Developments in Land-Based Closed-Containment System for Fish Production

Steven Summerfelt
• Fish provide between 40-60% of the world's protein

• Harvest of fish species that provide fish meal & oil has remained static, i.e., 20-25 million mton/yr
  – Many capture fisheries are over-exploited

• Human population and income growth has created a shortage of food fish

• Aquaculture must grow to meet this demand
Most Seafood Comes From Aquaculture

Salmon
Shrimp
Trout
Catfish
Tilapia

85% of U.S. Seafood is Imported
United States Farm Production

- **Fish production (approximate)**
  - CATFISH 210 million kg/yr
  - TROUT 16 million kg/yr
  - SALMON 18 million kg/yr
  - TILAPIA 9 million kg/yr

- **Terrestrial Animals**
  - POULTRY 17 billion kg/yr (#1 in World)
  - CATTLE 10.6 billion kg/yr (#1 in World)
  - HOGS 10.0 billion kg/yr (#2 in World)
  - **TOTAL** 37.6 billion kg/yr

0.5% of terrestrial animal production
Terrestrial animal production is highly regulated and controlled

- No point source discharge allowed
- Physical barriers help prevent pathogen spread
- Control of what the animal eats
United States Catfish Production

- Pond production is relatively environmentally friendly
  - Solar/algae powered treatment within ponds
  - Point source discharge is heavily regulated
Salmon Net Pen Production

• Like a CAFO, but
  - no discharge limits
  - no capacity to capture wastes
  - Inadequate physical barriers to prevent pathogens from spreading into or out of farm
Fish Farming: Major Environmental Challenges

- Resource constraints:
  - Limited water supplies
  - Limited marine fish meal/oil supplies
  - Water pollution & impacts on watersheds

- Separation of farmed fish from wild fish:
  - Transmission of pathogens into & out of the farm
  - Domesticated stocks escaping & interacting with wild populations
• How do we achieve new efficiencies in feeding a growing global population with increasing environmental impact conflicts and looming resource constraints?
Production Technologies must protect the environment and the wholesomeness of the fish, while providing for economic opportunity.
• Globally, agriculture consumes around 70% of available water
  – more than 80% of available water in the developing world.

• Land-based closed-containment systems for fish farming do not consume water, but return it to the environment after its use
  – Small water requirements are less impacted by climate change
Containment is Necessary for Sustainable Aquaculture

- **Insufficient water resources** for flow-through fish culture systems.
- Closed-containment system can increase production on a limited water supply by 5 to 100+ fold.
• Blue Lakes Trout Farms sold their water rights for $30 million
  – About 2 million lb/yr trout production in Snake River Canyon, Idaho
• Clear Springs Trout Farm might ask $300 million to sell water rights
  – About 20 million lb/yr trout production in Snake River Canyon, Idaho
Containment is Necessary for Sustainable Aquaculture

- Land-based closed-containment systems are essentially giant water treatment facilities
- Recirculating water is the engine powering the system
- Water use is typically < 1% of flow-through culture practices
Containment is Necessary for Sustainable Aquaculture

- Land-based, closed-containment systems:
  - Enhance separation of farmed and wild
    - Prevent escapees, disease, & interaction between wild & farmed fish
  - Optimize site selection
    - Move farms away from sensitive environments and closer to markets
    - Locate farm where electric & land are cheap
      - US$ 0.02-0.06 / KWH
Containment is Necessary for Sustainable Aquaculture

- Land-based, closed-containment systems
  - Exclude pathogens
  - Minimize use of pesticides, antibiotics, & chemo-therapeutics
- For 10 years & 200 ton production, we have not used
  - vaccines
  - pesticide
  - antibiotic
  - chemothrapeutic (other than salt)
Containment is Necessary for Sustainable Aquaculture

• RAS have a relatively small point source discharge
  – Must meet discharge permit limits
• Place wastes into relatively small & concentrated effluent flows.
  – Increase waste treatment efficiency,
    > 90-99% waste capture is possible;
  – Improved waste capture will reduce TMDL discharged,
    • Total Maximum Daily Load;
  – Reduce the size and cost of effluent treatment,
Containment is Necessary for Sustainable Aquaculture

• Reclaim nutrients
  – Agronomic application of biosolids to crops
  – Aquaponics (ultimate in local production)

Recent article: “Fertilizer is a better buy than gold”!
Fish Production in a Controlled Environment

- Control water quality, photoperiod, fish feed, density, & swimming speed
• Adopt new innovative technologies
  – Commercial-scale is an agri-business
  – Most competitive economics of production

Bell Aquaculture’s New 1000 ton/yr Addition
• Large and deep tanks are much more efficient in fixed & variable costs!

(Courtesy of Josh Goldman)
Research suggests that land-based closed-containment systems for *Atlantic salmon* are:

- **technically** viable
- **biologically** feasible, and
- **economically** sustainable at 3000 ton/yr scale

• pilot and commercial-scale projects must demonstrate economic viability
Examples of Existing Closed-Containment Fish Farms

• Atlantic salmon smolt (MANY worldwide)
  – Marine Harvest’s Sayward South Hatchery (BC)
Farms Now Producing Salmon in Land-Based Systems

- **Aquaseed** – *Sweetspring Salmon*, Rochester, **Washington** (Coho salmon)
- **Teton Fisheries LLC** – Miller Hutterite Colony, Choteau, **Montana** (Coho salmon)
- **Hill Fisheries LLC** – East End Hutterite Colony, Havre, **Montana** (Coho salmon)
- **Yantai Salmon Farm** – Shandong Oriental Ocean Sci-Tech Co., Yantai, Shandong Province, **China** (Atlantic salmon)
- **BDV SAS**, Normandie, **France** (Atlantic salmon)
Examples of Existing Closed-Containment Fish Farms
Examples of Existing Closed-Containment Fish Farms

- Teton Fisheries LLC and Hill Fisheries LLC
Yantai Salmon Farm
(Yantai, Shandong Province, China)

(slide courtesy of Idar Schei, AquaOptima)
Potential Projects

• **North America** potential projects for salmon growout in land-based closed containment systems:
  - British Columbia **6 projects** (2 in const; 5 planned)
  - U.S. **6 projects** (3 built; 3 planned)

• **Europe**
  - Denmark **2 project** (1 in const; 1 planned)
  - Scotland **1 project** (planned)

• **China** (2 built, several planned)

• **Chile** (2 planned)
• *Langsand Laks*, Hvide Sande, **Denmark** (Atlantic salmon); construction ending this fall
  - Deborah Haust, Atlantic Sapphire

• *Namgis First Nation – K’udas*, Port McNeill, **British Columbia**, Canada (Atlantic salmon); construction ending this fall
  - Eric Hobson, The SOS Marine Conservation Foundation

• *Sustainable Blue*, Centre Burlington, **Nova Scotia**, Canada (Atlantic salmon); converting to salmon with a 375-500 tonne farm planned
  - Dr. Jeremy Lee, Sustainable Blue
• There are more than a half dozen farms in the design, permitting or financing stage (as reported by the press)
  - *Atlantic Sapphire*, mid-Atlantic USA (Atlantic salmon)
  - *Palom Aquaculture*, Gouldsboro, ME, USA (Atlantic salmon)
  - *NeoSalmon*, Los Lagos Region, Southern Chile (Atlantic salmon)
  - *Danish Salmon AS*, Hirtshals, Denmark (Atlantic salmon)
Examples of Existing Closed-Containment Fish Farms

Yellow Perch
Bell Aquaculture, Albany, IN
Examples of Existing Closed-Containment Fish Farms

Bell Aquaculture, Albany, IN
Vertically integrated
Examples of Existing Closed-Containment Fish Farms

• Barramundi
  - Australis Aquaculture, Turners Falls, MA
Examples of Existing Closed-Containment Fish Farms

• Tilapia
  – Blue Ridge Aquaculture, Martinsville, VA

(photos courtesy of http://www.blueridgeaquaculture.com/tilapia.cfm)
Examples of Existing Closed-Containment Fish Farms

• Sturgeon
  - Northern Divine (Target Marine, BC)
  - Other farms in NC, FL, CA
Examples of Existing Closed-Containment Fish Farms

Virginia Cobia Farms
Conclusions

• Closed-containment systems have improved food security & reduced environmental impact:
  – Small water footprint
    • Water supply is less impacted by climate change
  – Efficient, with feed conversion near 1:1
  – Near zero waste discharge
  – Reduced antibiotic & chemotherapeutic use
  – Zero escapees - prevent genetic impacts on natural populations
  – Locate near the major markets, local production
Conclusions

• Land-Based Closed-Containment Systems
  – Confidence in technology is increasing
  – Scale of investment has increased to $5-25 million/project
  – Current N. American projects being built or planned with projected capital investment of ~$50-100 million
    • Atlantic salmon, Coho salmon
    • sea bream, yellow perch, cobia, sturgeon
    • Arctic char, walleye, sablefish, rainbow trout
Conclusions

- North America’s annual production of food-fish within closed-containment systems could increase by 10,000 to 50,000 ton in next 5 yrs
- Global annual production increases could total 100,000’s tons within closed-containment systems in next 5 yrs
  - Much growth in Atlantic salmon production in North America and China
Conclusions

• Advantages of fish farming in North America
  – Availability of enormous soy, grain, and protein byproducts for use as fish feed ingredients
  – Inexpensive electricity in some areas: $0.02-0.06/kwh
    • Much cheaper than China at $0.13/kwh
  – Close to major markets
    • Low CO2 footprint for shipping fresh product
  – Skilled work force
  – Reliable 3-phase power