



Korean Offshore Aquaculture, the Past, the Present, and the Future

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BACKGROUNDS

Characters of Korean Aquaculture

- ❖ **Traditionally family-oriented and small scale business: high production cost**
- ❖ **Complicated license systems on aquaculture activities**
- ❖ **Various culture species and culture grounds**
- ❖ **High consumption propensity for fisheries products**
 - **Per capita food fish supply: 38.5kg (world average: 13.4 kg)**
 - **Various fisheries dishes: raw fish, soup, grilled, boiled, dried, etc.**
- ❖ **Highly developed culture technology**
 - **Seed production, on-growing, culture facilities, etc.**
- ❖ **Full support from the government**
 - **Research fund, experimental permission etc.**

Environmental characters

West Sea (Yellow Sea)

- Wide tidal mudflats and high tidal range
 - ✓ Self-purification ability of water pollution
- High water temperature ranges: 4-30 °C
 - ✓ Limiting factor for warm-water fish culture

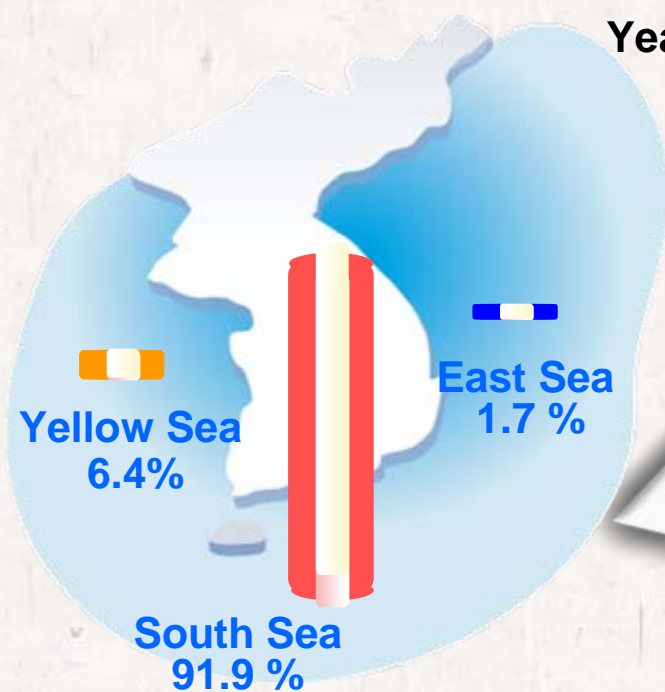
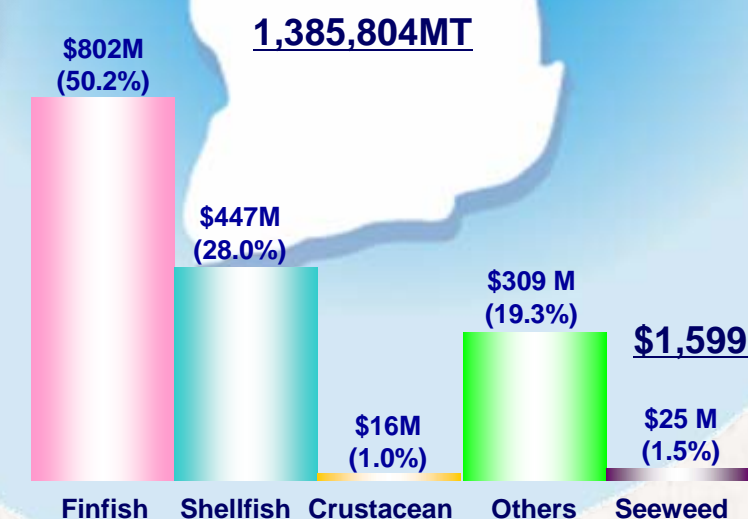
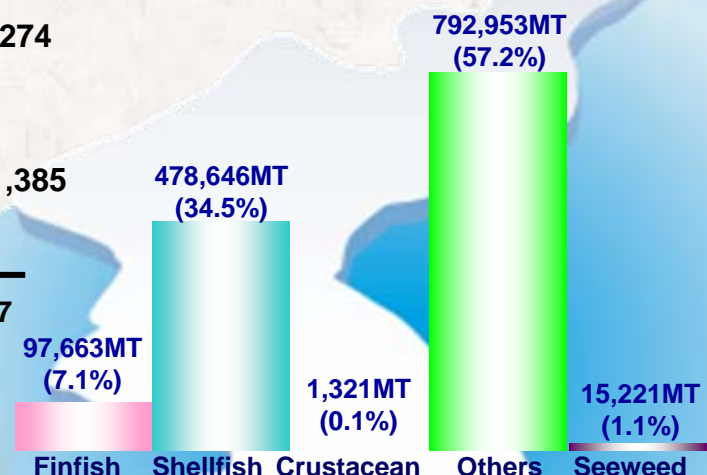
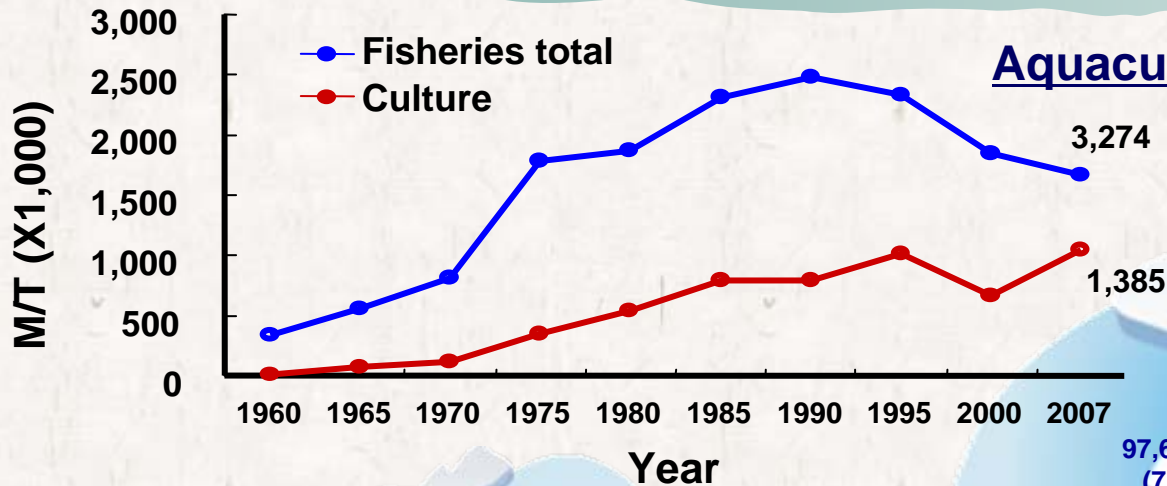
East Sea

- Monotonous coastlines, strong waves
 - ✓ Limited aquaculture species
 - ✓ Active fishery

South Sea

- Complicated coastlines
 - ✓ Suitable for net-cage cultures
- Relatively warm water temperature: 8-27 °C
 - ✓ Suitable environments for warm-water fishes
 - ✓ Main aquaculture farms are gathered

Aquaculture Production





What are the problems of Korean aquaculture in these days?

- ❖ **Over production in limited area**
 - **Low growth rate and pollution-driving disease outbreaks**
- ❖ **Seasonal strong storms and typhoons, red tide, environmental impacts**
- ❖ **Complex legal and regulation aquaculture systems**
- ❖ **Negative images on the products cultured by disease, red tide, antibiotics**
 - **Losing consumer' trust as valuable fish foods**
- ❖ **Domestic and overseas circumstances**
 - **Internally: demanding environment-friendly, seafood-safety in aquaculture**
 - **Externally: importing low-cost fishery products**
 - **Quantity-oriented, few investment for aquaculture engineering**

What can we do?

Current aquaculture paradigm shift

◆ *Relocation of aquaculture grounds*

❖ *Inshore*

- **Finfish aquaculture within environmental capacity**
- **Ecosystem-based aquaculture such as polyculture**
- **Improvement of culture grounds by seaweed culture**
- **Leisure/tourism-oriented coastal management**

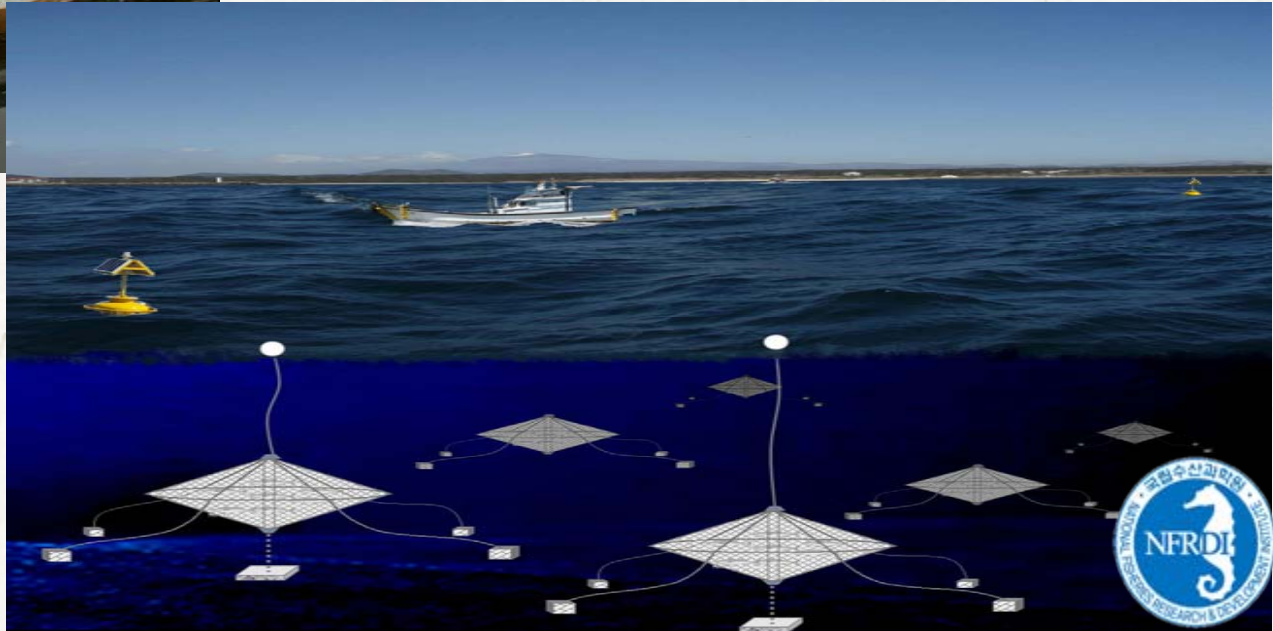
❖ *Offshore*

- *Large industrialized cage culture*

Offshore Aquaculture



OFFSHORE AQUACULTURE



Why Offshore Aquaculture?

- **Correspond to international standard for sustainable aquaculture**
 - ✓ **Ecosystem-based management**
 - ✓ **Environment-friendly aquaculture**
 - ✓ **Food-safety products**
- **Utilize the ocean three-dimensionally**
 - ✓ **Inshore: Integrated coastal management, marine leisure zone, etc.**
 - ✓ **Offshore: High-value fed aquaculture**
- **Strengthen the international competitiveness**
- **High investment for cage, autofeeder, workboat, and other facilities**
- **Risky activities for managing fish cultivation under the deep sea**

Brief History ?

- ❖ **May 2002: 1st Korea-U.S. Aquaculture Cooperation Meeting**
- ❖ **December 2004: Approved the new offshore aquaculture project**
 - **Project for Korean Offshore Aquaculture: 2005-2007**
 - ✓ **Project team formation**
 - ✓ **Site and cage selection, visit several oversea offshore companies**
 - ✓ **Legal permission from central government**
- ❖ **April to July 2005: Imported and installed offshore cages**
 - **Three SeaStation3000 and three SeaStation5400**
 - **Installed at southern Jeju coast**
 - **No financial support from the local and central governments at initial stage**
- ❖ **Financial support from government from 2006**
 - **\$1.4 million for each installation site**
 - **Tongyoung and Geomundo offshore aquaculture followed**



Current and Future Experimental Sites for Offshore Aquaculture



1. Offshore Aquaculture (Jeju)

♣ *Project: Technology Development for Offshore Aquaculture*

❖ **Experimental period: Three years (year 2005~2007)**

❖ **Team formation and major roles:**

- ✓ Jeju Fisheries Institute, NFRDI: Culture techniques, target fishes, feed, etc.
- ✓ Engineering department, NFRDI: Net-cage development suitable for Korean environments
- ✓ Environment department, NFRDI: Environmental assessment
- ✓ Noah Offshore Farm: Culture and business

❖ **Annual fund:**

- ✓ For research: R&D fund from NFRDI of \$700 thousand
- ✓ For business: Several million dollars from Noah Offshore Farm

❖ **Regal and social permission:**

- ✓ Experimental area: 10 ha



Major FACTORS **for Successful Offshore Aquaculture ...**

- ❖ **Where to settle? < A. Culture site >**
 - **Environmentally: temperature, currents, depth, substrates, etc.**
 - **Safety of net-cages against strong waves**
 - **Other facilities: seedlings, port, transportation, etc**
- ❖ **Which systems to choose? < B. Cage system >**
 - **Safety-first and then convenient**
- ❖ **What kinds of species to culture? < C. Target fish >**
 - **Adaptable to open sea and procurable enough artificial seeds**
 - **Economically and socially allowable fish**
- ❖ **Other considerations: law and regulation, residents, etc.**

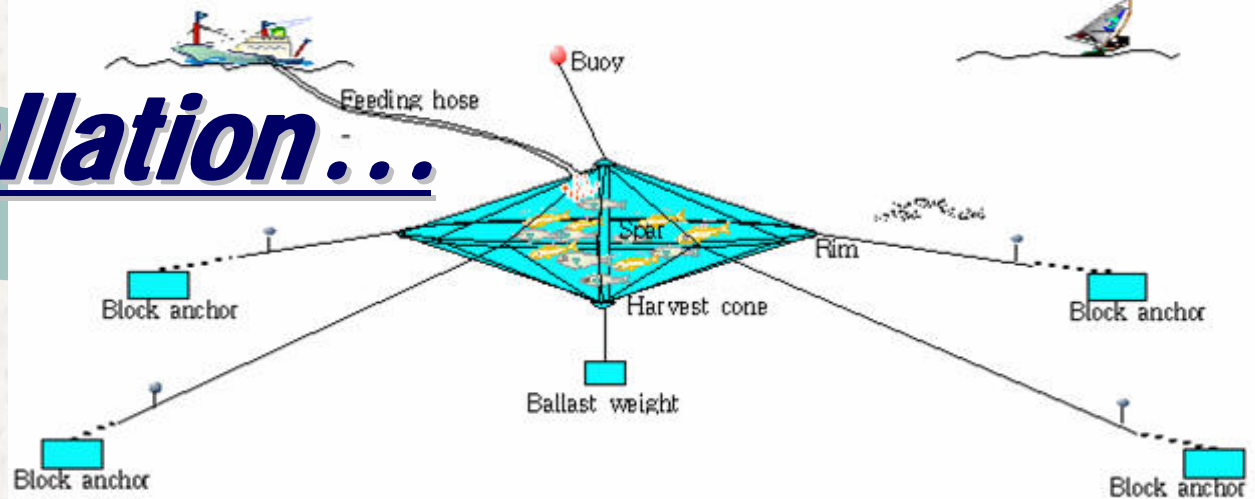
Culture Site...



- ✓ Location: Pyosun-ri, Seogipo City, Jeju Province
- ✓ Distance from the land: 4.5 km
- ✓ Water depth and temp.: 40~50 m, 13~26 °C
- ✓ Current velocity: 0.6~2 knots

Jeju site

Cage Installation...



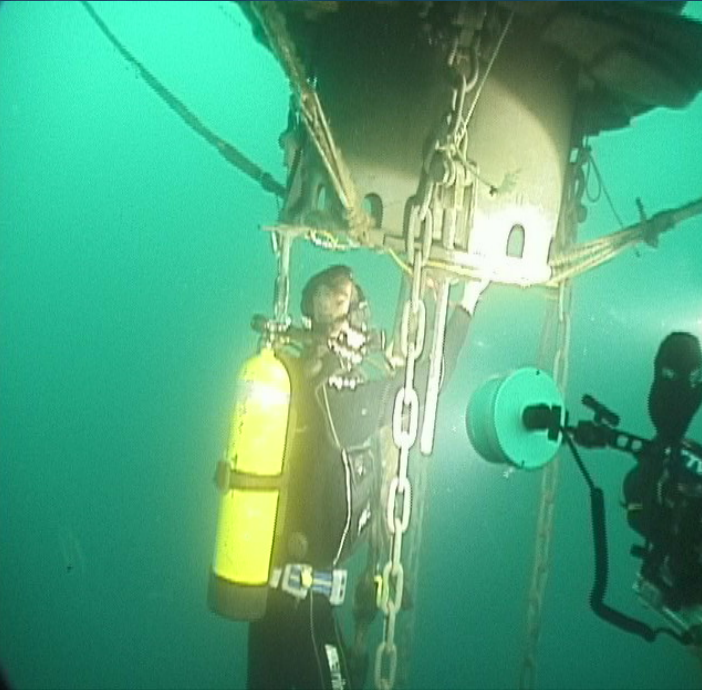
- ❖ SeaStation™ (OceanSpar LLC, USA)
- ❖ Main structure: Spar, rims, work desk, harvest cone, ballast weight, net, etc.

	SeaStation3000	SeaStation5400
No. cages	Three	Three
Date installed	May 5 – July 13, 2005	May 4 – 25, 2006
Height	15 m	22.5 m
Diameter	Φ25 m	Φ33 m
Total area	3,000m ³	5,400m ³
Anchor weight	25 ton, Four	37 ton, Four

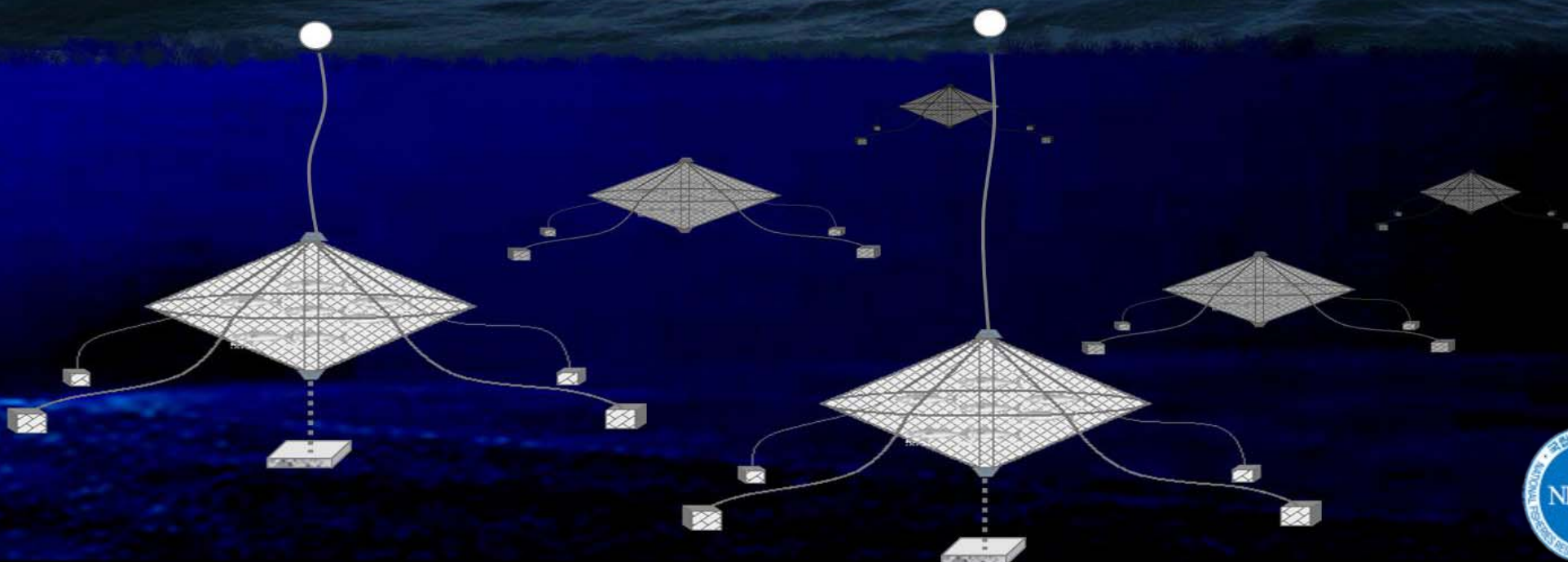
Cage Installation - Land and beach works



Cage Installation – Sea works



Cage Installation – Layout



Target fish...

❖ **Criteria for choosing culture fishes**

➤ **Economic considerations**

- ✓ Domestic and oversea market value?
- ✓ Competitiveness over other culture species?

➤ **Cultural considerations**

- ✓ Ecological and physiological stability to offshore aquaculture?
- ✓ Obtainable mass seedlings production technology?
- ✓ Growth rate and disease resistance?
- ✓ Adaptability for formulated feed?

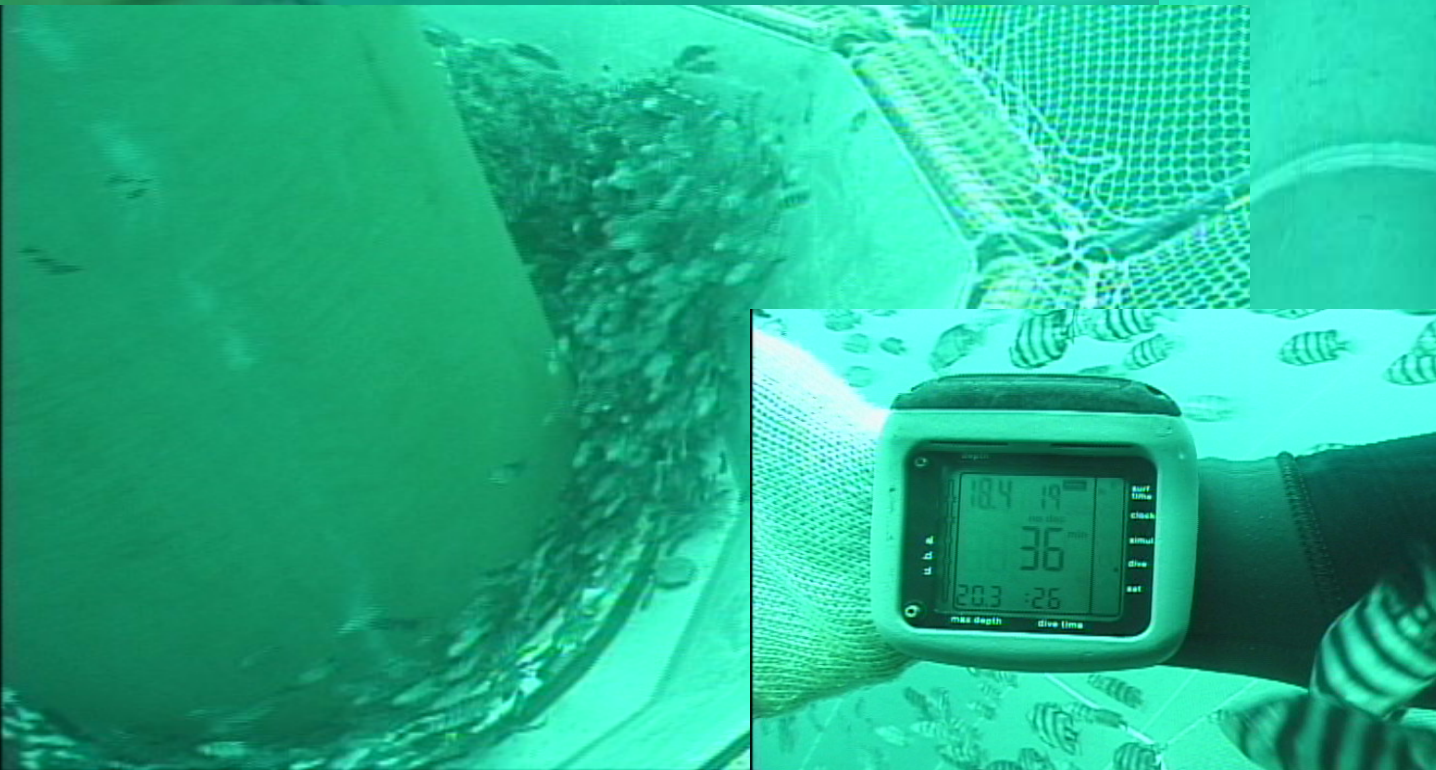
➤ **Social considerations**

- ✓ Adverse influence to current culture business?
- ✓ Social restriction?

- ❖ **Major culture fish at first phase : Parrot fish (*Oplegnathus fasciatus*)**
 - ✓ **Relatively expensive (larger fish size, higher market price)**
 - ✓ **Suitable for raw fish (taste, texture, etc.)**
 - ✓ **Artificial mass seedling production possible**
 - ✓ **Optimal temperature range in Jeju sea where cages are installed**
 - ✓ **Competition with inshore aquaculture fish species**



Fish Stocking and Adaptation



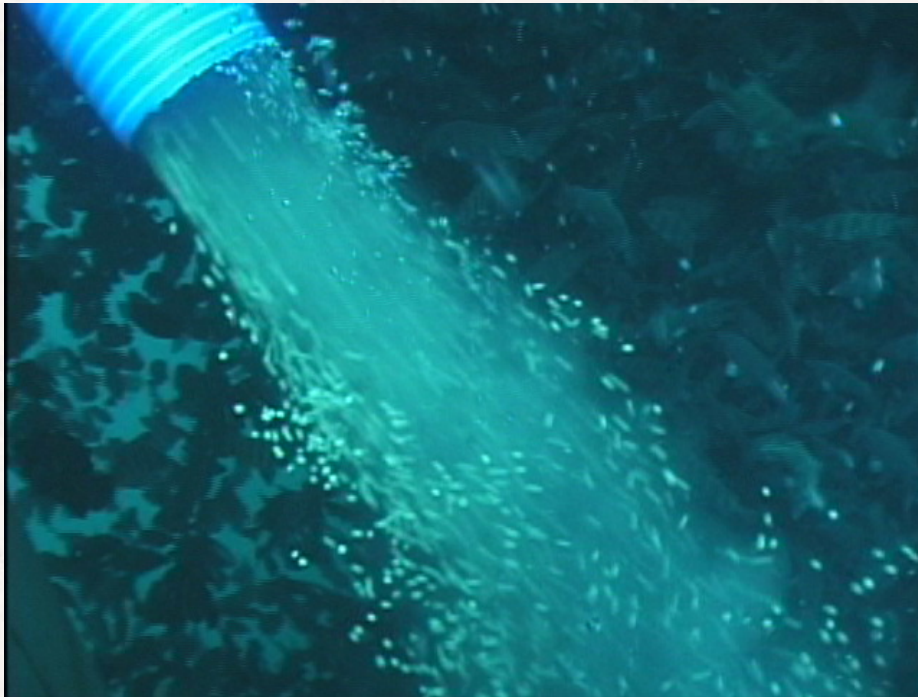
Adaptation and Rearing



Feeding

❖ Semiautomatic feeder

- ✓ Feeding by siphoning with water, 2 to 5 times per week
- ✓ No enough feeding by strong wave and water currents
- ✓ No feed storage and barge



Harvest and marketing

❖ Harvesting with live conditions for raw fish

✓ Loss by harvesting and transportation

❖ Marketing

✓ Good quality for Korean live fish market

✓ Tastes, texture, color, etc. to on-land culture fish

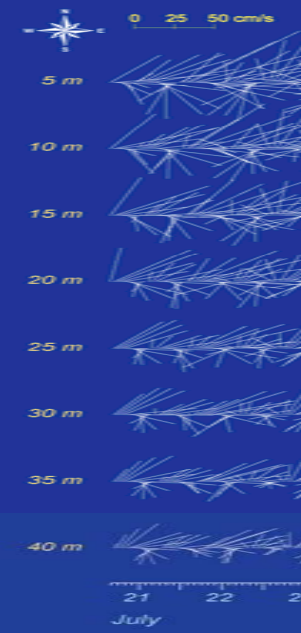
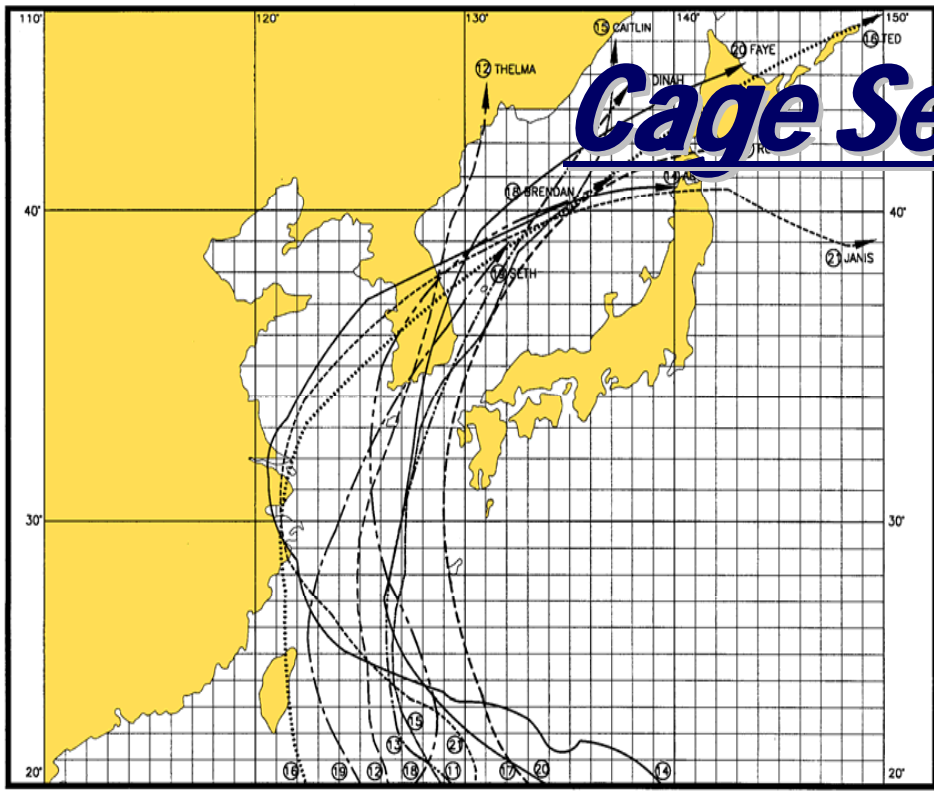


Workboat

Name	Tonnage	Size	Others
NORH (SGR-068944)	29 ton	Length: 18.16 m, width: 7.30 m, height: 2.20m	Duel hull and engines, crane for lifting



Cage Security



❖ By storms

- Three times of typhoons with 6 to 8 m wave
- Destroyed all buoys on the surface
- No damage of cage and animal
- Many times of big storms but no damage

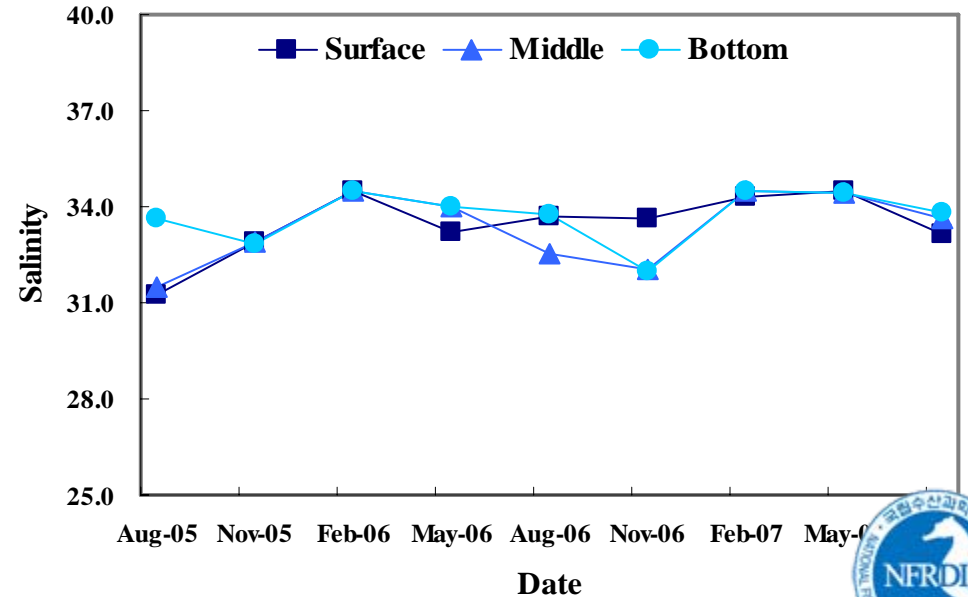
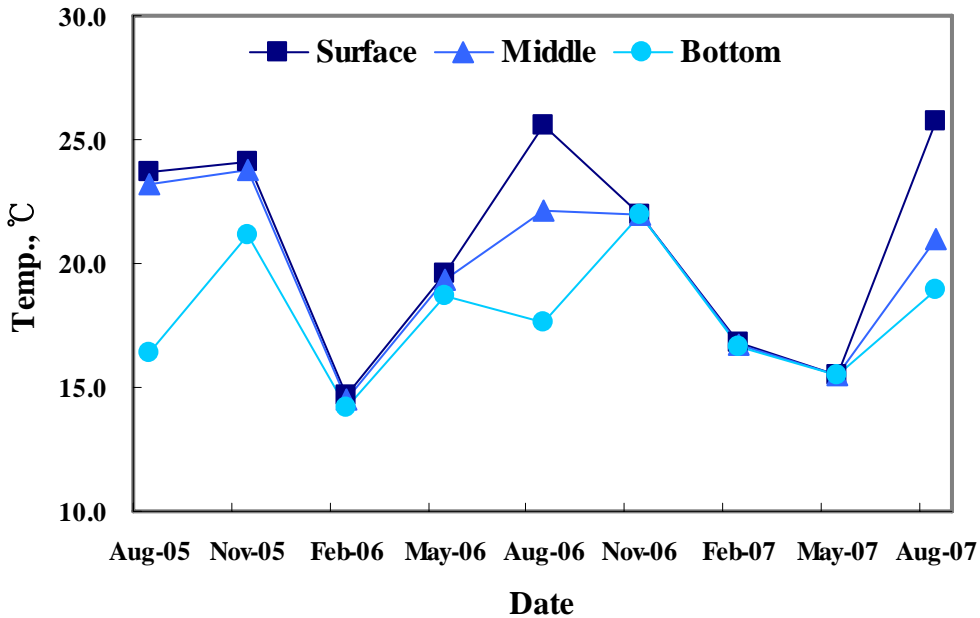
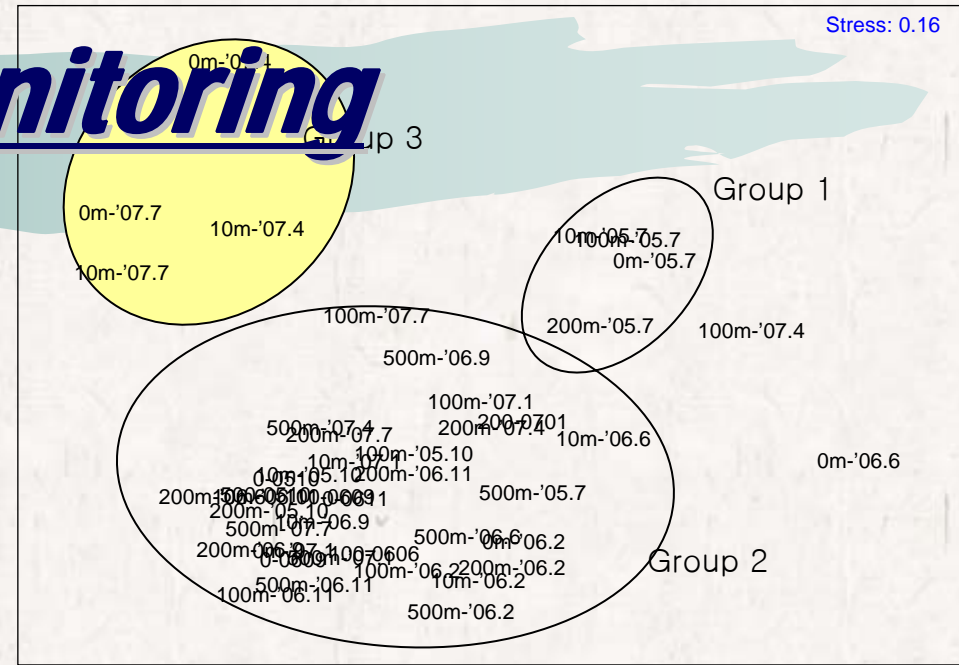
❖ By water currents

- 50 to 70 cm/s (max. 120 cm/sec)
- Enforced anchor lines



Environmental Monitoring

- ❖ Monthly WT: 15.3-22.6 °C
- ❖ Salinity: 33.1-34.0 psu
- ❖ Water quality
 - COD, BOD, SS, TOC, PON, TN, etc
 - No distinctive changes observed
- ❖ Polychaetes increased a little



Results

- ✓ **Input: June 9**
- ✓ **Transportation**
: truck for live fish ⇒ ship ⇒ cage (siphon)

Experimental fish

Fish	Production year	Size (means±SD/n=50)			
		Total length (cm)	Body length (cm)	Body height (cm)	Body weight (g)
Parrot fish	May 2004	17.7±1.5	15.2±1.3	7.4±0.7	124±32
Parrot fish	March 2005	5.9±0.4	5.2±0.4	2.8±3.2	4.6±0.8

● Growth and survival rate

Cage	Initial (Jun.24-Jul. 7, 2005)		Sep. 13, 2005		Nov. 21, 2005		Feb. 20, 2006		May 20, 2006	
	No. fish (10 ³)	Mean weight (g)	No. fish (10 ³)	Mean weight (g)	No. fish (10 ³)	Mean weight (g)	No. fish (10 ³)	Mean weight (g)	No. fish (10 ³)	Mean weight (g)
1	550	5	500	41	500	93	460	131	400	180
2	75	10	50 ¹⁾	60	50	150	50	164	48	210
3	80	123	65 ²⁾	250	65	327	64	357	20	380

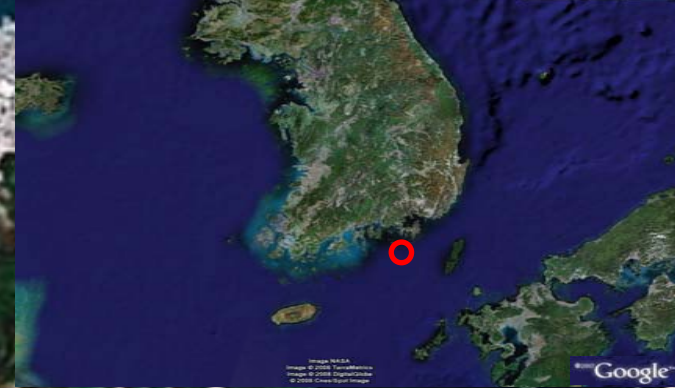
1) Escaped through opening loosely tied harvest cone with net,

2) Suffocated during siphoning to cages.

2. Offshore Aquaculture (Tongyoung)

- ❖ **Culture site: Tongyoung city, South Gyeongsang Province**
- ❖ **Period of experiment: 2006-2008**
- ❖ **Cage: Three types of experimental systems developed by KORDI**
- ❖ **Institution: Korea Oceanic Research Development Institute (KORDI)**
- ❖ **Major target fishes: Brown croaker (*Miichthys miuiiy*), Red seabream (*Pagrus major*)**

Culture Site...



Tongyoung site

Cage Installation

❖ Basic guidelines

- Wind: 35 m/sec
- Wave: 5 m high
- Current velocity: 50-150 cm/sec

Circular type



Submergible type



Rectangular type



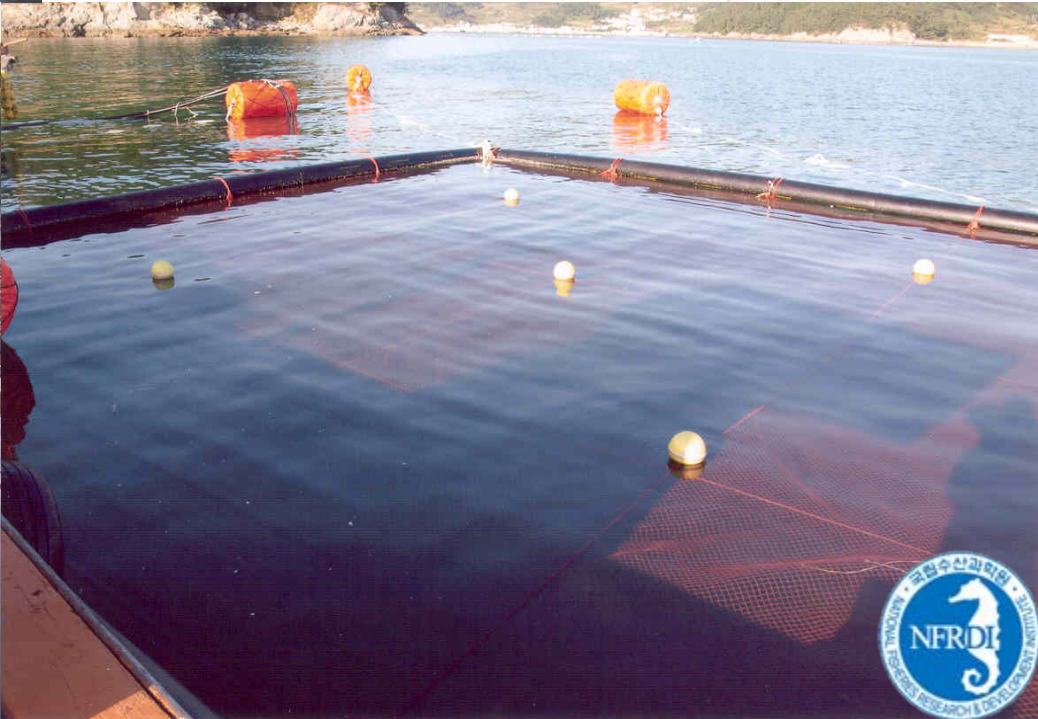
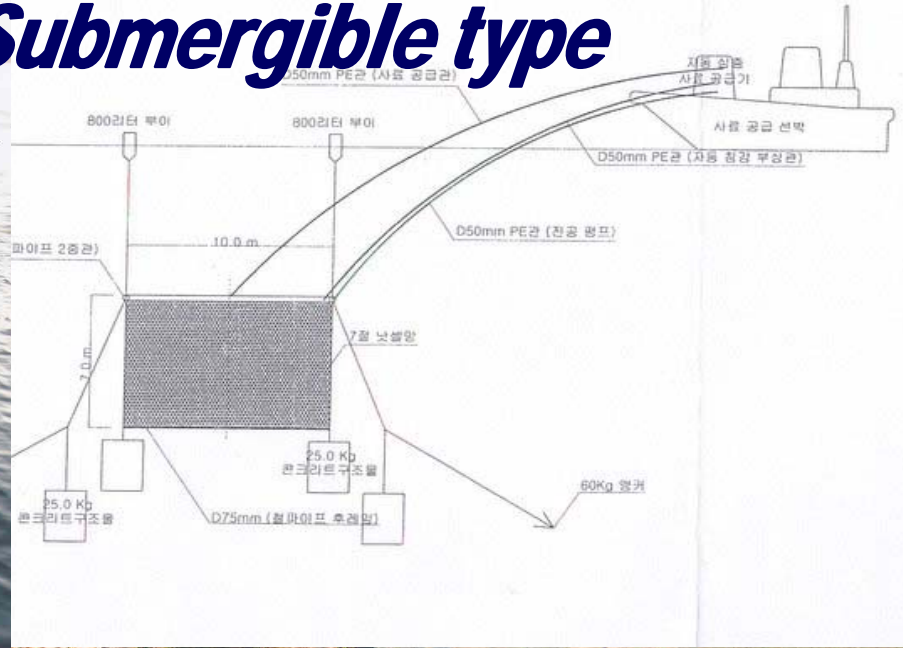
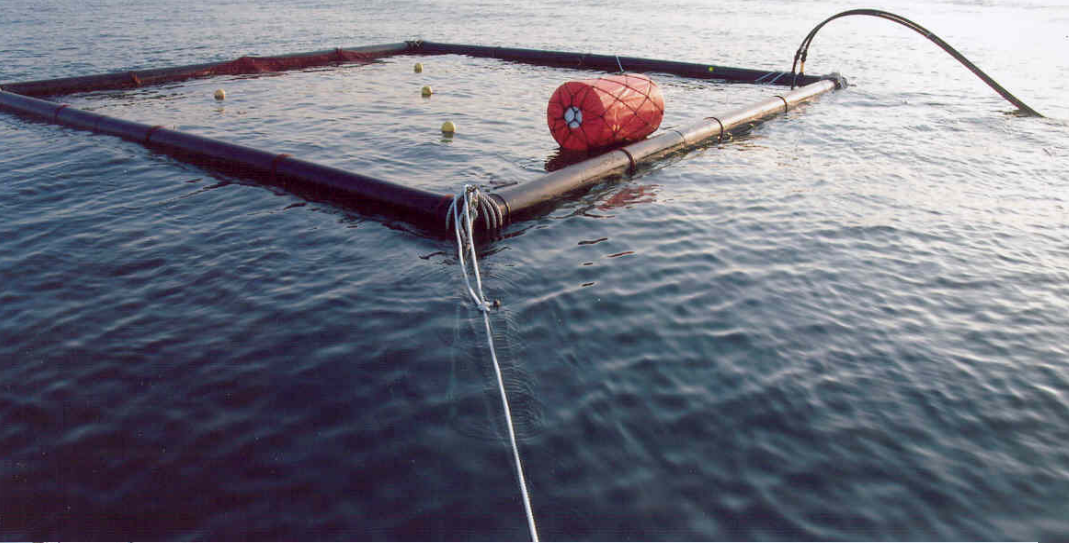
Cage Installation - Rectangular type



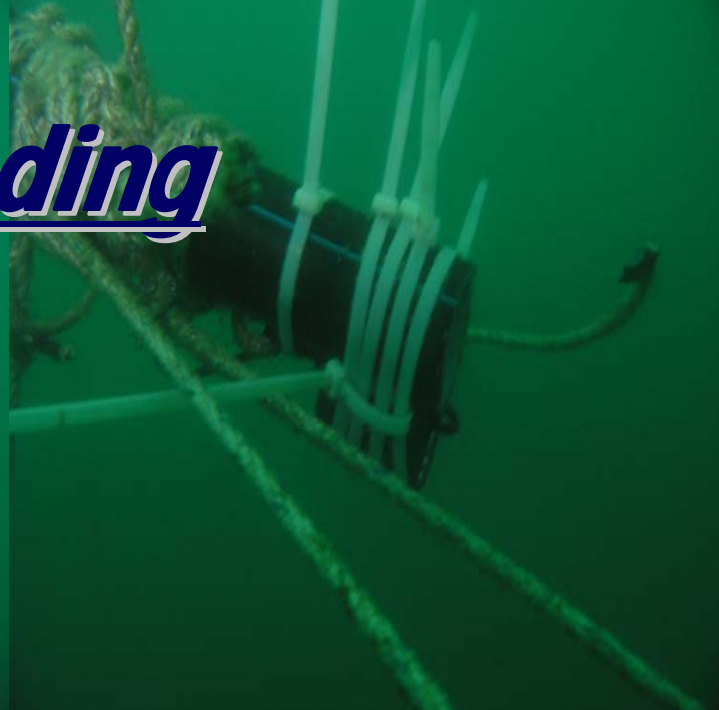
Cage Installation – Circular type



Cage Installation – Submergible type



Target fish and Feeding

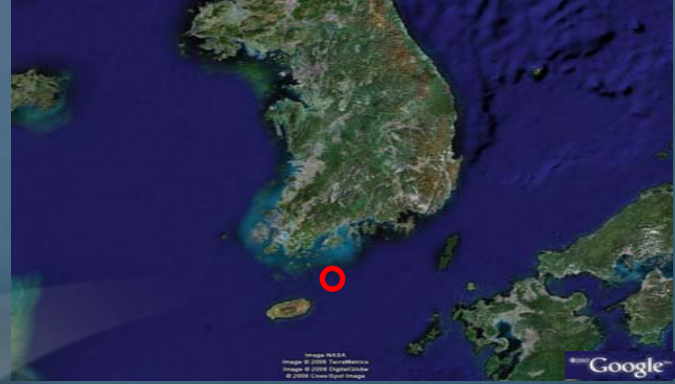


3. Offshore Aquaculture (Geomundo)

- ❖ **Culture site: Geomundo, South Jeonlla Province**
 - **Licensed 5 hectare**
- ❖ **Experimental period: 2007-2009**
- ❖ **Cage: Four SeaStation™5400/Grid mooring type**
- ❖ **Name of company: Geomundo Offshore Farms/NFRDI**
- ❖ **Major target fishes and production capacity**
 - **Parrot fish (*Oplegnathus faciatus*), Red sea bream (*Pagrus major*), Mackerel (*Scomber japonicus*)**

Culture site...

GEOMUNDO



Geomundo site

Cage Installation...

❖ **SeaStation5400™ (OceanSpar LLC)**

- **Volume: 5,400m³**
- **Composition: central spar of 22.5 m high, circular rims, harvest cone, net, etc**
- **Anchored with four concrete blocks of 37 tons**



Cage Installation - land and beachworks



Cage Installation – Sea works



Feeding

❖ Auto-feeder

- Feed storage: totally 20 tons (5 tons with 4 chambers)
- Feeding: Four separate feeding with water pumping
- Manufactured by Hosan Manufacturing Co.



Workboat

- ✓ 19.4 meter L, 4.8 meter W, 1.4 meter D
- ✓ 19 tons, 16 knots speed, 720 HP
- ✓ FRP, duel hull system



Culture

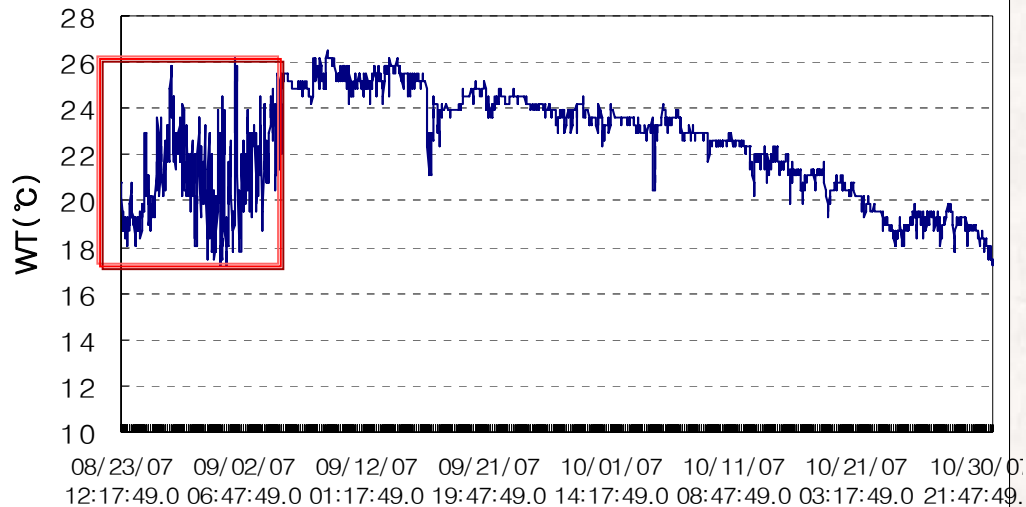
- ❖ Major target fishes:
 - Grouper (*Epinephelus septemfasciatus*), red seabream (*Pagrus major*)
- ❖ Annual production:
- ❖ Stocking:
 - July –August 2007
 - Stocked 1 year old fish over-wintered
- ❖ Feeding: two to five times per weeks depending water temp.



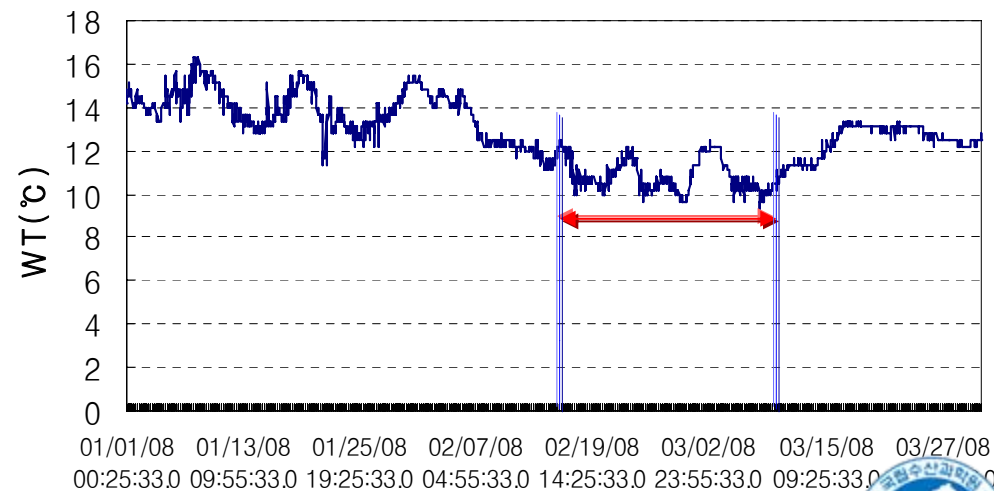
Environmental monitoring

- ❖ **Water temperature: 10 to 26 °C**
 - sudden cold water mass
- ❖ **Water quality: No distinctive changes after culture activities**
 - COD, BOD, DO, SS, TN, etc.

Water Temp. (summer, Aug. to Oct. 2007)



Water Temp. (Winter, Jan. to Mar. 2008)



Cage Safety

- ❖ Water currents ranged from 40 to 60 cm/sec.
 - No damage of fish and cages
- ❖ Typhoon NARI was attacked around offshore site
 - Forty meter per sec velocity and three days (Sep. 2007)
 - No damage to cage, anchoring, rim, spar and culture animals



OUTCOMES

✓ What's done successfully?


- ✓ Possible to successful offshore aquaculture business in Korea**
- ✓ Confirm cage safety against seasonal storms, typhoons, and currents**
- ✓ Know-how for offshore aquaculture management: stocking, feeding, harvesting, etc**
- ✓ Hold the upper hand over foreign aquaculture products**

✓ What's waiting to be developed?

- ✓ Specialized offshore cages for southern coast, and bottom-dwelling fish**
- ✓ Super high-value candidate fishes for offshore aquaculture**
- ✓ Automatic system of feeding, monitoring, swimming activity, etc.**
- ✓ Sorting, thinning, net cleaning, harvesting**
- ✓ Action dynamics of culture animal**

FUTURE TASKS

- ✓ **Development of cage and other structures**
 - ✓ **Cage systems for Korean topography and fish species**
 - ✓ **Auto-feeder, workboat, environmental monitoring systems, etc.**
- ✓ **Potential culture species not affecting current fish farms**
 - ✓ **Yellowfin tuna, cod, grouper, etc.**
- ✓ **Culture and management technology**
 - ✓ **Automatic feeding**
 - ✓ **Sorting, thinning, net cleaning, harvesting and transportation**
 - ✓ **Monitoring on cage, culture animal, and environment**

- 
- ❖ **Legal Amendment and social consensus**
 - **Relative laws and regulations**
 - **Participation with fish farmers and residents**
 - ❖ **Combined offshore aquaculture deployment with marine forestation**
 - ❖ **Policy for offshore aquaculture by central government**
 - **Legal preparation for offshore aquaculture in 2008**
 - **Financial support for offshore aquaculture farms**
 - **More offshore aquaculture demonstration sites until 2009**

Acknowledgements

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- ❖ *Dr. J. McVey and scientists of NOAA ,USA*
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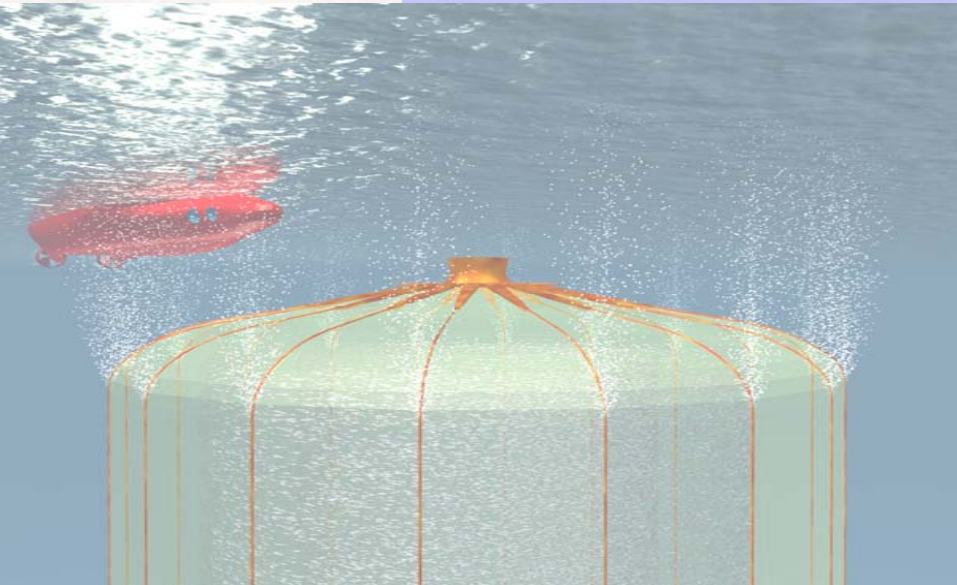


Thanks for your attentions!!!

Any questions???



Korean aquaculture in the future???



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