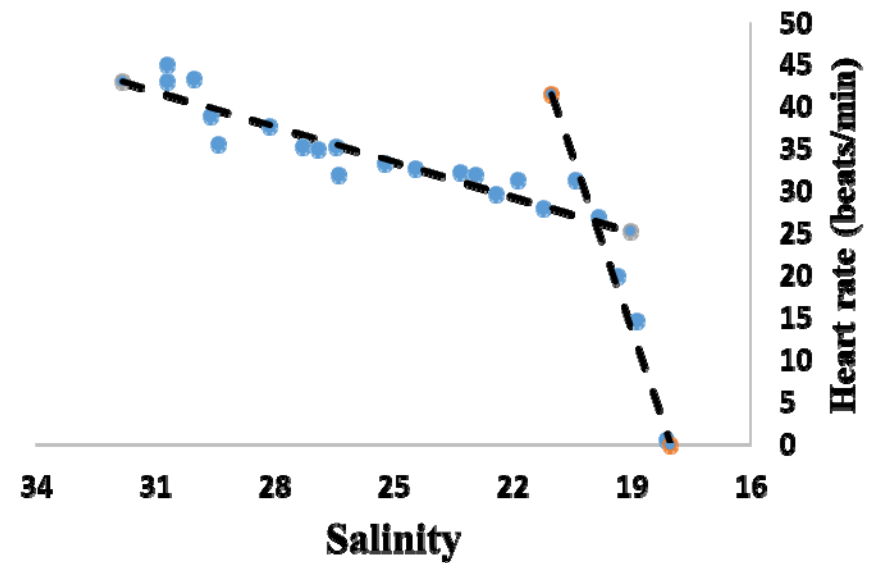
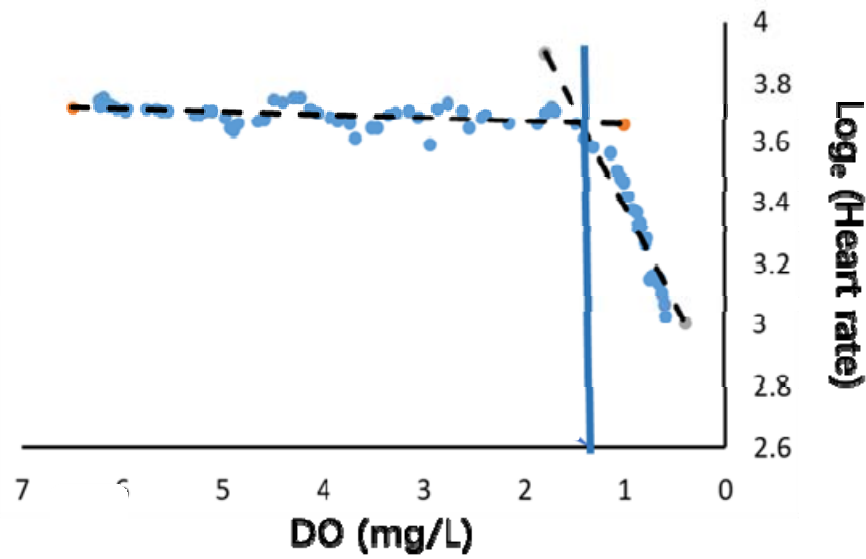
The ABT for different abalones

Arrhenius break temperatures (ABT) was calculated based on cardiac performance to verify the abalone thermal tolerance and it had been proven to be a effective method.



The ABT for different lines of Pacific abalone

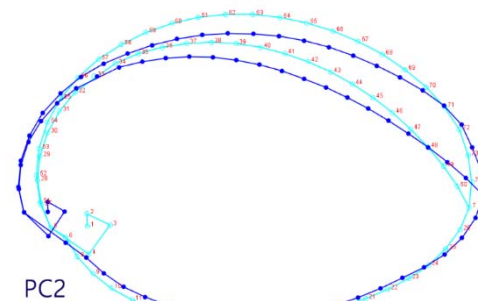
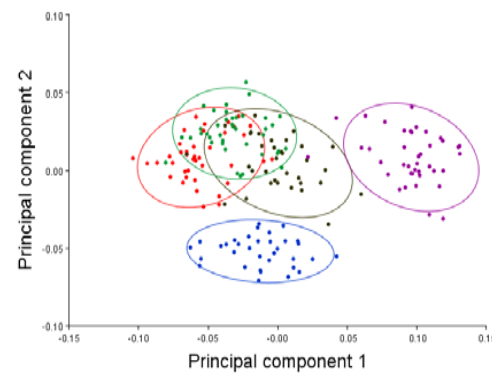
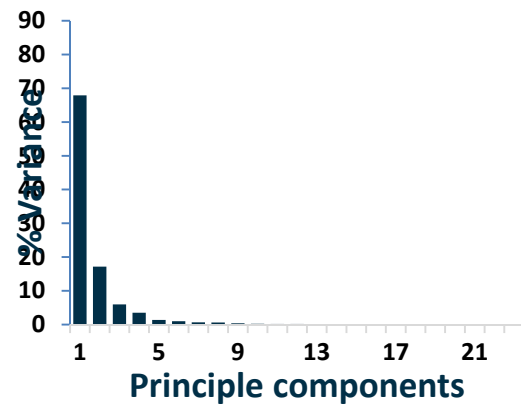
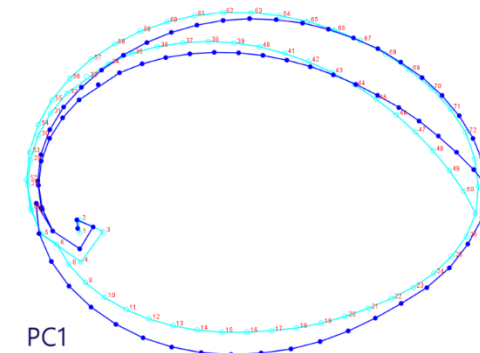
Other stress



The relations between heart rate and DO, salinity or air exposure were studied.

There were breakpoints observed when the oxygen or salinity declined

Quantitative analysis of shell shape



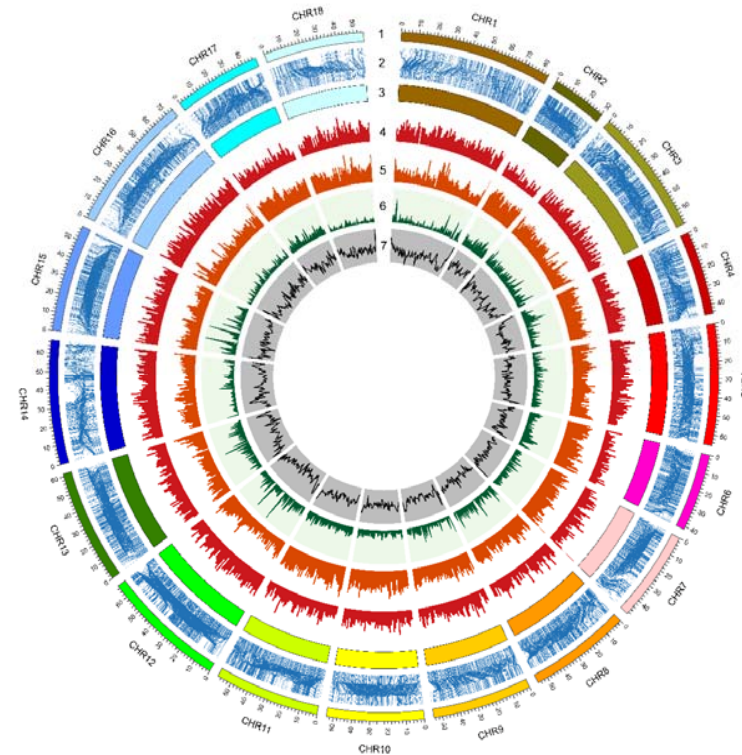
Genome assembly results of Pacific abalone

	Contig		Scaffold	
	Size (bp)	Number	Size (bp)	Number
Total	1,245,295,745	349,844	1,279,837,536	249,837
Longest	265,314	-	6,125,885	-
Number>=2000	-	74,608	-	13,799
N50 *	22,360	14,939	616,844	542
N60	16,667	21,386	427,240	792
N70	11,637	30,307	261,770	1,173
N80	6,812	44,134	107,506	1,914
N90	1,798	77,761	6,019	7,019

A high-quality reference genome was assembled spanning 1.28 Gb with contig N50 of 22 Kb and scaffold N50 of 617 Kb using SOAPdenovo approach.

Abalone genome landscape

3,531 assembled scaffolds were anchored on the 18 chromosomes and built a chromosome-anchored reference genome, covering about 1,038 Mb (81.09 %) of the assembled abalone genome.



Ongoing project: Genome-wide Association Selection for Pacific Abalone

Thank you and enjoy your time in Xiamen !

