light irradiated seawater were effective in inducing spawning in ripe male and female window-pane shell, *P. placenta*. Furthermore, UV light irradiated seawater triggered the synchronous release of sperm and eggs in *P. placenta*. The technique using UV light irradiated seawater as inducer of spawning is simpler, cost effective, and easier to perform than serotonin injection and can be applied to both individual and mass spawning experiments. On a routine basis, Madrones-Ladja said that she uses this method in producing gametes of the window-pane shell for other larval experiments. The planktonic larval stages of *P. placenta* is only 14 days. However, further experimentation should focus on environmental requirements of the larvae to optimize larval survival and improve larval quality.

P. placenta shells are refined and made into attractive home, office and hotel furnishings and decor and have become popular in the Philippines and abroad. The lampshade is a popular furnishing in some tasteful homes and hotels

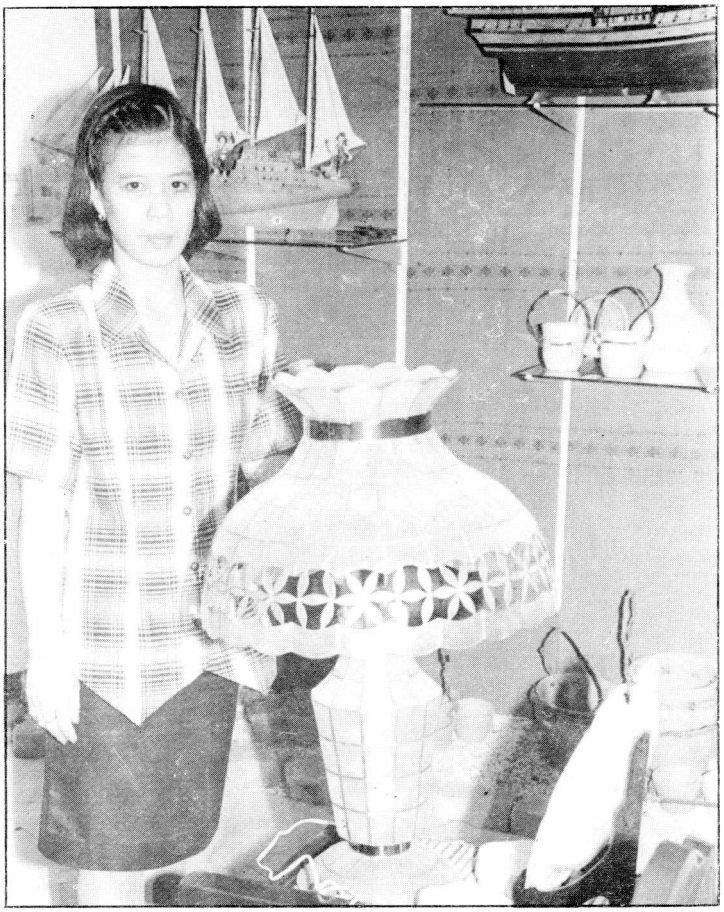

Photo courtesy of The Ilonggo Producers Association, Inc.

Original Paper Contribution

The impact of shrimp pond construction along the mangrove coastal accretion at southwest Ca Mau Cape, Viet Nam*

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Ca Mau peninsula of Viet Nam is a new, unstable land situated between the East Sea (South China Sea) and Thailand Gulf. Every year, alluvia from the Mekong River system and eroded soil from the east of the peninsula accumulate at the west coast. The potentially rich Southwest accretion area is an important natural ecosystem in Ca Mau peninsula.

**A complete list of references is available free of charge upon request.*

According to the laws on land, the premature accretion land outside river mouths are government property and should remain undisturbed.

Notwithstanding these regulations, since 1991 spontaneous migrants from Ca Mau town have transformed approximately 900 ha of the newly formed land into brackishwater ponds for shrimp faming. They have constructed firm chain embankments outside the unstable accretion land and built houses on stilts made of *Rhizophora* trunks roofed with *Nipa* palm.

Analyses of the characteristics and changes of the soil and water, the behavior of creatures in the ponds, as well as on the tidal mud flats have shown that the construction of chain embankments for shrimp ponds has led to severe degradation of the environment and a decrease in the natural resources of Ca Mau Cape.

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Changes of the physical environment

Ca Mau Cape accretion. The formation of Ca Mau Cape is basically different from those in large river mouths such as Red River mouth and Tien River mouth. In such areas, delta expansion is first the formation of small coastal sand hills, then alluvium from the river heighten the tidal flat inside those small sand hills to form the delta. The amount of alluvia from rivers is not very changeable and contains a lot of coarse grains (sand).

The accretion at Southwest Ca Mau Cape is formed in such a way that the materials come from distant points of the sea, thus, they are mainly made up of fine grains. In the first stage, large underwater flats are gradually raised by alluvium accumulation. With the sea encroachment by the delta border, the underwater flats are near the coast, thus are more quickly accreted. When the flats are higher than the low tidal level, *Avicennia* pioneers begin to develop and the ecological environment turns into a swamp type, new accretion delta according to a study by Hong and An (1994).

Moreover, the source of fine grains from distant points in the sea is not stable and changes in its dynamic characteristics considerably reduce the amount of alluvia and consequently, the accumulating process. One of such factors is the currents. The embankment construction has interfered with the exchange currents between the sea and the forest, between the east and the west coast of Ca Mau Cape, hence, it has limited the amount of alluvia brought in. Sediments at the accretions are chiefly fine grains (0.02-0.01 mm) in pasty mud form, very easily eroded, especially during the period of southwest monsoon. The construction of chain embankments around the accretions has created waves outside the embankment and excavation by waves occurs.

The construction of embankments that prevent seaward mangrove development also prevents alluvium accumulation which forms new accretions.

At the same time, the embankments at Bai Bun Bay and Bay Hap River mouth has fast encroached upon the sea while the accretion surface is still low and has created an artificial border. Along that border, the depth changes suddenly, leading to a decrease in the accumulating process and erosion of the embankment and bottom in some places. It is evident that this process limits development of the accretions.

Analyses of the characteristics and changes of the soil and water, the behavior of creatures in the ponds, as well as on the tidal flats have shown that the construction of chain embankments for shrimp ponds has led to severe degradation of the environment and a decrease in the natural resources of the entire Ca Mau Cape.

The increase in the bottom excavation outside the embankment can be shown by the composition and size of grains in the present bottom mud sediments - - the sediments reflect embankment construction. The sediment size at every point observed increases, sand and powdered sand (1.0-0.02 mm) account for more or less 50%, while clay makes up the major proportion, according to the usual law. These coarse-grained materials make up the bottom sediments, especially in the period of southwest monsoon. That is the time when the amount of alluvia brought in is small and the currents and waves become stronger.

Geological-geomorphological processes. At Ca Mau Cape, all geological-geomorphological processes such as forming topography, alluvium current, and erosion accumulation, have been dominated by the East Sea. The northeast monsoon with its high wind velocity combined with the dynamic characteristics of the sea (tide, wave, currents) has been strongly destroying the east-southeast coast; it has brought water together with alluvia past Ca Mau Cape to Thailand Gulf by the dense network of creeks and canals and sea current flowing from southeast to northwest.

The west coast receives a lot of alluvia and is strongly accreted in the dry season; the northwest monsoon and any interference with that natural process should be very carefully considered. The construction of many kilometers of chain embankments has prevented the creation of tidal rivulets on the accretions and reduced the ways that lead seawater to the accretion. The paths taken by alluvia that directly add to the network of creeks and canals may even increase.

Experience and research show that the rivulet mouths that bring in alluvia should be densely and evenly distributed throughout the whole section in order to promote the accreting process (as they were at Ca Mau tip in the past). Filling these rivulet mouths with the constructed embankment may result in partial erosion in places far from the main rivulet mouths due to lack of alluvia. Erosion of the border and bottom (outside the embankment) has also been observed.

Accretion process. The above mentioned data have indicated that the accretions southwest of Ca Mau Cape are now in the process of topographical surface raising. In order to become a real accretions delta, they need a developed swamp-mangrove environment and fine grain accumulation. Rational exploitation of the accretions should not hinder this process.

The building of the embankment along the accretions for shrimp ponds has stopped this development process

inside the shrimp ponds (near the mainland) because of the decreased amount of water with alluvia while the accretions outside the shrimp ponds near the sea are either excavated or accreted more slowly.

Changes in soil environment

The construction of firm embankments along the southwest coast of Ca Mau Cape outside the premature accretions has limited water exchange between the sea, the ponds, and the interior due to lack of sluice gates both in number and size considering a very small tide amplitude (0.5-0.8 m). When the tide is low, the ponds lie exposed to the sun. At spring tide, the sea water gets in slowly and the time is too short to change pond water. Thus, the environment inside the pond conspicuously degenerates after only 1 or 2 years.

In observing the dry bed of the pond, one can see *Oscillatoria* fully covering a 10 m wide stretch along the pond embankments. When the tide comes into the pond, this alga floats on the water surface, promoting the growth of lab-lab (Hong and An, 1992).

There are also white patches that stink strongly which means that H_2S is perceptible. Some low places where water is stagnant and covered by lab-lab also stink.

Usually, the very thick, black-green layer full of H_2S lies under the thin brown superficial layer which is about 3-5 mm. In the same area but outside the pond with some *Avicennia*, depth of the superficial layer is 20 cm or more, and the black-green layer lies much deeper. Analysis of the soil samples both outside and inside the pond (Table 1) also shows environmental degeneration.

The table shows that Fe^3, Al^{+3}, SO_4, H_2S contents and salinity inside the pond are higher than outside because the environment lacks tidal exchange and water evaporates fast.

Table 1. Some chemical factors of soil inside the ponds in comparison with that outside the ponds on the southwest accretion of Ca Mau Cape. A - accretiion (outside the pond); B - inside the pond

Places	Sign of samples	Percent N	P_2O_3	CaO	MgO	Fe	Al^{+3} (ppm)	SO_4 (%)	H_2S (ppm)	Salinity (%)
Accretion inside Ca Mau Bay	A	0.14	0.136	2.63	1.71	3.84	27.3	0.32	15.5	2.93
	P	0.14	0.145	4.04	1.88	3.89	84.2	0.62	21.2	4.08
Accretion south of Bay Hap Bay	A	0.11	0.121	1.96	1.54	3.46	25.5	0.33	15.2	2.96
	P	0.13	0.116	1.73	1.89	3.82	103.9	0.65	20.0	4.74
Accretion west of Go Cong	A	0.11	0.114	2.07	1.67	3.67	76.5	0.3	13.5	2.89
	P	0.13	0.114	2.38	1.95	3.96	111.2	0.68	19.7	4.53

Source: Hong and An, 1992.

Table 2. Chemical factors of water in ponds and in adjacent canals in Ca Mau Cape, Viet Nam in June 1992

Chemical factors	Canals and creeks (accretions)		Forests	
	Canals	Ponds	Canals	Ponds
PO_4 (mg/l)	0.030 - 0.077	0.147-0.168	0.055 - 0.097	0.076-0.114
NH_4 (mg/l)	0.029 - 0.042	0.047-0.106	0.024 - 0.045	0.061-0.119
N_2-N (mg/l)	0.015 - 0.068	0.006-0.138	0.050 - 0.162	0.007-0.072
NO_3-N (mg/l)	0.054 - 0.138	0.028-0.059	0.027 - 0.273	0.038-0.165

Source: Hong and An, 1992.

Changes in the water chemical property

Inside the pond, the chemical properties of water are largely different from those outside the pond as shown in Table 2. The formation and operation of extensive shrimp ponds on the accretions and mangroves have changed the chemical properties of the natural water:

- NO-N and N_2-N content inside the pond is lower than that of the canals outside the pond.
- PO_4 and NH_4 content inside the pond is lower than outside.

This shows that insufficient water exchange has caused contamination of the water. The disintegration of organic matter results in the shortage of oxygen and oxidation is weaker than deoxidation.

Changes in the characteristics of aquatic organisms

Analysis of the aquatic organisms on the accretion and inside the ponds showed the following:

Zooplankton and phytoplankton. In all the shrimp ponds on the accretions and in the mangroves, a decrease in the diversity of the organisms in comparison with the natural environment outside has been noted (Table 3). In the pond, the predominant species belong to *Oscillatoria,* a phytoplankton that develops quickly in the contaminated environment. Only zooplankton such as *Paracalanus parvus, Acartia clausi, Oithona nana,* and *Masopodosis*

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slabbari can withstand the environmental changes. *Oithona* has been rapidly developing and is now predominant.

The accretion at Ca Mau tip is a highly nutritious area with the predominant growth of *Oscillatoria* and *Oithona nana* in most of the places where samples were collected. The development takes place in two directions during the construction and operation of shrimp ponds:

- *Oscillatoria* develops fast and the number of zooplankton falls with the predominant species being *Oithona nana* and *Nauplius* larvae.
- The shrimp ponds risk being organically contaminated. The predominant zooplankton are *Acartia clausi* and tiny shrimps.

Benthos. The three groups of polychaetes, crustaceans, and bivalves are suitable only in a clean environment with regular water exchange. When shrimp ponds are constructed and water exchange becomes limited, *Oscillatoria* develops and produces lab-lab. Lab-lab die and when decomposed, take a lot of oxygen from the pond. Plenty of H_2S is generated, thus, the water smells. Consequently, benthos cannot survive. Only 1-2 species, such as *Nepthys oligobranchia* or *Masopodopsis slabbari* (motile ones), out of 22 survive.

Waste. Due to the degenerated, toxic environment inside the pond, shrimps live for only 15-17 days. The size and weight are small (800-1,200 shrimps/kg), hence, a big waste.

Changes in vegetation.

Vegetation at embankments. The embankment along the new accretions is a hindrance to the development of the pioneer *Avicennia alba*. This is due to the water and alluvium exchange which decreased when the embankment was constructed. Poor water exchange does not facilitate *Avicennia* growth and regeneration.

It was noted that *Avicennia* regenerated very quickly after 8 months in parts of the pond embankment where the sluice gates were broken in order to get tidal water in, while they did not grow in ponds where the sluice gates were retained.

Even when planted outside the embankment, mangroves do not take root because of the great depth and big waves that uproot the trees near the embankment.

Abnormal growth vegetation. The construction of embankments both outside and inside the forests with small sluice gates has reduced tidal entry from Thailand Gulf into the forests inside the accretions. This has led to abnormal growth of the vegetation, and the death of trees in the dry season due to the high salinity. The embankment has also prevented the entry of vegetative detritus from the forests which are food for creatures in the accretions or shallow waters near the coast. Some species are likely to migrate to more favorable areas. Meanwhile, plankton and benthos which are shrimp food also decrease.

Table 3. Diversity of the phyto- and zooplankton in the southwest coast of Ca Mau Cape, Viet Nam in June 1992

Aquatic environment	Number of species	Percentage of all species (%)	Number of species in 360 m^3 (max/min)	Number of cells/m^3 (max/min)	Dominant species
A. Phytoplankton					
Rivers, rivulets, accretion	55	83.33	23/12	848.000/ 13.000	*Oscillatoria subbrevis O. limosa Coscinodicus astrophalus, Nitzschia lorenziana*
Ponds in accretion	37	56.06	29/12	183.000/ 28.000	*Oscillatoria subbrevis, O. limosa*
Ponds in forest	31	46.97	16/10	400.000/ 57.000	*O. subrevis, O. limosa, Leptocylindus lanicus*
B. Zooplankton					
Rivers, creeks, accretions	26	100.00	14/9	9996/323	*Oithona nana, Oithona nana Acarthia clausi*
Ponds on accretions	9	34.62	9/3	22.253/ 850	*Oithona nana, Acartia clausi Nauplius copepoda*
Ponds in forests	12	46.15	10/8	1,768/ 498	*Oithona nana, Acartia clausi Mesopodopsis slabbari*

Source: Canh, Mien, and Loc, 1992.

Arising Social Problems

The exploitation of the southwest Ca Mau coastal accretion for shrimp ponds by the construction of surrounding embankment has caused conflict between people who get large benefits from collecting shrimps at the accretion ponds and local shrimp farmers whose crops fail because of the shortage of water and seeds.

Management of the population and protection of forest resources has also become more difficult.

The new community at the accretion is a complex mix of people who are not local inhabitants. Besides, the benefit from shrimps has attracted an influx of transmigrants from other areas. They have to build houses, make furniture,

burn firewood, cut trees for sluice gates and construct wave-buffer fences for shrimp ponds. This makes the protection of forests and the primary natural mangroves at Con Trong, Con Ngoai Islands at the Ong Trang river mouth meet with a lot of difficulties. If protective measures are not immediately taken, this area will be void of forests or perhaps only stunted forests would remain.

The law and regulations are defined but the accretion encroachment is difficult to stop. Once embankments are built on the accretions, the ecological consequences will be serious.

From the evaluation and analysis of the trends of environment change, we believe that the exploitation of the young southwest coastal accretions of Ca Mau Cape by building chain embankments for shrimp ponds can bring profit in the early years to the spontaneous migrants. Nevertheless, it has negative effects on the physical and ecological environment. These chain embankments interrupt the succession and development of the mangrove ecosystem and affect the protection and development of resources, not only at the accretions but also in adjacent forest and marine areas. Moreover, it results in complicated social problems which badly influence the security, discipline, and laws of the society. From this viewpoint, the clearance of shrimp ponds on the accretions is reasonable and necessary.

The construction of many kilometers of chain embankments has prevented the creation of tidal rivulets on the accretions and reduced the ways that lead sea water to the accretion.

Solutions to rationally utilize the accretions

Cardinal principles and actions to be taken. A solution to rationally utilize the accretions should be part of an overall plan for the whole mangrove area. To contribute to the building of that plan, we present some important recommendations in utilizing the accretions.

•The close relationship between the mangroves and the sea should be maintained. Forests supply the important source of detritus for creatures in the shallow sea as well as at the river mouths: Forests are also the nursery grounds for many important marine organisms. It can be considered a "green wall" to protect the coast from wave and tide effects. Forests cannot survive without adequate water and nutrition from tide and sea currents.

A break in this relationship will damage the highly productive ecosystems and valuable natural resources in tidal areas.

•The sea encroachment by the pioneer *Avicennia* forests should be guaranteed because these forests not only attract marine creatures but also reduce erosion, protect the accumulated soil, and promote the accumulation of sediments to raise the accretion surface.

•The relation between the east and the west coasts should be kept. Due to the special position of Ca Mau Cape, with different tide regimes and the strong effects of various monsoons, the eroded materials from the east coast come to accrete on the west coast.

The water and material exchange between the east and the west coasts should be facilitated to transport shrimp seeds, shrimp food, and other essential nutrients into the mainland, thus, the stable productivity of shrimps and of the forests and the expansion of the west accretions are assured.

•*Avicennia* forests which are rapidly encroaching on the sea should be carefully protected. The swamp stage ought to be hastened by planting *Rhizophora apiculata* together with natural *Avicennia alba* so that the latter will protect *Rhizophora* from being uprooted by waves or damaged by clinging creatures. In addition, *Avicennia* should be planted at accreting places to limit local erosion.

•After 3-4 years, with the protective *Avicennia* forest outside, a certain portion behind forests (which are young *Avicennia* at the moment) can be used for extensive shrimp ponds with high productivity on a small area. Permission for the development of these ponds should be in accordance with the comprehensive plan and given only after careful study.

•Fishermen should be encouraged to rear cockle-shells (on sandy soil) and oysters (on muddy soil) at the newly-formed accretions. The provincial authorities should assure consumption and export of these shells and oysters so that growers can concentrate on long term work. The regulation on the marine product catching area ought to be more practical. The complete prohibition at the moment makes local inhabitants jobless so they have to clear forests for shrimp ponds to earn their living.

•To solve the problem of environment and resources at the Ngoc Hien accretions and the adjacent areas, the government should help the province to draw up a production plan. This problem affects not only Minh Hai Province but also the utilization of wetlands with mangroves in the country and Southeast Asia.

Problems identified

This paper hopes to encourage cooperation among the countries in the region and generate interest from international organizations to conduct further research on the sustainable utilization of coastal resources and the environment. The following problems that require further research have been identified: (a) the hydrological and dynamic processes in the coastal zone in rivers, creeks and canals; (b) the relation and appropriate proportion of forests, aquaculture area, and agriculture land in topographically different areas; and (c) building of appropriate agro-fishery-forestry production models for high economic and environmental efficiency.