A Fish Farming Odyssey: where we've been - where we are now. An "old fellow's" perspective

Charlie E. Smith, USFWS, Retired

Background

- **My first job after college was with USFWS in 1961 at the Western Fish Nutrition Lab in Cook, WA (located at Willard WA) up river about 50 miles.**
- **Lab, under the direction of Dr. John Halver, established 1953 to identify nutritional requirements of salmon reared in hatcheries & to mitigate for dams being built on the Columbia river. Lab closed in 1978 - now operated by USGS**

1961 Involved in liver cancer research with RBT to determine cause —Assistant to – Dr. L.M Ashley, Histopathologist - funded by NCI - national pro. Worked at WFNL for 7 years and developed expertise in histopathology, hematology & nutrition. Also developed an interest in fish diseases.

Drs L.M. Ashley & J.E Halver at WFNL

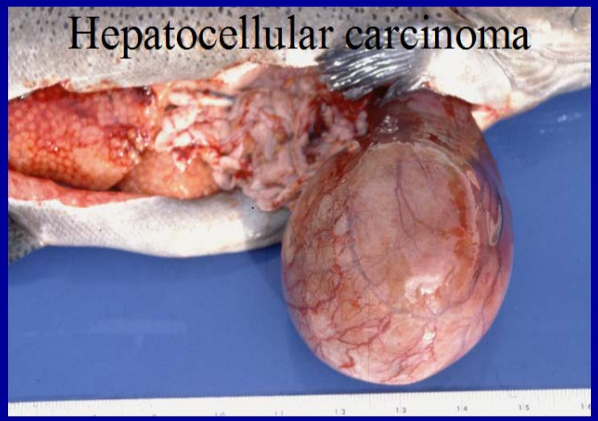
- **Transferred to FWS, Bozeman, MT Fish Technology Center in 1968 where I worked until 1993.**
- **Was Director of the Center from 1985 to 1993.**
- **Scientific Program varied; fish culture, nutrition, disease diagnosis & histopath. T&E, water treatment systems & oxygen supplementation**
- **After retirement from FTC worked from home half time for Rangen Research for 9 years, then contract histopathology for Dr Dave Erdahl, AADAP, & Dr.'s R. Barrows and W. Sealey nutritionists. Still do some diagnostic histopath, and work for some Rangen Inc.**

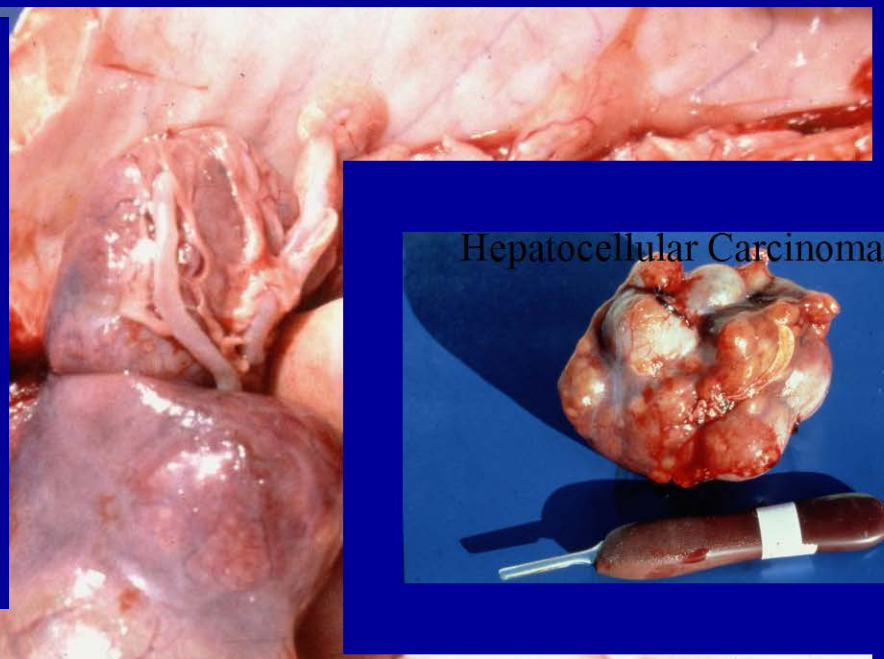
Nutrition

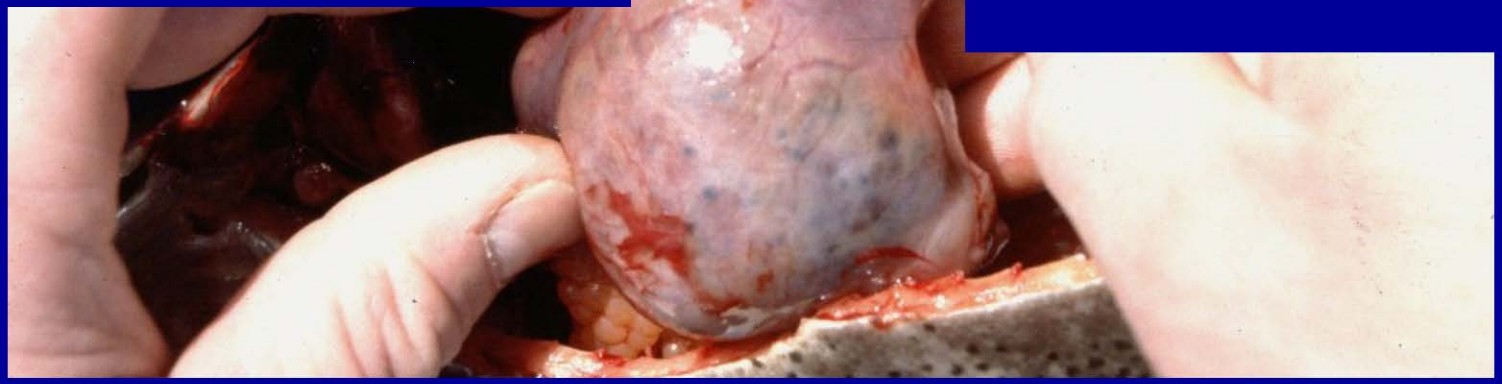
Hepatoma/ Hepatocellular Carcinoma

- **1960 –A shipment of rbt from commercial hatchery in ID examined at CA border and found to be affected by “whitish pustules” and refused entry into the state (later diagnosed as hepatoma/hepatocellular carcinoma – Liver cancer).**

- **Preliminary information suggested the disease was restricted to trout fed dry pelleted feed in which the vegetable protein was CSM.**
- **Studies at various hatcheries and labs confirmed the CSM being fed at @ 20% of the diet was contaminated with aflatoxin, produced by *Aspergillus* fungus was the cause of liver tumors**
  - **tumors were induced by feeding as low as 2 to 4 ppb aflatoxin over a 6-12 month period depending on water temperature**







Hepatocellular carcinoma

Trout Feeds 50's & 60's

- **Beef liver 12.5%, pork melts (spleens) 37.5% & 50% dry mix composed of wheat middlings & CSM.**
- **Also used tripe, horse meat, ground up fish.**
- **Development of dry pelleted feeds – 1950's Rangen, Inc., Moore Clark, Purina, Murray Elevators & Ziegler's in Eastern US**
- **USFWS began some diet formulation at same time at Spearfish NFH in South Dakota.**
- **Rangen Inc., followed by Silver Cup began manufacturing extruded feeds in early 90's**

Nutritional disorders seen in 60's – 80's

- Vitamin C deficiency
- Anemia - primarily due folic acid, & vitamin E
- Nutritional gill disease - (pantothenic acid deficiency- a B vitamin
- Cataracts – high ash fish meals/zinc deficiency
- Don't see many overt nutritional problems now

Vitamin C deficiency

Coho Salmon

Vitamin C

- **High temperatures during steam pelleting And extrusion destroys some of the vitamin**
- **Development of stabilized forms of phosphorylated vitamin C by Dr. Blake Grant, Rangen Inc, KSU & Zeigler has all but eliminated the problem – Prior, 40-50% lost rapidly**
- **Optimum levels of Vit C & other vitamins in extruded feeds recently determined for extruded feed by Dr. Barrows and coworkers**

Rick & Wendy - Vitamin Premix Study Termination

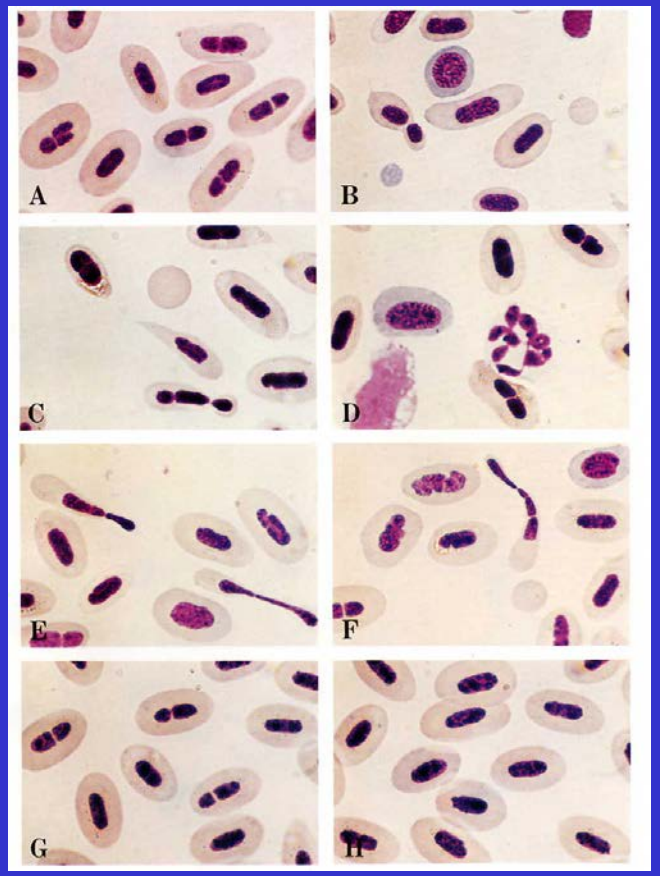
Abernathy Salmon Tech. Ctr

- Laurie Fowler – nutritionist. Started same year I did.
- Involved in practical research
- Feeding wet meat diet –equal amounts of beef & hog liver and spleen (2% salt binder) feed through large air powered ricer as wet diet. Same process at Willard NFH.
  - Responsible for development of the Abernathy Salmon Dry Diet (Open Formula Diet) Is still being used with good success by some salmon hatcheries primarily with Tule strain and URB Chinook salmon.

Anemia

- **Common in early feeds made of raw fish, meat and cottonseed meal mixed with with these**
- **Fresh liver usually solved the problem**
- **Nutritional anemia’s rare anymore**

Folic acid deficiency Coho salmon

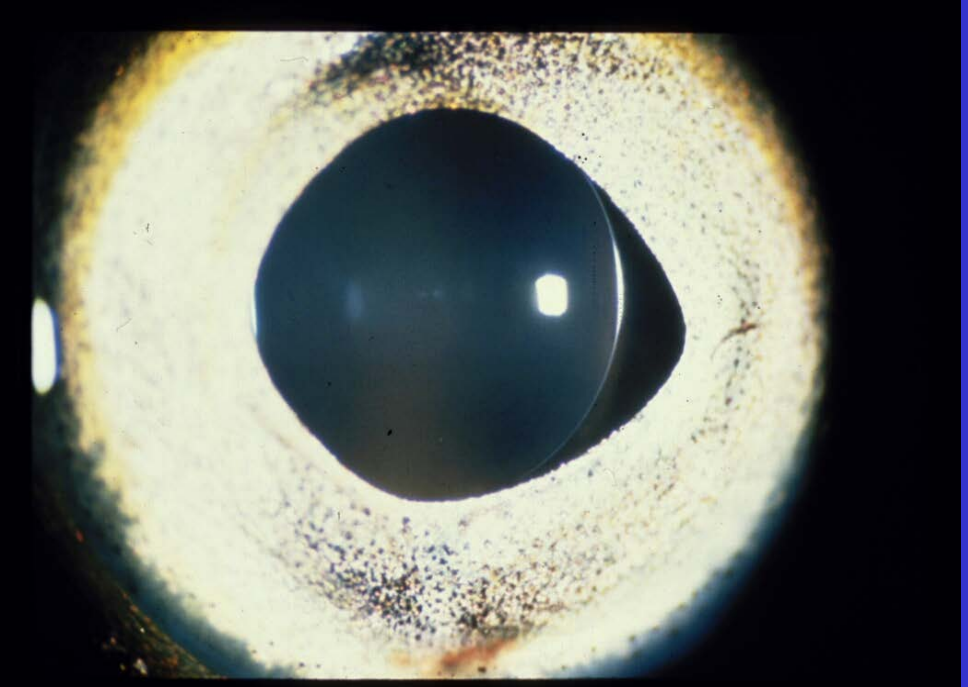


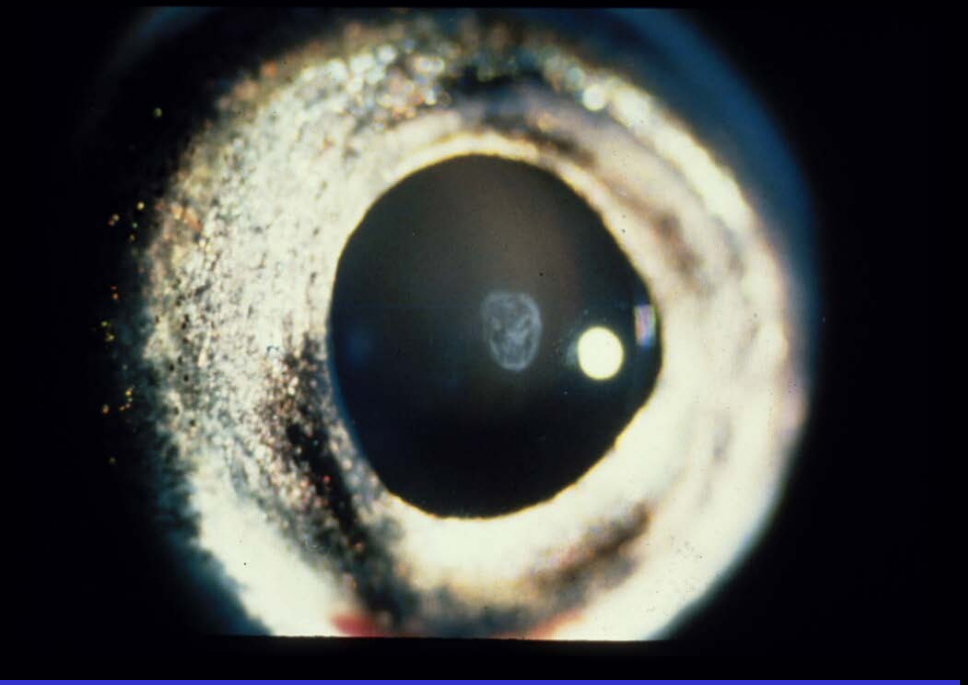
NGD

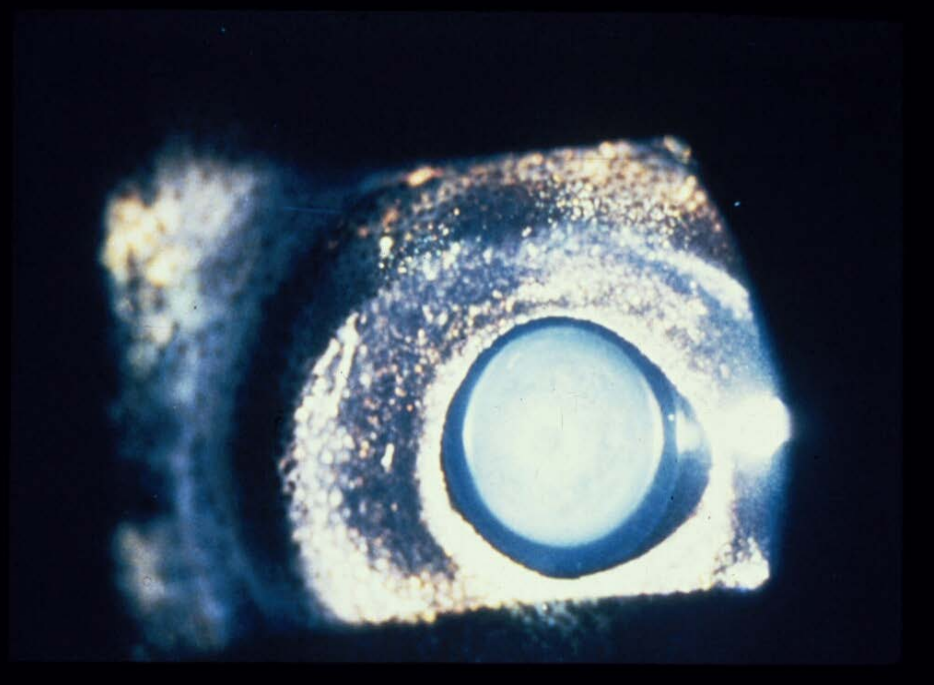
- **Caused by difficiency of B-vitamin, Pantothenic acid**
- **Common in early days of fish culture and somewhat in 70’s & 80’s**
- **Seldom seen anymore**

Nutritional Gill Disease

Nutrition Related Cataract



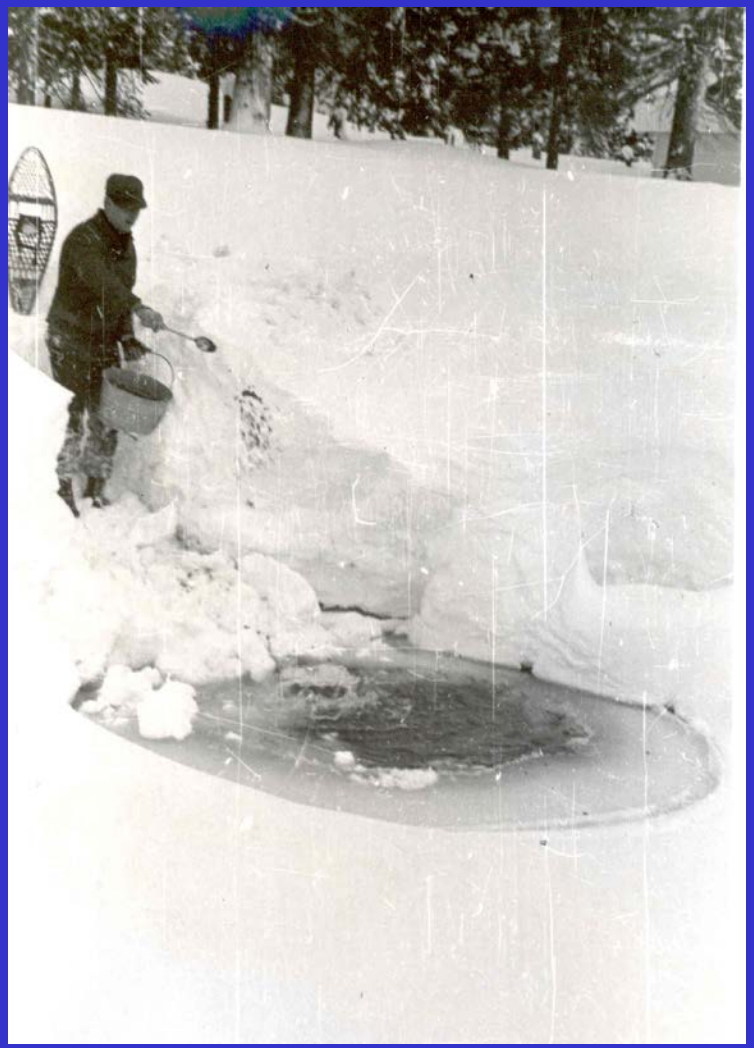




Primary Cause

- **Ennis experience – USFWS feed contract allowed feed be made with ½ herring & ½ whitefish meals (high in ash content) resulting manager calling HELP. Cataracts were prevalent in fish.**
- **Research by Dr.Geo..Ketola, Tunison lab of fish nutrition, Cortland, NY identified specific cause as zinc deficiency due to high ash limiting availability of zinc**

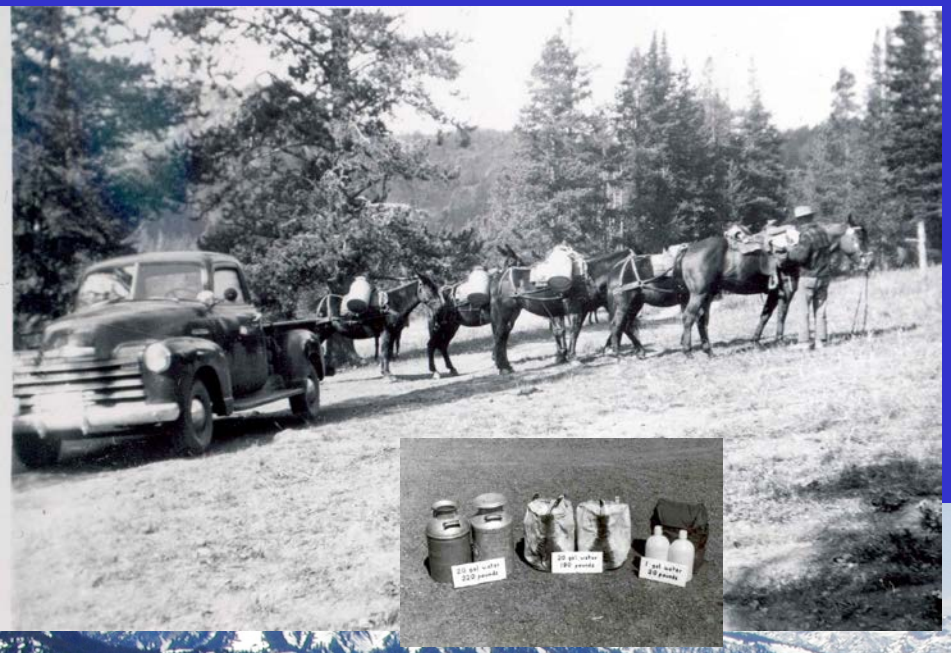
Feeding Methods



Feeding Methods

Net Pen Culture

Fish Transportation



Infectious Diseases

- **Origin of most infectious diseases of young salmonids in 1950's & 60's could be traced to feeding infected diets, or having infected fish in the water supply**
  - **In early years "wet feed" contained raw salmon carcasses & viscera = BKD; TB & IHN in salmon..**
  - **Millions of young sockeye salmon died from sockeye salmon virus disease (IHN) at Leavenworth, Entiat & Winthrop, NFH's**
  - **Later, pasturized carcass & viscera ok to use (OMP)**
  - **Pelleting, extrusion & good quality feed ingredients & sufficient vitamins & minerals have eliminated these problems**

ERM & CWD

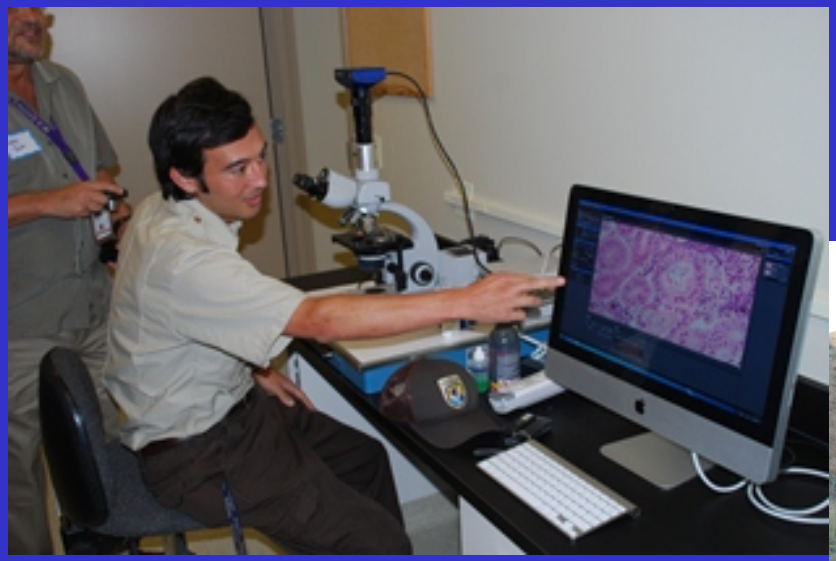
» **Enteric Redmouth (ERM)** ***Yersinia ruckeri***

Flavobacterium psychrophilia

- **Coldwater Disease (CWD)**

Coldwater Disease - systemic

Fish Health labs



AADAPP

- **Aquatic Animal Drug Approval Partnership (AADAP) Program**
- "Swimming Upstream to Obtain New FDA-approved Drugs for Use in Aquatic Species"

- Prior to the 1990s FDA chose not to regulate drug and chemical use in aquaculture (via "regulatory discretion")

  - Hence, fisheries managers were able to use virtually anything (and everything!!) they could get their hands on to meet management objectives

  - **The Bozeman National INAD Office (NIO) was established in 1995 with a staff of 2.5 FTEs and a base budget of $200K**

Mission

Why is AADAP's Mission Important to Fisheries Managers?

- FDA's decision to regulate left aquaculture with only 3 therapeutants and a single anesthetic approved for use in **all** fisheries programs

- Use of these approved drugs was limited by species, life stage, specific pathogen, and use pattern

- Effect of decision was exacerbated by FDA's broad definition of a "drug"…… that includes even apparently innocuous compounds such as *ice, salt, onion, and garlic*

Since 2003

AADAP Today

- Established in 2003 as a distinct Branch under the Division of the National Fish Hatchery System…..a National Program supervised by the WO
- Staff of 8 FTE's with a budget of ~$1000K
  - NADA management…New!
  - Information transfer…New!
  - Significantly increased research capabilities
- Active involvement in virtually all facets of the aquaculture drug approval process

Dr. Dave & JB

my
last load of
hay!

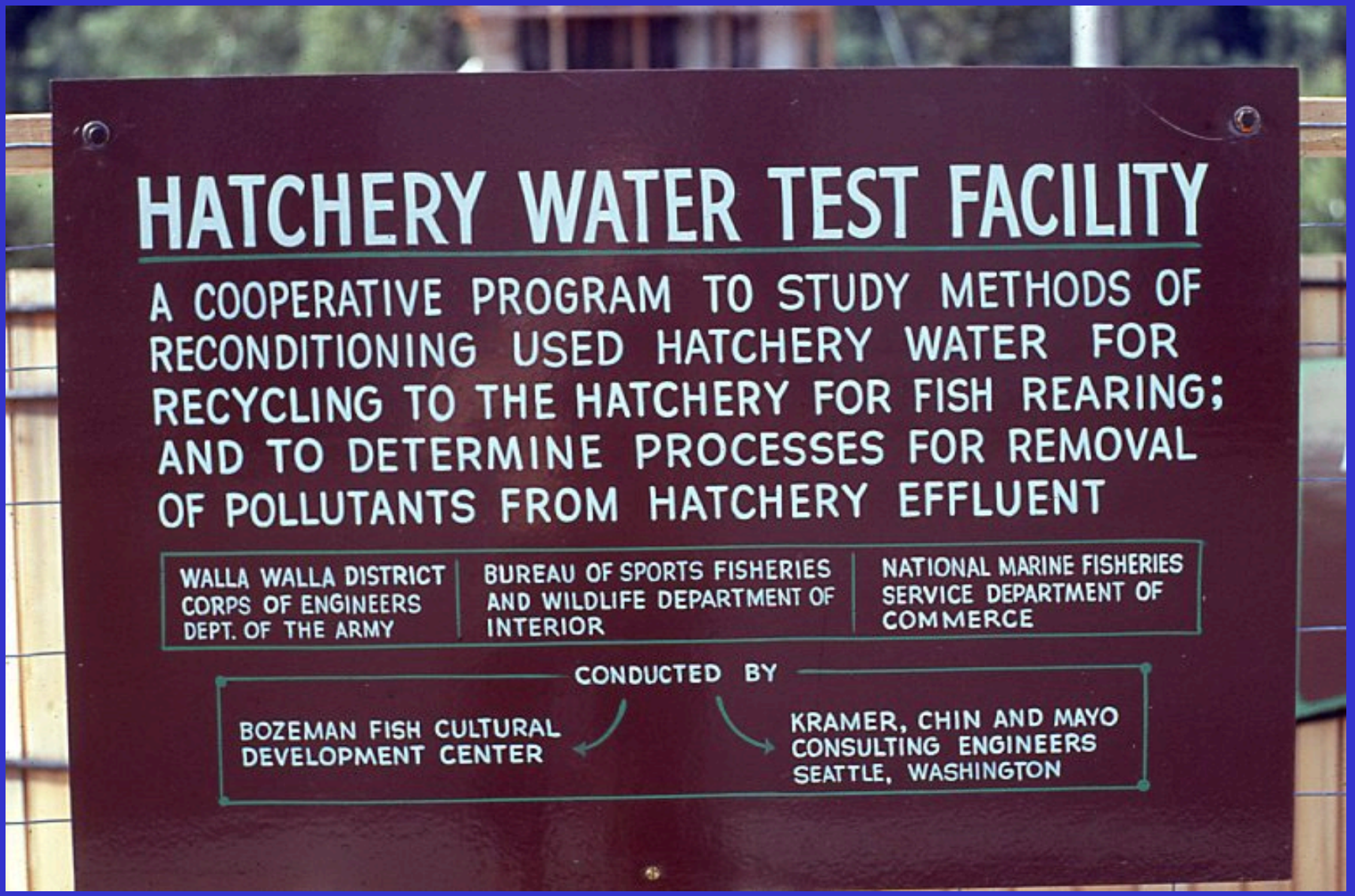
Didn’t do too good

Bull riding did worse

Fishing – did much better

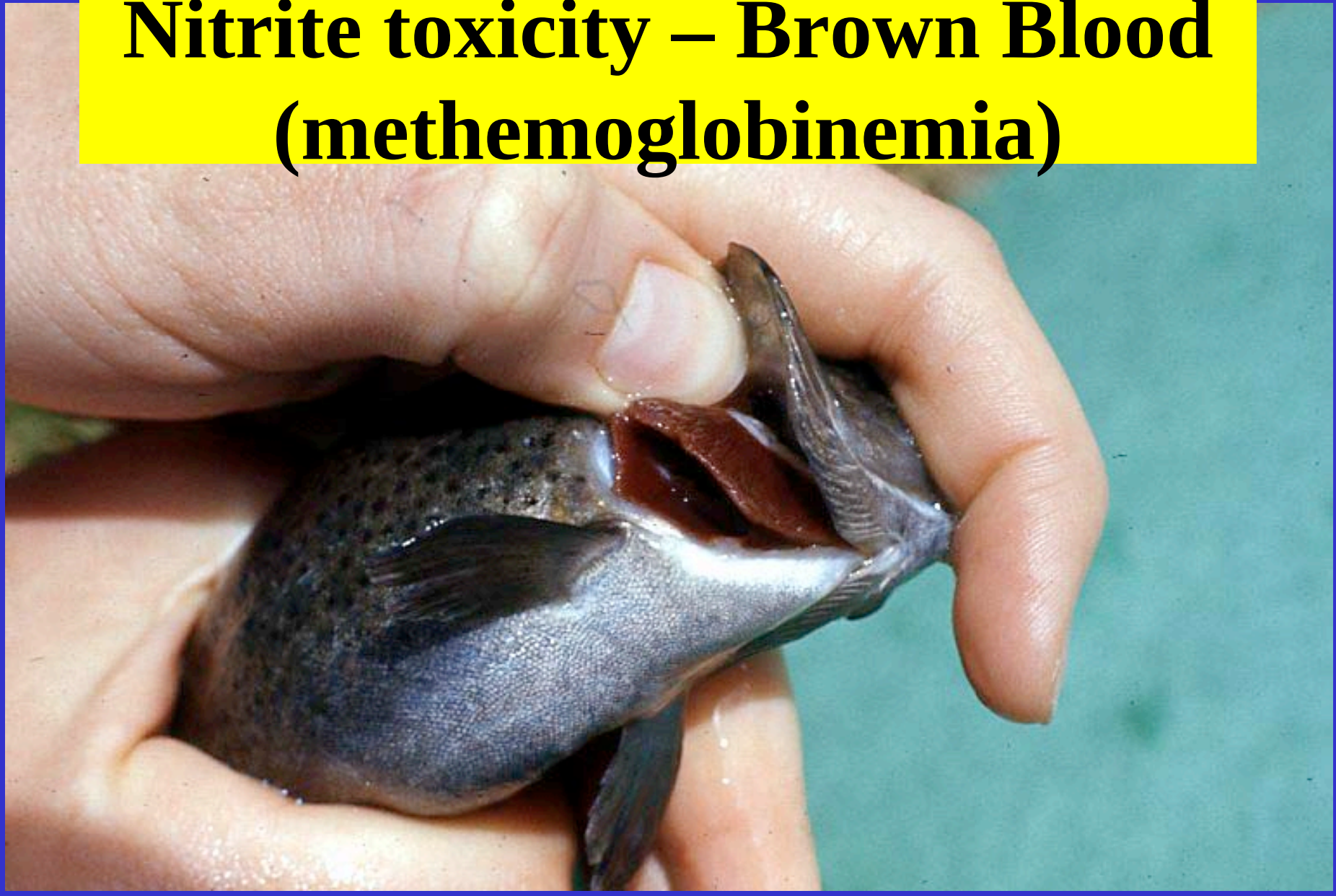
Water Reuse

Cooperative study
1970's



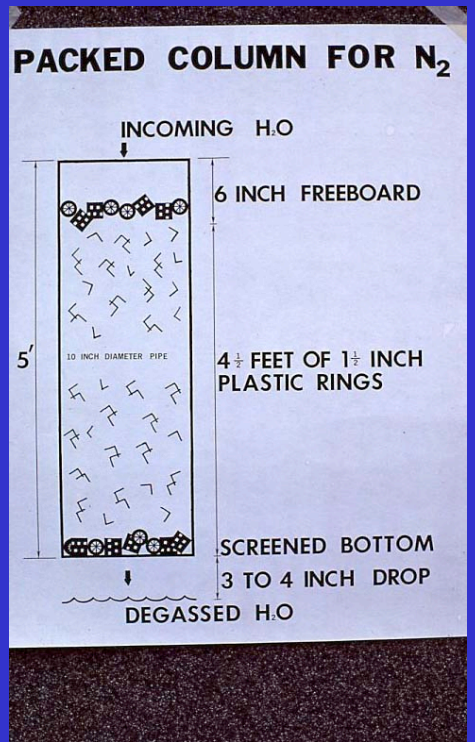

UPFLOW

Nitrite toxicity – Brown Blood (methemoglobinemia)



Dworshak NFH

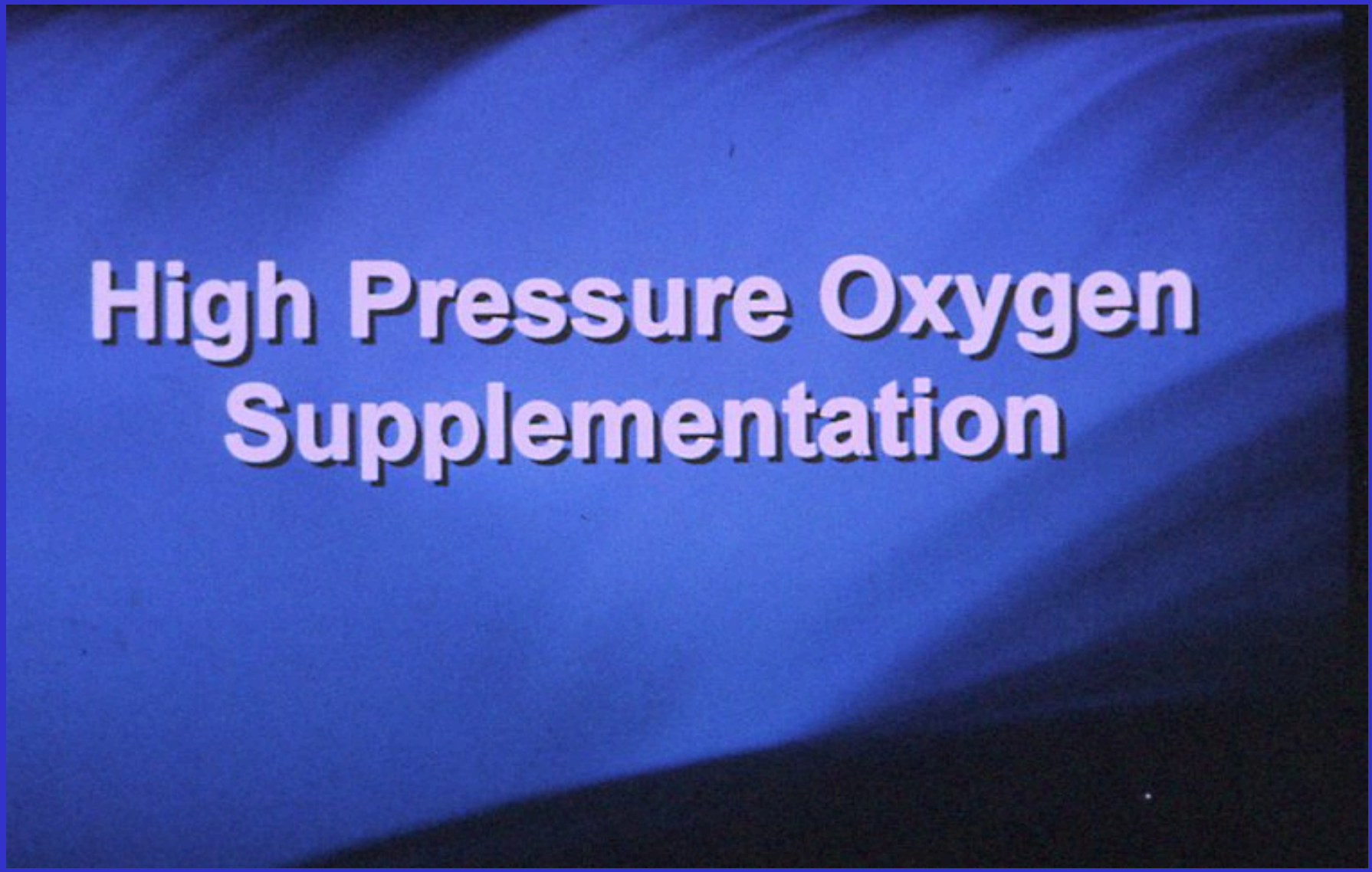
Development of Packed Columns

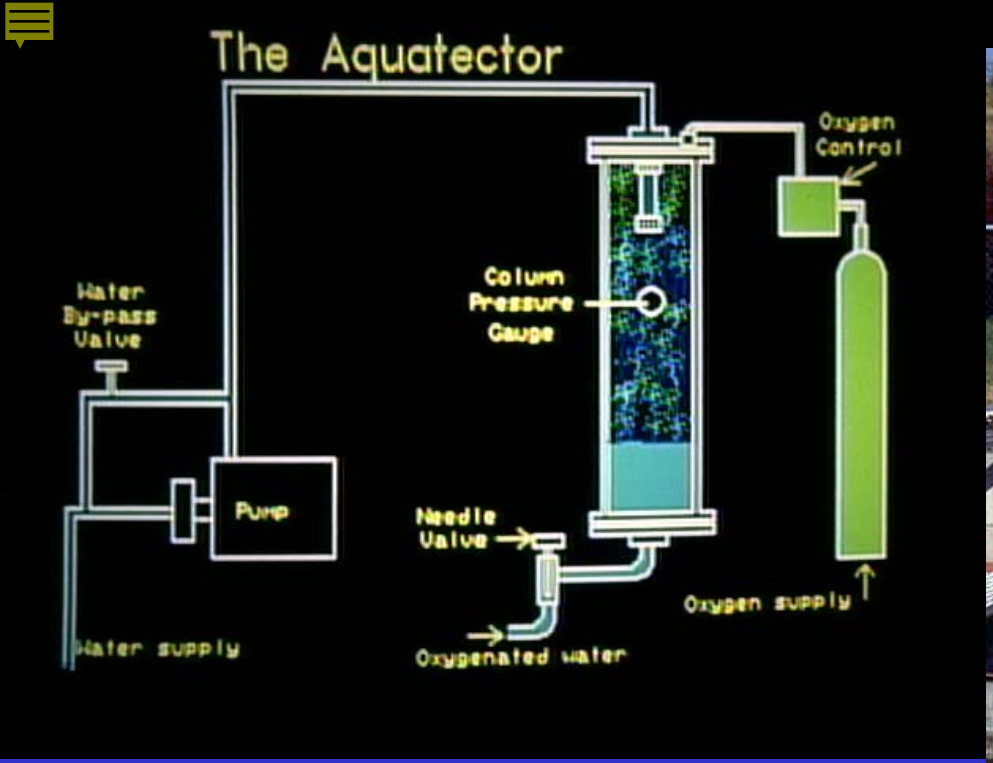

PACKED COLUMN FOR N_2
INCOMING H_2O
6 INCH FREEBOARD
5′
10 INCH DIAMETER PIPE
4½ FEET OF 1½ INCH PLASTIC RINGS
SCREENED BOTTOM
3 TO 4 INCH DROP
DEGASSED H_2O

Operation of packed columns

- **If designed properly and are receiving the proper flow for the diameter of the column**
  - **Oxgen saturation should be 85-90% of saturation after passing through columns**
  - **Nitrogen gas should be reduced to 101-103% of saturation**
  - **Columns make sense if you are already pumping water or have good hydraulic head pressure**

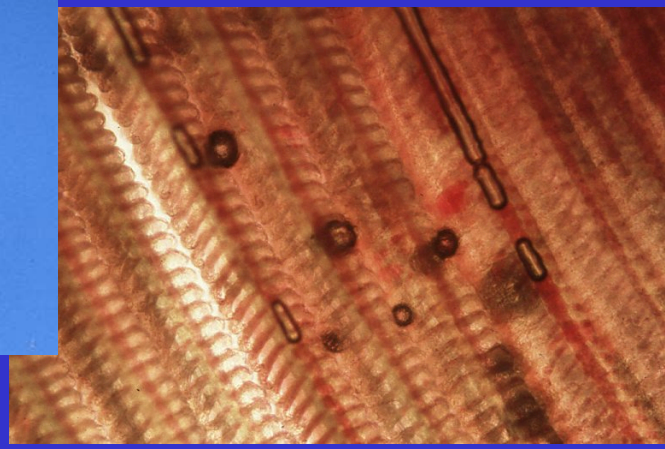
Oxygen Supplementation



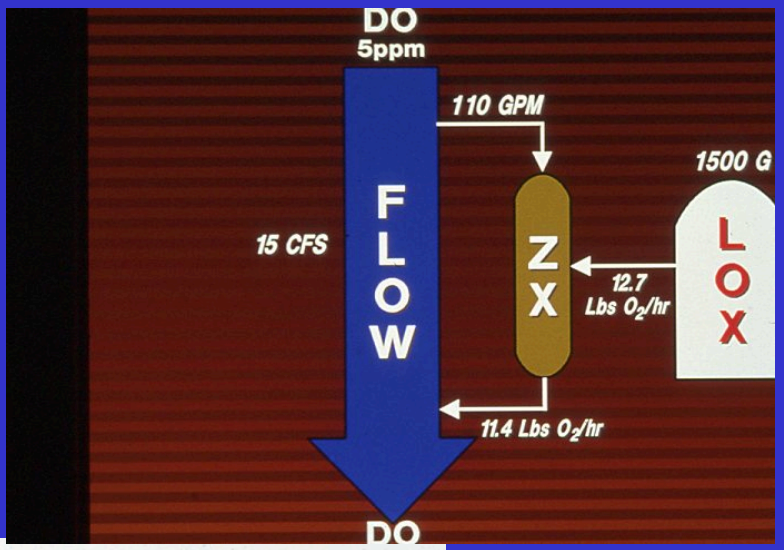


High pressure low water flow fine bubbles appear white. Easy to supersaturate water with oxygen. **But be careful!**

Oxygen induced GBD



Utah hatchery with ATEC unit



Before & after O2 injection

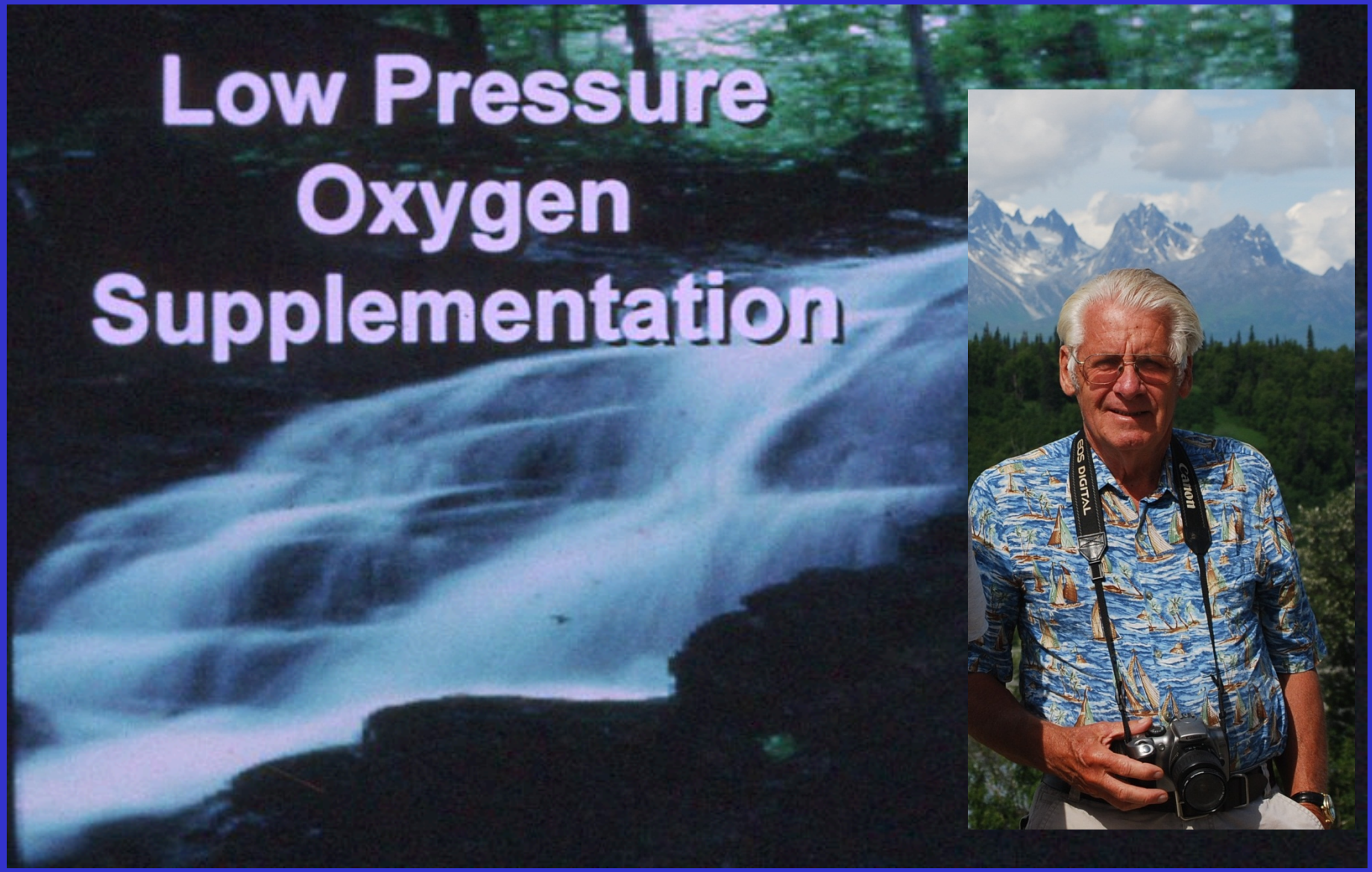
MIDWAY UTAH STATE FISH HATCHERY

Production of 1 raceway, before and after oxygen injection.

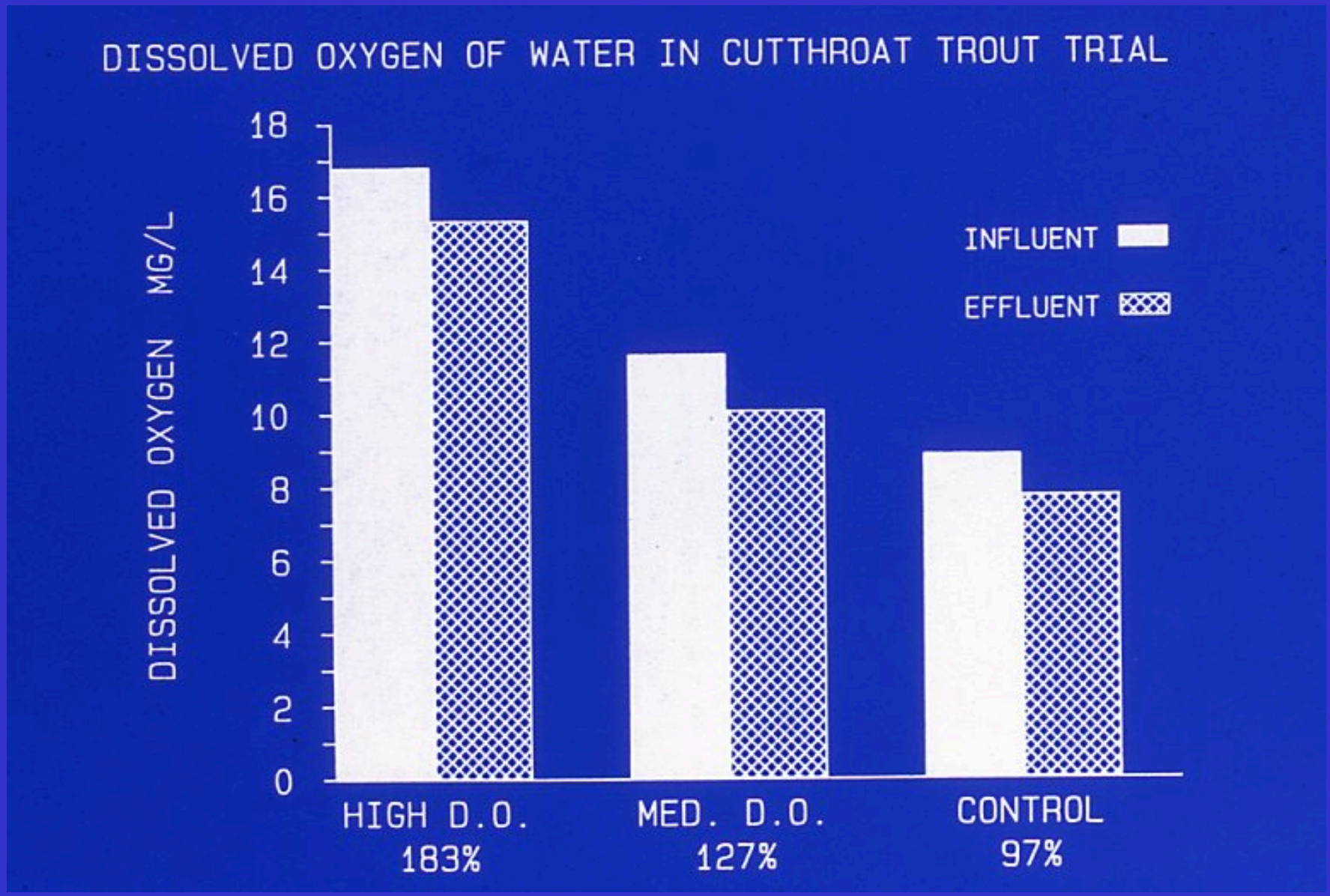
R. CREER 1988

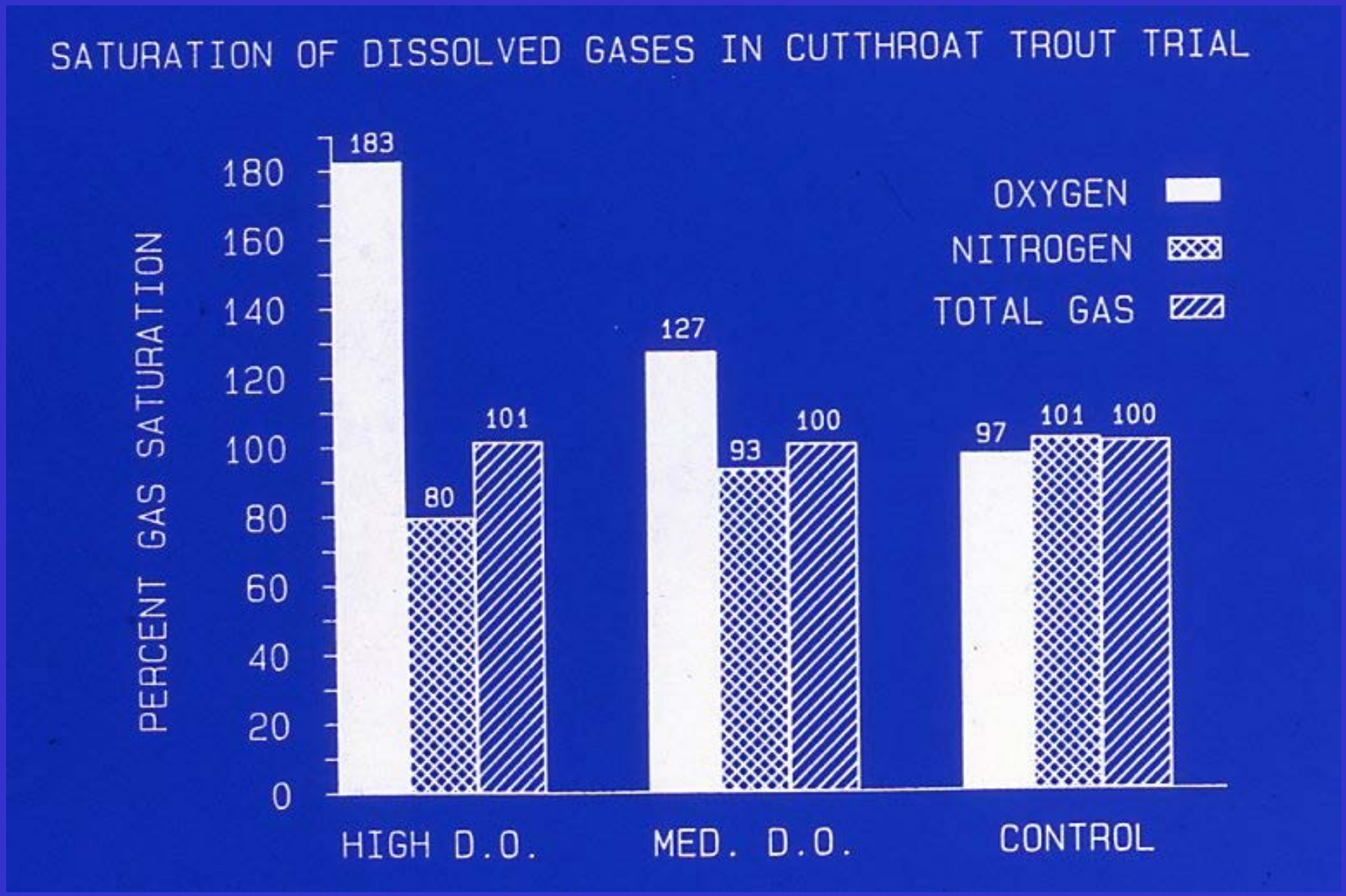
	BEFORE	AFTER
D.O.	6.2 in 5.0 out	8.6 in 5.0 out
gpm flow	530	530
lbs fish	2,316	5,024
# of fish	27,792	60,288
lbs/gpm	4.37	9.5
D.L.I.	.020	.023
feed conversion	1.35	1.10
lbs cu ft	.77	1.68

Oxygen Supplementation



Packed sealed columns


DISSOLVED OXYGEN OF WATER IN CUTTHROAT TROUT TRIAL
DISSOLVED OXYGEN MG/L
18
16
14
12
10
8
6
4
2
0
INFLUENT
EFFLUENT
HIGH D.O.
183%
MED. D.O.
127%
CONTROL
97%


SATURATION OF DISSOLVED GASES IN CUTTHROAT TROUT TRIAL
PERCENT GAS SATURATION
180
160
140
120
100
80
60
40
20
0
OXYGEN
NITROGEN
TOTAL GAS
183
80
101
127
93
100
97
101
100
HIGH D.O.
MED. D.O.
CONTROL

JACKSON WYOMING NATIONAL FISH HATCHERY
EFFECTS OF OXYGEN SUPERSATURATION ON PERFORMANCE OF SNAKE RIVER CUTTHROAT TROUT

91 DAYS

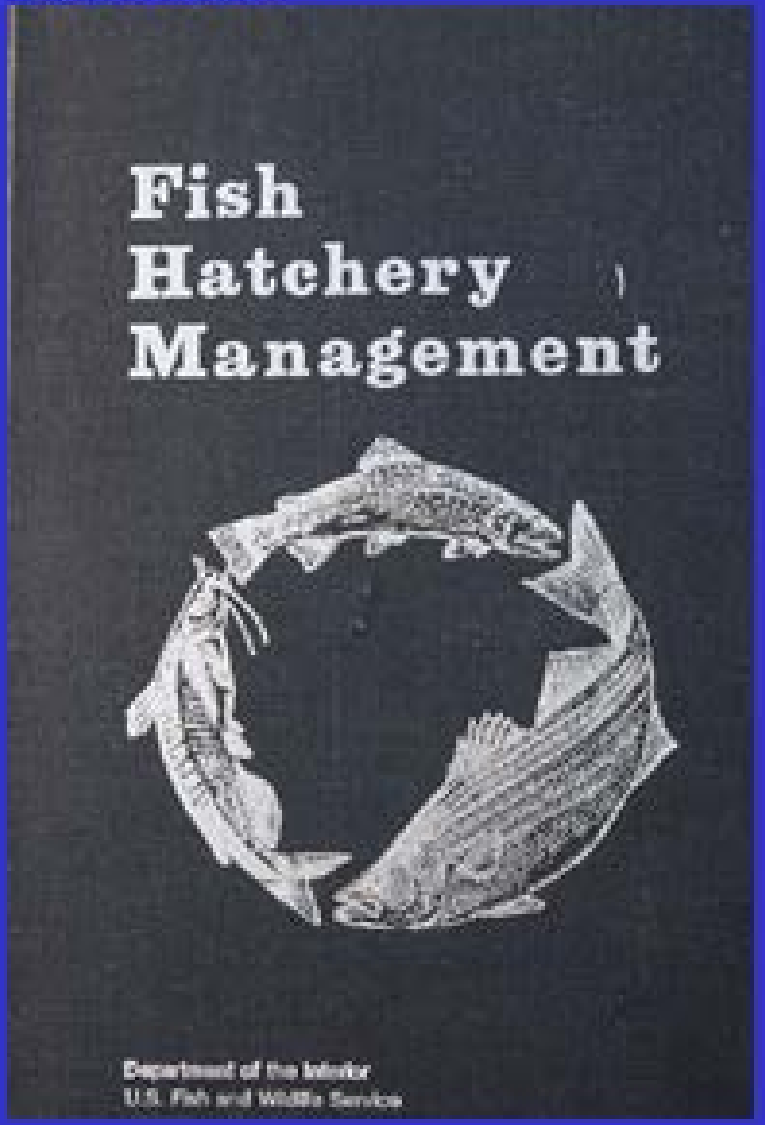
EDSALL AND SMITH 1988

% OXYGEN SATURATION	AVG WT GAIN (g)	FEED CONVERSION
183	7.6	0.81
127	7.9	0.84
97	8.0	0.84

Water and lots of it- a precious resource

Its been a good ride!

Fish Hatchery Management
R. Piper, editor



WRAC

Other changes (cont.)

- **Education opportunities increased with development of 2 year programs, Short course in Cold Water Fish Culture – USFWS, NCTC two week intensive course, mostly state and federal attendees, but individuals from private hatcheries welcome. Held annually in various parts of the country**

Its been a good ride!!