Intensive Hatchery Production in a Partial Reuse Recirculating Aquaculture System

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Background

- The Dubois Hatchery is one of ten fish rearing stations in the state of Wyoming belonging to the Wyoming Game and Fish Department.
- The facility is nestled along the continental divide at 7000 feet on the east side of the Wind River Mountains in the northwest corner of the state.
About the facility…

- The facility was originally built in the early 1940’s.
- In 2006, a comprehensive hatchery remodel was completed. This was due to whirling disease being discovered in the production water.
- This transformed an aging facility to a state of the art facility utilizing a partial reuse recirculating system for intensive hatchery production.
Why was Recirculation System Chosen???

- Limited water supply available
- Maximize production
- Pathogen exclusion through a closed system
- Effective waste control
Dubois Pre-Construction
Dubois Post-Construction
Facility Operation....

• The goal for the facility is to operate effective and efficiently by optimally managing multiple fish stocks for statewide production. This is accomplished through:
  – Utilizing closed pathogen free water sources with limited flow while maintaining production. This is achieved through intensive water reuse after treatment processes.
  – A pump system along with a recirculation box is used for flow build up and endless water uses on the secondary side of the facility.
Primary Water Source

- Closed water source from two artesian wells
  - 330 gpm (1,249 liters) supplied
  - 67 Fahrenheit (19.5 Celsius)
  - Iron (1.0-2.0mg/l)
  - Nitrogen (130-140%)
  - Low Oxygen (1.0-2.0mg/l)
Treating of the Primary Water Source

- Used to oxidize the iron enriched source with presence of an Low Head Oxygenator (LHO)
- Carbon dioxide stripper (a total of two in operation)
- Water is fed up through the carbon dioxide stripping tower where carbon dioxide levels are reduced also providing PH control
Further Iron Treatment

- The water source is pumped through an iron filtration system supplied by Smith & Loveless Inc.
- The system successfully filters particulates in the incoming water down to two microns.
Well H$_2$O
High in CO$_2$ & Fe
Treated $\text{H}_2\text{O}$
Secondary Water Source

• Closed water source from a small spring
  – Fluctuating flow but a majority of the year averages 70 gpm (265 liters)
  – Temperatures fluctuate between 43- 50 degrees Fahrenheit
Secondary water treatment

- The water is forced by gravity up the degassing chamber
- Water is then treated by a UV system before the incubator and hatchery usage
Treated H₂O
Circular Dual Drain Tanks

- These are self cleaning circulars equipped with swirl separators.
- Side box allows for 85% of the flow to return to the reuse system.
- Center drain accounts for the other 15% of the flow leaving the tank. From this approximately 20% of the flow in the swirl separator will take settable solids out of the system. The remaining water goes to reuse.
- A net loss of approximately 3% water to the system during each usage.
- The center drain captures the settable solids and up to 80% of the total suspended solids leaving the tank.
Oxygenation Systems

- LHO’s used between all uses (a total of seven in operation)
- Maximize oxygen adsorption efficiency
- Units degas nitrogen while adding oxygen
Oxygenation Systems Cont.

- Oxygen generators providing 95% pure oxygen
- When injected at the LHO’s the oxygen forces out the nitrogen gas
Treated H$_2$O

Reuse
Drum Filters

- Two drum filters in operation equipped with 60 micron size screens
- Aid in the removal of fish waste left in system (i.e. ammonia)
- Filters capture up to 80% of the suspended solids put through this process
Pump System

- Reuse water is pumped from here to the secondary side of the facility
Recirculation box

- After construction, the facility witnessed a 27% loss of artesian well water. In 2011, this recirculation box was constructed.
- Allows staff to build up and manage flows for the secondary side of the facility
- Water velocities increased in tanks allowing for ideal tank operation
- Reuse water can be managed for almost endless uses
Treated H₂O

Reuse
Routine System Maintenance

• All equipment is routinely maintained to ensure its correct operation
• A checklists of duties with daily, weekly and monthly schedules are kept up
• All employees are trained on correct routine and preventive maintenance procedures
Equipment Failure and Troubleshooting Procedures

- An extensive and very detailed operations manual has been developed to assist in this process.
- Staff are properly trained in the replacement of necessary equipment.
- Extra parts are purchased and kept on hand as much as possible.
- A few examples of our equipment: Fibrotex, oxygen generators, VFD, PLC, UV system, blowers.
Production Challenges and Solutions...

- Rearing multiple fish stocks
- Water Supply
- Egg and Fish Production Planning
- Fish Health and Bio-security
- Monitoring of treatment processes
Rearing Multiple Fish Stocks

• Challenge:
  – Ten fish stocks are reared which include: Yellowstone, Snake River, Bear River and Colorado River Cutthroats, Fall, Fire Hole and Eagle Lake Rainbows, Brook Trout, Brown Trout and Arctic Grayling.
  – These stocks are reared for various stocking sizes and release times throughout the year. Many of which are restoration stocks that require specific or unique rearing techniques.

• Our Solution:
  – Experience, observation skills, thinking outside of the box, detailed notes and planning.
Water Supply

• Challenge:
  – The limited amount of fresh water available
  – Water chemistry issues such as extreme water hardness
  – Above optimal rearing temperatures
    • 90% of the circular rearing tanks are supplied with 60 to 67 F (15.5 to 19.5 C) water temperature year round.

• Our Solutions:
  – Rely on a partial recirculation system
  – Minimize other stressors to fish and keep up on removing hard water build up on everything.
  – Try to focus on using elevated rearing temperatures on stocks more tolerant and when possible use the temperature to our advantage.
    • Examples:
      – Minimizing Bacterial Cold-Water Disease outbreaks
      – Obtaining growth rates as high as 0.055 delta L
Egg Planning

• Challenge:
  – Incubate up to 5.2 million eggs from green to eyed egg from various stocks
  – Incubation water is limiting.
  – Space is also limiting so water temperature manipulation is critical for combining many takes of fish.

• Our Solutions:
  – Utilize drip incubators that can incubate 500,000 eggs on 5 gpm
  – Water temperature manipulation is used for combining many spawning takes. The use of a chiller and the two water sources gives us the ability to utilize incubation water temperature ranging from 39 to 65 F (4 to 18.3 C)
  – This allows us to achieve target size and timing objectives throughout the year.
Manipulation of Egg Development with Water Temperature

Days

Temperature Units

Lot 1
Lot 2
Lot 3
Lot 4
Lot 5
Lot 6
Fish Production Planning

• Challenges:
  – Producing catchables in both spring and fall while still achieving target goals for restoration plants.
  – Maximizing the capacity of the facility while rearing a diversity of fish stocks.

• Our Solutions:
  – Our production programs are set-up based on growth rates, carrying capacities, water temperatures, optimal density and flow indexes and particular feeding regimes.
  – Production mapping done in advance using maximum density index and flow index parameters.
  – Every week fish are sampled, feed calculated and the production is updated.
Fish Health / Bio-security

- Challenges:
  - Keeping the fish as healthy as possible while providing effective Bio-security at the facility.

- Our Solutions for Fish Health:
  - Production levels in tanks are managed throughout the year by keeping density indexes under 0.25 and flow indexes under 0.99.
  - Monitor pounds fed per tank per gpm of inflow
  - Measure all flows in rearing units at least weekly
  - Pick mortality at least twice a day (more often if a disease persists)
  - Pull center drain sumps twice a day to ensure waste flushing
  - Only treat fish with antibiotics when absolutely necessary
  - Handling fish
    - Keep fish in 0.5 to 1.0% salt concentrations when fish are handled, split and hauled.
    - Keep fish off feed for 1-3 days prior to handling depending on size
    - Add oxygen stones to tanks where handling occurs
    - Keep net loads light and keep fish from being overcrowded
Fish Health/ Bio-security cont.

• Our Solutions for Bio-security:
  – Virkon filled foot baths in place in entrances to incubator and hatchery buildings
  – Signage in place throughout the facility to inform visitors of dangers.
  – All incoming egg shipments are disinfected with PVP iodine at recommended rates
  – Eggs are disease certified before going into the hatchery building
  – After tanks are emptied they are pressure washed, treated with Virkon and allowed to air dry
  – Each trough and tank have separate brushes and nets
  – All equipment and gear is disinfected with Virkon between and after uses
  – Hand sanitizer used throughout facility
Monitoring of Treatment Processes

• Challenges:
  – Monitoring takes more time than the actual feeding and cleaning of the fish.
  – Consistently monitor that all phases of the system are operating correctly.
  – This includes: extensive gas monitoring, recirculation flow management, settable and suspended solids discharge.

• Our Solutions:
  – Make monitoring an essential priority
  – Keep measuring and monitoring equipment in excellent working condition.
How are we doing????

- Pre-construction production 1989-1999
  - 18,850 pounds on 1600 gpm (6,057 liters) of inflow
- Post-construction production 2006-2007
  - 24,125 pounds on 550 gpm (2,082 liters) of inflow
- Present day production 2011-2012
  - 27,959 pounds on 400 gpm (1,514 liters) of inflow
Pounds of Fish

- 1989-1999: 18,000 pounds
- 2006-2007: 24,000 pounds
- 2011-2012: 28,000 pounds
Pounds Produced per GPM of Fresh Inflow

- 1989-1999: 75 pounds
- 2006-2007: 60 pounds
- 2011-2012: 90 pounds
What this all says....

• With the partial reuse recirculation system this year we will be producing 48% more pounds of fish, 48% more fish and doing all of this on 25% of the original pre-construction flow.
• The water requirements for this facility have been dramatically reduced since construction.
• The degree of uncertainty and the amount of second guessing of what this facility is capable of doing has been significantly reduced.
• Utilization of the closed water sources and strict bio-security measures have kept the facility relatively disease free and as intended Whirling Disease free.
What does the Future Hold???

- We believe that we can increase our total production another 14% from present day levels to around 32,000 pounds. That will equate to 80 pounds produced annually per gallon per minute of inflow.
- Installation of additional RFUV unit to treat the secondary recirculation water to minimize potential disease issues down the road.
Questions ???