Best Management Practices of Finfish Cage Culture in Korea

-focused on black rockfish-

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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℃**
  - **growth ranges: 12~23℃**

  Cage site: where optimum temp. remains longer
- **Over 25℃**
  - **physiological function decrease dramatically and morality increasing**
- **Below 12 ℃**
  - **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 Taean: Internet Chosun June 16, 2007

Culture Environments for Black Rockfish – cont.

- **Management during high temperature time**

  >23℃: 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)**

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

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)

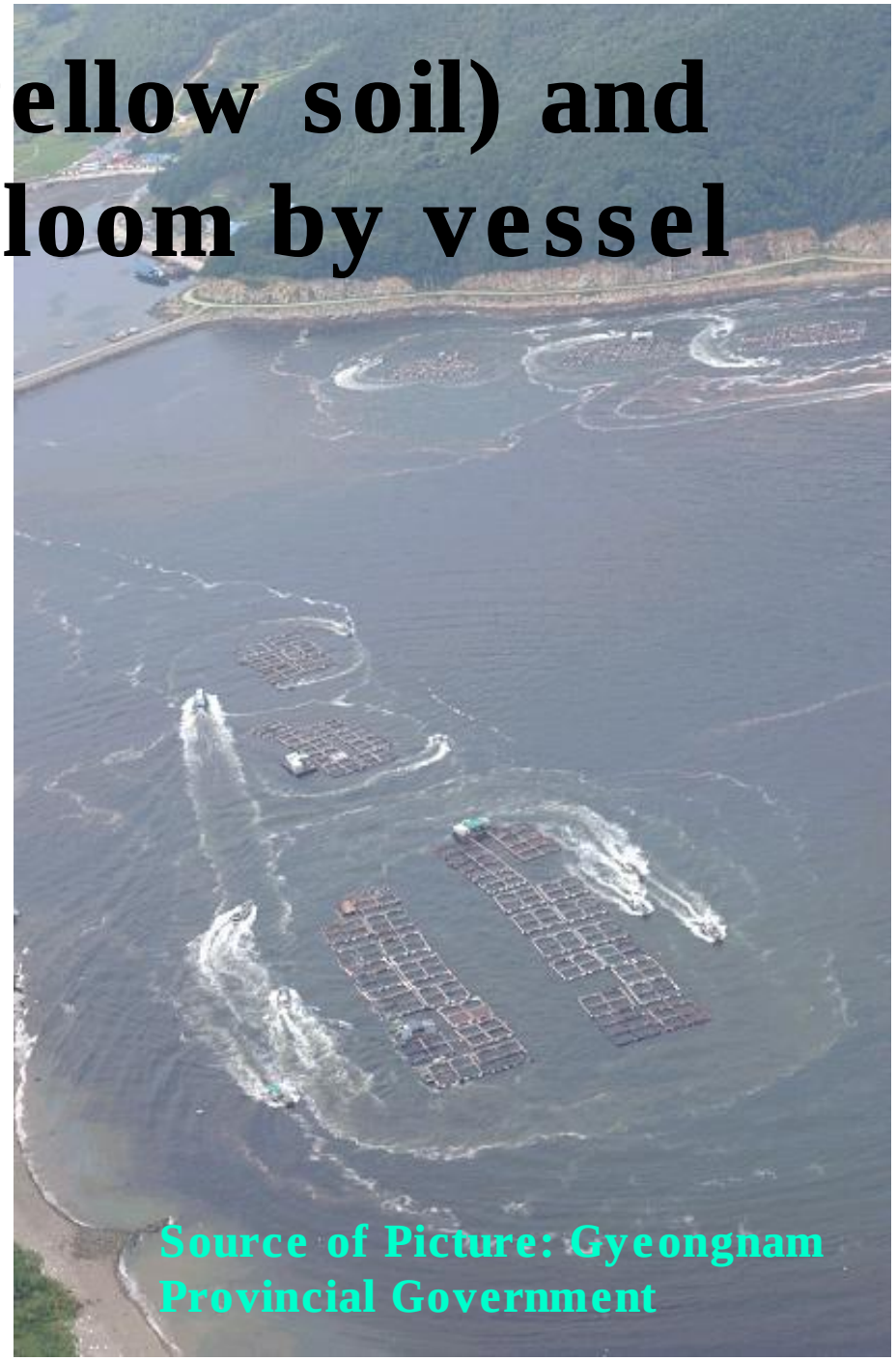
Red Tide Protection

- 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)

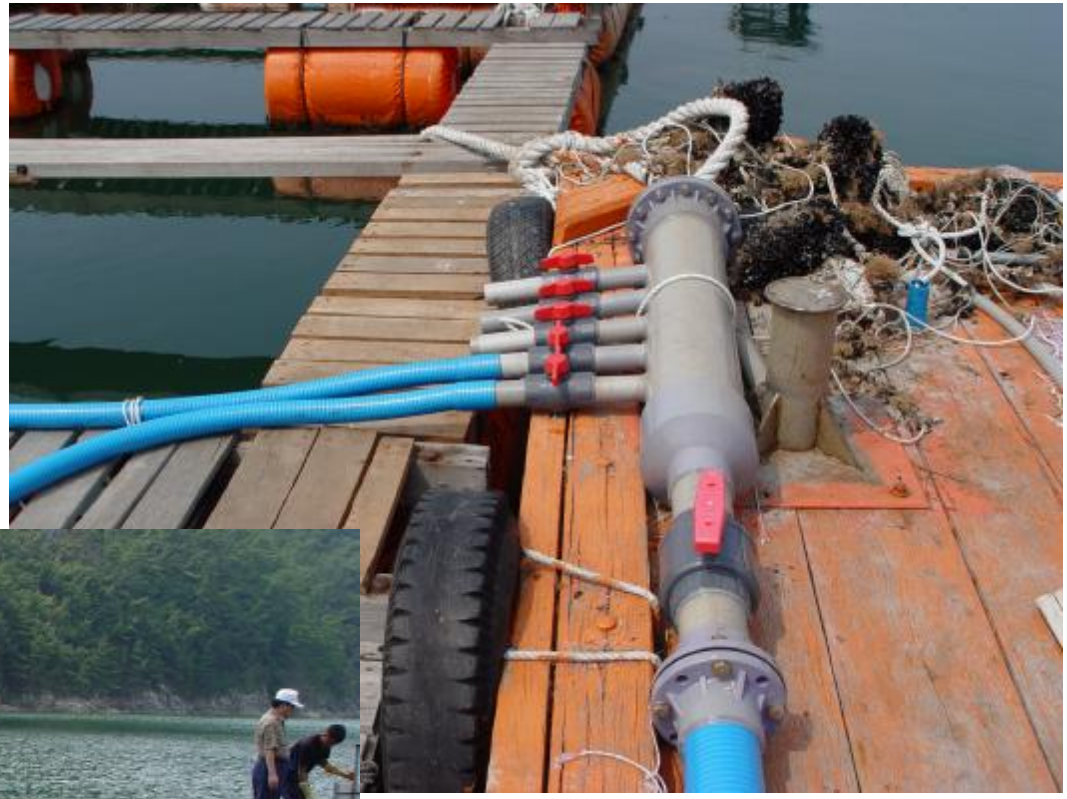
Push out algal bloom by vessel

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

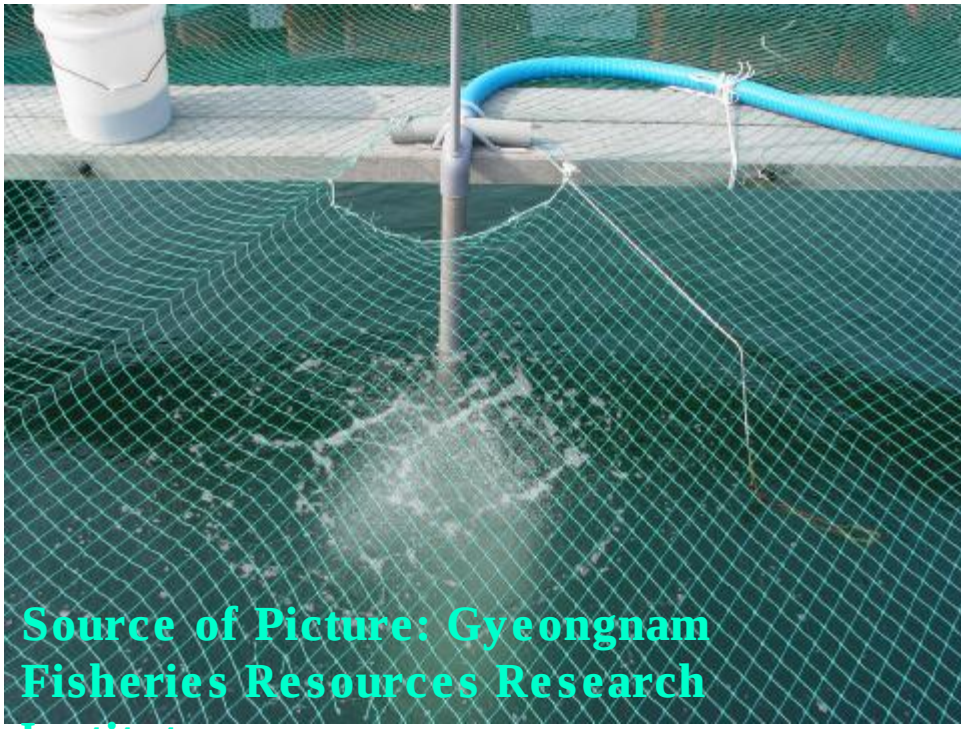


Water from 10 m

put into 2~3m below surface

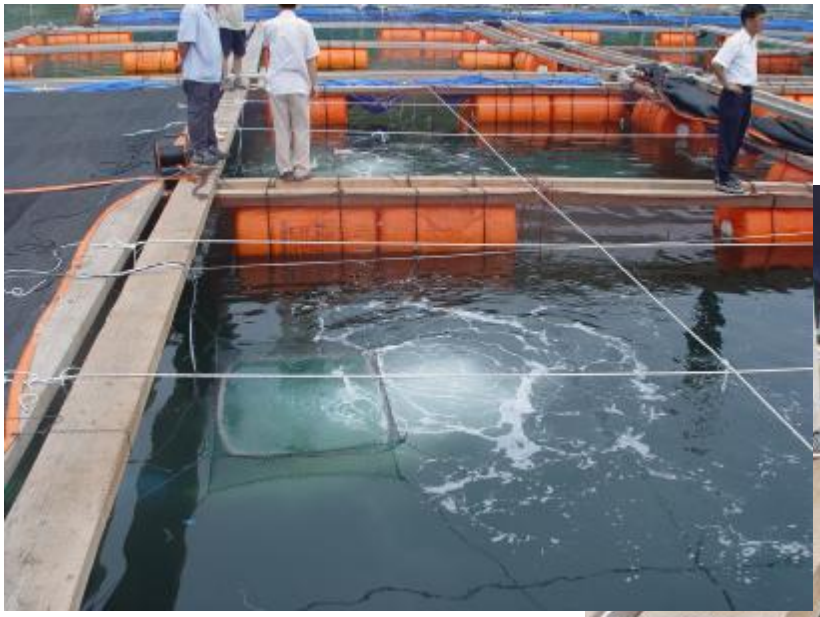
Source of Picture: Gyeongnam Fisheries Resources Research

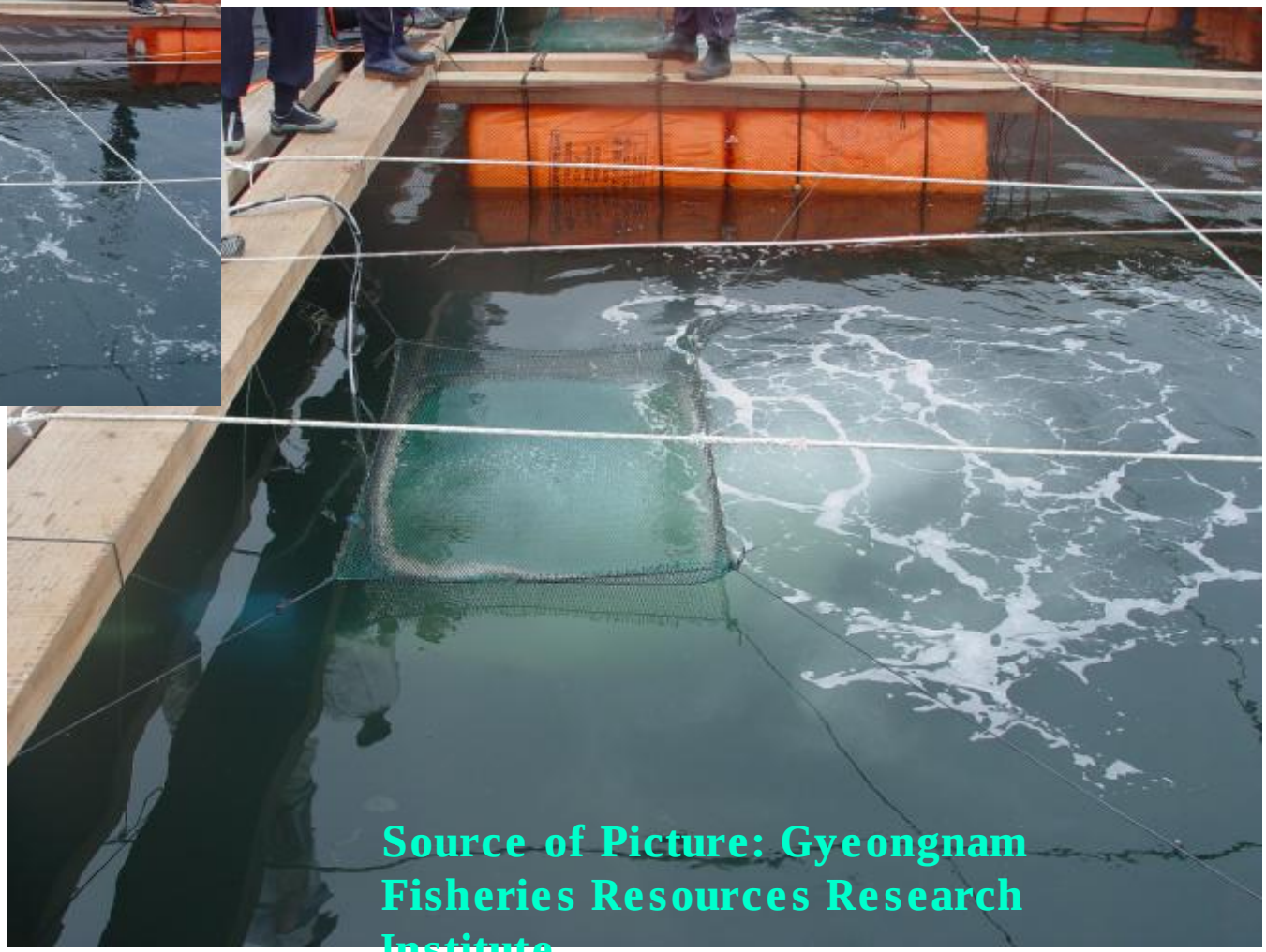
Put out algal bloom from cages mainly by air bubble



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

Cover plastic sheet around cage

Source of Picture: Gyeongnam Fisheries Resources Research Institute

Fouling Problems of Net

- **Net must 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 reducing 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?

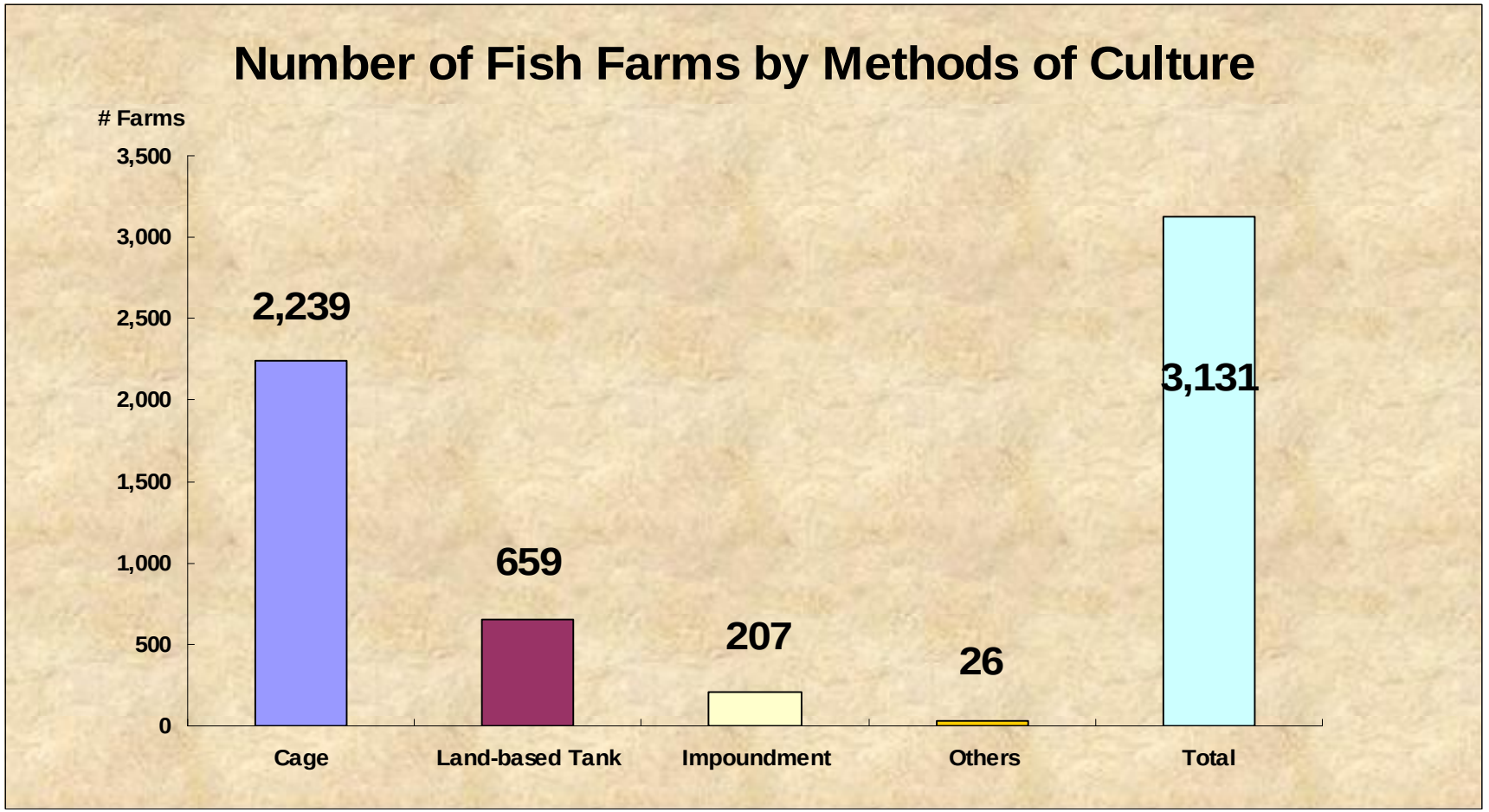
- **Financial support for first investment and operating costs from government**
- **Need government R & D – already started**

  - 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,**

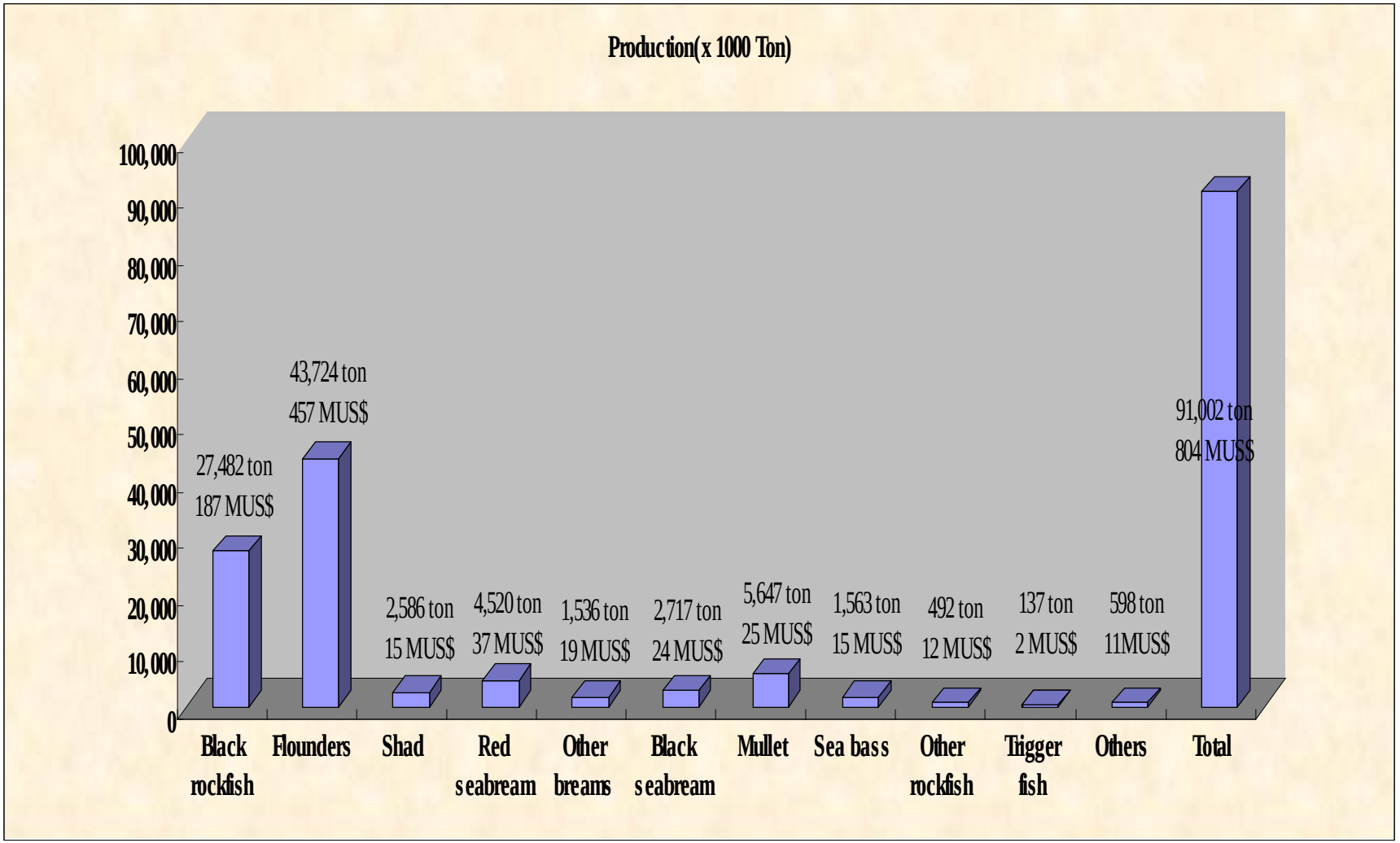
Conclusions

- **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**

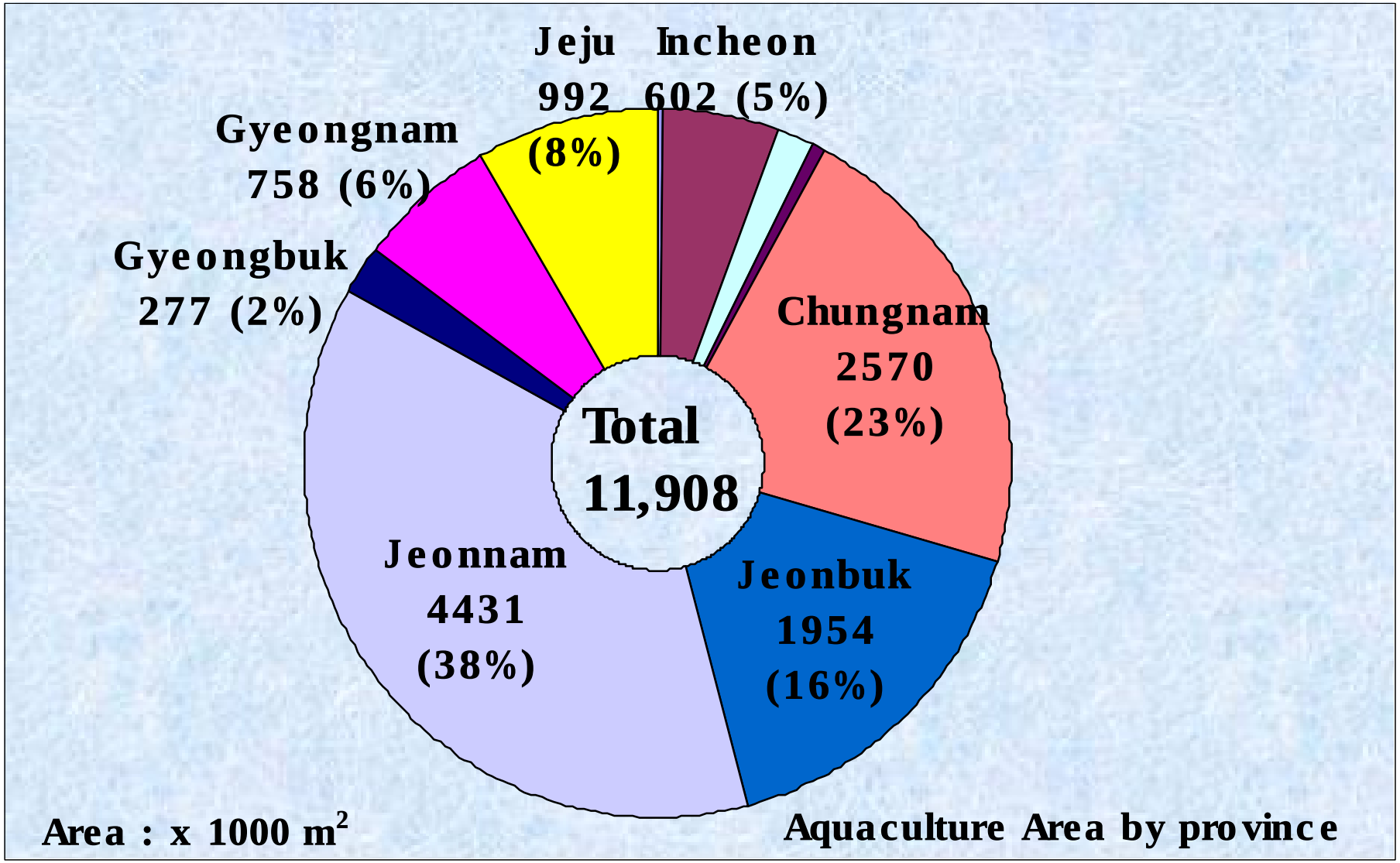
Number of Fish Farms by Methods of Culture



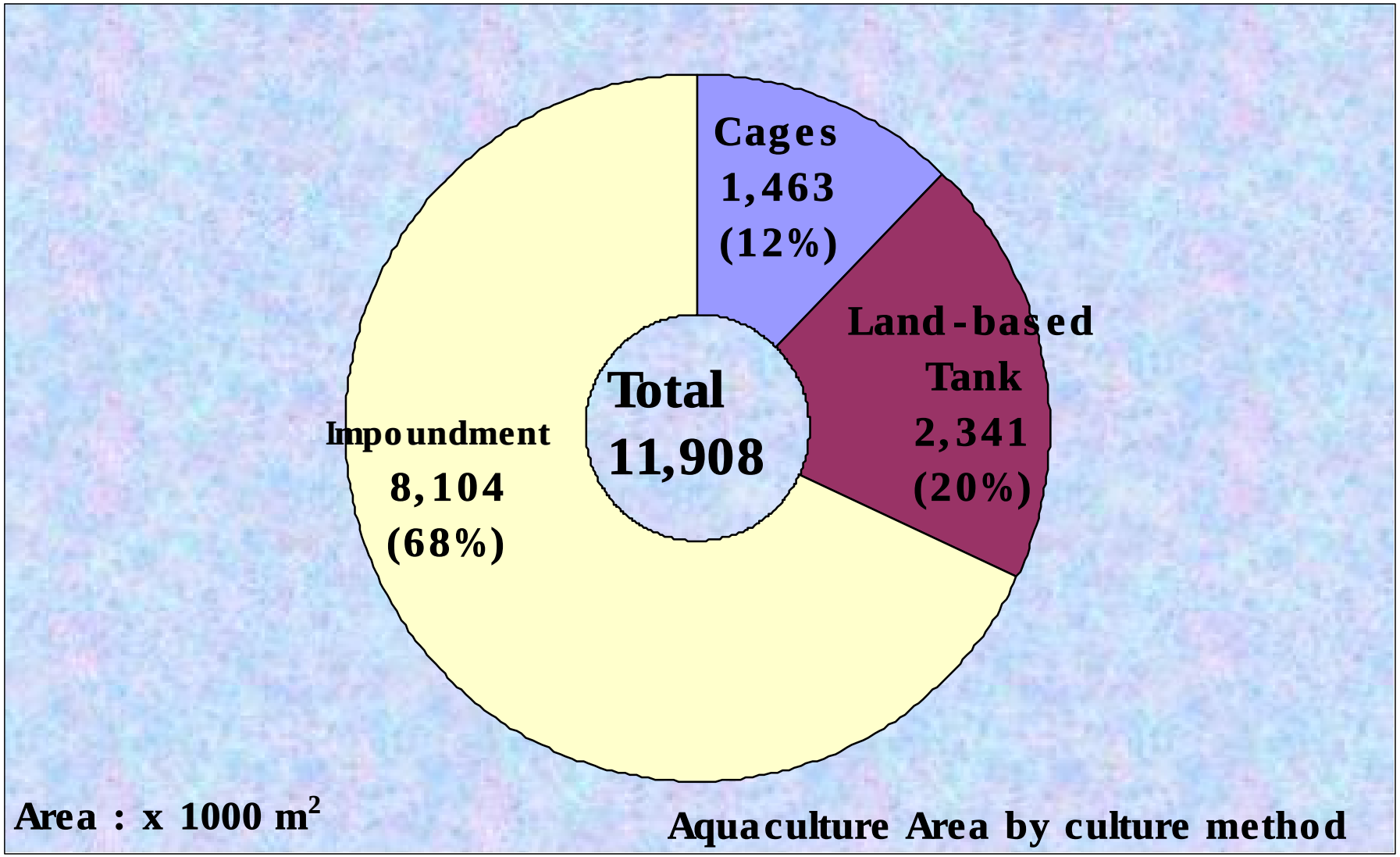
Production of Marine Finfishes in 2006



Aquaculture Area by Province



Aquaculture Area by Culture Method



Changes of Culture Area by Culture Methods