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VARIATION IN THE WATER QUALITY OF ORGANIC AND CONVENTIONAL SHRIMP PONDS IN A COASTAL ENVIRONMENT FROM EASTERN CHINA

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Abstract

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Eleven water quality variables were measured at intervals in organic and conventional shrimp ponds during the production cycle (April – August 2002, a 115 days period) located within Xuwei Salt field, Lianyungang City of Jiangsu Province. The average harvest for organic pond was 1001 kg ha^{-1}, with an average size of 15.7 g; while the harvest for conventional pond was 753 kg ha^{-1}, with an average size of 12.7 g. During the shrimp growing period, mean values for temperature, salinity, pH and dissolved oxygen (DO) in ponds, inlet and outlet water were not significantly different, whereas the levels for Chlorophyll *a*, nutrients, chemical oxygen demand (COD) and total organic carbon (TOC) showed the highest in the outlet water, followed by ponds and inlet water. The inlet water quality was found to be closely associated with outlet water quality. Chlorophyll *a*, nitrate, nitrite, inorganic phosphorus, COD and TOC were lower in organic pond than in its conventional counterpart. But for ammonium, the level is higher in the organic pond than in the conventional system. The authors conclude that, compared with the conventional system, organic shrimp system had significantly comparable yields and higher environmental profits. Its significance could prove vital for the sustainability of increasing shrimp farming in the world.

Key words: organic aquaculture; shrimp; water quality; inlet water, outlet water

Introduction

Shrimp farming has undergone extraordinary expansion since 1976. Current annual production stands at around 1 million metric tones, which is equivalent to one third of total world shrimp supply (FAO, 2001). This development generates profit and income, but it also bears risks of negative environmental impacts (Neiland et al., 2001; Páez-Osuna, 2001; Kautsky et al., 2000; Senarath et al., 2001). The main input in most conventional shrimp culture systems is shrimp feed, which is partly transformed into shrimp biomass and partly released into the water as suspended organic solids or dissolved mater such as ni-

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trogen and phosphorus, originating from surplus food, faeces and excretions via gills and kidneys. Other pollutants are residuals of drugs used to cure or prevent disease. Organic aquaculture emerged with the aim of solving a series of environmental, safety and health problems faced by the modern conventional aquaculture. In contrast to conventional aquaculture, organic aquaculture is a relatively new concept, and standards have to be developed that take into account the rapid development of industry as well as consumers' and environmental NGOs concerns about the sector.

Standards for organic aquaculture were first developed by Naturland association, an internationally operating certifier for organic agriculture (Bergleiter, 2001). The guidelines of organic aquaculture production have been developed successively (e.g. KRAV, 2001; NASAA, 2001; Naturland, 2002; OFDC, 2002) in order to elaborate an alternative opposite to the development in conventional production. Main aspects of criticism were the use of chemical substances, especially inorganic fertilizers and pesticides. The International Federation of Organic Agriculture Movement (IFOAM), a large umbrella organization, has also drafted organic aquaculture standards (IFOAM, 2000), and meanwhile have found application all over the world. The Food and Agricultural Organization/World Health Organization's international Codex Alimentarius Commission has finalized organic crop, livestock, processing, labeling, inspection and certification guidelines (FAO, 2001). But organic aquatic animal standards are not yet in place and still in its draft form. The organic sector in the world is booming with the largest ever wave of farm conversions underway (Willer and Yussefi, 2001) and aquaculture is also the fastest growing sector. There will likely be a niche for farmers interested in going the extra mile for organic aquaculture certification (Brister and Kapuscinski, 2000).

A fundamental goal in organic aquaculture production is to minimize its environmental impact as much as possible while developing a valuable and sustainable aquatic ecosystem. Organic production is sometimes hailed as the true "sustainable agriculture" (O'Riordan and Cobb, 2001). Its advocates claim that it is alleged to produce many advantages (environmental, social and economic) associated with a change of direction of a more sustainable agricultural future. A number of comparison studies have been conducted between organic and conventional agriculture (Biao et al., 2003). However there have been no published studies comparing the consequences of organic and conventional shrimp farming, including the differences of water quality in organic and conventional shrimp farming systems. Temporal variations in water quality variables have been described in detail for shrimp ponds (Gao et al., 1993; Yu, 1995; Chen et al., 1996; Lin et al., 1997; Sun et al., 1998). Most of this information has been applied by shrimp farmers and technicians to water management in shrimp farming. This present study offers a quantitative description of water quality characteristics at two shrimp farms (one organic and other conventional) in shore of Yellow Sea, north of Jiangsu province, China, for one growing cycle of shrimp production (April to August 2002). This information was used to: (a) summarize values of 11 water quality variables from effluents and source water; (b) evaluate the influence of monthly variations on water quality dynamics in conventional and organic shrimp ponds; and (c) assess the variation of water quality of converting to organic shrimp farming.

Material and Methods

Shrimp farm management

The study was carried out in a commercial intensive shrimp farm in Xuwei Salt field (acreage 98 km^2), shore of Yellow Sea, Lianyungang City of Jiangsu Province (Plate 1). From April to August 2002, 2 replicate shrimp farming ponds for each of the organic and conventional production systems respectively were chosen for study (Plate 1). The pond was about 0.33 ha (110 m length × 30 m width) and 2.8 m in depth (9240 m^3 in volume). A 1500-W aerator was fixed in the center of each pond to prevent water from stratification and to increase the concentration of dissolved oxygen to a small extent. We chose appropriate man-

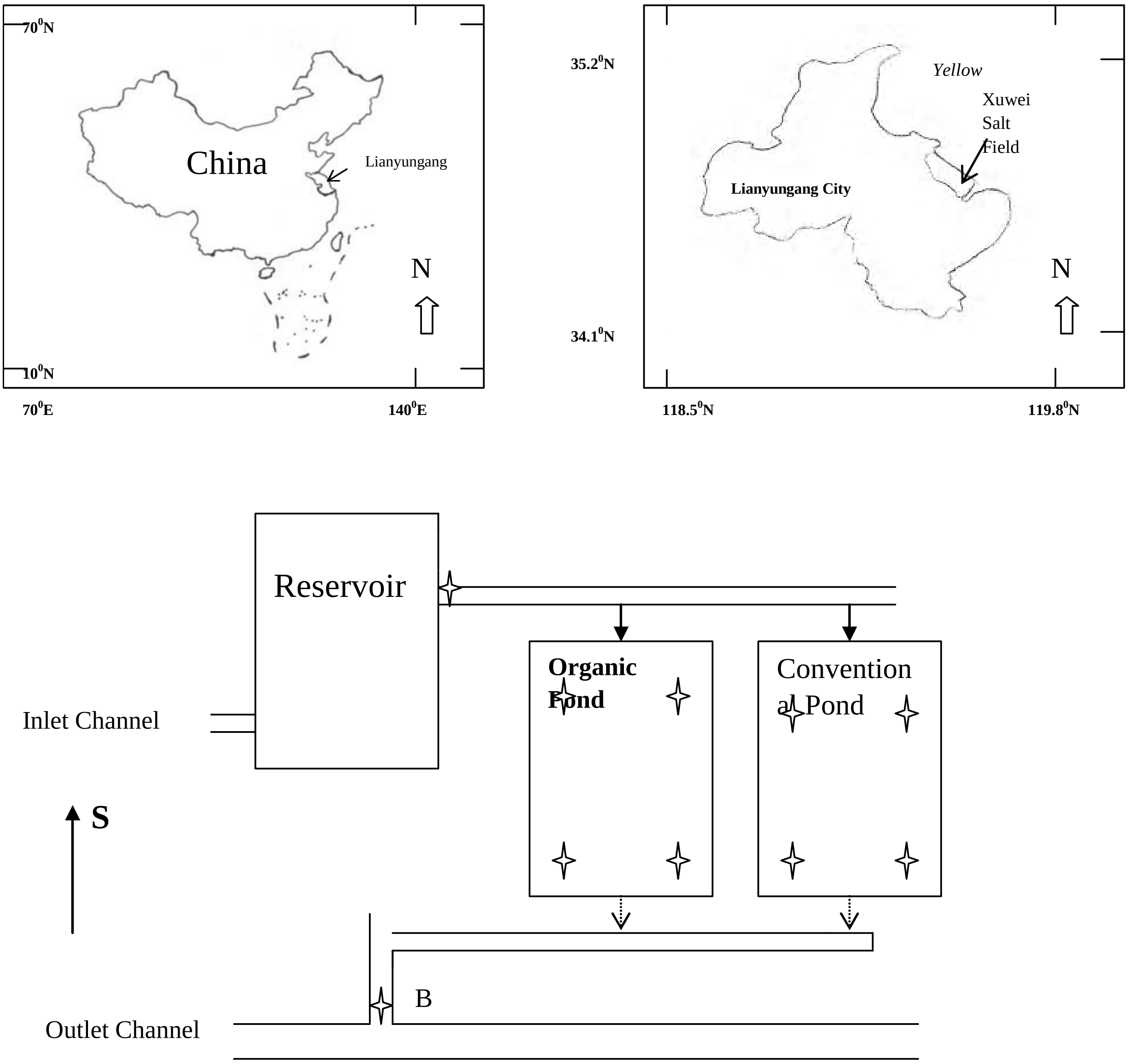

Plate 1. Geographical situation of the Shrimp ponds and corresponding sampling stations (✧)

agement practice for the two systems (organic and conventional) (Table 1). The management for organic shrimp pond was based on the regulations in Basic Standards for Organic Production and Processing of International Federation of Organic Agriculture Movements (IFOAM) (IFOAM, 2000) and Naturland Standards for Organic Aquaculture (Naturland, 2002).

It had one intake structure and one inlet tidal channel. Filling and exchanging water was pumped from the reservoir, which connects the inlet channel (Plate 1). The supply of water first passed through a 200 mm mesh bag to prevent access to predators and competitors, and then enter the reservoir. Each pond drained through an effluent ditch which brought water back to the adjacent outlet channel (Plate 1).

The juvenile native Penaeus chinensis Chinese

Table 1
Management practices for organic and conventional shrimp ponds in 2002

Management items	Organic shrimp pond	Conventional shrimp pond
Selection of site, interaction with surrounding ecosystems	Physical buffer zones around the organic pond; no mangrove existed.	No buffer zones; no mangrove existed.
Species and origin of stock	Native Penaeus chinensis adopted; no GMO involved;	Native Penaeus chinensis adopted; no GMO involved;
Breeding	Natural reproduction, no hormones used.	Natural reproduction, no hormones used.
Designing of holding systems, water quality, stocking density	Water quality conforming to the natural requirements of the species; 7.2 pieces/m^2	Water quality conforming to the natural requirements of the species; 7.2 pieces/m^2
Health and Hygiene	No medicine and treatment used; adopting optimized husbandry, rearing and feeding measures permitted in the Naturland Standards for Organic Aquaculture and IFOAM Basic Standards .	Bleaching powder, Calcium oxide, Keng iodine disinfectant and bioremediation products used during the culture period
Oxygen supply	A 1500-W aerator, temporarily used	A 1500-W aerator, temporarily used
Organic fertilizing	Certified Organic fertilizer (1000 kg/ha)	Composted chicken manure (1000kg/ha)
Feeding	Organic soybean, wild artemia and clam	Commercial pellet

Table 2
Variables studied and corresponding methodology

Variable	Method
pH	mV mete/Glass Electrode
Dissolved Oxygen	Oxygen meter/Electrochemical probe
Salinity	Refaractometry
Temperature	Thermometer
Ammonium	Nesselerization/Spectrophotometry
Nitrite	Diazotization/Spectrophotometry
Nitrate	Cadmium reduction/diazotization
Inorganic phosphorus	Ammonium molybdate/Spectrophotometry
chlorophyll a	Spectrophotometer
COD	Alkaline permanganate oxidation
TOC	TOC meter/Nondispersive infrared absorption

shrimp were bought from the shrimp farm of Sea Institute of Shandong Province. Shrimp were stocked in two systems on 26 April 2002 at a density of 7.2 individuals/m^2 with the body length of 0.86±0.14 cm.

The production cycle for the two systems began on April 26 and was concluded after 115 days. One month before stocking, the two systems were fertilized to cultivate natural food, with 1000 kg ha^{-1} of certified organic fertilizer (32% organic matter, 8.6% N, 5.4% P_2O_5 and 4.9% K_2O) in the organic pond and 1000 kg ha^{-1} (43% organic matter, 2.7% N, 2.4% P_2O_5 and 1.9% K_2O) of composted chicken manure in the conventional pond.

A commercial (conventional) pellet (2 - 4 mm diameter) manufactured by the local Sulanlin Fishery Feed Co. Ltd., Jiangsu province, China was supplied, with a total of 1.42 t ha^{-1} of conventional feed supplied during the production cycle in the conventional shrimp pond. The composition of the conventional feed was: dry matter 87%; crude protein 40%; crude fat 6%).

A formulation (organic feed) with wild artemia from local salt pans, organic soybean from OFDC (one IFOAM accredited organic certifier in China) certified farms and natural clam was found as the feed to organic shrimp, which is in accordance to organic requirements. A total of 1.08 t ha^{-1} of organic feed was supplied for the organic shrimp pond during the production cycle. The composition of the conventional feed was: dry matter 89%; crude protein 54%; crude fat 13%).

Feeding behavior was the same for the two systems. There is a feeding tray that is 0.56 m^2 in area set in each pond. The shrimp were fed directly on a daily basis. The water in the systems was exchanged and seawater plus underground fresh water was added at the appropriate time to make up for losses due to evaporation, seepage and to improve the water quality in the ponds. The two systems had the same total water nitrogen and phosphorus inputs.

Sampling and analytical methods

All the variables studied here were monitored from the first week of the grow out cycle until harvest. To determine growth, a random sample of 20 shrimp was removed weekly from each pond with a 10 mm mesh size seine. The shrimp were individually weighed considering a precision 0.1g. At harvest, shrimp were captured with a net bag in the outlet through the sluicegate. The entire crop and sub samples of individual shrimp were measured and weighed to determine the shrimp biomass.

A variety of parameters were monitored (Table 2). Water quality parameters include pH, temperature, DO, salinity, Chlorophyll a, nutrients (ammonium, nitrite, nitrate and inorganic phosphorus), COD and TOC. Five monthly sampling expeditions were car-

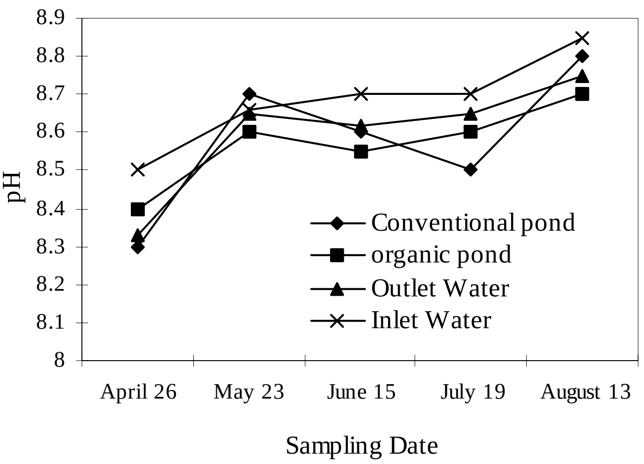

Fig. 1. Variation of pH in the organic pond, conventional pond, outlet and inlet waters

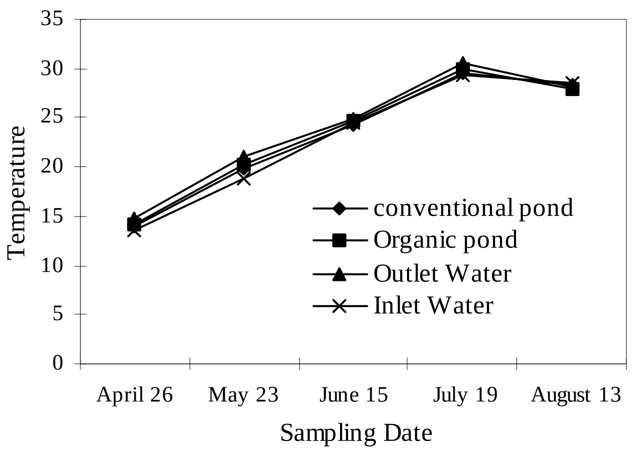

Fig. 2. Variation of temperature in the organic pond, conventional pond, outlet and inlet waters

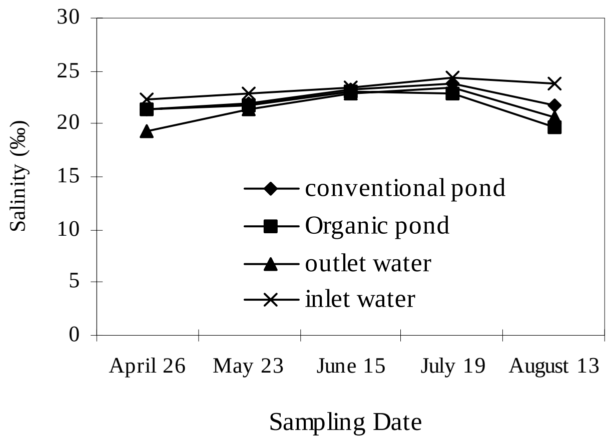

Fig. 3. Variation of Salinity in the organic pond, conventional pond, outlet and inlet waters

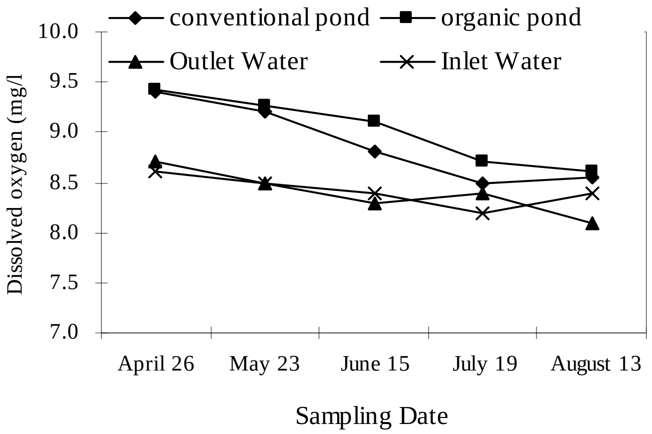

Fig. 4. Variation of dissolved oxygen in the organic pond, conventional pond, outlet and inlet waters

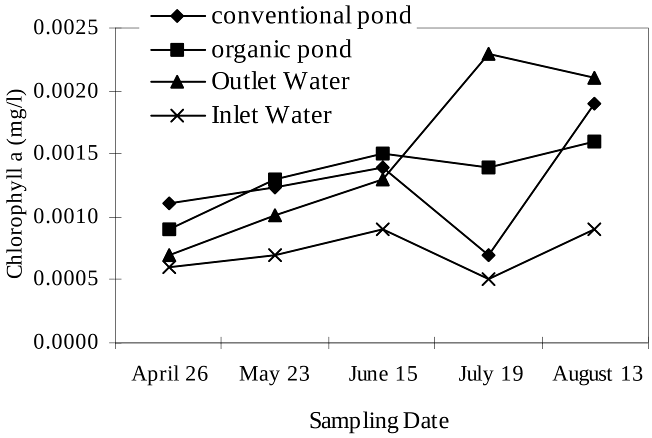

Fig. 5. Variation of Chlorophyll *a* in the organic pond, conventional pond, outlet and inlet waters

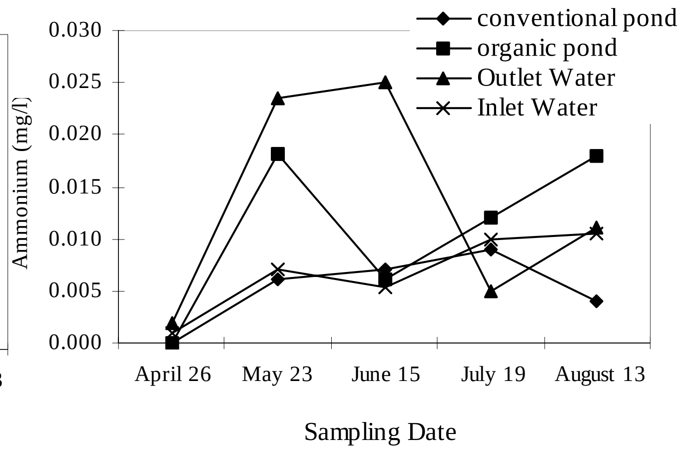

Fig. 6. Variation of ammonium in the organic pond, conventional pond, outlet and inlet waters

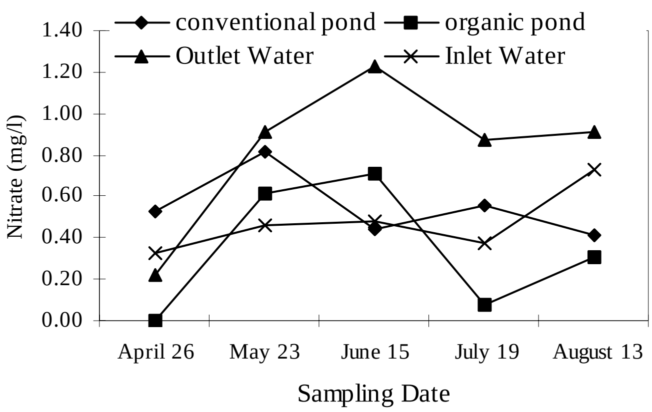

Fig. 7. Variation of nitrate in the organic pond, conventional pond, outlet and inlet waters

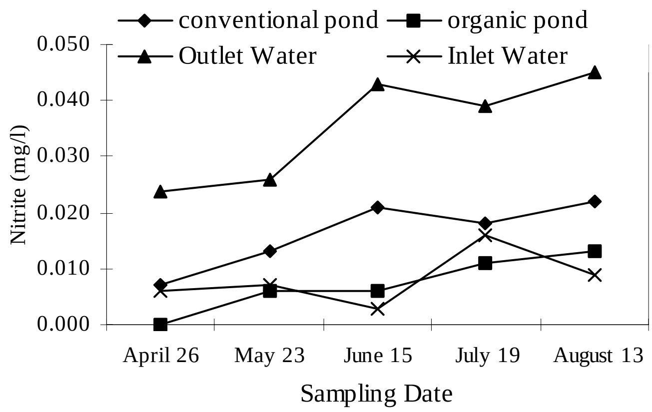

Fig. 8. Variation of nitrite in the organic pond, conventional pond, outlet and inlet waters

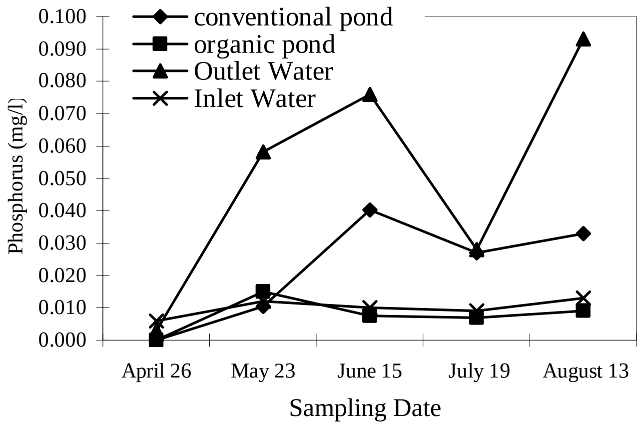

Fig. 9. Variation of inorganic phosphorus in the organic pond, conventional pond, outlet and inlet waters

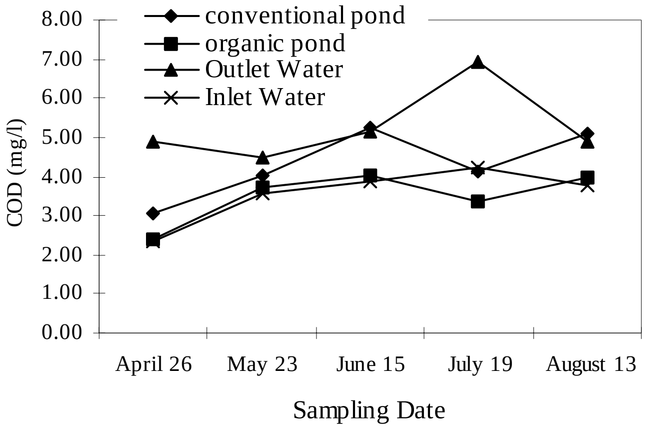

Fig. 10. Variation of COD in the organic pond, conventional pond, outlet and inlet waters

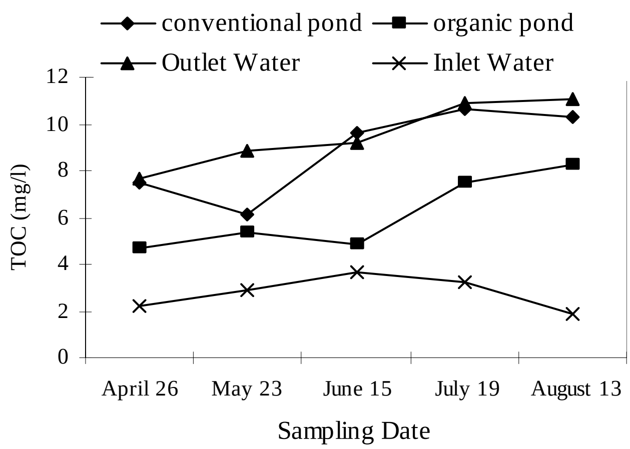

Fig. 11. Variation of TOC in the organic pond, conventional pond, outlet and inlet waters

ried out on April 26, May 23, June 15, July 19 and August 13 during the shrimp growing season. Water samples were taken 30 cm below the water surface in the four corners of the ponds, close to the sluice gate of inlet channel (station A) and at the outlet channel (station B) respectively (Plate 1). Sampling time was between 11.00 and 13.00 h.

Measurements of temperature, salinity, dissolved oxygen and pH were performed *in situ* during the sampling process. At each sampling station, three replicate samples were taken from surface water for quantifying ammonium, nitrite, nitrate, inorganic phosphorus, chlorophyll a, COD and TOC in the laboratory. Water samples were firstly filtered by using a 0.45 μm filter (Seagull brand, produced by Hailing medicine Co., Ltd. of Zhejiang province). All samples were collected in polypropylene bottles and returned immediately to the lab for analysis by applying standard methods (National Oceanographic Bureau, 1991).

Results

Shrimp in the two systems was harvested in 13-15 August 2002. The harvested organic shrimp had average body length of 11.8 cm, and fresh body weight of 15.7 g, dry body weight of 5.7 g, which is higher than conventional shrimp with average body length of 10.2 cm and average fresh body weight of 12.7 g, dry weight of 4.6 g.

Survival in ponds was 88.5% and 82.3 % for organic and conventional pond respectively. Production for organic and conventional pond was 1001 kg ha^{-1} and 753 kg ha^{-1} respectively. Feed conversion (weight of feed added/fresh weight of shrimp produced) was 1.08 and 1.89 for organic and conventional ponds respectively.

Table 3 presents a summary of the statistics of raw water quality data. Typical cases of monthly variations for each water quality variable are displayed in Fig. 1 to 11. pH values in organic pond water varied from 8.4 to 8.7, a little bit lower than those in conventional pond water (Figure 1), which was similar to those recorded in the outlet water. The pH values in the inlet

Table 3
Water quality data from shrimp farm

Parameter	Crop cycle (26 April to 13 August 2002) Mean±Standard deviation			
	Organic Pond	Conventional Pond	Outlet Channel	Inlet Channel
pH	8.6±0.2	8.6±0.1	8.6±0.2	8.7±0.1
Temperature (^{o}C)	23.2±6.4	23.4±6.3	23.9±6.2	23.0±6.7
DO (ml/l)	8.9±0.4	9.0±0.4	8.4±0.2	8.4±0.1
Salinity (‰)	22.4±1.0	21.7±1.4	21.6±1.6	23.3±0.8
Chlorophyll a (mg/l)	0.0008±0.0004	0.0006±0.0003	0.0016±0.0018	0.0009±0.0005
Ammonium (mg/l)	0.002±0.003	0.008±0.007	0.020±0.012	0.023±0.021
Nitrite (mg/l)	0.5±0.3	0.2±0.3	1.1±0.5	0.5±0.2
Nitrate (mg/l)	0.014±0.014	0.004±0.004	0.043±0.048	0.007±0.006
Inorganic Phosphorus (mg/l)	0.022±0.017	0.010±0.010	0.052±0.036	0.008±0.005
COD (mg/l)	4.3±0.9	3.5±0.7	5.3±0.9	3.6±0.7
TOC (mg/l)	8.8±2.0	6.1±1.6	9.5±1.4	2.8±0.7

water showed a little higher than those monitored in the ponds. No significant differences in pH values were found among ponds, inlet and outlet water during the growing phase.

In the ponds, inlet and outlet water, temperature increased with time, starting at about 15^{o}C and increasing to 29^{o}C. Temperature trend in the ponds was similar to that described for inlet and outlet water in the crop growing seasons (Figure 2) and the mean values obtained were similar each other too.

Salinity in inlet water ranged from 22.4 to 24.3 and showed a tendency to be higher than in ponds and outlet water, where salinity varied from 19.6 to 23.8 and from 19.4 to 23.5 (Figure 3) respectively. Salinity in the ponds and outlet river were similar each other.

Dissolved oxygen concentrations recorded in ponds were comparable to those found in the inlet and outlet water during the growing cycle and, at the beginning of the cycle, were higher than those recorded during the harvest (Figure 4).

The total phytoplanktonic biomass in inlet water, determined by chlorophyll *a* concentration, was the lowest and showed no significant changes during the crop cycle; levels recorded in ponds and outlet water tended to increase during the cultivating period (Figure 5) but levels recorded in outlet water showed the highest, followed by the levels in conventional pond and organic pond.

The ammonium concentration levels tended to increase with the cultivating period (Figure 6). Ammonium level in the outlet water showed the highest, followed by ponds and inlet water.

The path of nitrate concentration observed was different in ponds, inlet and outlet waters (Figure 7). For nitrite, concentrations in ponds and inlet were similar, with the exception of outlet water, which had higher mean concentration than others. It was noticeable that during the cultivating season, nitrite, nitrite and inorganic phosphorus concentrations showed similar trends to increase with culture time in ponds, inlet and outlet water (Figures 7, 8 and 9). For these three nutrients, levels recorded in outlet water were significantly higher than those observed in ponds and inlet water.

COD and TOC in organic pond, conventional pond, outlet water and inlet water tended to increase throughout the growing season and levels were significantly higher than those recorded in the inlet water (Figures 10 and 11).

Discussion

Different feed and management practices may explain why the body length, body weight, yield of shrimp and feed conversion in the organic pond were significantly higher than that in the conventional pond. The results of the water quality in the ponds, inlet and outlet waters were discussed as follows.

pH

Due to the acidic character of the faeces and fish food, the shrimp farming activities caused some decrease in the pH of the water. The lower values were sampled in Outlet River and conventional shrimp pond, where the effluent inputs are located and a conventional diet was inputted compared to organic shrimp pond for which wild artemia, clam and organic soybean were used.

Temperature

Water temperature regimes recorded were typical of conditions in the shore of Yellow sea, north of Jiangsu province, China.

Salinity

Salinity conditions are typical of the hyper saline regimes of the coastal sea water in the region, which are influenced by the evaporation rate and the rainfall during the crop growing season. Differences in salinity gradients among ponds, outlet water and inlet water were mainly attributed to the different water management. The marked difference in salinity found between ponds and inlet water is due to underground fresh water pumped into the ponds, which reduce the salinity of the shrimp ponds to the natural requirements of the shrimp species.

Dissolved oxygen

The tendency of dissolved oxygen to decrease during growth time may be explained by two factors: (1) the levels of dissolved oxygen decline as the growing season progresses and feeding rates increase, and (2) as the summer season approaches and the water temperature increases (Figure 2), the solubility of oxygen decreases.

DO levels in shrimp ponds are higher than in the inlet and outlet water, but not stable. There is no obvious difference for DO levels in both organic and conventional shrimp ponds. This may be attributed to the temporal aerator operation located in the middle of each pond so as to increase the concentration of dissolved oxygen (more than 5 g/ml) for higher shrimp growth (Ministry of Agriculture, 2002).

Concentration of dissolved oxygen is higher in inlet water than in outlet water. Regarding the inlet water (Figure 4), since it comes from inlet tidal channel without previous treatment, the dissolved oxygen evolution observed during growth time, is the result of the hydrodynamics of the tidal system. On the other hand, the DO behavior of the outlet water is clearly different, with the shrimp farming activities being responsible for the low values recorded in the outlet water, probably due to the high consumption of dissolved oxygen into the shrimp farm especially during the later growing stage and to the redox processes involved in the degradation of nutrients.

Chlorophyll a

Differences in the chlorophyll *a* mean concentration among ponds, inlet water and outlet water, found during the crop growing cycle, could be related to the nutrient supply through feeding.

Chlorophyll *a* levels in ponds and outlet water tended to increase towards the end of the cycle and this can be explained considering that, as daily feed allotment increased in response to shrimp growth throughout the culture, higher amounts of metabolic wastes entered the water. Thus, the availability of nutrients would correspondingly increase, promoting phytoplankton abundance.

The phytoplanktonic biomass fluctuated synchronically in both ponds as well as in the inlet water. This indicates that algae biomass evolution was driven mainly by environmental factors, such as solar radiation and water temperature, which vary according to the season; but the average magnitude of chlorophyll *a* level in organic pond is higher than in conventional pond, and this may be attributed to different pond management practices and feeding system.

***Nutrients** (ammonium, nitrite, nitrate and inorganic phosphorus)*

Ammonium levels in ponds tended to increase as the growing season progressed as a result of the accumulation of ammonium in wastes, as feeding rates increased throughout the season. Ammonium is the major nitrogenous product excreted by crustaceans (Claybrook, 1983; Sun and Ding, 1999) and may also accumulate in culture systems due to both microbial decomposition of organic material (Boyd, 1982; Ding et al., 1997; Lin et al., 1998).

Ammonium level is higher in the organic pond than in the conventional system. This may be attributed to the high NH_3 excretion rate from the gills of organic shrimp. Previous studies have shown that the main source of ammonium in the shrimp ponds was ammonia excreted from shrimp gills (Burford and Williams, 2001). Maximum concentrations of ammonium were found in the outlet water, where amounts of wastes from shrimp ponds were received.

Nitrite, nitrate and inorganic phosphorus levels in the conventional system were higher than in the organic system, with maximum concentration found in the harvest season. This effect can be explained by the following opinions. The main specifications in organic shrimp farming have to do with the renunciation of pesticides and mineral nitrogen, with the handicap to minimize the amount of bought-in conventional feed (IFOAM, 2000). According to IFOAM Basic Standards for Organic Production and Processing, aqua feeds shall generally contain 100% certified organic components, or wild aquatic feed resources. When certified organic components or wild marine resources are not available, the certification body/standardizing organization may allow a maximum 5% of the feed (by dry weight) to be of conventional origin. Reduction of pollution is reached by a systemic and causally related approach, while conventional strategies are often more based on technical and management related measures.

In this study, the range of animals uses different types of food resources and carries out different management practices (Table 1). The nutrient quality and composition of feed are likely to have a significant impact on nitrogen and phosphorus leachates. In organic pond, shrimp feed on wild artemia, clam and organic soybean; while in conventional pond, a commercial (conventional) diet was inputted. Artemia is one of the best live foods for and can be digested fully by shrimp. Its protein conversion rate amounts to about 80%, significantly more than fishmeal (Li, 1983; Zeng et al., 1998). Produced soybean has a low phosphorus level (Che, 1998), which can causes low phosphorus leaching if used as feed of aquatic animals. There is little evidence for a system-related effect on the results of organic aquaculture production due to the use of organic aqua feed in the organic shrimp system. But in contrast to conventional produce, organically produced product should be environmental-safe and healthier (Schupbach, 1986).

During the cultivating season, inorganic phosphorus concentrations in organic shrimp pond showed the same order of magnitude as those in the inlet water. This indicates that the inorganic phosphorus level of organic pond water is controlled by inlet water quality. But for the outlet water, the levels of nutrients (nitrite, nitrate and inorganic phosphorus) were higher than in the ponds and inlet water, and this is explained by the following mechanism. The levels of nutrients in the outlet are controlled by the discharge water quality from shrimp farms located beside the outlet.

Distinctive paths found for the evolution of nutrients (nitrate, nitrite and inorganic phosphorus) in the ponds, inlet water and outlet water throughout the grow out cycle, could have been influenced by rainfall and runoff events, which affected the water nutrients levels in a different way, due to inherent characteristics of each water body (i.e. morphology, sediment composition and biological communities)

COD

Differences in the COD mean level between organic pond and conventional pond could be related to accumulation of remnant nutrient through feeding, and excrement and dejection of shrimp and zooplanktons, which were greater in the conventional pond than in the organic pond. COD level in outlet water was close to that in conventional pond. This indicated that outlet water quality was controlled by the quality of discharge water from the shrimp ponds. COD concentration in inlet water was the lowest, but still showed the increasing trend during the growing cycle. This may be attributed to the environmental factors, such as hydrodynamics of the tidal system and water temperature, and recycling of outlet water.

TOC

Compared to the reported TOC value in the natural water body located in the bay and firth (0.6 – 10.8 mg/l) (Wang et al., 1998; Cai and Han, 1990; Peng et al., 1997; Sun and Yang, 1992; Patrons, 1995; Lin et al., 1996; Guo and Hong, 1991; State Oceanic Administration, 2000), TOC in the ponds and outlet water was obviously higher. But TOC level in the inlet water showed a little bit lower. This may contribute to the high biomass and high commercial pellet input in the shrimp pond system. TOC concentrations in the ponds showed the tendency to increase during the growing cycle, which were the same as reported by You and Ma (2002). The discharged water from the ponds increased the organic carbon load in the outlet water.

Conclusions

During the shrimp growing period, mean values for temperature, salinity, pH and DO in ponds, inlet and outlet water were equivalent. Ammonium level in the outlet water showed the highest, followed by organic pond, conventional pond and inlet water. For Chlorophyll *a*, nitrite, nitrate, inorganic phosphorus, COD and TOC, Mean levels in the outlet water were found to be highest, followed by conventional pond, organic pond and inlet water. Chlorophyll *a*, nutrients, COD and TOC tended to increase with the cultivating period in the ponds, outlet water and inlet water.

The inlet water quality was found to be closely associated with outlet water quality. This can be explained as part of the physical and chemical properties and recycling of the nutrients into the inlet water.

Temperature and salinity in ponds are controlled by the inlet water quality, which in fact is driven by the weather and water management.

The evolution of most of the water quality variables monitored in ponds was strongly influenced primarily by pond management practices. Our results showed that organic shrimp production system is better for the water quality (Chlorophyll *a*, nitrite, nitrate, inorganic phosphorus, COD and TOC) than its conventional counterpart. But for ammonium, the level is higher in the organic pond than in the conventional system.

Acknowledgements

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References

Bergleiter, S. 2001. Organic Shrimp Production. Ecology and Farming, May 2001, 22-23.

Boyd, C.E., 1982. Water quality management for pond fish culture. Elsevier, Amsterdam, 318 pp

Brister, D.J. and A. R. Kapuscinski. 2000. Organic Aquaculture: A New Wave of the Future. http://library.kcc.hawaii.edu/praise/news/aquacon6.html

Burford, M.A. and K.C. Williams. 2001. The fate of nitrogenous waste from shrimp feeding. Aquacultre, **198**: 79-93

Cai, Y.Y. and Han, W.Y., 1990. Organic Carbon in the Pearl River. Marine Environmental Science, 9(2):8¡-13

Che, Z.L., 1998. Aquaculture feed and environmental impact. *Journal of Oceanography in Taiwan Strait*, **17**: 201-204

Chen, S.T., Su, G.C. and Zhang, Y.P., 1996. Characteristics of Water Environment in the semi-closed shrimp farming system. Tropical Ocean, **15(4)**:85-90

Claybrook, D. L., 1983. Nitrogen metabolism. In L.H. Mantel (ed.). The Biology of Crustacea, Vol. 5, Internal. Anatomy and Physiology Regulation. Academic Press, New York, 163-213

Ding, M.L., Lin, L. and Li, G.Y., 1997. Organic pollution impact on internal and external environment of *Penaeus chinensis*'s body, Oceanologica Et Limnologia Sinica **28(1)**: 7-12

Dong, C.Y. and Zhang, J.R., 1993. COD changes and impact on shrimp growth and output in shrimp pond system, Marine Sciences **3**: 8-12

Food and Agricultural Organization (FAO). 2001. FISHSTAT Plus. Universal software for fishery statistical time series. http://www.fao.org/fi/statist/ fisoft/ fishplus.asp

Gao, S.D., Wu Y.P. and Wei, J,G, 1993. Changes of water quality and bottom mud in shrimp pond during the cultivation period,**12(3)**:7-14

Guo, L.D. and Hong, H.S. 1991. POC Distribution and Changes in the South of Taiwan Strait. In: Hong, H.S. and Qiu, S.Y., Eco-system Study on upward Stream Area of Shallow Fishery Ground in the Mingnan-Taiwan Strait. Beijing Science Publication House, **231**-239

International Federation of Organic Agriculture Movements (IFOAM) (2000), Basic standards for organic production and processing, D-66606 St. Wendel, Germany, 67 pp.

Kautsky, N., Ronnback, P., Tedengren, M., Troell, M., 2000. Ecosystem perspectives on management of disease in shrimp pond farming. *Aquaculture* **191**: 145-161

KRAV. 2001. Standards. Idetryck Grafisk Uppsala, Sweden, pp. 60-69

Li, R. 1983. Assessing the artemia as feed of aquatic animal. *Marine Sciences*, **5**: 61-69

Lin, L., Ding, M.L. and Sun J.J., 1998. Experiment of the increase of shrimp sensitivity to pathogenic fungus through organic pollution, *Acta Oceanologica Sinica* **20(1)**: 90-93

Lin, R.G., Wu, J.Y. and Ma, L., 1997. Water Eutrophication and Countermeasures in shrimp pond system, Acta Oceanologica Sinica **19(6)**:127-133

Lin, W.L., Wang, J. and Huang, X.F. 1996. Changing Characteristics for Suspended Organic Carbon, Nitrogen and Phosphorus Particles in the Eastern Lake of Wuhan. Beijing Science Publication House.

Ministry of Agticulture, 2002. Shrimp Farming Technique Regulations for no social effects of pollution (NY/T5059-2001). http:// www.aweb.com.cn/2002/ 8/21/2002 821 141319.htm

NASAA (The National Association for Sustainable Agriculture Australia, Limited). 2001. The Standards for Organic Agricultural Production. Stirling. S.A 5152, Australia, pp. 37-38

National Oceanographic Bureau. 1991. Water monitoring and analysis. Specification of Oceanographic Survey (HY003-1-91). Ocean Press, Beijing, pp. 1-24

Naturland. 2002. Naturland Standards for Organic Aquaculture. Kleinhaderner Weg 1, 82166 Grafelfing, Germany, 20pp

Neiland, A.E., S. Neill, J. B. Varley et al., 2001. Shrimp aquaculture: economic perspectives for policy development. *Marine Policy*, **25**: 265-279

Organic Food Development Center of State Environmental Protection Administration (OFDC). 2002. Organic Certification Standards. Nanjing, China, pp. 30-32

O'Riordan T. and D. Cobb. 2001. Assessing the consequences of converting to organic agriculture. *Journal of Agricultural Economics*, **52**: 22-35

Paez-Osuna, F. P., 2001. The environmental impact of shrimp aquaculture: a global perspective. *Environmental Pollution*, **112**: 229-231

Pang, L.Q., 2001. The problem confronted and development strategy of shrimp culture industry in China, *Shangdong Fisheries*, **18(3)**: 22-25 (In Chinese)

Parsons, T..R., Particulate Organic Carbon in the Sea, Chemical Oceanography (2nd ed.), London: Academic Press, 1995: **365**-383

Peng, X.Y., Hong, H.S. and Sang, S.L. 1997. Organic Carbon Dynamics in the Taiwan Stait. ACTA OCEANOLOGICA SINICA,**19(3)**:57-65

Schupbach, M., 1986. Spritzmittelruckstande in Obst und Gemuse, *Deutsche Lebensmittel Rundschau*, **82 (3)**: 76-80.

Senarath, U., C. Visvanathan. 2001. Environmental issues in brackish water shrimp aquaculture in Sri Lanka. Environmental Management, **27(3)**: 335-348

State Oceanic Administration of China. 2000. Report on the State of the Oceanic Environmental Quality in China for the end of 20 Century. http:// wdc-d.wi.gov.cn/20shijimo/

Sun, B.L., Zhang, G.Q. and Wang X.B., 1998.

Fulminic epidemic disease prevention and control measures for shrimp farming, Modern Fishery News,**13(6)**:1-4

Sun, J.J. and Ding, M.L., 1999. Effects of ammonia-N on anti-disease ability of Penaeus Chinensis, Oceanologia et Limnologia Sinica, **30 (3)**, 267-272

Sun, Z.Q. and Yang, H.M. 1992. Distribution and Changes of Particle Organic Carbon in the Seawater of Jiaozhou Gulf. Marine Science, **2**:52-55.

Wang, J.K. Managing shrimp pond water to reduce discharge problems. *Aquacultural Engineering* **9**: 61-73

Wang, J.T., Yu, Z.G. and Zhang, J. 1998. Dissolved OrganicCarbon in the Mouth of Yalu river. *Journal of Ocean University of Qingdao* **28(3)**:471-475

Willer, H. and M. Yussefi. 2001. Organic Agriculture Worldwide Statistics and Future Prospects Bad Durkheim : SOL, 22-23

X. Biao, X.R., Wang, Z.H., Ding, and Y.P., Yang. 2003. Critical Impact Assessment of Organic Agriculture, *Journal of Agricultural and Environmental Ethics* **16**: 297-311

You, K. and Ma, S., 2002. Preliminary study on organic carbon in shrimp cultural ecocystems, *Journal of Ocean University of Qingdao*, **32(1)**: 51-55

Yu, Z.G.,1995. Analysis of reason and prevention strategy for shrimp fulminic epidemic disease, *Ocean Environmental Science* **14(2)**:53-60

Zeng, G.Y., Li, R. and Guo, L., 1998. The preliminary analysis of protein, fatty acid, amino acid, mineral contents of Huangqihai Artemia Flakes. *Acta Scientiarum Naturalium Universitatis NeiMongol*, **29**(2): 199-201.

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