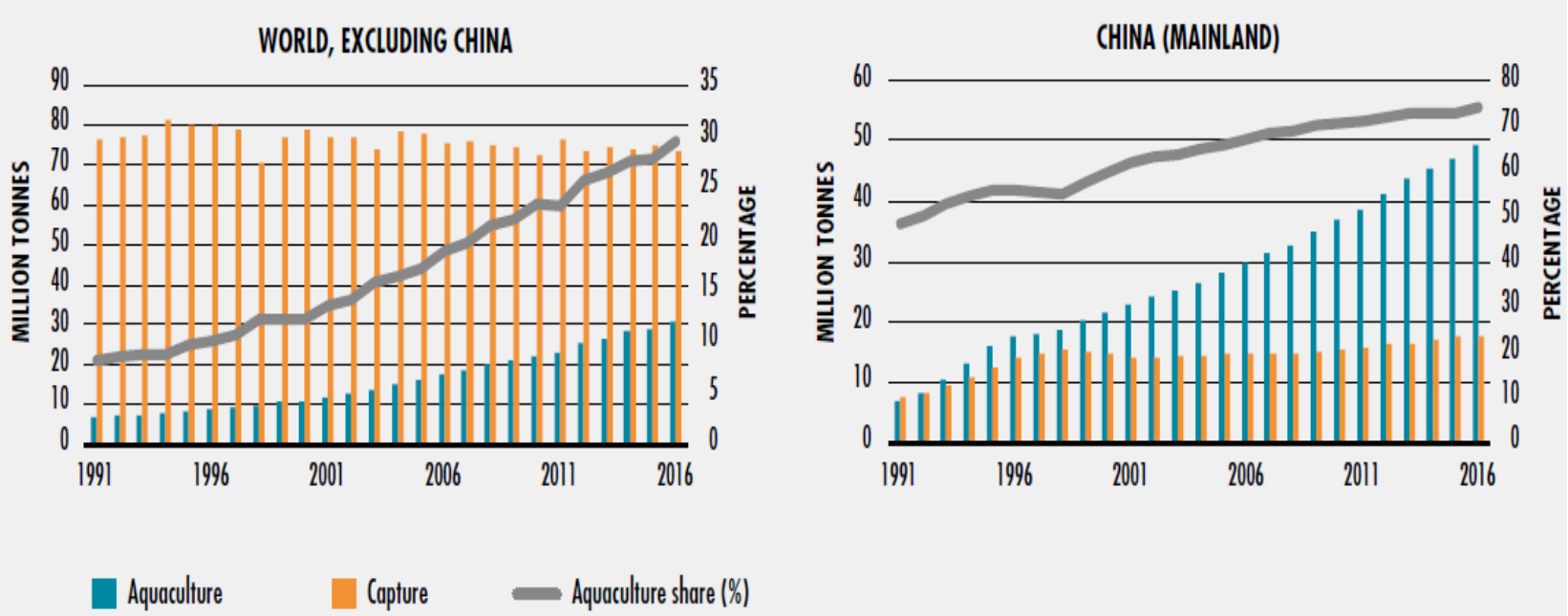
Norway 2019/10/31

Development of sea based farming of salmon and trout in the Yellow Sea, China

Shuanglin DONG
Ocean University of China

In 2018, China's total fisheries production was 64.58 mt, 1/3 the world fisheries production, and its aquaculture production was 49.91 mt, 57% of the world's aquaculture production.



Green Development of Aquaculture

Challenges:

“The *distribution* and *structure* of aquaculture industry are unreasonable, and the stocking densities in some waters are too high.”

农业农村部副部长于康震就《关于加快推进水产养殖业绿色发展的若干意见》答记者问——加强顶层设计 推进水产养殖业绿色高质量发展

日期：2019-02-15 18:50　作者：　来源：农业农村部新闻办公室　【字号：大 中 小】　打印本页

“Some Suggestions on Accelerating the Green Development of Aquaculture”

From Coastal Mariculture to Offshore or Far-offshore Mariculture

Mariculture output for fish is
1.5 mt/yr in China
Pollution, low quality

Over 1.3 mt/yr
of Norwegian salmon farming
High quality

Blooming of offshore and far-offshore mariculture in China

Deep Blue 1, Shandong

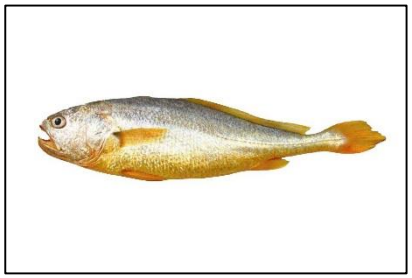
Dehai 1, Guangdong

Changjing 1, Shandong

Zhenyu 1, Zhejiang

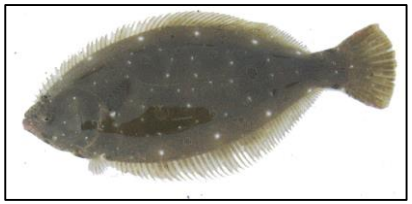
Chengshan 1, Zhejiang

Seawater fish farming in China



Yellow croaker ***Pseudosciaena crocea***
Production: 0.20 mt
Net cages

Common Sea perch ***Lateolabrax japonicus***
Production: 0.17 mt
Ponds and net cages



Flounder ***Paralichthys olivaceus***
Production: 0.11 mt
Tanks indoor

Salmon and trout farming in China

Rainbow trout ***Oncorhynchus mykiss***
Production: 38,606 t 70%
Landlock

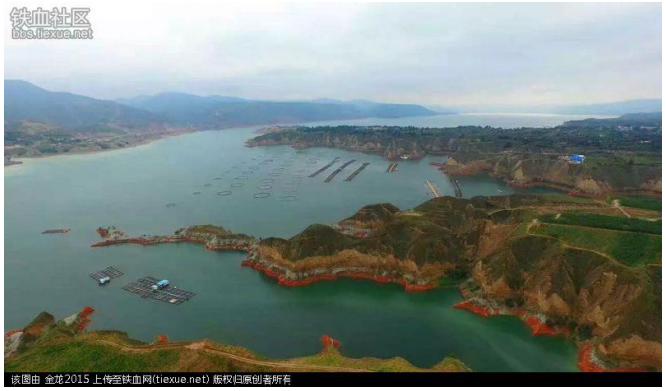
Atlantic salmon ***Salmo salar***
Production: 2,446 t
RAS and sea cages

Stealhead trout ***Oncorhynchus mykiss***
Anadromous, Sea cages

The total production of trout, salmon and smelt fish was 55,301 t in China in 2018.


Salmon & trout farming in China
Google
图像 © 2017 TerraMetrics 中国 使用条款 100

Rainbow trout culture in the reservoirs along upstream of the Yellow River (Tibet Plateau)

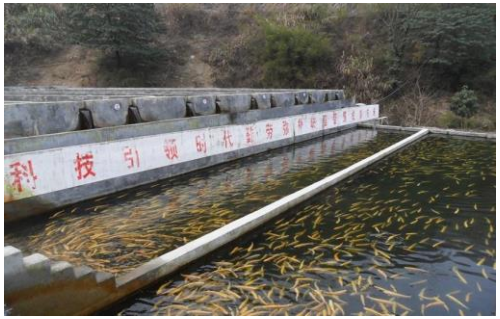


Longyangxia Reservior 10,000 t/yr

Liujiaxia Reservior 3,000 t/yr

Rainbow trout culture with spring water or underground water in mountain areas

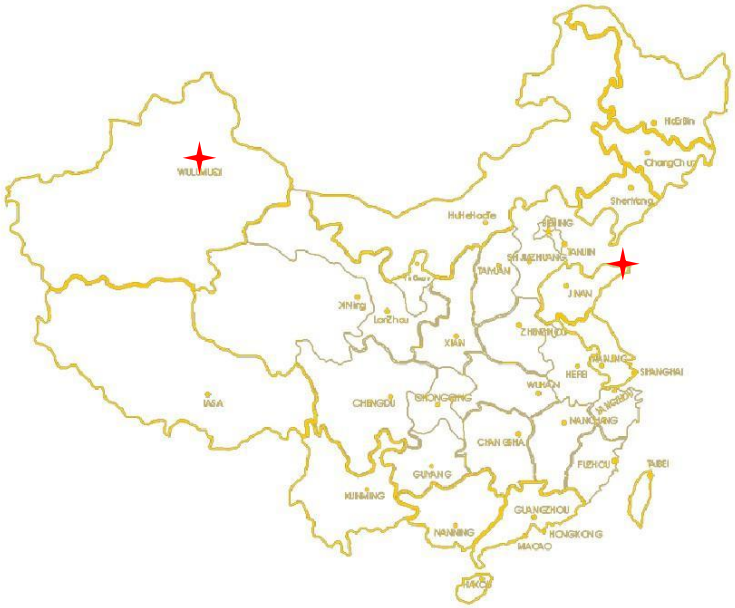
Huairou near Beijing

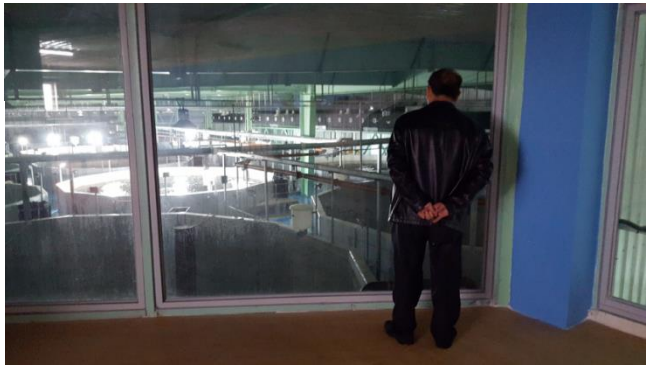


Hubei in the center China

Yunnan in the southern China

Salmon and trout culture in recirculating systems

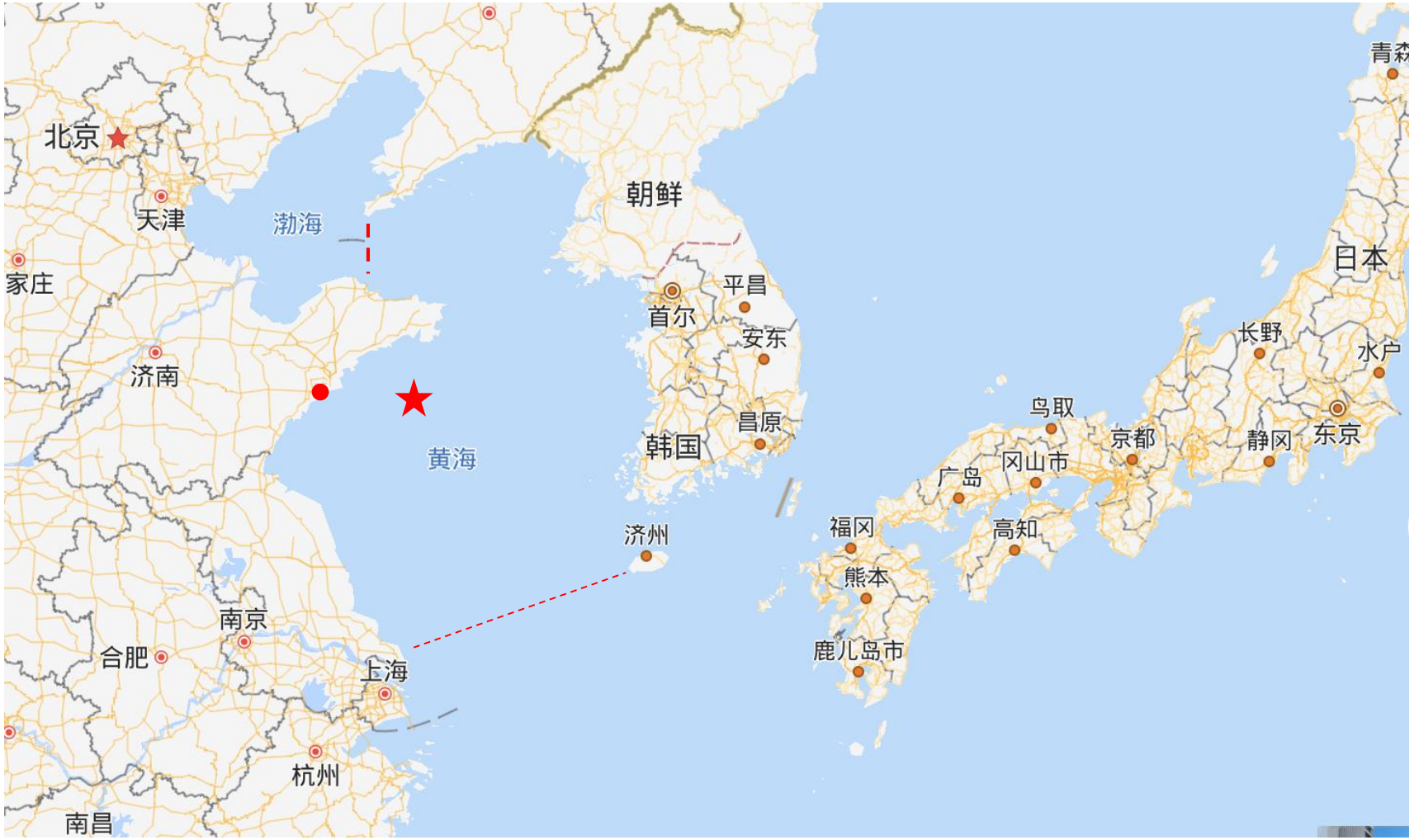


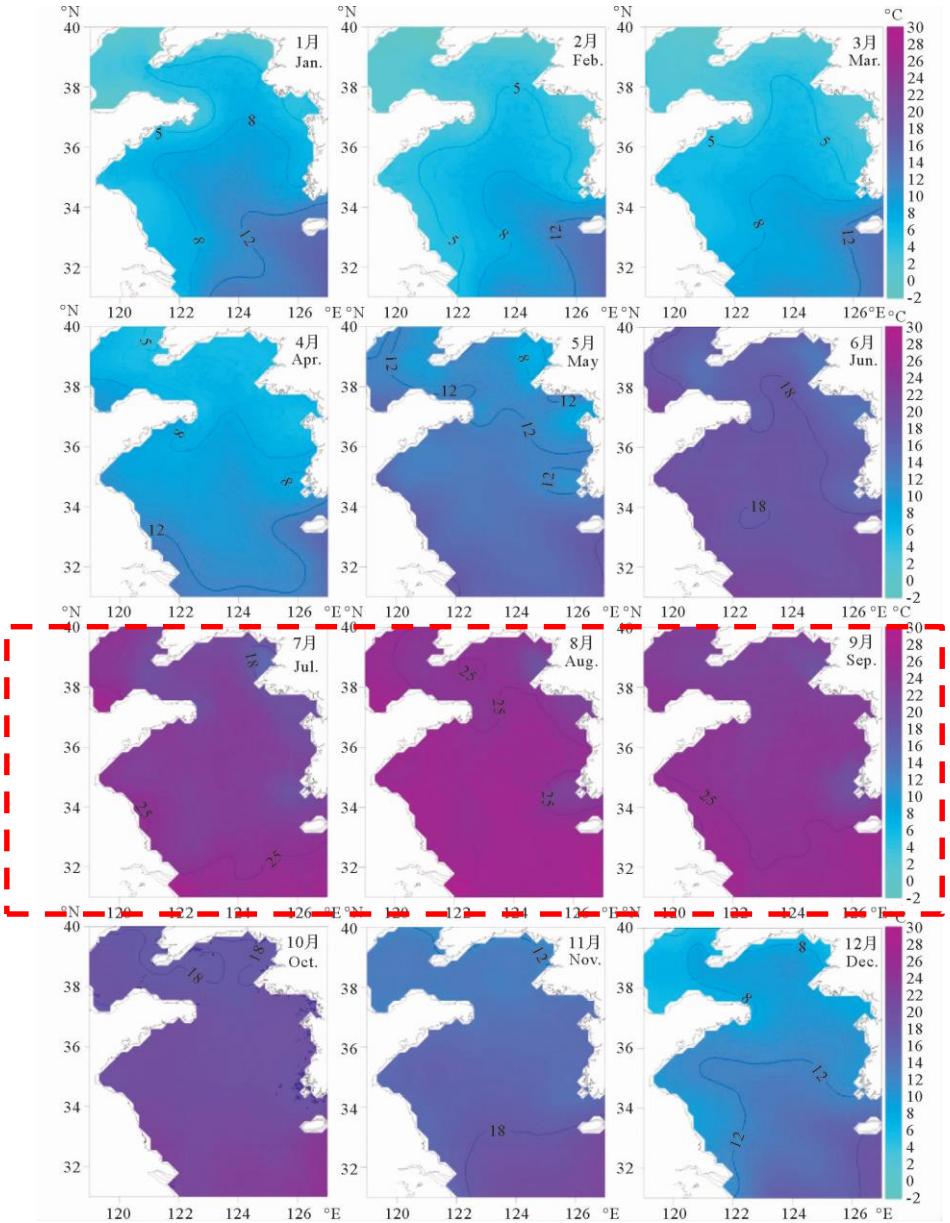


RAS for trout in Xinjiang, introduced from Denmark

RAS for salmon in Shandong Province, introduced from Norway, mariculture

Salmon farming in the Yellow Sea



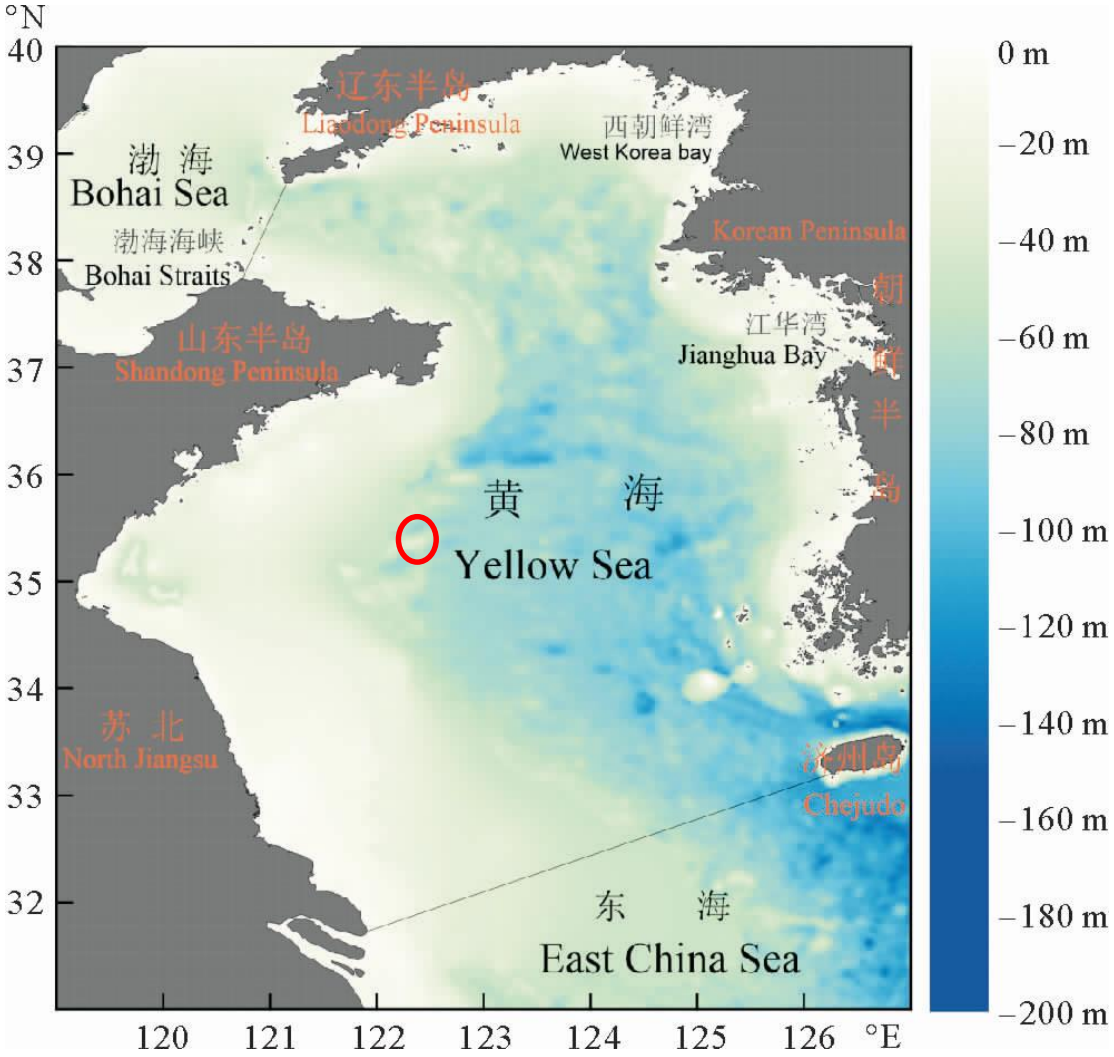


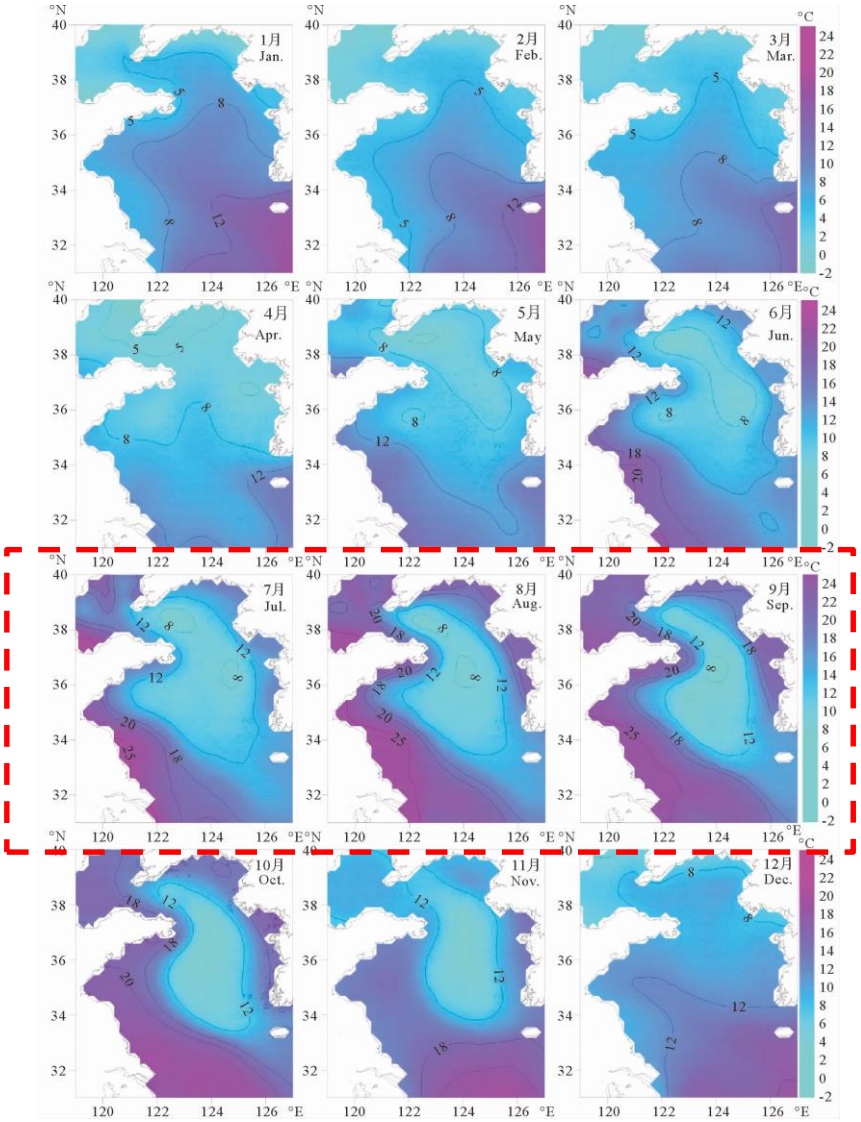
Water temperature distribution at upper layer of the Yellow sea

It is not suitable to farm salmon and trout at the upper layer from July to September.

Liu *et al*., 2019

Topographic map of the Yellow sea



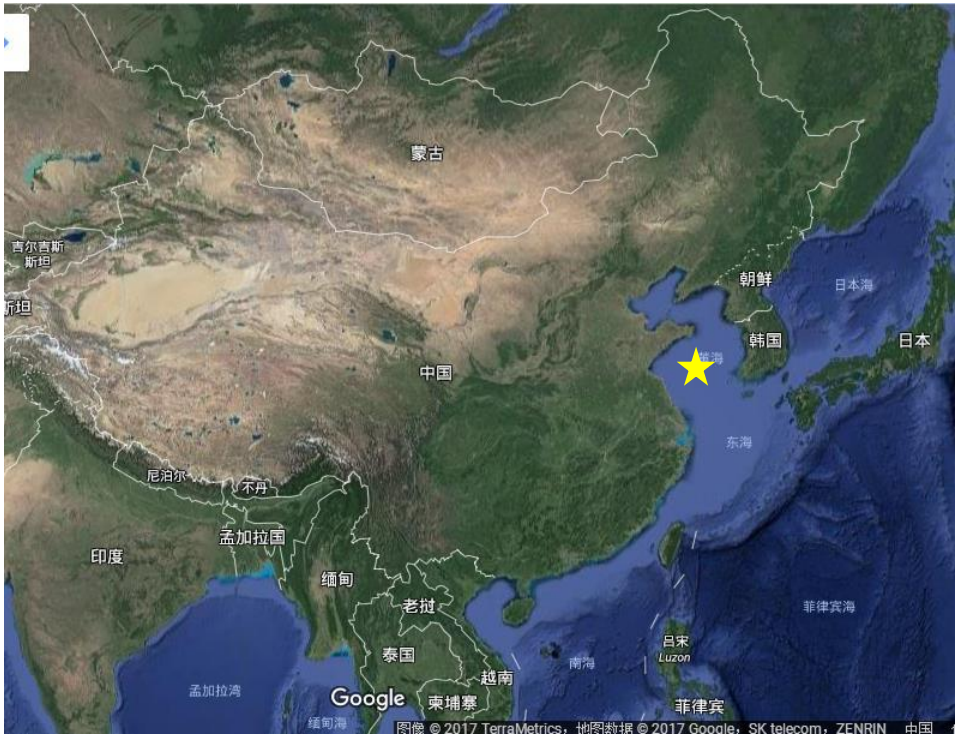


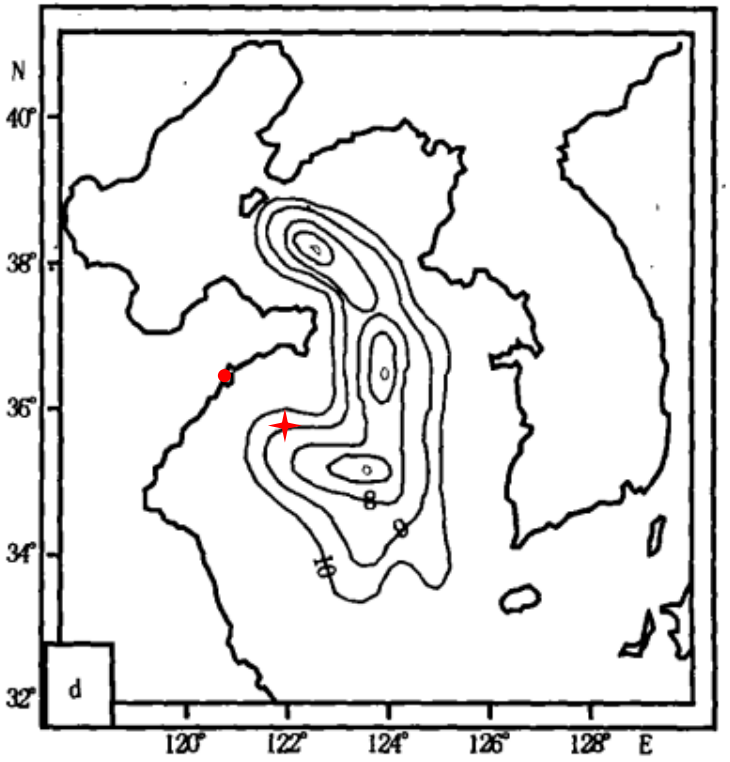
Water temperature distribution at bottom layer of the Yellow sea

It is suitable to farm salmon by using bottom water from July to September.

Liu *et al*., 2019

Sea based farming of trout and salmon in the Yellow Sea



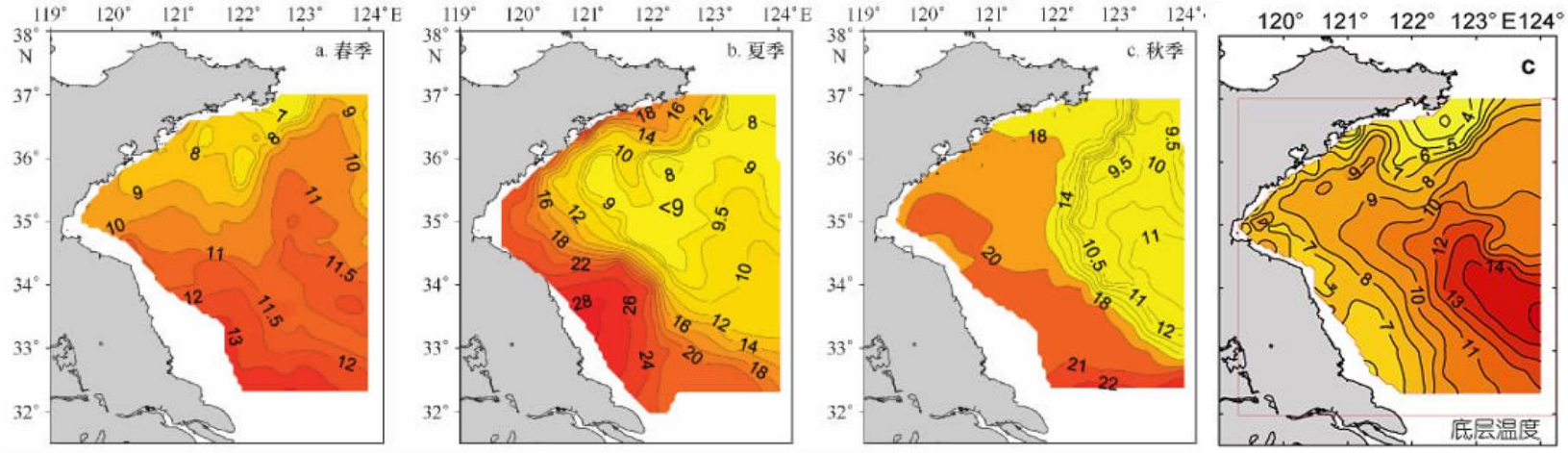


Water temperature in summer on bottom of Yellow See (Cold Water Mass in the Yellow Sea)

Area: 130,000 km^2

Volume: 500 billion m^3

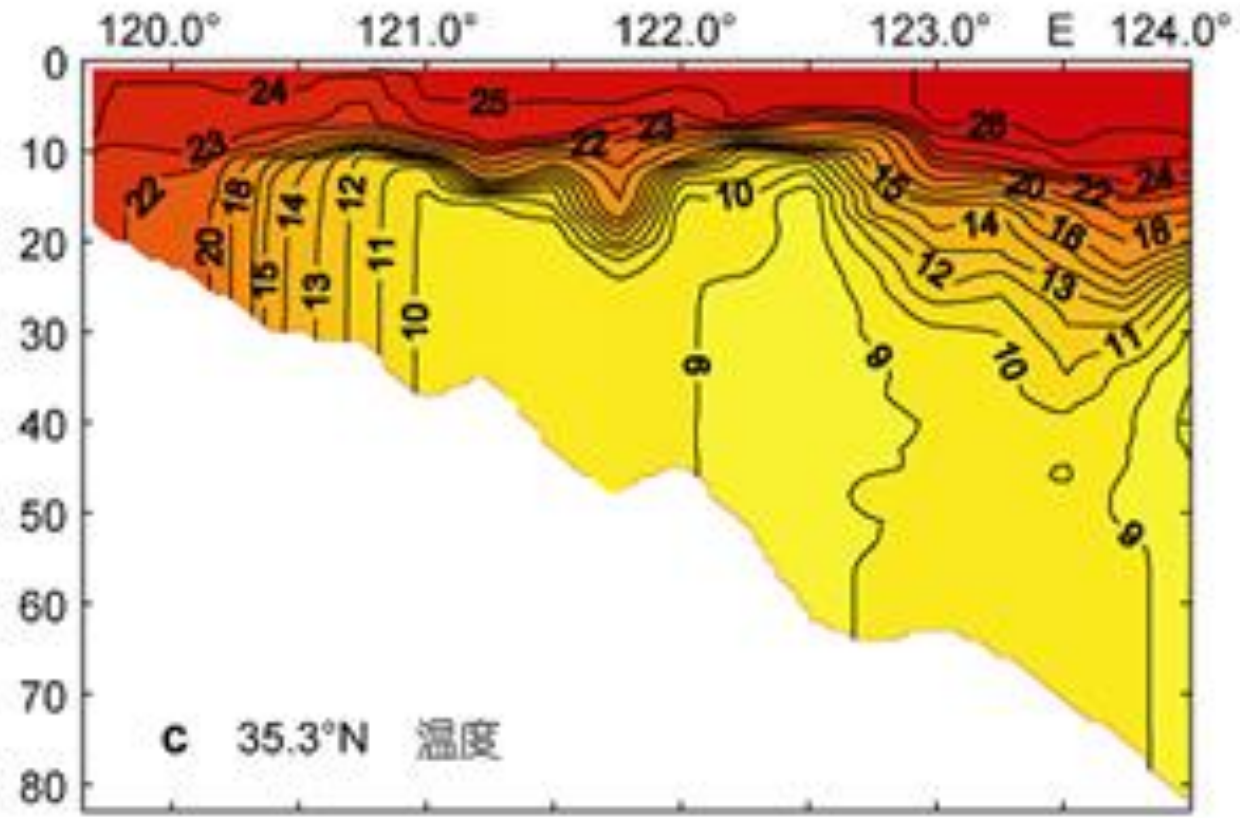
Water temperature distribution at bottom layer of the southern CWM



Spring **Summer** **Autume** **Winter**

Wei *et al*., 2013

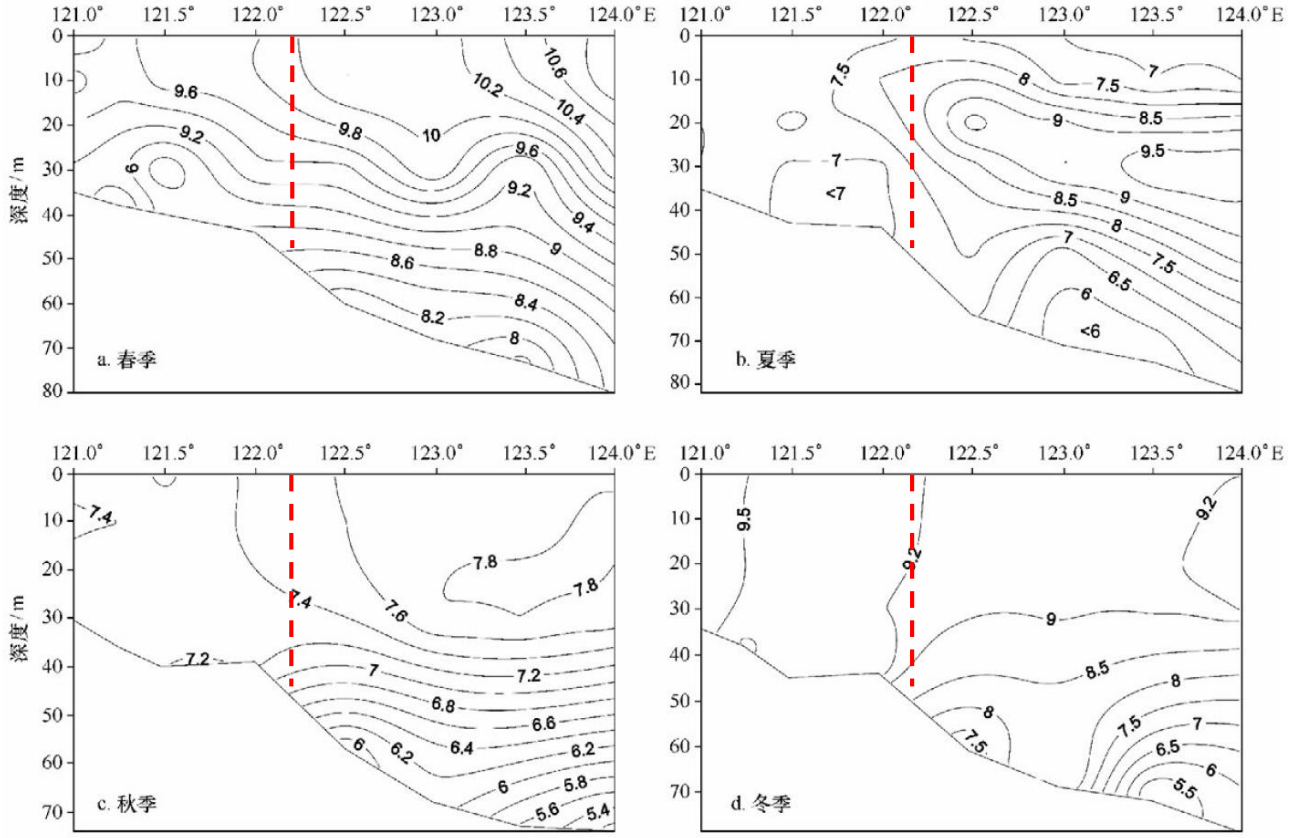
Thermocline of the Clod Water Mass in summer



Shallow —— about -25m, unique

Wei *et al*., 2013

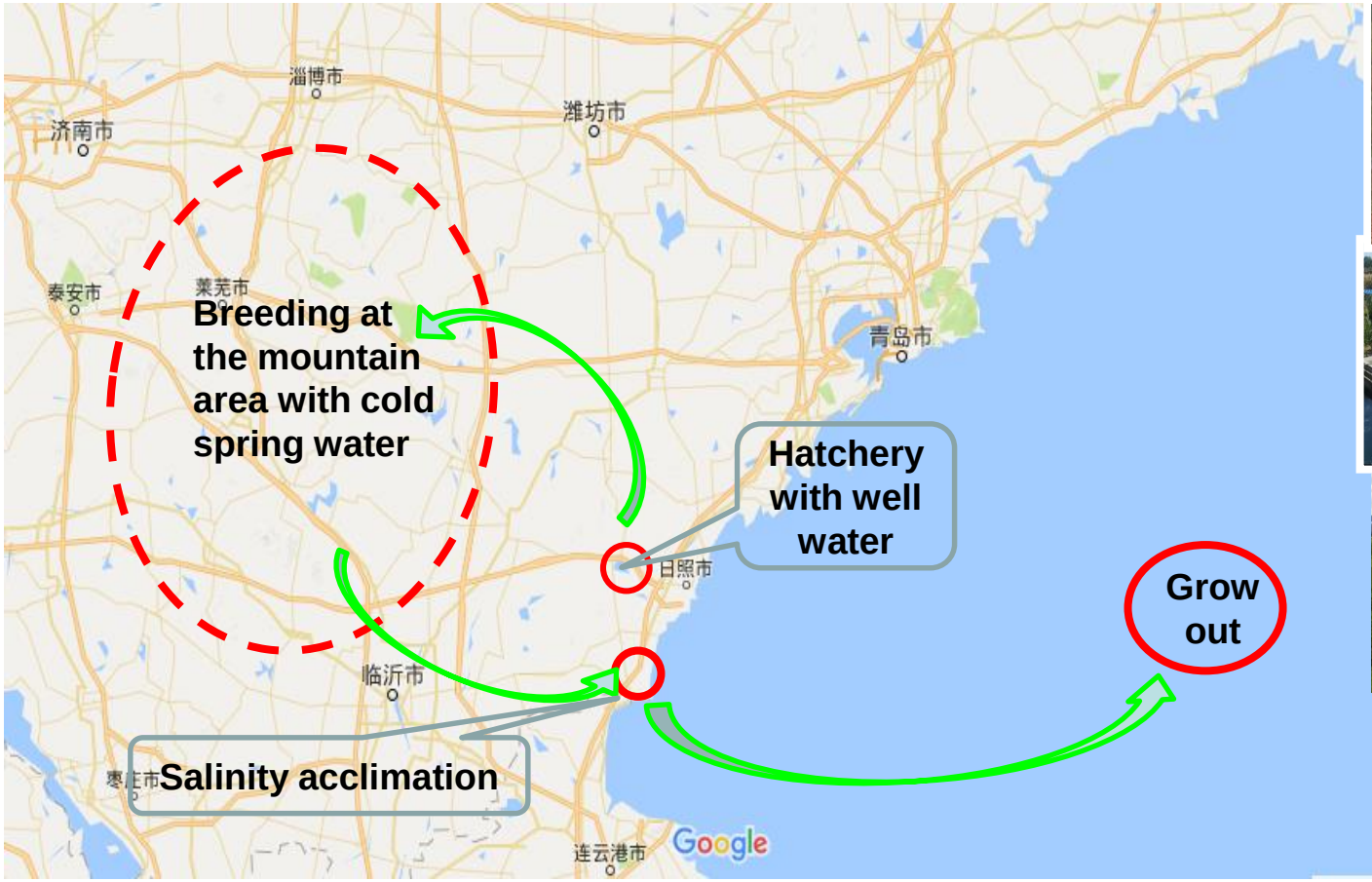
Dissolved oxygen (mg/L) distribution of southern CWM (35.3° N)



Dissolved oxygen is sufficient at bottom of CWM for salmon farming

Wei *et al*., 2013

Culture pattern—— “Mountain and sea relay”



Mariculture vessel（鲁岚渔养61699)

July 2, 2017 Start using

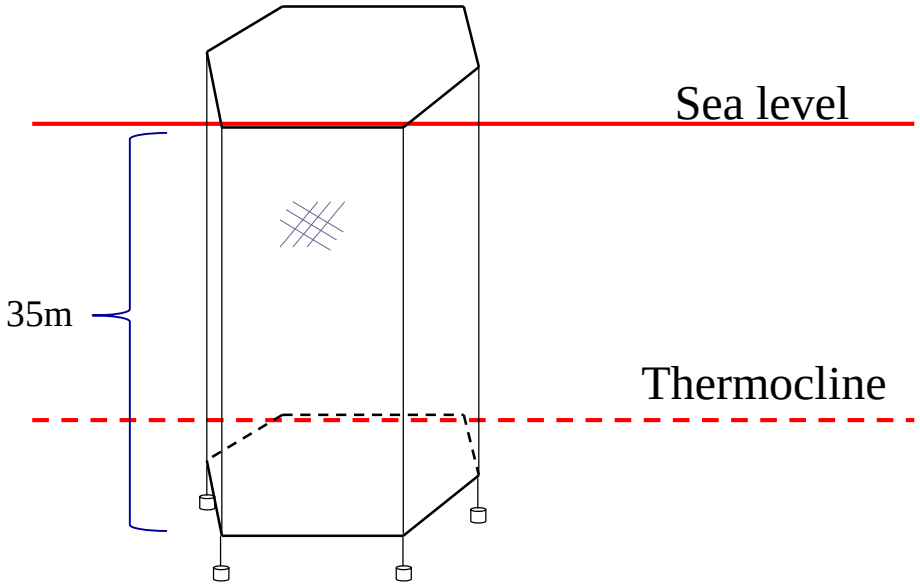
Displacement 3500 t

Aquaculture volume is 2000 m^3

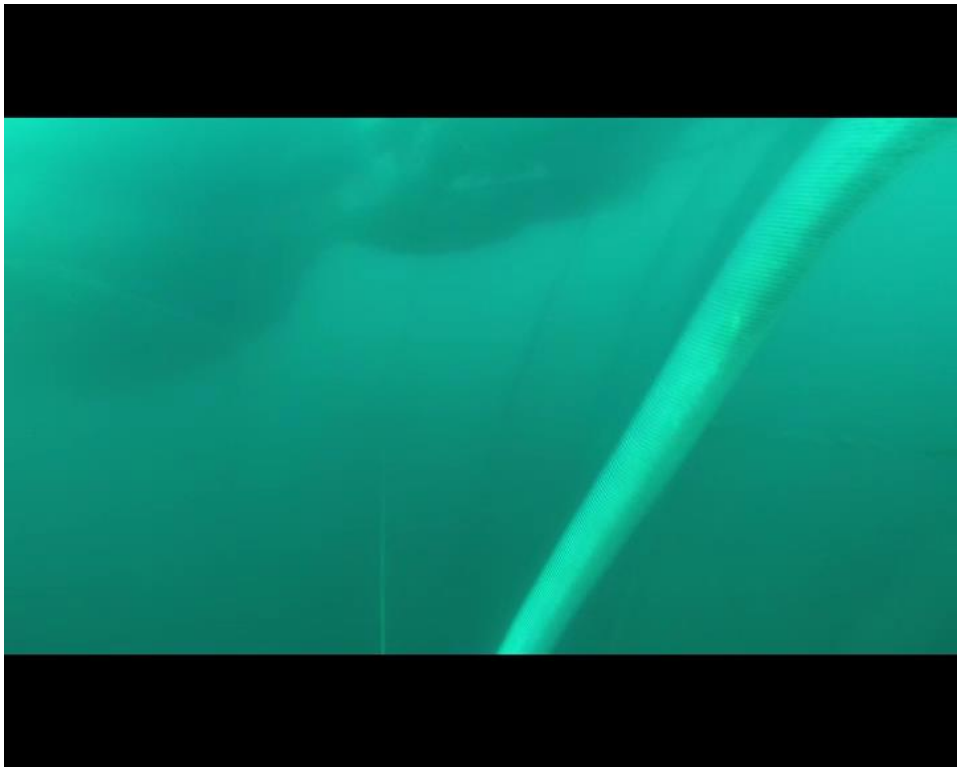
In 2017, it is verified that the vessel can used to culture salmon and trout by pumping the Cold Water Mass.

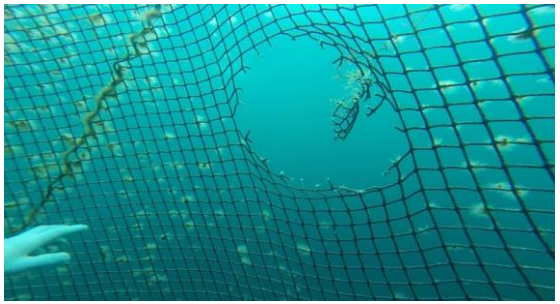
Confirmatory test *in situ* by net cage in 2017

The net cage crossing thermocline



The technical road map was verified successfully in 2017





Attached by shark in Aug.

The stealhead trout were cultured at CWM area. The fish submersed into -23m level in early summer. The fish were fed and grew well.

Submersible “Deep Blue 1” in 2018

Perimeter: 180 m
Volume: 50,000 m^3
Summer on bottom floor
Air dome for replenish air in swim blade

2018年4月下水
Launching ceremony on April 28, 2018

深蓝1号试验 Deep Blue 1 trial

深蓝1号2018年5月31日托往冷水团海域，7月沉底养殖。2019年1月4日上浮、收获。试验取得成功。**May 31, 2018 moved to the Cold Water Mass area, settled down to the sea bottom in July, floated up to the surface and harvested at Jan. 4, 2019.**

The cage condition in Summer and in winter

Sea level

In winter

In summer

Biofouling cleaning and fish harvesting

Biofouling cleaning condition

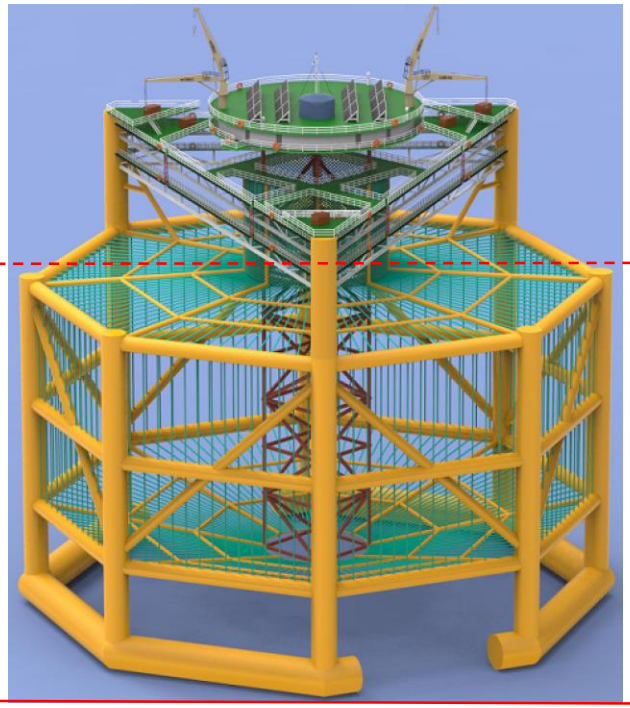
Fish harvesting condition

Sea level

New Deep Blue 1 in 2019

The Deep Blue 1 has been modified into a new integrated one (feeding, monitoring, power generation). It is planned to harvest the first batch of fish in coming January.

Semisubmersible “Deep Blue 2”



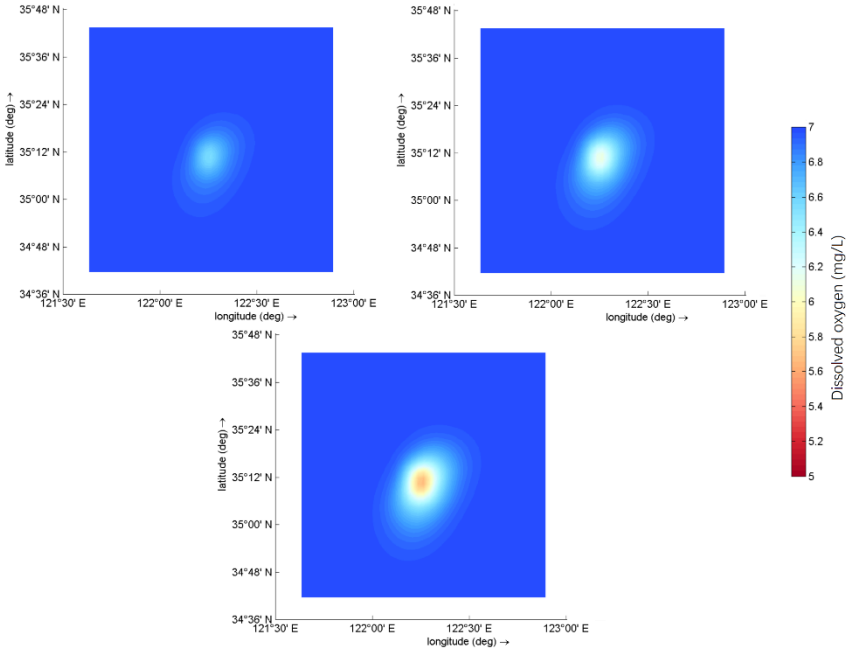
Sea level

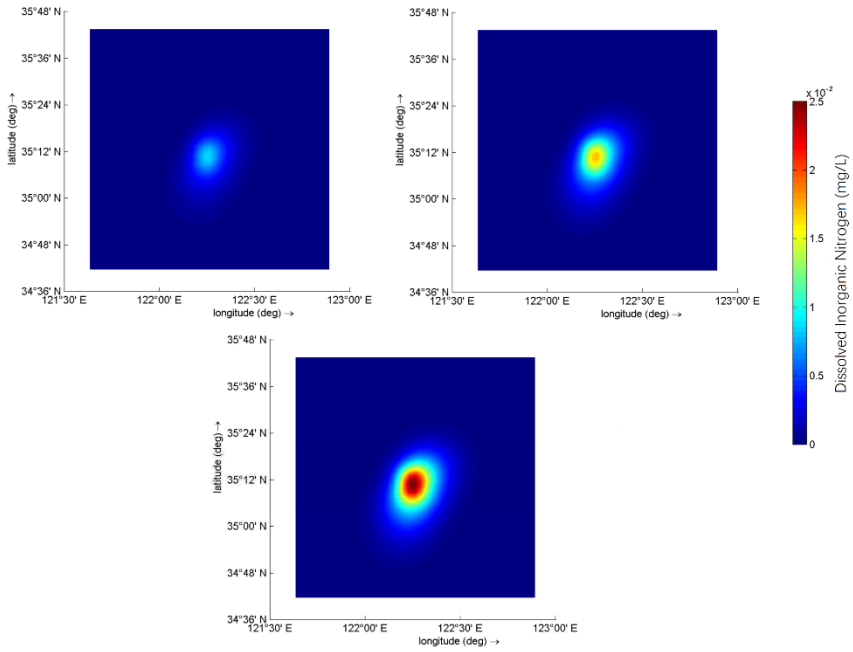
Launching in 2020
Volume 150,000 m^3

Sea floor

Integrated design (green energy, net cage, control system)
Functions of Total harvest or Partial harvest
Smart operation (feeding, lighting, aeration etc.)

Carrying capacity of selected area (80 km^2)





Dissolved oxygen

Dissolved inorganic nitrogen

Salmon and trout farming far offshore in China

空气罩补气对虹鳟生长的影响(28天)

Effect of air dome on rainbow trout growth after 28 day's submerged culture

处理 Treatment	终重 Final Weight (g)	增重 Weight Gain (%)
对照 Control (open)	196.09±7.85^{a}	40.95±2.75^{a}
不补气 Net cover	158.72±15.13^{b}	16.33±14.73^{b}
补气 Net cover + Air dome	175.83±8.62^{ab}	28.90±8.29^{ab}

28 day's experiment showed that the rainbow trout long time submerged grew slower by 60.1%, while the fish with Air dome grew slower by 29.4% only comparing with control.

The lowest temperature of stop eating

Atlantic salmon		Stealhead trout	
Weight（g）	Stop eating Temp（℃）	Weight（g）	Stop eating Temp（℃）
2.02±0.07	6.4	2.02±0.06	3.4
5.01±0.12	5.9	4.89±0.17	2.8
13.08±0.25	5.0	14.29±0.11	2.4
32.05±0.59	4.7	30.42±0.36	1.9
60.55±1.42	4.3	61.44±1.07	1.4
115.14±0.94	4.1	121.42±1.24	1.1

Effects of salinity acclimation on thermal tolerance of rainbow trout

Pre-acclimation temperature (℃)	Acclimation temperature (℃)	CTmax (℃) Mean±SD
14	14	25.37 ± 0.85^{a}
19		27.33 ± 0.41^{b}

Optimal salinity for trout parr (3-20g)

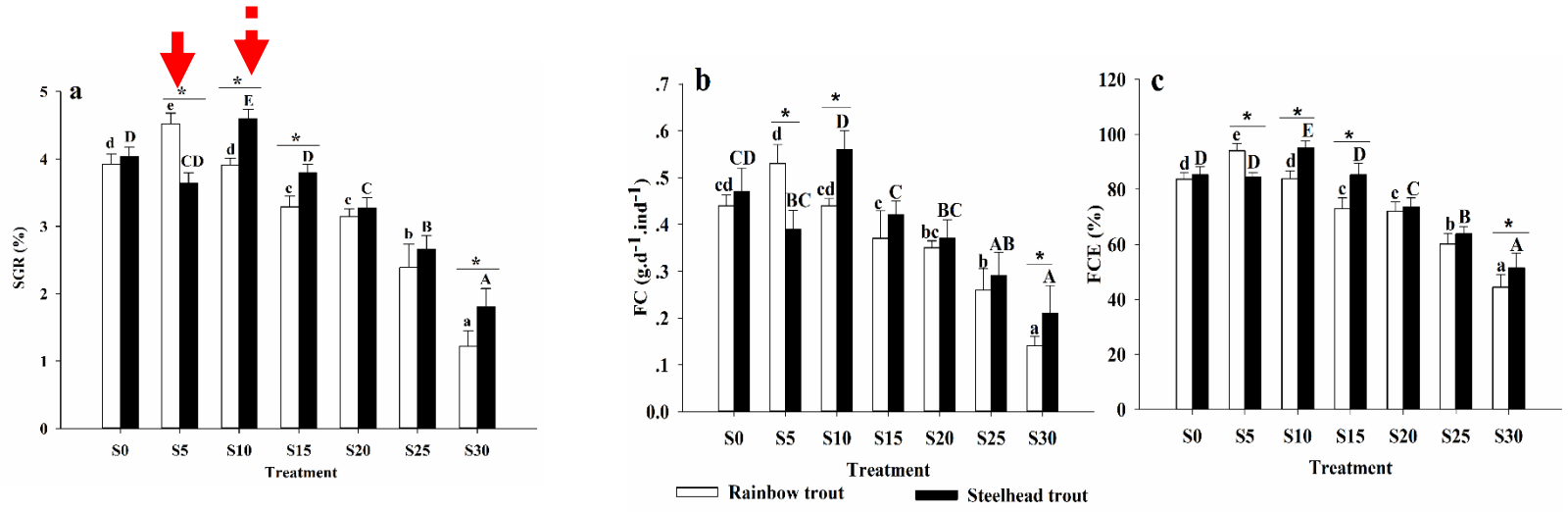


Fig. 1-1 Specific growth rates (SGR), food consumption (FC) and food conversion efficiency (FCE) of rainbow and steelhead trout during the whole experiment

Optimal salinity for rainbow trout fingerling is 5 ppt;

Optimal salinity for stealhead trout is 10 ppt;

In higher salinities water stealhead trout grow faster than rainbow trout.

Researching topics in the Laboratory of Aquaculture Ecology, OUC

Comparison of farming species in physiology and ecology (temperature, salinity tolerance etc.);

The relationship between the carrying capacity and global climate change;

The critical size (window time) and mechanism of salmonid fishes entering the sea (size, time, salinity, nutrition etc.);

The ecological basis of smart farming:

- **Parameters for smart feeding (digestive physiology, feeding behavior, social behavior, etc.)**
- **Parameters for smart lighting (light intensity, light color, light cycle, gonad development, etc.)**
- **Parameters for smart aeration (environmental change rules, respiratory physiology, aeration technics etc.)**

Ecological nutrition;

Biofouling cleaning Ecology;

Disease prevention ecology;

……

Thanks for your attention !

中国海洋大学 1924 OCEAN UNIVERSITY OF CHINA

萬澤豐

深海冷水团 DEEP SEA COLD WATER