ICM Solutions

Transforming Traditional Pond Aquaculture to Modern Ecological Aquaculture in Dongying, PR China

- Dongying City of Shandong Province, PR China, has transformed traditional pond aquaculture to ecological aquaculture by using the natural process of tide and nutrients to farm sea cucumber, shrimps, and crabs.
- Applying multiple uses of seawater has resulted in a zero nutrient emission from Dongying's aquaculture industry along with significant social and economic benefits to the local community.
- Ecological aquaculture products are very much accepted in markets. Dongying City has developed and implemented strategies to take a higher percentage of market share of its fishery products by adopting industrial management practices, branding its products, and delivering timely and efficient public services to ensure the quality and safety of its ecology-friendly products. Growing markets for ecologically friendly aquatic products promise continued return on investments in ecological aquaculture.
- Enabling national, provincial, and local strategies, policies and legal instruments have helped Dongying City establish reliability in pursuing its sustainable farming practice.

CMC UNDP WORLD BANK GROUP PEMSEA

Context

In the last three decades, extensive coastal areas along the Yellow River Delta were converted into fish ponds for the cultivation of high value marine commercial species such as shrimps, abalones, and sea cucumbers. Widespread farming techniques required heavy inputs of commercial feeds for shrimp farming or fertilizers to increase benthic algae or primary productivity in abalone and sea cucumber farming. Such aquaculture practices have resulted in wastage of commercial feeds, increased sedimentation, and bacteriological/virological contamination and high concentrations of nutrients in the water column. Collectively, this resulted in a high mortality rate of the farmed animals due to oxygen depletion and diseases from viruses, bacteria and other harmful microorganisms.[1,2] Uncontrolled or inadequately controlled application of antibiotics for disease prevention and treatment further contaminated the aquaculture product and posed health concerns to consumers.[3]

In 2009, the Chinese Government called for the development of marine industries and establishment of modern industry clusters to boost economic growth. In May 2009, Dongying adopted an ICM Strategy, which included actions to achieve the dual objectives of developing the aquaculture industry and improving the marine environment through the demonstration of intensive and highly efficient modern aquaculture.[4]

Ecologically friendly aquatic products such as sea cucumbers fetch high market prices, with the support of market development and consumer awareness.

Solutions

Gain political support. Since 2007, aquaculture was identified by the Dongying municipal government as a main innovative industrial area in alignment with the Yellow River Delta Efficient Ecological Economy Program. In March 2008, Shandong Province developed plans for the use of designated water areas and tidal flats for aquaculture. The Provincial Government also provided guidance on the efficient and rapid development of the area. On the basis of these policies, the Dongying municipal government began to develop a 20,000 hectare demonstration area for efficient ecological aquaculture.

As of 2014, 67,000 hectares of modern fishing demonstration core areas were constructed for ecological farming of sea cucumber, seafood ecological farming, salt production, and so on.

Aquaculture demonstration area of Dongying City.

Establish an interagency coordinating mechanism. Modern aquaculture is an engineered system that involves the marine fisheries bureau, tax bureau, planning bureau, construction committee, and other departments. Dongying City accordingly set up a special lead group to coordinate the Yellow River modern aquaculture demonstration area. Headed by Dongying City Oceanic and Fishery Bureau, the lead group supervises and monitors the development of the aquaculture industry, and coordinates activities among relevant departments.

Use the ocean's natural processes for farming. Ecological aquaculture in Dongying City demonstrates a cycle of healthy ecological farming (fig. 1). Farming of sea cucumber, shrimps and crabs, and artemia is practiced using the concept of resource sharing and recycling whereby all aquaculture wastes are fully utilized. Clean, grade I seawater is kept and stored in a reservoir through natural tide and is then pumped into a sedimentation basin. After settling, high quality seawater is pumped into the sea cucumber aquaculture zone. Benthic algae flourishes in the sea cucumber farming zone, which are full of rocks and sand. The seawater in this zone is replaced when there is an increase in algae abundance. Compared with the pond-farmed sea cucumber, ecologically farmed sea cucumber's growth period is longer as feed/baits and antibiotics are not added, thus maintaining the quality of seawater.[5]

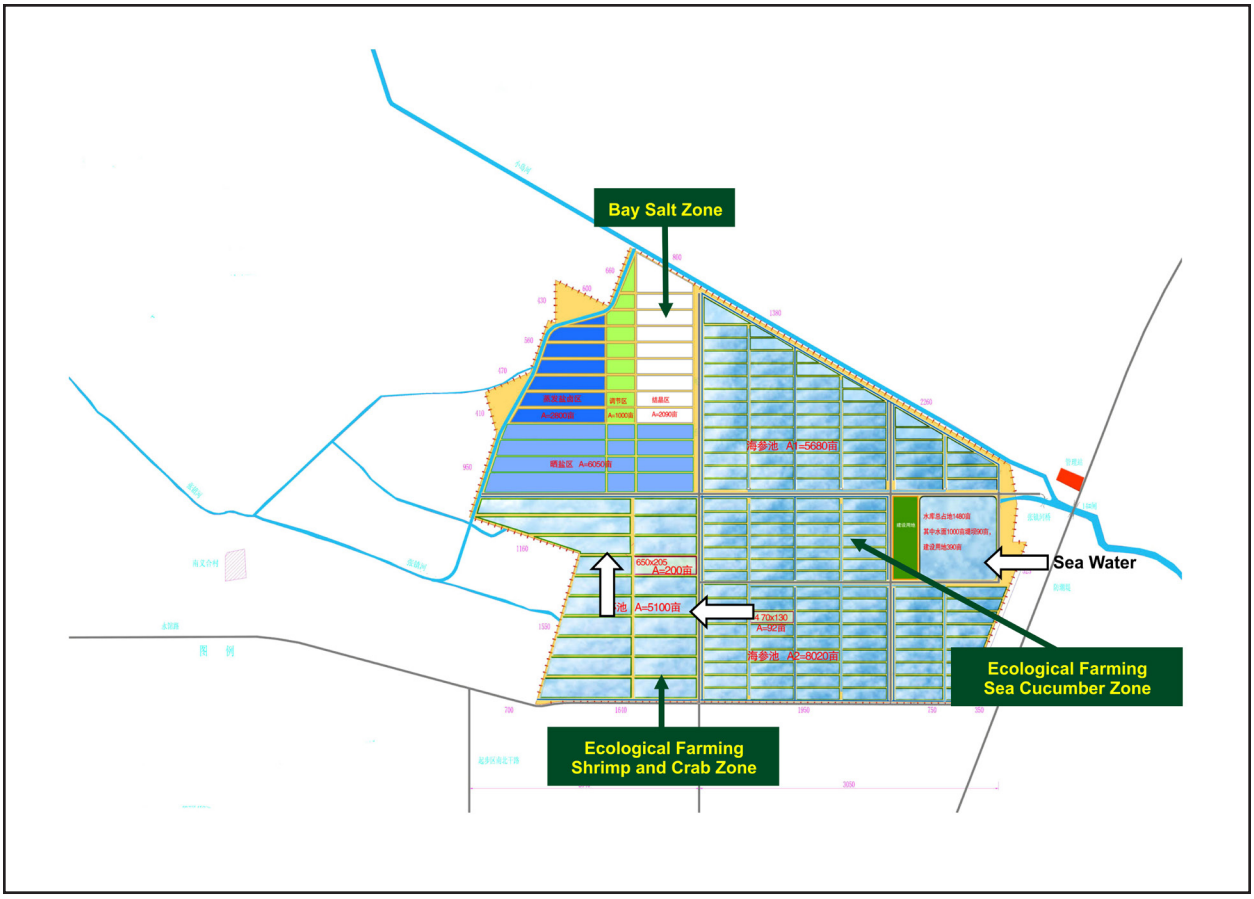


Figure 1. Efficient seawater cycle ecological aquaculture of Dongying City.

Use seawater multiple times. With evaporation, seawater salinity in the sea cucumber farming zone increases, a condition that is no longer suitable for the growth of sea cucumber. At this point, seawater is pumped into the shrimp and crab farming zone. After further water evaporation in the shrimp and crab farming zone, the seawater is pumped into the artemia farming zone. Ultimately, the highly saline seawater is used to process bromine salt and magnesium chloride. This model of multiple uses of seawater (fig. 2) results in efficient use of resources.[6]

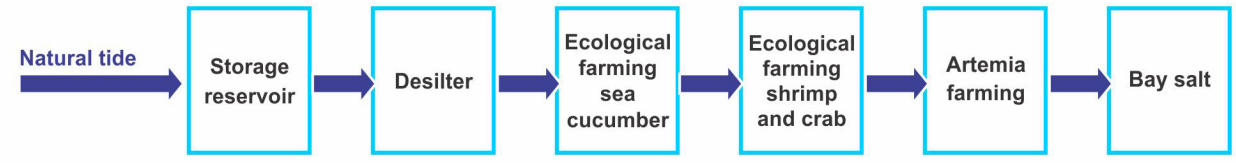


Figure 2. Seawater flow system under circulating model.

Close the nutrient cycle through multi-tropic farming. Under the ecological aquaculture system in Dongying, different species living under various tropic levels are farmed in such a way that nutrients in the farming areas can be recycled. Under the traditional aquaculture mode, sea cucumber feed is added to the ponds, and some amounts of the feed and feces end up in the water column. Under the ecological aquaculture mode, sea cucumber can be raised with the natural nutrients in seawater. After seawater is discharged from sea cucumber farming ponds into shrimp farming ponds, shrimps and crabs will consume some of the particles of feed and feces of the sea cucumber and thus can grow faster or bigger than they might otherwise have done.

Apply industrial aquaculture management practice (IAMP). Dongying City actively applies modern management practices to improve aquaculture operations. Dongying City has adopted an industrial aquaculture management practice (IAMP) with standardized production and management procedures to ensure quality of aquaculture.

Tighten quality and safety surveillance. In order to realize healthy aquaculture products, a quality monitoring system is being implemented by the Dongying Oceanic and Fishery Bureau. Awareness and education activities have been conducted to improve the consciousness of the whole society regarding the quality and safety of aquaculture products. A random testing mechanism for aquaculture products was also set up. The entire process of the business chain is operated strictly in observance of the legal provisions, which guarantees the aquaculture products' quality and safety from raw materials to finished products. This is further ensured through the requirement of compliance with the Hazard Analysis and Critical Control Points (HACCP) system.

Strengthen law enforcement. Supervision and management of the ecological aquaculture have been tightened. The Dongying Oceanic and Fishery Bureau organizes and implements relevant monitoring and inspection systems to ensure the quality of aquaculture products. Relevant legislation and administrative orders include the Shandong Province State-owned Waters Mudflat Aquaculture Management Regulations, Interim Measures of Shandong Province for the Administration of Production Licenses for Aquatic Fingerlings and the Dongying City Comprehensive Management Program for Rural Aquaculture Product Safety.

Build aquaculture zone development into a business. In order to strengthen the organization and management of modern aquaculture demonstration area, Dongying City incorporated the Yellow River Estuary Fisheries Ltd., Dongying City. This entity has the overall responsibility for the development and construction of the aquaculture area.

Results

Modern Ecological Aquaculture *is practiced by using seawater in multiple ways, using the ocean's natural processes for farming, closing the nutrient cycle through multi-tropic farming and applying industrial management standards. This approach has significantly reduced the concentration of nutrients in coastal areas surrounding Dongying City while being recognized as an important sea cucumber breeding base and significant supplier of eco-aquaculture products in PR China. This in turn has added social and economic benefits to the City.*

Significantly reduced nutrients and recognized base for supply of eco-aquaculture products. Sea cucumbers grown under the ecological aquaculture mode are excellent in quality and fetch a market price twice those from former pond-grown areas. Pollution to the seawater column is prevented as there is no need to feed and apply antibiotics. Table 1 summarizes the monitoring results at two locations of the aquaculture farm in 2007 and 2014. The values of COD, nitrite, ammonia nitrogen, and petroleum in 2014 are lower than those in 2007. Today, Dongying City is recognized as an important sea cucumber breeding base in PR China.

Table 1. Monitoring results of eco-aquaculture farms in 2007 and 2014.

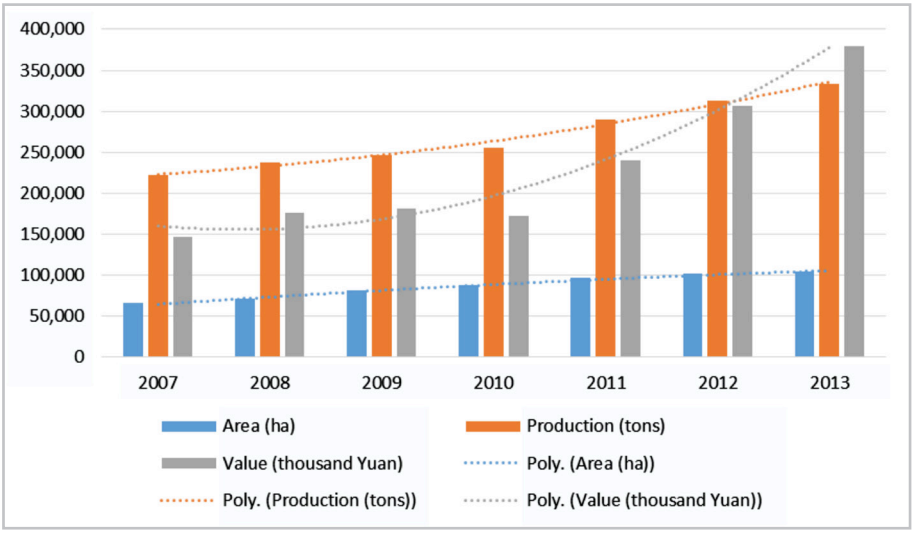
Date	depth	pH	salinity	DO	COD	phosphate	Nitrite	Nitrate	Ammonia nitrogen	Petroleum
m/d/y	m			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
10/15/2007	5.4	8.13	25.14	8	5.09	0.026	0.035	0.05	0.299	0.06
10/22/2014	6.5	8.00	29.19	8.34	0.927	0.00597	0.0477	0.269	0.104	0.0385

Source: Dongying Ocean and Fishery Bureau, Shangdong Province, PR China

Increased social and economic benefits. The aquaculture area has increased from 66,000 ha in 2007 to 104,000 ha in 2013, a 58 percent increase. During the same period, production has increased from 222,198 tons to 333,167 tons, an increase of 50 percent which is commensurate to the increase in areas. On the other hand, the annual sales value of aquatic products has increased from 176 million yuan (US$ 27.5 million) in 2007 to 379 million yuan (US$ 59.2 million) in 2013, an increase of 158 per cent (fig. 3). Clearly, economic benefits from eco-aquaculture are much higher than from traditional aquaculture practices.

In accordance with the aquaculture industry development plan, Dongying City is targeting to develop 140,000 ha of aquaculture farms by 2020, with annual outputs of 660,000 tons of aquatic products and an increase of annual average income of fishers to US$ 4,500.

Figure 3. Aquaculture area, production, and production value in Dongying City from 2007 to 2013.



Source: Dongying Ocean and Fishery Bureau, Shangdong Province, China.

Lessons Learned

Align with national and local development strategies. Ecological aquaculture demonstration and replication are only possible with strong backstopping from national, provincial and municipal government. An enabling land and sea use zoning plan, coordination mechanisms, legislation, law enforcement, and quality control and monitoring have created a business and investment landscape for ecological aquaculture.

Partner with academia for technical support. To overcome the technical barriers to investors, the demonstration zone entered into partnership agreements with Yantai University and Qingdao Agriculture University to provide technical support and transfer of technology, breeding of new varieties, disease prevention and control, monitoring of water environment, and quality criteria of farmed products. Research projects were also conducted by the two universities to find solutions to identified technical issues.

Incentivize participation by local investors. At the early state of demonstration, about 150 ha of land were allocated for the "Industry to Benefit Household Project." The project provided land, management support, construction, and other incentive measures to local investors, namely fishers, associations of fishers, and cooperatives. Training opportunities were conducted on the standardization of aquaculture management processes, large-scale farming, intensive aquaculture farming, and so on. These incentive measures attracted investment from local people who ultimately benefited from the investment.

Facilitate the development of the supply chain from aquaculture farming, processing, marketing, and logistics. To facilitate large-scale aquaculture industry development, the Dongying municipal government leased 200 ha of land to investors to build and operate processing facilities for aquatic products. The processing industries provided job opportunities for thousands of skilled workers. Meanwhile, trade centers were registered to facilitate market access of aquatic products. Roads were built to provide easy access to highways which led to key consumer markets.

A growing consumer market conscious of food safety. Through its modern fisheries demonstration and replication program, Dongying City has developed and implemented strategies to target a higher percentage of the market share of its aquatic products. Meanwhile, developing its ecological aquaculture product into well-known brands was also initiated by creating a market environment for ecological-friendly products. The strategies have proven successful with the increasing population of middle-income consumers. In turn, the enabling legal, institutional, market-oriented approaches and mechanisms will leverage rapid transformation of the traditional aquaculture sector into a more sustainable and modern fishery model in other areas and markets.

Endnotes

[1] Li Zhen and Chen Yu-li, "Nutrition Control Measures on the Water pollution in Aquaculture [J]." Guangdong Feed 13, no. 2 (2004): 41-43.

[2] Shen Pei, "Aquaculture Water Nitrogen Cycle [J]." Scientific Fish Farming 2, (2001): 78.

[3] Hu Wen-jia, Yang Sheng-yun, and Zhun Xiao-ming, "The Impact of Mariculture on the Marine Ecosystem and Studies on Bioremediation [J]. Journal of Xiamen University 46, no. 1 (2007): 197-202.

[4] Shandong Dongying Ocean and Fishery Bureau, May 2009. Shandong Dongying Integrated Coastal Management Strategy.

[5] Han Shi-dong and Xiao Qiu-ying, "The Development of Efficient Ecological Fishery to Promote Dongying Coastal Comprehensive Development [J]." China Hi-Tech Enterprises 148 (2010): 8-9.

[6] Zhou Xin and Xu Xue-gong, "Typical Models of Efficient Ecological Fishery in Dongying City [J]." Journal of Shanghai Ocean University 23, no. 3 (2014): 463-469.

Keywords

Ecological aquaculture, nutrients, multiple seawater use, management process, blue economy, sea cucumber, ICM.

For further information, please contact:

- **Ms. Yi Dan, Project Manager, China-PEMSEA Sustainable Coastal Management Cooperation Center, Qingao, China (yidan@fio.org.cn)**
- **Mr. Liu Pei, Program Officer, Dongying Ocean and Fishery Bureau, Shandong Province, China (1007599171@qq.com)**
- **Mr. Guo Yinfeng, Sustainable Development Specialist, PEMSEA (gyinfeng@pemsea.org)**

"ICM Solutions" is a digest of some of the contributions to an ICM case studies publication currently being prepared by PEMSEA, Coastal Management Center (CMC) and the World Bank (publication pending).

PEMSEA

PEMSEA Resource Facility

Tel.: (+632) 929 2992
Fax: (+632) 926 9712

info@pemsea.org
www.pemsea.org