USDA NATIONAL COLD WATER MARINE AQUACULTURE CENTER SALMON BREEDING PROGRAM

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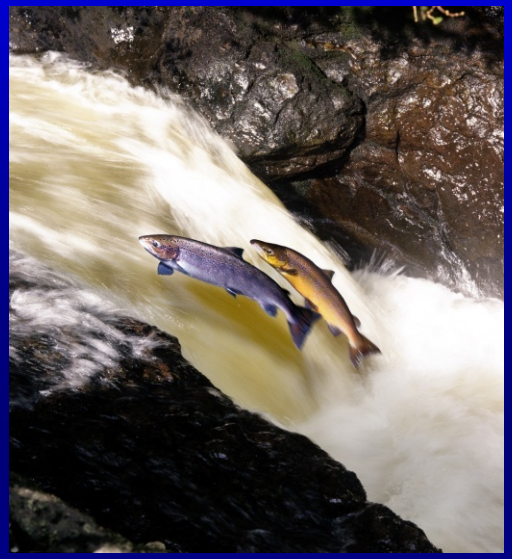
RESEARCH MISSION/INDUSTRY BENEFITS

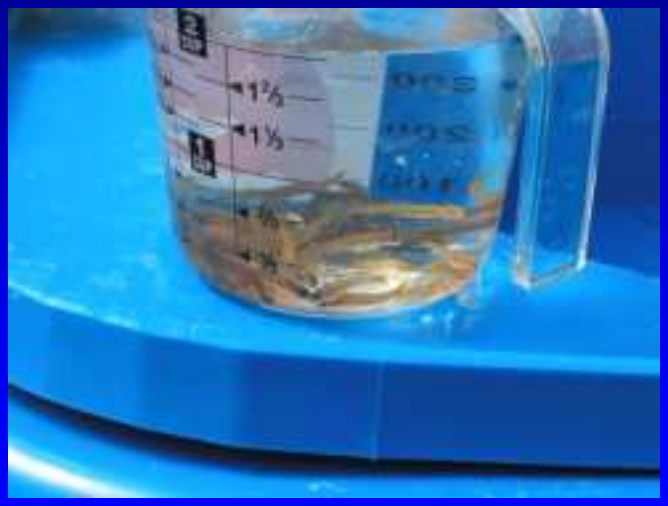
- Conduct research to enhance sustainable and profitable aquaculture of cold water marine finfish
- Primary objective: Atlantic salmon breeding program utilizing North American stocks
- Goal: Develop improved stocks for release to producers and consumers

FRANKLIN RESEARCH SITE



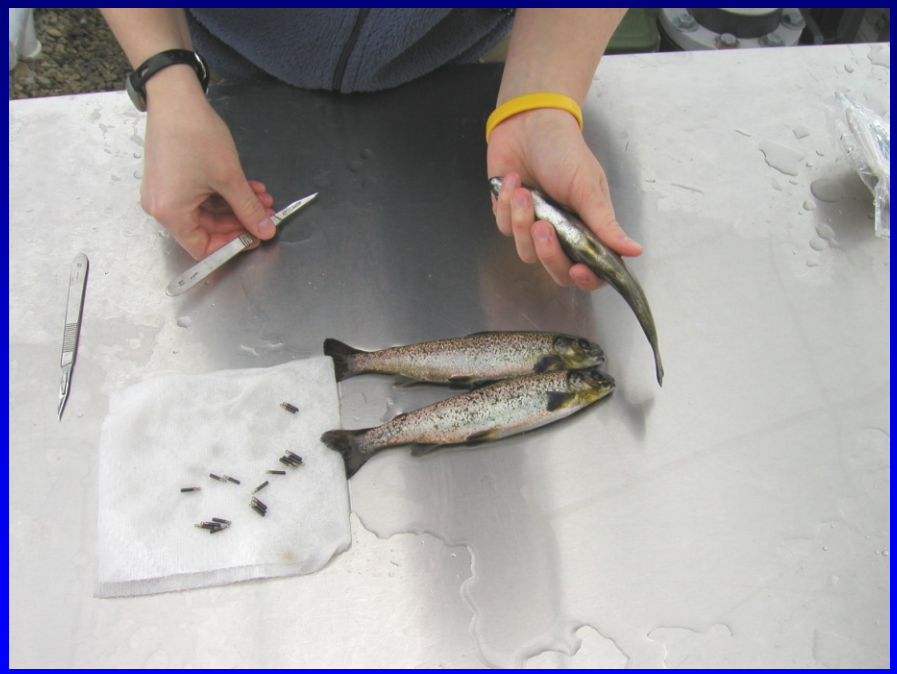
Status of Research Program

- Initial stocks obtained in winter 2003 – now have five year classes on site – 2006-2010
- Initially obtained eyed eggs from 5 stocks/strains – Penobscot, 2 St. John's River, Landlocked, and Gaspe
- Certified North American and disease free stocks – Biosecurity a critical aspect of program!



Fish Culture Details

- Parr individually pit tagged, vaccinated, and stocked communally into smolt tanks
- 1 group of fish to sea cages – 1 group stays in bio-secure facility as future broodstock



Harvest

Fish harvested from sea cages around 3 years of age – approximately 18 months after stocking into sea cage

Data collected at processing plant on weight, stage of sexual maturity, survival, fillet color, and fat content

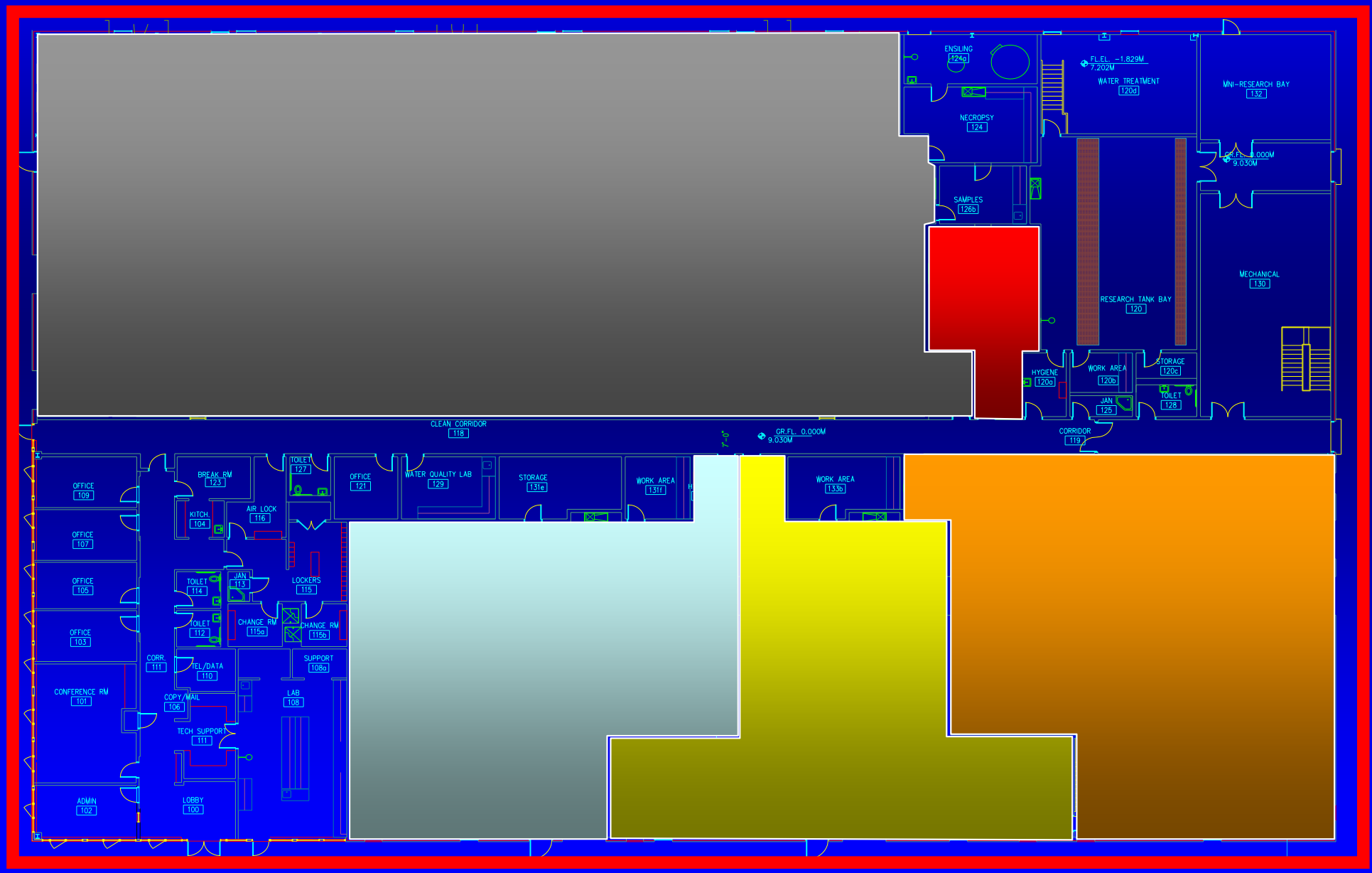
Industry Collaboration

- So far stocked 2003-2008 year classes into industry net pens
- 2003, 2004, 2005, 2006 and 2007 have been harvested and data analyzed. Select broodfish spawned in 2007, 2008, 2009 and 2010
- Approximately 500,000 eggs transferred to industry in 2007, 2008, 2009, and 2010.
- Collaboration critical to success of breeding program

New Facility Completed – May 2007

- Offices, conference room, analytical labs
- Parr, smolt, ongrow, and broodstock tank bays
- Incubation, necropsy and research labs
- Two research buildings outside main building
- Effluent treatment building

NCWMAC Building Floor Plan



Breeding Program/Bioplan

- Each year parr individually pit tagged, vaccinated, and stocked communally into smolt tanks
- 1 group of fish to sea cages – 1 group stays in bio-secure facility as future broodstock
- Fish are inventoried at least 1x/year and “move” through the building - parr, smolt, ongrow, brood tanks

Parr Tanks

Ongrow Tanks

Broodstock Tanks

NCWMAC Water Supply

- Makeup water:
  - 97.5% flow is reused
  - 467 L/min (123 gpm)
- Multiple sources of makeup water
  - fresh well water (0 ppt salinity)
  - brackish well water (2-3 ppt),
  - salty well water (8-12 ppt),
  - seawater (33 ppt)

Salty Well Water
Cooling Tower – Reservoir T

NCWMAC Fish Culture Systems

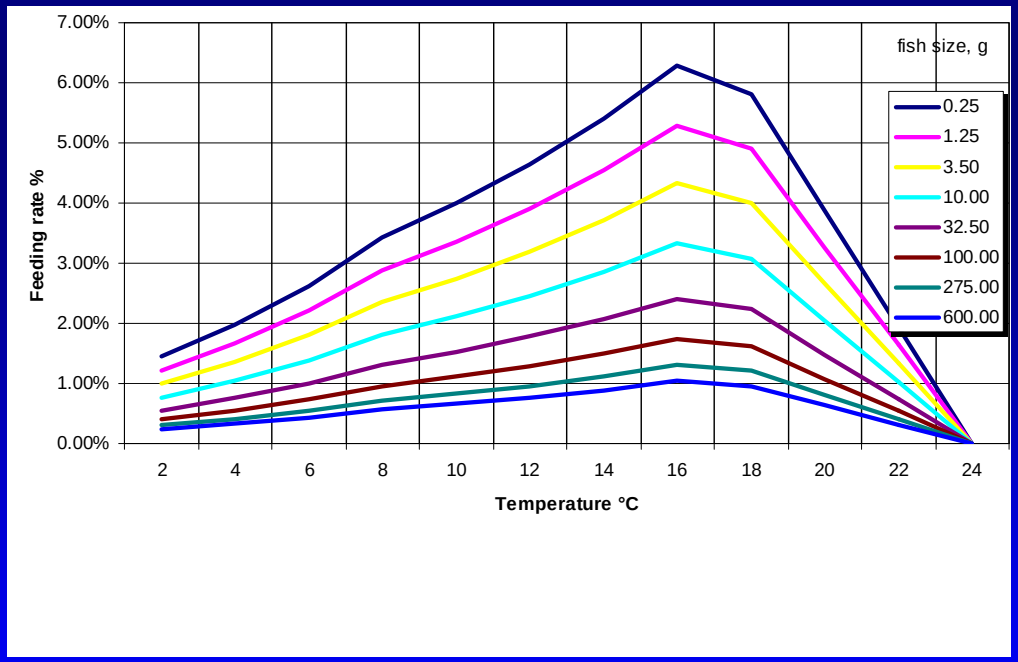
8 Separate RAS in 5 Separate Rooms

Culture System	Tanks	Tank Size (m3)	Tank System Volume (m3)	Pump Sump (m3)	Biofilter/ LHO Volume (m3)	Predicted Maximum Biomass (kg/m3)	Design Recirculation Flow Rate (lpm)	Makeup Water Required at 2.5% of Flow (lpm)	Predicted Maximum Feeding Rate (kg)
Parr	234	0.14	33	9.0	13.2	1,320	1,250	31	17
Smolt 1	3	9	27	7.2	13.7	1,100	870	22	45
Smolt 2	3	9	27	7.2	13.7	1,100	870	22	45
Ongrow	4	36	144	22.6	42.7	5,760	4,470	112	101
3 Yr Broodstock 1	4	46	184	22.6	42.7	7,360	4,470	112	165
4 Yr Broodstock 2	4	46	184	22.6	42.7	7,360	4,470	112	165
5 Yr Broodstock	1	90	90	13.3	32.2	3,600	2,230	56	26
Total	253		689	104.5	201.1	27,600	18,630	467 (123 gpm)	NA

Also, an egg incubation RAS.

Fish Feeding Systems

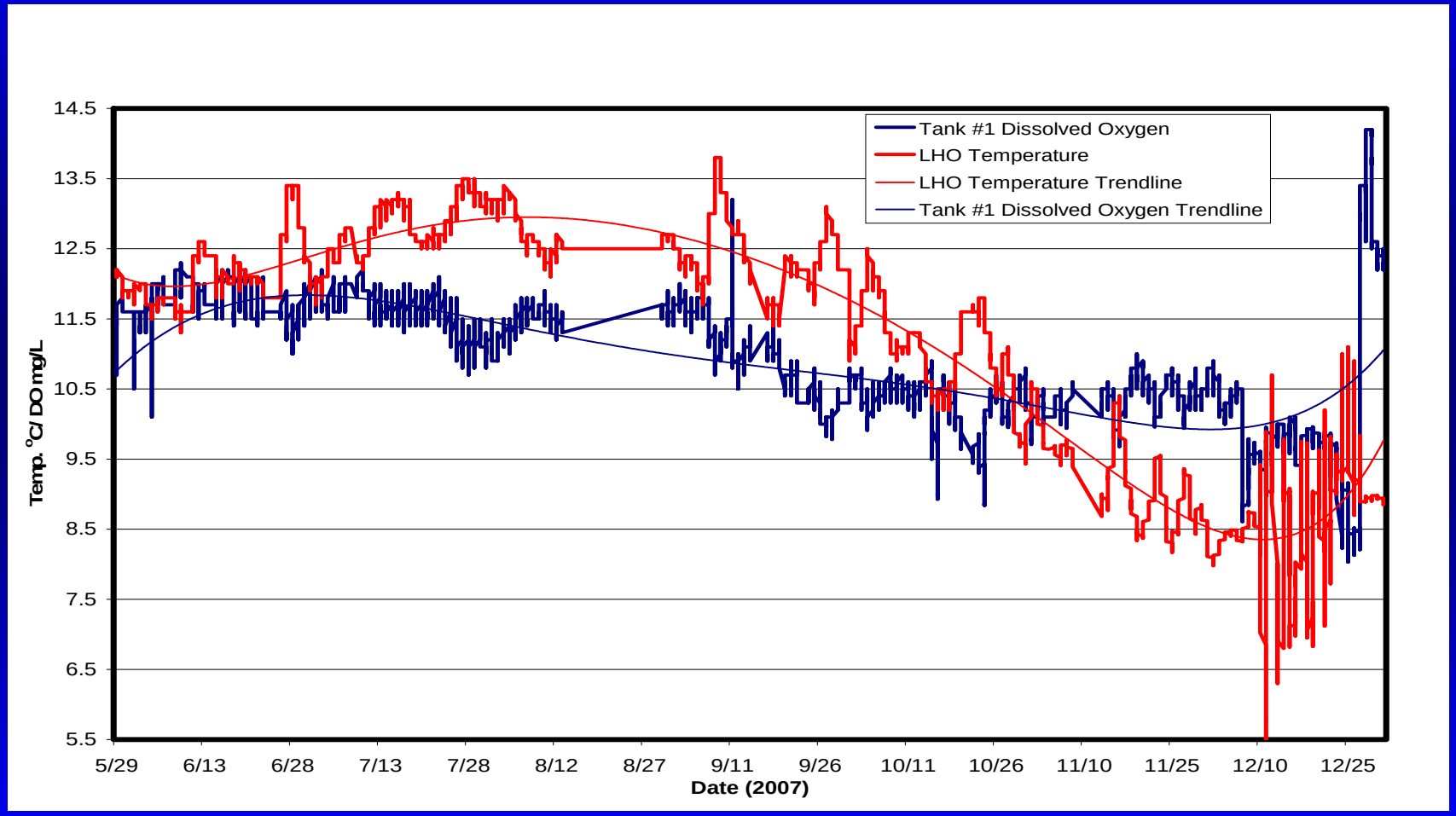
Fish culture systems equipped with feeders or robots and fish are fed based on water temperature and fish size. Computer program provides accurate feeding and inventory . Monthly reports sent to state of Maine on inventory, feed used, and discharge water quality.



Water Quality Monitoring

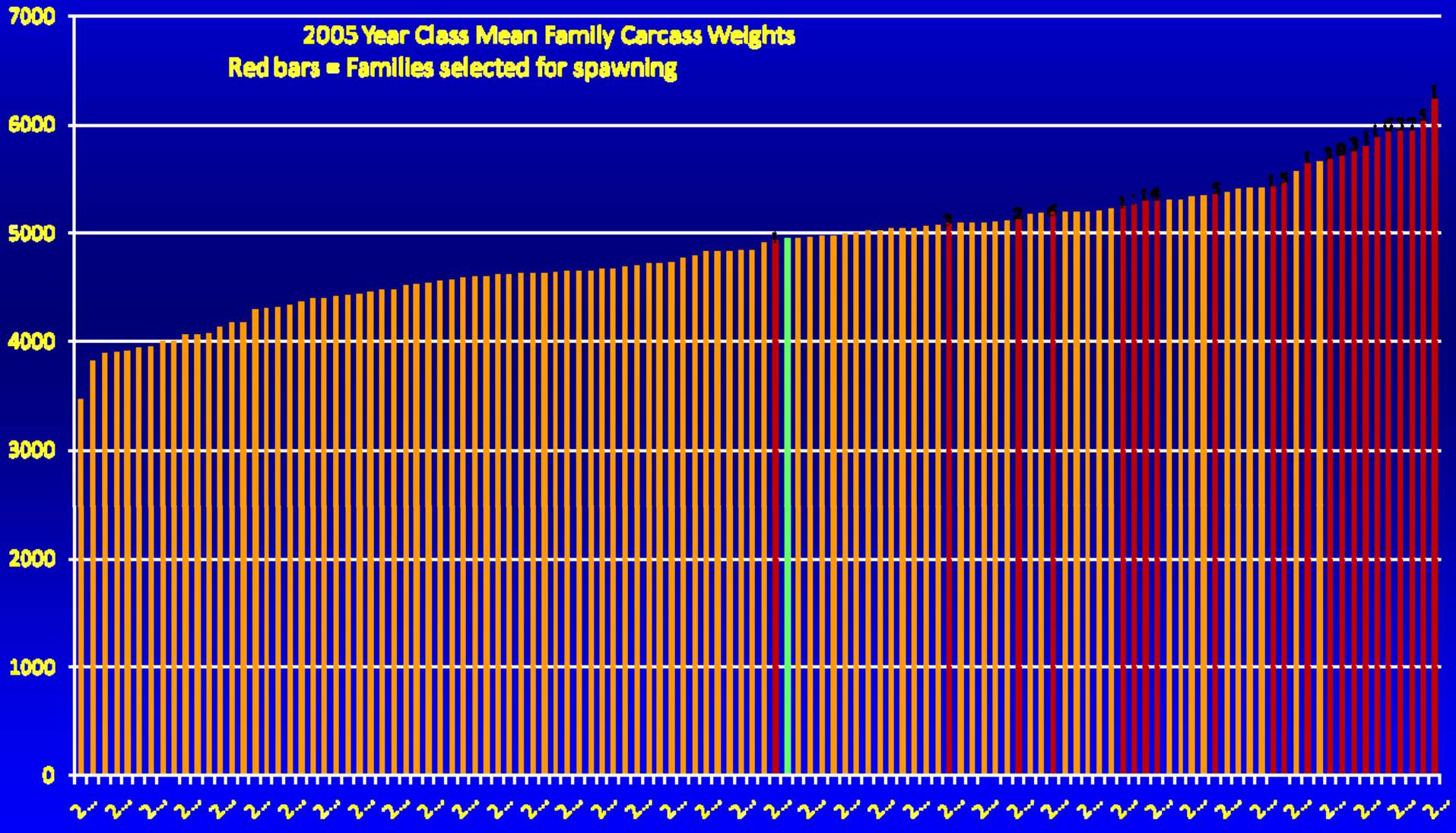
- Continuous monitoring of temperature, oxygen (tanks and LHOs), and ORP (for ozone)
- Over 150 alarm points for water quality and equipment (pumps, water levels)

NCWMAC Water Temps and Oxygen Levels May – December 2077

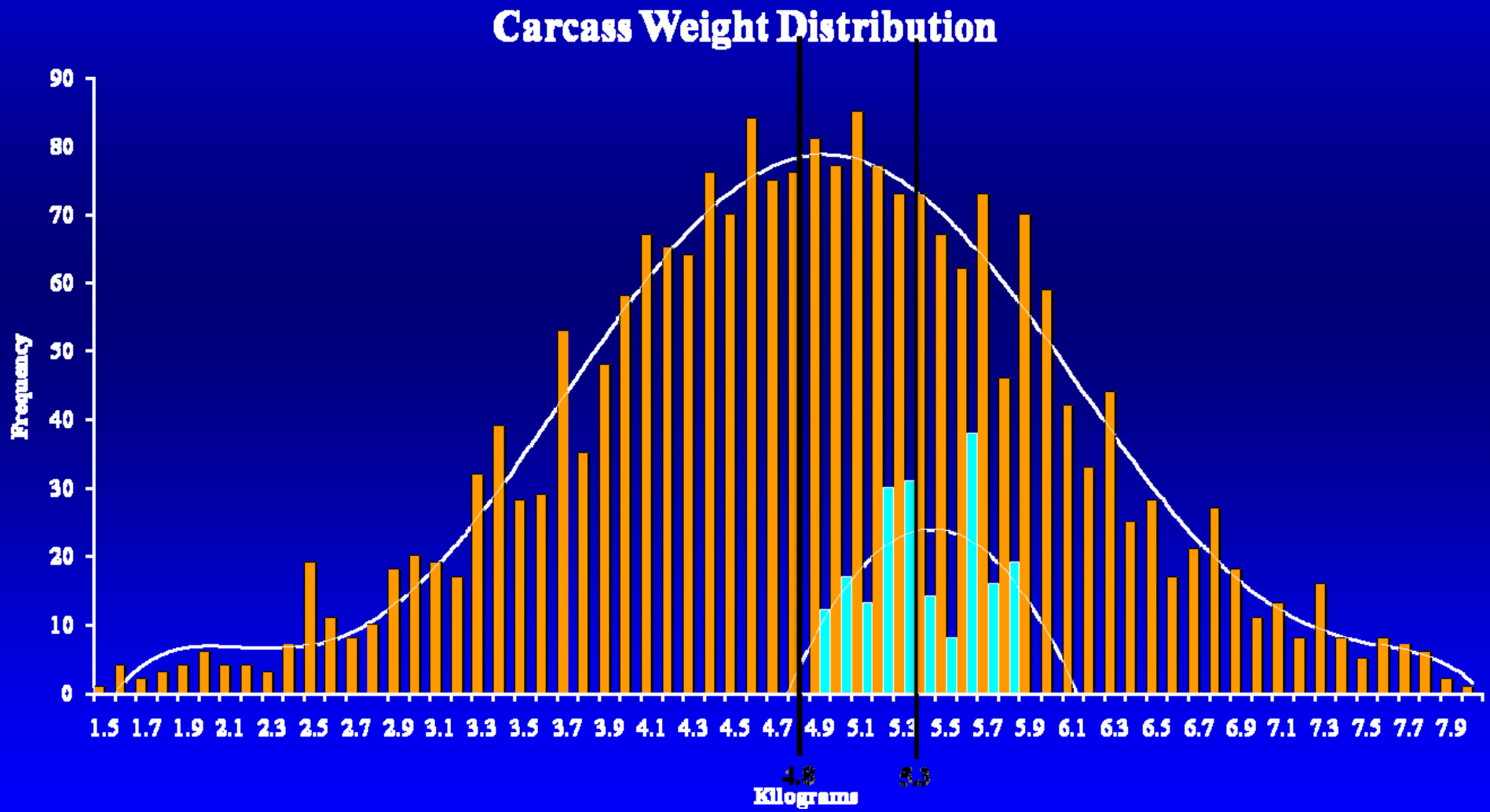


Tank water temps impacted by outside ambient air temps and room temps.
No supplemental heating or cooling required.
Water temp ranged from 13.8C in July to 5.5C in December.

YC2005/2006 Family Mean Weight



YC2005/2006 Fish Carcass Weights



Growth Comparisons

Year	Control - PR	Industry	USDA – SJR
2003	2.7	4.3	4.1
2004	2.9	4.3	4.6
2005	2.8	4.2	4.9
2006	2.3	3.9	5.0

Control – Wild Penobscot River salmon
Industry – Harvested same day from same cage
USDA – St. John's River fish pit tagged in cage
SJR fish 70-100% larger than PR fish

NCWMAC Fish Culture Systems Conclusions

- Atlantic salmon in NCWMAC breeding program grow well in recirculating aquaculture systems
- Systems were operated at approximately 98% reuse – 2% makeup water on basis of flow rate
- Water quality in systems nearly same as flow through with better solids capture
- Recirculating systems allow large biomass with limited groundwater resources
- Biosecurity of recirculating systems and water supplies has resulted in fish health certification for facility and fish stocks
- Three germplasm releases of ~500,000 eggs/year

Germplasm Releases

Weight Loss and Fillet Quality Characteristics of Atlantic Salmon (*Salmo salar*) After Purging

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Introduction

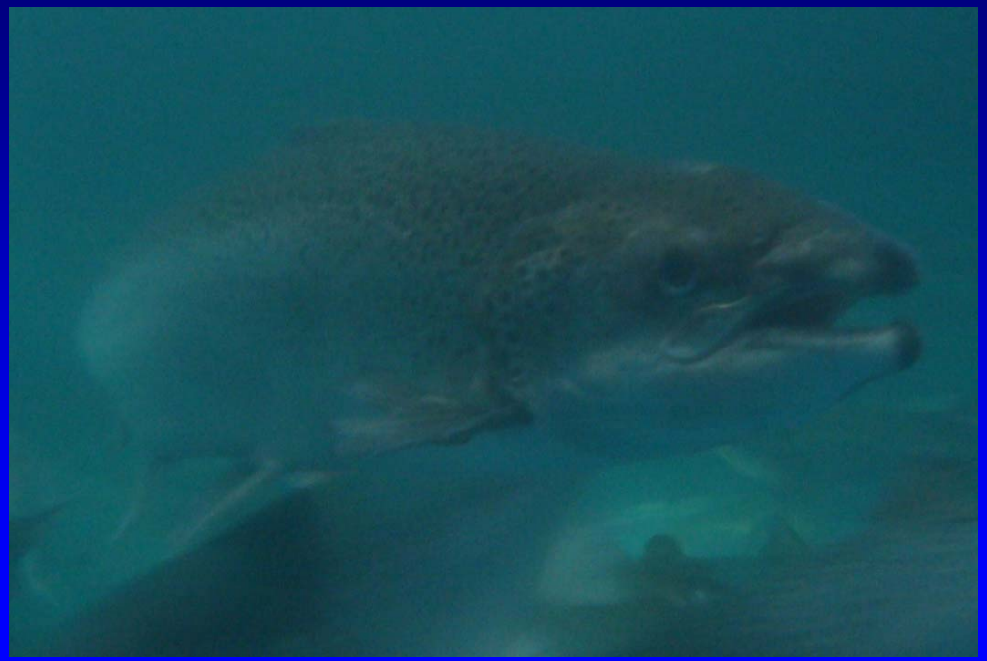
- Traditionally, Atlantic salmon (*Salmo salar*) have been cultured in marine net pens.
- Recently, interest in culturing Atlantic salmon on shore in recirculating systems

- Culturing fish in recirculation systems can result in fish having an “earthy” or “musty” flavor

- Produced by **actinomycetes** and cyanobacteria
- In RAS, actinomycetes are the main contributors and found mostly in biosolids and aerobic sites
- Two compounds are responsible for the earthy/ musty off flavor
  - Geosmin
  - 2-Methylisoborneol (MIB)

Geosmin and MIB

- Removal of these compounds from fish flesh can be accomplished by reduction of levels in the water
- Another concern during depuration is weight and lipid loss
- Question:
  - How much time is required to depurated fish while maintaining fillet quality?



Methods

- 108 fish were kept in a 36-m^3 tank connected to a recirculating system for 3 weeks and fed a commercial diet prior to depuration
- 12 fish were sampled on day 0. Body weight, carcass weight, fillet weight, color score and fat content of the fillet were measured
- 48 fish were transferred to a clean system supplied with flow through water and 48 were kept in the recirculating system.

Methods

- On day 5, 10, 15 and 20, 12 fish from each system were sampled and measured for total weight, carcass weight, fillet weight, fillet color and fillet fat content.
- Color was measured with a portable colormeter (Hunterlabs Miniscan XE)
- Fat content was measured gravimetrically with a fat extractor (Ankom XT-10)
- Geosmin and MIB were measured using microwave distillation and solid phase microextraction and GC-MS

Conclusions

- Geosmin levels were well below reported sensory detection levels for other fish species. Geosmin was not a contributor to the off flavor problem in this system
- **Preliminary sensory analysis indicated that sampled fish were acceptable at day 10.**
- Further analysis is being conducted with a trained taste testing panel to establish MIB detection levels.

- From this study fish need to be purged at least 10 days but not more than 15 days to limit the loss of lipids.