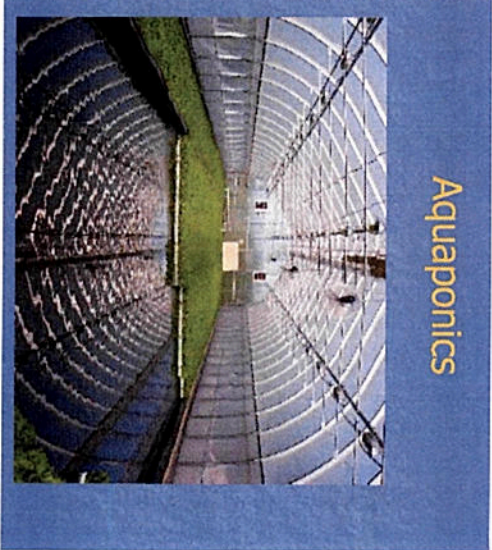
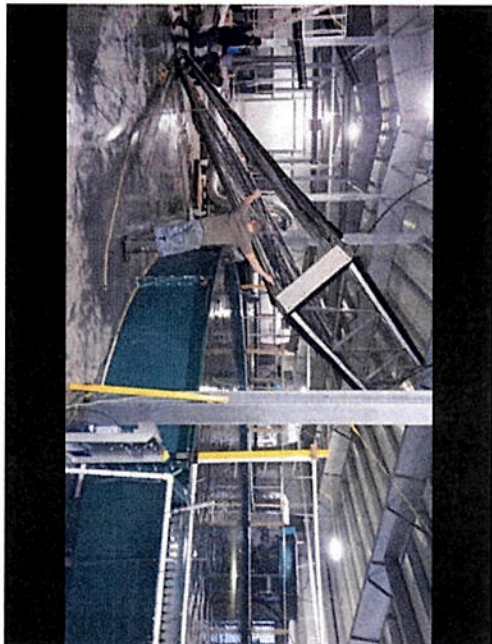


LITTLE CEDAR FALLS



Aquaponics

## AQUAPONIC cycle



AQUAPONICS is the Combination of Aquaculture and Hydroponics  
 In a Sustainable Re-Circulating Food Production System

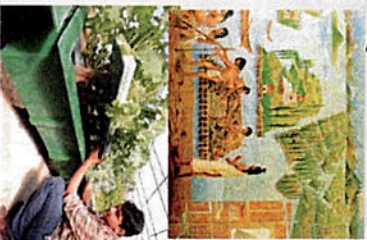
Low Stress, Freshwater Fish Culture and Naturally Organic Hydroponic Crop Production

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## AQUAPONIC History



- Meso-American 'Chinampas' Farming – Integrate plant culture above stocked fish ponds, as early as 1150 CE.
- Estimated at 1/2 to 2/3 of Aztec food production.
- Anyone who has had access to a pond, river or lake has done aquaponics.
- Goal is the inclusion of many trophic levels, fill as many biological niches as possible
- These edge zones maximize biological surface area (BSA) and are the 'engine' of aquaponics as your biotlier

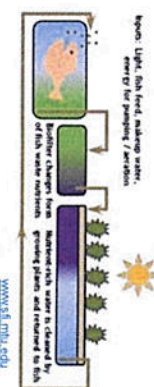
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## Why Aquaponics?

- ❖ Nitrate is a by-product in intensive aquaculture systems and must be removed
- ❖ Denitrification systems can be complex and add an additional cost
- ❖ Plants provide a denitrification function and provide an additional saleable crop



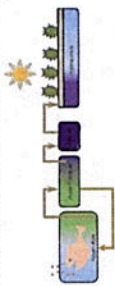
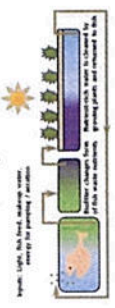
www.usa.mbu.edu



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## Coupled v. De-Coupled Systems

- ❖ Coupled Systems
  - Common water for fish and plants
- ❖ De-coupled Systems
  - Independent recirculation systems for fish and plants
  - Nutrients transferred from fish to plants via digester



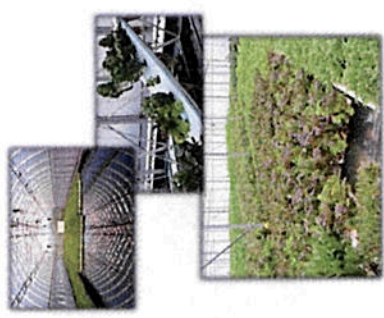
## Media Bed Technique

- ❖ Inert medium (clay balls, coco fibre) used to secure roots
- ❖ Beds flooded and drained or drip-irrigated
- ❖ Advantages:
  - High surface area for growth of beneficial bacteria in root zone
  - Excellent for vine crops
- ❖ Disadvantages:
  - In aquaponics, media can trap solids and promote growth of deleterious bacteria



## Deep Water / Raft Technique

- ❖ Common in aquaponics
- ❖ Plants float on rafts
- ❖ Advantages:
  - Allows for well-mixed, aerated troughs
  - Relatively low risk
  - Water volume provides thermal mass for stable temperatures
- ❖ Disadvantages:
  - Structural requirement to support weight of water
  - Solids settling in troughs



## Nutrient Film Technique

- ❖ Plants placed in shallow troughs with fast-flowing water
- ❖ Advantages:
  - Higher plant densities
  - Lower weight enables vertical stacking



## AQUAPONIC fish



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# PRODUCTIVITY TREND chart

Annual Production trend for an Aquaponic farm

Year	Production (Units)
0.5	100
1.0	120
1.5	150
2.0	200
2.5	250
3.0	300

**AQUAPONIC PRODUCTIVITY**  
The Gross production almost doubles for the period of four years without any additional investments or increase in growing area.

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## Comparative growth trials shows aquaponics is better

Crop	Hydroponics	Aquaponics
Tomatoes	~3.5	~6.5
Cucumbers	~2.5	~4.5

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## Fresh City Farms, Canada

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## Four Seasons Greens – Muskoka

## Aqua Greens Mississauga Indoor, Stacked, Lighting

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## Trend Aqua

- 50 tonnes annual fish production
- 400,000 – 600,000 heads of leafy vegetables
- Organic certification for fish and vegetables

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Green Relief – Flamborough. Nelson & Pade, tilapia, cannabis



Target Marine – Sechelt, BC White Sturgeon, Coho Salmon Organic Aquaponics



# AQUAPONIC Canadian Challenges



AQUAPONICS = FARMING

- Heating, OMG Winter.
- Artificial Lighting – bulb type, LED, waste heat output, Lumens per sq ft? Watts per sq ft?
- Risk is not well understood
  - Fish Kill = Crop Disruption = Revenue + Margin erosion
- Supply chain is not well established
- Lack of Human Capital
- Steep learning curve
- Few commercially successful operations, no 'models'

## Section 2

### Production Requirements

- Water supply – quality & quantity
- Eggs & Fingerling Supply
- Nutrition & Growth
- Fish Health Management
- Permits, Licences, etc.
- Nutrient Management

## Water Resources

Parameter	Recommended Level
Temperature	15°C (1-24°C)
Dissolved Oxygen	> 6 mg/L
Hydrogen Sulphide	<0.002 mg/L
Iron	<0.15 mg/L
Hardness	100-500 mg/L
pH	6.5 – 8.0
Total Gas Pressure	<102%
Total Ammonia (NH3)	<0.0125 mg/L
Nitrite (NO2)	<0.005 mg/L
Nitrate (NO3)	<100 mg/L
Chlorine	<0.03 mg/L
Manganese	<0.01 mg/L
Phosphorus	<0.01 mg/L






## Surface Water

### Advantages

- Large quantities available
- Warmer summer temperatures
- Can be gravity flow

### Disadvantages

- Fluctuating temperatures
- Variable water chemistry
- Possible exposure to contaminants and pathogens



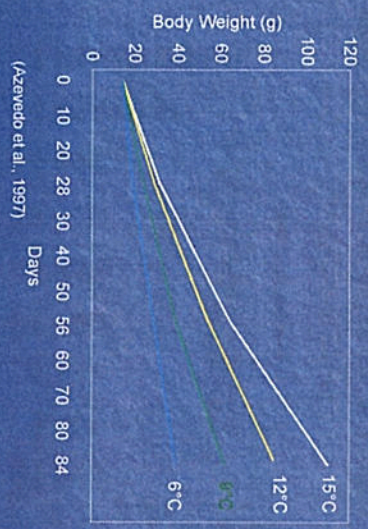
### Ground Water

- Advantages
  - Stable chemistry & temperatures
  - Generally good quality
  - Contaminant & pathogen free
- Disadvantages
  - Temperature generally below optimum for growth of rainbow trout
  - Quantity may be limited



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### Trout Growth v. Temperature



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### Egg & Fingerling Supply

- Several commercial hatcheries in Ontario produce eggs and fingerlings for sale to on-growers
  - Many have own broodstock
  - Some import eggs from Troutlodge (WA)
  - Canadian rainbow trout broodstock program being developed



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### Feed

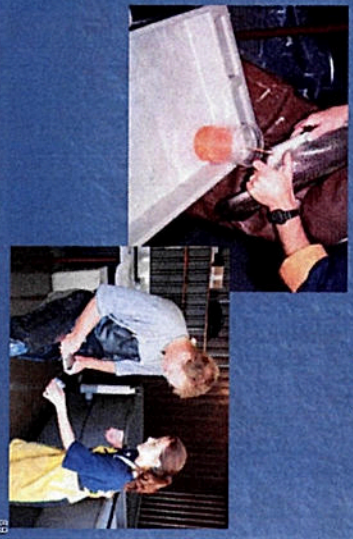
- It is important to use a high-quality diet
  - High digestibility
  - Low waste output
- Feed Conversion Ratio
  - FCR = kg gain / kg feed
  - = 1.0 – 1.3



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### Egg & Milt Collection

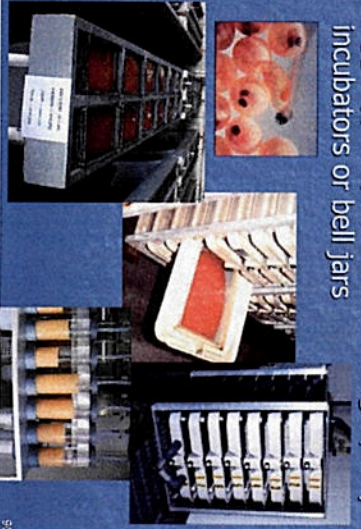
Eggs available 12 months per year



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### Hatching

Eggs typically hatched in troughs, tray incubators or bell jars



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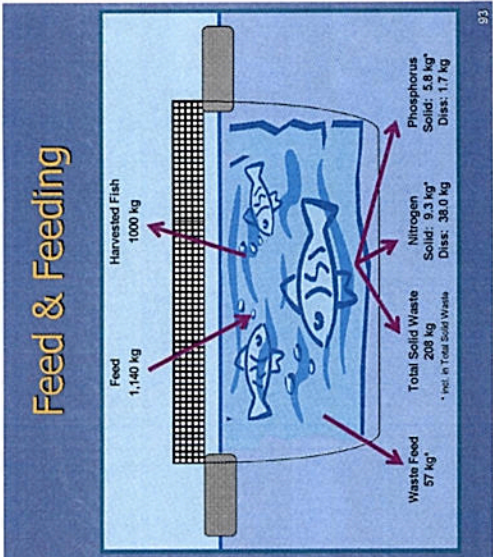
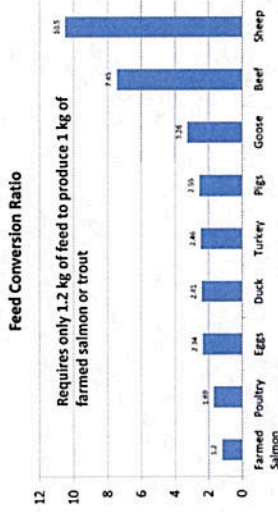
16



## Fingerlings

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Aquaculture is one of the most efficient protein producing sectors...



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## Feed Delivery

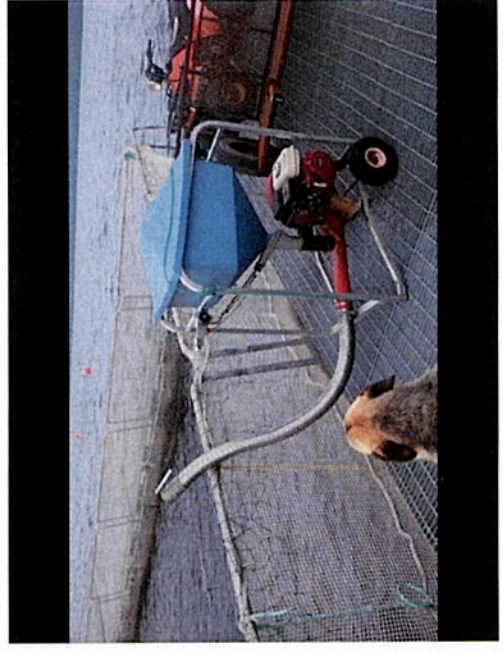
- Hand Feeding**
  - ✓ Observation
  - ✗ Labour-intensive
  - ✗ Difficult in adverse weather
  - ✗ Careless delivery is a major cause of feed waste
- Demand Feeders**
  - ✓ Behaviour-driven (ad lib)
  - ✗ Competition for feed
  - ✗ 'play' can waste feed

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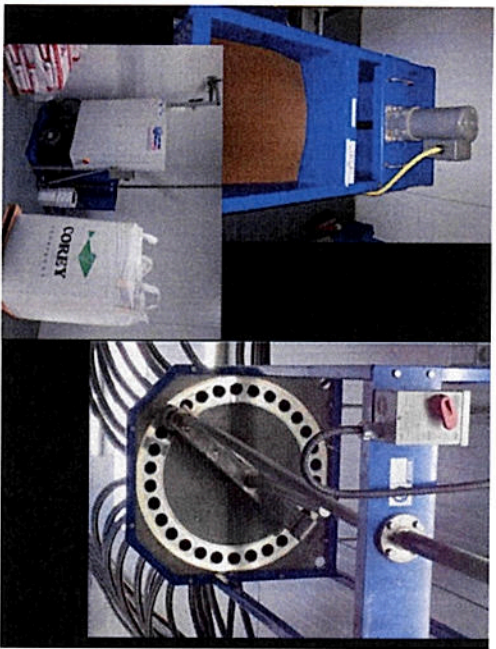
## Feed Delivery

- Automatic Feeders**
  - ✓ Programmable
  - ✓ Reduced Labour
  - ✗ Dependent on good production modelling
  - ✗ May feed when fish aren't eating
- Operator controlled**
- Automatic**

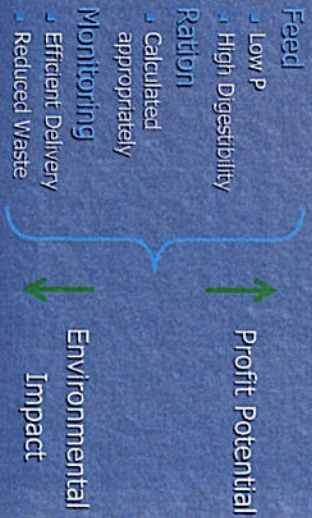
95







### Benefits of Improved Feed & Feeding



### Fish Health Management

- Issues raised in the past have included:
  - Introductions of disease to wild fish populations,
  - hormone use,
  - Genetically Modified Organisms,
  - antibiotic usage,
  - sea lice,
  - ISA virus ... etc!

*What do we really need to be concerned about in Ontario?*

### Use of Therapeutic Agents

- Antimicrobials are not used for growth promotion
- Antimicrobials are used in aquaculture if fish have a microbial disease (therapeutic intervention) and administered through feed mixed under a veterinary prescription at the feed mill
- Antimicrobials are used only under veterinary supervision
- All cage farms have a fish health management plan
  - Proper fish husbandry is key to keeping fish healthy and growing
  - Stressed and sick fish do not grow
  - Mortalities are expensive!



### Fish Health Summary

- No records of disease transmission from farmed to wild fish in Ontario
  - Industry has an excellent fish health record
- Managing stress through proper water quality, farm management and husbandry, bio-security, densities and reduced handling is key to healthy fish
- If disease is manifest (with >1000 mortalities) the MNR must be notified within 48 hours (condition of license).
- Mandatory notification of detection of 10 diseases
  - Fisheries & Oceans Canada – Fish Health Protection Regulations




### Aquaculture Regulation

- Principal Government Agencies
  - Municipal
  - Conservation Authorities
  - Ministry of Natural Resources
  - Ministry of the Environment
  - Ministry of Agriculture, Food and Rural Affairs
  - Fisheries and Oceans Canada
  - Canadian Food Inspection Agency
  - Health Canada





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### Why are Regulations Required?

- ❖ To protect you
- ❖ To protect others
- ❖ To avoid user group conflicts
- ❖ To protect the environment, including physical and biological
- ❖ To allow fair, sharing of resources

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### Authorities

Municipal Governments

- ❖ Business Licensing
- ❖ Zoning and Land-Use Bylaws
- ❖ Effluent entering municipal drains

Conservation Authorities

- ❖ Building or digging on flood- plains
- ❖ Hazard land zoning
- ❖ Discharging water to wetlands

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### Ministry of Natural Resources & Forestry


*Lakes and Rivers Improvement Act*

- ❖ Application for work permit within a water body

*Fish and Wildlife Conservation Act*


- ❖ Aquaculture License
- ❖ Fish Stocking License
- ❖ License to Collect Fish from Ontario Waters
- ❖ Species permitted for culture in Ontario (e.g., Rainbow Trout, Arctic Charr, Tilapia)

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### Aquaculture License – Aquaculture Regulations (664/98) under the FWCA

You need a licence(s) to culture/buy/sell fish and transport live fish in Ontario. The only exemption from the need for an aquaculture licence is if the fish are cultured in an aquarium for personal use or the aquarium trade (O.Reg.664/98 s.24). There is also an exemption from the need for a licence to buy/sell goldfish, koi and tilapia if they are bought or sold for the purpose of the aquarium trade (O.Reg.664/98 s.24(2)).



Size of a commercial operation is not a factor. Raising fish in an aquarium, but selling them for anything other than the aquarium trade, an Aquaculture Licence is still required.

The small, plastic or concrete lined ornamental water garden is considered an aquarium (if for personal use or aquarium trade), and would not require a licence.

### Aquaculture Licensing Flow Chart

```

    graph TD
      A[ARE YOU CULTURING FISH?] -- Yes --> B[Are you exempt from an aquaculture licence?]
      A -- No --> C[No aquaculture licence needed]
      B -- Yes --> C
      B -- No --> D[Are the fish to be cultured on O. Reg. 664/98-- Schedule B?]
      D -- No --> E[No aquaculture licence needed]
      D -- Yes --> F[Application review by Ontario Introductions and Transfers Committee (OITC)]
      F --> G[Aquaculture licence needed]
  
```

Exemptions:

1. The person cultures fish in an aquarium for personal use
2. The person cultures fish in an aquarium for the purpose of engaging in the aquarium trade
3. The person cultures fish in an aquarium located at an educational institution or facility
4. The person cultures fish in an aquarium located at premises that are generally open to the public for the sole purpose of exhibiting the fish to the public at the premises.

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### Species Permitted for Culture

Atlantic Salmon	Rainbow Trout	Crayfish	Burbotose Minnow
Brown Trout	American Eel	Walleye	Fairhead Minnow
Lake Trout	Lake Herring	Sauger	Redbelly Dace
Brook Trout	Northern Pike	Yellow Perch	Finescale Dace
Arctic Char	Muskellunge	Largemouth Bass	Common Shiner
Chinook Salmon	Carp / Goldfish	Smallmouth Bass	Golden Shiner
Coho Salmon	Trapia	Channel Catfish	Emerald Shiner
Pink Salmon	Bullgill	Brown Bullhead	White Sucker
Lake Sturgeon	Lake Whitefish	Black Crappie	Pumpkinseed

Added in 2013 – Pacific White Leg Shrimp  
 Added in 2016 – Giant Freshwater Prawn and Barramundi.

### The Ontario Fisheries Regulations PROHIBIT the possession of live:

- Ruffe
- Grass Carp
- Bighead Carp
- Silver Carp
- Black Carp
- Snakehead
- Rudd
- Round Goby
- Tubenose Goby

### Risk Assessments for "new" species for the OITC process

- Clarius – African catfish
- European Sea Bass
- Gilthead Sea Bream
- Hybrid Striped Bass
- Turbot
- Shortnose Sturgeon
- White Sturgeon
- Sea Cucumber
- Tiger Shrimp

### Largemouth Bass - Biology and Culture



- Female Largemouth Bass do not always lay all their eggs in one nest. Producers stock more males than females in spawning pools, to increase the likelihood of fertilization. Males take the role of guarding nests from predators.
- There is no common accepted method of culture.
- Most are farmed in ponds, but raceways may be used too.
- Characteristics including their large mouth, cannibalistic tendency and resistance in accepting feed makes this species a challenging species to culture.

<http://www.rcrcinc.org/RIS/en/yref/42E438CC-7C9E-42AE-8B18-219E0066A92D/0/gmnlhbass32300.pdf>



- Most producers combine a prepared diet and live fish for their stock to eat. However, fingerlings can also be raised on insects (usually 2 – 4 inch fingerlings held at low densities) or can be habituated to accept a prepared diet (usually 1 – 2 inch fingerlings)
- The easiest way to achieve spawning is to place adults into a fertilized pond that is free of other fish. This method provides variable outcomes, ranging from a couple hundred to a possible 50, 000 fish/acre.

<http://www.rcrcinc.org/RIS/en/yref/42E438CC-7C9E-42AE-8B18-219E0066A92D/0/gmnlhbass32300.pdf>

- Ponds are fertilized with inorganic or organic fertilizers to maintain optimal zooplankton densities.
- Fingerlings will reach a length of 1.5 – 2.0 inches within 20 – 40 days after hatching.
- Largemouth bass become very cannibalistic once they deplete their zooplankton source. Just a couple days can result in a large number of lost fish.
- A 75 – 80% harvest can be obtained with the use of good management skills.



<http://www.rcrcinc.org/RIS/en/yref/42E438CC-7C9E-42AE-8B18-219E0066A92D/0/gmnlhbass32300.pdf>  
 Wolf Lake Fish Hatchery, Michigan



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### Walleye Culture



- In the last several years techniques have been developed to successfully raise walleye to market size in recirculation systems - from eggs to a 1 kg
- No longer need a fingerling pond production phase.



### Whitefish Culture



- In the last decade techniques have been developed to successfully raise whitefish to market size in recirculation and flow through systems - from eggs to market size.
- Current project looking at open water net pen farming techniques.

### Yellow Perch (Perca flavescens)



- In Canada, this cool-water species can be found in Nova Scotia, Quebec, the Great Slave Lake of the NWT, various watersheds of BC and is especially abundant in the Manitoba & Great Lakes.
- Important both recreationally and commercially, the yellow perch features white, flaky flesh that is common in popular "fish and chips".

### Culturing of Yellow Perch & its Limitations

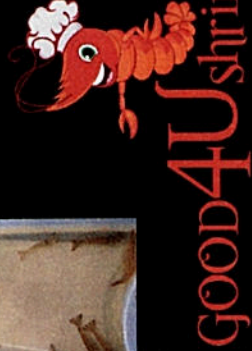
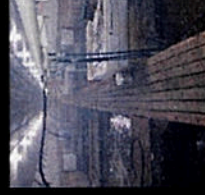
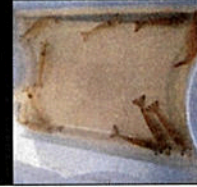
- Conflicting biological factors include differences in growth rate between males and females (females mature much faster) and the fact that sexual maturity is reached before the fish is at the desirable market size.
- Limited knowledge of nutritional requirements and problems with meeting demands of fingerlings also contribute to complications in the culturing of yellow perch.
- Producers can obtain brood fish by capturing wild fish just before spawning or by raising their own fish until they are reproductively mature.



<http://www.mcrac.org/NR/rdonlyres/6296E4D7-3D07-4CBD-BDC4-D7CE8FFD2212/0/YellowPerchPub.pdf>



### Pacific White Shrimp



### Aquaculture Licence

- Aquaculture Regulations under FWCA
- Private property
- No closed seasons
- No catch limits
- Valid for "X" years - new policy under development
- Transferable
- \$50 a year
- Facility inspection - risk of escapes

