

## FISH AQUACULTURE



## INTENSIVE x (EXTENSIVE) AQUACULTURE

- Maximum economical effect (time and area)
  - Extensive aquaculture (ponds) **100 – 500 kg/ha**
  - Intensive aquaculture **50-150 kg/m<sup>3</sup>**
- Very low portion of natural feed – or not at all.
- Specifics:
  - Control of environment (high price!)
  - high fish concentration
  - high production from water volume
  - Complex feed (high price!)
  - high level of management

12-14

<http://kzr.agrobiologie.cz/>

2

## INTENZIFIKATION

- artificial reproduction
- Optimal conditions for breeding
  - t°
  - O<sub>2</sub> (aeration)
  - pH
  - disinfection (biofilter, UV, ...)
- Kvalita and quantity of feed
- Stock density
- Genetics and breeding programs



12-14

<http://kzr.agrobiologie.cz/>

3

## ARTIFICIAL REPRODUCTION

1. Hormonal induction - GnRH – Gonadotropin Releasing Hormone. From dead fish, injected into live fish
2. Artificial spawning



12-14

<http://kzr.agrobiologie.cz/>

4

## ARTIFICIAL REPRODUCTION

Female

Male



More males for one female...we don't know who is father exactly.

12-14

<http://kzr.agrobiologie.cz/>

5

## ARTIFICIAL REPRODUCTION

1. Roe (egg) incubation



12-14

<http://kzr.agrobiologie.cz/>

6

## ARTIFICIAL REPRODUCTION

Slowly flowing water with high oxygen content



12-14

<http://kzr.agrobiologie.cz/>

7

## ARTIFICIAL REPRODUCTION

- Critical period when embryos start with exogenous feeding



12-14

<http://kzr.agrobiologie.cz/>

8

## FEED AND FEEDING

- **FEEDING** = direct intensification factor
- High protein content
- Optimization (quantity, time, ...)
- Dependence on temperature and oxygen

12-14

<http://kzr.agrobiologie.cz/>

9

## FRESHWATER AQUACULTURE

1) Cage culture



2) Tank culture  
flow-through systems



3) Recirculating Aquaculture Systems (RAS)



12-14

<http://kzr.agrobiologie.cz/>

10

## CAGE CULTURE

- **Tropics – subtropics**
  - Tilapia, catfishes (*pangasius*) (100 kg/m<sup>3</sup>)
- **Temperate zone**
  - Salmonids (salmon, trout,...)

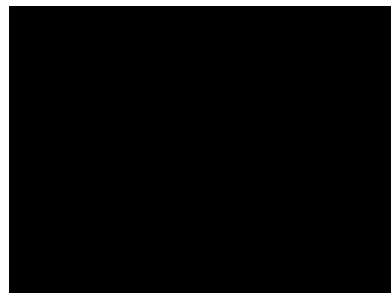


12-14

<http://kzr.agrobiologie.cz/>

11

## CAGE CULTURE - VIDEO



12-14

<http://kzr.agrobiologie.cz/>

12

### FLOW-THROUGH SYSTEMS

Sturgeon in Czech Rep.



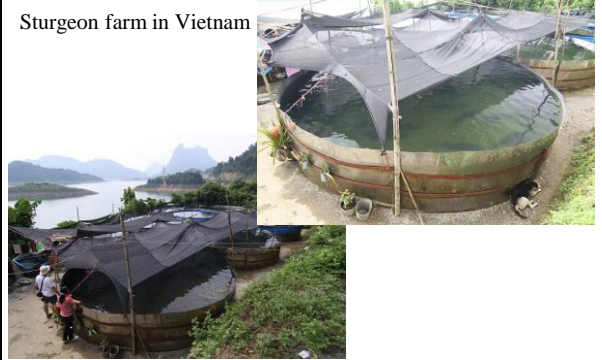
12-14

<http://kzr.agrobiologie.cz/>

13

### FLOW-THROUGH SYSTEMS

Sturgeon farm in Vietnam



12-14

<http://kzr.agrobiologie.cz/>

14

### FLOW-THROUGH SYSTEMS

- CYPRINIDS – ornamental fish  
indoor or outdoor



12-14

<http://kzr.agrobiologie.cz/>

15

### FLOW-THROUGH SYSTEMS



12-14

<http://kzr.agrobiologie.cz/>

16

### RECIRCULATING AQUACULTURE SYSTEMS (RAS)

- Total or partial recirculation.
- Mechanical and biological filter, disinfection (UV).
- „Zero discharge“ with minimal water waste  
breeding fish in deserts

12-14

<http://kzr.agrobiologie.cz/>

17

### TILAPIA

One of the most spread on the world



- *Oreochromis niloticus*



- *Oreochromis mossambicus*



Mouthbreeders

12-14

<http://kzr.agrobiologie.cz/>

18

## STURGEON



Long span life  
Complicated artificial spawning

RAS

[VIDEO](#)



12-14

© 2008/12/14/14

<http://kzr.agrobiologie.cz/>

19

## Fish from Vietnam



## Pangasius

Pangasius bocourti - basa



Pangasius hypophthalmus - Tra



## Pangasius/pangas

- 20 years ago - fish for poor in Mekong delta
- 1 MT, 1mld \$
- Export 80 countries
- cage culture: 100-150 fish/m<sup>3</sup> 100-120 kg/m<sup>3</sup>
- Pond culture: 60- 80 ryb/ m<sup>2</sup> 250-300 t/ha
- What is the carp production from 1ha of pond in Central Europe?





**TESCO**

Poznámka                      mražené filety 1 kg, Pangasius  
mražené filety 500 g 42,90  
(100 g = 8,58 Kč)

Platnost

Cena                              **84,90 Kč**

**SALMON**

**Two phases:**

1. Juvenile in freshwater (6-24 months)
2. Adult in seawater (2-3 years)

12-14                              <http://kzr.agrobiologie.cz/>                              27

**SALMON**

*Norsk Laks \* Norwegian Salmon*

FERSKVANN/FRESH WATER                      SJØVANN/SEA WATER

ROGN SALMON EGGS                      NYKLETT YNGEL FRY                      SMOLT UTSATT I SØ SMOLT READY FOR SEA WATER                      LAKS KLAR FOR SALG SALMON READY FOR SALE

1 - 2 mnd/months                      6 - 24 mnd/months                      12 - 24 mnd/months

**Salmon farming in Norway.**

Salmon eggs hatch in fresh water in early spring. Within the first year, the fry will develop into smolt, and is then placed in sea cages where it spends between one and two years. During this growth phase, quantity and quality of feed is carefully adjusted in line with water temperatures and other biological conditions.

Two to three years old, the salmon reaches its ideal market weight and "Superior" quality.

The 700 Norwegian salmon farms have a total annual production of approximately 290,000 tonnes. 99% of this is sold outside Norway.

Skretting is the largest supplier of feed to Norwegian salmon - the world's finest.

**Skretting**  
Føring for lønnsombet

12-14                              <http://kzr.agrobiologie.cz/>                              28

**SALMON**

**FRESHWATER**

12-14                              <http://kzr.agrobiologie.cz/>                              29

**SALMON**

**Desinfection by UV filter**

**Oxygenation**

**Biological filter**

12-14                              <http://kzr.agrobiologie.cz/>                              30

## SALMON

Automated feeding – pneumatic



12-14

<http://kzr.agrobiologie.cz/>

31

## SALMON

Transport of fish



Sorting..



Medication...



12-14

<http://kzr.agrobiologie.cz/>

32

## SALMON

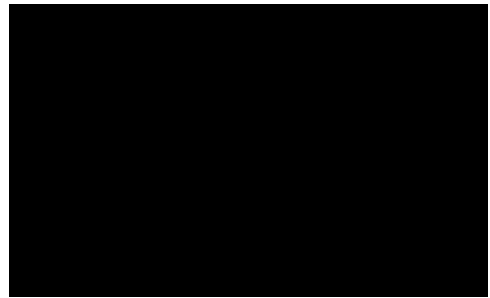


12-14

<http://kzr.agrobiologie.cz/>

33

## SALMON



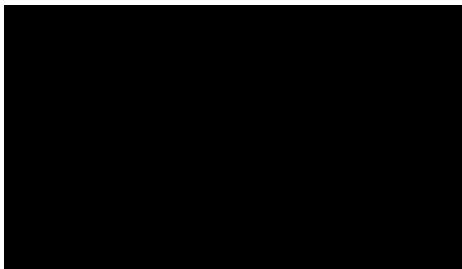
400.000 fish in one tank

12-14

<http://kzr.agrobiologie.cz/>

34

## SALMON



12-14

<http://kzr.agrobiologie.cz/>

35

## SALMON

From eggs to customer..  
[video](#)

12-14

<http://kzr.agrobiologie.cz/>

36

## MARINE AQUACULTURE

**"It is time to farm the ocean  
as we farm the land."**

Jacques Cousteau, 1973

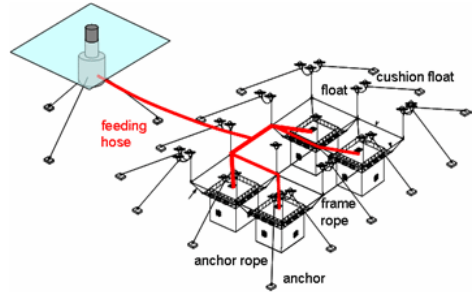
Coastal Auaculture x Offshore Aquaculture

12-14

<http://kzr.agrobiologie.cz/>

37

## OFFSHORE AQUACULTURE



12-14

<http://kzr.agrobiologie.cz/>

38

## OFFSHORE AQUACULTURE



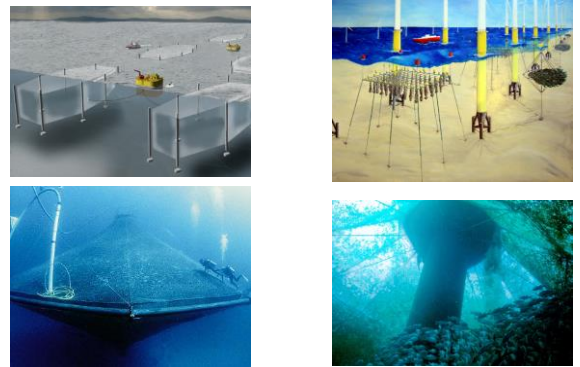
Oceansphere – future breeding system

12-14

<http://kzr.agrobiologie.cz/>

39

## OFFSHORE AQUACULTURE

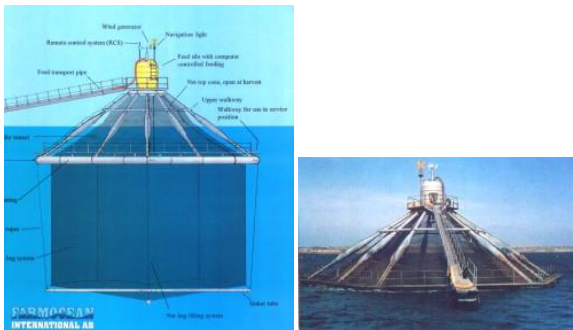


12-14

<http://kzr.agrobiologie.cz/>

40

## OFFSHORE - FARMOCEAN



12-14

<http://kzr.agrobiologie.cz/>

41

## OFFSHORE AQUACULTURE

Marine aquaculture..  
[video](#)

12-14

<http://kzr.agrobiologie.cz/>

42

### Marine species in culture

- Salmon
- Sea bass
- Cod fish
- Cobia
- Tuna
- Flatfish



12-14 <http://kzr.agrobiologie.cz/> 43

### SEABASS - *DICENTRARCHUS LABRAX*



12-14 <http://kzr.agrobiologie.cz/> 44

### Cod – *Gadus morhua*

Difficulties with artificial breeding  
Colaps of natural populations due to high fishery pressure



12-14 <http://kzr.agrobiologie.cz/> 45

### COBIA

Cobia - *Rachycentron canadum*



(USA, South-east Asia, China).

Cobia - video



12-14 <http://kzr.agrobiologie.cz/> 46

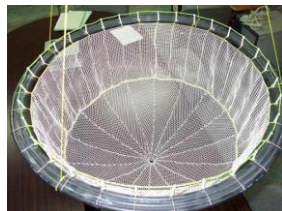
### TUNNA FISH - *Thunnus*



Most demanded fish on the world  
Heavy pressure by fishery

VIDEO

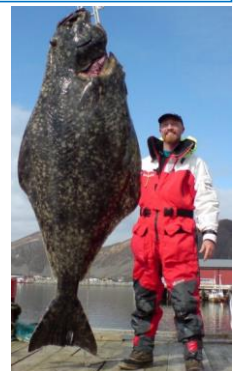
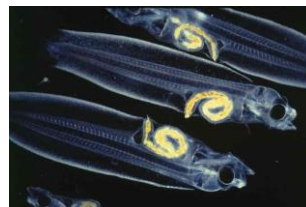
dP



12-14 <http://kzr.agrobiologie.cz/> 47

### FLATFISH

- Halibut *Hippoglossus hippoglossus*
- (Canada, Norway)



12-14 <http://kzr.agrobiologie.cz/> 48

## FLATFISH

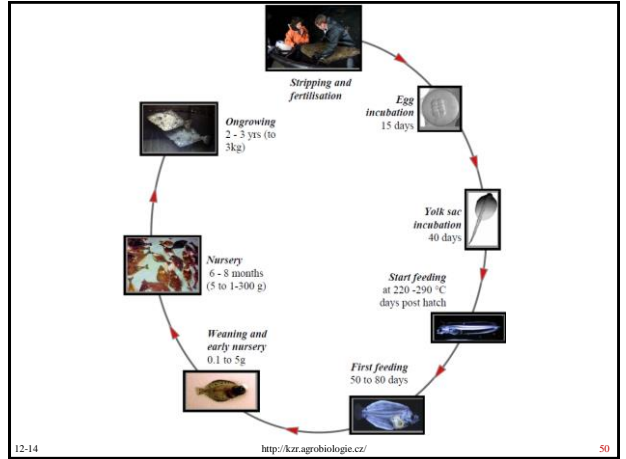
spawning



12-14

<http://kzr.agrobiologie.cz/>

49



12-14

<http://kzr.agrobiologie.cz/>

50

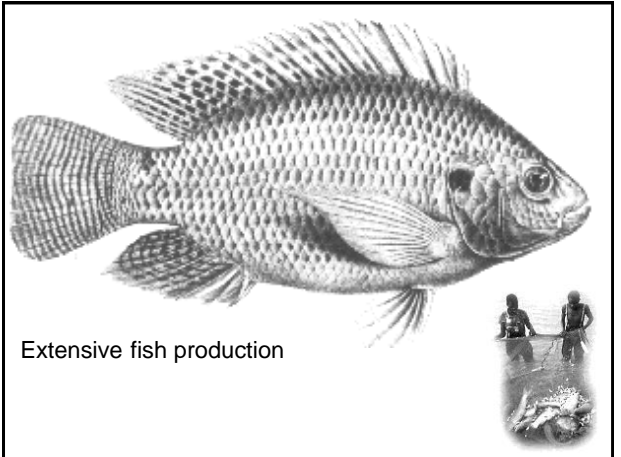
## SOURCES AND LINKS

- T. V. R. Pillay and M. N. Kutty, Aquaculture: Principles and Practices (2nd edition), 2007
- J. Kouřil, Využití recirkulačních systémů s biologickým čištěním vody k intenzivnímu breedingu ryb, 2006
- [http://ec.europa.eu/fisheries/cfp/aquaculture\\_processing/aquaculture/type\\_cs.htm](http://ec.europa.eu/fisheries/cfp/aquaculture_processing/aquaculture/type_cs.htm)
- [http://ec.europa.eu/fisheries/cfp/aquaculture\\_processing/aquaculture/species\\_cs.htm](http://ec.europa.eu/fisheries/cfp/aquaculture_processing/aquaculture/species_cs.htm)
- [http://www.aquabait.com.au/aquabait\\_worm\\_farm\\_photo\\_gallery.phtml](http://www.aquabait.com.au/aquabait_worm_farm_photo_gallery.phtml)
- <http://www.nordtrade.com.au/farmlife-text.html>
- <http://www.ccar.umaine.edu/>
- <http://www.youtube.com> ©

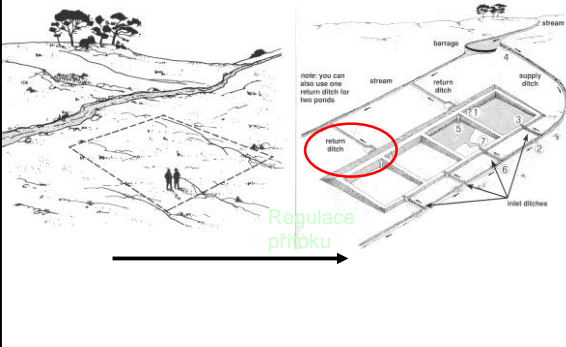
12-14

<http://kzr.agrobiologie.cz/>

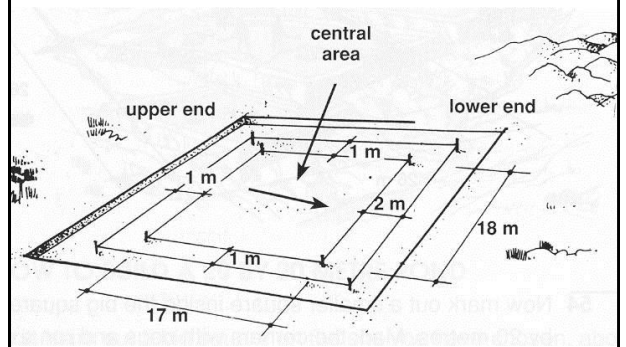
51



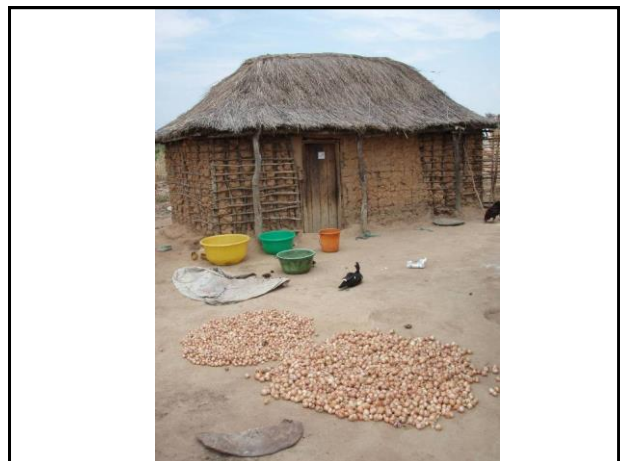
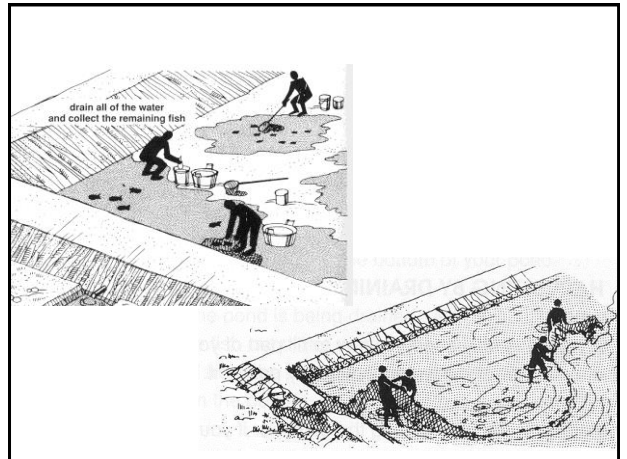
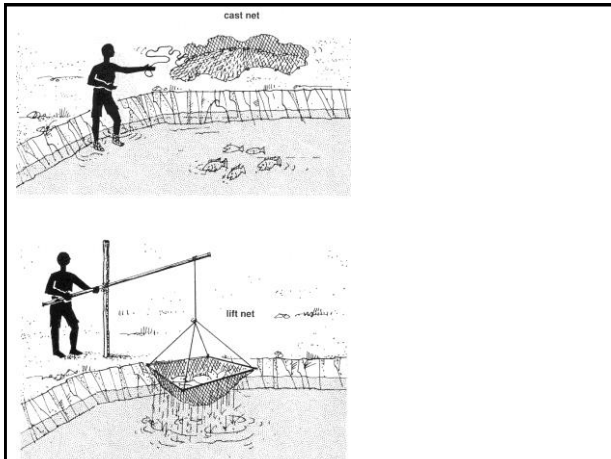
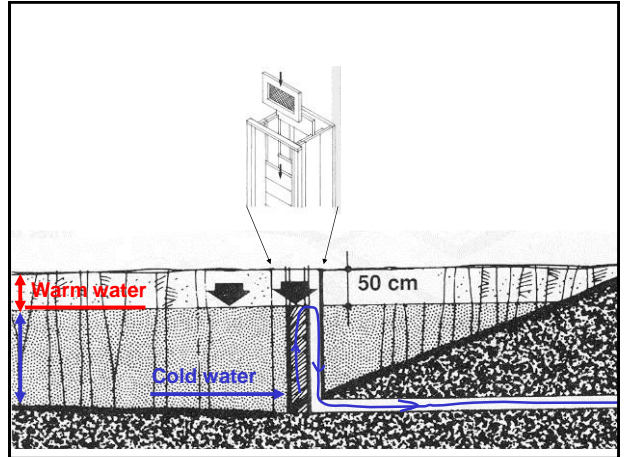
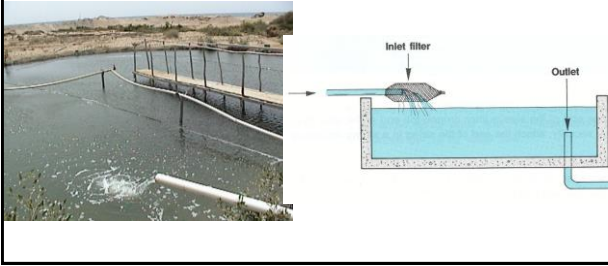
## Pond



## Pond construction



# Oxygenation

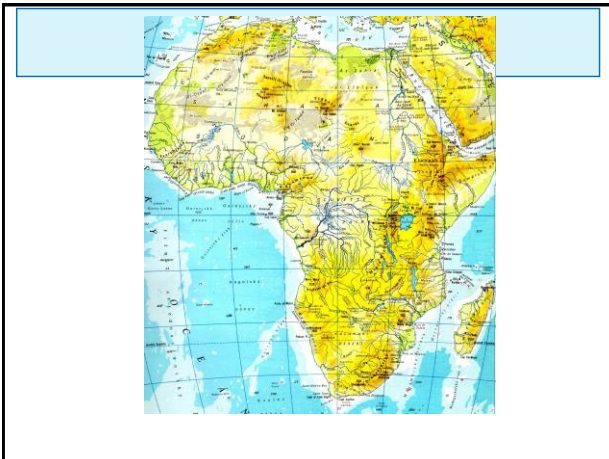
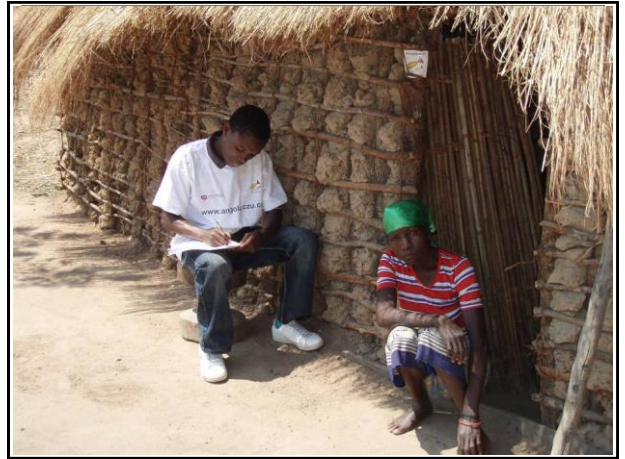






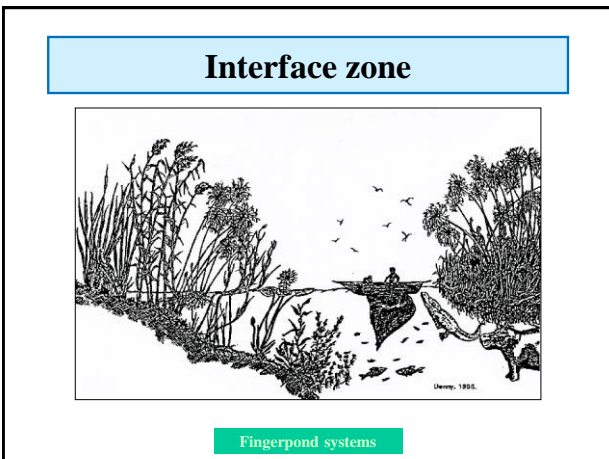




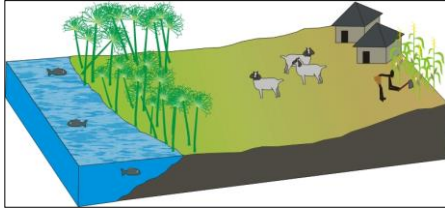


### Fingerponds

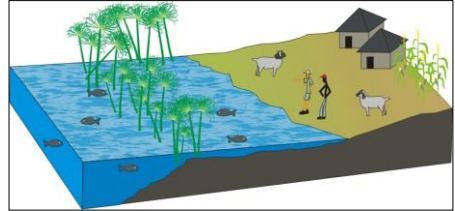
- small elongate pools excavated by hand in the flood zones of Victoria Lake and Rufiji River.
- 24 fingerponds were dug in three participating countries (Kenya, Tanzania, Uganda) during 2002. In each country two villages participate in the project, their communities each digging 4 fingerponds of individual size c. 8 x 24 m.



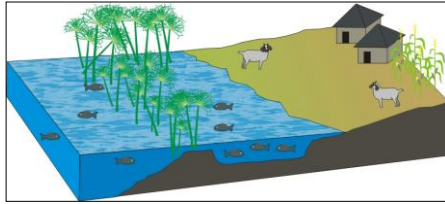
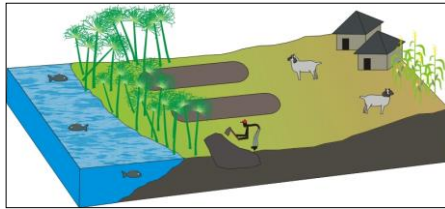
Fingerpond systems – natural system, dry season



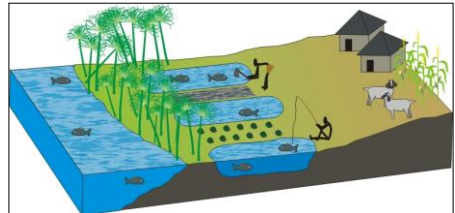
Fingerpond systems – natural system, wet season



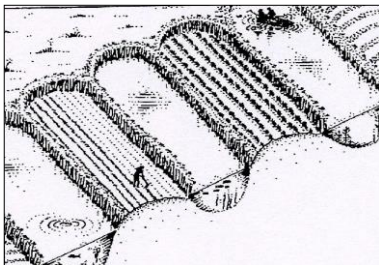
Fingerpond systems – construction and flooding



Fingerpond systems – in use

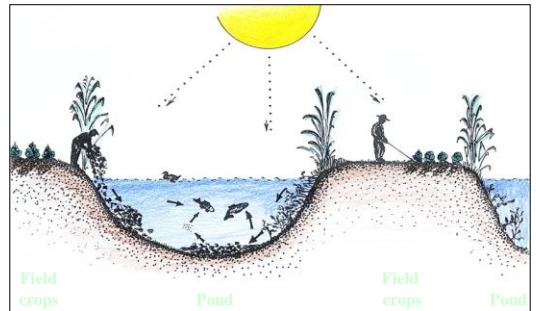


### Fingerponds system



Fingerpond systems

### Fingerpond systems scheme



Fingerpond systems

### Site selection



### Digging



### Fertilizing



### Natural fish stock

- *Tilapia nilotica*, *T. leucostiscus*, *T. variabilis*, *Haplochrominae*, *Gambusia affinis*, *Aplocheilichthys*, *Ctenopoma*, *Clarias sp.*, *Protopterus aethiopicus* are most common species trapped in Fingerponds.
- Several hundreds individuals in one pond . Total average weight up to 2kg in Uganda sites, c. 2.2 and 8.7 kg in Kenyan sites.





**Zooplankton structure in fingerponds**

Fish predation pressure

low                  medium                  high

**Zooplankton structure in ponds of temperate zone**

Fish predation pressure

low                  medium                  high



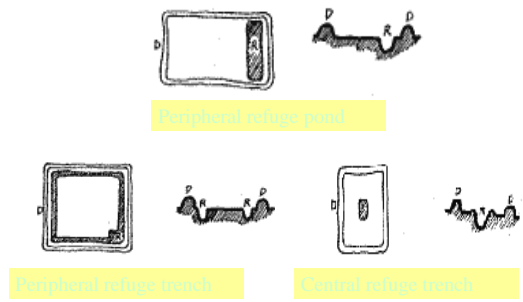
**1. Introduction**

- **Rice (*Oryza sativa* L.)** is the **most important staple food** in the world
- Daily diet of more than **3 billion people** is rice-based, esp. in Asia
- **Annual production** of almost 600 million tonnes
- **World rice area** around 150 million hectares
- **Global average rice yields** increased by 70% since the 1960s („Green Revolution“)
- **Declining growth rates** of rice production since the 1980s and a **complete standstill** in the recent years
- **Decreasing per capita rice consumption** in Asia and **falling rice prices**
- **Integrated rice-fish production** may be an alternative path due to **optimized resource use** and **improved nutrition values** for the people esp. in rural areas

### Types of rice-fish culture

- **Rotating rice and fish production**
  - One rice crop and one fish crop annually
  - Two rice crop and one fish crop in one year
- **Concurrent rice and fish production**
- **Concurrent rice and fish production with continued fish production after rice harvest**

### Field layout



### Rice-fish production with poultry and azolla fern



### Poultry faeces as fertilizer



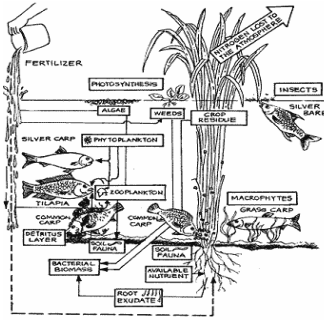
### Rice field with central pond



### Rice-fish in China



### Simplified nutrition flow



### Fish species stocked in rice fields Typical countries

Fish species stocked in rice fields	Typical countries
Grass carp ( <i>Ctenopharyngodon idella</i> )	China, India
Silver carp ( <i>Hypophthalmichthys molitrix</i> )	China
Common Carp ( <i>Cyprinus carpio</i> )	China, India, Vietnam, Indonesia, Madagascar, Zimbabwe, Japan
Bighead Carp ( <i>Aristichthys nobilis</i> )	China
Indian major carps ( <i>Labeo rohita</i> , <i>Cyrrhinus mringala</i> , and <i>Catla Catla</i> )	India
Silver barb ( <i>Barbonymus gonionotus</i> )	Thailand, Vietnam
Nile Tilapia ( <i>Oreochromis niloticus</i> )	Vietnam, Philippines, Tanzania, Gabon
Gourami ( <i>Trichogaster pectoralis</i> )	Various Asian countries
Catfish ( <i>Clarias macrocephalus</i> )	Various Asian countries
Snakehead fish ( <i>Channa striata</i> )	Various Asian countries
Freshwater prawn ( <i>Macrobrachium rosenbergii</i> )	India

### Grass carp (*Ctenopharyngodon idella*)



### Common carp (*Cyprinus carpio*)



### Silver carp (*Hypophthalmichthys molitrix*)



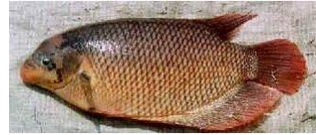
### Bighead carp (*Aristichthys nobilis*)



### Catla Catla



### Gourami



### Nile Tilapia (*Oreochromis niloticus*)



### Catfish (*Clarias macrocephalus*)



### Fish yield

- The **rate of production of fish** depends on factors such as the method of production (intensive or extensive), species cultured, the depth of the water, the interest of the farmer and the production potential of the fish
- **Data on fish yield** vary typically between 200 to 700 kg/ ha, extreme values vary between near to zero up to 2250kg/ha
- **Fish polyculture** appears to stimulate increased fish yields due to utilization of trophic niches in the rice field
- An **optimal fish stocking density** helps to increase fish yields
- The **application of inputs** such as extra feed, mineral fertilizer or manure (e.g. cow dung) is recommendable to enhance fish growth

### Costs and Revenues

- **Increased costs**
  1. **Investment costs**
    - Refuge pond/ trenches
    - Robust dikes
  2. **Variable Costs**
    - Fry/ fingerlings
    - Fish feed
    - Labor costs
- **Reduced Costs**
  - Less chemical pest and weed control
  - Less fertilizer
- **Increased Revenues**
  - Stocked fish
  - Increased rice yield



## Socioeconomic Benefits

### Farm and household level

- Increase of farm income
- Increase of liquidity
- Diversification of agricultural production
- Utilization of excess family labor
- Off-season occupation
- Improvement of nutrition value by supply of high quality protein, lipids and vitamins esp. for rural areas

### Macroeconomic level

- Source of additional income in rural areas
- Supply on a market with rising demand for (freshwater) fish
- Improved utilization of scarce resources (esp. land and water)

## 5. Ecological effects of rice-fish systems

## Pest and weed control of fish

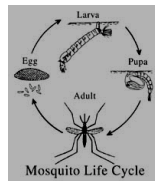
### Control effect proven

(by stomach content analysis, Pest sampling, and damage assessment)

- **Brown plant hopper** (*Nilaparvata lugens*)
- **Golden apple snail** (*Poamcea canaliculata*)
- **Mosquitoes (eggs and larvae)**
- **Rice caseworm** (*Nymphula depunctalis*)
- **Floating and submerged weeds and algae** by up to 100%

### Control effect assumed, but not proven

- **Rice stemborer** (*Chilo suppressalis*)



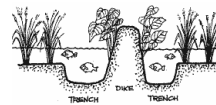
## Effect of Fish on Rice Yields

### Negative Effects

- Reduction of the rice area due to the need of a fish refuge
- Possible damage of young rice plants by macroherbivorous fish species (e.g. grass carp)

### Possitive Effects

- Excretion of faeces and ammonia by fish (fertilizer)
- Increased mineralization of organic nutrients
- Less gaseous N-losses in the form of  $N_2O$  and  $NH_3$
- Improved biological N-fixation
- Weed control
- Pest control



## Constraints and Possible Solutions

### Lack of knowledge and skills among the farmers

Education and extension work

### Higher labor and capital required

Credits, subsidies, loans

### High pesticide application

Can often be reduced without negative effects on rice yield

### Theft

Fields near the house, fences

### Technological and infrastructure problems

Development of infrastructure, Improved management

### Unfavorable political framework

Go to vote, become a politician!











