Global Conference on Aquaculture 2010

Farming the waters for People and Food

22-25 September 2010, Phuket, Thailand

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Global Conference on Aquaculture 2010

Expert Panel Presentation 1.1:

Responsible use of Resources for Sustainable Aquaculture

By

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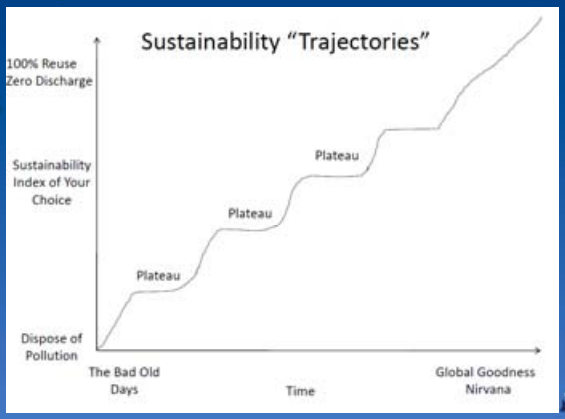
22–25 September 2010, Phuket, Thailand

Resource Use in Aquaculture

- Status (production, water, energy, feed, seed, space)
- Trends
- Forecasts



Production (FAO, 2009)

China accounted for 67% of global production (2006)

34.4 million metric tons/51.7 MMT

Rest of the world, production was 17.2 MMT
Outside of China, aquaculture provided **23%** of world fisheries production, not **47%**

Most global aquaculture production remains—for all the controversies—freshwater fish (**54%**) and mollusks (**27%**)

Food Systems	FCRs (kg dry feed/kg wet weight gain +/- SD)	% Edible	Production Efficiencies (kg dry feed/kg of edible wet mass)
Tilapia	**1.5 (0.2)**	**60**	**2.5**
Catfish	**1.5 (0.2)**	**60**	**2.5**
Marine Shrimp	**1.5 (0.5)**	**56**	**2.7**
Freshwater Prawns	2.0 (0.2)	45	4.4
Milk	3.0 (0.0)	100	3.0
Eggs	2.8 (0.2)	90	3.1
Broiler Chickens (Verdegem et al., 2006)	2.0 (0.2)	59	3.1
Swine	2.5 (0.5)	45	5.6
Rabbits	3.0 (0.5)	47	6.4
Beef	5.9 (0.5)	49	10.2
Lamb	4.0 (0.5)	23	17.4

Water

- High water use in ponds in comparison to terrestrial agricultural protein production systems
- Severe water competition growing with alternative users
- Massive damming and urbanization in Asia diverting water to coastal cities and agriculture

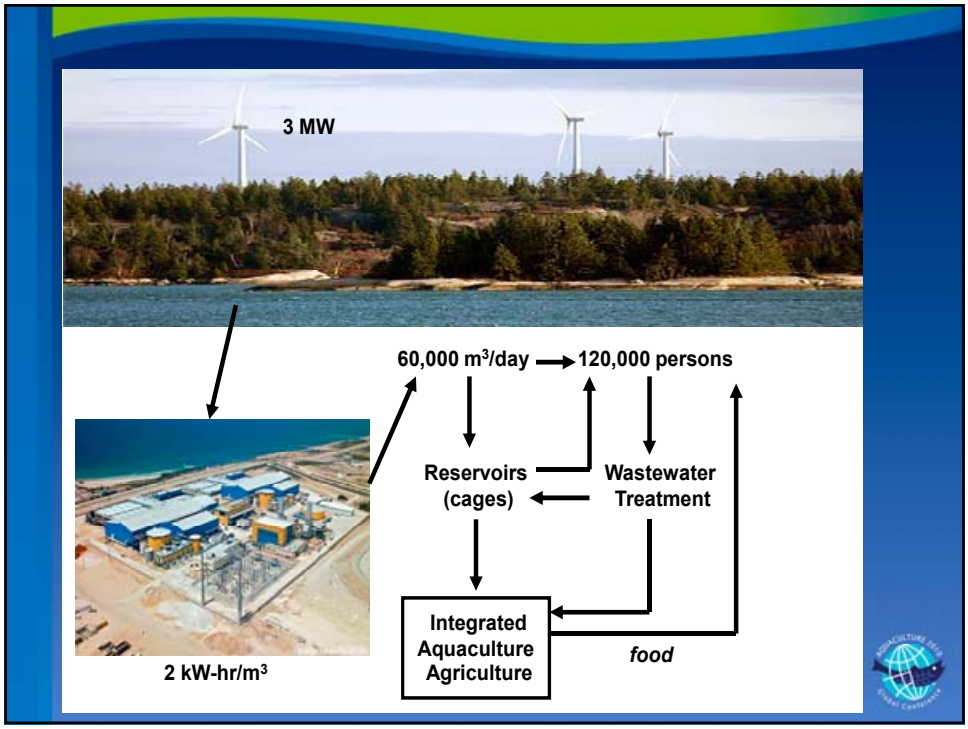
Consumptive water use in aquaculture and terrestrial agriculture

- Low (<3000 L/kg product); High (3000-10,00); Extreme (>10,000)
- shellfish, seaweeds, marine fish in cages, small pork, row crop vegetables, fruit tree crops, milk, wheat, millet, rye, soybeans, eggs, recirculating aquaculture
- shrimp, olive oil, trout, butter, beef, sheep, *Pangasius* catfish

Water (2050)

- Upstream dams cut off downstream users
- Freshwater use conflicts and droughts increase in aquaculture production zones closing many pond areas
- More rapid development of cage systems in open waters
- Rapid decrease in the costs and increased efficiencies of intensive, recirculating systems that use water more efficiently than ponds and terrestrial animal production systems
- Multiple uses of water in landscape scale systems of mixed reservoir production with downstream aquaculture/agriculture
- Changes to traditional rice/fish systems in Asia, with large scale land modification, addition and replacement of rice with high value species (prawns) in Bangladesh, Vietnam and China
- Development of seawater farming systems in arid areas
- Development of low energy membranes with wind turbines break 2kW/hr/m^3 barrier accelerating seawater use

Developments	kW-hr/m^3
Min theoretical electricity need	0.86
1990's RO plants	5-7
(250,000 m^3/day)	3.85
R&D (Affordable Desalination Collaboration	1.5



Energy

- Globalization and intensification of food production increases energy density and use in fed aquaculture in comparison to fishing and terrestrial agricultural protein production systems

Fossil Fuel Consumption in Aquaculture and Terrestrial Agriculture

- Low (<20 kcal/kcal protein); High (20-50); Extreme (>50)
  - shellfish, seaweeds, rangeland beef, traditional carp & tilapia ponds, sheep, row crop vegetables, dairy
  - flatfish fisheries, seabass cages, feedlot beef, shrimp & lobster capture fisheries

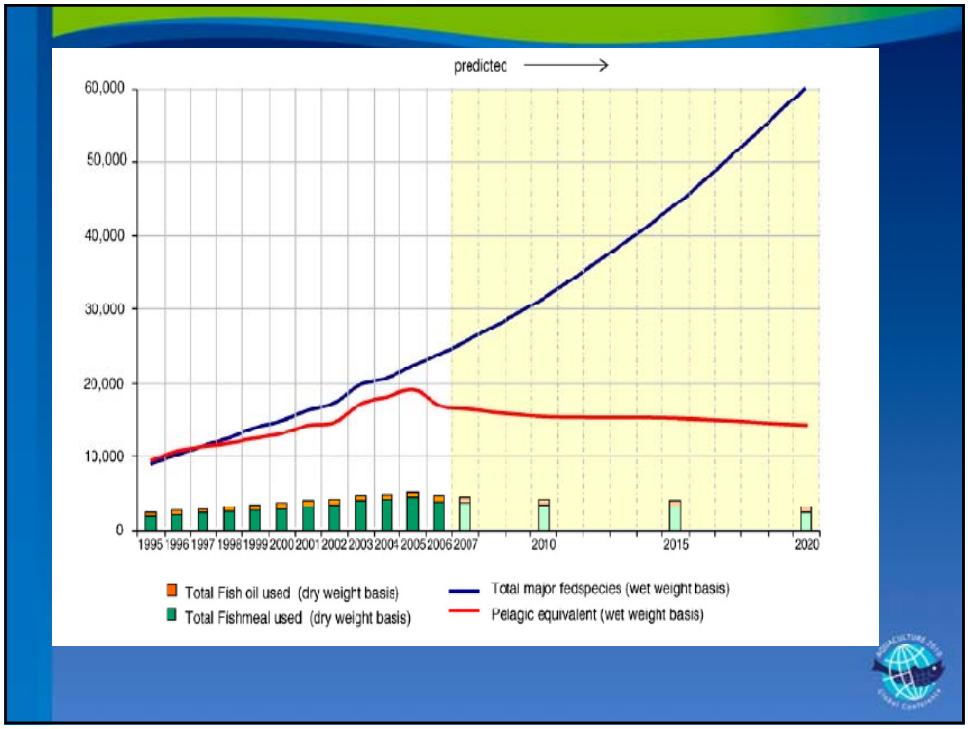
Food Systems	Production (MT/ha)	MJ/MT
Sugar Beets	57.9	550
Potatoes	47.0	940
Soybeans	2.5	2,950
Wheat	8.2	3,100
Salmon Net Pen Water-Based	1,000	26,900
Salmon Bag System Water-Based	1,733	37,300
Salmon Flow-through Land-Based	2,138	132,000
Salmon Recirculating Land-Based	2,406	233,000

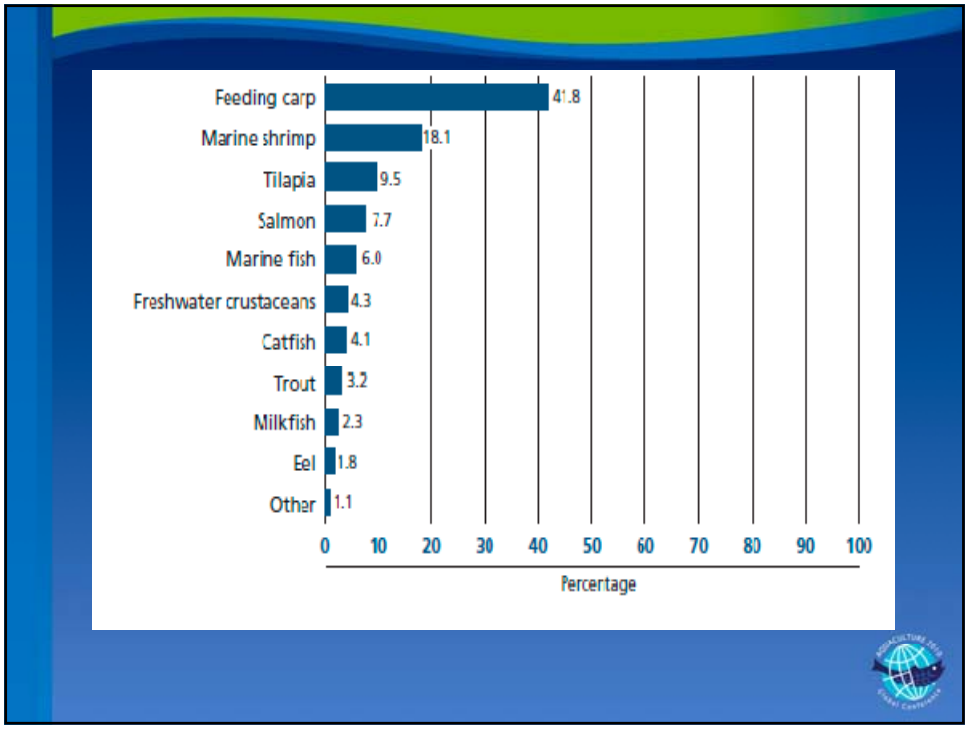
Energy (2050)

- **Recirculating systems are energy intensive compared to other systems and have large carbon footprint**
- **Life Cycle Assessments show advantages/disadvantages of aquaculture**
- **Large scale development and use of cost-effective renewable energy systems make intensive recirculating systems more widespread and accessible**

Feed

- **Overuse** of marine meals/oils threatening sustainability of pelagic fish stocks
- High feed **costs**
- Fish feed ingredients imported and there is a crisis in feed **qualities**
- Meat-bone meal also imported but quality is not assured
- **Social equity/poverty** concerns with use of pelagics as feeds rather than as direct human foods
- PCB and mercury **contamination** of fish meals/oils


predictec
60,000
50,000
40,000
30,000
20,000
10,000
0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2010 2015 2020
Total Fish oil used (dry weight basis)
Total Fishmeal used (dry weight basis)
Total major fedspecies (wet weight basis)
Pelagic equivalent (wet weight basis)


Feeding carp 41.8
Marine shrimp 18.1
Tilapia 9.5
Salmon 7.7
Marine fish 6.0
Freshwater crustaceans 4.3
Catfish 4.1
Trout 3.2
Milkfish 2.3
Eel 1.8
Other 1.1
0 10 20 30 40 50 60 70 80 90 100
Percentage

Feed (2050)

- Increased use of imported fishmeals/oils in formulated feeds for traditional carp & imported tilapia species in Asia, esp. China, decreasing FCR
- Increased use of wet feeds (cakes, wastes from poultry processing plants) & chicken manures in South Asia fish culture with high FCR (>3.0) resulting in deterioration of water quality
- Decreased use of marine meals/oils in intensive cage/tank systems & improvement in FCRs
- Replacement of marine meals/oils by agricultural sources & by algal/bacterial/fungal bioreactors but new issues arising about aquaculture leading to deforestation
- Use of biotechnology to elongate/upgrade essential fatty acids
- Cleansing of oils by high technology

Subsidized aquaculture	FIFO (1995)	FIFO (2008)
Salmon	7.5	4.9
Trout	6.0	3.4
Eels	5.2	3.5
Misc. Marine Fish	3.0	2.2
Shrimp	1.9	1.4
Net production aquaculture		
Chinese carps		0.2
Milkfish		0.2
Tilapia		0.4
American catfish		0.5
Freshwater prawns		0.6

Alternative Meals/Oils	Notable Research & Developments
Soybean Meals	Shrimp in semi-intensive culture in ponds could be grown on *defattened soybean meal as their sole protein source*
Insect Meals	Meals made from mass-producing insects in culture; Indonesia constructing 4,000 maggot farms for fish feeds using palm oil byproducts
Bacterial Protein Meals (BPM)	BPM investigated as protein sources in salmon, rainbow trout, halibut feeds with comparable results for growth, feed intake and utilisation up to 36% incorporation for salmon and trout.
Vegetable oils and Animal fats	*~75% of dietary fish oil* can be substituted with alternative lipid sources without significantly affecting growth performance, feed efficiency and intake for almost all finfish species studied
Rendered animal proteins	Dietary inclusion of animal protein meals have contributed to decreasing fish meal levels in feeds for top consumer species as salmonids and shrimp

Seed

- Inadequate and unreliable supply of quality seed
- Poor **genetic quality** of seed
- Basic production from regional hatcheries—the human infrastructure, financial & business/marketing support and policy and legal frameworks **are not in place** in many nations
- Impacts of **uncontrolled releases** of cultured seed stocks

Seed (2050)

- **Rapid expansion** of export-oriented international seed trade esp. of high-value species
- Increasing need to introduce **quality assurance** measures beyond simple official zoosanitary certificates
- Regional **hatchery infrastructure** taking shape in many nations

Space

- Ponds have **high land use** in comparison to terrestrial agricultural protein production systems
- Rice fields are increasingly being **converted** in to fish ponds in many countries
- Application of the use of "**footprints**" to quantify areas of ecosystem support services required per mt of aquaculture production as important metric being used.

System types	Descriptions	Production (kg/ha/year)	Efficiency of Land Use (m^2/MT)
Extensive	On-farm resources	100-500	20,000-100,000
Extensive	On-farm resources, fertilizers	100-1000	10,000-100,000
Semi-intensive	Supplemental feeds, static	2000-8000	1,250-5,000
Semi-intensive	Supplemental feeds, water exchanges	4000-20,000	500-2,500
Semi-intensive	Supplemental feeds, water exchanges, night aeration	15,000-35,000	300-700
Intensive	Complete feeds, water exchanges, night aeration	20,000-50,000	*200-500*
Intensive	Complete feeds, water exchanges, constant aeration	20,000-100,000	*100-500*

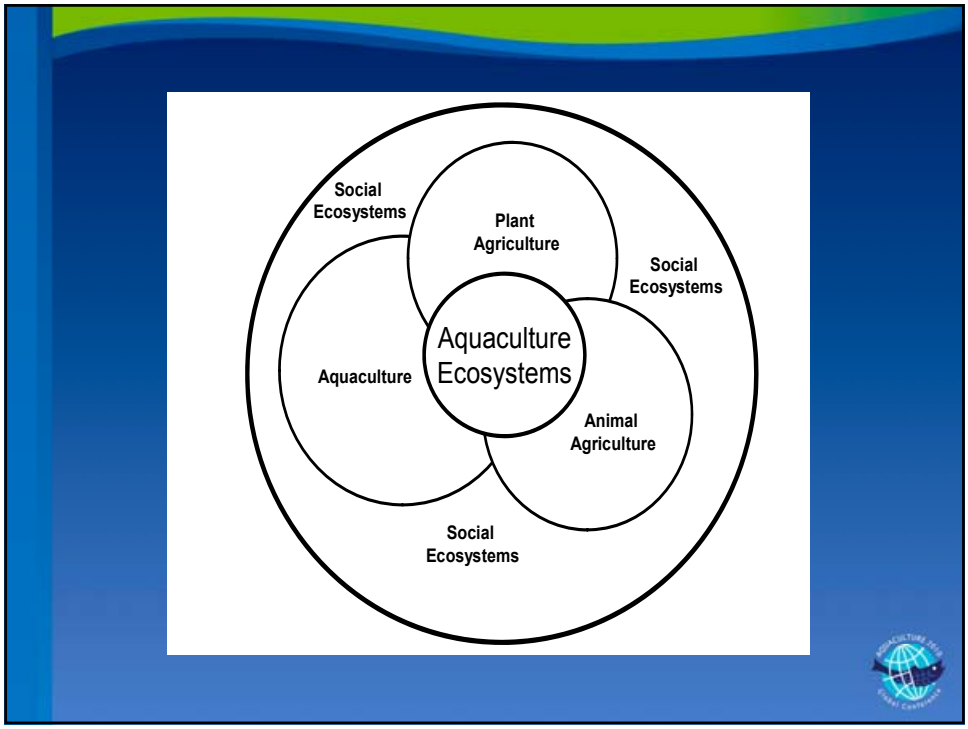
Salmon Species, Systems	Area Use (ha/MT)
Farmed Chinook	*16.0*
Farmed Atlantic	*12.7*
Fished Chinook	11.0
Fished Coho	10.2
Fished Sockeye	5.7
Fished Chum	5.2
Fished Pink	5.0

Space (2050)

- Ponds taken over by urbanization
- Cage systems proliferating with user conflicts driving development/use of submerged systems. Widespread use of cages in small water bodies, reservoirs and coastal open waters
- Intensive, recirculating systems are more efficient uses of land & will remain uneconomic in most areas in comparison to other production systems *UNLESS RENEWABLES USED*
- More widespread use of integrated aquaculture into landscape-scale systems of mixed aquaculture/land uses
- Greater use of land/water use planning to address growing land/water user conflicts

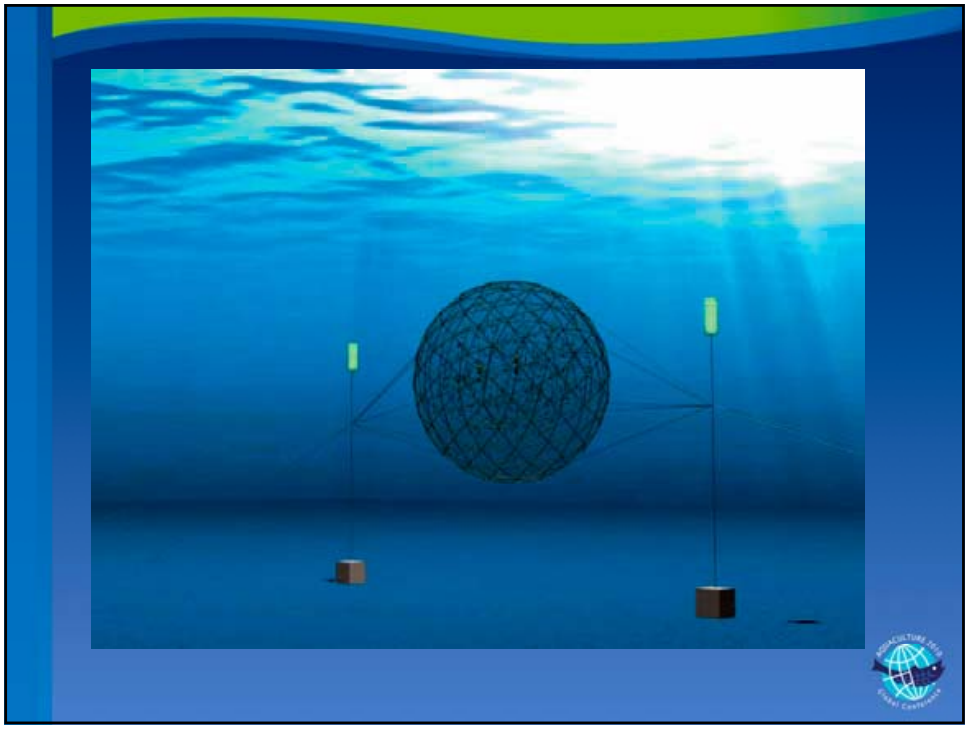
Conclusions

- move to the ocean, lakes and reservoirs
- use of renewable energy, recirculating develops rapidly
- multiple uses of water landscape scale
- tighter integration with agricultural and fisheries/marine resources
- new professionalism



Biculture cage systems

- Muller and Varadi (1984)
- Costa-Pierce and Hadikusumah (1990)
- Costa-Pierce (1997)



Recommendations

- Ecosystem approaches to aquaculture = market forces
- Sustainable sources of supply = aquaculture and fisheries
- Transdisciplinary integration = education & training