



Best Management Practices of Finfish Cage Culture in Korea - focused on black rockfish-

**Korea- China Symposium & Workshop on the
Sustainable Mariculture in the Yellow Sea
18~20 June, 2007,
West Sea Mariculture Research Center, NFRDI
Taeon, KOREA**

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History of Cage Culture in Korea

- **1974: started for holding wild caught yellow tail fingerlings**
- **2~3 month holding and sold to Japan**
- **Start to raise other fishes such as trigger fish, parrot fish, rockfish etc.**
- **1977: test culture of carp in Uiam lake**
- **1979: large number of cages installed in artificial dam lakes and reservoirs –**
 - **very successful until mid 1990s. – end of 1990s, no more freshwater cages exist**

- **Early marine cages: stocked**
- **and raised various fingerling**
- **fishes caught from wild**



www.shinyuu.web.infoseek.co.jp

Collecting yellowtail fingerlings



www.mie.suiko-van.or.jp/ka/s/mojako.jpg

Collected yellowtail fingerlings in a cage



www.stn.tea-nifty.com/sinbun/images/mojako-big_3.gif

- **Mid 1980, when artificial fingerling production of olive flounder and black rockfish were succeeded, these species were raised in cages**
- **But olive flounder culture moved to land based tank soon because:**
 - **not growing well without hard bottom in cage**
 - **short growing season (no growth in winter)**
 - **dump to market at end of fall season**
- **Black rockfish is the most common species in cages**



www.gyokyou.com



www.fishexp.pref.hokkaido.jp/.../hirame.jpg

Materials for cages

Frames

- **Marine : square wooden club of apitong**
(*Dipterocarpus* spp.)
- **Freshwater: galvanized steel pipe**

Floats

- **Marine: Styrofoam floats, sizes of 400, 600, 800 L dep. size of cages**
- **Freshwater: 200- L plastic drum can**

Size of cages

- **Most common size: 10 x 10 m**
Unit of cage: “Zo”, 10 x 10 m is 1 “Zo”
- **Fingerlings: 5 x 5 m cage**
- **Pelagic fishes: 11 x 11m to 14 x 14m**
- **Depth of net: 3~4 m for fingerlings**
5~7 m is common
- **Anchors: 75 kg anchor or wooden post,**
size of 10 cm diameter, 3 m length

Culture Environments for Black Rockfish *Sebastes schlegeli* in Cages*

- **Water temperature:**
 - optimum: 15~18 °C
 - growth ranges: 12~23 °C

Cage site: where optimum temp. remains longer
- **Over 25 °C**
 - physiological function decrease dramatically and morality increasing
- **Below 12 °C**
 - reduce feeding, once every 2~3 days

* Source of information: Son et al. (2007), Standard Manual of Black Rockfish Culture, NFRDI (TR- 2007- AQ- 002)

Fish in the Yellow Sea Black Rockfish



**Recreational fishermen in offshore Taeon: Internet Chosun June 16,
2007**

Culture Environments for Black Rockfish – cont.

- **Management during high temperature time
>23 °C: stop feeding, grading, net changing**
- **Before summer: harvest & sell market
size fish; reducing density in cages**
- **Prepare liquid oxygen or oxygen
generator for emergency supply**

Stocking Number

- **Number of fish stocking in a cage:**
 - **Depends on the size of the fish**
- **Relationship between number of fish (Y) and size of fish (X in total length)**

$$Y = 276,955X^{-1.2694} \quad (r^2=0.8478, n=40)$$

Stocking Density of Various Sizes of black rockfish in 5x5x5m(D) cage

Total Length (cm)	Body Weight (g)	Stocking Density (per 5x5x5m cage)	
		Number	Weight (kg)
5	2	34,400	69
8	9	18,700	168
10	17	14,000	237
15	59	8,300	488
20	142	5,700	809
25	281	4,300	1,199
30	491	3,400	1,654
35	787	2,800	2,171

•Source of information: Son et al. (2007), Standard Manual of Black Rockfish Culture, NFRDI (TR- 2007- AQ- 002)

Relationship between total length (TL) and body weight (BW) of black rockfish

TL(cm)	BW(g)	TL(cm)	BW(g)	TL(cm)	BW(g)	TL(cm)	BW(g)
3	0.4	13	38	23	217	33	657
4	1	14	48	24	248	34	720
5	2	15	59	25	281	35	787
6	4	16	72	26	317	36	857
7	6	17	86	27	355	37	932
8	9	18	103	28	397	38	1012
9	12	19	121	29	442	39	1096
10	17	20	142	30	491	40	1184
11	23	21	165	31	542	-	-
12	30	22	190	32	598	-	-

•Source of information: Son et al. (2007), Standard Manual of Black Rockfish Culture, NFRDI (TR- 2007- AQ- 002)

Feeds

- **Frozen fish, moist pellet(MP) and dry pellet are common feed for on growing fish**
- **Fish farmers prefer MP – grow faster**
 - **Need more manpower for preparation,**
 - **Need equipments – refrigerator, MP maker**
 - **Dissolve easily**
- **Dry pellet proved same efficiency of MP (NFRDI)**
 - **Only need feed storage**

Feeds – cont.

- **Daily feeding frequencies**
2~3 for fingerlings, 1~2 for on growing
- **Optimum amount**
80% of satiation for fingerlings
70% of satiation for on growing fish
- **Dry pellet: careful for over feeding**

Growth Rate

- **In cage:**

from 2~3 g

250~400 g in 18 month

300~500 g in 24 month

450~550 g in 36 month

- **In land based tank:**

from 7.5 g

- 300 g in 12 month

- 450 g in 18 month

- 600 g in 24 month

*** Because of lower temperature during winter season, fish grew slower in the cages than in the land based tank.**

*** However, not many farmers culture this fish in the tank because of economical reasons.**

Growth rate of black rockfish in cages

	June, July	Oct.	Apr. + 1 yr	Dec. + 1 yr	June + 2 yr	Dec. + 2 yr
* Months	1	4	10	18	24	30
BW (g)	1~2	30~50	120~ 180	250~ 400	300~ 500	450~ 550
TL (cm)	4~5	12~14	19~22	24~28	26~30	29~31

*** Months after stocking**

- Source of information: Son et al. (2007), Standard Manual of Black Rockfish Culture, NFRDI (TR- 2007- AQ- 002)**

Red Tide Protection

- **When red tide is developed around cages**
 - **Stop feeding when algal density is high**
 - **Reduce feeds when density is low**
 - **put yellow soil into the red tide**
 - **Disperse algae by aeration, paddle wheel, agitator, or with vessel engine**
 - **Oxygenation with liquid oxygen if needed**
- **After extinction of red tide**
 - **Clean up or replace cage net and start to feeding fish**

Spread loess (yellow soil)



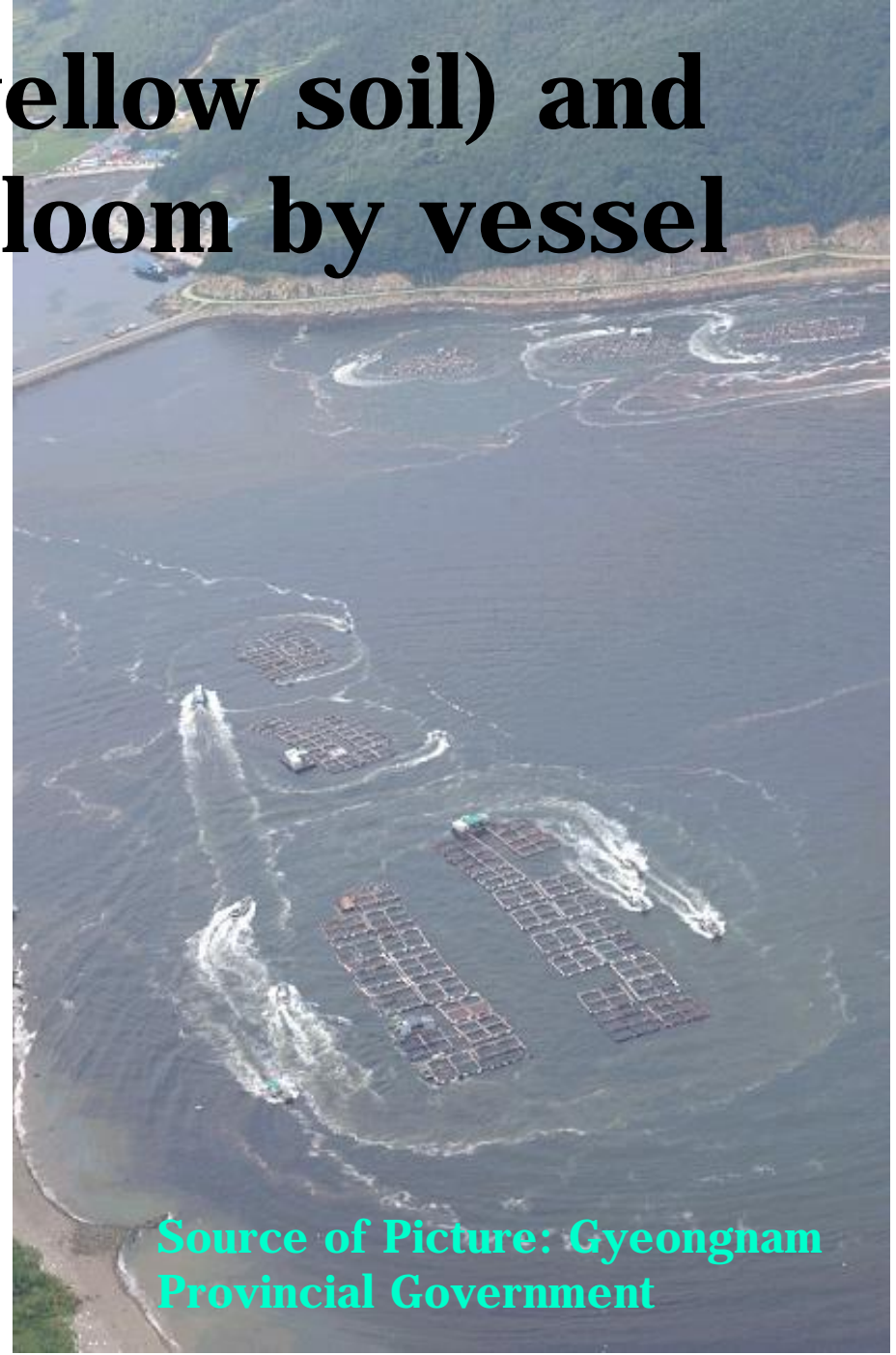
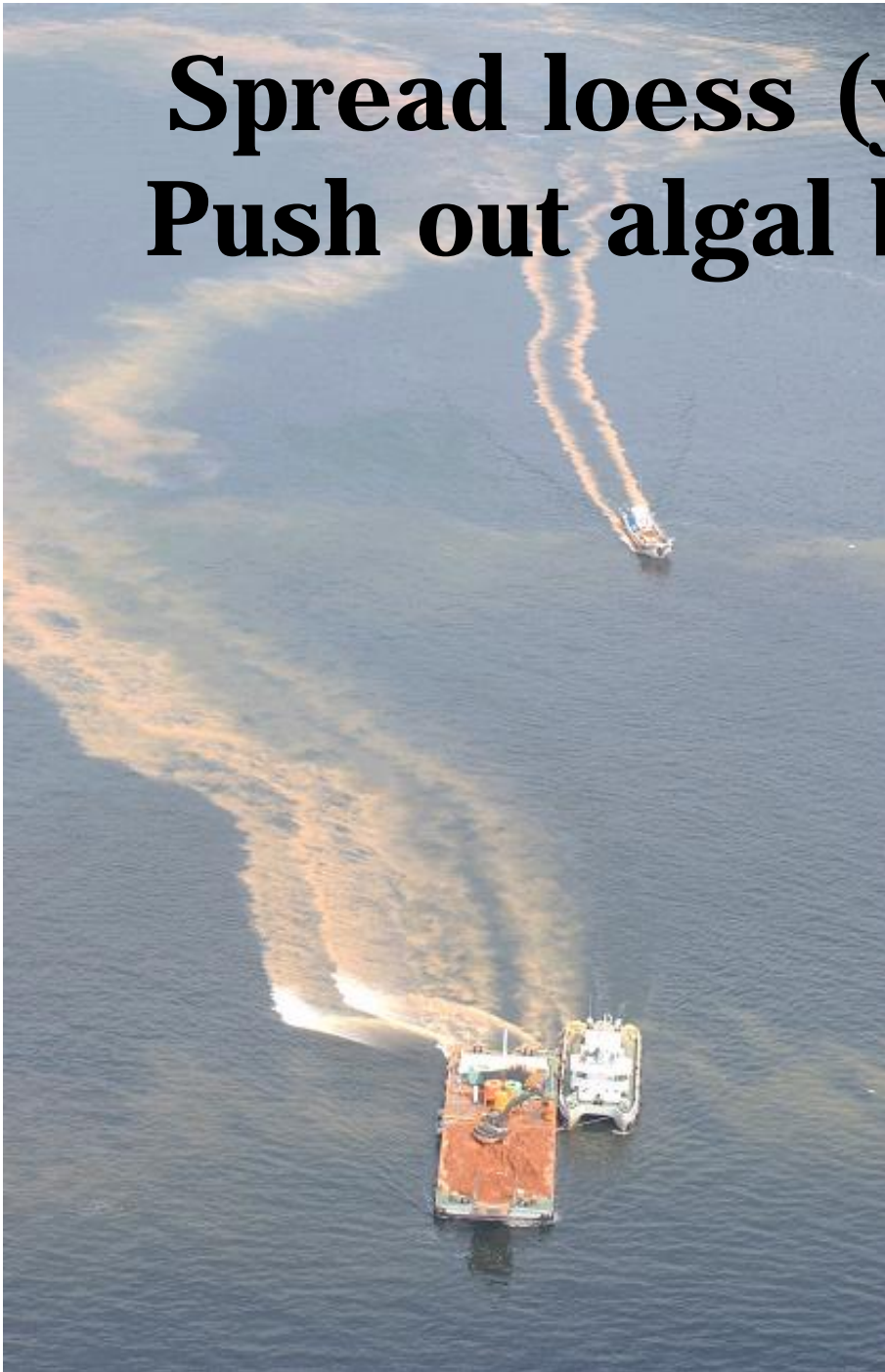
Source of Picture: Gyeongnam
Provincial Government

Push out algal bloom by vessel



Source of Picture: Gyeongnam
Provincial Government

Spread loess (yellow soil) and Push out algal bloom by vessel



Source of Picture: Gyeongnam
Provincial Government

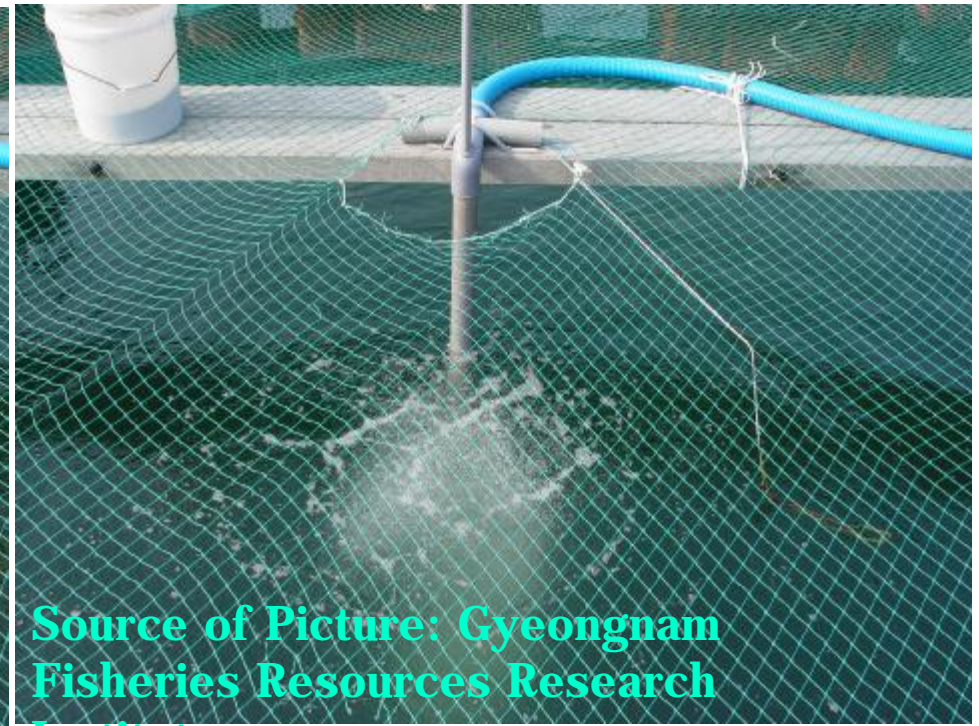
Pumping water and put into cages with air



**Water from 10 m
put into 2~3m
below surface**

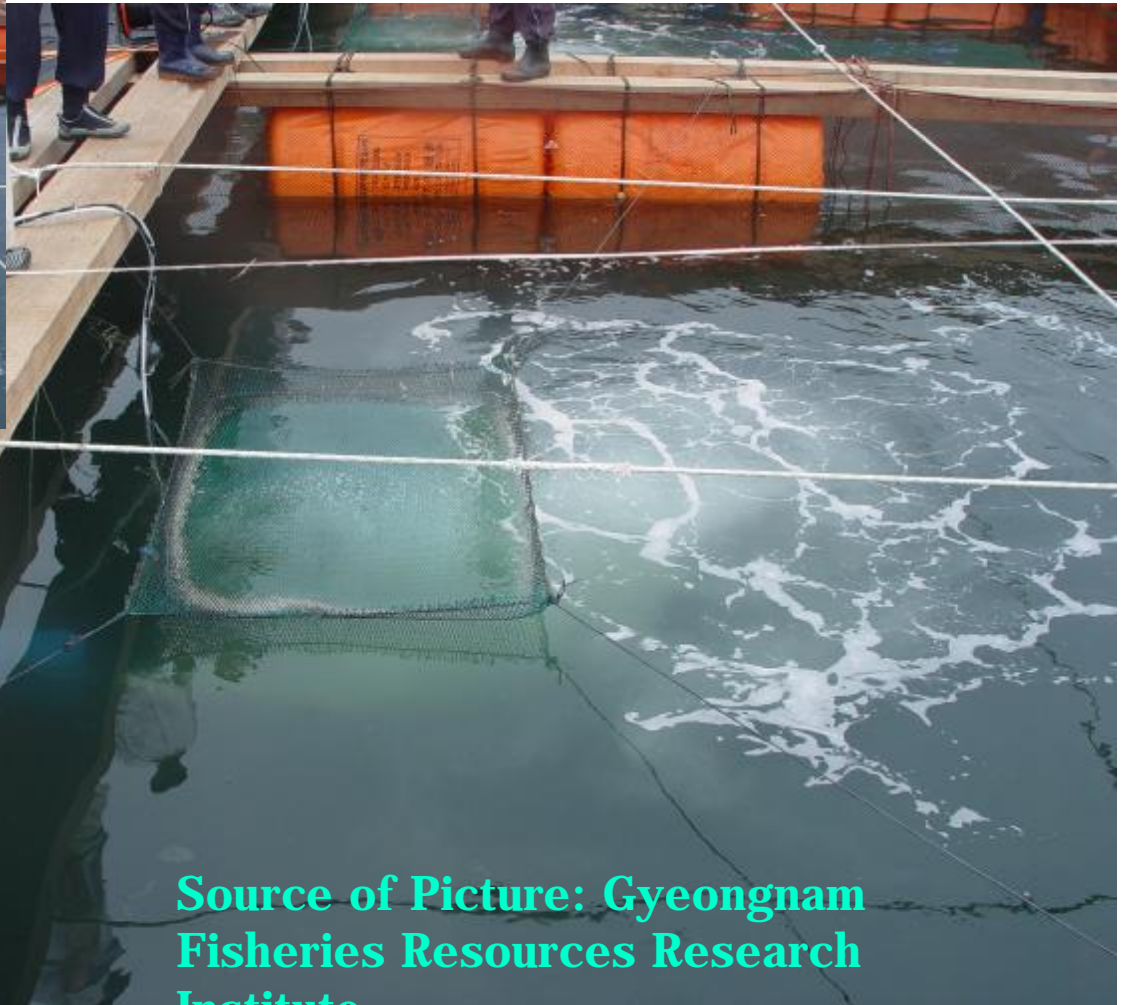
**Source of Picture: Gyeongnam
Fisheries Resources Research**

Put out algal bloom from cages mainly by air bubble



Source of Picture: Gyeongnam
Fisheries Resources Research
Institute

Oxygenation with liquid oxygen



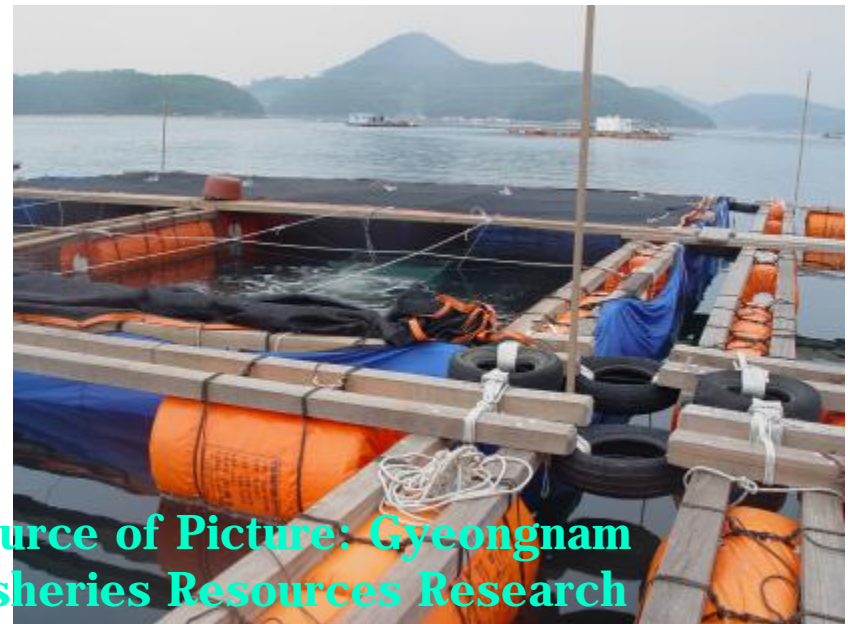
Source of Picture: Gyeongnam
Fisheries Resources Research
Institute

Cover plastic sheet around cage



Source of Picture: Gyeongnam
Fisheries Resources Research
Institute

Cover plastic sheet around cage



Source of Picture: Gyeongnam
Fisheries Resources Research
Institute

Fouling Problems of Net

- **Net must be changed often for good water circulation every 2 weeks**
- **Treatment of anti fouling agent, extend net changing period up to 4 months**
- **Fish farmers using fish to reduce fouling organisms – file fish**
- **Can extend net changing period one unit longer with file fish**

Treatment of Anti Fouling Chemical on Net



File Fish, 馬顏魚



Source of Picture: Gyeongnam
Fisheries Resources Research

Policy Advises for Cage Culture

**Do we have to continue
inshore cage culture?**

Inshore: a lot of human activities and effects

- Recreational activities- fishing, swimming, sailing, picnic, etc.**
- Industrial – commercial fishing, shipping, transportation route, anchorage area**
- Final destiny of home and industrial wastes, agriculture chemicals, pollutants, etc.**

Aquaculture also a source of organic wastes

- **Feeding aquaculture=finfish culture
Produce metabolic wastes**
- **@ 30% of ingested feed become solid wastes**
- **@ 3% of feed weight excreted as ammonia**
- **Affect to natural body of water – enhance eutrophication effects**

Increasing recreational concern in the inshore

- **Outdoor activities increases with increasing family income**
- **Governments of all developed countries prepare these facilities for people**
 - **no aquaculture facilities allowed in public inshore area**
 - **only open for public**
- **Korea: on the way to developed country**



www.bahamasgateway.com



www.elh.co.uk

Increase public concern about pollution

- People in developed countries concern of well being, high quality life**
- Korean people also want clean water, clean air, clean environment**
- Also 5 days work & 2 days off per week: accelerate outdoor activities of Korean**
- They need clean inshore environment for better quality life and well being**

Do you want this beach?

www.oceanservice.noaa.gov



www.hickerphoto.com



**Or this
beach?**

www.beachtownpress.com



beach-park.philippinepictures.com

We have to move all feeding aquaculture facilities to offshore

- **All feeding aquaculture facilities = finfish cage culture facilities
Move to offshore site**
- **Only natural feeding organisms like shellfishes, or non-feeding organisms like seaweeds culture left in inshore sites**

Advantages: move cages to offshore

- **Remove organic loading from cages and clean inshore environment**
 - **good for all people including fishermen**
- **Avoid red tides: annual event in Korea**
- **Better growth, minimum mortality, high efficiencies of culture fishes – high chance to find foreign markets**

Advantages: move cages to offshore – cont.

- **Good for outdoor activities, attracts people**
- **Increase income to fishermen by guiding people for fishing, sailing, diving and other recreational activities**

- **Good for government**

People will support government in elections

County chief. Mayor. Governor. President

Disadvantages: move cages to offshore

- **Need much money to build and move**
Fish farmers do not have money to invest
- **Develop new species for mass production**
- **Develop new markets**
- **Develop proper technologies – stocking, rearing, feeding, grading, harvesting, etc.**
- **Protect from burglary**

How do we solve these problems?

- **Financial support for first investment and operating costs from government**
- **Need government R & D – already started**
 - **on species of fishes, managerial technologies to reduce production costs, new markets including export markets**
- **Methods of protection from burglary by Coast Guard with patrol boats, helicopters,**

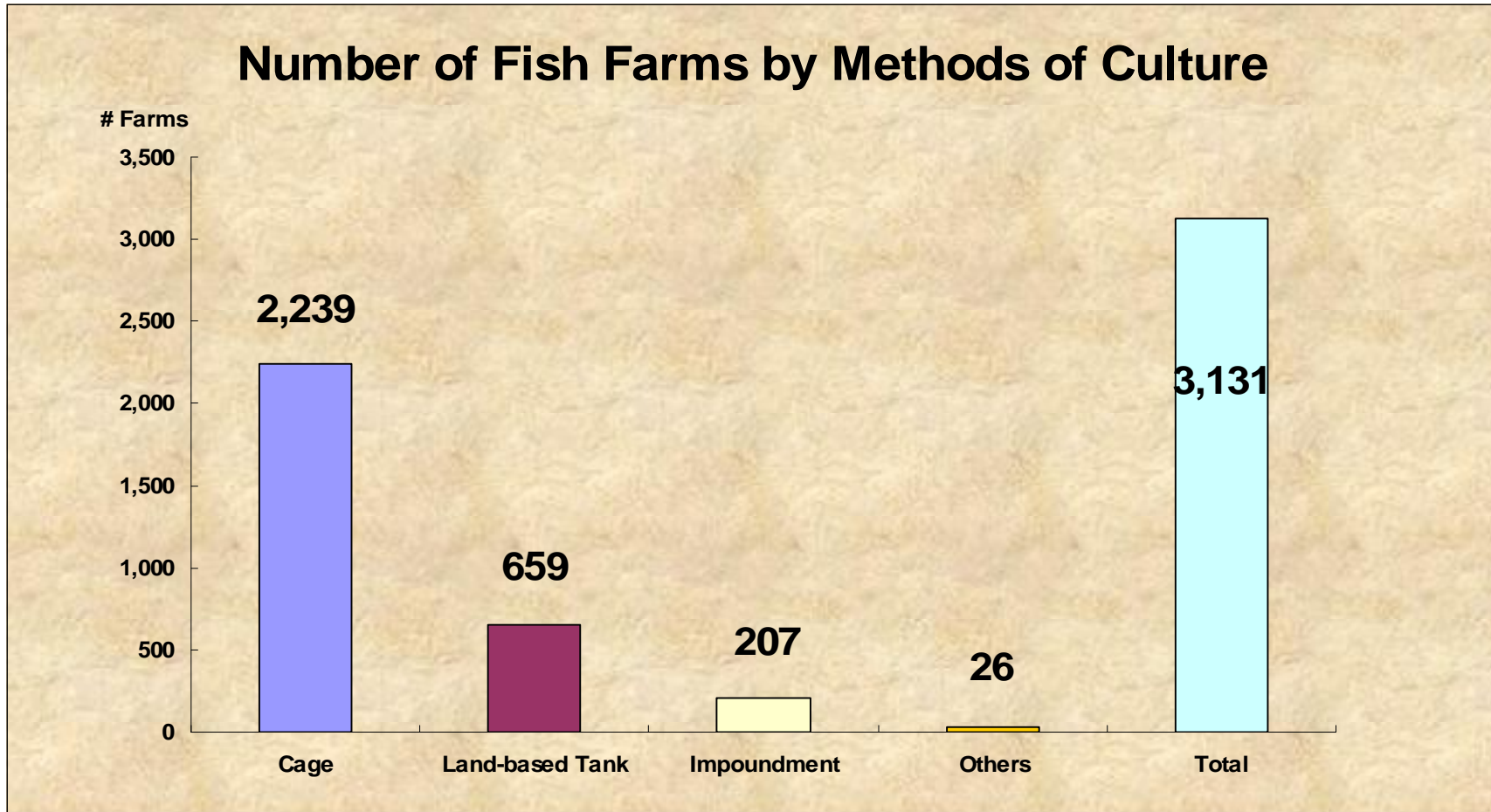
Conclusions

- **Using dry pellet to reduce production costs and pollution**
- **Stop feeding at high and low temperatures**
- **Gradually, substitute inshore cages to offshore ones for both fish farmers and people**
- **Finally, natural feeding and non-feeding aquaculture only are allow at inshore**

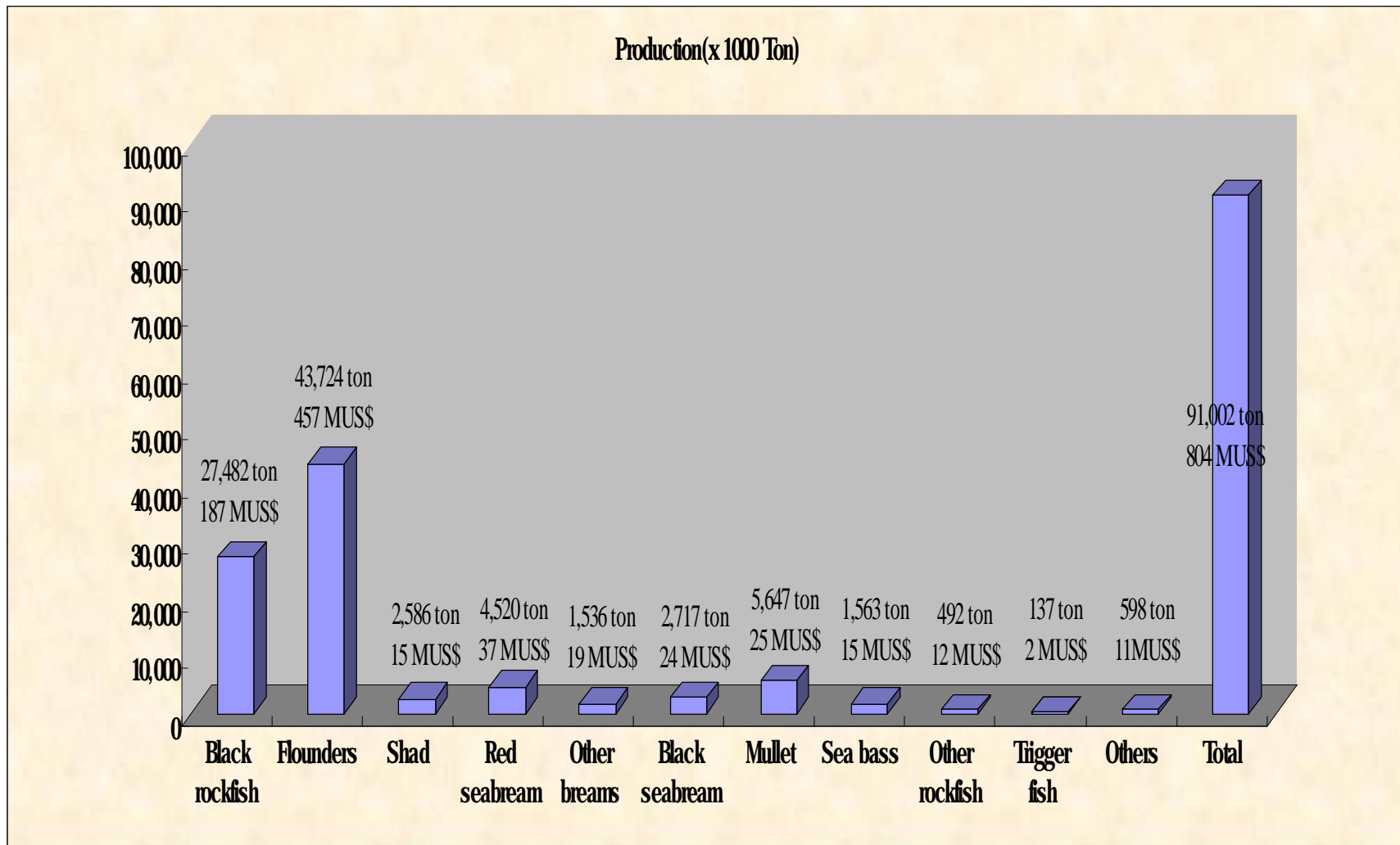
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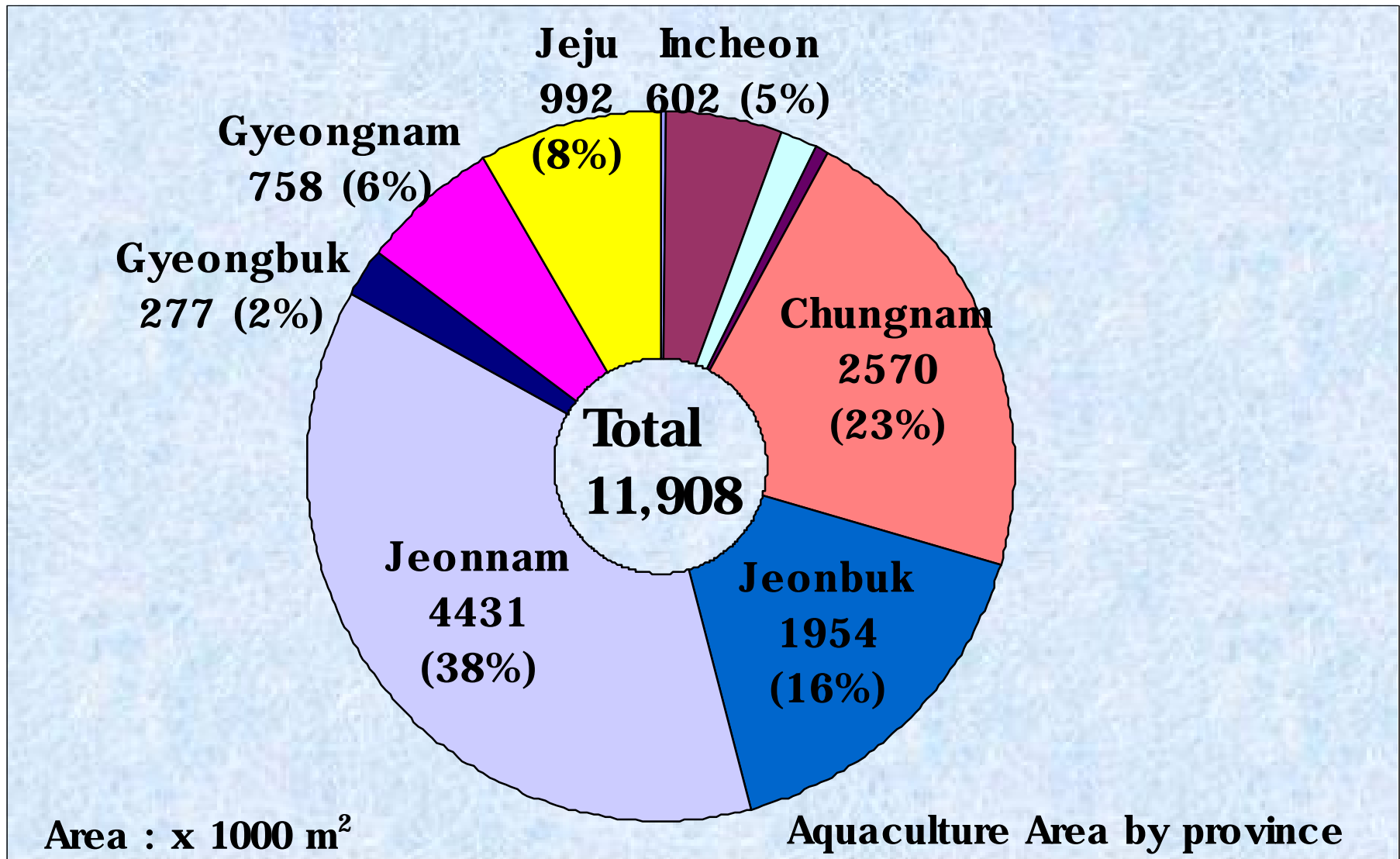
Number of Fish Farms by Methods of Culture



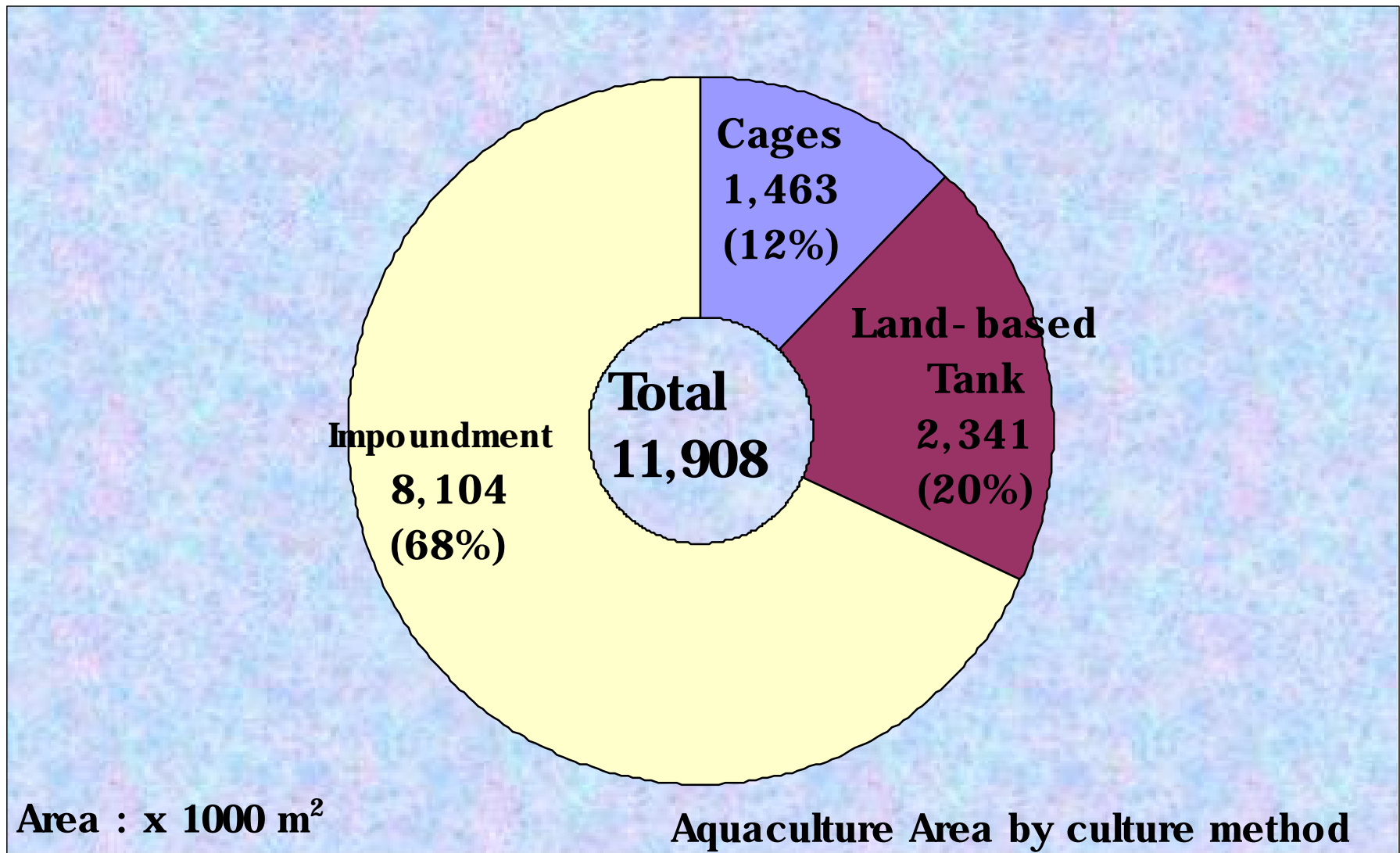
Production of Marine Finfishes in 2006



Aquaculture Area by Province



Aquaculture Area by Culture Method



Changes of Culture Area by Culture Methods

