INTEGRATED MANAGEMENT OF LAGOON ACTIVITIES
IMOLA PROJECT II

REPORT ON

THE FEASIBILITY STUDY OF THE BIVALVE CULTURE AREAS IN VINH HIEN AND LOC BINH COMMUNES, CAU HAI LAGOON, THUA THIEN-HUE PROVINCE

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Hue, November 2009

PEOPLE'S COMMITTEE OF THUA THIEN HUE PROVINCE

THE FEASIBILITY STUDY OF THE BIVALVE CULTURE AREAS IN VINH HIEN AND LOC BINH COMMUNES, CAU HAI LAGOON, THUA THIEN-HUA PROVINCE

For Integrated Management of Lagoon Activities (IMOLA) Project

of Thua Thien Hue Province (FAO, GCP/VIE/029/ITA)

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Executive Summary

A feasibility study of the proposed bivalve culture areas in Vinh Hien and Loc Binh was conducted and the assessment of physical and chemical properties of the potential areas through a field trip on the 14 September 2009. This report was written based on the information which was obtained from the field trip.

The investigation the three study sites near the Tu Hien inlet indicated that all 3 sites (1 in Vinh Hien and 2 in Loc Binh) have potential to culture bivalves such as clam, oyster, and mussel. The study sites have acceptable condition for the bivalve culture such as water quality, biological and chemical parameters that may affect the growth and survival rate of bivalves. A series of recommendations for culture species and methods for each site were made at the end of the report.

1. General Overview of the Tam Giang - Cau Hai Lagoon

The Tam Giang – Cau Hai Lagoon system is a water body with 68 km in length and total area of 216 km^2, accounting for 4.3% of the land or 17.2% of plain of Thua Thien Hue Province. The Tam Giang – Cau Hai Lagoon system is the biggest in Southeast Asia. The tidal regime of the Lagoon system is semi-daily.

Tam Giang – Cau Hai water body is divided into three main parts, namely Tam Giang Lagoon (52 km^2), Sam and Thuy Tu Lagoon (60 km^2), and Cau Hai Lagoon (104 km^2). The Tam Giang Lagoon has 24 km in length from the O Lau River to the mouth of the Huong River and has average width of 2.5 km and the depth of 1.6 m. The Cau Hai Lagoon is a large semi-circled hollow with about 13 km in length and average depth of 1.5 m, expanding from the mouth of The Truoi River to the Vinh Phong Mountain area.

The Tam Giang – Cau Hai Lagoon system has 2 inlets, namely Thuan An and Tu Hien inlets. The Thuan An inlet have 600 m in length, 350 m in width, and 11 m in depth. The Tu Hien inlet is narrower with 100 m in length, 50 m in width, and 1.5 m in depth.

According to Vo Van Phu (2004), the Tam Giang –Cau Hai Lagoon system has rich biodiversity with 62 of families, 100 genus, and 171 species of aquatic animals including 43 species of seaweeds, 30 species of crustacean, more than 20 economically valuable species of fishes, and a lot of valuable mollusc species.

Figure 1: Map of theTam Giang – Cau Hai Lagoon with 2 inlets, Thuan An (red circle) and Tu Hien (orange circle) (Google Earth, 2009)

Figure 2: Map showing 3 potential sites for bivalve culture: sites 1 and 2 located in Loc Binh Communes; site 3 located in Vinh Hien (Google Earth, 2009)

2. Study Objective

The objective of this feasibility study was to assess physical, chemical, and biological characteristics of the potential bivalve culture areas in Vinh Hien and Loc Binh Communes and to suggest appropriate models of bivalve culture for these sites.

3. Site Selection

The three sites for this feasibility study were pre-selected by the IMOLA Project based on the Project's preliminary survey on these sites and discussion with local fisherfolk on the availability and culture potential of bivalves. See Figure 2 for the site locations.

4. Data Collection and Analysis

Water environment parameters such as temperature, salinity, DO, NO2, NO3, NH3, pH, and bottom type were directly measured in the field. Other parameters such as TP, TN, chlorophyll a, zoo benthos, phytoplankton, and toxic algae were sampled in the field and analysed in the laboratory of RIA1 in Bac Ninh. The species composition of mollusc in each study area was also identified through observation. The biological parameters at each site were sampled and analysed with three replicates. The additional information on Tam Giang-Cau Hai Lagoon was also collected from the IMOLA Project, the Department of Agriculture and Rural Development of the Province, and the Internet.

5. Findings and Analysis

5.1 Site 1 (Loc Binh)

Site 1 is located in Loc Binh Commune. The depth of water body is about 2 meters.

a) The substrate structure and the appearance of zoo-benthos

The bottom of this site is black in colour and mixed by mud, sand, mollusc shells and rock, that make the bottom very hard and not depressible. Consequently, the distributed zoo-benthos is also very poor (see Table 1). There are two species in this site including *Cerithium cingulata* (Gastropod) and *Nereis sp.* (Polichaeta) with 20 units/m^2 (1.24 g/m^2) and 20 units/m^2 (0.08 g/m^2) respectively. The result is indicating that the substrate is not appropriate for zoo-benthos distribution due to the hard bottom.

Table 1: Species of zoo-benthos identified in Site 1(14 September 2009)

No.	***Zoo benthos species***	***Biomass***	
		units/m^2	gr/m^2
A	**Gastropod**		
	Cerithium cingulata	20	1.24
B	**Polichaeta**		
	Nereis sp	20	0.8

b) Water environmental conditions

Table 2 shows that the key water parameters such as temperature, salinity, DO and pH are suitable for aquatic animal growth and survival in general. The other parameters related to

organic pollution of the water such as nitrite (NO_2), nitrate (NO_3) and ammonia (NH_3) are under the regulated standard level for aquaculture (TCVN 5943, 1995). There are differences in salinity and pH between the water surface and the bottom (under 1.5m). This is important information when considering the type of bivalve culture to be undertaken, particularly for rainy season when fresh water is dominant in the Lagoon.

Table 2: Water environmental parameters in Site 1(14 September 2009)

No.	Parameters	Water Surface				Bottom			
		Rep1	Rep2	Rep3	**Average**	Rep1	Rep2	Rep3	**Average**
1	Tempt (^{0}C)	32	32	32	**32**	32	32	32	**32**
2	Salinity (ppt)	5.00	5.00	5.00	**5.00**	16.00	16.00	16.00	**16.00**
3	DO (mg/l)	5.00	4.50	5.50	**5.00**	5.00	5.00	5.00	**5.00**
4	pH	7.60	7.60	7.60		8.50	8.20	8.50	
5	NO_2 (mg/l)	0	0	0	**0**	0	0	0	**0**
6	NO_3 (mg/l)	0.20	0.20	0.00	**0.13**	0.20	0.00	0.00	**0.07**
7	NH_3 (mg/l)	0	0	0	**0**	0	0	0	**0**
8	Total P	0	0	0	**0**	0	0	0	**0**
9	Total N	0.34	0.25	0.25	**0.28**	0	0	0	**0**

The quantity of phytoplankton biomass in aquatic ecosystem can be regarded as a water quality and ecosystem health indicator. Chlorophyll-a, a ubiquitous photosynthetic pigment, often associated with other pigment in freshwater and coastal marine phytoplankton; and thus chlorophyll-a could serve as a useful indicator for both the photosynthetic potential and biomass of phytoplankton (Flemer, 1969). Chlorophyll-a also plays a direct role in reducing light penetration in water (Lorenzen, 1972). The chlorophyll-a level in Table 3 indicates that water in the Site 1 is mesotrophic (Kilgour, 1998).

The results in Table 3 shows that there are six phyla of phytoplankton in water body including *Bacillariophyta, Chlorophyta*, *Euglenophyta*, *Cyanobacteria, Dinophyta*, and *Chrysophyta*. The phytoplankton density ranges from 57,501 (bottom) to 83,333 (middle) cells/litter, which is low in general. Total N and total P levels as well as the phytoplankton density have proven that the nutrient in water in the Site 1 was poor at the study time (14 September 2009).

There are also three species of toxic algae found in the Site 1. Those are under *Dinophyta* phyla including *Gonyaulax polyedra*, *Prorocentrum micans*, and *Peridinium minutum*. According to the threshold suggested by Kristensen, Petrunin, Andersen, and Andersen (1995), *Gonyaulax polyedra* occurres at low density (500–1333 cell/liter), and it may not thus negatively affect bivalves in the Site 1. *Prorocentrum micans* and *Peridinium minutum* also occur in lower densities than standard levels, and thus it may not provide harm to bivalve species.

Table 3: Algae and toxic algae densities in Site 1 (14 September 2009)

No.	Parameters	Surface	Middle	Bottom
1	***Chlorophyll-a (mg/m^3)***	2.4	1.7	1.2
2	***Phytoplankton (cell/liter)***			
2.1	Bacillariophyta	61,500	61,500	41,167
2.2	Chlorophyta	2,500	5,333	1,333
2.3	Euglenophyta	0	0	167
2.4	Cyanobacteria	8,333	10,000	5,000
2.5	Dinophyta	6,500	6,500	8,167
2.6	Chrysophyta	1,667	0	1,667
	Total	***80,500***	***83,333***	***57,501***
3	***Toxic algae (cell/liter)***			
	Dinophyta			
3.1	*Gonyaulax polyedra*	500	1,167	1,333
3.2	*Prorocentrum micans*	0	167	0
3.3	*Peridinium minutum*	333	0	0

5.2 Site 2 (Loc Binh)

Site 2 is located in Loc Binh Commune near the Tu Hien inlet (see Figure 2). The site is directly connected to the sea by the inlet with relatively high and stable salinity level. The level of salinity and water current depend largely on the tidal regimes. The salinity is normally higher during high tidal period and lower during low tidal period.

a) The substrate structure and the appearance of zoo-benthos

The bottom is leaning from the bank to the inlet-bed. The structure of substrata is mostly sandy and a few mollusc shells and rocks, it is soft and depressible. The surface of the bottom is smooth

The result of the zoo-benthos sampling in Site 2 shows that there are 11 species belongs to 7 families, 3 orders, and 3 classes (see Table 4). Among this total, there are 6 species belonging to *Polichaeta* class; 3 species belonging to *Bivalve* class; and 2 species belonging to *Gastropod* class. The number of species and biomass in the bottom indicates that zoo-benthos, especially *Polichaeta*, in Site 2 is reasonable, so the site could be a potential place for bivalve culture.

In addition, the occurrence of natural clam species *(Meretrix meretrix)* in abundance in Site 2 suggests that some other bivalves such as oyster and other clam species could be cultured in this area.

Table 4: Species and biomass of zoo-benthos identified in Site 2 (14 September 2009)

No.	*Species*	*Biomass*	
		Units/m^2	*gr/m^2*
A	**Bivalve**		
1	*Aloidis* sp	40	1.44
2	*Glaucomdae chinensis*	20	234.46
3	*Meretrix meretrix*	34	870.5
B	**Gastropod**		
4	*Cerithium cingulata*	180	20.46
5	*Cerithium* sp	60	13.14
C	**Polichaeta**		
6	*Heteromastus filiformis*	20	0.14
7	*Goniada maculate*	40	2.52
8	*Lumbriconereis latrelli*	40	1.22
9	*Ophelia acuminate*	20	0.18
10	*Spiophanes bombyx*	20	0.08
11	*Orbinia latreilli*	120	22.58

b) Water environmental conditions

Table 5 shows that the general environmental parameters in Site 2 including temperature, salinity, DO, and pH are suitable for bivalve growth and survival. There are no significant threats from water pollution, which is indicated by NO_2, NO_3 and NH_3. Almost all samples that have tested had zero values (see Table 5).

Table 5: Water environmental parameters in Site 2 (14 September 2009)

No.	**Parameters**	**Water Surface**				**Bottom**			
		Rep1	Rep2	Rep3	**Average**	Rep1	Rep2	Rep3	**Average**
1	Tempt (^{0}C)	32	32	32	**32**	32	32	32	**32**
2	Salinity (ppt)	17	17	17	**17**	17	17	17	**17**
3	DO (mg/l)	5.50	5.50	5.00	**5.33**	5.00	5.00	5.00	**5.00**
4	pH	8.20	8.50	8.20		8.50	8.20	8.50	
5	NO_2 (mg/l)	0	0	0	**0**	0	0	0	**0**
6	NO_3 (mg/l)	0	0	0	**0**	0	0	0	**0**
7	NH_3 (mg/l)	0	0	0	**0**	0	0	0.10	**0.03**
8	Total P	0	0	0	**0**	0	0	0	**0**
9	Total N	0	0	0	**0**	0	0	0	**0**

The sampling results summarized in Tables 5 and 6 indicate that the nutrient of water body is at low level. There are four species of algae with low density. This low algae density in water also supports that the nutrient level in water body is poor. One toxic alga, *Oscillatoria limosa,*

is also found in Site 2, but is not frequent and under low density; therefore, the toxic algae may not pose the threat to aquatic animals as well as humans.

Table 6: Algae and toxic algae densities in Site 2 (14 September 2009)

No.	Parameters	Surface	Middle	Bottom
1	***Chlorophyll-a (mg/m^3)***	0.0	0.0	0.4
2	***Phytoplankton (cell/liter)***			
2.1	Bacillariophyta	52,870	26,468	33,069
2.2	Chlorophyta	67	2,667	467
2.3	Cyanobacteria	13,333	0	2,666
2.4	Dinophyta	668	535	734
	Total	66,938	29,670	36,936
3	***Toxic algae (cell/liter)***			
	Cyanobacteria			
3.1	*Oscillatoria limosa*	0	0	22,217

5.3 Site 3 (Vinh Hien)

Site 3 is located in Vinh Hien Commune near the Vinh Hien-Loc Binh bridge. The field trip indicated that the site is a shallow dune of about 1–2 ha. The fresh water from Cau Hai Lagoon and salt water from the sea mix in this area, and the site might be experiencing the high fluctuation in salinity (this point needs to be confirmed with seasonal water testing in this site).

a) The substrate structure and the appearance of zoo-benthos

As in Site 2, the structure of substrata is mostly sandy with a few mollusc shells and rocks. The substrata are soft and depressible. The surface of bottom is smooth and homogenous.

Table 7 shows that there are 12 species of zoo-benthos that belong to 10 families, 4 orders, and 3 classes. Among this total, there are 5 species belonging to *Polichaeta* class, 4 species belonging to *Bivalve* Class, 2 species belonging to *Gastropod* class, and 1 species belonging to *Oligochaeta*. The species of zoo benthos in Site 3 is the highest in biodiversity as compared to Site 1 and 2.

The general environmental parameters in Table 8 indicate that the site area is appropriate for aquatic animals. There are no significant organic pollution detected that would adversely affect the aquatic animals.

Table 7: Species and biomass of zoo-benthos in Site 3 (14 September 2009)

No.	*Species*	*Biomass*	
		Units/m^2	*gr/m^2*
A	**Bivalves**		
1	*Aloidis sp*	27	4,667
2	*Meretrix meretrix*	22	520.2
3	*Glaucomidae chinensis*	60	0.86
4	*Corbicula sp*	20	0.08
B	**Gastropod**		
5	*Cerithium cingulata*	40	4.24
6	*Melanoides tubeculatus*	80	7.58
C	**Polichaeta**		
7	*Glycera sp*	40	0.34
8	*Goniada inceria*	40	9.6
9	*Ancistrasyllis contrica*	20	0.02
10	*Lumbriconereis latrelli*	20	0.02
11	*Nerine cirratulus*	20	0.24
D	**Oligochaeta**		
12	*Branchiura sowerbyi*	20	0.12

b) Water environmental conditions

There are four phyla of phytoplankton identified in this area; however, the density of the algae in water is low (Table 9). Algae rely on the nutrients available in water body, but the for water nutrient parameters such as total N, total P, and chlorophyll-a indicated that the nutrient content of the water in Site 3 is low (Tables 8 and 9). However, as mentioned above, the nutrient level may vary depending on the changes in water current and tidal regime.

Table 8: Water environmental parameters in Site 3 (14 September 2009)

No.	**Parameters**	**Water Surface**				**Bottom**			
		Rep1	Rep 2	Rep 3	**Average**	Rep 1	Rep 2	Rep 3	**Average**
1	Tempt (^{0}C)	33	33	33	33	33	33	33	33
2	Salinity (ppt)	11	11	11	11	11	11	11	11
3	DO (mg/l)	5.5	6	6	5.8	5.5	5.5	6	5.7
4	pH	8.2	8.5	8.5		8.5	8.5	8.5	
5	NO2 (mg/l)	0	0	0	0	0	0	0	0
6	NO3 (mg/l)	0	0	0	0	0	0	0	0
7	NH_3 (mg/l)	0	0	0	0	0	0	0.1	0.0
8	Total P	0	0	0	0	0	0	0	0
9	Total N	0	0	0	0	0	0	0	0

In Site 3, there are three toxic algae found through the sampling. Two of them belong to *Dinophyta* phylum while one belongs to *Cyanobacteria* phylum. The density of toxic algae under *Cyanobacteria* phylum is between 19,333 and 134,833 cells per litter. This range of the algae is not harmful to the bivalves. On the other hand, two species of algae under *Dinophyta* phylum, including *Gonyaulax polyedra* (density between 667 and 2,667 cells per litter) and *Peridinium minutum* (density between 667 and 1,333 cells per litter), are over the limit (Kristensen et al., 1995). These two algae species could pose harmful effects on the bivalves.

The above result has an important implication for the planning of the bivalve culture models as the toxic algae are not only harmful to the aquatic animals but also to the human beings if consumed. As the sampling was done only in one day (14 September 2009), to confirm the general level of toxic algae in this site, more frequent testing would be required.

Table 9: Algae and toxic algae densities in Site 3 (14 September 2009)

No.	Parameters	Surface	Middle	Bottom
1	***Chlorophyll-a (mg/m^3)***	0.0	1.5	0.6
2	***Phytoplankton (cell/liter)***			
2.1	Bacillariophyta	45,333	50,167	38,000
2.2	Chlorophyta	500	3,167	2,500
2.3	Cyanobacteria	0	0	167
2.4	Dinophyta	147,833	91,000	186,500
	Total	**13,500**	**8,833**	**12,833**
3	***Toxic algae (cell/liter)***			
3.1	**Dinophyta**			
3.2	*Gonyaulax polyedra*	2,667	667	0
3.3	*Peridinium minutum*	667	833	1,333
	Cyanobacteria			
3.4	*Anabaena circinalis*	19,333	66,000	134,833

6. Conclusion

Although all study sites are close with each other, the water parameters such as salinity, total N, total P, chlorophyll-a as well as biological characteristics such as zoo-benthos and algae in each site are different reflecting the complex dynamics of the lagoon. In general, the environment parameters in surveyed areas are suitable for bivalve survival. This conclusion is supported by the fact that there is natural occurrence of mollusc speceis such as oyster, green mussel, clam, and gastropods in all surveyed areas.

There are six toxic algae found in study sites belonging to *Dinophyta* and *Cyanobacteria* phylum. The density of toxic algae under *Cyanobacteria* phylum (density between 22,000 and 135,000 cells per litter) would not be harmful to aquatic animals including bivalves. By contrast, two species of toxic algae under *Dinophyta* phylum are found to be over limit, and

could potentially be harmful to the bivalves and humans in Site 3 -- *Peridinium minutum* appeared with the density range of 667-1,333 cells per litter, and *Gonyaulax polyedra* appeared with the density range of 2,667 cells per litter respectively. This tentative conclusion, however, needs to be confirmed with more frequent testing in the future.

7. Recommendations

It would be recommended that the selected sites above be cultured with bivalve mollusc species groups including oyster, green mussel, and hard clams. However, the culture experiment should not go beyond the borders of selected sites as the different places in the Lagoon have different conditions due to the substrate structure, salinity, and current of water.

The potential culture species that are suitable for these sites would be five species including local species such as oyster *(Crassotrea rivularis),* hard clam *(Meretrix meretrix),* and green mussel *(Perna viridis)* and non-local species such as pacific oyster *(Crassostrea gigas)* and Ben Tre clam *(Meretrix lyrata).* This species selection was made based on water environment, substrata structure, water current, and the appearance of local species in water body in each site.

There are many different bivalve culture techniques available for different species and culture conditions such as floating raft culture (oyster and mussel culture), net fencing culture (clam), pole culture (green mussel), and bottom bag culture (oyster). The cultures techniques that can be applied to the selected sites are summarized as follows:

- **Site 1:** This site should be cultured with local oyster *(Crassostrea rivularis)* and green mussel *(Perna viridis)*. Local oysters should be cultured by floating rafts and bottom bags, and green mussels should be cultured by floating rafts and poles. One necessary consideration would be stratification of the water in this site. The salinity was low on the water surface (5ppt) while it was higher on the bottom (16ppt) (see Table 2). This stratification may affect oysters and mussels if they are hanged in the shallow water. It would be thus recommend to hang oysters and mussels in the deeper water, at 2 m or below, and move them to the bottom to avoid the negative effects of fresh water during the long-lasting rainy periods.

- **Site 2**: This site should be cultured with pacific oyster *(Crassostrea gigas),* local oyster *(Crassostrae rivularis),* and local clam (*Meretrix meretrix*) because this site has stable environmental conditions including salinity and temperature. The culture technique should be floating raft for oysters and fencing culture for clams.

- **Site 3**: This site should be cultured with Ben Tre clam (*Meretrix lyrata*), because this species can adapt to the wider environmental conditions including salinity and temperature as compared to the local clam species.[1] *Meretrix lyrata* can be a good candidate for culturing in this site as this site might experience some changes in environmental condition. The culture technology should be fencing culture.

[1] Without having high adaptation ability to wide ranges of environment, *Meretrix meretrix* usually moves to other places when the environmental conditions in water body have changed, by secreting mucus as an umbrella. The clam with its mucus floats on the water surface to move. *Meretrix lyrata* do not have the same behaviour.

The bivalve seeds for culture can be provided by both natural collection from the Lagoon (local clam, local oyster, and local green mussel) and immigration from the Thanh Hoa Province (Ben Tre clam) and the Hai Phong Province (pacific oyster).

All suggested mollusc species could be cultured around the year at the selected sites by using the methods and techniques as mentioned earlier. However, the salinity in the Lagoon would be reduced from September up to March due to the rainy season, and the resulting low salinity may damage the culture species. Therefore, the culture period and stocking size should be carefully considered. The author would recommend that the culture period be between 6- 8 months, starting in April and harvesting before September. The stocking size should be relatively big, between 1000 to 1500 units per kilogram for clam or mussel and 700 to 1000 units per kilogram for oyster, reflecting the shorter culture duration in the Lagoon.

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Appendix

1. Floating ratf culture

(Source: http://images.google.com.vn/images)

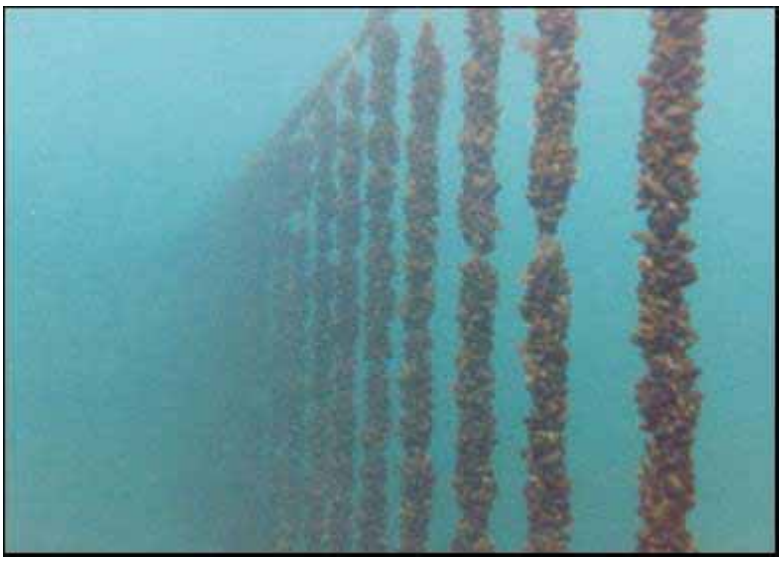
2. Hanging raft culture (for collecting wild seed)

(Source: http://images.google.com.vn/images)

3. Bottom bag culture

(Source: http://images.google.com.vn/images)

4. Rope culture



(Source: http://images.google.com.vn/images)

5. Fencing culture

(Source: Chu Chi Thiet, 2007)