UNDP/GEF PROJECT ENTITLED "REDUCING ENVIRONMENTAL STRESS IN THE YELLOW SEA LARGE MARINE ECOSYSTEM"

UNDP/GEF/YS/SM/3
Date: 15 June 2007
English only

The YSLME Symposium and Workshop
On the Sustainable Mariculture in the Yellow Sea
- Reducing Environmental Stress in the Yellow Sea Large Marine Ecosystem -
Taean, ROK, 18th – 20th June 2007

PROCEEDINGS

FOR

THE UNDP/GEF Yellow Sea Project
Korea-China Symposium & Workshop on the Sustainable Mariculture

UNDP/GEF 황해생태계보전사업

지속가능한 수산양식을 위한 한·중 심포지엄 및 워크숍

UNDP/GEF Yellow Sea Project
Korea-China Symposium & Workshop on the Sustainable Mariculture

황해광역생태계의 환경스트레스 감소를 위하여
Reducing Environmental Stress in the Yellow Sea Large Marine Ecosystem

2007. 6. 18-20
국립수산과학원 서해특성화연구센터

June 18-20, 2007
West Sea Mariculture Research Center, NFRDI
Republic of Korea

West Sea Mariculture Research Center, NFRDI

UNDP/GEF Yellow Sea Large Marine Ecosystem Project

심포지엄 순서

UNDP/GEF Yellow Sea Project
Korea-China Symposium on the Sustainable Mariculture

2007. 6. 18(월) 10:00-17:00 태안문화예술회관 소강당

Jun. 18 (Mon) 10:00-17:00 at Taean Culture Center

10:00 등록 Registration

1 부 개회식 Opening Ceremony

진행 장인권 박사(Dr. In Kwon Jang)

10:30 개회 및 환영사 (박덕배 국립수산과학원장) Opening and Congratulatory Address (Mr. D.B. Park, General Director of NFRDI)

10:40 환영사 (중국 황해수산연구소 부소장) Welcome Address (Dr. Qingyin Wang, vice Director of YSFRI, China)

10:50 축사 (배승철 세계양식학회장) Congratulatory Address (Dr. S.C. Bai, President of World Aquaculture Society)

11:00 심포지엄의 배경과 목적 (YSLME 사업단장) Background of Symposium (Dr. Yihang Jiang, Project Manager of UNDP/GEF YSLME)

11:10 휴식 Coffee Break

2 부　환경스트레스 감소를 위한 양식기술

Aquaculture Technologies for reducing environmental Stress

좌장　전임기 (부경대 교수)　Dr. I.G. Jeon (Bukyeong Nat'l Univ.)

11:20　한국 서해안의 축제식 복합양식 (강희웅 박사, 국립수산과학원 서해수산연구소)

Pond polyculture in the West Sea of South Korea (Dr. H.W. Gang, NFRDI, Korea)

11:40　중국의 복합양식 (J.G. Fang, 황해수산연구소, 중국)

Polyculture in embayments and ponds of China (Dr. Jianguang Fang, YSFRI, China)

12:00　점심　Lunch

13:00　해수 순환여과시스템에서 넙치사육시험 (이배익 박사, 국립수산과학원 동해특성화연구센터)

Culture of the olive flounder in marine recirculating aquaculture system (Dr. B.I. Lee, NFRDI, Korea)

13:20　해수순환여과시스템에서의 사육수 처리시설 (K. Qu, 황해수산연구소, 중국)

The facilities of seawater treatment in recirculating mariculture system (Dr. Keming Qu, YSFRI, China)

13:40　한국의 외해양식 (이정의 박사, 국립수산과학원 양식관리팀)

Offshore aquaculture in Korea (Dr. J.U. Lee, NFRDI, Korea)

14:00　중국의 외해양식 기술 및 응용 (J. Zhang, 황해수산연구소, 중국)

Open-sea aquaculture technology and practices in China (Dr. Jihong Zhang, YSFRI, China)

14:20　휴식　Coffee Break

3 부 수산양식을 위한 최적관리기술 Best Management Practices for Aquaculture

좌장 이정열 (군산대 교수) Dr. J.Y. Lee (Kunsan Nat'l Univ.)

14:40 타가영양방식을 이용한 실내고밀도 새우양식 (장인권 박사, 국립수산과학원 서해특성화연구센터)
Intensive shrimp culture in indoor tanks using heterotrophic methods (Dr. I.K. Jang, NFRDI, Korea)

15:00 실내고밀도 새우양식기술 (J. Kong, 황해수산연구소, 중국)
Indoor intensive shrimp culture in China (Dr. Jie Kong, YSFRI, China)

15:20 어류의 가두리 양식을 위한 최적관리기술 (조재윤 교수, 부경대학교)
Best management practices in cage culture of finfish in Korea (Dr. J.Y. Jo, Bukyeong Nat'l Univ.)

15:40 중국의 가두리양식 최적관리기술 (C. Guan, 황해수산연구소, 중국)
Introduction of good aquaculture practice in cage culture in China (Dr. Changtao Guan, YSFRI, China)

16:00 한국의 패류양식 현황 (최광식 교수, 제주대학교)
Recent advances in Korean shellfish aquaculture (Dr. K.S. Choi, Cheju Nat'l Univ.)

16:20 산동지역의 패류양식 최적관리기술 (Z. Qiu, 산동성해산양식연구소, 중국)
Best management practices in Sandong shellfish culture (Dr. Zhaoxiong Qiu, Shandong Mariculture Institute, China)

16:40 폐 회 Closing Remarks

워크숍 일정

Workshop

on

Aquaculture in the Yellow Sea for Environmental and Economic Sustainability and Commercial Profitability

2007. 6. 19(화) 10:00-18:00 서해특성화연구센터

Jun. 19(Tue), 2007 at West Sea Mariculture Research Center, NFRDI

- 만과 사육지에서의 복합양식 Polyculture in embayments and ponds
- 어류양식을 위한 순환여과시스템 Recirculating tank production system for finfish culture
- 사육수 비교한 새우양식기술 Limited water exchange technologies for shrimp culture
- 외해양식기술 및 응용 Open-Sea Aquaculture technology and practices
- 어류의 가두리 양식을 위한 최적관리기술 Best management practices in cage culture of finfish
- 패류 양식을 위한 최적관리기술 Best management practices in shellfish culture
- 사료와 사료공급에 대한 최적관리기술 Best management practices for feeds and feeding
- 어떻게 SAP 준비를 해야 하는가 How to contribute to the preparation of SAP

CONTENTS

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PROVISIONAL AGENDA

Provisional Agenda
for
the YSLME Symposium and Workshop
on the Sustainable Mariculture in the Yellow Sea
- Reducing Environmental Stress in the Yellow Sea Large Marine Ecosystem -

18th– 20th June, 2007

West Sea Mariculture Research Center, NFRDI
Taean, Republic of Korea

Sunday, 17th June, 2007

Afternoon Chinese participants arrive Incheon, Korea
Move to Taean by rental car
Check-in Hotel in Taean
Welcoming reception hosted by WSMRC, NFRDI

Monday, 18th June, 2007

Symposiun on "Sustainable Mariculture in the Yellow Sea" at Taean Culture Center, Taean

10:00 **Registration**

PART I OPENING CEREMONY

Chair : Dr. In Kwon Jang, NFRDI

10:30 **Opening and Congratulatory Address**
Mr. Duk Bae Park, General Director, National Fisheries Research & Development Institute, Korea

10:40 **Welcome Address**
Dr. Qingyin Wang, Vice Director, Yellow Sea Fisheries Research Institute, China

10:50 **Congratulatory Address**
Dr. Sungchul C. Bai, President of World Aquaculture Society

11:00 **Background and objectives for the symposium and workshop**
Mr. Yihang Jiang, Project Manager, YSLME/GEF Yellow Sea Project, UNDP

11:10 **Coffee break**

PART II AQUACULTURE TECHNOLOGIES FOR REDUCING ENVIRONMENTAL STRESS

Chair : Dr. Im Gi Jeon, Former President of Korean Aquaculture Society

11:20 **Pond polyculture in the West Sea of South Korea**
Dr. Hee-Woong Gang, West Sea Fisheries Research Institute, NFRDI, Korea

11:40 **Polyculture in embayments and ponds**
Dr. Jianguang Fang, Yellow Sea Fisheries Research Institute, CAFS, China

12:00 ***Lunch***
13:00 **Culture of the Olive Flounder in Marine Recirculating Aquaculture**
Dr. Bae-Ik Lee, East Sea Mariculture Research Center, NFRDI, Korea

13:20 **The facilities of seawater treatment and design of technological process in recirculating mariculture system**
Dr. Keming Qu, Yellow Sea Fisheries Research Institute, CAFS, China

13:40 **The new challenge of offshore aquaculture in Korea**
Dr. Jung-Uie Lee, Headquarters of Aquaculture, NFRDI, Korea

14:00 **Open-sea aquaculture technology and practices in China**
Dr. Jihong Zhang, Yellow Sea Fisheries Research Institute, CAFS, China

14:20 ***Coffee Break***

PART III BEST MANAGEMENT PRACTICES FOR AQUACULTURE

Chair : Dr. Jung Ryul Lee, Kunsan National University

14:40 **Intensive shrimp culture indoor tanks using heterotrophic methods**
Dr. In Kwon Jang, West Sea Mariculture Research Center, NFRDI, Korea

15:00 **Indoor intensive shrimp culture in China**
Dr. Jie Kong, Yellow Sea Fisheries Research Institute, CAFS, China

15:20 **Best management practices in cage culture of finfish in Korea**
Dr. Jae Yoon Jo, Bukyeong National University, Korea

15:40 **Technique and development for sustainable cage mariculture in China**

Dr. Changtao Guan, Yellow Sea Fisheries Research Institute, CAFS, China

16:00 **Recent advances in Korea shellfish aquaculture**
Dr. Kwang-Sik Choi, Cheju National University, Korea

16:20 **Standard management practices in shellfish culture in Shandong**
Dr. Zhaoxing Qiu, Shandong Mariculture Research Institute, China

16:40 **General Discussion and Closing Remarks**

Tuesday, 19th June, 2007 (10:00-18:00)

Workshop on 'Aquaculture in the Yellow Sea for Environmental and Economic Sustainability and Commercial Profitability' at West Sea Mariculture Research Center, Taean

Topics and panellists of Workshop

Before the discussion of each topic, discussion leaders [underlined] will give general introduction using Power point or printed materials for 5-10 min.

- Polyculture in embayments and ponds
  Dr. Hee-Woong Gang, West Sea Fisheries Research Institute, NFRDI, Korea
  Dr. Jianguang Fang, Yellow Sea Fisheries Research Institute, CAFS, China

- Recirculating tank production system for finfish culture
  Dr. Bae-Ik Lee, East Sea Mariculture Research Center, NFRDI, Korea
  Dr. Keming Qu, Yellow Sea Fisheries Research Institute, CAFS, China

- Limited water exchange technologies (or heterotrophic systems) for shrimp culture
  Dr. In Kwon Jang, West Sea Mariculture Research Center, NFRDI, Korea
  Dr. Jie Kong, Yellow Sea Fisheries Research Institute, CAFS, China

- Open-Sea Aquaculture technology and practices
  Dr. Jung-Uie Lee, Headquarters of Aquaculture, NFRDI, Korea
  Dr. Jihong Zhang, Yellow Sea Fisheries Research Institute, CAFS, China

- Best management practices in cage culture of finfish
  Dr. Jae Yoon Jo, Buyeong National University, Korea
  Dr. Changtao Guan, Yellow Sea Fisheries Research Institute, CAFS, China

- Best management practices in shellfish culture
  Dr. Kwang-Sik Choi, Cheju National University, Korea

Dr. Zhaoxing Qiu, Shandong Mariculture Research Institute, China

- Best management practices for feeds and feeding
  Dr. Jong Yun Lee, Aquafeed Research Center, NFRDI, Korea
  Dr. Mengqing Liang, Yellow Sea Fisheries Research Institute, CAFS, China

- How to contribute to the preparation of SAP
  Dr. In-Ja Yeon, West Sea Fisheries Research Insitute, NFRDI, Korea
  Dr. Mark Walton, UNDP/GEF Yellow Sea Project

Wednesday, 20th June, 2007

Field trip: finfish cage culture farms and hatcheries in Cheonsu Bay, Chungnam Province

Thursday, 21st June, 2007

Morning: Hotel check-out and departure to Incheon (by rental car)
Afternoon: Return home

PART I

OPENING CEREMONY

Opening and Congratulatory Address

Duk Bae Park

Director-General of National Fisheries Research & Development Institute

Thank you, scientists from the United States and Korea.

Ladies and gentlemen, it's my greatest pleasure to present "my welcoming address" to your outstanding scientists. On behalf of the National Fisheries Research and Development Institute, I would like to express my warmest appreciation to invited speakers and all of participants attended in the symposium and workshop on the sustainable mariculture in the Yellow Sea.

Shrimp is one of major farmed species in the west coast of Korea. More than 95% shrimp farms locates along the west coast. Farmed shrimp production in Korea was about 2,500mt in 2003 from 450 farms. However, outbreaks of viral disease is the most serious problem in shrimp farming industry in Korea like other shrimp producing countries in Asia and America. Because of virus-related diseases, about fifty percent of shrimp farms in Korea had total loss of farmed shrimp crops in 2003 and shrimp farmers suffered great economic loss.

Currently most of shrimp farms in Korea are culturing Chinese fleshy shrimp, *Fenneropenaeus chinensis.* To solve disease problems of this farmed shrimp, my institute introduced the Pacific white shrimp from Hawaii, U.S.A. because this species is known to be more resistant to diseases than Chinese fleshy shrimp. So far, culture with the white shrimp is very successful in many farms but it still causes disease problems in some farms.

To solve and overcome the problems facing with unexpected and unsustainable shrimp farming in Korea, we need to exchange information in the field of the shrimp diseases, sustainable shrimp production practices, and shrimp feed and nutrition.
In this seminar, I hope we can have the opportunity to share our knowledge and experience on the shrimp culture between two countries.

Again, I would like to appreciate all of you for joining this symposium and workshop. I'm sure we can strengthen our cooperative research activities for the sustainable mariculture in the Yellow Sea between Korea and U.S.A.

Thank you very much.

Congratulatory Address

Sungchul Charles Bai

President of World Aquaculture Society

Good morning, distinguished speakers, Mr. Duk Bae Park, General Dircector, NFRDI, Korea, Dr. Qingyin Wang, Vice Director, Yellow Sea Fisheries Research Institute, China, Symposium/ Workshop participants, organizing committee members, Ladies and Gentlemen!

It is an honor and a privilege to give my congratulatory address in this valuable and very important Symposium and Workshop as the President of World Aquaculture Society.

First of all, I would like to convey my heartful congratulations on holding the Yellow Sea Large Marine Ecosystem (YSLME) Symposium and Workshop on “Sustainable Mariculture in the Yellow Sea” to prepare the Strategic Action Plan of the UNDP/GEF (United Nations Development Programme/Global Environment Facility) Yellow Sea Project. Also, I would like to express my best wishes for the success of each one of all your deliberation at the Symposium and Workshop here in Taean. This Yellow Sea Project is so important for both countries, as its mission statement indicating, to protect, conserve, and manage the Yellow Sea through sustainable use of the waters and watershed, by reducing development stress and by promoting sustainable exploitation of the resources.

For the 21st century, one of the most important challenges of Aquaculture Industry around the world would be “Environmentally Friendly Aquaculture”. World Aquaculture Society, an international society of aquaculture professionals organized for educational and scientific purposes, have committed the same challenges for a long time since it has been established to the progressive and sustainable development of global aquaculture through promotion of excellence in science, technology, education, and information exchange.

As I understand this meeting is organized and hosted by West Sea Mariculture Research Center, NFRDI, which is one of the best research and development institutes in the area of fisheries and aquaculture in Korea, and assisted and participated by Yellow Sea Fisheries Research Institute, which is also one of the best research institute in the area of mariculture in China. Today’s high level professional Symposium and Workshop will provide the proper framework to the Strategic Action Plan of the Project through the exchange of expert views and innovative ideas. I am sure that this meeting will be an important step to accomplish the goals to prepare the Strategic Action Plan of the Project. Again, on behalf of all the Korean participants, especially, members of West Sea Mariculture Research Center, NFRDI, I would like to extend my warm welcome to all Chinese participants who have traveled from the other side of Yellow Sea from here in Taean to attend this meeting. And, I thank you and congratulations again for all of your hard work behind the scenes and successful initiation and organizing of the Symposium and Workshop.

For your information, I should like to make a special announcement for the next WAS annual conference and exhibition (WA2008 Busan) in Busan, Korea from May 19-23. As the first Asian WAS President, I am looking forward to hosting WA2008 Busan, and all of you are invited and welcomed to the annual WAS conference and exhibition in Busan where is the biggest port city and one of the most beautiful cities in Korea. Asia has 90% of world aquaculture activities. Nevertheless, because of language barriers and cultural differences it is not easy to get them involved in WAS activities. Therefore, WAS needs each one of you to help to let the Asian peoples increase their representation in the WAS more in the future through your participation to the meetings.

In conclusion, Taean is a very beautiful peninsular on the west cost of Korean Peninsular, and it can provide you with lots of sea food dishes and Korean cultures. I hope that not only you can work hard for the meeting but also you can enjoy the Korean traditional and sea food dishes and cultures. So that you can take lots of fond memories with you on the way back to your home. I wish that your stay in Taean will be a rewarding and pleasant one.

Thank you very much!

축 사

세계양식학회장 배 승 철

존경하는 박덕배 국립수산과학원 원장님, Qingyin Wang 황해 수산연구소 부원장님, 심포지엄 및 워크숍 발표자 여러분, 본 심포지엄의 준비위원 여러분, 그리고 내외 귀빈 여러분! 세계양식학회 회장으로써 본 심포지엄 및 워크숍에서 축사를 하게 된 것을 무한한 영광으로 생각합니다.

우선, 저는 UNDP/GEF 황해 프로젝트의 전략적 대처방안을 준비하기 위하여 "황해에서의 지속가능한 양식"에 관한 Yellow Sea Large Marine Ecosystem (YSLME) 심포지엄과 워크숍이 열린 것에 대해 진심어린 축하를 드리고 싶습니다. 또한, 태안에서 열리는 심포지엄과 워크숍에서 여러분 한분 한분의 심도있는 협의가 성공적인 결실을 맺기를 간절히 소원합니다. 본 황해 프로젝트는 개발로 인한 스트레스를 줄이고 자원이용의 지속성을 장려하여 황해를 보호, 보전 및 관리하기 위한 프로젝트로 양국모두에게 매우 중요 하다고 생각 됩니다.

21 세기에 있어서 전세계 양식산업의 중요한 과제 중 하나는 "환경친화적인 양식"을 어떻게 이루어 나가는가 하는 것입니다. 세계양식학회는 양식업계의 전문가들로 구성된 국제적 단체로써 교육과 과학적 연구에 목적을 두고 구성되었으며, 오랜 기간 동안 전세계 양식산업이 직면하고 있는 이러한 과제를 해결 하고자 탁월한 과학, 기술, 교육 및 정보 교류를 활성화 해오고 있습니다.

오늘의 회의는 대한민국의 수산업과 양식분야에서 최고의 연구 개발 기관 중 하나인 국립수산과학원 서해 수산 연구소가 초청 및 주관을 하고 중국의 해양양식 연구분야에 최고의 권위를 자랑하는 연구기관 중 하나인 황해 수산 연구소가 지원 및 참여를 통해 이루어진 것으로 알고 있습니다. 최고의 수준을 자랑하는 오늘의 심포지엄과 워크숍은 전문가들의 견해와 혁신적인 아이디어 교류를 통하여 본 프로젝트의 전략적 대처방안 강구를 위한 기본골격을 제공하게 될 것입니다. 오늘의 회의가 목표로 하는 전략적 대처방안을 준비하는데 중요한 발걸음이 될 것이라 생각합니다. 다시 한번, 이 자리에 참석해 주신 모든 한국분 들과 특별히 국립수산과학원 서해수산연구소 관계자 분들의 뜻을 모아 황해를 건너 이 곳 태안에 오셔서 본 회의에 참석해 주신 중국 참석자 여러분들을 진심으로 환영합니다. 또한, 본 심포지엄과 워크숍을 성공적으로 뒤에서 준비해 주시고 개최해 주신 여러분들의 수고에 진심으로 감사와 축하를 드립니다.

잠시, 여러분들에게 내년 2008 년 5 월 19 일부터 23 일까지 부산에서 열리는 세계양식학회 연차총회 및 박람회에 대한 특별한 안내를 드렸으면 합니다. 아시아 최초의 세계양식학회 회장으로써 내년 한국의 가장 큰 항구도시이며, 가장 아름다운 도시 중에 한곳인 부산에서 개최되는 세계양식학회 행사에 대한 기대가 크며, 여러분 모두를 초청하고 환영 하고자 합니다. 아시아는 세계양식산업활동의 90%를 차지하고 있지만, 언어장벽과 문화적인 차이로 인하여 아시아인들의 학회참여는 쉽지 않습니다.

따라서, 세계양식학회는 아시아인들의 학회행사 참석 등을 통해서 향후에 좀더 본 학회에 많이 관여 할 수 있도록 하는데 여러분 한분 한분의 도움을 필요로 합니다.

마지막으로, 한반도 서쪽 해안에 위치한 태안은 매우 아름다운 반도로써 다양한 수산물과 한국의 문화를 제공 할 것으로 알고 있습니다. 여러분들께서 오늘의 심포지엄을 통해 심도 있는 토의 뿐만 아니라 한국의 전통적이며 좋고 신선한 수산물과 한국의 문화를 즐기시고 접하시기를 바랍니다. 더불어, 여러분들께서 돌아가실 때 다양한 좋은 기억들을 함께 같이 가져가시기를 바라며, 다시 한번, 여러분들께서 이곳 태안에 머무시는 동안 성공적이고 즐거운 회의가 되시기를 기원 합니다.

대단히 감사합니다!

BACKGROUND AND OBJECTIVES
FOR THE SYMPOSIUM AND WORKSHOP
Prepared by Yihang Jiang, Project Manager
UNDP/GEF Yellow Sea Project

Dear Colleagues and Friends,

First of all, on behalf of the UNDP/GEF Yellow Sea project, I would like to warmly welcome all of participants attending this important workshop to discuss a critical issue: sustainable mariculture. I wish to express our sincere thanks to the National Fishery Research and Development Institute (NFRDI) for organising this workshop in Taean, Korea, in particular I would like to thank Dr. In Kwon Jang for his delicate work in organising the workshop.

Ladies and gentlemen, as all of you well know, over the period 1995 to 2004, Yellow Sea mariculture production increased rapidly from 400 thousand tonnes/year to over 6 million tonnes/per year. What does this increase mean? The total mariculture productions of China and Korea increased from 41% of global total production to about 70%.

How was this rapid increase generated? Does this increased production need increased marine area devoted to mariculture, and have how farming densities changed?

Over the period 1995 to 2004, the area devoted to mariculture on the west coast of Korea has increased from 32,000 ha to 56,000 ha while mariculture production has remained essentially unchanged at 200,000 tonnes.

The area devoted to mariculture in China has increased from 400,000 ha to 1,000,000 ha over the same period. The total mariculture production from the Yellow Sea in China has increased by a factor of 2.25.

With all these important factors, one can ask a series questions, but the most important question that should be asked first is - Are these developments sustainable? As you all know, to answer this question is not easy. We need to check our knowledge on mariculture in various respects: cultured species, density, disease prevention, impacts on marine and coastal environment, and market price, etc. As the experts in this field, most of you have tried very hard to find a solution for many years.

What the UNDP/GEF Yellow Sea project can help?

The project brings experts from both countries together to identify what are the problems in mariculture; what are the priorities of these problems; what are the causes; what are the possible management actions we need to take to achieve what regional targets. It is the intention of the project that some demonstration activities to identify usefulness and effectiveness of the management actions.

The project also tries to establish a regional network with all possible stakeholders to solve those transboundary problems with co-operation of all. This network is necessary to share necessary information, such as carrying capacity of mariculture areas, to come up with a strategic action programme for sustainable mariculture, and to set up an early warning system for potential mariculture diseases.

The project is aiming at to upgrade the national capacities on the sustainable mariculture to maximise benefits of mariculture, and to minimise the environmental impacts from mariculture activities.

This workshop is one of the series of activities planned under the framework of the project. We also plan to have other activities this year, for instance, the carrying capacity workshop, and disease prevention workshop. We hope through these series of activities, and preparation of the regional Strategic Action Programme, we will end closer to our target of sustainable mariculture.

Ladies and gentlemen, there is a lot of argument over the fact that mariculture causes negative impacts to the marine and coastal environment. But the in the meantime, we also need to fully understand that mariculture provides a lot of protein to the people in the coastal countries of the Yellow Sea. Will it be possible to have sustainable mariculture to minimise the environmental impacts, and meet the requirements of people? The answer has to be yes, if we are to ensure food security and the long term future of the industry. We need to find ways together.

I wish you all a successful workshop, and I hope you have a nice stay in Korea.

PART II

AQUACULTURE TECHNOLOGIES FOR REDUCING ENVIRONMENTAL STRESS

Pond polyculture in the West Sea of South Korea

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Polyculture in south Korea has been performed with combination of sea squirt + sea mustard + sea tangle in south part of the East Sea, abalone + sea tangle + seaweed fusiforme in middle part of the West Sea, manila clam + surf clam + laver in south part of the West Sea and oyster + sea squirt + blue mussel in the South Sea(1994). Pond culture has been performed mainly with shrimp, but it goes through many difficult viral disease occasionally from the middle of 1990's. Pond polyculture developing in south Korea could decrease the disease of shrimp and could increased the production according to complementary biology action between the cultured creatures. Because there was an effect to decrease viral disease of shrimp by the river puffer in a pond polyculture in taean Chungnam, rearing experiment was performed to compare polyculture with single culture for shrimp(pacific white shrimp, fleshy shrimp) and river puffer production in four culture farm from June to September 2005. For water quality environment(water temperature, salinity, DO, pH, alkalinity, turbidity) and/or concentration of inorganic nutrient(NH_4-N, NO_2-N, NO_3-N, PO_4-P) is maintained a propriety range in growth of shrimp and river puffer, but the concentration of inorganic nutrients in pond polyculture shows 2~5 times higher than single culture. It is important that control a quality of rearing water in pond polyculture. Due to white spot viral disease, the whole of fleshy shrimp in single culture were died at 52 days after rearing start, polyculture with fleshy shrimp and river puffer occurred mass mortality at 58 days after rearing start showed that mortality of fleshy shrimp was decreased by restrain of viral disease and showed that final survival of fleshy shrimp was 4%. Final survival of pacific white shrimp in polyculture with river puffer and single culture without river puffer was investigated 32.4% and 18.2%, respectively, and production per area of shrimp in the polyculture and in the single culture were investigated 0.22 ㎏/㎡ and 0.13 ㎏/㎡ respectively so that survival and/or production of shrimp in polyculture shows each 14.2%, 69.2% higher than that in single culture. Land pilot experiment was performed to examine whether productivity difference between polyculture and single culture was affected the predation of infected shrimp by river puffer. The results showed that the survival of river puffer was 100% and the survival of shrimp was 76.4% in single culture, and the survival of healthy shrimp and the survival of infected shrimp in single culture was 92.8% and 88.0%, respectively. In polyculture with river puffer and healthy shrimp, the survival of healthy shrimp was 76.4%. In polyculture with river puffer, healthy shrimp and infected shrimp, the survivals of healthy shrimp and infected shrimp were 89.1% and 46.0%, respectively. For the future developmental polyculture in the West Sea, appropriate polyculture species(puffers, shellfishes) based salinity concentrations in pond polyculture farm and appropriate size of rearing start must be find out, pond polyculture in the West Sea of South Korea will be expected great commercialize income as culture form harmony with natural ecology.

한국 서해안의 축제식 복합양식

강 희 웅

국립수산과학원 서해수산연구소

한국 연안에서 이루어진 기존의 복합양식은 동해남부지역의 우렁쉥이 + 미역 + 다시마, 서해중부지역의 전복 + 다시마 + 톳, 서해남부지역의 바지락 + 동죽 + 김, 남해지역의 굴 +우렁쉥이 + 진주담치의 형태였다(1994). 서해안 축제식양식은 새우가 주종을 이루었으나 '90 년대 중반 이후부터 바이러스 질병이 지속적으로 증가하여 많은 어려움을 겪고 있다. 축제식 복합양식은 새우의 질병을 감소시키고, 양식생물간의 상호보완적 생태활동으로 생산량을 증대시키는데 목적이 있으며, 한국의 축제식 복합양식은 아직 기술개발단계에 있다.

충남 태안소재 축제식 양식장에서 황복에 의한 새우 바이러스질병 억제 효과를 조사하고자 2005 년 6~9 월에 걸쳐 4 개의 시험양식장을 이용하여 새우(흰다리새우, 대하)와 황복의 복합양식 및 단독양식을 비교하는 사육시험을 실시하였다. 전반적인 일반 수질환경(수온, 염분, DO, pH, 알칼리도, 투명도) 및 영양염(NH_4-N, NO_2-N, NO_3-N, PO_4-P) 농도는 새우와 황복의 성장에 적합한 범위를 유지하였으나, 복합양식장은 단독양식장에 비해 영양염 농도가 2~5 배 높게 나타나 복합양식시 사육수 수질관리에 주의가 요구되었다.

대하 단독양식장은 흰반점바이러스 발병으로 인하여 52 일째 전량 폐사하였으며, 대하-황복 복합양식장은 58 일째 대량폐사가 발생하여 조기수확한 결과, 생존율은 4%로 조사되어 대하는 황복과 복합양식할 경우 바이러스발병이 약간 지연 혹은 억제되는 것으로 나타났다. 흰다리새우-황복 복합양식장과 흰다리새우 단독양식장은 최종 생존율이 각각 32.4%, 18.2%였으며, 단위생산량은 0.22 ㎏/㎡, 0.13 ㎏/㎡로 흰다리새우는 황복과 복합양식할 경우, 단독양식에 비해 생존율은 14.2%, 생산량은 69.2% 높은 것으로 나타났다.

새우(흰다리새우) 단독양식과 복합양식의 생산성 차이가 황복에 의한 감염새우의 포식에 의한 효과인지를 조사하기 위한 육상 pilot 실험을 실시하였다. 황복의 생존율은 100%였으며, 건강새우는 단독사육시 생존율이 93.3%였다. 건강새우와 감염새우만을 사육시 생존율은 각각 92.8%, 88.5%로 감염새우가 4.3%로 낮게 나타났다. 황복과 건강새우 복합사육시 새우의 생존율은 76.4%였다. 또한 황복과 건강새우, 감염새우 복합사육시 건강새우와 감염새우 생존율은 각각 89.1%, 46.0%로서 감염새우가 43.1% 낮게 나타났다. 따라서 황복은 정상새우보다 감염새우가 함께 사육될 경우, 건강새우보다는 거의 감염새우만을 포식하는 것으로 조사되었다.

향후 서해안 복합양식의 산업화를 위해서는 축제식 사육지의 염분농도에 따른 적정 복합양식 품종(복어류, 패류)과 적정 입식크기가 규명되어야 하며, 서해안 축제식 복합양식은 생태조화형 양식형태로 큰 경제적 이익의 창출이 기대된다.

Polyculture in embayments and ponds

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Polyculture in pond has been well developed in China since late 1980's. In the polyculture system in northern China, especially in the pond along the coastal line of Yellow Sea, the dominant species of polyculture is shrimps, while clam, fishes, sea cucumber co-cultured with shrimp are usually regarded as the environment-improvers and the by-product of pond culture In china, there are two kind of polyculture in inshore and offshore areas. One is somewhat similar to the sea ranching, ant the other is well practised for suspending aquaculture. Sea ranching is often prompted in the areas where the water depth is relative deep and that the polyculture of suspending aquaculture is located in the relative shallow waters. The general situation of polyculture is described by the following two cases.

1. Sea ranching in zhangzidao island, liaoning province

Zhangzidao Island is located in the northern Yellow Sea and is comprised of nine islets. The land is about 40 miles away from main land of Liaoning Province, with the total area 14 km2, but the islets are surrounded by 60,000 ha of inshore coastal seas. In this area, the sea ranching area is ranged from 10 to 40m in depth. The max current speed is almost 100 cm/sec.

The Zhangzidao Fishery Group Co., Ltd, was authorized to farm this area with the total sea area of nearly 40,000 ha. Currently, 26,500 ha are used for stock enhancement of scallop *Patinopecten yessoensis*, 660 ha for sea cucumber Apostichopus japonicus, 100 ha for abalone *Haliotis discus hannai*, and 10,000 ha for arkshell *Scapharca broughtonii* enhancement. In the culture areas of sea cucumber, abalone, sea urchin, the polyculture or polyculture has practiced with Japanese scallop for more than ten years. Total harvest reached 28,000 tons, with a value of more than $60 million ($US), and profit of $18 million ($US). Now the company has become the one of the most famous enterprise in China mainly benefit from polyculture in off shore.

2. Polyculture in off shore in suspending way in Sungo Bay

Sungo Bay, located in the most east end of Shandong Peninsula (37°01-37°09', 122°24'-122°35'), is one of the most important mariculture regions for scallop *Chlamys farreri* and kelp *Laminaria japonica* in northern China. Polyculture has been implemented in the bay since early 1980's. The mainly species for polyculture is shellfish (scallop, oyster, mussel, abalone) and seaweeds (*Laminaria, Undaria, Gracilaria*, *Gracilaria).*

Nowadays, the longline culture is expanded to the areas where the water depth is 20-30m outside of Sungo bay and about 8km away from coastal line. The polyculture species has been changed from scallop+kelp to Abalone+kelp in the bay. During the culture period of *Laminaria*, abalone is polyculture with kelp shared with same area. In this way, abalone can use alive *Laminaria* as its food at least for half year. When *laminaria* is harvested, the workers will feed the abalone with dried *laminaria.* The economic benefit of such polyculture is about three times higher than other kind of polyculture of shellfish and seaweed.

Culture of the Olive Flounder, *Paralichthys olivaceus* in a Marine Recirculating Aquaculture System

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Total waste products of nitrogen and phosphorus coming from finfish culture facilities for 100,000 ton amount to the waste production generated from human activities of 3 millions (Maruyama. 1999). These waste products originated from fish feces and uneaten pellets are can be a key sources for marine pollution, and therefore waste treatments are required. At the same time, finfish cultures are hindered by occurrence of unfavorable culture waters due to terrestrial influence, frequent outbreak of red tides, or influence of cold water mass.
Intensified researches have been practiced for the development of marine recirculation culture system. For instance, Central Research Institute of Electric Power Industry and Miyazaki university in Japan have studied the system for olive flounder and puffer fish, some contraries like United States, France, and Norway have focused on the development of the system for summer flounder, turbot, sea bass(Timmons et al. 2002, Yada, 2004). Domestically, basic researches for the system development have been studied (Son et al. 2000, 2005). For the olive flounder culture, IBK (Intensive Bioproduction Korean) recirculation culture system has been studied, so far (Bang et al., 2005).

The present study focuses on the system development for the effective removal of nitrogenous products, using fiber filter and fluidized bed filter. This study also studied growth related filtering rate to give information for the development of the recirculation culture system, specifically for the olive flounder that occupied about 50% of marine finfish production. The recirculation culture system used in this study is of 4 culture tanks (Φ 3 m, 3.5 ton) equipped with physical filter system used fiber filter and settling chamber, and biological filtering system used fluidized bed filter and micro bead filter.
The velocity analysis using three dimension electron flowmeter(KENEK, VMT3-200-13P) and computational fluid dynamics analysis showed a water velocity of 0.4 m/s on average with location-different velocities showed 0.5 m/s near wall of culture tank (0~0.3m), 0.3 m/s for the water of 0.5~1.0 m apart the wall, and 0.5 m/s near draining spot. And computational fluid dynamics analysis revealed that some eddy occurred near 0.3 m~0.8 m from the wall of culture tank. Although the eddy did not block a removal of solid matter during the experiment period which might be originated from the olive flounder swimming in bottom of fish tank and this behavior pattern help to removal of fish feces and uneaten feed. But it might be problematic in case that the culture species are different.

Ammonia removal by fluidized bed filter was conducted for the sponge-typed media which occupying 30% of total water volume after 7~8 minutes of Hydraulic Retention Time at 12~15℃. Forty five analyses showed 38% of NH_4-N removal efficiency (from 0.70±0.18 mg/L to 0.43±0.14 mg/L). The time to the stabilization of activity in the fluidized bed filter was about 40 days for *Nitrosomonas*, and 50 days for *Nitrobactor*. The olive flounder used in this study was 17.1±1.5 cm in total length and weighed 86.1±14.5 g. The fish were contained in the culture tank (initial density, 6.1 kg/㎡) and fed with commercial pellet. Net water exchange was 3~4 m^3/hr/tank by adding new water (0.05~0.07 m^3/hr/tank). The fish growth was compared with the fish grown in the flow-through system.

The water temperature in the recirculation culture system was influenced by the air temperature rather than coastal water temperature. Water temperature of the recirculation culture system was 0.1~2.2℃ higher than that of flow-through system for initial 180 days. Thereafter, water temperature of the two systems became equalized. DO remained over 4 mg/L, the level agreeable for normal feeding activities for the fish (Yada, 2004). Salinity remained 32.2~34.1 psu. The nitrogenous products in the recirculation culture system were 0.40±0.12 mg/L for NH_4-N, 0.092±0.075 mg/L for NO_2-N, 1.13±0.57 mg/L for NO_3-N. The figures were slightly higher than those found in the flow-through, but still remain agreeable for olive flounder culture (Suzuki et al., 2000).

The final growths were 31.0±2.2 cm and 539.4±108.5 g for recirculation culture system and 27.5±2.4 cm and 395.9±106.6 for flow-through system. The weight gains were 453.3 g for recirculation culture system and 309.8 g for flow-through system. Survival rates were 96.7% for recirculation culture system and 94.4% for flow-through system. Food efficiencies were 1.06 for recirculation culture system, 1.22 for flow-through system. The final culture densities were 36.9 kg/m^2 for recirculation culture system and 26.7 kg/m^2 for flow-through system. The final density of recirculation culture system was 1.4 folds higher than that of flow-through system. This figure in the recirculation culture system was higher to the figure (31 kg/m^2) which was gained after 259 days after recirculation culture system in Japan Central Research Institute of Electric Power Industry (Kikuchi et al., 2002).

Phathological survey which was done by every 30 days showed no bacterial infection observed at the recirculation culture system, but showed an occurrence of parasitic *Trichordina* sp. in day 210. The occurrence of phatogenic agents in the flow-through system was much more significant: 3 times occurrence of *Trichordina* sp., 2 times *Gyrodactylus* sp., 2 times bacterium (*Vibrio* sp.) during the experiment.

From these results recirculation aquaculture system confirmed have a merit in stable water quality, production based on low water exchange water, increased production, reduced mortality and bio-security compared the flow-through system. In the future realizing for sustainable mariculture more research will proceed in recirculation aquaculture system specially reducing the cost of equipment.

해수 순환여과시스템에서 넙치, *Paralichthys olivaceus* 사육 시험

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어류 10 만톤 생산시 배출되는 질소 및 인 량은 약 300 만명의 인구에서 생성되는 량과 상당하다는 보고(丸山. 1999)가 있으며, 양식 결과 생성되는 어류의 배설물이나 미섭취 사료 등은 고농도의 영양분을 함유하고 있어 그에 따른 처리방안이 요구된다. 또한 최근 육지로부터 오폐수 유입, 잦은 적조 및 냉수대 발생 등으로 인해 사육에 필요한 양질의 해수를 확보하는 데에 어려움이 있다. 현재 세계 각국에서는 환경 친화적인 순환여과방식 개발에 심혈을 기우린 결과 일본에서는 전력중앙연구소, 미야자끼대학 등에서 넙치, 복어 등을 대상으로 실용화 시험을 실시하고 있으며, 미국, 프랑스, 노르웨이 등은 Summer flounder, 터봇, 농어류를 대상으로 실용규모의 생산이 검토되고 있고(Timmons et al 2002, 失田 2004), 국내에서도 시스템 개발을 위한 기초 기술 개발 연구(손 등 2000, 2005)와 IBK(Intensive Bioproduction Korean) 순환여과시스템에서 넙치 사육시험(방 등, 2005) 등이 보고되어 있다.

본 연구는 질산성 영양염을 효율적으로 제거하여 환경오염을 절감하는 육상 양식 시스템을 개발할 목적으로 섬유사여과기와 삼상유동상여과기를 주 여과기로 이용한 순환여과시스템에 국내 해산 어류 양식 생산량의 약 50%를 차지하는 넙치를 대상으로 사육특성 및 여과특성 등을 조사하여 순환여과시스템 개발 자료로 활용하고자 하였다.

시험에 사용한 순환여과시스템은 Φ 3 m 사육조(사육수량 3.5 ton) 4 조에 물리적 여과시스템으로 섬유사여과기 및 침전조를, 생물학적여과시스템으로 삼상유동상여과기 및 미세비드형 여과기를 여과시스템으로 한 시스템을 제작하여 이용하였다. 3 차원 전자유속계(KENEK, VMT3-200-13P) 및 전산유체역학적 유동해석 결과 사육조내 평균 유속은 0.4 m/s 로 나타났으며, 사육조 벽면 주변(0~0.3 m)에서 평균 유속은 0.5 m/s, 벽면에서 0.5~1.0 m 부근에서의 평균유속은 0.3 m/s, 배수구 주변에서의 평균 유속은 0.5 m/s 로 나타났다. 또한 전산유체역학적 수치해석 결과 유속이 떨어지는 벽면에서 0.3m~0.8m 구간에서 난류와가 발생하는 것으로 확인되었으나, 사육시험시 배설물 등의 찌꺼기 배출은 원활하였으며, 이는 주로 저서에서 유영행동을 하는 넙치가 움직일 때의 유동이 찌꺼기 배출을 도운 것으로 사료되며, 타 어종을 수용 할 경우 주수구 및 배수구의 개선이 필요한 것으로 나타났다.

삼상유동상여과기의 암모니아성 질소 제거율 조사는 수온 12~15℃, Hydraulic Retention Time 7~8 분에서 여과조 체적 30%의 스폰지 Type 여과메디아가 충진된 상태에서 실시하였으며, 총 45 회 분석 결과 여과조 유입 전 암모니아 평균농도 0.70±0.18 mg/L 에서 유입 후에는 암모니아성질소 평균 농도가 0.43±0.14 mg/L 로 감소하여 38% 암모니아성 질소 제거효율을 보였다. 또한 본 삼상유동상 여과기에서 암모니아에서 아질산으로 분해하는 세균(아질산생성세균)이 숙성하는데 40 일 정도 소요되는 것으로 나타났으며, 아질산에서 질산으로 분해하는 세균(질산생성세균)이 숙성하는 데는

아질산생성세균 보다 10 일정도 지난 50 일 정도 소요되는 것으로 나타났다. 사육시험은 평균 체장 17.1±1.5 cm, 평균체중 86.1±14.5 g 넙치를 6.1 kg/㎡ 밀도로 수용하여 210 일간 수행하였으며, 먹이는 시판 넙치용 배합사료를 공급하였다. 순환수량은 3~4 m^3/hr/tank, 순환여과시스템의 보충수량은 0.05~0.07 m^3/hr/tank 이었으며 순환여과시스템과 동일한 조건의 유수식과 성장특성을 비교하였다.

동해안에서 빈번하게 발생하는 냉수대의 영향을 받지 않으며 실내 기온의 영향을 받는 본 순환여과시스템은 180 일까지는 평균 수온이 유수식보다 0.1~2.2℃ 높게 나타났으며, 이후는 기온의 하강으로 유수식과 동일하였다. 용존산소는 순환여과시스템 및 유수식 모두 넙치가 양호하게 섭취 행동을 하는 4 mg/L(矢田, 2004) 이상이 유지되었으며, 염분은 32.2~34.1 psu 이었다. 순환여과시스템에서 암모니아성 질소 평균농도는 0.40±0.12 mg/L, 아질산성 질소 평균 농도는 0.092±0.075 mg/L, 질산성 질소 평균농도는 1.13±0.57 mg/L 로 나타나 유수식보다는 다소 높은 범위에 있었으나 순환여과시스템에서 양호한 넙치의 성장을 보인 질산성 질소농도 범위(Suzuki et al., 2000)를 초과하지 않았다.

시험 종료 시 넙치의 평균체중은 순환여과시스템이 평균 체장 31.0±2.2 cm, 평균체중 539.4±108.5 g, 유수식이 평균 체장 27.5±2.4 cm, 평균체중 395.9±106.6 g 으로 나타나 210 일간 증중량은 순환여과시스템이 453.3 g, 유수식이 309.8 g 으로 순환여과시스템이 1.5 배 빠른 것으로 나타났다. 최종 생존율은 순환여과시스템 96.7%, 유수식 94.4%로 나타나 순환여과시스템이 유수식보다 2.3% 높게 나타났으며, 사료계수는 순환여과시스템 1.06, 유수식 1.22 로 순환여과시스템이 사료효율이 좋은 것으로 나타났다. 이는 순환여과시스템의 경우 냉수대와 같은 급격한 환경변화에 의한 스트레스가 적은 것과 관련이 있는 것으로 생각되어진다.

시험 종료시 사육밀도는 순환여과시스템이 36.9 kg/m^2, 유수식이 26.7 kg/m^2 로 나타나 순환여과시스템이 유수식보다 1.4 배 높은 사육밀도를 보였으며, 이는 일본 전력 중앙연구소에서 수용적 10 m^3 의 순환여과시스템에서 259 일간 사육실험 결과의 최종사육밀도 31 kg/m^2 보다 높은 밀도이었다(Kikuchi et al., 2002). 30 일 간격으로 총 7 회에 걸친 질병조사 결과 순환여과시스템의 세균성질병은 전 사육기간중 검출되지 않았으며, 기생성질병은 사육종료 시점인 210 일째 트리코디나가 1 회 검출되었다. 유수식의 기생성질병은 트리코디나가 3 회, 아가미흡충이 2 회, 세균성 질병은 비브리오가 2 회 검출되어 적은 량의 자연해수를 소독하여 사용하는 순환여과시스템이 질병 발생이 적다는 사실이 시사되었다.

이상의 결과로부터 순환여과시스템은 유수식에 비해 안정된 수질의 유지, 용수 절감, 생산량 증가, 폐사율 감소, 생물 안전성 확보라는 장점이 확인되었으며, 향후 지속가능한 수산양식이 이루어지기 위하여서는 순환여과시스템의 시설비 절감 등에 대한 연구가 계속하여 이루어져야 할 것으로 생각된다.

The facilities of seawater treatment and the design of technological process in recirculating mariculture system

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1 Design of technological process

The system technological process was as follow: fishpond - automatic micro-screen drum filters - fast filter - biological purification pond - water temperature regulating reservoir - ultraviolet ray disinfection pond - highly effective oxygen dissolved tank - water quality monitor - fishpond (Figure 1).

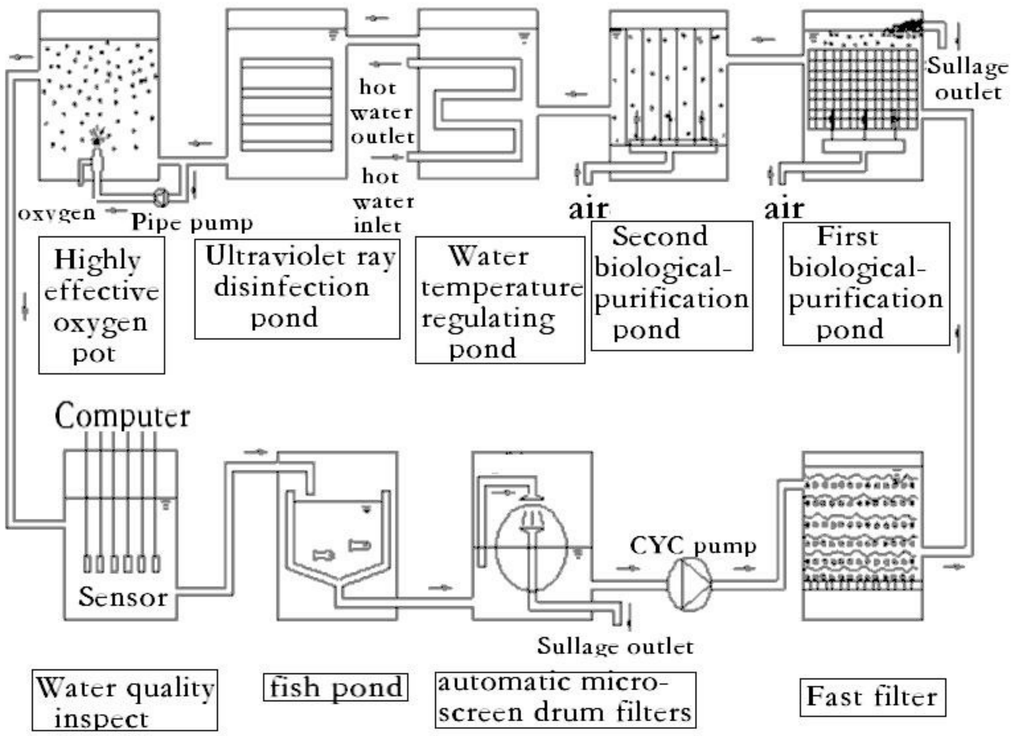

Fig.1 The system technological process

2 The engineering design of water treatment system

2.1 The height design
2.2 The plane design
2.3 The design of water flow condition in circulating system
2.4 Details of the supporting facilities for industrial aquaculture

Tab. 1 Details the supporting facilities

facilities	Type	performance	amount
micro-screen drum filter	ZLW14-A	400 m^3/hr	1
foam separator	HY863-50	50 m^3/hr	1
fast filter	KSG-1800	200 m^3/hr	3
oxygen dissolved tank	GXR-1800	400 m^3/hr	1
oxygen generator	KDFO-6、ZY-6	6 m^3/hr	2
Medium frequency ozone generator	KV-C	2 g/hr	1
Ultraviolet ray disinfector	ZHC30-15	400 m^3/hr	1
Vertical centrifugal pump	ISG100-125	100 m^3/hr	5
Vertical centrifugal pump	ISG65-160	50 m^3/hr	1
Vertical pipcline pump	SG25-4-20	20 m^3/hr	1
Unoiled lubrication air compressors	WW-1.8/7	1.8 m^3/min	2
Compressed air refrigeration drier	TCLF-2.0/10	2.0 m^3/min	2
Roots blower	L32LD	6.81m^3/min	2

3 The manufacture of facilities

3.1 The automatic micro-screen drum filter
3.2 The oxygen dissolved tank
3.3 The oxygen generator
3.4 The new fast filter
3.5 The disinfection technologies
3.5.1 Medium frequency ozone generator
3.5.2 Ultraviolet ray disinfector
3.6 The foam separator
3.7 The biological purification pond

4 The results of turbot culture in the recirculating system

THE NEW CHALLENGE OF OFFSHORE AQUACULTURE IN KOREA

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Marine finfish aquaculture industry in Korea has traditionally performed in inshore where net-cages might be protected by storms, and expanded remarkably in recent years beyond environmental capacity causing environmental impacts at the culture grounds. To confront the difficulties by developing bio-security and environment friendly aquaculture, offshore aquaculture cages (Ocean Spars) were installed off southern Jeju Island in year 2005 and 2006. The culture site was surveyed and chosen on the bases of oceanographic and environmental characters, such as water temperature, currents, depth and substrate composition, etc. Its bottom was consisted mainly of coarse sand and dotted with rocks, and water depth ranged from 45 to 50 m.

Two age groups of parrot fish, *Oplegnatus fasciatus*, produced artificially in 2004 and 2005 year (average body weight of 123 g and 5 to 10 g, respectively) were stocked in three cages on early July in 2005 and started cultivation. They were fed on formulated pellet once or twice per day except stormy days. They grew up 180 g, 210 g, and 380 g in three cages on May 20 in 2006, showing different growth rates accordingly stocking fish sizes and densities. Survival rates were shown relatively high except accidental mortality during stocking procedures into net cages.

Table. Survival and growth of parrot fish stocked at three offshore net-cages in year 2005

Cage 1)	July 7, 2005		Sep. 13, 2005		Feb. 20, 2006		May 20, 2006	
	No. fish (10^3)	B.W. (g)	No. fish (10^3)	B.W. (g)	No. fish (10^3)	B.W. (g)	No. fish (10^3)	B.W. (g)
1	550	5	500 2)	41	460	131	450	180
2	75	10	50 2)	60	50	190	48	210
3	80	123	65 3)	237	64	357	20 4)	380

1) Fish in cage 1 and 2 was produced in 2004, and that in cage 3 was in 2005.
2) About 25 thousand fish was escaped through opening connecting harvest cone with net.
3) About 15 thousand fish was dead of suffocation during socking to cages by siphoning method.
4) Ten tons of fish were harvested.

We have monitored periodically the environmental impacts around culture sites. The current velocity of major factors affecting net security has fluctuated by tidal movement and seasons as 32 to 121 cm per second, east to west wayward. So far no serious damages were found unless the elongation of anchor lines roughly 20% by strong currents.

외해수중가두리를 이용한 양식기술 개발

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국립수산과학원 양식개발팀

세계양식 흐름을 한번 마디로 표현한다면 production-oriented aquaculture (생산지향적 양식)에서 environment-oriented aquaculture (환경지향적 양식)로 바뀌었다고 할 수 있다. 다시 세분하여 말하면, 세계양식 트랜드는 sustainable (지속적), responsible (책임 있는), environment-friendly (환경친화적), ecosystem-based (생태계 기반을 둔), food-safety (식품안전) 양식에 근간을 두고 있다. 이제 양식은 이러한 기반을 두지 않고는 존립자체가 어려운 시점에 이르렀다고 생각된다. 이러한 흐름을 따라가기 위해서는 어류양식처럼 오염유발 가능성이 있는 양식방법은 외해로 나가야 할 수 밖에 없다.

그러나, 우리나라에서 어류양식은 시설물 유지가 용이한 남해안의 내만에서 전통적 방법으로 집중적으로 이루어지면서 태풍 등 피해가 매년 반복되고 있는 실정이지만, 근년에 연안을 이용한 해양레저 및 체험관광 개발 요구 등으로 주민과의 반발이 한층 고조될 것으로 우려된다. 양식으로 인한 연안 환경오염 증가로 적조 및 질병에 의한 피해가 날로 증대되고 있지만, 국민에게 값 싸고 질이 좋으면서 식품안전성이 확보되어 있는 수산물을 공급하는 방안을 제시하는 것이 우리의 책무이다. 대내외적 환경을 살펴보면, 한미 FTA 체결과 함께 향후 중국과 인접한 수산 강국과의 자유무역협정을 추진하고 있는 시점에서 한국 양식업을 현 체제로 유지할 경우는 또 다른 위기에 봉착할 수밖에 없어 시급한 대안이 필요하다.

이렇게 문제점을 안고 있는 한국양식 산업의 돌파구는 기존 양식시스템을 개선하고 발전시키는 방법과 새로운 개념의 양식을 개발하는 것이라 할 수 있다. 본 시험연구팀에서는 기존 양식시스템을 개선하는 방안보다는 한국 양식산업 패러다임을 전환시킬 수 있는 방안으로 접근하였다. 즉, 기존의 연안 양식장은 생태계 기반을 둔 환경친화적인 해조류나 패류양식을 추진하고, 환경부담이 크면서 고부가가치 있는 양식인 어류양식은 외해로 나가는 것이다. 본 연구사업은 한국외해양식 가능성을 타진하고 새로운 대안을 제시하고자 외해가두리를 이용한 양식연구를 추진하게 되었으며 여기서 간략히 소개하고자 한다.

본 연구는 국립수산과학원의 MCP 과제인 양식, 해양, 공학 등 연구 분야가 통합된 연구과제로서 2005 년부터 2007 년까지 3 년간에 걸쳐 추진되고 있다. 또한 산업화를 최대한 조기에 달성하기 위해서 참여기업(노아외해양식영어법인)도 본 연구사업에 동참하였다. 외해가두리 시설은 미국 해양대기청(NOAA)에서 개발한 2 종의 OceanSpar 6 기를 도입하여 제주도 남제주군 남원읍 표선면 표선리 외해에 시설하였다(그림). 사업수행 전에 적지조사와 함께 주민설명회를 거쳐 해양수산부에 시험어업 승인을 받은 후 현재 진행 중에 있다. 시험어는 돌돔을 위주로 총 150 만여

마리를 수용하였고, 사료 설계 및 제조는 국립수산과학원 사료연구센터와 수협사료에서 이루어졌다.

현재까지의 연구결과를 요약하면 본 과제에서 가장 중요한 항목인 시설물 안전성을 점검하기 위해 매주 정기적으로 스쿠버 다이버를 투입하여 시설물을 점검한 결과, 안전하다고 평가되었다. 특히, 2005 년과 2006 년의 2 회에 걸친 태풍(파고 6m 이상, 1 주일간 지속)에도 시설물이나 그물 등에 대한 손상이 없어서 안전성 검증되었다. 그러나 2 노트 내외의 강한 조류에는 앵커라인이 늘어나 2 중 앵커라인 시설 완료하였다. 사육생물은 질병이 전혀 관찰되지 않아 생존율이 90% 이상 유지되었고, 성장도 기존 양식방법에 비해서 20%이상 우수한 것으로 평가되었다. 또한 매월 정기적인 물리, 화학, 생물학적 요인 등의 환경조사를 실시하였으나, 환경에 대한 영향력이 거의 없는 것으로 분석되었다. 생산된 돌돔에 대해서 70 여명의 감정위원을 대상으로 자연산 돌돔을 비교 평가한 결과, 품질에서 차이가 없는 것으로 평가되었다. 경제성 분석(AQUASIM 프로그램 이용)에서도 내부 순익율이 12-28%로 매우 높게 나타나 경제성이 클 것으로 예상되었다. 따라서 이러한 외해양식은 생태기반과 식품안전성이 확보된 양식 체계 조정으로 WTO 와 FTA 등에 대비한 국제 경쟁력 확보 및 해외시장 진출 기반을 마련할 수 있을 것으로 평가되지만, 현재까지 얻어진 결과보다도 더 많은 난제가 우리 앞에 놓여 있다고 볼 수 있다.

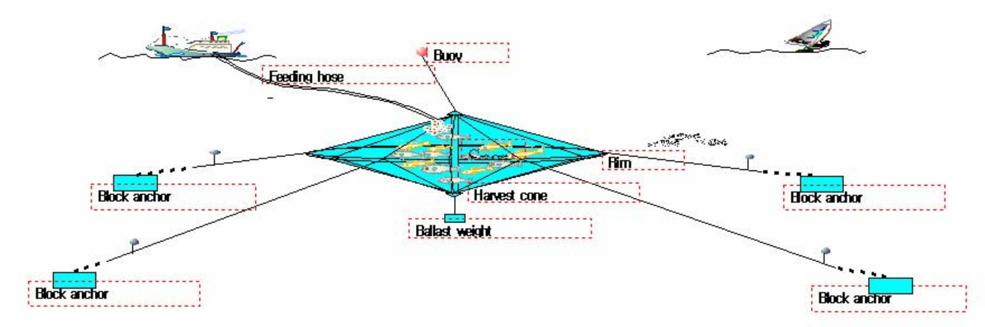

그림. 외해가두리 시설(Sea Station) 1 조 전개도(직경: 25m, 높이 15m, 용량: 3000 ㎥)

Open sea aquaculture technology and practices

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Open sea aquaculture industry in China and around world have developed very quickly over the past ten years. There are two major reasons promoting the development of this industry. One is serious environmental impact come from inshore locations and another reason is that there are many advantages in open sea aquaculture industry, because the improved water exchange in the open sea will support better fish or shellfish health and reduces environmental impact.

Biology, engineering, environment and economics are the key focuses to be investigated. In the present, firstly, the progress status on the open sea aquaculture industry in the world will be summarized generally; secondly, the open sea aquaculture technique and practice in china, especially in the area of Yellow Sea will be introduced; and finally, we will simply make suggestion on what we will do for improving the aquaculture industry.

PART III

BEST MANAGEMENT PRACTICES FOR AQUACULTURE

Intensive shrimp culture in indoor tanks using heterotrophic methods

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Shrimp farming in Korea was developed in 1980s. Farmed shrimp production has been rapidly increased since the 1990s and reached 3,256 mt from about 2,600 ha of 437 farms in 2001. However, due to more frequently occurring outbreaks of shrimp diseases, the farmed shrimp production decreased to 2,332 mt in 2004. The unit production of farmed shrimp was 1.25 mt/ha in 2001, but it was 1.11, 1.07 and 1.02 mt/ha in 2002, 2003 and 2004, respectively.

Two indigenous species, *Fenneropenaeus chinensis* (fleshy shrimp) and *Marsupenaeus japonicus* (Kuruma shrimp) were cultured before the mid-1990s in Korea, but *M. japonicus* has not been cultured since the first outbreak of WSSV (white spot syndrome virus) which occurred in 1993. However farmers culturing *F. chinensis* had also been suffered from viral diseases thereafter and the white shrimp was introduced as an alternative of *F. chinensis*. In 2003, SPF (specific pathogen free) broodstocks of Pacific white shrimp, *Litopenaeus vannamei* were introduced from Hawaii to the Crustacean Research Center (= the West Sea Mariculture Research Center), NFRDI for the first time.

Culture of the white shrimp has been increased during last three years and the farmed production occupied about 28% of total farmed shrimp production in Korea in 2006. About 10,000 SPF broodstocks of the white shrimp were imported to commercial hatcheries for larval production in 2007 and culture of this species is expected to occupy more than 70% of total shrimp farming in this year. Although the white shrimp is known to have higher resistance to diseases than the fleshy shrimp, the presumptive HHS (high health shrimp) postlarvae produced from SPF broodstock might be easily exposed to various pathogens including viruses when it is stocked to outdoor ponds and many farmers can experience heavy crop-losses due to viral outbreaks. Thus there is a need for the development of new production practices that are environmentally sustainable and biosecure.

Super-intensive indoor shrimp culture may be an alternative technology which can keep high biosecurity and minimize the risk of viral infection from environment. There are three kinds of indoor culture methods for shrimp production. The first method is shrimp production using a RAS (recirculating aquaculture system) which consists of grow-out tanks for shrimp and separate biofiltering facilities, like as traditional finfish RAS culture. The second is the flow through tank culture system which is applied to shrimp production in commercial scale in China. The third method is shrimp production practice using limited water exchange and heterotrophic technology. This system consists of grow-out tanks or raceways equipped with air blower and solid removal facilities such as foam fractionator. In this system, entire nitrogen cycle (removal of toxic nitrogen compounds) takes place in grow-out tanks where bacterial flocs are intensively developed. Current technology advancement suggests that yields higher than 8 kg/m^3 are feasible in commercial scale production systems using this method. The presentation will provide a description and production figures from different super-intensive grow-out systems used in research and commercial facilities and compare it with other methods.

타가영양방식을 이용한 실내고밀도 새우양식기술

장 인 권

국립수산과학원 서해특성화연구센터

한국에서의 상업적인 새우양식은 1980 년대에 발달하기 시작하였으며 양식생산량은 1990 년대 들어와 급속도로 증가하여 2001 년에는 전국 437 개 양식장 (3,256ha)에서 3,256 톤을 생산하였다. 그러나 빈번한 질병의 발생으로 인하여 2004 년 양식생산량은 2,332 톤으로 감소하였다. 단위면적당 생산량은 2001 년 1.25 톤/ha 이었으나 이후 점차 감소하여 2002, 2003, 2004 년에는 각각 1.11, 1.07, 1,02 톤/ha 으로 떨어졌다.

1990 년대 중반까지 한국에서는 고유종인 대하와 보리새우 2 종이 양식되었다. 그러나 1993 년 흰반점바이러스(WSSV)가 국내에 처음 발병한 이래로 보리새우는 양식이 중단되고 대하 1 종만 양식하게 되었으나 그 이후 바이러스질병에 의한 피해는 계속 증가하였다. 이에 대한 대안으로 2003 년 국립수산과학원에서는 미국 하와이로부터 무병 (SPF, specific pathogen free) 흰다리새우 (*Litopenaeus vannamei*, Pacific white shrimp)를 이식하여 연구하기 시작하였다. 흰다리새우는 한국으로 이식된 2003 년 이후 점차 양식이 확산되어 2006 년에는 전국 양식새우생산량의 28%를 점유하였다. 2007 년 민간 새우종묘배양장에서 약 1 만 마리의 무병어미새우를 하와이에서 수입하여 양식용 종묘를 생산하고 있으며 올해 전체 양식장의 70% 이상이 흰다리새우가 입식 될 것으로 예상된다. 비록 흰다리새우는 대하에 비해 질병내성이 높은 것으로 알려져 있지만, 무병어미새우에서 생산된 흰다리새우의 종묘가 축제식양식장에 입식되면 바이러스의 수평적인 감염을 피할 수 없게 되며 따라서 정도의 차이는 있겠지만 양식어업인들은 예전과 마찬가지로 바이러스에 의한 대량폐사의 피해를 입게 될 것이다. 따라서 질병의 감염을 최소화하고 지속가능한 새우양식을 위해서는 새로운 양식기술의 접근과 개발이 필요하다.

초고밀도 육상새우양식은 환경으로부터의 바이러스 감염 위험을 최소화시키고 방역사육을 유지함으로써 지속가능한 새우양식을 가능하게 하는 대안의 방법이 될 수 있다. 현재까지 고밀도 육상새우양식 방법은 3 가지가 개발되어 있다. 이중 하나는 기존의 어류 순환여과양식시스템과 같이 생물여과조와 양성조가 별도로 분리되어 있는 전통적인 순환여과방식 (RAS, recirculating aquaculture system)이다. 두번째는 유수식 육상새우양식방법으로 현재 중국에서 대규모 새우양식장에서 적용되고 있는 방법이다. 마지막으로 타가영양방식을 이용한 사육수비교환 육상수조양식시스템이 있다. 이 시스템은 에어블로와 및 폼프랙셔네이터가 부착된 양성용 수조의 단일 구조로 구성되며 질소화합물의 분해는 전적으로 양성조에서 진행된다. 즉 양성조의 사육수에는 세균총이 매우 잘 발달되어 있어 이들이 독성의 질소화합물을 분해하게 된다. 현재 개발된 상업적 규모의

기술로는 톤당 8kg 까지 생산이 가능한 것으로 알려져 있다. 여기에서는 여러가지의 고밀도 새우육상수조 기술을 소개하고 각 특성을 비교하고자 한다.

Techniques and development for sustainable cage mariculture in china

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1. General description of cage mariculture in China

Sea cage fish farming in China started in early 1970s and developed rapidly during the 1980s and 1990s. By the end of 2006, there are more than 1 million cages in all and about 30 species of fish are farmed in sea cages. The annual production is around 300 000 tons which accounts for 60% of the total marine fish production cultured annually. Sea cage farming has become a mainstay in the whole industry of mariculture in China.

2. Classification and structures of sea cages in China

Sea cages in China are technologically classified as two kinds. One is the traditional cages and the other is the offshore deep sea cages. The frames of the traditional cages are usually made from bamboos, wood or steel pipes with size of 3m×3m to 5m×5m in square and the net bags are made from PE netting with the depth of 3m to 5m. The offshore cage defined in China as deep sea anti-waves cage is a revolution against the traditional ones. These cages are specially designed in structures and fabricated with special materials, thus the cages can be used at more exposed sites and deeper waters. Now several types of offshore cages have been developed, such as the HDPE circular floating cage, flexible cage made from ropes and floats, the HDPE submersible cages, two-cones-shaped net cage, etc. The newly developed offshore cages are large in carrying capacity with water volume of 800 m^3 to 3000 m^3 and the perimeter between 40 m to 80 m.Because of the economic, social and ecological advantages, the offshore cage farming is welcomed by both the government and the farmers. Only in a few years, the quantity of the cages has exceeded 3800.

3. Environmental problems of cage mariculture in China

In general, cage mariculture in China is still in low level. Among the 1 million cages, most of them belong to traditional designs. Because these cages cannot withstand the strong wind and big waves in heavy sea, more and more cages have to be crowded in the near shore shallow and sheltered areas and many problems have been brought in. For instance, the stocking density is beyond the carrying capacity of environment and the lack of effective method to prevent net bag from fouling makes the exchange of water difficult. The accumulation of waste metabolite and the waste feeds polluted the farming environment and problems of self-pollution are serious. Moreover most of the near shore waters are polluted by waste from on-land industries. All resulted in fish disease to break out and fish quality and economic efficiency to decrease, which have restricted the healthy development of cage mariculture in China.

4. Cage mariculture of China in the Yellow Sea

Generally, cage mariculture of China in the Yellow Sea takes the same steps with the development of the industry of the country. From the cage distribution point of view, cages are mostly congregated in the East China Sea and the South China Sea. About 85% of the total cages distribute in the three provinces of Fujian, Zhejiang and Guangdong. The three provinces of Shandong, Liaoning and Jiangsu which locate along the coast of the Yellow Sea take only 10% of the total. There are two aspects which restricts the scale of cage mariculture in Chinese coast in the Yellow Sea. Firstly, the Yellow Sea is comprised of shallow areas of continental shelf and there are few sheltered bays with enough water depth along the coast for cage farming. Secondly, The water temperature in the Yellow Sea is relatively low during the winter, which allows only a few species of fish (now mainly *Sebastes schlegeli*, sea bass and *Hexagrammos otakii*) to live through the winter time inside the cages. Because the cages are not as crowded as those in the East China Sea and the South China Sea, the environmental problems resulted from the cage culture in the Yellow Sea are not as serious either.

5. Sustainable development of cage mariculture in China

In recent years, Chinese government has paid much attention to cage mariculture industry. On the one hand, cage mariculture is a good way for fishermen to change their jobs from fishing to culturing. On the other, with the quantity of sea cages increasing, the environmental problems have become more obvious. The main techniques and strategies for sustainable cage mariculture in China are as follows:

· **Introduction and development of new cages** Since 1998, when China imported the offshore cages from Norway, the Chinese government has found more than 50 million yuan (about 6.5 million USD) for the research and development of offshore deep sea cages and has achieved rapid progress. Because these cages can be sited in more exposed and deep water areas where the better water flow through the cages carries the waste metabolite and waste feeds away, mariculture by using these advanced cages are considered to have little effect to the water environment. Moreover, high survival rate and economic profit can also be achieved. Now the Chinese government has taken various measures to encourage the development of offshore deep see cages.

· **Macro-control and rational planning of cage mariculture** The fishery management departments of the central government and coastal provinces have made the planning of the development of cage mariculture and the licensed system for cage farming is established.

· **Development of effective compounded feeds and feeding technology** Feed and feeding are very important in cage farming. Waste feed can not only polluted the water environment but makes the cost of farming increase also. Efforts have been made in China in recent years to develop high efficient feed to substitute the traditional feed of trash fishes.

· **Study on the carrying capacity and remediation technology** Although we know that the bad management and practice of cage culture affect the environment, the mechanism and the actual results affected by the cage culture need to be studied further. The research and studies on the proper distance between the cages, the optimum stocking density, the exchange of water body in certain current, the quantitative and qualitative analyses on the wastes from the culture practice and even the remediation technology are carrying froth in China now.

· **Compliance with the Good Agricultural Practice in cage culture** Under the National Standards of Good Agricultural Practice, Cage Culture Base Controls Points and

Compliance Criteria has been made and is in the process of authorization for enforcement. In the standard, the cage site, grouping of cages, cage facilities and equipment, management on sea areas, feed and feeding, routine management, safety and security, training on workers and even the welfare of the workers and animals have been standardized in details. The enforcement of the standard concerning the good practices in cage culture in China is certain to be helpful to the sustainable development of cage mariculture in the Yellow Sea.

Recent advances in korean shellfish aquaculture

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Korean peninsula consists of three oceanographically different coasts where at least 23 different shellfish species have been cultured. In 2004, Korea produced 954,720 MT of aquaculture products and the shellfish production accounted for 309,559 MT from oysters (*Crassostrea gigas*), mussels (*Mytilus galloprovincialis*), clams (mostly *Ruditapes*, *Meretrix*, and blood cockles), abalones (*Haliotis* spp) and shrimps (*Penaeus orentalis*). The West coast has highly turbid water and well developed muddy tidal flats where the Manila clam, *Ruditapes philippinarum* are commonly cultured. The clam production has been declining since early 90's due to habitat changes and disease-associated mortality; 27,000 MT of clams produced in 2004 from the coastal Yellow Sea. From the west coast, 2,500 MT of shrimp was produced in 2004. The southern coast comprises of many enclosed bays, estuaries and islands which have been used as various shellfish culture ground for several decades. Particularly the Pacific oysters have been intensively cultured using hanging long-line culture technique in the middle of the bays. In 2004, Korea produced 240,000 MT of oysters and most of the oyster farms were located on the southern coast. On the southern coast, the hanging long-line culture technique is widely applied in some commercially important shellfishes including the mussel, pearl oysters and the blood cockles, although the annual production is much lower than the oyster productions. Sea squirt (*Halocynthia roretzi*) culture using the hanging long-line is also commonly practiced in the bays along the southern coast; 7,500 MT of the sea squirts were produced in 2004. Mass mortalities of clams, sea squirts and oyster have been reported from major culture grounds and these disease incidences were in part attributed to the intensive way of culture as well as environmental contamination.
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Standard management practices in shellfish culture
Shellfish culture in Shandong

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China has a long history for shellfish culture. As early as 2500 years ago, oyster culture data can be found in historical records. In recent 10 years, shellfish output takes up to 80% mariculture gross product in china, Shandong shellfish culture is in the vanguard of china.

Fairly large scale shellfish culture began in 1970s' in Shandong Province. At first, it was artificial collection and culture of Mussel and *Chlamys farreri*; later, the artificial breeding of rare shellfish such as *Chlamys farreri* and abalone succeeded. In 1980s', breeding techniques of shellfish made great success; in 1990s', shellfish culture grew fast in Shandong province, shellfish output was growing year by year, some shellfish products of high quality were exported to foreign countries.

In late 1990s', the breeding culture technique of improved shellfish got mature, improved shellfish drove the development of scallop propagation and culture in Shandong province, and made great contribution for marine economy in Shandong Province.

After years of efforts, the techniques such as the breeding technique of marine healthy shellfish, baits cultivation, choice of parent shellfish and Spawning Inducement Technique, shellfish breeding with high density, water quality control are becoming more and more mature.

I am happy to exchange and share my achievement and experience on marine shellfish culture, and warm-heartedly welcome every expert to Shandong for exchange and visit.

Feed formulation and feeding regime vs waste production of aquaculture

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Inherent to the practice of intensive aquaculture is the generation of waste, and these wastes have immediate and very broad effects on the aquatic environment. There is a growing consensus about the need to reduce waste production in aquaculture to minimize the negative impacts on the environment. Nitrogen and phosphorus wastes are major concern for many aquaculture operations. In the past, formulation of diets in intensive aquaculture has often been aimed at meeting requirements for maximum growth, while more recently, formulation are being designed to meet other desired production goals. One such goal is to increase the sustainability of various ecosystems. Aquaculture wastes are largely dietary in origin with estimates of 52%-95% of feed nitrogen ending up as wastes（Wu,1995）.

The aquaculture production increased very much in past 10 years in China. The total production of aquaculture has been over 30 million tonnes. With the fast increase in aquaculture, there also come some problems. The most important problem of aquaculture is self- pollution, especially in intensive aquaculture, resulting from:

1) Poor growth and feed utilization. Although, aquafeed production has advanced rapidly in the past several years, the feed quality still needs improvement. The feed conversion ratio for most species is still very high (more than 1.5). This is a significant waste of the feed ingredients, especially since food resources are limited in China.
2) High nitrogen and phosphorus loading. The waste production including nitrogen and phosphorus is still very high resulting in a threat to the marine ecosystem.
3) Poor feed formulation and poor water quality also results in the increased incidence of fish disease. The treatment on fish diseases could introduce other problems such as the use of antibiotics etc.

In order to solve those problems in aquaculture, our focus is mainly on feed formulation and feeding management.

a) Feed formulation

The improvement of diet formulation includes the balance of nutrients, reducing nitrogen and phosphorus loading, and reducing the use of trash fish.

Nutritional requirement is the base of diet formulation. Our research has provided the data for the requirement of protein, amino acids, lipid, fatty acids, minerals and vitamins etc. Digestibility of different feed ingredients has been determined in some species for the nutrient balance of diet formulation.

In order to reduce the nitrogen and phosphorus loading, the research work has been focusing on increasing palatability, increasing digestibility, suitable EAA：NEAA, using lipid and carbohydrate to decrease the dietary protein, selecting suitable protein sources and using some enzymes to increase the feed utilization. Feeding stimulants have been studied and used to increase the feed palatability. Using fish protein hydrolysates increases the digestibility and palatability of feed. In addition, fish meal quality affects the impact of fish farm effluents on environment. Replacement of trash fish with formulated diet could result in high growth and feed utilization for marine fish. Suitable diet formulation could successfully replace trash fish and result in high growth and high nitrogen retention.

b) Aquaculture management - feeding regime

Suitable management could also help to decrease the waste production in aquaculture. This includes feeding regime and compensatory growth.

Feeding regime studies examined feeding frequency, feeding rate, and feeding rhythm Bioenergetic modelling was included to predict the growth and feed requirement to build a dynamic feeding regime. In some fishes, such as red seabream, Japanese flounder, rockfish compensatory growth period could increase feed utilization and decrease nitrogen loading.

In conclusion, as environment protection is more and more urgent new technologies should be used in aquaculture to decrease the impact on environment stress.

How to contribute to the preparation of SAP

Mark Walton
UNDP/GEF Yellow Sea Project

The UNDP/GEF Yellow Sea Project has used the best available scientific advice to drive decision making on environmental issues in the Yellow Sea. To date scientists in national and regional working groups on Biodiversity, Pollution, Ecosystem and Fisheries have compiled reports on the status, problems, causes of those problems and future threats. At present we are now in the process of identifying the environmental regional targets that will need to be met by 2020. The next step will be the formulation of management actions that are required in order for those environmental targets to be met. The challenges facing the mariculture are well known and include two major components, reducing the impact of mariculture on the environment and improving the reliability and profitability of the industry. These two facets are not mutually exclusive and need to be made to work synergistically to improve both performance and sustainability. This and future workshops aims to identify how the problems noted in the national reports, and the solutions proposed in the workshops can actually be implemented.

The project seeks to pilot two sites within in the Yellow Sea for demonstration of relevant management actions on sustainable mariculture activities. Due to the limited time available the selection criteria of the sites will be based on:

1) The amount of mariculture research performed in the area (ie mariculture knowledge);
2) Whether the management actions are driven by scientific advice;
3) Whether changes in mariculture activities are passive (no legal enforcement) or active (government driven);
4) The receptiveness of the local mariculture farmers to scientific advice.

These pilot sites will be used to demonstrate the financial and environmental advantages of practicing sustainable mariculture in the hope of persuading both farmers and policy makers to adopt more sustainable techniques and management strategies. At these sites it is hoped that the carrying capacity model developed by Yellow Sea Fisheries Research Institute, and explained during the second mariculture workshop in China, will be used to assess the density required to optimize production and address the falling productivity per unit area noted in the national reports. Polyculture will be encouraged to promote nutrient balance within the site while increasing harvests.

The introduction of best management practices for control of disease is critical in if lessons are to be learnt from the shrimp farming industry. The workshop in October will explore the issues surrounding disease control and prevention and methods of insuring that disease outbreaks are quickly identified and reported.

The three workshops will pool an enormous amount of information, but what is the best method of dissemination. The project is interested in the way that farmers obtain knowledge in both countries and what linkages exist between scientists and mariculture farmers. The project would like to explore ways of improving the flow of information between scientists and farmers and marine policy planners. There are various ways this has been addressed in other countries, including government centres that have demonstration sites which run courses, aquaculture extension workers that dispense advice and listen to grievances, representatives of the feed industry that also provide advice in return for purchase of feed, and technology driven systems such as the aquaculture information cell phone text service trialled by SEAFDEC AQD in the Philippines and internet solutions. But which is the most applicable method for this region?

We hope that our activities will improve the exchange of information on a regional scale between China and Republic of Korea and locally between farmers, scientists and policy makers.