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Shrimp farming sustainability in the Mekong delta Environmental and technical approaches

Proceedings of the Workshop held in Travinh (Vietnam), 5-8 March, 2002

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Editors: J. Populus, J.L. Martin, Nguyen Tac An

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Foreword and Acknowledgements

The economic performance of shrimp rearing is governed by three types of factors a) the environmental conditions prevailing around the farms, b) farmers' zootechnical practise and know how, c) economic management.

The Gambas project aims at identifying the relative role played by these parameters in the success or failure of small-scale shrimp farming enterprises of the Mekong delta in Vietnam. It is being conducted by French and Vietnamese partners under the co-leadership of Ifremer and the Nha Trang Institute of Oceanography.

From March 5th to 8th 2002 a workshop was held on one of the project sites (Tra Vinh) where a panel of fisheries officers from district and province levels met. The meeting aimed at examining the notion of sustainability and the primary conditions to achieve it, based on Gambas first results. Three sessions were designed to deal with the above mentioned parameters whose monitoring was recognized capital towards success.

The preliminary results presented there have shown that the southern part of the Mekong delta exhibits a great spatial an temporal diversity. Ecological and hydrobiological parameters witness a natural environmental dystrophic state. More than elsewhere, aquaculture will not thrive unless a thorough understanding is acquired of how zootechnical aspects can counterbalance this dystrophic state and instability.

Areas recently converted from paddy to shrimp show globally good results. Paradoxically, areas under stronger marine influence which have been for the last ten years devoted to the mixed mangrove-shrimp system, reveal yields much poorer than expected. Studies underway in Gambas aim at confirming these observations and possibly at finding explanations, from both environmental and zootechnical standpoints.

This program is funded by the Directorate Development of the European Commission (contract 99/362-B7/6200-DG Development)

Workshop on "*Shrimp farming sustainability in Mekong Delta: environmental and technical approaches* "

Travinh, Vietnam, 5-8 March 2002

Presentation of the GAMBAS project

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Abstract

While playing a leading role in farmed shrimps with almost 80% of Vietnam shrimp culture production (158,775 tons/420,168 ha in 2001), The Mekong delta suffered drastic collapses at the turn of the 90's. The main reason for the decrease of production was identified as deteriorating water quality and the emergence of numerous pathogens. Excessive and unplanned farm development and poor pond management have exacerbated this trend. Aquaculture is so dependent on the health of the environment that it cannot succeed in unsuitable or degraded sites.

GAMBAS is an EC project implemented by IFREMER (France) and Institute of Oceanography of Nha Trang (Vietnam) during 2000 – 2003. Based on the results of previous research conducted with the support of EU (STD3/DG12) from 1994 to 1997, the project aims at promoting the sustainable development of shrimp farming in the Mekong delta while avoiding ecosystem degradation and production collapses.

Beside the studies on the ecological parameters and environmental indicators, the dialectic relationship between the mangrove and the limitation of shrimp farming area and the socio-economic characteristics will be analyzed for sustainable shrimp farming development and environment protection and for enhancing the commercial quality of cultured shrimp. The information concerning the access to know-how, pond size related to the farmer's management capacity, water renewal as well as quality of post-larvae will be treated.

The proposed questions with high priority are capacity building, dissemination, public education and limiting of the conflicts between the economic sectors while developing the brackish water shrimp farming in the Mekong delta. It is intended to have a practical impact on farming communities through local fisheries authorities.

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Mekong Delta water quality and sustainable aquaculture development

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Abstract

There are 2 separated seasons in the Mekong delta: dried season (from the middle of November to March of next year) and rainy season from middle of May to October). Average air temperature is about 26 – 28^{0}C (varies from 25 to 36^{0}C), average water temperature is about 28^{0}C (varies from 18 to 35^{0}C).

Channel density is about 20 – 30m/ha, channel area occupies 9% of the delta area. The tidal regime of the delta is semi-diurnal. The tidal amplitude is about 1,5 – 30 m. The tide can propagate into inland, about 50 - 100 km far from the coast with the velocity of 0.75 – 1,8 m/s.

Salinity at the estuaries often varies from 15 - 20‰, sometime attains to 30‰. During the months from June to November, the salinity is relatively low, about 0 - 12‰ and during November to May of next year, the salinity has higher value: about 12 - 30‰.

Natural risks should be paid attention are drought (in dried season from December to April – May), flood (about three months/year), storm surge...

The pH of sediment is about 6,7 (varies from 6.2 – 7.3), showing a weak acidity. The organic carbon concentration in sediment is 1,11% (varies from 0.22 – 7,69%), Nitro: 0.07% (0.01 – 0.29%), organic phosphor: 0.07% (0.01 – 0.14&).

The pH of the water varies from 6.8 – 7.0. The dissolved Oxygen is relatively low, especially in the rainy season: 3.45 – 4.45 mlO_2/l, saturation is about 58 – 84%. The nutrients have average values as following: 266.25 $mgNO_3/m^3$ (67 – 561 $mgNO_3/m^3$), 115 $mgNH_4/m^3$ (28 – 182 $mgNH_4/m^3$), 41.8 mg PO_4/m^3 (18 – 99 $mgNH_4/m^3$). The suspended matter is about 159 mg/L (3 – 525 mg/L).

In reality, for commercial farming, it should focus the most important factors and the easiest monitored factors as the indicators and scientific basis for proposing treatment solutions. For example: for Tiger shrimp farming, there are three main parameters which are pH, salinity and suspended matter; for management of the growth status and the water quality of the ponds, it should daily monitor three parameters: pH, dissolved oxygen and water transparency.

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Selection of environmental indicators for shrimp aquaculture site selection

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Abstract

Shrimp aquaculture is performed according to several ways, ranging from full extensive to full intensive. Between them are included other ways such as improved extensive and semi intensive rearing. For full extensive, shrimps needs are brought by the surrounding environment, while for full intensive, the needs are brought by adding feeds pellets in the pounds. Intensive aquaculture withdraws organic matter (= production of shrimps through primary production) from the environment, while intensive aquaculture introduces organic matter (unconsumed feed pellets, faeces...) into the environment. In this paper we make an analysis of the needs of the different kind of shrimp aquaculture in relation to the characteristics of the environment, with special emphases on several parameters related to the environment, such as the confinement level, the capacity to accumulate or eliminate the organic matter, the ability for natural oxygenation, the primary production potential...

Shrimp aquaculture is performed according to several ways, ranging from full extensive to full intensive. Between them are included other ways such as improved extensive and semi intensive rearing. For full extensive, the surrounding environment brings shrimps needs, while for full intensive, the needs are brought by adding feeds pellets in the pounds. Intensive aquaculture withdraws organic matter (= shrimps) from the environment while intensive aquaculture introduces organic matter (unconsumed feed pellets, faeces, unconsumed feed pellets....) into the environment. Then, the needs concerning environmental feature will be different according the type of rearing. The main characteristics concerning extensive aquaculture is to be productive enough to sustain the growth of the shrimps trough the production of preys, while the main problem concerning intensive aquaculture concerns the capacity of the environment to eliminate the organic wastes. The figure shows the relationships between the two main type of aquaculture on the one hand, and the environmental features on the other hand. These features are expressed regarding the seawater renewal capacity of the surrounding environment of the rearing farms. When the seawater renewal capacity is high (high "energy", low confinement), the capacity of the site for accumulating organic mater is low, and the capacity for water oxygenation is high. On the contrary, when the seawater renewal capacity is low (low "energy", high confinement), the capacity of the site to accumulate organic matter is high, while its capacity for oxygenation is low. These characteristics will determine the kind of aquaculture potentially workable. For intensive aquaculture type, optimal conditions are met in water showing low confinement characteristics (such as open sea water) presenting a high capacity to eliminate quickly and efficiently the organic wastes. It is to be noted that most of problems encountered by intensive aquaculture concerns the input of organic wastes into the surrounding environment leading to its increasing degradation. This explains most of collapses which occurred during the last 15 past years, all around the world.

Coastal ecosystems are structured according to these two characteristics of "energy" and confinement. Thus, when the energy is high and the confinement low, oligothrophic characteristics are encountered (low concentrations of phytoplankton, low concentrations of organic matter....). In confined environment, dystrophic conditions are encountered (low oxygenation capacity, organic matter accumulation, high concentrations of bacterias....). The structures of phytoplanktonic and bacterial populations varies according to the level of confinement.
Extensive aquaculture is supported by the natural trophic web. In oligothrophic environmental conditions, the growth of the reared organisms is not efficient. On the contrary, in dystrophic environment, the conditions are unfavorable for shrimp rearing. Thus, the main problem concerning extensive aquaculture is related to the positioning of this activity according to the characteristics of the ecosystem. The environment must allow a good natural production of shrimp feed (preys) while ensuring a satisfactory elimination of the wastes: used water and sediment particles accumulated on the bottom of the pounds (this includes also the organic wastes for "ameliorated extensive" rearing). The best positioning for extensive aquaculture is located within the "eutrophic" area of the ecosystems. This area shows a high primary production (production of phytoplankton), with sufficient oxygen production, and, consequently, a potentially high production of shrimps preys (secondary production), such as copepods, nematodes....

It exists two categories of environmental indicators. The first category relies to the physiology of the reared species. Temperature and salinity are the most relevant parameters in this category. Temperature does not constitute a problem in the Mekong Delta environment regarding shrimp aquaculture. On the contrary, salinity present a wide range of fluctuation either spatial or seasonal. The implementation of aquaculture activity has to take this characteristic into account. It is well known that *Penaeus monodon* can be reared at very low temperature. Nevertheless, it must be noted that one of the main requirement for aquaculture sustainability relies to the stability of the environment. Regarding the salinity, a high sustainability means that this parameter must be stable, but, furthermore, it must be within the salinity *preferendum* of the reared shrimp. A fluctuating environment leads to a weakening of the shrimps, with, as consequence, a higher sensibility to external aggression such as bacteria, vibrios, chemical pollutants... So, it can be assessed that the first required quality for sustainability relies to the fact that the

The second categories of environmental indicators relies to the trophic level of the ecosystem. These parameters indicate the level of confinement and "energy" in relation with the metabolism of the organic matter (which support the primary production) and of the state of oxygenation. Thus in confined environment, with high concentration of organic matter and low capacity for oxygenation, higher the concentration of Sulphate Reducing Bacterias lower the capacity of the environment to sustain aquaculture activity. Similarly, denitrification process, related to oxygen deficiency, can lead to the development of phytoplanktonic cells such as some variety of characteristic cyanobacterias. Measurements of the Particulate Organic Carbon and of Particulate Nitrogen, gives informations on the nature of the organic matter being in the water, from detritic origin or not, and able to participate directly to the process of the production of shrimp food (preys). Informations on the confinement level of the ecosystem can be given by analyzing pigments, nutrients...

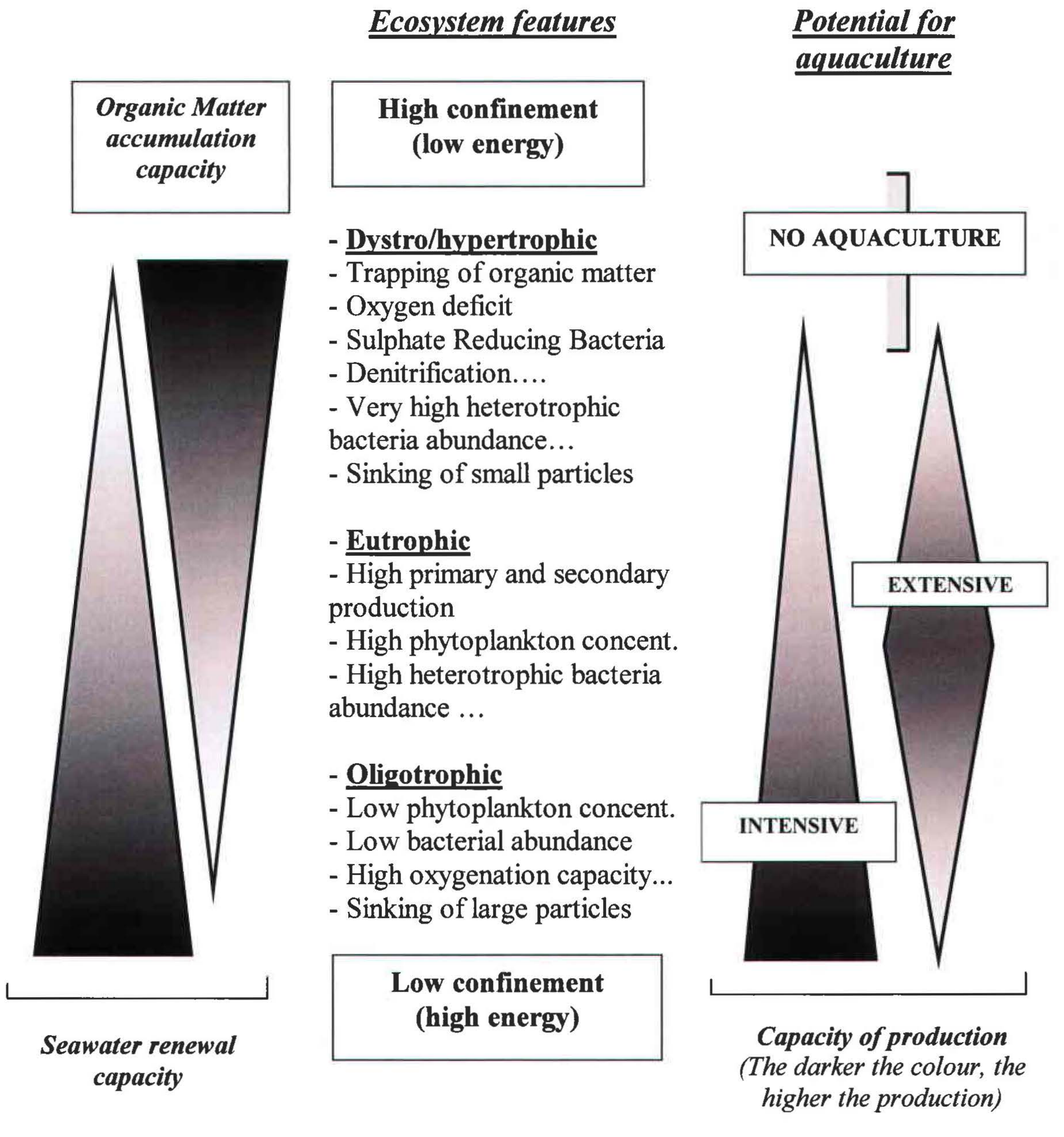

Fig 1. Positioning of the different types of aquaculture, and their potential performances, according to the trophic characteristics of the environment. (*The maximum of production is expected in the oligotrophic area for intensive aquaculture, while this maximum occurs in the eutrophic area in the extensive way. In dystrophic/hypertrophic area, except for some species, aquaculture is not possible*).

Investigations are also carried out on the characteristics of the aquatic sediment. Thus, the sedimentation of very small particles may occur only in low "energy" (current, waves, tidal amplitude, rate of water renewal...) area . In fact, it exists a relationship between the energy of the environment and the size of the particles. The higher the "energy" of the ecosystem, the larger the size of the sunk particles. Now, it exists an inverse relationship between the size of the particles and the concentrations of elements (such as chemical contaminants, but also bacterias, virus...) adsorbed on these particles. As a consequence, the sediment can be considered as a potential indicator regarding the capacity of the environment to host aquaculture activities, in relation to the level of confinement of the site.

As has been previously said that the confinement of a site is related to its seawater renewal capacity. For the Mekong Delta, whose structure is made of linear water bodies, this capacity is related to 3 main geomorphologic characteristics (1) the distance of the site (inside the land) from the sea shore, (2) the surface of the cross section of the water body, (3) the tidal range. Thus, it can be hypothesized a coefficient relying to the confinement of the sites according to the formula:

$$\alpha = d \times 1/S \times 1/T$$

where d is the distance from the seashore; S is the surface of the water body cross section; T is the tidal range.

The aim of the research carried out on the environmental characteristics of Mekong Delta is to determine the validity of such environmental indicators, including the coefficient of confinement, putting them in relation with the production performances and the rearing techniques of selected farms on selected sites of the Mekong Delta ecosystem. The ultimate goal is to set up a tool to help in site selection for shrimp aquaculture.

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Planktonic indicators of the quality of Mekong delta waters

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Abstract

The water quality in relation to the shrimp aquaculture potential of delta Mekong water is discussed with a special focus on the phytoplankton community structure and productivity. Phytoplankton biomass was assessed using chlorophyll concentration, microscopic counts, flow cytometry, HPLC pigment analysis and molecular probes. Phytoplankton production was measured using the standard ^{14}C *method. First results indicated a dominance of the picoplankton (plankton with a size less than 3 µm) in the two prospected areas (Ca Mau and Tra Vinh). Picocyanobacteria was the most important component of the phytoplankton assemblage. Picoeukaryote compartment was dominated by chlorophyta. Pelagophyceae, Bolidophyceae, Prymnesiophyceae, Pseudoscourfieldiales, Mamiellales, Ostreococcus, Micromonas and Bathycoccus were the family and genus identified in the picoplankton. Phytoplankton production measured in an incubator (same light intensity) was strongly correlated to biomass (as chlorophyll). Minima of phytoplankton biomass and production were observed in the main channels with high turbidity.*

1 - Water quality and aquaculture potential

Mekong waters entering shrimp culture ponds are charged in organic and mineral matter. The organic matter is composed of living organisms (bacteria, phytoplankton and zooplankton) and detritus (Figure 1).

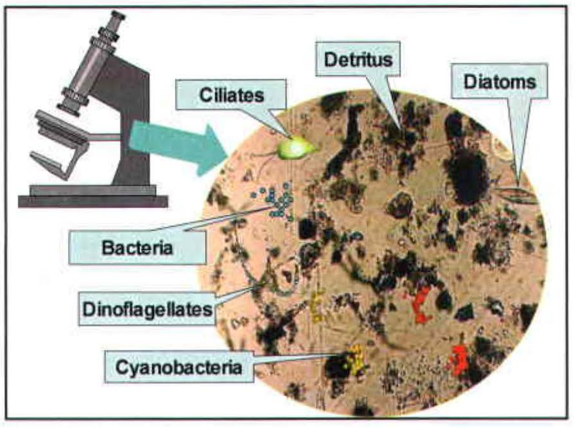

Figure 1: Scheme of particulate organic matter

After some hours inside the pound a part of this matter will sediment onto the bottom. The organic matter could be used by all the animals present at the surface or inside the sediments, shrimp included. Heterotrophic bacteria have a positive and a negative role in the pound ecosystem. They mineralize detritus producing nutrients available for primary production but they consume dissolved O_2 and they produce catabolic substances. When bacteria are poorly consumed, a great part of the nitrogen is stocked inside this compartment and not available for primary production.

Natural assemblages of phytoplankton are mostly valuable for aquaculture. They utilize nutrients and purify the water. They produce oxygen which is indispensable for all animals. At the least, they produce fresh organic matter (food) which is necessary for shrimp aquaculture, even if shrimps can not graze directly onto the phytoplankton. The measurement of phytoplankton production is therefore very important to estimate the aquaculture potential of the site. In other hand, the taxonomic composition of phytoplankton will give valuable informations on the water quality.

The phytoplankton is composed of photoautrophic organisms. These organisms are cyanobacteria (prokaryotes) and algae (eukaryotes). During many years, the very small phytoplankton, now called picoplankton (with a size less than 0.003 mm), was unknown. Thanks to the use of new apparatus like a flow cytometer, we are now able to count these tiny organisms which are very abundant in tropical waters. In this size class, we find the coccoid cyanobacteria *Synechococcus* and *Prochlorococcus*, but also numerous species of unknown algae.

The large organisms (0.003-0.02 mm) can be counted and determined using an optical microscope. The measurement of phytoplankton pigments by HPLC (High Pressure Liquid Chromatography) can also be used to assess the contribution of the different algal groups to total biomass.

Other very small organisms like heterotrophic bacteria (0.0002-0.002 mm) can also be counted using a flow cytometer.

2 - Sampling strategy

Sampling was carried out at high tide more or less 2 hours to be on studying the water mass likely to fill the basins. Fifteen stations were prospected in Ca Mau and twenty in Tra Vinh (Figure 2). Sampling in the water column was carried out at the surface and at 2 m depth and one meter above the bottom.

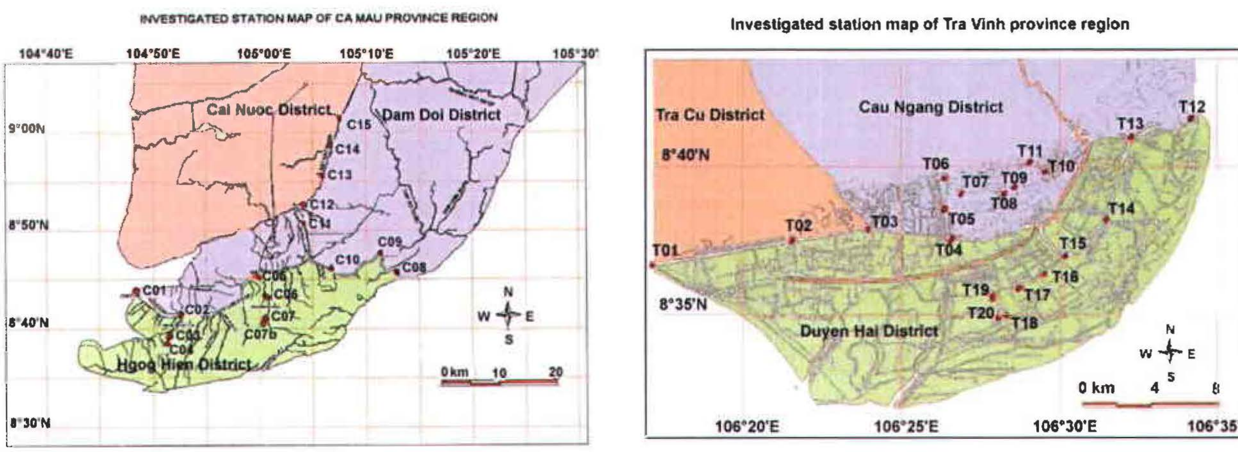

Figure 2: Sampling stations prospected in the Mekong delta

- Planktonic parameters measured in the Mekong river

Phytoplankton biomass

The total phytoplankton biomass was estimated by measuring the concentration of the most important pigment of photosynthetic organisms: the Chlorophyll_*a*. However, total chlorophyll data do not give informations on the composition of the phytoplankton assemblage. Phytoplankton size cannot be assessed using filtration on different pore size filters because of the large amount of very fine sediments in the water. Therefore, we use a flow cytometer to assess the small size cells biomass and a High Performance Liquid Chromatograph to estimate the contributions of different taxonomic groups to total biomass. As it was impossible to transport these equipments in the field, we had to fix (for cytometer) and froze the samples in liquid nitrogen before analysis in the IRD laboratories.

To complete our knowledge on the taxonomic phytoplankton composition, we use molecular probes to assess the biomass of the small picoeukaryotes. Indeed, these organisms can be very abundant and very little information exists in the literature, especially in brackish waters.

Phytoplankton production

The phytoplankton production is the increase of its biomass by unit of volume and time. The main factor controlling phytoplankton production is the light energy which varies according to the cloud coverage. As we decide to use this parameter to compare the fertility of farm sites, we did all the measurements at the same light energy level (7800 lux) during the same time (3 hours), inside an incubator with flowing water to avoid an increase of temperature.

3 - Preliminary results

In Ca Mau the prospected stations were strongly influenced by sea water. Indeed, all stations except stations C13 to C15 presented salinity higher than 20 PSU. At the contrary, in Tra Vinh in all stations except T19, salinity was below 10 PSU.
The flow cytometer was able to distinguish and to count 2 populations of picoplankton: a population of picocyanobacteria and another one of picoeukaryotes; and after coloration, a population of heterotrophic bacteria (Figure 3).

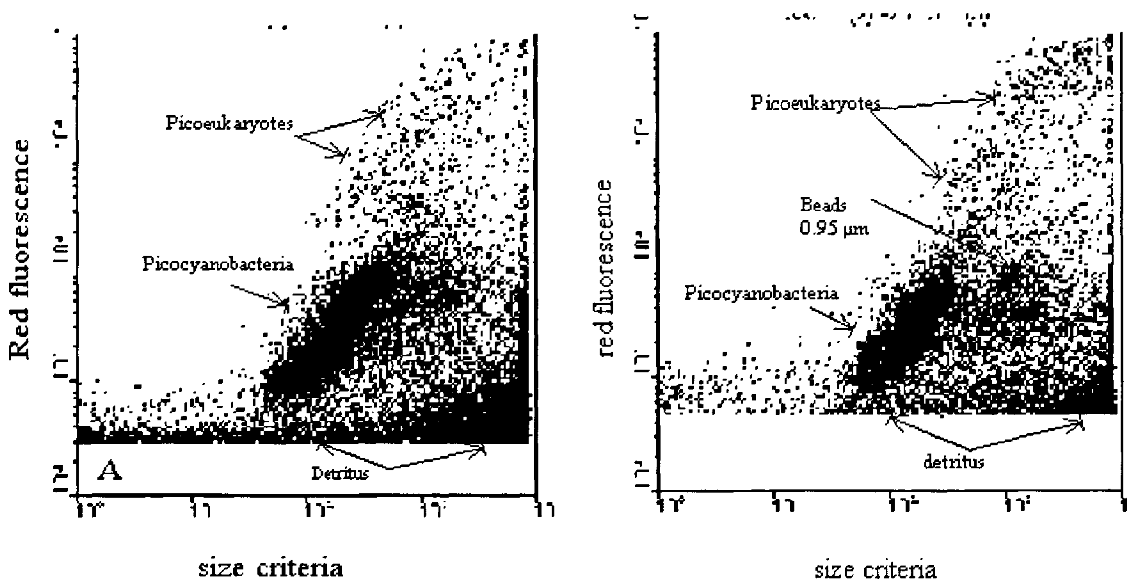

Figure 3: Example of flow cytometry data from Ca Mau (left) and Tra Vinh (right) inJanuary 2001

Picocyanobacteria ranged between 10^3 and 10^6 cells ml^{-1} while picoeukaryotes ranged between 10^2 and 0.2 10^6 cells ml^{-1} and heterotrophic bacteria between 10^6 and 10^8 cells ml^{-1} (Table 1).

The phytoplankton biomass estimated by the chlorophyll concentration in the upper layer (0 – 2 m) of Mekong River is highly variable. Such range (1 to 28 µg l^{-1}) indicates a strong difference in the quality of the water entering the shrimp pounds (Table 1).

Table 1: Chlorophyll (µg l^{-1}) and abundance per ml of picoplanktonic organisms in January 2001

	Chlorophyll	picocyanobacteria	picoeukaryotes	bacteria
Tra Vinh				
maximum	1.56	$1.1x10^6$	$1.7x10^5$	$2.4x10^8$
minimum	14.61	$9.8x10^2$	$1.5x10^2$	$4.8x10^5$
Ca Mau				
maximum	1.17	$8.0x10^5$	$1.0x10^5$	$1.5x10^7$
minimum	11.91	$8.5x10^3$	$1.1x10^4$	$2.1x10^6$

Phytoplankton production (P) is correlated to phytoplankton biomass (B). However, some stations present a low P/B and other a high P/B. As the level of energy was the same for all incubations, environmental factors like nutrient availability or high turbidity could be responsible for the P/B variability (table 2).

Table 2: Chlorophyll (µg l^{-1}) and production (µg C l^{-1} h^{-1}) in October 2001

	Chlorophyll	Production	Prod/Chl
Tra Vinh			
maximum	0.9	8.1	3.2
minimum	28.2	257.7	14.4
Ca Mau			
maximum	0.4	14.7	3.6
minimum	16.9	154.8	27.2

In October 2001, in Ca Mau, the richest stations in term of Chlorophyll_*a*nd productivity were located between Nam Can and the Omo mouth (C1 to C5 and C10). These stations were characterized by high concentrations in Chlorophyll_*a*nd fucoxanthin. Two stations, stations C3 and C4 were particularly rich in zeaxanthin (cyanobacteria) and divinyl Chlorophyll_*a* (*Prochlorococcus*).

FISH-TSA is applicable on natural samples of Mekong delta. Given the improved sensitivity of this detection and identification system, we used this method to study natural communities from Mekong waters (Figure 4).

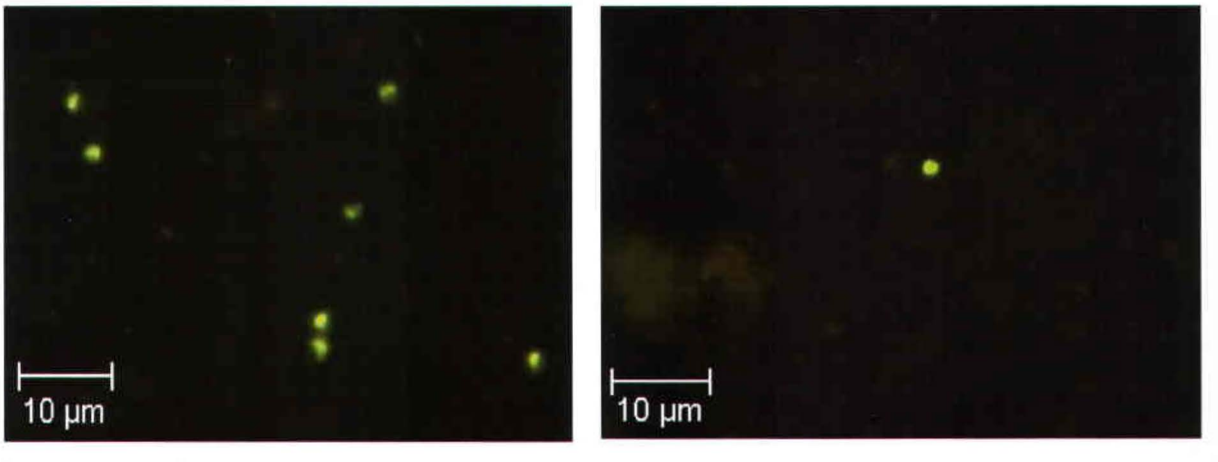

Figure 4: Epifluorescence microscopy images of natural samples. At the left sample harvested at Roscoff (France), hybridized with the probe CHLO01. At the right, sample from C1 st8 (Vietnam) hybridized by the probe BOLI02

At Ca Mau (station 8, 0 m, January 2001), we identified 3 taxa :Chlorophyta, Prasinophyta and Bolidophycae (table 3). It is the first time that Bolidophycae are reported in a brackish environment (Figure 5).

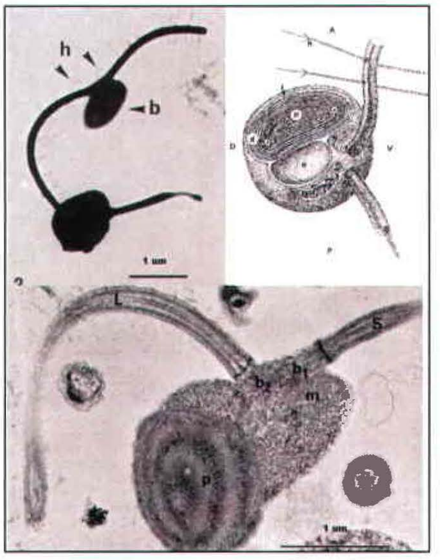

Figure 2: *Bolidomonas pacifica*

Table 3: Taxa identified in the Mekong delta

Nam Can St8	Oligonucleotide-probes	% taxa
Picophytoeukaryotes	EUK1209R	100
Chlorophyta	CHLO02	41
Prasinophyta	PRAS02	11
Non-chlorophyta	NHLO01	40

In table 4 appears the 8 families and genus identified in the Mekong delta.

Table 4: Family and genus identified in the Mekong delta

	Tra Vinh St 12	Ca Mau St 5	Ca Mau St 8
Pelagophyceae	YES	YES	YES
Bolidophyceae	YES	YES	YES
Prymnesiophyceae	YES	NO	YES
Pseudoscourfieldiales	YES	NO	NO
Mamiellales	YES	YES	YES
Ostreococcus	YES	YES	YES
Micromonas	YES	YES	NO
Bathycoccus	NO	YES	NO

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Seasonal change of ecological characteristics in investigated areas of Tra Vinh and Ca Mau

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Abstract

In framework of Gambas program, during 1 preliminary and 2 formal field trips, the team of Ecology Task have collected and analyzed approximately 2000 samples. As the results around 4000 data of different ecological parameters have been obtained. The analyzed data have shown significant difference between two sites and strongly changed by season. It is worthy to notice that there are some parameters, such as salinity, temperature, chlorophyll-a, Vibrio..., showing higher values in Ca Mau area than in Tra Vinh while the others are mainly in lower values. Organic carbon and nitrogen content in particulate matter change strongly according to the season and probably make change values of primary production, total sulphate-reducing bacteria...These valuable data should be essential when characterizing the quality of water of investigated areas in order to contribute to aquacultural development in the region

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Shrimp farming and mangroves

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Abstract

The present knowledge concerning the actual links between mangrove ecosystems and shrimp farming is still rather poor. Because many hydro-biological, physical, chemical and socio economical ill-quantified parameters are involved. Another probable reason for such a situation is related to the fact that this topic involves a numerous amount of specialities from hydrology, soil science and plant physiology to water regimes, water qualities and their implications on the primary productivity of the phytoplancton and on the growth of mangrove trees.

For all these reasons it is essential to clearly identify the areas for which a sufficient knowledge is now available for sustainable management practices and those areas which still need further basic scientific research before any mangrove conversion to other uses is carried out.

Depuis environ 20 ans les pouvoirs politiques de la plupart des pays ont décidé de restaurer les mangroves avec des objectifs généralement différents :

- production de bois (Malaysia, Venezuela, Columbia, Vietnam, etc)
- production côtière contre l'érosion, les ras de marée, les cyclones (Bangladesh, India, Central America, Caribbean islands, etc)
- garantie de rendements des pêches côtières (Indonesia, Thailand, Philippines, Pakistan, etc)
- préservation de l'environnement et de la biodiversité de chaque pays (Florida USA, Bali, Australia, United Arab Emirates, etc).

En réalité, la réhabilitation est de type "multi-purposes" et les objectifs ne sont pratiquement jamais orientés vers un seul type de production.

Toutes ces fonctions sont réunies au delta du Mékong mais on ne connaît pas les bénéfices réels du couple "mangrove - aquaculture de crevettes" parce que cela n'a pas été étudié avec précision. C'est un domaine dans lequel la connaissance est souvent plus empirique, traditionnelle ou intuitive que scientifiquement démontrée, dans chaque site.

Il est incontestable que l'écosystème "mangrove" est hautement productif en matière organique (10 à 15 tonnes/ha/an) qui retourne à l'écosystème aquatique (fig. 1). La production primaire reste élevée même en milieu aride (fig. 2). Dans tous les cas l'aquaculture en bénéficie (matière organique, protection des berges, production de juvéniles, etc).

Cependant, les inconvénients peuvent provenir d'une accumulation excessive de matière organique et de dérivés de la biodégradation (tanins). C'est un problème de régime hydrique qu'il convient d'étudier et d'adapter cas par cas.

La coexistence de mangroves de différents types et d'aquaculture de crevettes n'est pas simple et n'obéit pas à des règles universelles. Chaque partie du delta a des propriétés physico-chimiques particulières mais les exigences écologiques des mangroves (régime hydrique, cycle des nutriments, stabilité du substrat) ne sont pas nécessairement compatibles avec celles de la crevetticulture (*Penaeus monodon*). Il faut donc inventer le meilleur compromis garantissant le bon développement de la mangrove et le bon fonctionnement hydrique des bassins d'aquaculture de telle manière que les rendements maintiennent une continuité d'une génération à l'autre.

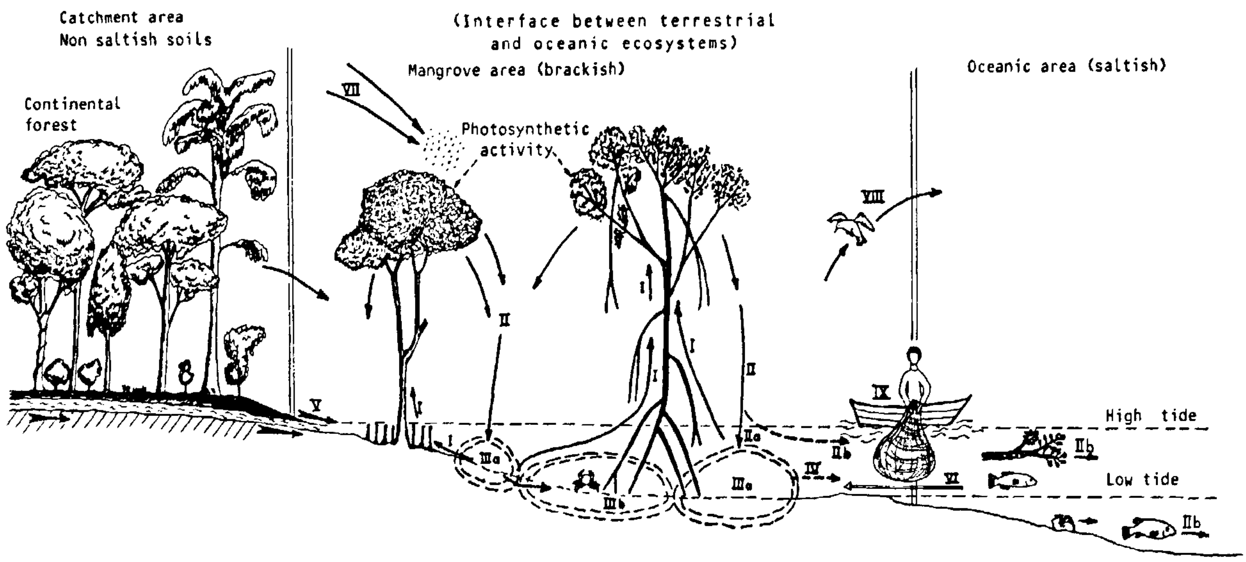
Si le régime hydrique favorable aux mangroves est garanti, on sait que le rapport 3 hectares de mangroves pour 1 hectare d'aquaculture peut apporter un rendement soutenu et une forme de développement durable pour les populations côtières.

Pourquoi ne pas réfléchir en même temps à une diversification future des productions. Par exemple, en étudiant la possibilité probable de développement comprenant par exemple dans les mangroves :
- *Xylocarpus sp.* et élevage de crabes. Les *Xylocarpus* produisent un bois de valeur en menuiserie.
- *Heritiera fomes* (et élevage de crabes ou autres). *Heritiera fomes* produit un bois d'ébénisterie de grande valeur (India - Bangladesh - Myammar). Son introduction et sa sylviculture dans le delta du Mékong pourraient être testées rapidement car l'expertise écologique et sylviculturale est disponible (seed collection, nursery, planting, thinning, rotation, etc).

Les figures 1 et 2, ainsi que les tables 1 et 2 donnent des informations théoriques et pratiques sur le fonctionnement, les biomasses et l'évolution des mangroves.

Conclusion
Les connaissances scientifiques sur l'écologie des mangroves et des crevettes ne constituent pas une réponse aux problèmes d'aquaculture de crevettes car interviennent obligatoirement de multiples paramètres tels que l'expertise des fermiers, les questions zootechniques et épidémiologiques et le contrôle socio-économique.

Le programme Gambas devrait produire des avancées dans l'intégration de ces données, dans l'intérêt des populations du delta du Mékong.



SUMMARY

- o I - Absorption; complex metabolic processes
- II - Primary production
  - oIIa - Fraction returned to the ecosystem
  - •IIb - Organic export. Decomposable organic material, plant litter etc...; enrichment of coastal waters
- oIIIa - Microbial decay
- oIIIb - Larval cycles + detrital feeding (fish, shrimps etc...)
- • IV - Nutrient export
- ⊕V, VI, VII - Mineral ions (inorganic) and organic matter transported by fresh water or by tidal flooding (VI) or by winds (VII)
- oVIII - Water birds and other sedentary vertebrates
- •IX - Human exploitation of the ecosystem

o = Conservation of the nutrient pool
• = Withdrawn from the nutrient pool
⊕ = Adding to the nutrient pool

Figure 1. Bio-physical process in mangrove functioning

Table 1: An estimate of total mangrove biomass and annual litterfall in the UAE (Dodd, Blasco 1999, Saenger, Snedaker 1993)

Biomass (t ha^{-1}) = 141.405 - 46.393 $\log_e$ (latitude/tree height)
Dense, tall mangrove at 24° N

78 to 110 t ha^{-1}	(4 to 8 metre high)
14 to 65 t ha^{-1}	(shrubby)

Litterfall (t ha^{-1} yr^{-1}) = 10.366 -1.669 $\log_e$ (latitude/tree height)
Dense, tall mangrove at 24° N

7.4 to 8.5 t^{-1} ha^{-1} yr^{-1}	(4 to 8 metre high)
5.1 to 6.9 t^{-1} ha^{-1} yr^{-1}	(shrubby)

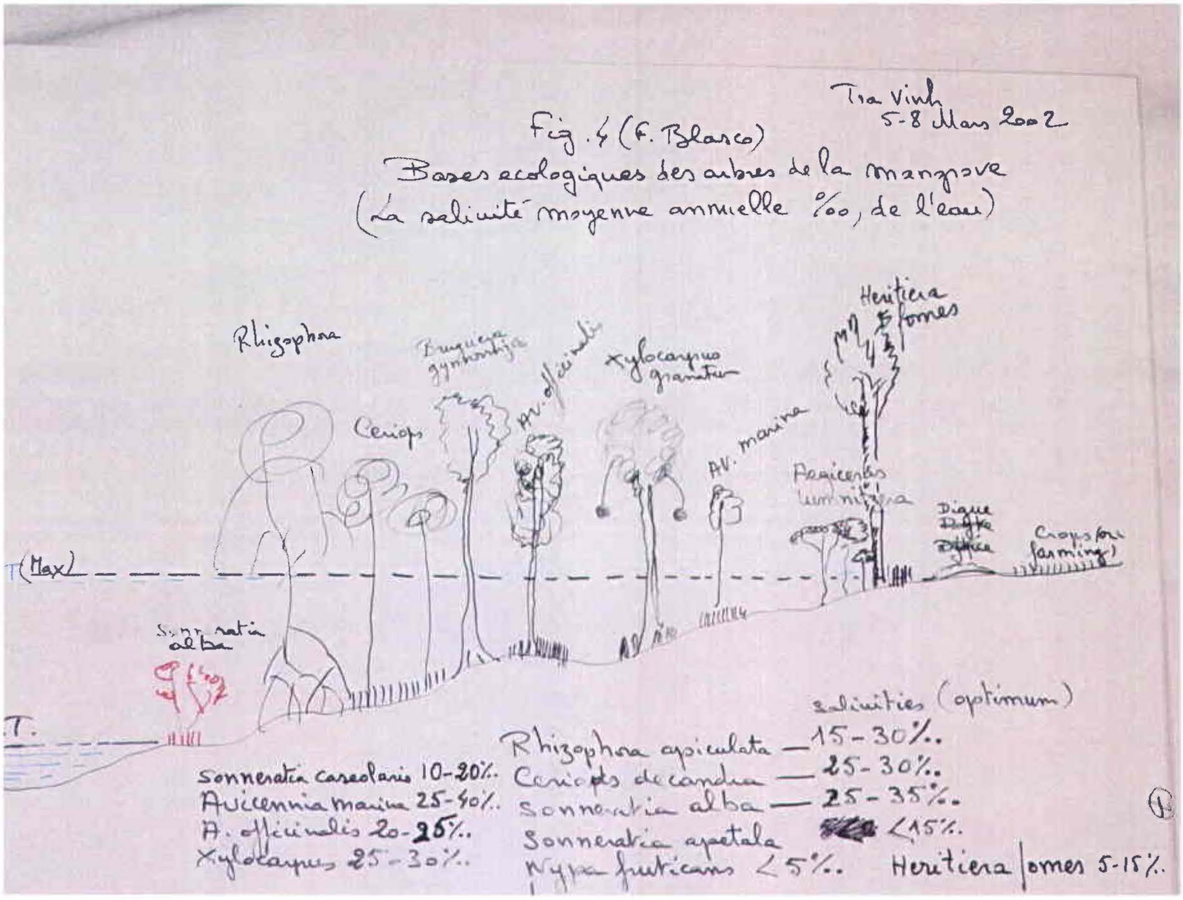


Figure 2 : ecological zonation of mangrove trees

Table 2. Paramètres déterminant le fonctionnement des écosystèmes « mangroves ».

1) régime hydrique et apport d'eau douce	fortement influencés par - type climatique local - couvertures végétales - actions humaines (irrigation, barrages etc)
2) disponibilité des nutriments	voir les cycles des principaux cations
3) stabilité du substrat	- vitesse des courants - géomorphologie - tidal amplitude - apports d'eau douce - pluviométries
	- charges sédimentaires - géologie - land use - couvertures végétales
	- salinité de l'eau - apports d'eau douce - pénétration des marées - évapo-transpiration, etc ...

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Mangrove in Mekong Delta and its role for resource, biodiversity and environment

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Abstract

The mangrove forest is tropical high productive ecosystem. In Vietnam, the mangrove in Mekong delta have been known as the largest area with more than 200,000 ha in 1950. The mangrove forest itself is creating the vegetative biodiversity, at the same time, it supplies the good habitat for aquatic and terrestrial organisms.

The results of investigations were carried out by many authors showed that there are 33 true mangrove and more than 50 mangrove associates species in Mekong delta. They form a biodiversities in the mangrove communities such as: *Avicennia marina, Avicennia officinalis, Avicennia alba, Rhizophora apiculata- Bruguiera parviflora, Rhizophora apiculata- Avicennia alba, Lumnitzera racemosa- Ceriops tagal, Excoecaria agallocha, Phoenix paludosa, Sonneratia caseolaris, Nypa fruticans...*

The fauna in mangrove forest is also abundant: 64 species of fishes, 25 species of shrimps, 9 amphibious species, 22 species of reptilians, 67 species of birds, 21 species of mammals were found in the mangrove of Mekong delta.

For the long time, mangrove forest in Mekong delta have played the important role to the economy and society in region, it has supplied to the coastal dwellers the forest products and aquatic resources. At the same time, mangroves have also protected the coastline, against the erosion, deposit the sediment and expand the land...

Recent years, under the population and economic pressures, especially quickly conversion of mangrove areas to shrimp ponds, human settlements... has led to the severe reduction of mangrove area, has caused changes in the environment and structure of vegetation and soil. In Ca Mau, in 1998 the land covered by mangrove was 72,593 ha (in 1954: 149,982 ha). In Tra Vinh, in 2000 only 6,678 ha mangrove area remained (before the wars: 40,000 ha). The resources, biodiversity and quality of environment in mangrove areas have also reduced.

The development quickly of shrimp- farming bring to richness for a part of people and distribute to socio- economic development in region, but lots of parts become into poverty, because of the loss of mangrove, fishery resources are reduced, environment is polluted and diseases outbreak in aquaculture.... In consequences of those get a part of local people to be into poverty and debt, dwellers continue destroy the mangrove.

At present, the solutions for mangrove restoration, sustainable land use and aquaculture in Mekong delta are necessary.

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Mekong delta water dynamics

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Abstract

The Mekong delta is limited by Cambodia in the Western North, the Saigon – Dongnai river's basin in the North, the South China Sea in the South and the Gulf of Thailand in the southern West with the Natural area about 39,000 km^2 , occupies 12% the total area of Vietnam.
Mekong delta could be divided into 5 principal zones: Plain of Reeds, Long Xuyen Quadrangle, Trans-bass, Camau Peninsula, Saline coastal Areas

According to the statistical data in 1994, the population of the Mekong delta was about 15,8 millions. It produces 40% of food products of Vietnam. Actually, the aquaculture is strongly developing and becomes the key economical sector of the provinces in the region.

Based on the measured data from several sources (from 1960 up to now), some principle water dynamic features of the Mekong's mouths and the East and West coastal zones will be presented. The examined water dynamic factors include: river currents, tide and the factors related to the dynamic regime of the region (topography of the delta, water way and climatologic features.

In the lecture, the speaker will try to propose some simple methods for measuring, assessing, forecasting the natural parameters (water level, current...) of the estuarine areas to serve the practical demands such as agriculture, aquaculture and water resource exploitation.

At the same time the speaker propose the comments about the effect of the dynamic regime on the environmental quality, hydrological conditions, aquatic organisms in the coastal waters and the orientations of adequate planning, management, exploitation for sustainable development of the Mekong delta 's coastal zone.

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Remote sensing and land use mapping

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Abstract

Remote sensing is used to address a wide variety of management and scientific issues in the coastal zone. The most common objectives include the production of coastal habitat maps and the identification of change in habitat cover, usually as a result of development. Monitoring of mangrove loss and aquaculture development is a particular concern. This lecture presents some basic conceptions of application of remote sensing technique in coastal management, and particularly in assessment of the evolution of mangrove forest with time and their relationship of aquaculture development in Mekong Delta. The results for application of RS technique in land use mapping in Mekong Delta are used as illustrated examples for lecture.

As a introduction of remote sensing applications in coastal zone management lecture presents some applied levels of remote sensing technique in coastal zone management base on considered results of Green et al. (1996) by questionnaire from manager and scientists of the world. From these results show that managers and scientists need to think clearly about the precise objectives they wish to achieve using and fully explore alternatives in terms of costs and effectiveness.

Next, the choice of image type is of critical importance, as users must be certain that images are sustainable for a particular application before large amounts of money and time are invested in purchasing and processing the data. Fundamental characteristics, such as spatial, spectral, radiometric and temporal resolutions are outline and the main limitations are discussed. The truly applications for each imagery type also are presented.

Both geometry correction and radiation correction are the importance processes in imagery processing. These corrections can be time – consuming and problematic for non-professional users who apply the remote sensing technique as a complementary tool for owner study. So this problem only presents in outline type.

Field survey is building the linkage between Image and reality. Field survey is essential to identify the habitats present in the studied area, to record the locations of habitats for multispectral image classification (i.e creation of habitat maps or land used map) and to obtain independent reference data to test the accuracy of resulting land used maps. Field surveys should be planned to represent the range of physical environment within the study area. To ensure that all habitats are adequately represented by field data, a stratified random sampling strategy should be adopted. The unsupervised image classification and maps of main

physical environments can be used to stratify sampling effort. Some sites for guiding multispectral classification (the training sites) and an additional others for accuracy assessment. The importance of accuracy assessment should not be under- estimated: a carefully produced land used map does not guarantee high accuracy and inaccurate information can mislead decision - makers in planning. Several complementary methods of assessing the accuracy of maps are available.

Image classification is the process of identifying image pixels with similar properties, organizing them into groups and assigning labels (e.g. habitat names) to those groups. The end product of this process is a map of habitats (or land use map for terrestrial areas) . Beside the visual interpretation method base on isolating of habitats under colour composite images (from difference spectral bands), there are 2 main approaches to classifying multispectral digital image :

- Unsupervised classification, where the computer automatically classifies pixels in an image into number of classes (set by the operator) on the basic spectral similarity , was found useful in planning field survey.
- Supervised classification, where field survey data are used to identify pixels of particular habitat types and guide the derivation of spectral signature for those habitats from image data, was usually found to generate the most accurate classification.

A combination of visual interpretation, unsupervised classification, field survey input and supervised classification techniques ultimately provide the most accurate habitat maps.

The finally, conversion the classified image (in raster type) to the land use map (in vector type) by any GIS packages. The assessment of the evolution of physical environment or establishment of database will carry out easily in this format type.

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Farming management in Mekong delta extensive systems

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Abstract

Vietnam's marine and brackish water shrimp culture area has been developed to more than 300,000 ha of which 80% are extensive and improved-extensive practises. The best shrimp yields of extensive system were recorded prior to 1993 with more than 1 ton/ha/year. Recently, shrimp yields have been 50-150 kg/ha/year. The ratio of high value shrimp *Penaeus indicus* also decline from 50% before 1993 to 20-30% recent years. The low yield and low value Metapenaeus in harvest making the income from shrimp become unsatisfied the farmer family living standard. To develop the shrimp culture extensive system, the shrimp yields should get 500 kg/ha/year through improving farm management and stocking hatchery shrimp.

Current practices are analyzed to propose better farming management for higher yield including: Farm and sluice design, water exchange management, wild seed recruitment, harvest technique.

Farm management for stocking *Penaeus monodon* is also analyzed. Several parameters are taking into account, including stocking density, nursing shrimp, postlarvae quality, stocking season, model for intensification of shrimp culture in extensive ponds

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Mekong delta development policy: land planning and environment

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Abstract

The Mekong delta has high biodiversity and is very sensitive so that the basis principle for exploitation planning is to combine closely the economic development and environmental protection.

Land-use planning should base on the ecological features of the region in order to attain the goal of adequate and efficient exploitation of resources (mainly fishery and forestry), taking of the full advantage for strategic products, increasing the economic growth rate but it should ensure the sustainable development. The proposed goals are as following: average production value of 1 ha for aquaculture attain 59,76 million VND/year and the income attains 38,84 million VND/year.

The area for aquaculture increases fast, attains 484,000 ha. Some areas formerly planned for intensive agriculture or salt marsh or protective forest but now they were changed for aquaculture. Some of the aquaculture region passed the planned area. So that there were some bad consequences happened such as the mangrove forests were damaged, the environment was polluted, salt intrusion affecting upstream soils, including paddy fields. Damming up changed the dynamics processes, hydrological regime and limited the capacity of draining off water.

It should changes the thinking of management, planning of development policy, investment strategy in order to be able create the concentrated production regions, combine area expanding with intensive investment based on the application of sustainable and ecological production models managed by several economic sectors.

Applying the advanced technologies in exploiting, using the different water potentials such as freshwater, brackish water, salt water for the development. For the freshwater, it should pay attention to the rivers, ponds, lagoons, reservoirs and rice-fields with the area about 2,123,330 ha; brackish water such as littoral, coastal zone, estuaries, channels with the area about 1,040.660 ha.

The marine region is the one which still has many potentials so that it should be studied, planned, exploited with the strategic orientation of making the most of coastal zone to develop the aquaculture

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Public policy for shrimp farming in Vietnam

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<u>Abstract</u>

In spit of its relative oldness, the common resources management is a quite new concept to apply in Vietnam. Land tenure system and water resources management reform are important stakes in order to ensure a sustainable aquaculture activity. They are then under a strong pressure and need to evolve to face property rights and uses rights challenges. It's a preliminary and crucial step to achieve in order to ensure the attraction and the success of important investments but also to avoid conflicts use among users (local community, fishermen, shrimp farmers, rice farmers, etc.). Two main axis for a sustainable aquaculture are developed, both in terms of space and in terms of times scale: the equity intra and inter-provinces concerning land use and the equity from one generation to another one (looking for the duration of the activity).

These reforms are presented through the classification of the different kinds of aquaculture implemented in Vietnam (coastal aquaculture in bays, in mangrove areas, lagoon an tidal areas, urban areas or rivers as well as in terms of species grown). Land management is under the State responsibility but free access to numerous resources remains the main case encountered. Some use rights can be allocated for a determined period or according an auction process. This allocation can take place as well as the village, cooperative, groups or individual level. The individual allocation, or private allocation, can be either concentrated or spread in potential areas, underlining the diversity and the specificity of production systems. This diversity has to be controlled and framed to ensure the collective action to reach the success of the common resource management through the diversity of users. Regulations, decision making process and frameworks are presented, highlighting all the difficulties and stakes for developing a sustainable aquaculture and more especially a sustainable shrimp aquaculture in Vietnam.

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Public Policy and Collective Action for Sustainable Shrimp Farming in Mekong Delta

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Abstract

This paper emphasizes the needs for public policy and collective action for sustainable shrimp farming in Mekong Delta. Background and scope are well known and illustrate the contradictory nature of shrimp farming :

- raising strong expectations for high incomes compared to alternative activities (thus generating a strong mobilization of individual interest to develop it, even at the cost of by-passing rules) thus contributing both to poverty alleviation at the local/regional level and to economic wealth creation at the national level (rent culture for export);
- competing for space with ecosystems of which uses become rapidly incompatible with shrimp farming (mangrove cutting, salt intrusion in paddy fields) thus generating use conflicts;
- being very uncertain or variable because of dependence towards the environment (shortage of references for practices adequate to the diversity of environments), both empirical and scientific knowledge are too short to provide a rapid selection of adequate technical systems (complexity of interdependences) and because of vulnerability to diseases (maintenance of livestock).

This supports diverse strategies expressing strong dimensions of unsustainability : from environmentally very speculative to socially disruptive profiles. Face these strategies, human action organizes along two lines : individual action and collective action;

- individuals have specific interests (preferences),
- there is also a level of collective interests, that may be consistent or contradictory with individual interests,
- institutions build up for collective action ; they consist of cultural norms, rules (customary and positive law, contracts), organizations (political and administrative, interest group representation) and decision-making processes,
- cultural norms are more "sticky" than institutions, they are produced in the long run and constitute strong limits but also channels for expression both of individual and collective preferences.

Public policy is one area of collective action. Both are applied to the field of shrimp farming with advantages and limits related to Mekong Delta's frame. This is read and translated into a theoretical approach based on objectives versus means and a first attempt to hierarchise the stakes: building up institutions and regulations scheme, stakeholders (interest/user groups),

command and control, monitoring issues. There is a dialectical relation between objectives and means, they are intimately linked. But when resources for public policy are limited, the ways for public policy are very different if more resources are devoted to define and monitor objectives or to define and monitor procedures.

At the light of the theoretical approach, the top-down model versus the bottom-up policy making, implementation and enforcement is discussed, focusing on integration, cooperation, responsible citizenship and participative management, centralization/decentralization, place and role of experts (scientists, engineers, administration, politicians, producers, consumers), etc.

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Shrimp Farms Economics – A review of production systems

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Abstract

The purpose of this paper is to present the main determinants of the shrimp farms' economic performance and factors affecting this performance. These factors are based on:

- internal factors related to pond management and pond ecology
- and external factors related to the ecological and environmental conditions, to the social and institutional context, to the economic context and to the shrimp demand characteristics.

The different combinations of the above parameters lead to different kind of production systems and organisation modes. Each of them can be characterised and compared through their economic performance based on a proposed set of indicators. The application to different case studies allows a comparison in terms of intensification level as well as in terms of management mode (such as the seasonal management), taking into account the high variability of the different production systems. But it also underlines the limits of the solely economic performance approach by illustrating paradoxical results. The logics attached to each farm's context (external factors mainly) is another explaining factor of the farm performance, from a lottery logic to a speculative one or to a more conservative one. The value chain concept, as an integrated economic tool, is a first step to illustrate this more global view of the farms performances and their attached logic, leading to different organisation modes.