Discussion Document

This document represents the discussions that took place following the presentations given on 19th June 2007 at the “Workshop on aquaculture in the Yellow Sea for environmental and economic sustainability and commercial profitability” at the West Sea Mariculture Research Centre in Taean.

1. Polyculture

The best combination for polyculture is a mix of fish/shellfish and seaweed, but for pond culture no suitable seaweeds have been identified that can with stand the summer water temperatures.

For suspended polyculture a combination of filter feeders, seaweed and abalone is the most profitable. For seabed polyculture the combination of seaweed + abalone + sea urchin + sea cucumber + scallop has recognized as the most profitable in China. When selecting suitable organisms for polyculture and planning species combinations and density there is a need to consider:

1. Carrying capacity
2. Economic benefit to the farmers
3. Environmental impact
4. Socio-economics

The main problems for polyculture are fouling and predator control.

2. Carrying capacity

Models have been developed to estimate the mariculture carrying capacity of coastal embayments, in China this has centred on Sungo Bay. These models give density predictions for various mixtures of species that are frequently cultured together as discussed above. The model is still undergoing testing, however, the main problem in China is non-compliance by some farmers who increase density to increase profit when others around them have complied and decreased density to the agreed stocking levels.

As farmers were reluctant to follow the guidelines on reduction in density of cultured animals, initial demonstration sites were set up in a small area. As a result many farmers are following these guidelines. Two new demonstration sites in Sungo Bay were

proposed one in each culture area (the sea bed and the suspended culture areas).
It was also suggested that the government could help by changing the way coastal areas are leased for the 15-30 years to include agreements on density and the species cultured based on the carrying capacity.
In Chile, problems in the lantern culture of scallop resulted in an examination phytoplankton density and composition and the culture density was then set according to the phytoplankton density.

The effect of these releases of hatchery produced stocks of scallops, sea urchins, abalone, etc. on the genetic diversity of wild stock is as yet unknown for most species. The continuous release of *F. chinensis* (the fleshy shrimp) may have resulted in some genetic loss, the data is limited. For oysters and scallops only a few fathers are used to produce most of the offspring so the possibility of genetic loss is very high amongst hatchery-raised seed, as is the likelihood of this genetic loss impacting the wild population. Although, there is substantial variation in the genetic diversity in wild stocks, so any loss in diversity may be due to natural drift.

At present there is no regulation of genetic diversity in stock enhancement, this is not the case for disease. In ROK regulations are being prepared at the moment, while in China there are no plans, but there is protection of certain animals and habitats

Pond polyculture is more important in ROK as no expansion of mariculture is permitted in the sea. The main problem is that there are few types of seaweed than can survive the high summer temperatures in a pond. Green laver may be a suitable candidate as survives it the summer in recirculation systems in ROK. In China, *Ulva* is cultured in *P. japonicus* ponds to reduce the nitrogen load. In addition amphipods are grown and are the exclusive source of shrimp food for the first 2 months. The high value *Codium* and *Gracilaria* were proposed as candidate species for pond polyculture in ROK.

3. Recirculating tank production

Recirculation systems can be advantageous over flow through tanks systems as the reduced water exchange enables better treatment of incoming/outgoing water which can reduced the likelihood of disease entering or exiting the culture facility, limits the release of nutrients into the coastal zone and reduces the effect of red tides of cultured organisms. Land based aquaculture facilities should be recirculating to reduce the environmental impact and reduce water use. However, there are bottlenecks to the development of recirculation systems and these include the high initial investment cost of equipment and the cost of energy required to drive the pumps.

These barriers to the widespread adoption of recirculation technology may be over come by following the example of the EU and USA where there are strict limits on the discharge of nutrients and taxes have to be paid per unit of nutrient discharge. These charges could well act to compensate the initial cost. At present the technology for freshwater recirculation systems in ROK mean that approximately 20% of culture area has to be sedimentation area, but this varies with different flow-through rates. If the farm has good filter facilities then the area can be reduced. In order to maintain the biological filtration the water flow has to be maintained at all times and nutrient levels changed slowly. In ROK commercial scale freshwater systems already are in use and seawater systems are being developed. While in China some big companies are using recirculation systems.

Probiotic bacteria start-up culture produced in ROK are also used in China as inoculation for biofilters. Saltwater biofilters are less efficient in nitrogen removal than comparable FW versions, however both fish and shrimp are much less sensitive to ammonia and nitrite concentrations in SW and an survive 20ppm NH4 and NO2. Some FW species can also support high N levels especially those bottom living fish.

Extruded pellets that do not disintegrate quickly in water were found to be better than moist pellets for recirculation systems, as biofilters cannot cope with large amounts particulate material. Drum filters were reported to be very useful for removal of particulate material however there are some problems in cleaning and labour.

Loss of trace elements was mentioned as a problem caused by protein fractionation. However, 2% water exchange is enough to prevent changes in alkalinity. There is no treatment of the outflow as a result of the 2% water exchange although some developments have been made. In China, some companies have used the following techniques to treat the outflow of land based aquaculture: outflow water→pond (culture of shrimp + filtering animals) → salt field.

4. Heterotrophic shrimp culture

There are still some problems that need to be overcome. The high cost of construction is a major obstacle to the introduction of this culture system in ROK, although many pre-existing tanks can be adapted and any material can be used.

There is also the high energy/operational cost, but this can be reduced by using a well-insulated green house with a double layered skin with an air pocket. Moreover, the cost of heating the water can be reduced using underground water or cooling water from power plants or efficient heat exchangers. Oxygen may not be needed and could be substituted by an efficient aeration system. There is also a lack of knowledge and experience to train the farmers, through this may be supported by an implementation research project. Additionally, in ROK there is a lack of infrastructure to provide SPF seeds or HHS larvae- good quality. This method should be implemented in the ROK for indoor culture, as the whole can be isolated from disease. Most culture here is either successful or faces total collapse from disease problems

In China, the indoor culture of shrimp is just in small commercial scale and it has been developed slowly because of the higher cost and low price for both *F. vannamei* and *P. chinensis* (USD 3/ kg) and therefore could not make a profit. The government supplies Specific Pathogen free (SPF) juveniles, and support companies to keep broodstock indoors in biosecure systems. There are now 4 shrimp breeding government facilities that supply SPF seeds at the same price as regular seeds. SPF seed are not normally more resistant to disease than regular shrimp. Once they leave the secure facility they are now High Health Shrimp (HHS). Specific Pathogen resistance (SPR) is achieved through genetic selection.

5. Open Sea Aquaculture Technology and practices

Until 2009 only one license per province in ROK for offshore culture demonstration sites has been issued. However on of the problems that remain is how to define offshore?

Around the world it depends on the depth and distance from shore, in ROK there is no definition yet. In China applications for offshore culture have to be submitted, and so far

the definition of offshore has not been set, but >10km is being considered. At present in China long-line culture and deep sea cages have to be in >15m-20m and after 5 yrs the government will encourage cage development in 20 – 40m. Also in areas near Chinese cities no aquaculture is allowed within 1500m from shore. While in ROK all coastal waters < 15m in depth belongs to the village people cooperatives, therefore all other activities have to be in deeper water. Offshore/deep water culture is not really appropriate in the Yellow Sea as Chinese farmers try to save money by placing the cages nearshore as the Yellow Sea is very shallow which would mean that deep sea cages are unpractical as they would have to be so far offshore.
The government in ROK wants to encourage the movement of nearshore cages to offshore locations by 2010 and there are also plans to move the Chinese cage culture offshore to deeper water.

Offshore cage culture is more sustainable and responsible than nearshore culture as initial results suggest:

- It is environmentally friendly as the deeper water ensures greater dispersion of any nutrient inputs and less seafloor deposition of uneaten food
- HACCP principle: food safety of the produce is improved as it less likely to affected by anthropogenic pollution
- Utilization of the ocean in a 3 dimensional manner
- That better quality fish produced from offshore culture commands higher prices
- There is reduced coastal pollution caused by accumulation of feedstuffs
- Improved tourism potential as visual and water quality impact of nearshore cage culture are reduced
- Better growth and survival of culture animals as a result of improved water quality

6. Best Management Practices (BMP) on finfish/shellfish culture

In order to grow fish faster and healthier and in a more sustainable manner BMPs need to be followed. Details of BMPs were outlined in the presentation. Unstressed fish were reported to have better growth and survival.

In China fish cages are often grouped which can create environmental problems from localized enrichment but in other countries the cages culture are separated by greater distances eliminating this problem. In ROK, FW licenses were issued for 10 yr periods, but due to rising nutrient levels in the culture areas, no more licenses have been issued which had caused the cessation of FW cage culture. However, this was probably a mistake as no improvement in water quality has been noted subsequently, suggesting that nutrients are coming from elsewhere.

For shellfish one of the major concerns in China is the Manilla clam summer mortality, caused by an influx of the freshwater from storms together with slow water movement. In order to avoid these stresses, they now practice rotation of culture sites and have expanded the culture area to the sub-tidal zone (5-6m below sea level) where the growth rates are much higher. Manilla clam was also reported to grow well in ponds.

Also of concern is the fact that clams are now cultured in areas close to cities where there is an increase in concentration of biotoxins and land-based pollution. This may make them unsafe for human consumption.

7. Best management for feed and feeding

One of the major advances is the formulation of better diets using suitable ratios of nutrients, energy, fatty acids, amino acids and protein ratios that are adapted for each species. These features combined with improved water stability and better manufacturing techniques have resulted in higher quality diets that pollute less as the proportion of the diet excreted is less, due to improved palatability, water stability and digestibility. Regulation of the feeding frequency, amount and time of feeding through automatic or manual feeding can also help reduce wastage and environmental impact. The use of alternative protein and fatty acids sources can help reduce the amount of fish biomass (trash fish) used in the diet as can careful selection of the species used for aquaculture

The use of trash fish has become a major issue, as not only are trash fish more polluting when used as a feed, in many countries the same fish are also used for human consumption. In ROK, fishermen are catching undersized fish illegally for use as trash fish. These trash fish are normally caught offshore in coastal areas, in this region anchovy is the preferred trash fish. Compound feeds used for cage culture in China contain 30% fishmeal by dry weight, in ROK this increases to 50% dry basis for cage culture pellets. This is still much less than 100% for trash fish. Therefore it is necessary to persuade the farmers to use dry pellet, but this is very difficult as trash fish appears much cheaper. In China there is a 20% subsidy for dried pellets to encourage use, and the government plans to ban the use of trash fish within 10 years. At demonstration sites farmers were given compound foods (pellets) and asked to compare the resulting growth and survival with fish fed trash fish, and even though the results for pellets were superior, some farmers were still reluctant to use the compound food. Price is still the major issue.

In many shrimp diets the use soybean meal and poultry by product has been a research focus to help decrease the amount of fishmeal used and reduced the price of feeds. The selection of culture animal used can also have a major impact on the amount of protein (=fishmeal) that is required in the diet. For example *Penaeus vanamei* requires ~ 20% protein, *Fenneropenaeus chinensis* ~ 40% and *Penaeus japonica* > 50%.

8. Information exchange between scientists. policy makers and farmers.

8.1. China

Mariculture is regulated by Central Government through the Agriculture Ministry. This ministry in combination with the Provincial Govt Ocean Fisheries Bureau operates a Fisheries Technical Extension Service to run training courses, workshops and demonstration sites. Moreover, at every level from Provincial Ocean Fisheries Bureau down to City and County levels there are also mariculture and inland fisheries institutes that regulate and provide information and advice. In addition, institutes like the YSFRI, under the control of the Agricultural Ministry, are very closely linked to the commercial enterprises so the flow of information is very good. The government actively encourages companies and scientists to work closely.

Agricultural ministry gets advice from technical reports, project outcomes and experts.

8.2. Republic of Korea

Ministry of Mariculture and Fisheries (MOMAF) operates >10 local maritime fisheries offices with extension workers that offer small scale workshops for farmers. Bigger issues are addressed in bigger workshops. In addition, the National Fisheries Research and Development Institute (NFRDI) hosts workshops every year on each species. They also operate service agents, offer information and advice through their website, produce technical guides for various species that are distributed amongst farmers, and operate demonstration sites where new technologies can be explained. There are also 7 different websites that have aquaculture/mariculture chat room where farmers and experts can exchange views

Mariculture in ROK uses a self regulation system, and every year symposiums are held for the Fisheries Cooperative (80% are fish farmers) to disseminate information which the farmer are encouraged to follow as they receive benefits from the government and have to attend the courses.

NFRDI provides advice to MOMAF and the Government give projects to KORDI/KMI to evaluate management decisions. Korean aquaculture and fisheries societies also provide information