Opportunities for research collaborations using fish and UI Hagerman assets

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Hagerman Fish Culture Experiment Station is part of the University of Idaho's Aquaculture Research Institute (ARI)

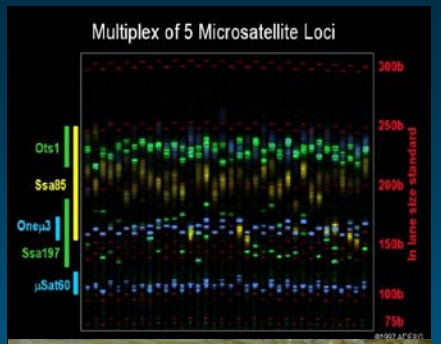
Located 90 miles SE of Boise, near Twin Falls

70% of trout farmed for food in USA grown within 20 miles of Hagerman Station

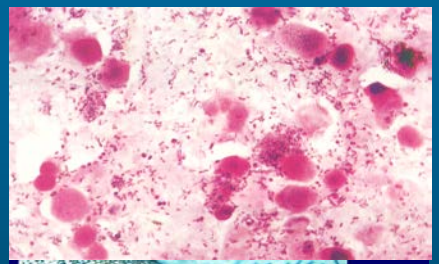
Research Specialties at the Hagerman Fish Culture Experiment Station

Broodstock Selection

Feed Trials and Diet Formulations

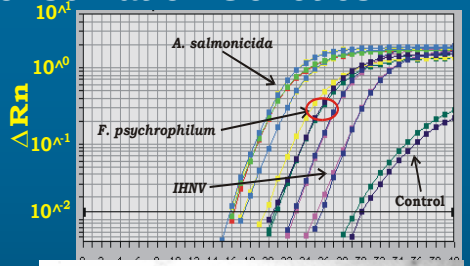


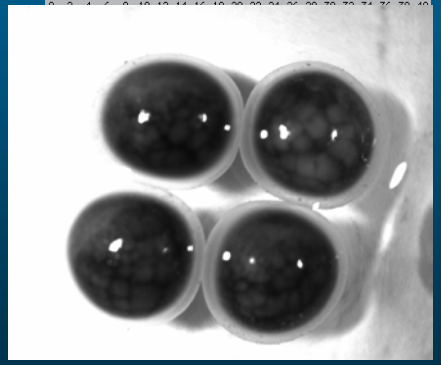
Conservation Genetics



Disease Detection

Effluent Pollution





Molecular Diagnostics

History of HFCES

- **1996:** Idaho legislature funded Director position and start-up money for UI to operate mothballed USFWS facility. This was facilitated by NSF EPSCoR funding at $50k.
- **Nov ’98:** Property transferred to the UI thanks to Idaho’s Congressional delegation
- **FY00:** Congress approved first USDA/ARS position at HFCES
- **2000:** Idaho legislature funded lab operating expenses
- **FY02 & 03:** Congress approved two more USDA/ARS position at HFCES (scientists hired in Fall 2003)
- **Today:** staff grown from 2 to 30, funding increased from $0 to $3.5 million per year, 93% from grants & contracts

Strategy for past 8 yrs

- Define areas of specialization based on…
  - Avoiding competition with existing labs
  - Selecting areas in which there are unfulfilled needs in Idaho and region, and that connect with big issues (water, ag, endangered species, pollution, sustainability)
  - Chose programs that attract funding and collaboration
- Find interesting scientists with varied backgrounds who want to work in rural Idaho
- Build capacity and resources to create barrier of entry to competition
- Position lab as “go-to” place to get things done, i.e., aggressive, entrepreneurial, nationally-recognized center of expertise in strategic areas

Resources & Expertise at ARI/HFCES

- Nutritional Biochemistry
- Molecular Genetics
- Fish Pathology/Disease/Fish Immunology
- State-of-the-art molecular laboratory
- New buildings with video conferencing capabilities (June 06 completion)
- Complete experimental feed production and fish culture facilities
  - Rainbow trout, zebrafish, ornamental species, all sizes & all ages

Nutritional Biochemistry

- Five PhDs

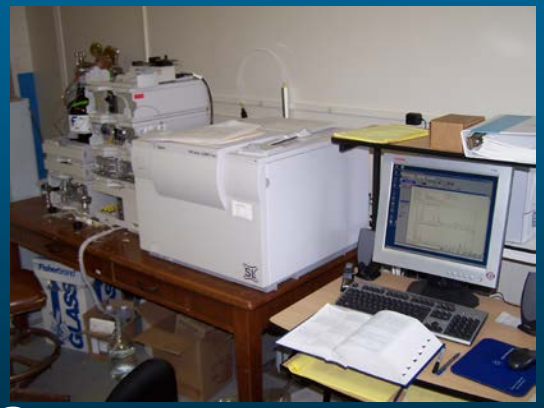
plus 5 techs

Resources for nutritional research

$3.5M feed production laboratory (operated with ARS)

Capabilities:
extruded fish feed
ornamental fish feed
larval fish feed

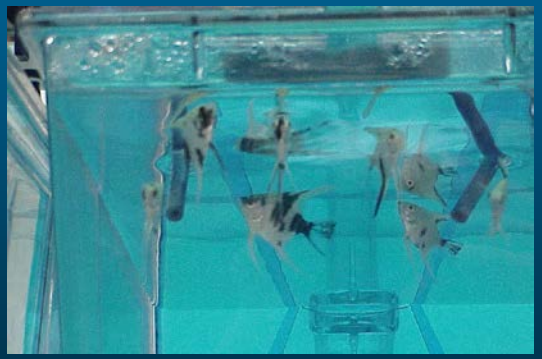
Analytical laboratories for:
Proximate analysis
Fatty acids
Most metabolites in animal tissues



Agilent LC-MS

Fish rearing facilities

Best trout research lab in North America



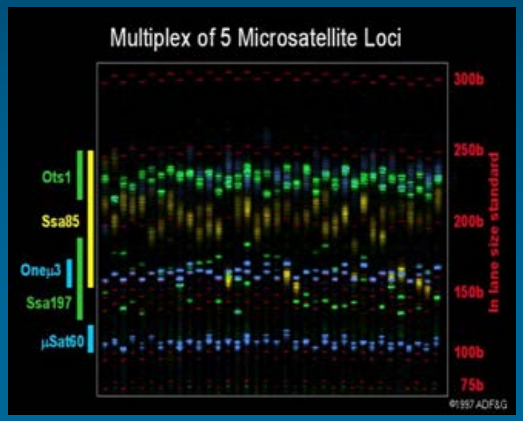
Ornamental fish lab

Zebrafish research tanks

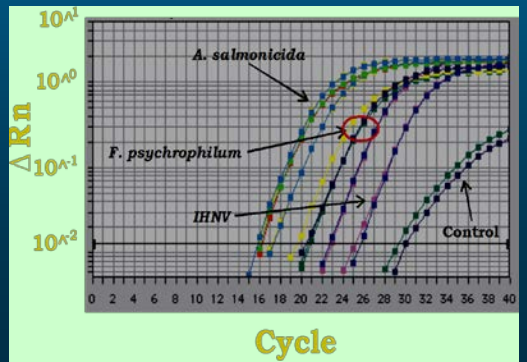
Molecular Genetics

Three PhDs plus six techs

Molecular Genetic Resources



ABI Prism 3730 & 3130 Genetic Analyzers for sequencing and microsatellite analysis
ABI Prism 7900HT Sequence Detection System for real-time PCR
Tecan HS400 hybridization station for microarray slide processing
Perkin Elmer ScanArray Express for microarray analysis
Eight PCR machines
Zeiss Axioplan digital fluorescence microscope
Qiagen 3000 robot for DNA/RNA extraction
Qiagen 8000 robot for liquid handling
Fluorescent multilabel plate reader for enzyme kinetics



Status of new building

Foundation in, floor will be poured in two weeks, then walls and roof built

Growth of global aquaculture production requires cost effective ingredients made from sustainable ingredients…like Idaho barley

- Increase use of proteins from grains & oilseeds
  - Balance protein with crystalline amino acids
  - Reduce antinutritional factors with enzyme treatment
- Reduce protein levels
  - Recycle nutrients
- Reduce nutrient losses
  - Attractants
  - Physical integrity of pellet
  - Prevent leaching through encapsulation
- Boost immune system

First generation of trout selected for faster growth on barley-based diets

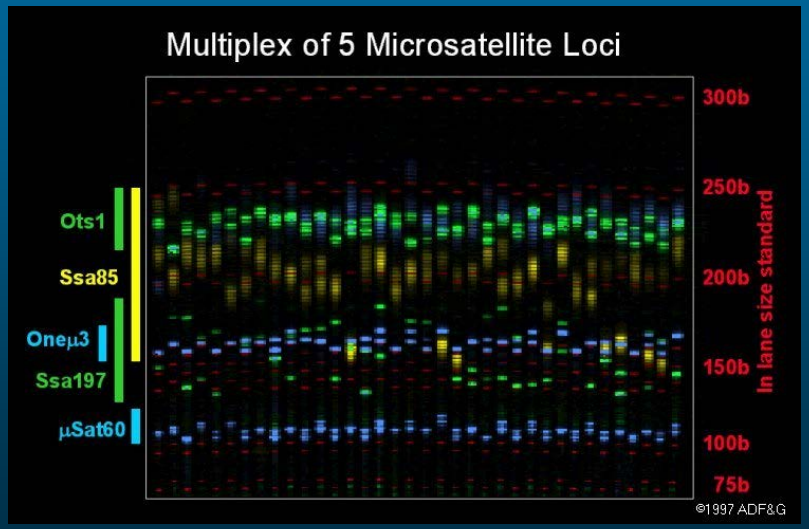
Selected

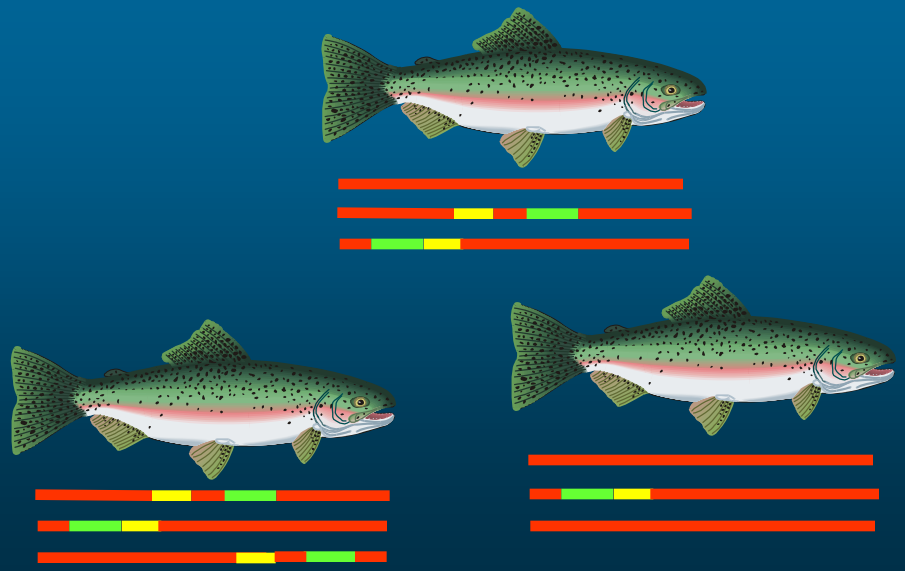
Non-selected control

Genetic Improvement in Rainbow Trout

Marker Assisted Selection

Find markers of interest for a trait such as growth on cereal grain diets. Use these markers to screen a population of fish and then select those animals that possess those positive markers to for broodstock.





Center for Salmonid and Freshwater Species at Risk - programs

- Genetic analysis of fisheries stocks for fisheries managers
- Real-time genetic monitoring of returning salmon from endangered chinook and sockeye populations
- Development of new genetic tests to assess disease status, fitness, and other important characteristics of wild fish populations
- Tissue archive for threatened and endangered fish species
- Functional genomics

Hatchery-Wild Trout Interactions

IMPORTANCE

1. Most ESA petitions to list fish species in the western United States include hybridization with hatchery fish as a major cause of decline.
2. The most controversial legal arguments for or against ESA listings or management of fish populations are whether or not hatchery fish should be considered genetically the same as a wild population.
3. The USFWS and NOAA Fisheries' legal policies on hybridization are undergoing difficulty being approved by the Solicitor General's office. Thus, most all litigation now involves "hybridization" issues.
4. The most widely used and scientifically accepted tool to recover critically endangered fish populations is artificial propagation in hatcheries.

All these arguments are based on studies of non-gene DNA

Hatchery-Wild Trout Interactions

Nature vs. Nurture

Are hatchery fish different functionally?

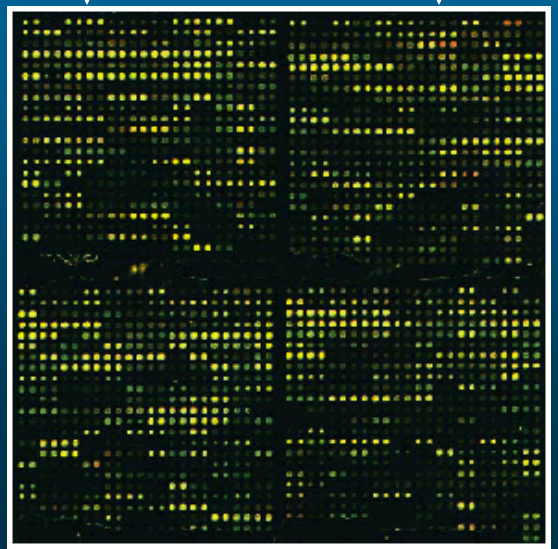
Can they be raised so they are not different from wild counterparts?

Strategies

1. **Use molecular technology to assess the effect environmental conditions have on the expression of genes.**

2. **Identify specific, functional genetic differences between hatchery and wild stocks in the same environments.**

Functional Genomics and Microarray Analysis



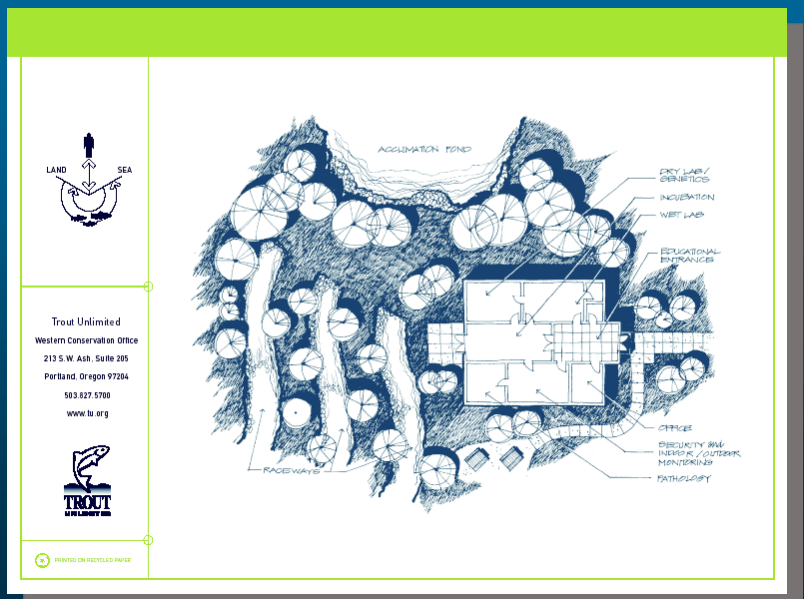
FUNCTIONAL GENOMICS

Differential gene expression can be used to help researchers determine what FUNCTIONAL differences are important for fish survival

MICROARRAY ANALYSIS

The University of Idaho is using this technology of comparing gene expression to assess differences between fish raised in different environments (hatcheries and the wild) or genetically different fish in the same environment

Hatchery Reform



Engineered Streams / Fish Interactions

Experimental flume in Moscow lab to study fish behavior and interactions

Natural-type raceway

Engineered or restored stream

Replicated Streams will be constructed at Billingsley Creek in Hagerman

New Strategy for next 5 yrs

- Capitalize on intellectual and physical assets
- Expand from “working on fish” to “working on fundamental issues using fish as a tool”
- Expand activities using scientific base into:
  - Selected medical and developmental questions
  - Idaho’s ag economy to add value (fish and grains, organic fish, etc)
  - Water allocation issues based on needs of fish (define needs of fish using better science and functional genomics)
  - Engineered (replicated) stream research
    - Pertains to restoration based on needs of fish, species interactions, flow, structure, etc.
    - Engineered streams to double production of migratory salmon and steelhead from Idaho (connected with water, dams, Native Americans)
  - Farmed fish products as functional foods for human health
  - Nanotech (small sensing devices for fish physiology, stream ecology, etc.)

Using fish in medical research

- Diabetes
  - Fish model: insulin production regulated by two genes that are coupled in people, not coupled (separate) in fish so their function can be studied separately
- Muscle wasting in cancer/AIDS/autoimmune disease (Cachexia)
  - Old model: caused by reduced food intake coupled with higher metabolic needs
  - New model: caused by specific muscle gene inhibition and up-regulated degradation resulting from chronic immune stimulation, e.g. TNF
- Muscle growth – study genes involved in hyperplasia in fish and their regulation
  - Hypertrophy – fibers get bigger (mammals)
  - Hyperplasia – more fibers are produced throughout life cycle (FISH)
    - Key Question: What gives fish this ability and how can it be applied to human health issues?
- Immune and metabolic systems – certain fish physiology systems are similar to humans as far as they go
  - Currently we have >45 DNA probes for specific physiology pathways
  - Can measure effects of, say, diet, stress, drugs, bugs, etc. on immune system response

Water-streams-fish

- Water allocation in Idaho increasing regulated by (perceived) needs of fish
- Needs of fish are based on field observations & descriptive science, not experimental science
- Our approach: Use assets and NFS EPSCoR grant to determine needs of fish based on experimental evidence
  - Watershed research (UI)
  - Hydrology in watersheds (BSU)
  - Stream ecology (ISU)
  - Fish growth and physiology (UI)

Fish as functional foods

- Boost selected nutrient levels in farmed fish
  - Omega-3 fatty acids
  - Antioxidants
- Reduce levels of pollutants in farmed fish compared to wild
  - PCBs, mercury, etc.
- Increase or decrease fillet lipid level

All can be manipulated through feeds

Nanotechnology

- Status: just beginning discussions with UI nanotechnolgy researchers (Dr. David McIlroy)
- Interaction fostered through NFS EPSCoR grant
- Possibilities include micro sensors in fish, streams, underground (hydrology)

Summary

- The research platform at Hagerman is nearly in place
  - Critical mass of scientists
  - Complete range of equipment for biotech – molecular research
  - Fish rearing capacity is best in the nation
  - New building to be completed in June 2006
- We intend to use this platform in innovative ways
  - Continue fish research in commercial aquaculture and conservation biology
  - Expand research scope using fish as tools to study basic genetic and developmental questions
  - Focus research capacity on questions critical to Idaho
- We will seek collaboration with other Idaho scientists, industry and agencies to utilize our strengths to expand Idaho's science base

Take home message

ARI in the past: Like Dr. Ken Chew (U Wash) and his little walleye from Salmon Falls reservoir

“Tried to look bigger than we were”

ARI today: Like Dr. Del Gatlin (Texas A&M)
“Going after bigger game”