

A large number of small, silvery fish, likely rainbow trout, are swimming in clear water over a sandy bottom. The fish are densely packed in some areas, creating a shimmering effect. The water is clear, and the sandy bottom is visible at the bottom of the frame.

Aquaculture Opportunities in Ontario

Little Current, May 30, 2018

steve.naylor@ontario.ca

Alma Aquaculture Research Station

- Getting Started in Aquaponics and Aquaculture – full day workshop, 4 times a year.
- steve.naylor@ontario.ca

Next Workshop – June 14, 2018

Where Does Our Fish & Seafood Come From?

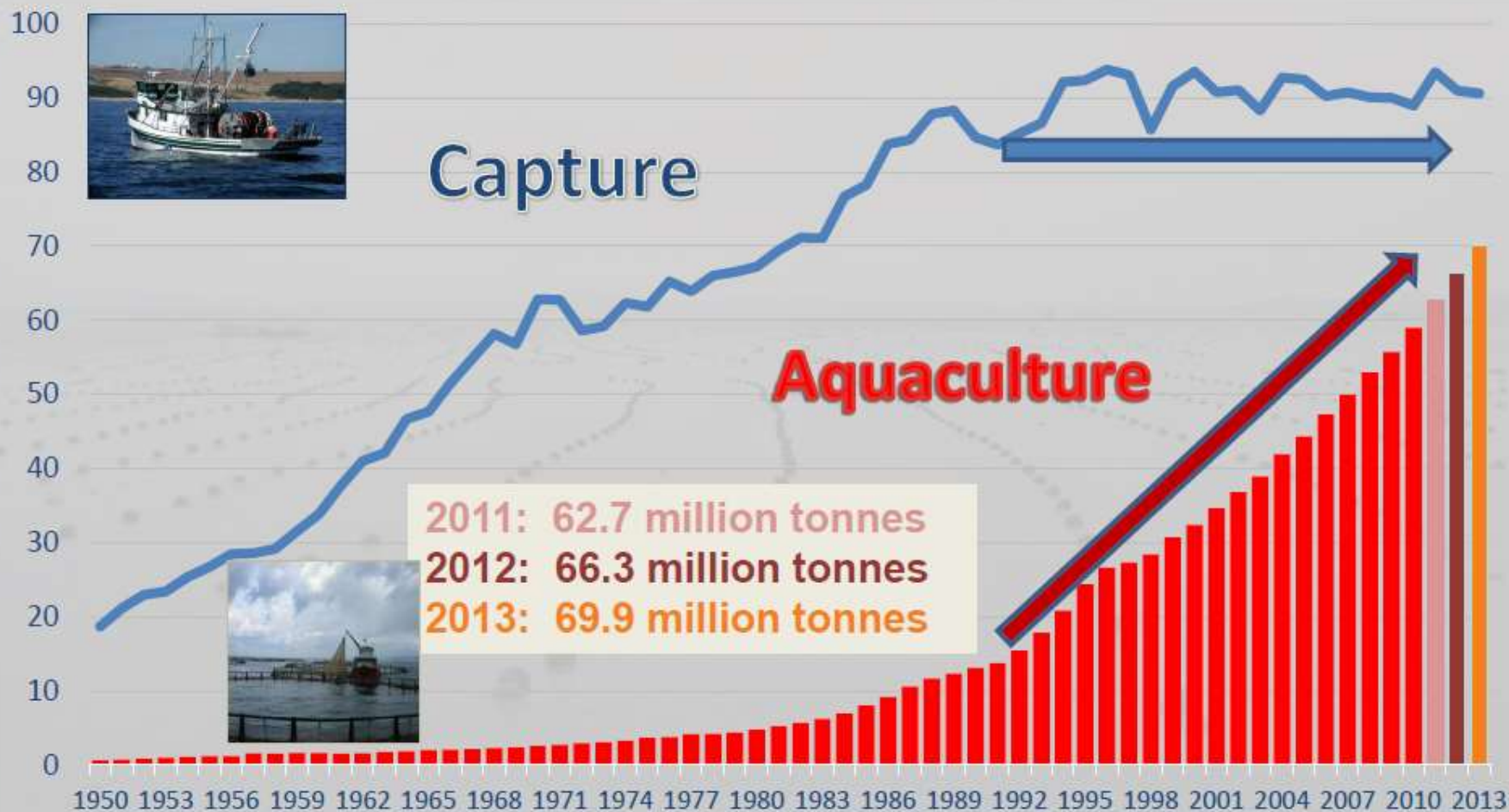


Source: Tidwell

- ❖ Historically – our lakes and oceans
- ❖ When we needed more, we just fished
 - Harder,
 - Longer,
 - Deeper
 - or Further Away

Seafood Production

million tonnes live weight



2012: estimate; 2013: forecast

Why Aquaculture?


- ❖ Demand for seafood exceeds fisheries capacity
- ❖ Represents a sustainable and healthy source of food
- ❖ Provides a means to rehabilitate wild populations
- ❖ 10 years from now aquaculture will need to increase by 50% to supply the growing demand for seafood. There is no possibility to increase wild capture fisheries worldwide.






fish 42 mT (63% in value)

Courtesy John Bostock




molluscs 14 mT (12 % in value)

FAO, 2013



crustaceans 6 mT (21% in value)



seaweeds 21 mT (4% in value)

Courtesy Ferenc Lévai

Benefits of Aquaculture

- ❖ Economic development in rural and coastal communities
- ❖ Year-'round operations
- ❖ Capability to produce to meet market demand and consumer needs
- ❖ Expanding domestic and international markets
- ❖ Enhanced balance of trade (exports)
- ❖ Non-extractive, renewable resource industry
 - i.e. sustainable development
- ❖ Considerable un-developed potential
- ❖ Augments productivity of entire fishery sector



Common Challenges to Aquaculture Development

- ❖ Opportunities awareness
- ❖ Access to financing
- ❖ Training & skills development
- ❖ Availability of objective information
- ❖ Capacity to develop opportunities
- ❖ Infrastructure, transportation costs & economies of scale in often remote locations



Regional Distribution of Aquaculture



Salmon (72%)



Trout (4%)

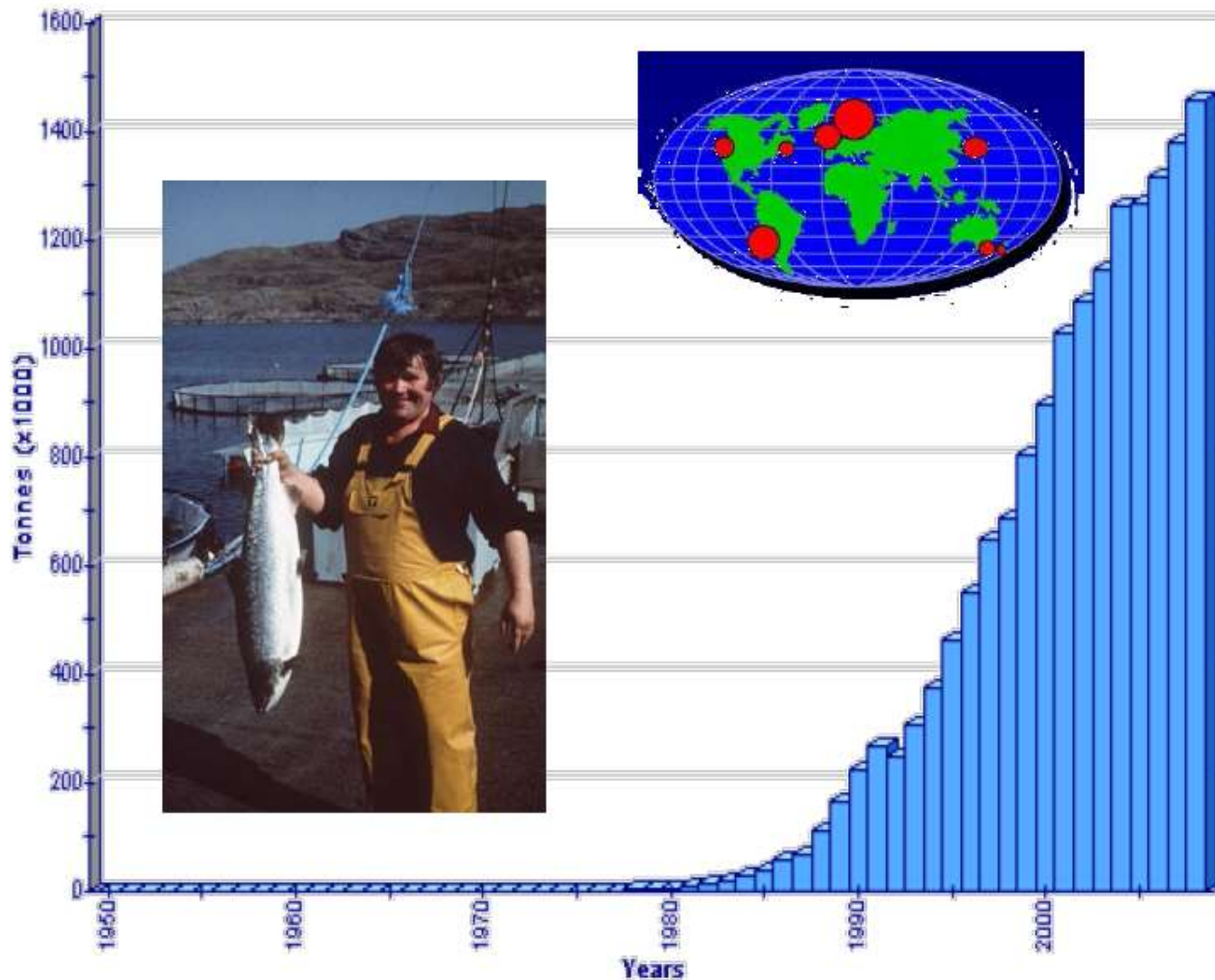


Oysters (6%)

Mussels (14%)



WORLD SALMON PRODUCTION

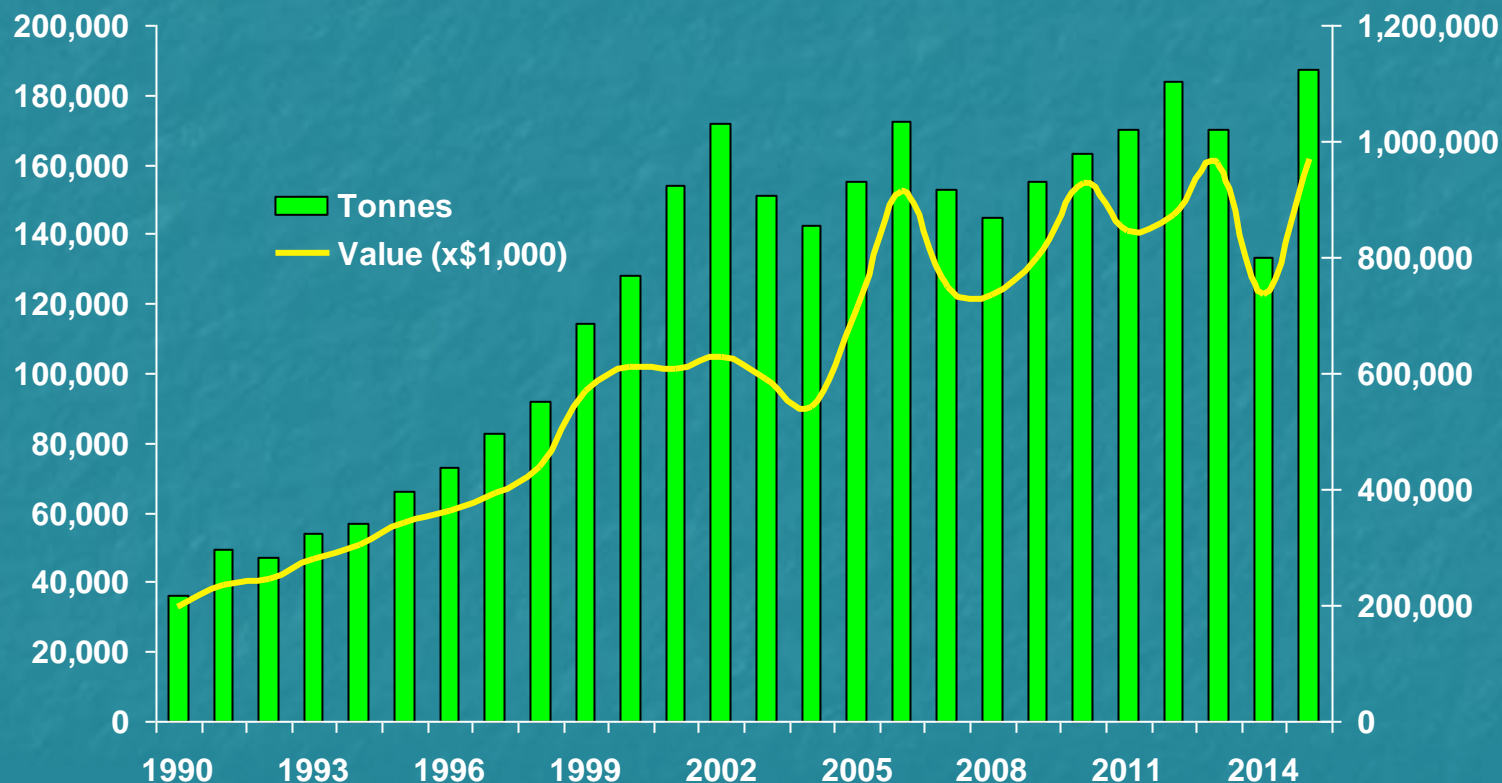


Canadian Aquaculture (farm-gate)



Tonnes

Value



Data taken from Statistics Canada.
Excludes production in Manitoba, Saskatchewan, and Alberta.

Output by Province

❖ BC leads provinces

- 54% of total output
- 95% salmon

❖ NB is second

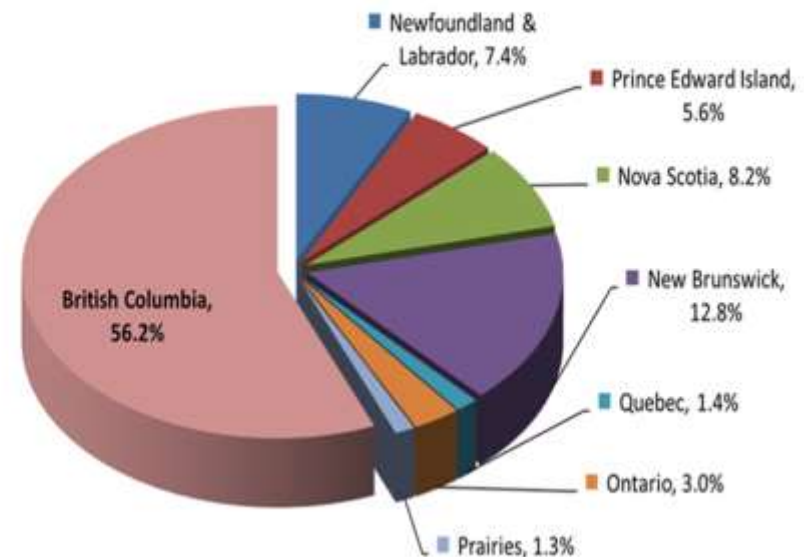
- 25% of total output
- 98% salmon

❖ NL & NS also mainly salmon producers

❖ PEI mainly mussels

❖ ON, QC & Prairies produce mainly trout

2014 Canadian Aquaculture Production Value
at Farm-gate, by Province
733 million dollars



Trout & Charr Aquaculture



We raise these!

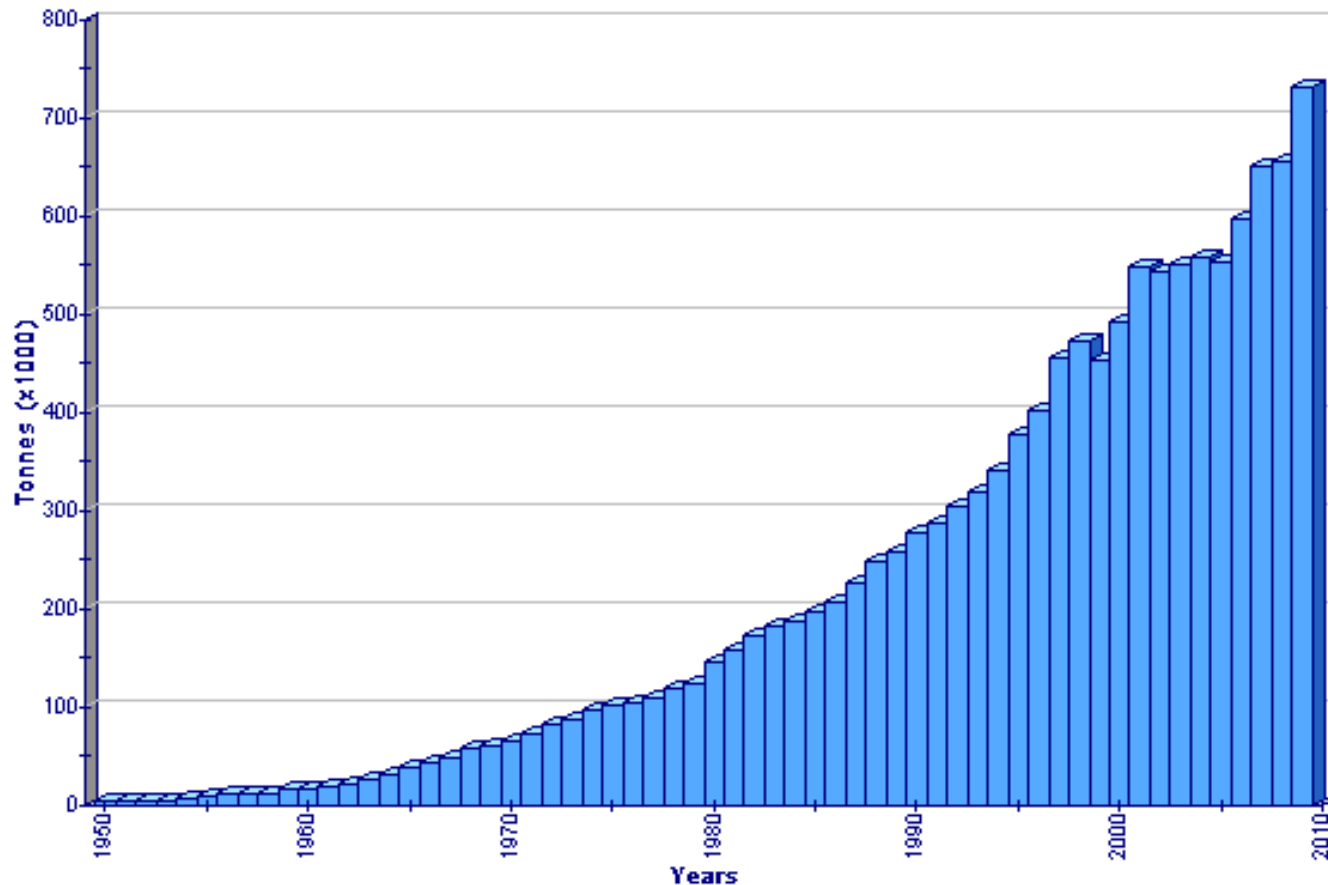
- Introduced by fisheries managers into all the Great Lakes from the west coast



- Genetically plastic, hardy
- Small scale escapes not an issue
- Naturalized



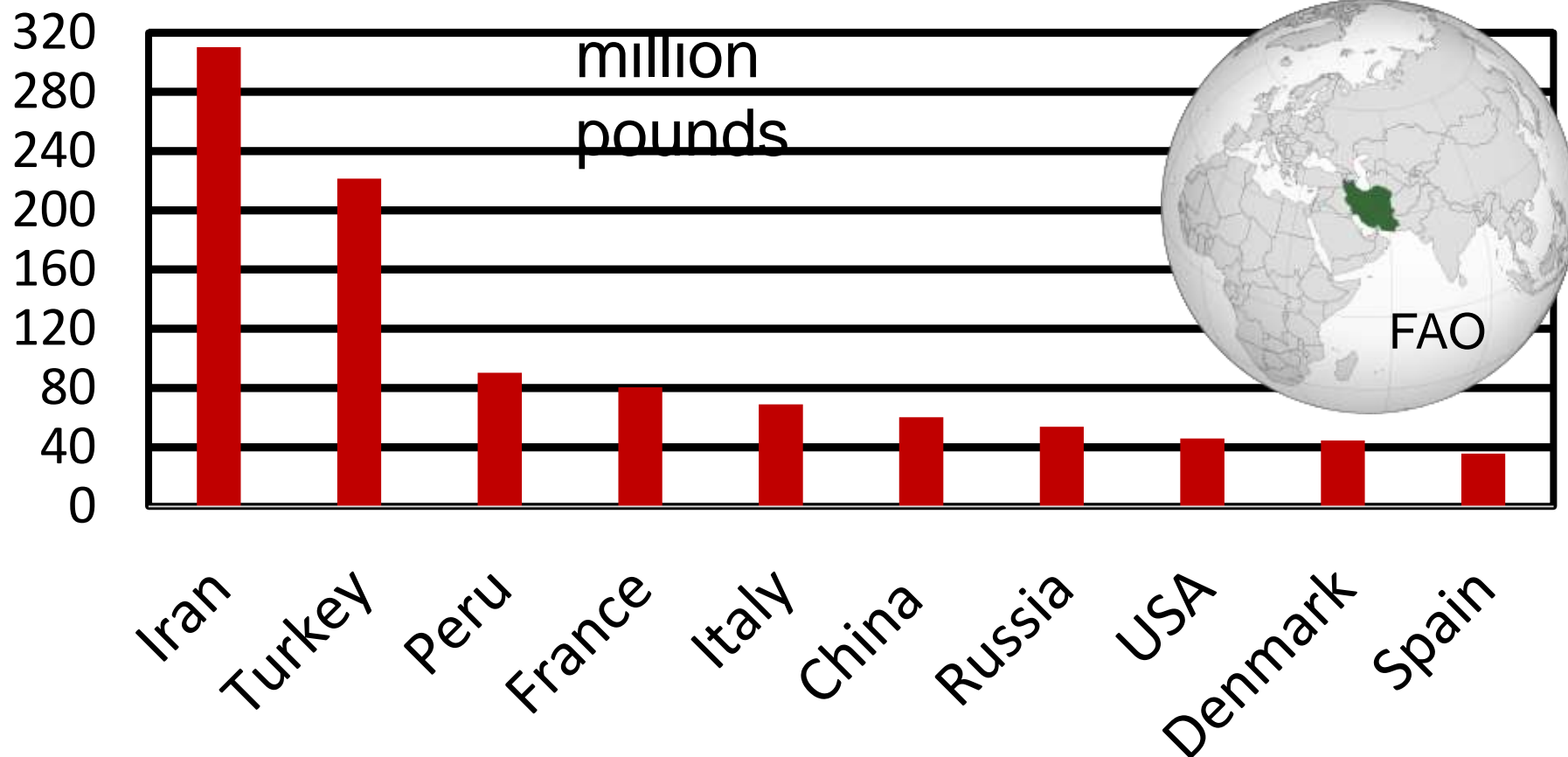
World Production of Rainbow Trout



2009 production of 732,432 tonnes (23% increase over 2006)
2011 production of 770,385 tonnes (31% increase over 2006)



2015 Top 10 Trout Producing Countries



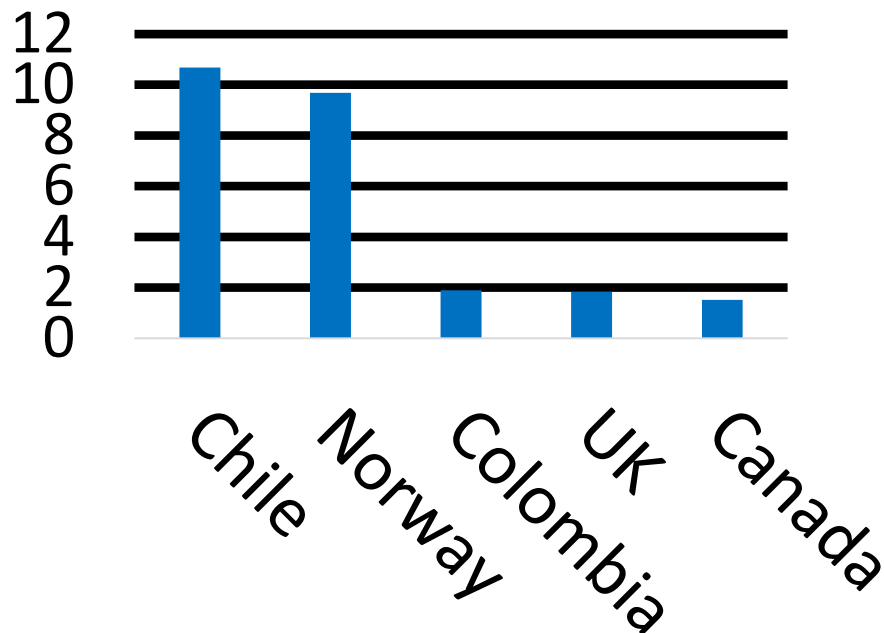
The abundant potential...



- 20% of the world's freshwater,
- Plentiful biophysical resources,
- Developed culture technology,
- Still not meeting domestic demand,
- Substantial export potential with proximity to the U.S. market,
- The industry has the experience, expertise and desire to support development.

US trout imports - 90 % of 2017 Imports came from...

Million Pounds Trout
Product



NMFS



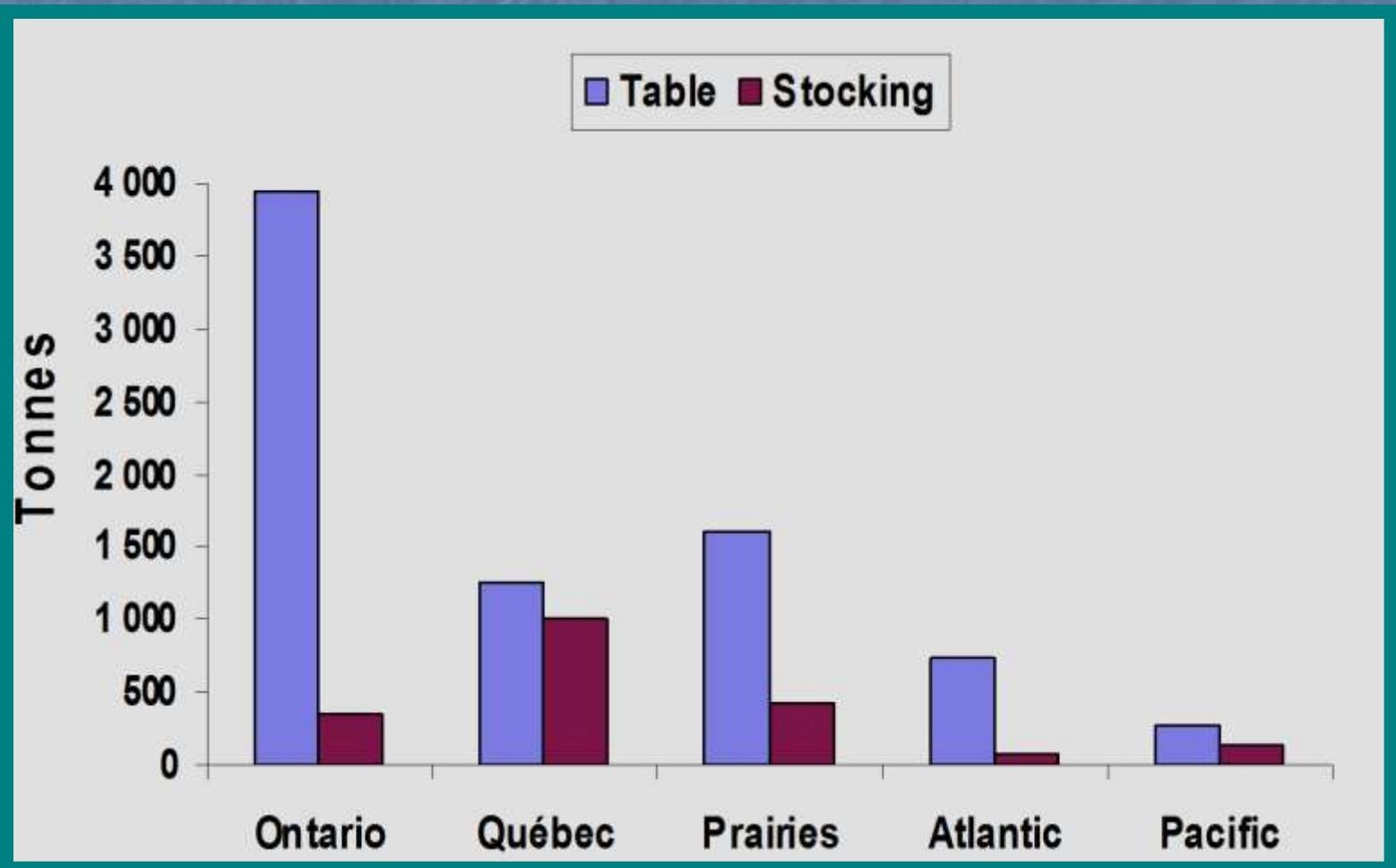
...relative to 2016: 10% down pounds
12% up dollars

Why Rainbow Trout?

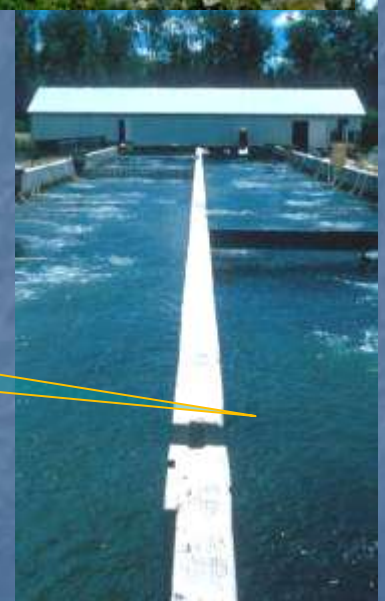
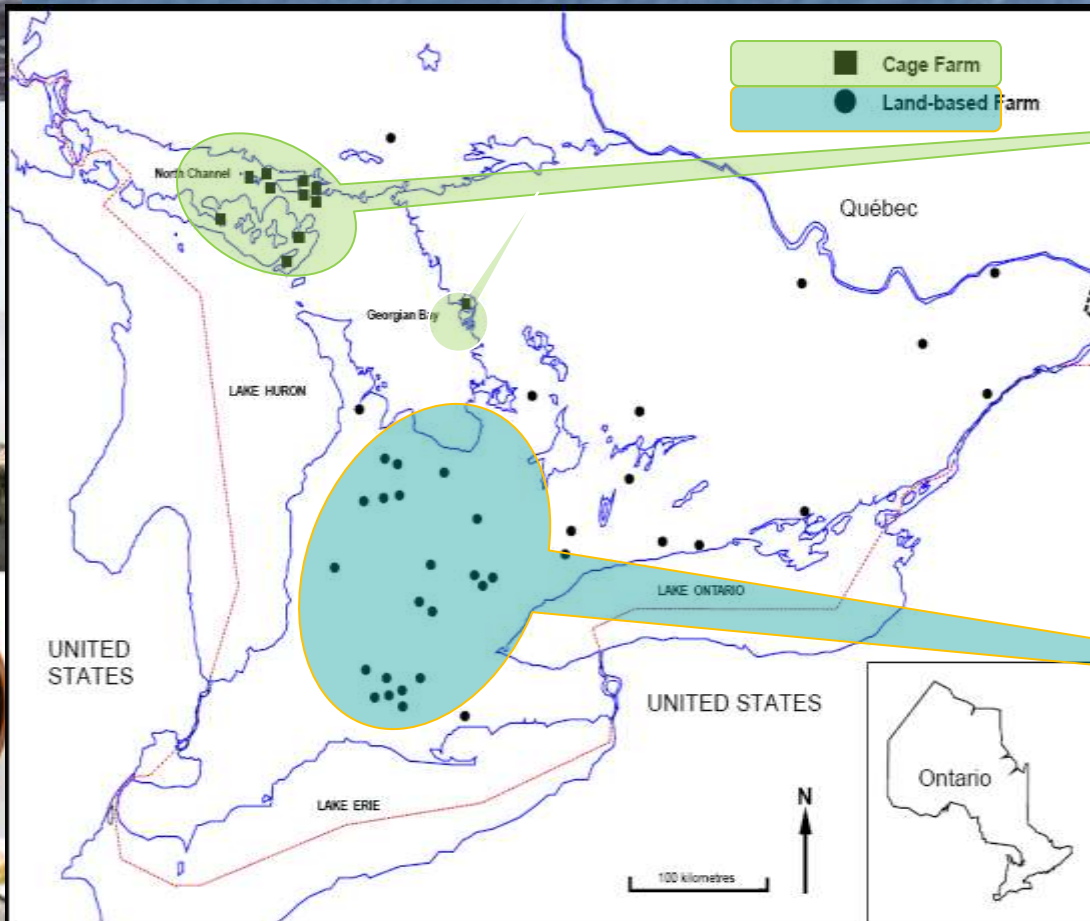
- ❖ Culture techniques, based on more than 100 years of research and practice, are well established;
- ❖ Domesticated strains of trout have been bred to improve performance and yield;
- ❖ Nutritional requirements are well defined and efficient commercial feeds are available from several suppliers;
- ❖ Water temperatures and the biophysical resource base throughout much of Canada are near ideal for the species;
- ❖ An established market exists for rainbow trout; and
- ❖ Naturalized species in most parts of the country and thus poses little to no genetic threat to feral populations.



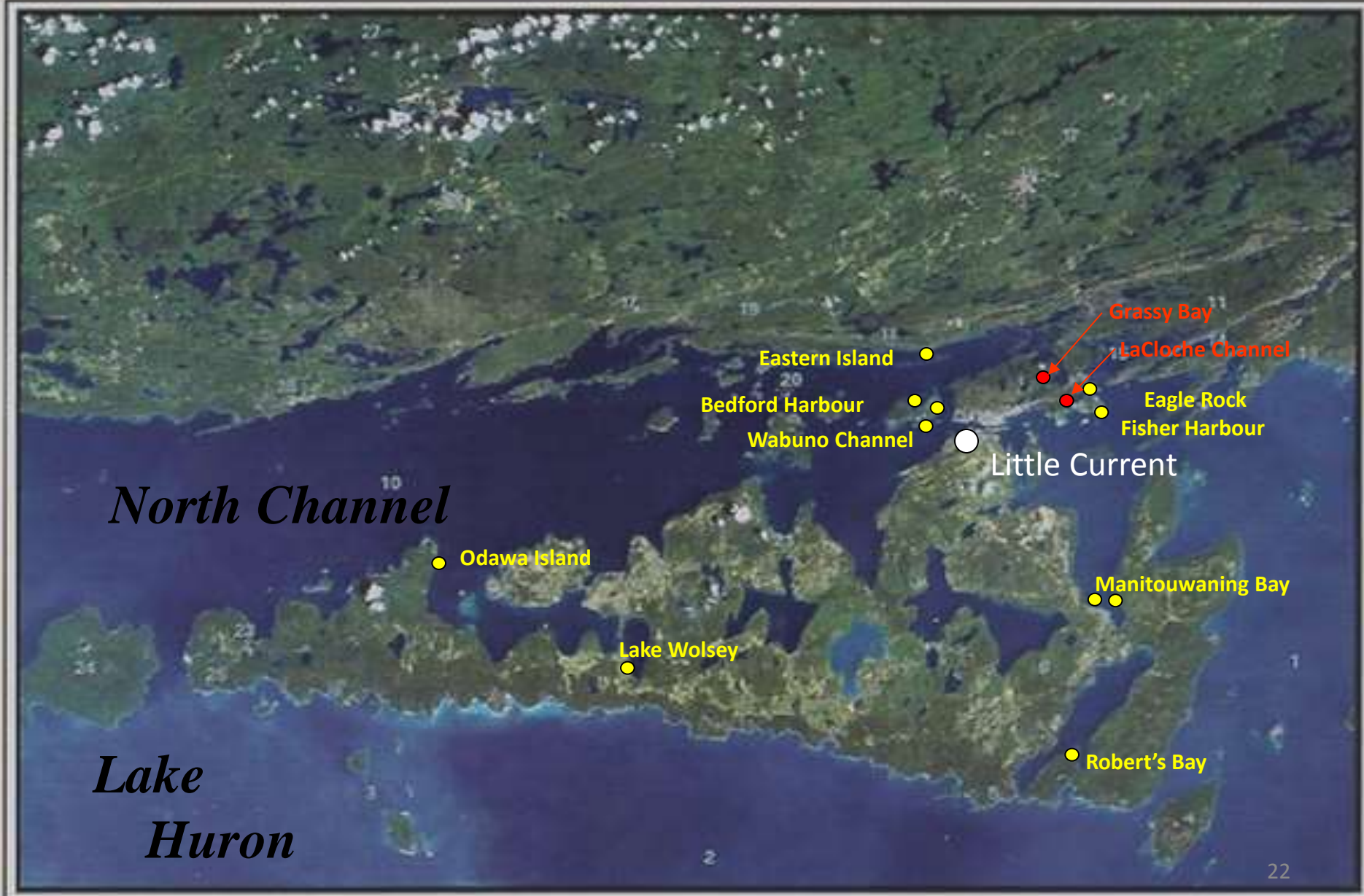
Freshwater Aquaculture Regional Production



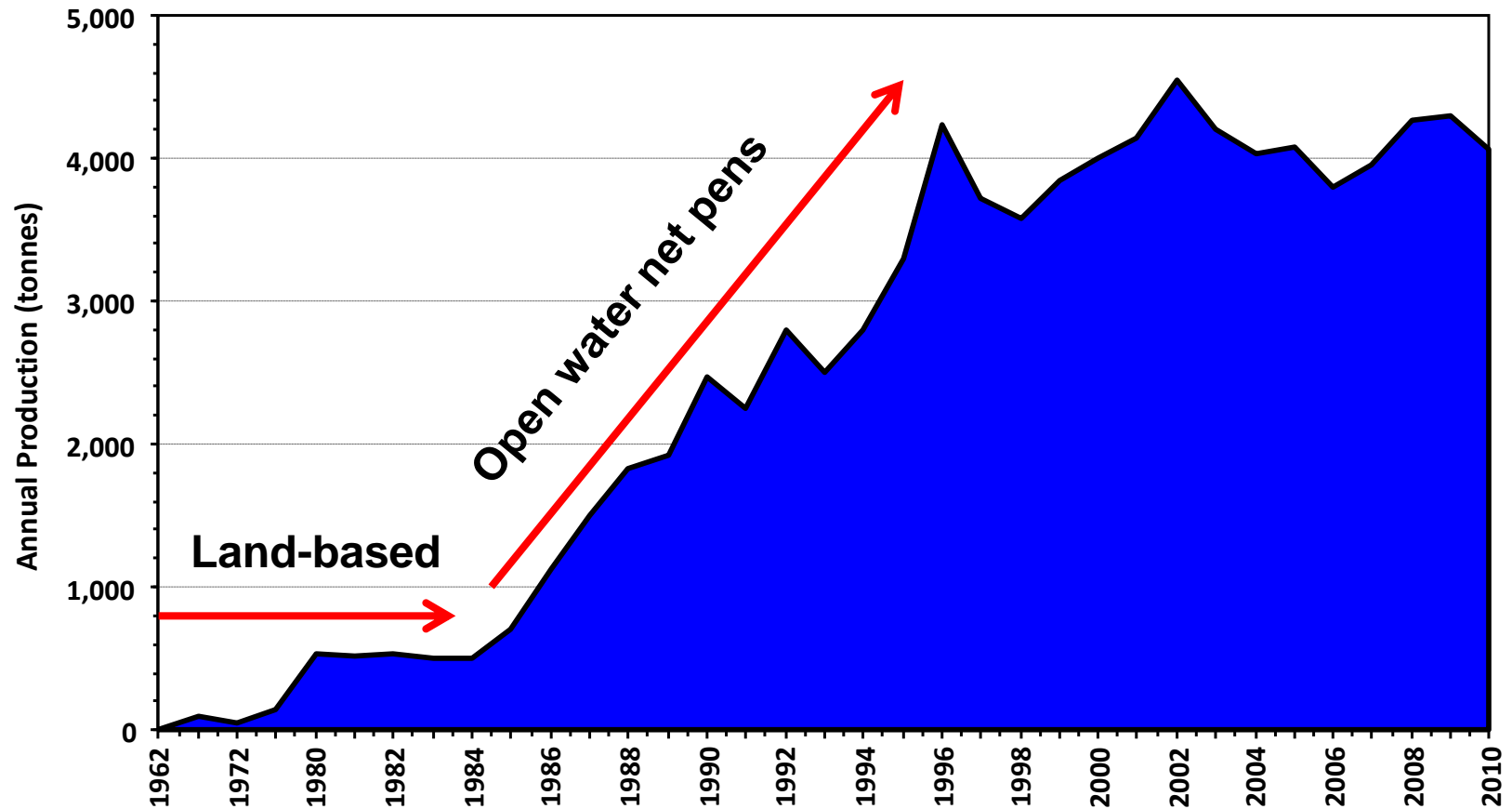
Distribution of Trout Farms in Ontario



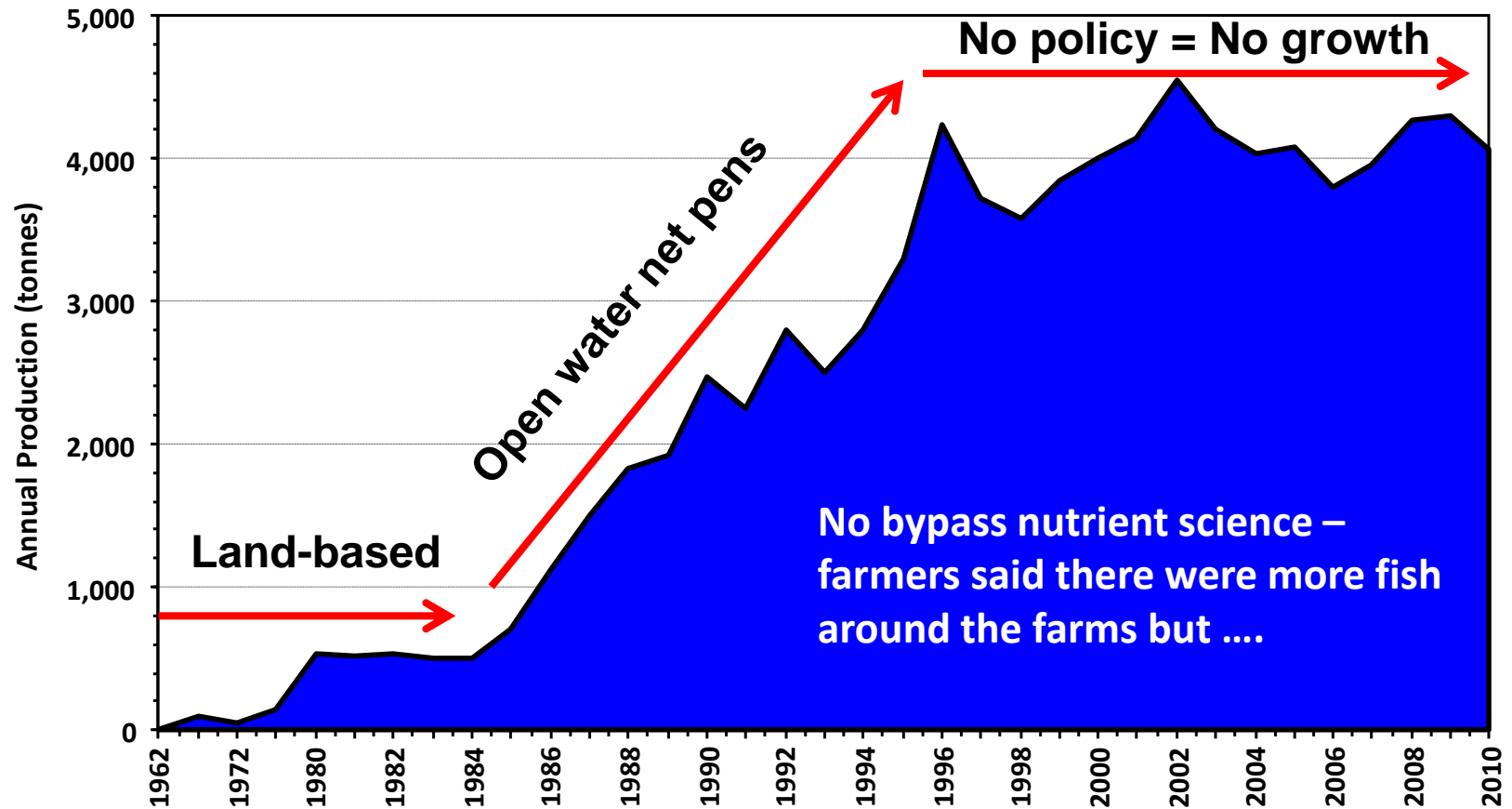
THE NORTH CHANNEL - MANITOULIN ISLAND



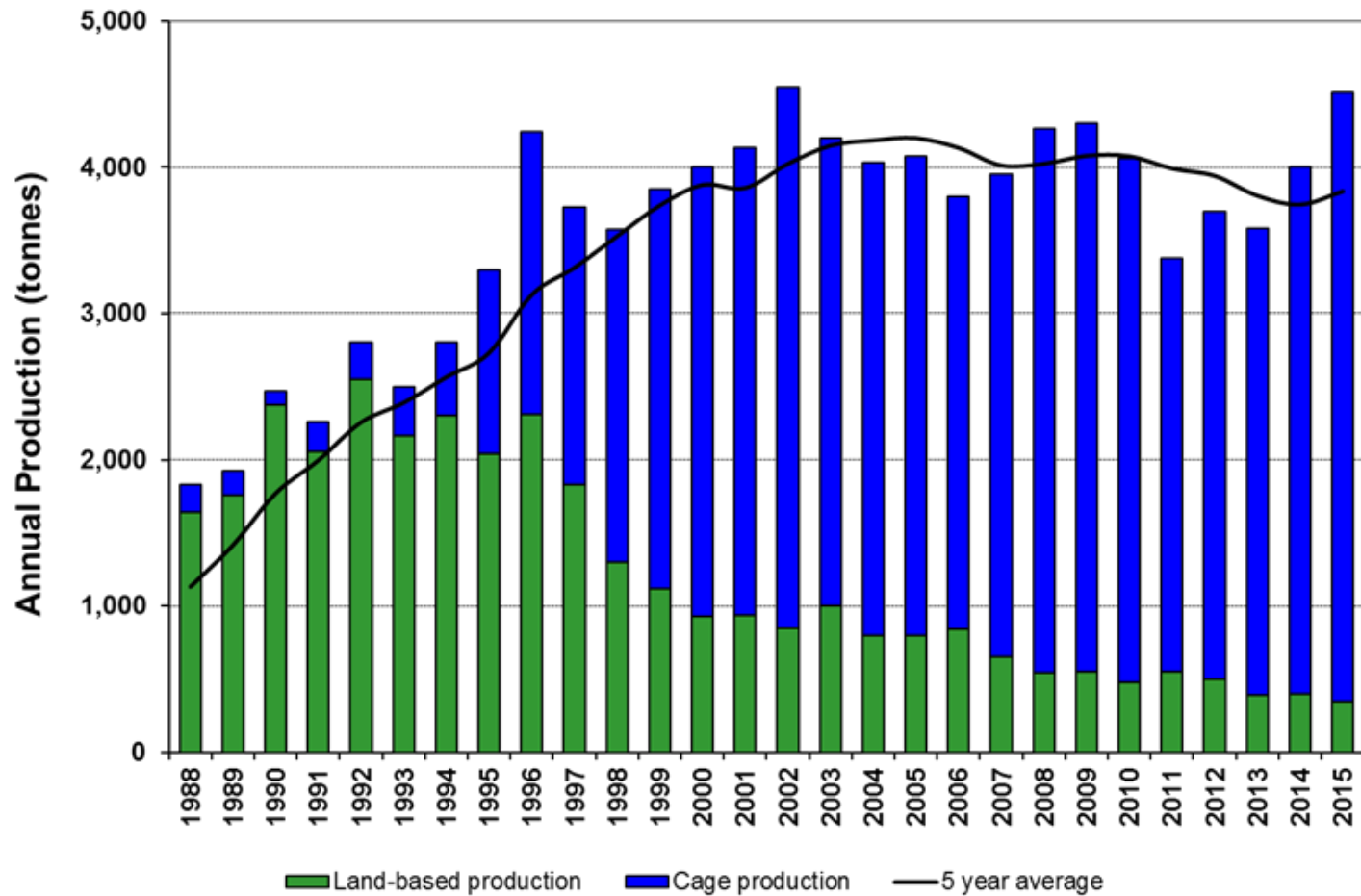
Ontario farmed trout production between 1962 and 2010



Ontario farmed trout production between 1962 and 2010

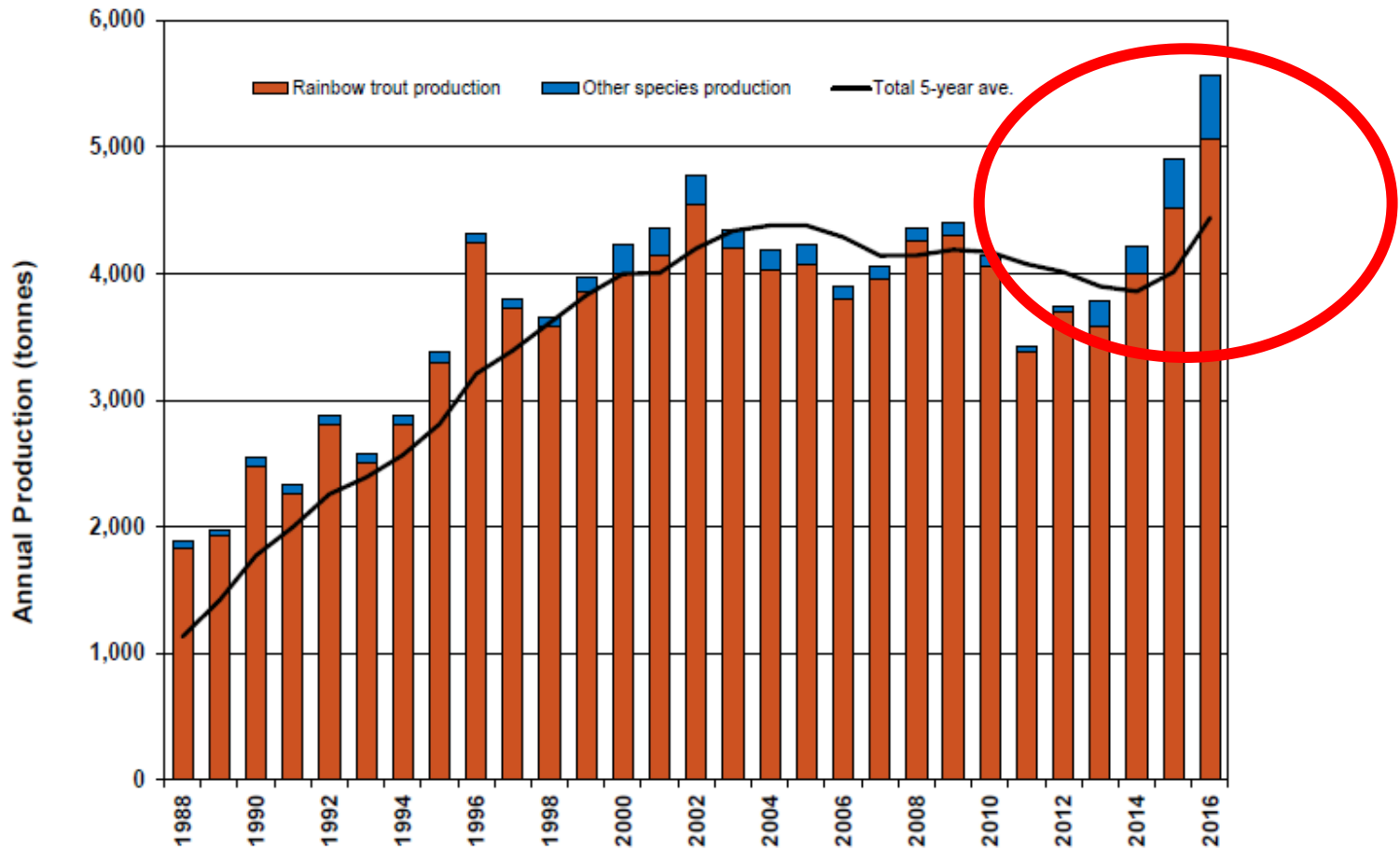


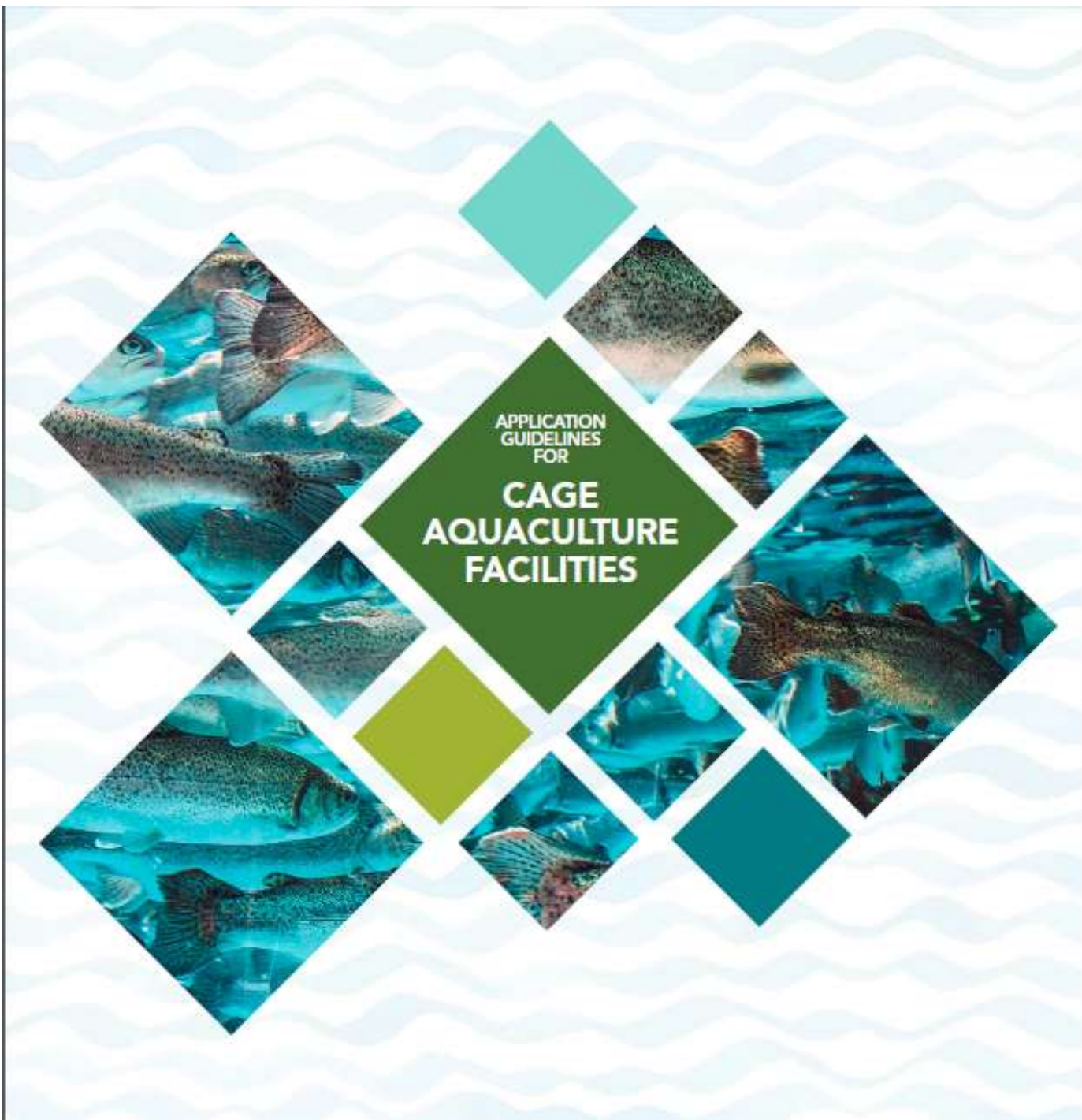
Ontario Farmed Trout Production



Ontario Aquaculture Production

Figure 1. Ontario aquaculture production between 1988 and 2016.





Industry Consolidation over the last several years

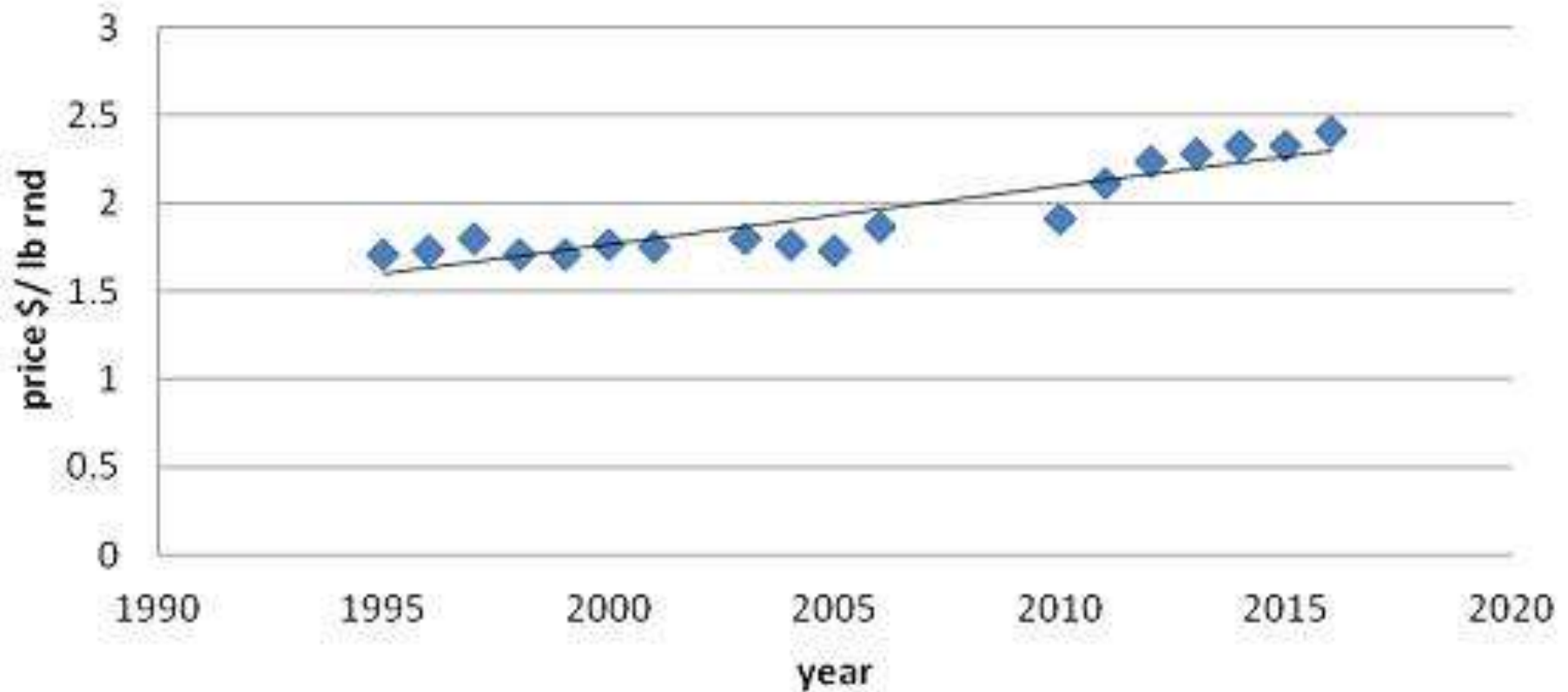


**Ontario Aquaculture Association (formerly NOAA)
Ontario Fishery Enhancement and Aquaculture Association**

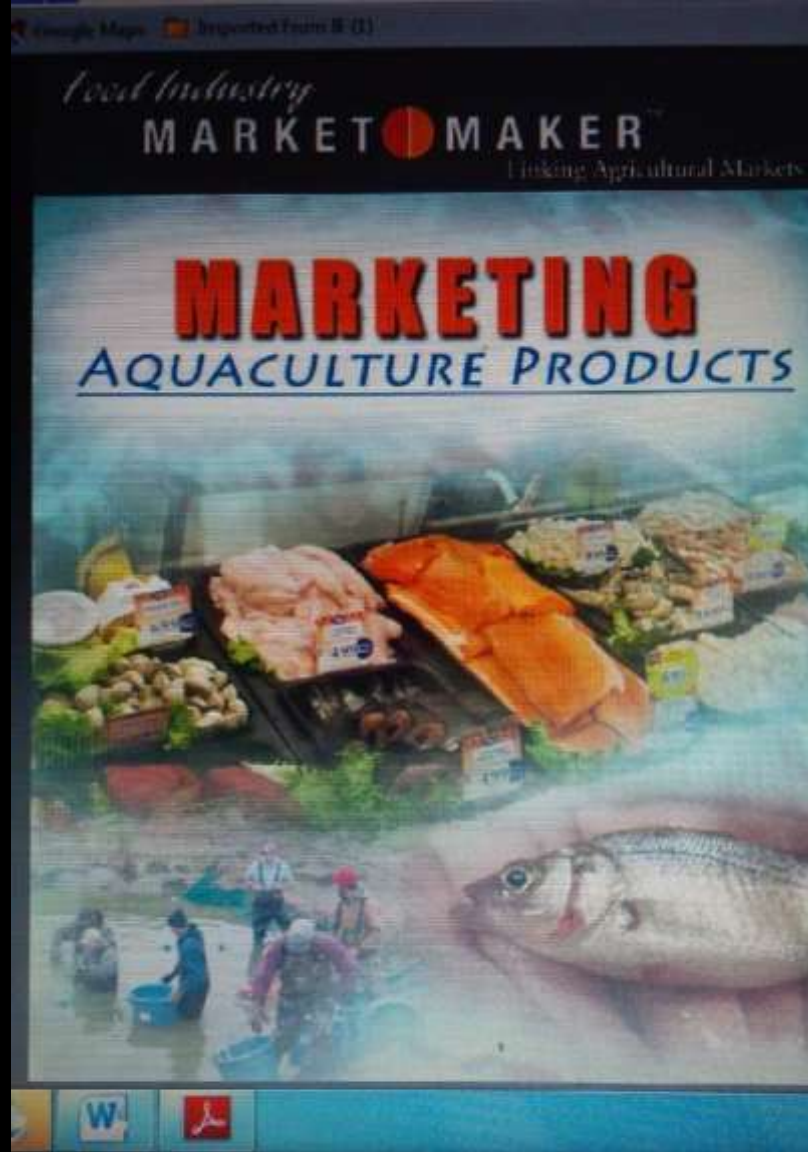
ontariofishfarmers.com
eattrout.ca
Ontarioaquaculture.net



ON wholesale average trout price



- 2017 wholesale net pen in the round farm-gate ~\$2.45
- **Land-based farms up to \$10/lb – niche marketing**
- Price predictability



<http://www.ncrac.org/files/MarketMaker-Pub-0034.pdf>

Market Factors - Consumer Trends

❖ Safety

- Contamination; product traceability

❖ Communications / Media

- Considerable power to influence consumer behaviour (e.g. salmon); sustainability

❖ Marketing

- Consumers influenced most by quality, convenience, value

❖ Dining out

- HRI market is dominant

❖ Sustainability

- Environmental & Socio-Economic



Canadian Trout Market

- ❖ Québec (39%) and Ontario (23%) are the principal Canadian markets for trout
 - Other eight provinces and the three territories consume the balance (38%)
- ❖ Foodservice:
 - Hotels, restaurants and institutions (HRI)
 - ~50% of tonnage but 66% of value
- ❖ Retail:
 - e.g. Loblaw's, Metro, Fortino's, Zehrs, Sobey's, etc.
- ❖ Club Stores:
 - Costco
 - Seafood expected to play a more important role in the future of club stores.



GTA live fish markets



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Live Stripe Bass
游水鱸魚

\$ **7.59** /LB





IN-STORE SPECIAL

本店特價

**LIVE AUSTRALIA
BARRAMUNDI**

游水澳洲桂花魚

7.99 / lb
\$17.61/kg

IN-STORE SPECIAL

本店特價

LIVE AUSTRALIA



TONE TAI

Fresh Australian Bass

桂花魚

\$ 2.99 /LB

鼎泰

NO 6



Live Green Bass

游水青斑

^{\$}**9.99** /LB



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First Choice 超市 *First Choice* 超市 *First Choice* 超市 *First Choice* 超市

*** IN STORE SPECIAL ***

FRESH GREEN BASS

新鮮青斑魚

本週特價

NO CLEAN: **\$3.29/LB**

CLEAN: **\$3.59/LB**

原價: ~~\$5.99/LB~~

First Choice 超市 *First Choice* 超市 *First Choice* 超市 *First Choice* 超市



Organic Aquaculture Production – Standards under CGSB

Wild  T COAST	FRESH HALIBUT Steak	Farmed  IRELAND	ORGANIC STEELHEAD TROUT Fillet		Farmed  CANADA	FRESH RAINBOW TROUT Fillet	
Texture: Medium Firm Medium Flake	\$ 13.99 lb \$30.84 kg	Texture: Medium Firm Medium Flake	\$ 16.99 lb \$37.46 kg		Texture: Medium Firm Medium Flake	\$ 8.99 lb \$ 19.82 kg	
Flavour: Mild & Sweet		Flavour: Mild & Sweet			Flavour: Mild & Sweet		
Cooking: Broil, Grill, Sauté, Steam		Cooking: Bake, Broil, Grill, Steam			Cooking: Bake, Broil, Grill, Steam		



Meeker's Aquaculture, Lake Wolsey



CANADIAN
AQUACULTURE
INDUSTRY ALLIANCE

ALLIANCE DE L'INDUSTRIE
CANADIENNE DE
L'AQUACULTURE

Farming Canadian Waters with Care

Seafood Certification Programs



Monterey Bay Aquarium Seafood Watch & Eco-certification

- ❖ Helps consumers make choices for healthy oceans
- ❖ Recommendations indicate which seafood items are "Best Choices," "Good Alternatives," and which to "Avoid"

Seafood Watch - Seafood Guide

Trout, Rainbow



SEAFOOD	RATING	MARKET NAMES	WHERE CAUGHT	HOW CAUGHT
<u>Lake Trout</u>	GOOD ALTERNATIVE	Laker, Namaycush, Togue, Mackinaw, Char, Salmon Trout	Lake Superior	Wild-caught
<u>Lake Trout</u>	AVOID	Laker, Namaycush, Togue, Mackinaw, Char, Salmon Trout	Lake Huron, Lake Michigan	Wild-caught
Rainbow Trout	BEST CHOICE	Golden Trout	U.S.	Farmed



Ocean Wise Seafood Program



NOT RECOMMENDED

VARIETY

Rainbow trout, steelhead
Oncorhynchus mykiss

METHOD

Wild
Midwater gillnet



NOT RECOMMENDED

VARIETY

Rainbow trout
Oncorhynchus mykiss

METHOD

Open net pen



UNDER REVIEW

VARIETY

Steelhead
Oncorhynchus mykiss

METHOD

Farmed
Open net pen



What's Needed for Continued Sustainable Growth?

- The sector completes Best Aquacultural Practices certification through the whole supply chain
- Obtains Ocean Wise certification through environmental data transparency – “one-click” public facing website
- Moves towards larger net pens and automated feeding systems to improve farm efficiencies and environmental performance
- With the majority of current production and all known future sites being licensed through Band Council Resolutions, we need DFO to recognize those Band Council Resolutions in legislation to trigger AAR reporting



Enhancement of lake fish populations as a by-product of cage aquaculture

Results of five years of rainbow trout cage aquaculture at the Experimental Lakes Area, northwestern Ontario

Ken Mills



Fisheries
and Oceans Pêches
et Océans



Experimental Lakes Area (Dept. of Fisheries & Oceans)

- Established in 1968
 - **Controlled experiments to address aquatic issues**



Lake 375 Cage Aquaculture (2003 – 2007)



Approximately 10,000 rainbow trout cultured each year
Added as fingerlings in the spring and harvested each fall

Lake 375

Fish Community

- Abundant (many present)
 - lake trout
 - white sucker
 - fathead minnow
- Much less abundant
 - pearl dace minnow
 - northern redbelly dace minnow
 - finescale dace minnow
 - slimy sculpin

**13 Years
background
data**

Fish Population Parameters

- Abundance
- Annual survival
- Recruitment (reproduction)
- Growth
 - Length
 - Fatness
- Age at maturity



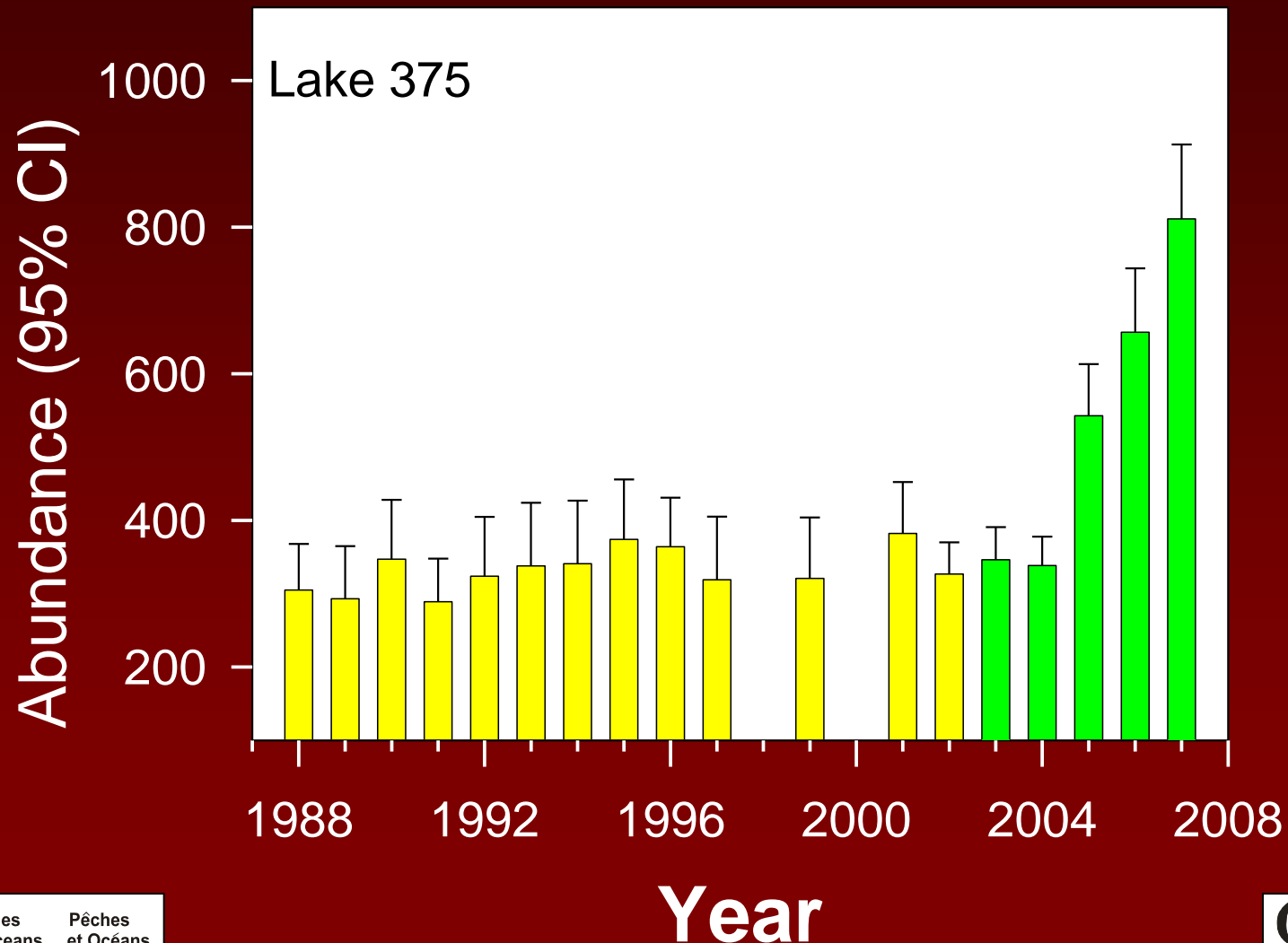
Fish Capture



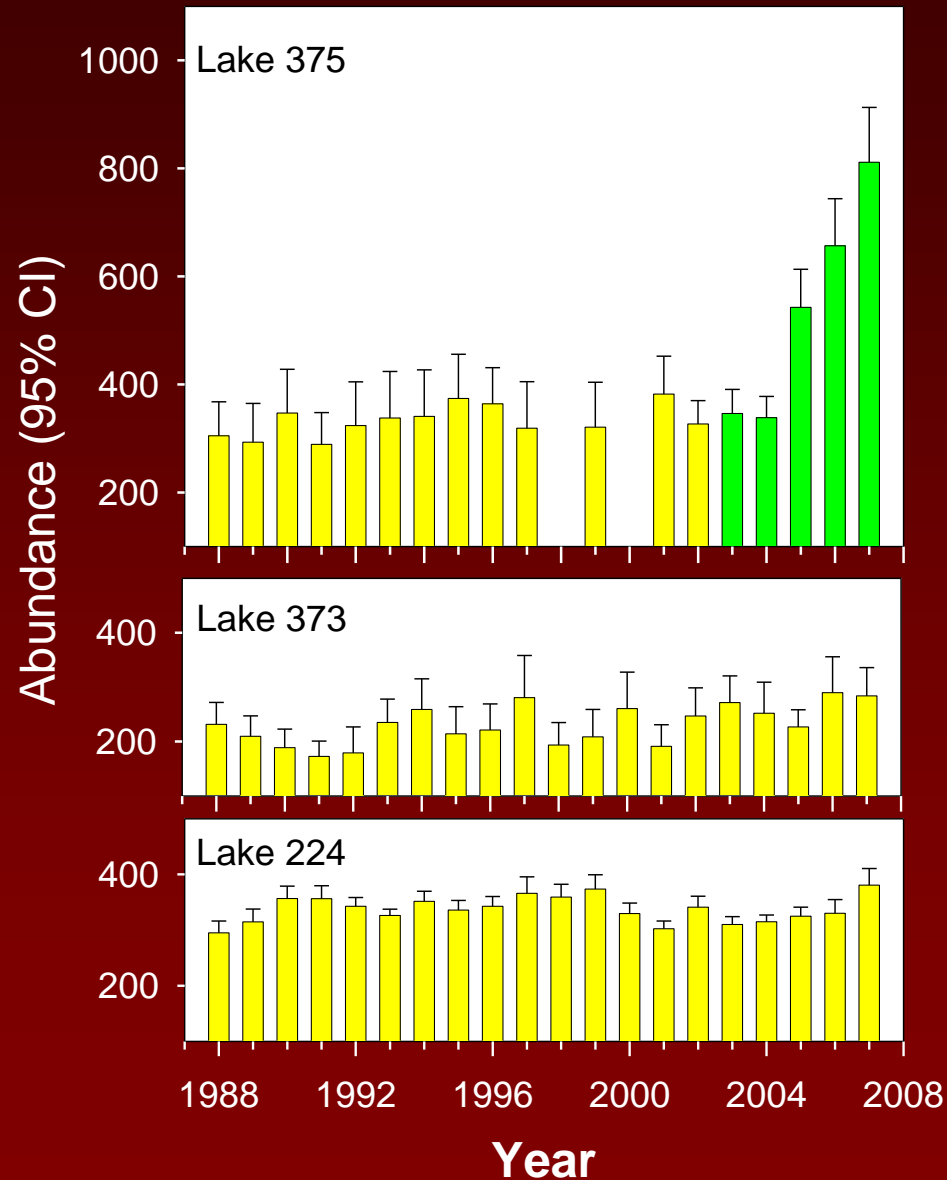
Lake trout



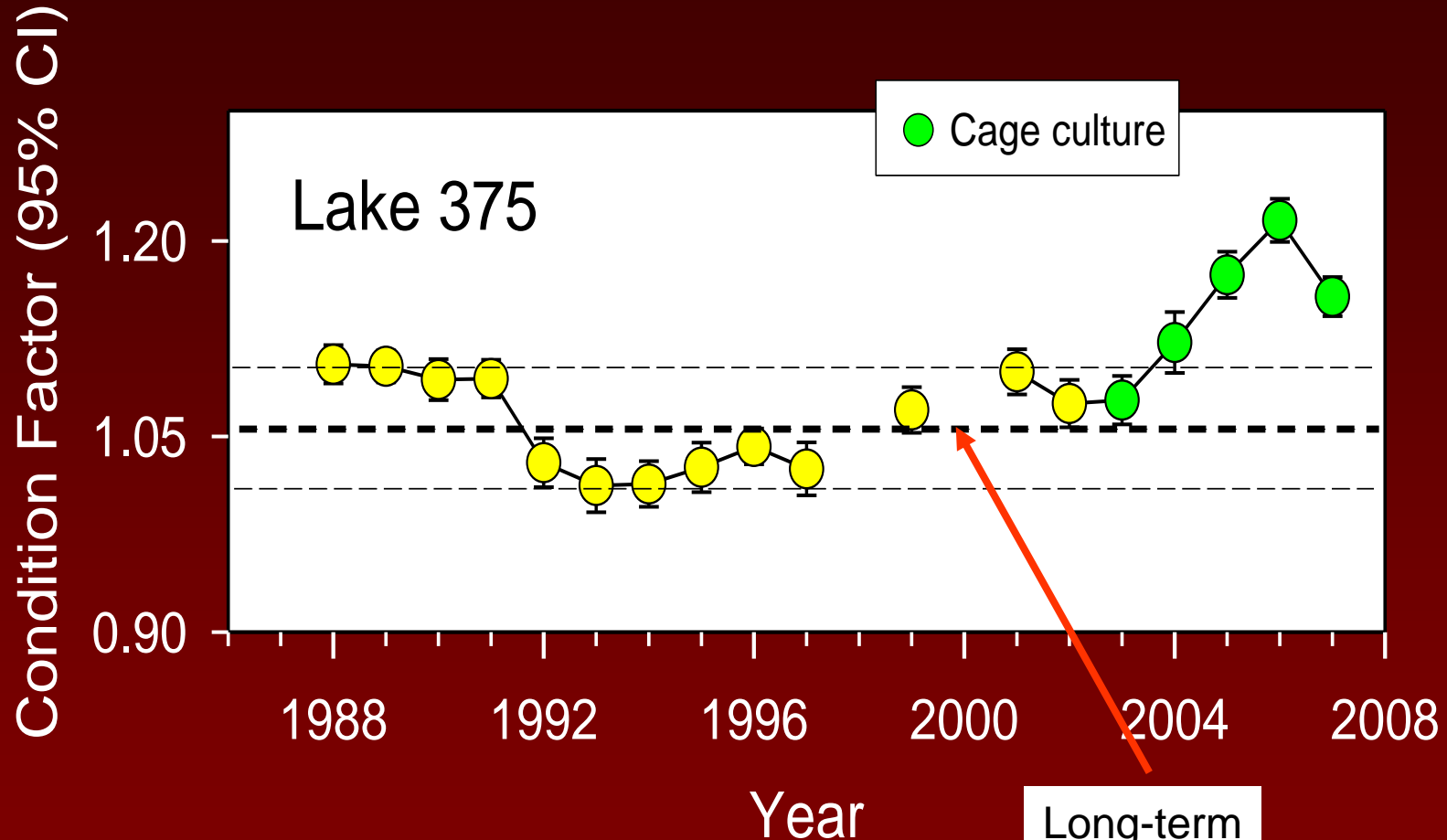
Lake trout abundance (age 1 and older)



Lake trout abundance



Lake trout fatness



Summary

- Abundance of most fish populations increased during the 5 years of cage culture
 - No negative impacts
- **Lake trout**
 - **Fatter**
 - **Grew faster**
 - **Earlier age of sexual maturity**
 - **More females spawning each year**
 - **Annual survival increased**
 - **Increased “recruitment”**



Lake trout prey species

Fathead minnow



White sucker



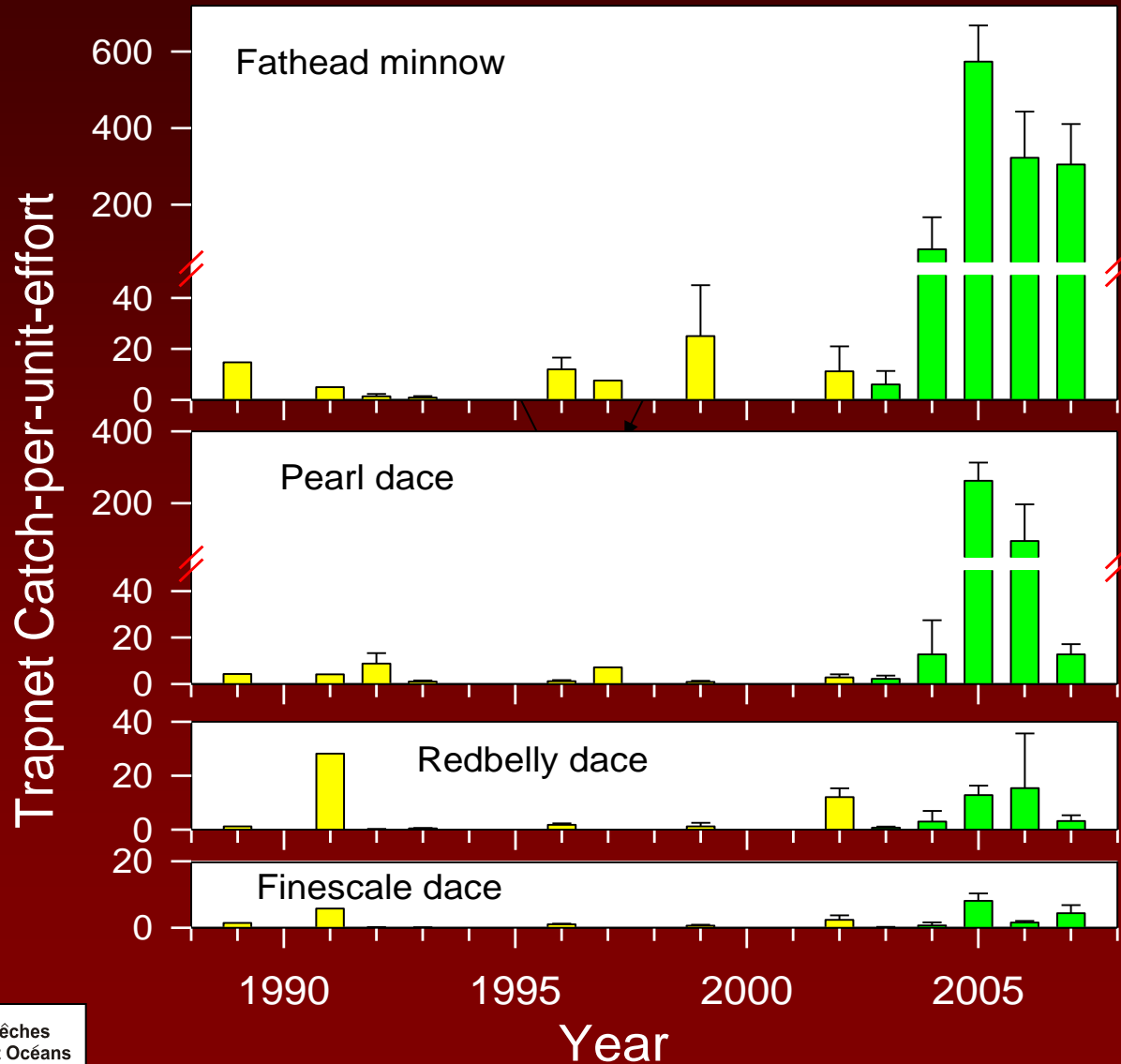
Pearl dace



Slimy sculpin



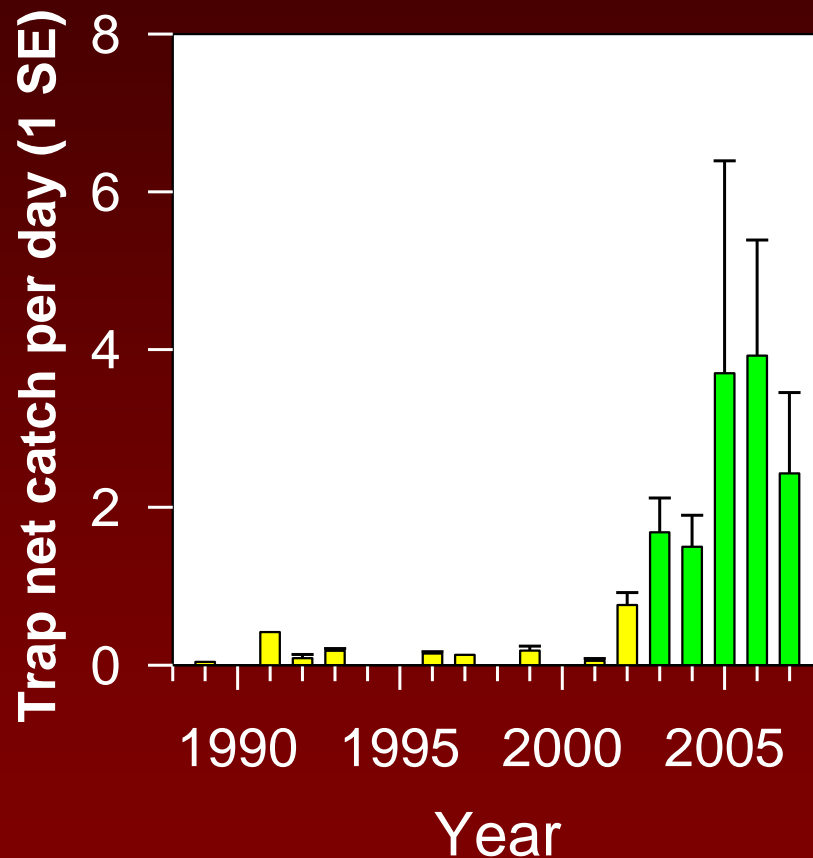
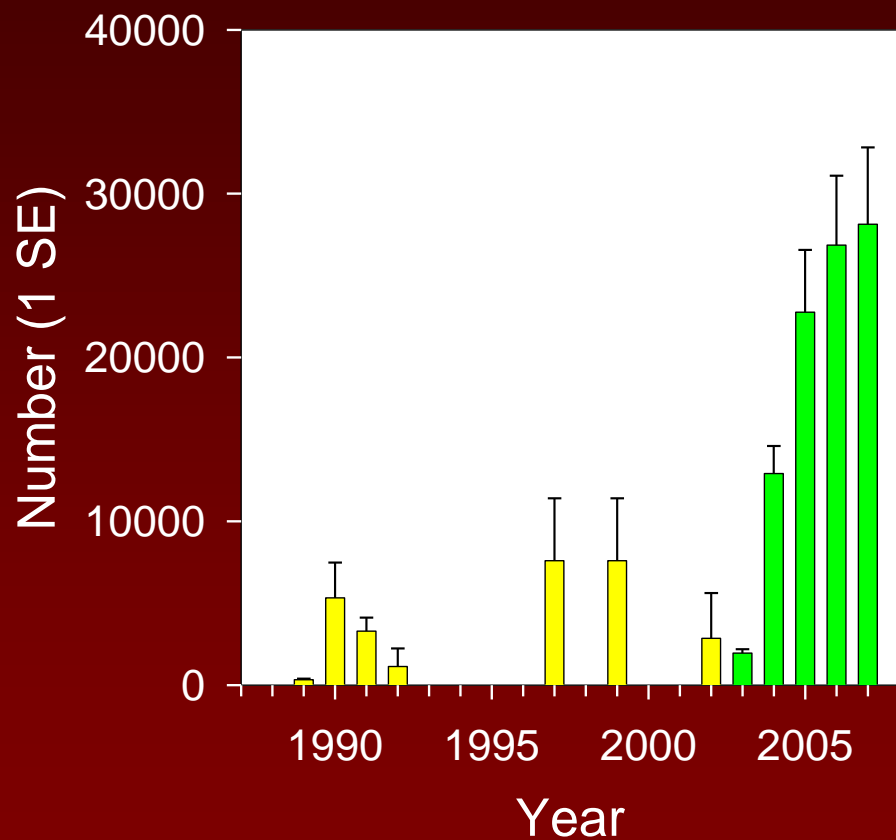
Minnow abundance



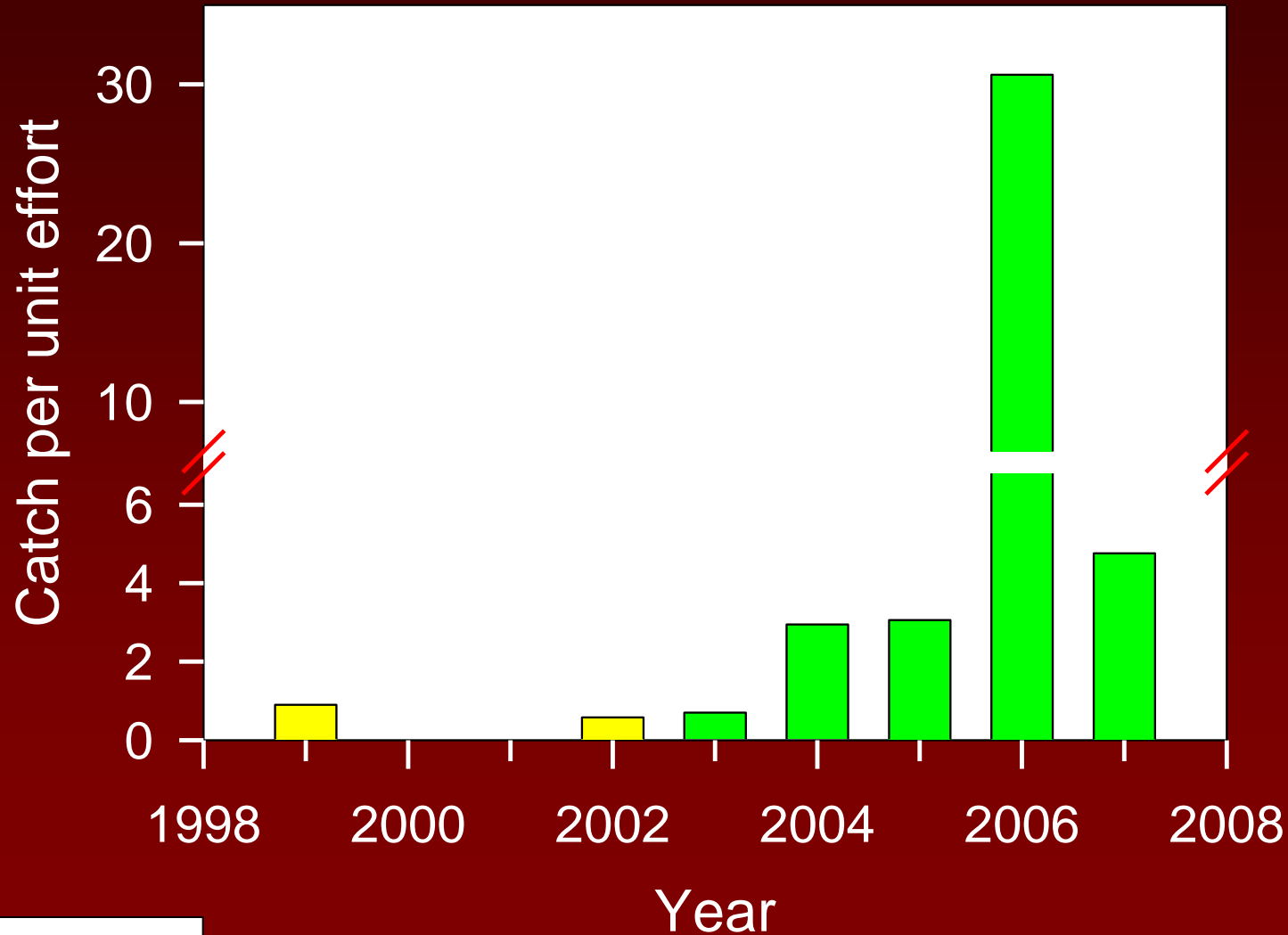
Abundance

White sucker

Slimy sculpin



Crayfish



Post Cage culture

“The Big Crash?”

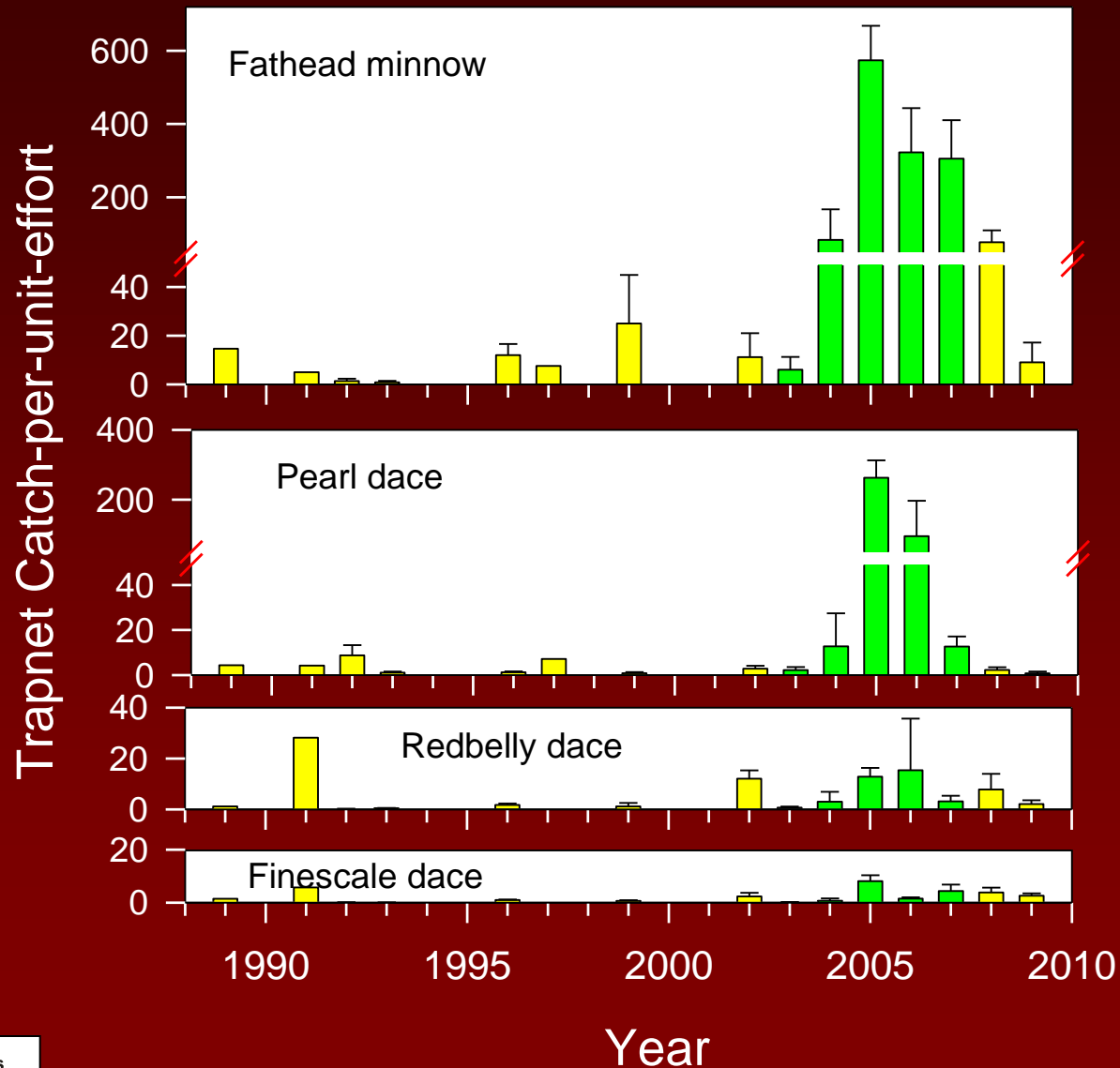


Fisheries
and Oceans

Pêches
et Océans

Canada

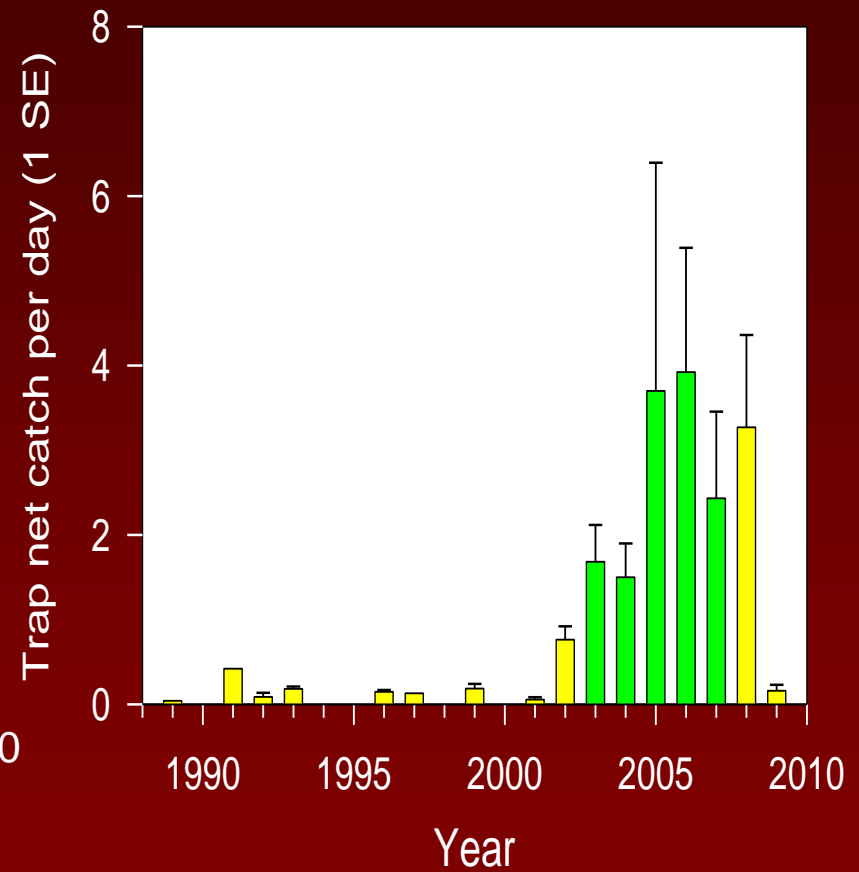
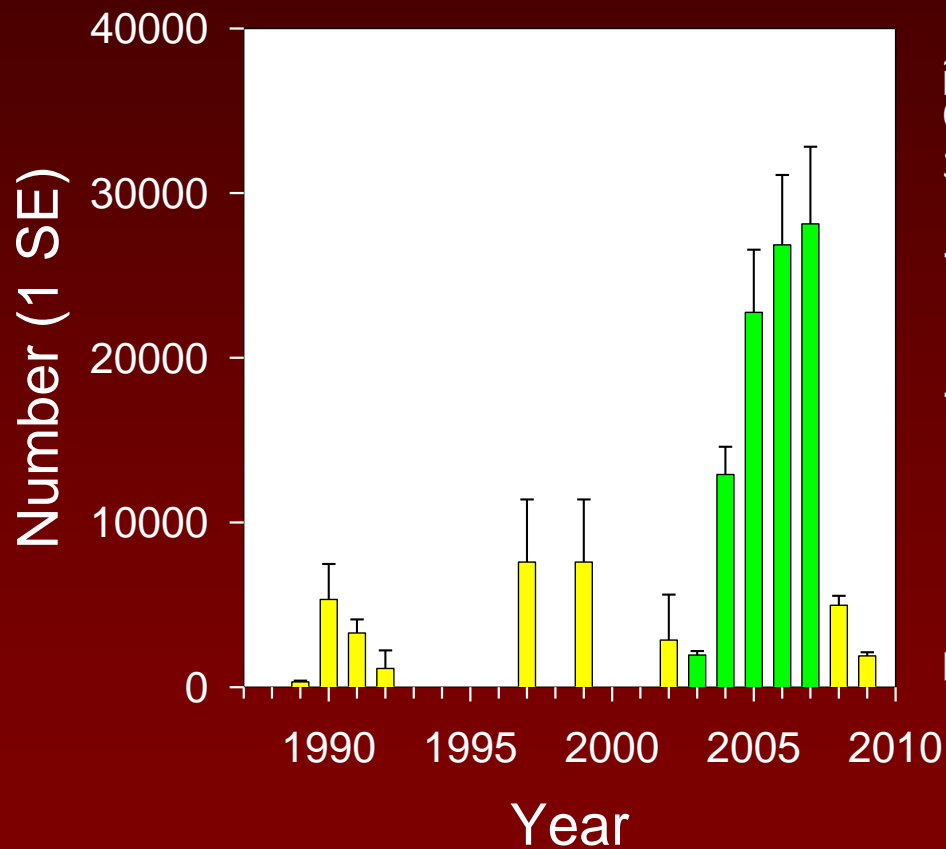
Minnow abundance



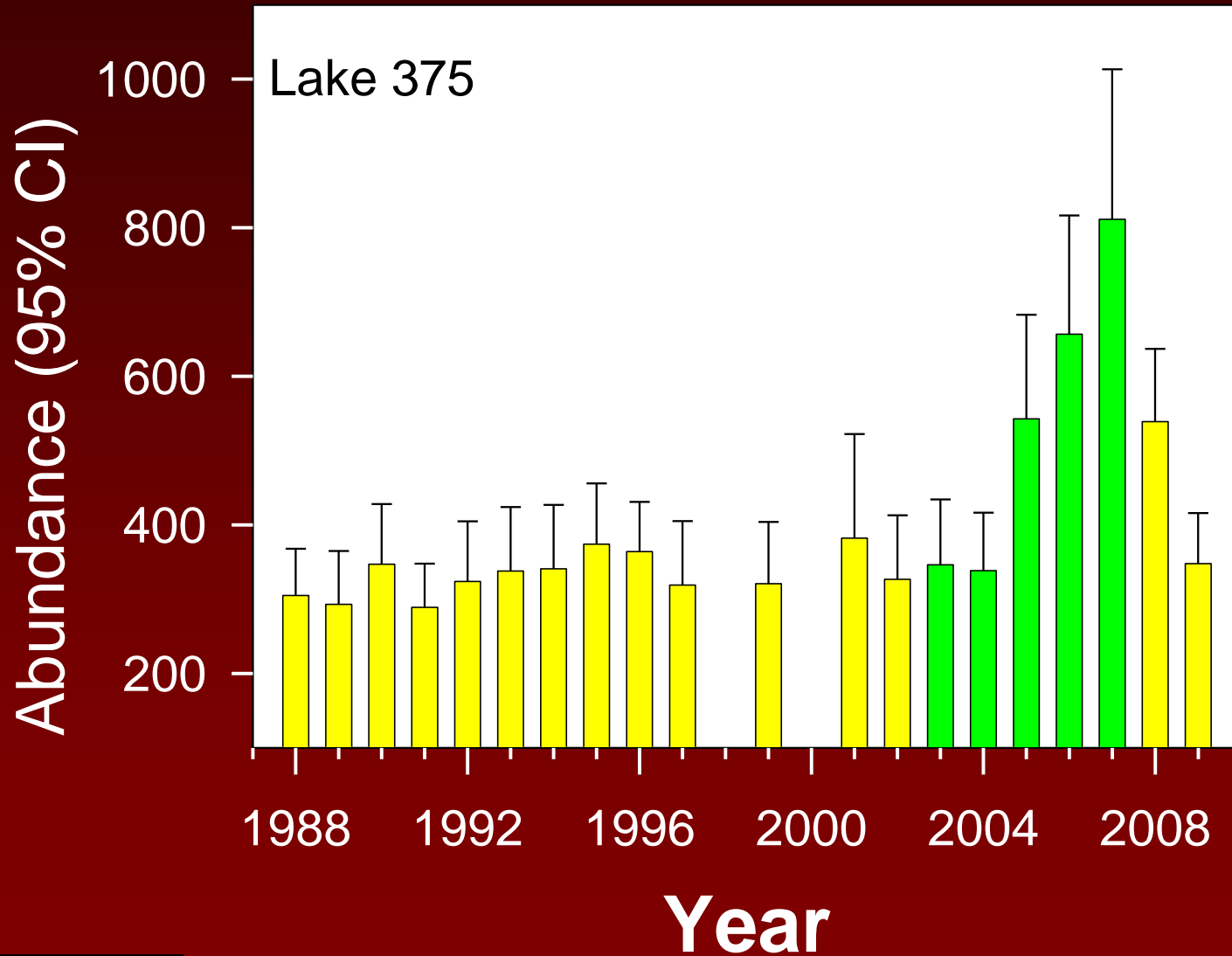
Abundance

White sucker

Slimy sculpin



Lake trout



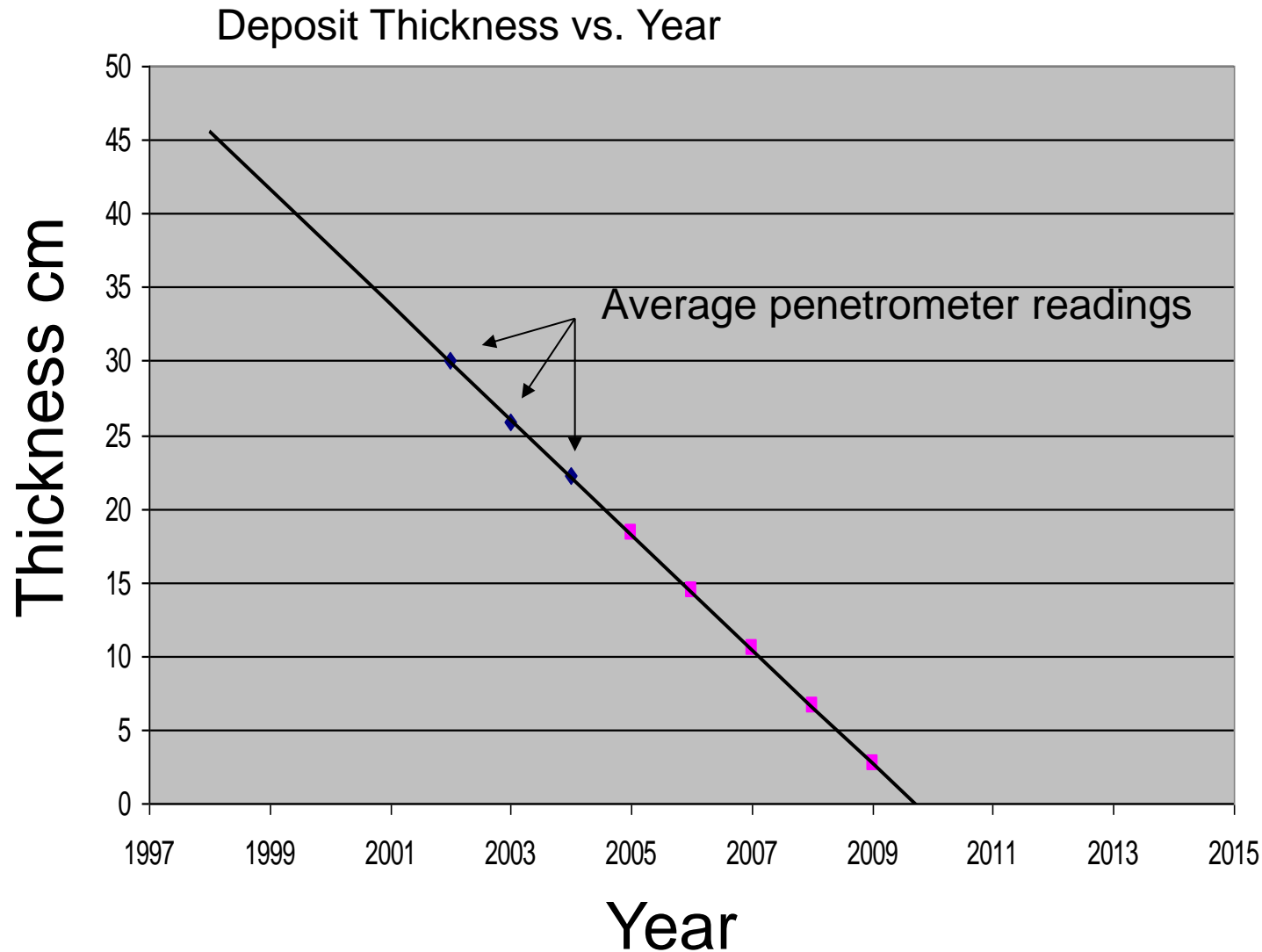
Summary: Post Culture

- All fish populations returned to pre-culture abundance two years after cage culture stopped
- **Lake trout**
 - Fatness decreased
 - Growth decreased
 - Increased age of sexual maturity
 - fewer females spawning each year
 - decreased annual survival
 - greatly decreased “recruitment”

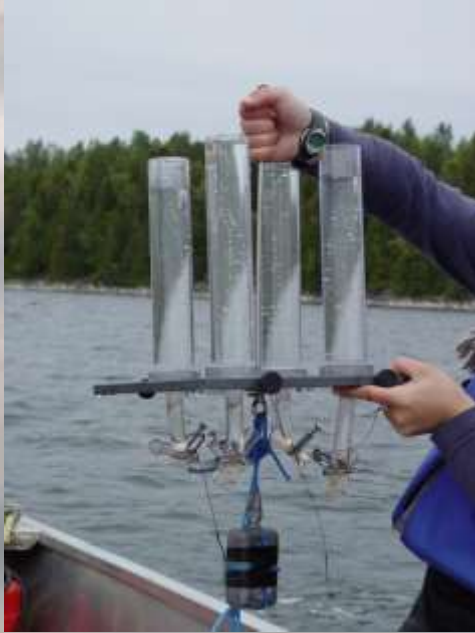




Deposit thickness measurements in 2002, 03, 04 suggest the lifespan of the present deposit extends to 2010 if decomposition is linear.



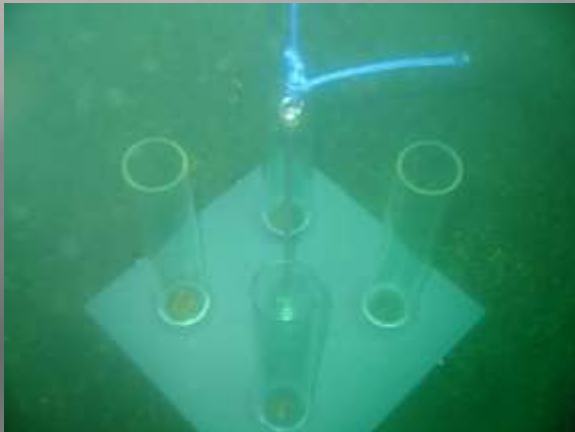
Measuring sedimentation - North Channel Farms



24hr set sedimentation traps around farm.

Material measured as TSS (total suspended solids) and Carbon (C).

Faecal material is approximately 38% C (ELA)
37.5% (Burynuik et al. 2006, *Salmo salar*)

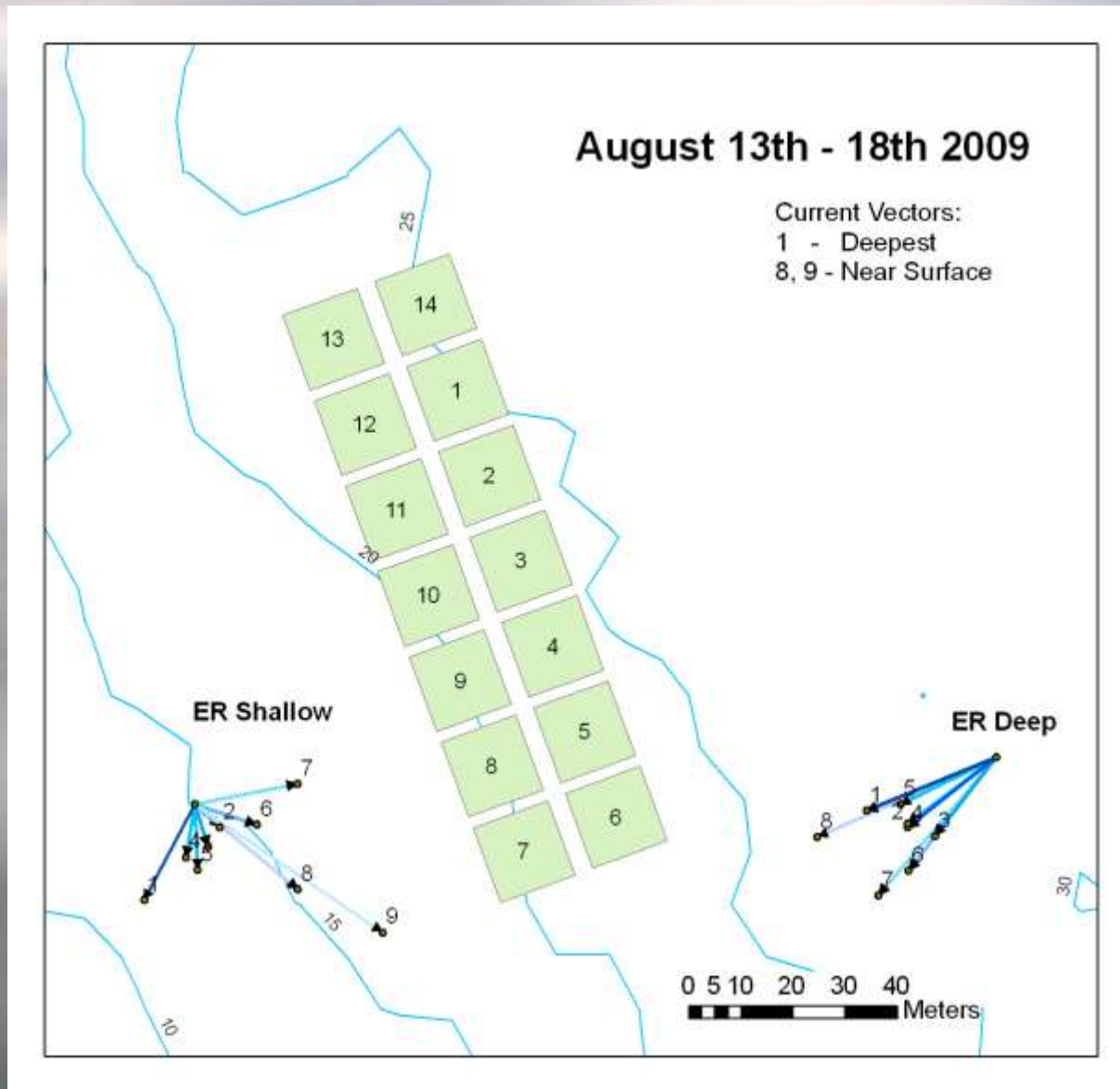


2009 sedimentation trap sampling sites at Farm 4

Each trap in for ~24hr.

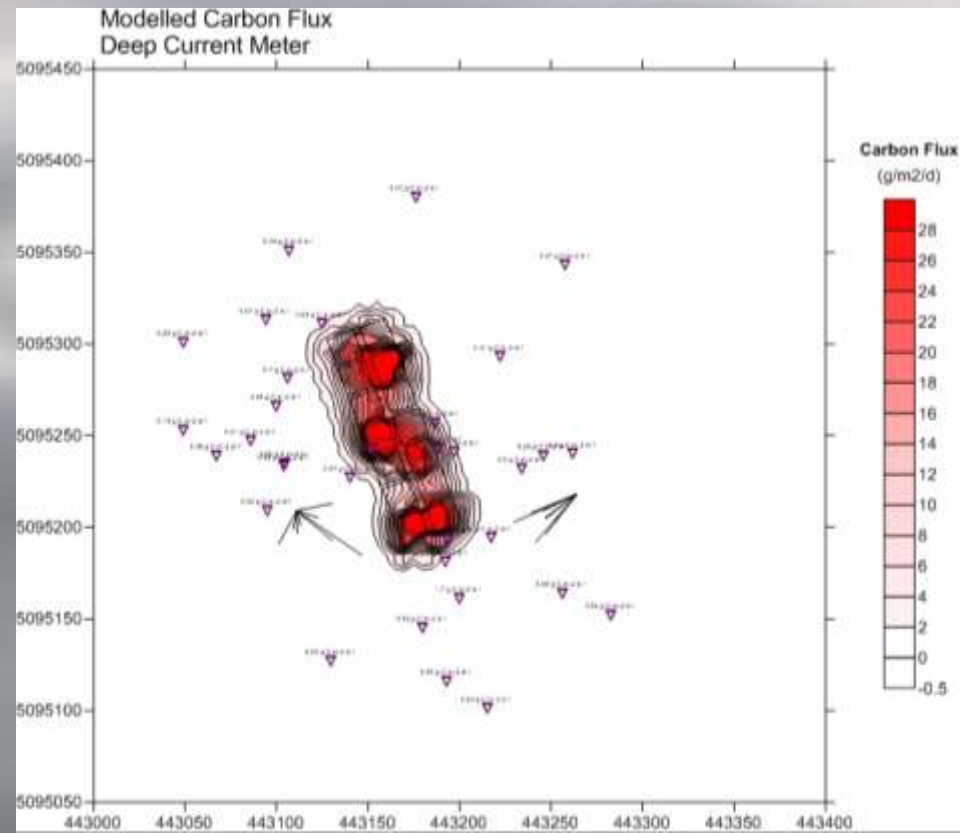
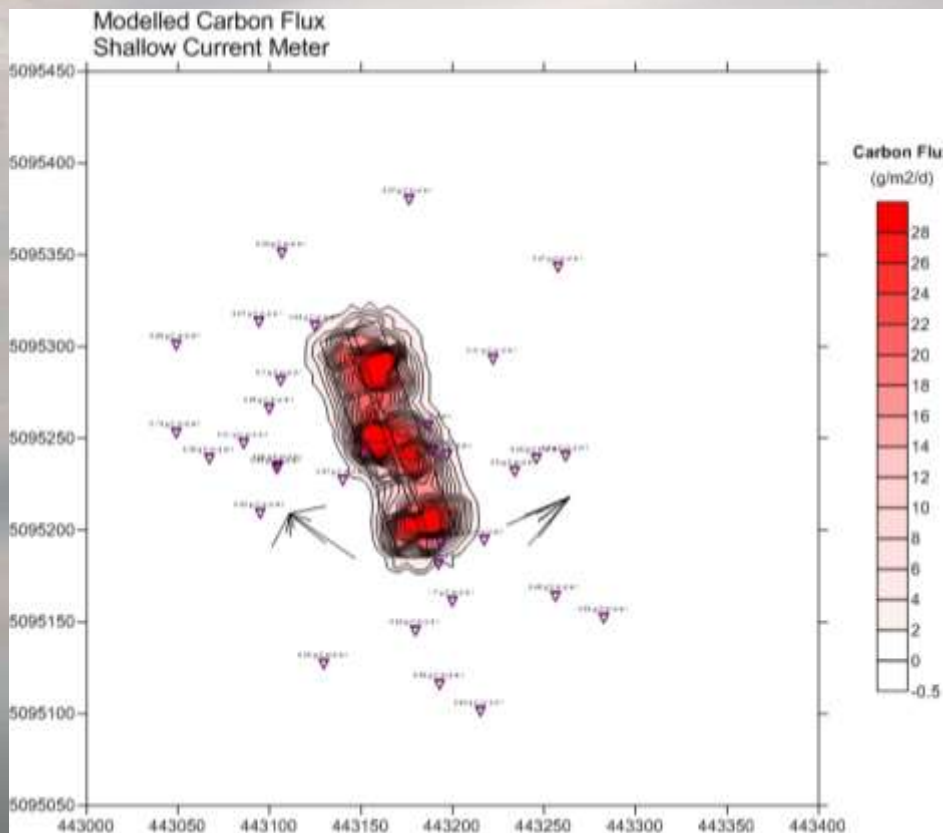
Traps that drifted were omitted from data set





2 current meters provide differing resultant vectors – which to use for DEPOMOD?

Comparison of outputs from shallow *versus* deep meter



Current meter location irrelevant

High deposition under cages, limited footprint

Trout & Charr Aquaculture



Rainbow Trout / Arctic Char Production Cycle

❖ Ova

- Commercial hatcheries
- Selected brood stock / strains
- Hatch in 30-100 days



❖ Sac Fry

- Absorb nutrients from yolk
- ~60 days



❖ Fingerlings

- Moved to large tanks or cages at ~10-20 grams



❖ Harvest

- On-growing for 12-16 months
- 0.9 – 1.5 kgs
- Two 8-12 oz fillets per fish



Reproduction Egg & Milt Collection

- ❖ Eggs available 12 months per year from
 - Ontario Hatcheries
 - Troutlodge (Hendrix Genetics)

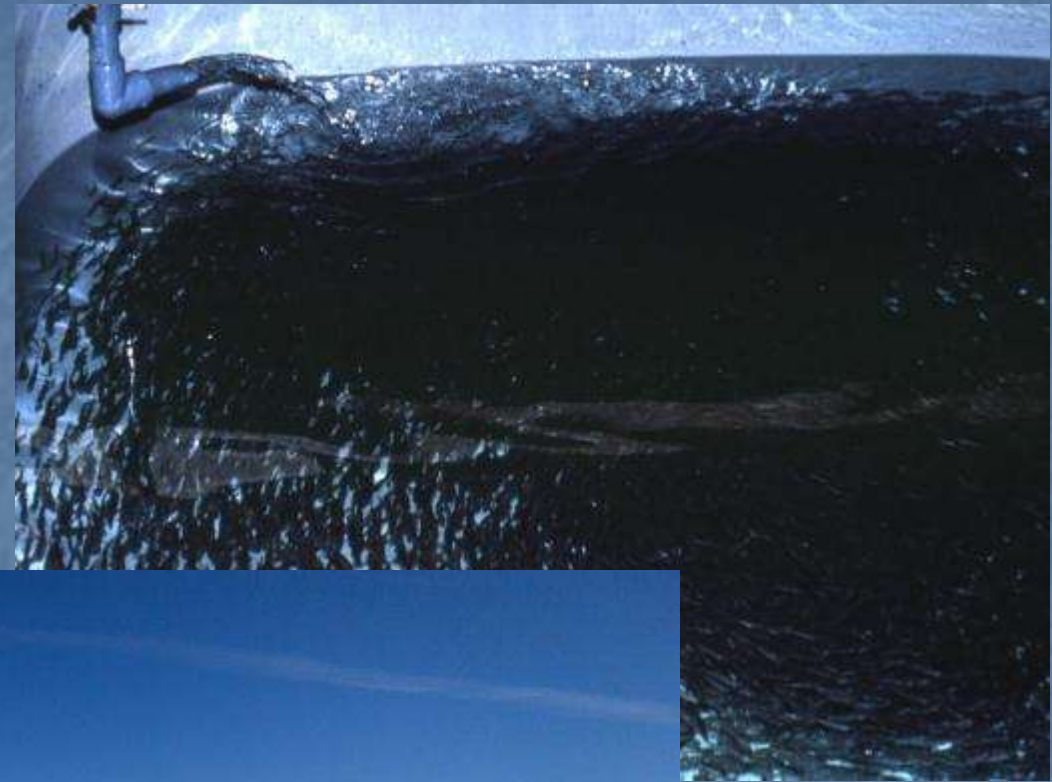


Hatching

- ❖ Eggs typically hatched in troughs, tray incubators or bell jars



Fingerlings



Potential “New” Species

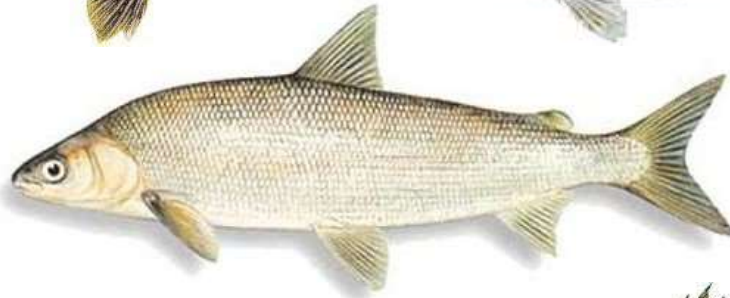
❖ Sturgeon



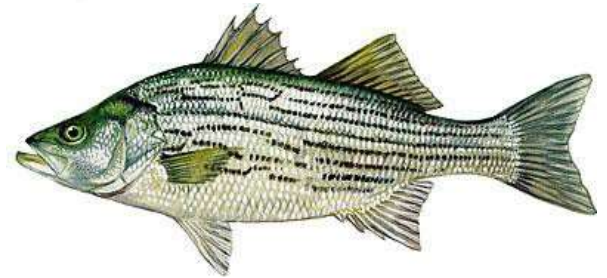
❖ Walleye /
Saugeye



❖ Whitefish



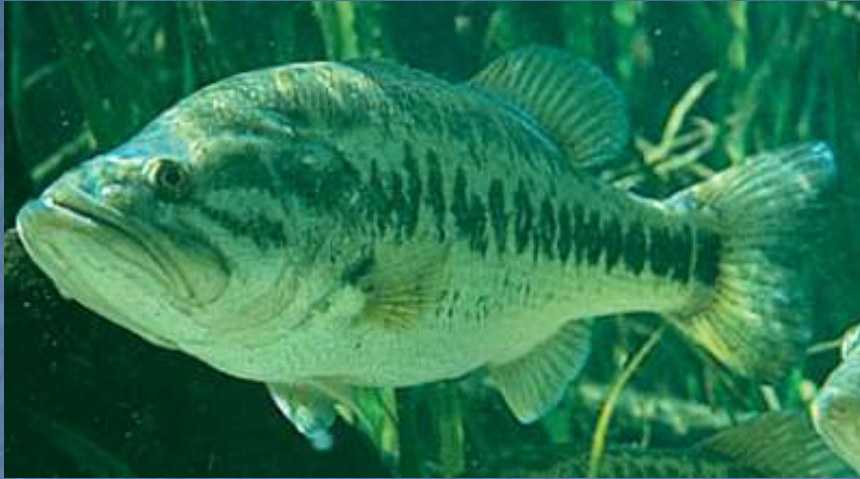
❖ Bass



❖ Pacific White-legged Shrimp



Largemouth Bass - Biology and Culture



- ❖ Female Largemouth Bass do not always lay all their eggs in one nest. Producers stock more males than females in spawning pools, to increase the likelihood of fertilization.
- ❖ Males take the role of guarding nests from predators
- ❖ There is no common accepted method of culture.
- ❖ Most are farmed in ponds, but raceways may be used too.
- ❖ Characteristics including their large mouth, cannibalistic tendency and resistance in accepting feed makes this species a challenging species to culture.

Walleye Culture

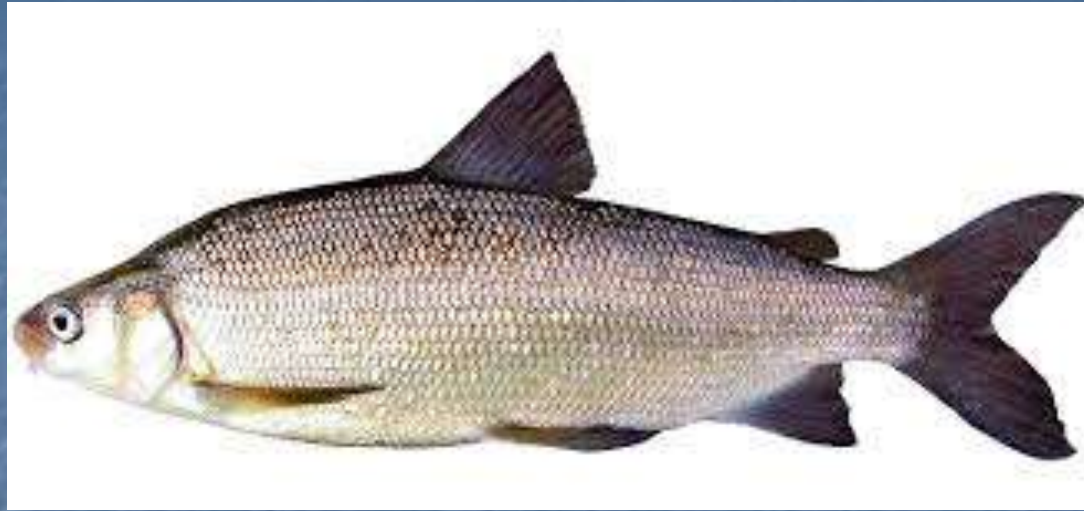


- In the last several years techniques have been developed to successfully raise walleye to market size in recirculation systems - from eggs to a 1 kg
- No longer need a fingerling pond production phase.

2 day walleye culture workshop March 2016
- Presentations available through Nick/Steve



Whitefish Culture



- In the last decade techniques have been developed to successfully raise whitefish to market size in recirculation and flow through systems - from eggs to market size.
- Current project looking at open water net pen farming techniques.

Yellow Perch (*Perca flavescens*)



- ❖ In Canada, this cool-water species can be found in Nova Scotia, Quebec, the Great Slave Lake of the NWT, various watersheds of BC and is especially abundant in the Manitoba & Great Lakes.
- ❖ Important both recreationally and commercially, the yellow perch features white, flaky flesh that is common in popular "fish and chips".

Pacific White Shrimp



First Ontario Shrimp



Pond Culture





Raceway Culture



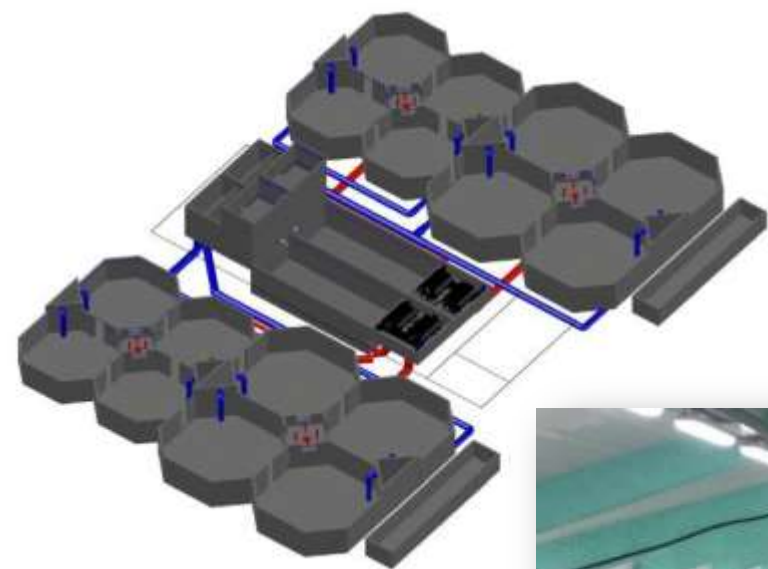




Circular Tank Culture



Octagonal Tanks



Floating Containment Systems



New Opportunities

- Many acres of self contained water bodies have been by the extraction of aggregate and peat
- These water bodies are often well suited for fish production
- Considered to be private waters and unless directly connected to Crown waters do not have the same degree of regulatory control as public waters
- Allows for more innovative technology



Aquaculture – Emergence of Net Pen Culture

- ❖ Modern (for-profit) phase of finfish aquaculture began in the 1970s
 - Development of large-scale cage culture operations
 - Countries saw the advantage of growing fish in the oceans and in large bodies of freshwater
 - Technology and economics became favourable
- ❖ This strategy has been highly effective on a global scale; e.g.
 - Salmon in Norway, Scotland, Chile, Canada, Australia
 - Sea bream and sea bass in Mediterranean countries



We have ice to deal with ...



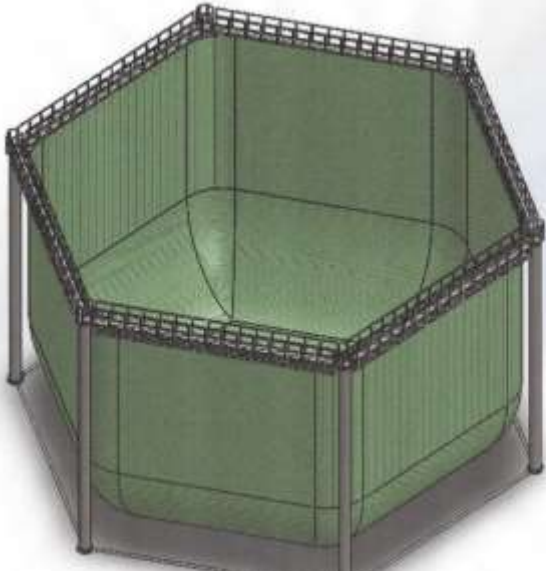
Solution for Ice Damage - Submersible Net Pens

Mike Meeker - Premiers Award for Agrifood Innovation



Net Pens for High Energy (cooler) Environments

stormsafesubmersible.com





Most of our trout now come from Indigenous fish farms





Aquaculture – Evolution of RAS

- ❖ More sophisticated rearing strategies such as re-circulating aquaculture systems (RAS) have been developed
 - Suited to production of high-value species and juveniles
 - Advantage in areas with limited water supplies
- ❖ These systems are expensive (capital and operating costs) and some can be technically complex
- ❖ Can be deployed anywhere there is a sufficient supply of water and access to power and other infrastructure
- ❖ For the most part, they are isolated from the natural environment



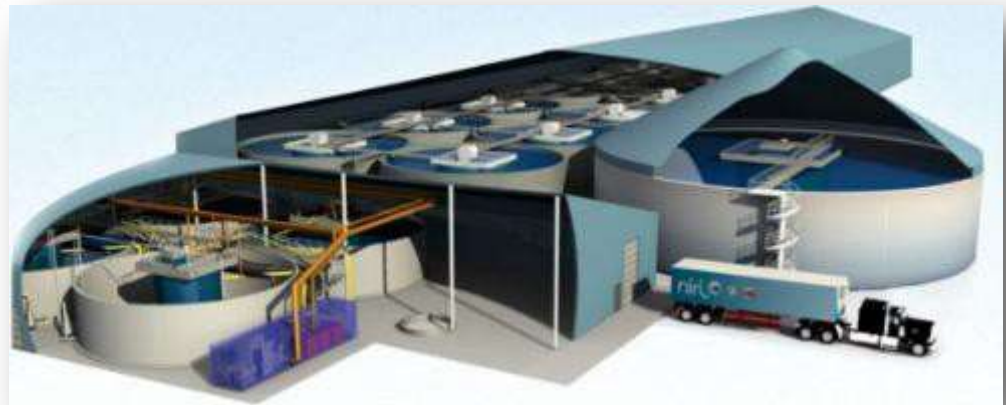
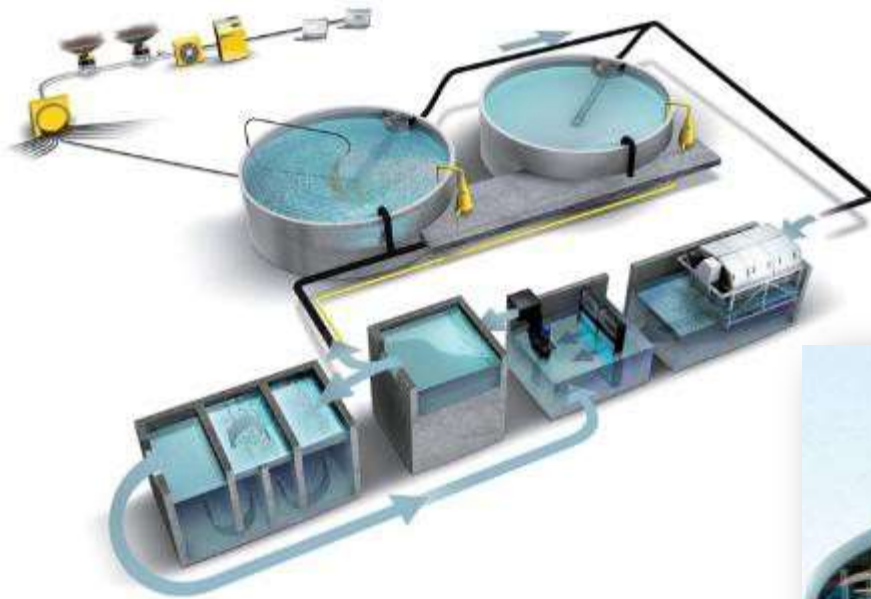
Land-Based Facility Design

- ❖ Unlike in traditional animal production systems and in net pen aquaculture, there is a lack of standardization in land-based aquaculture



Various Land-Based Designs

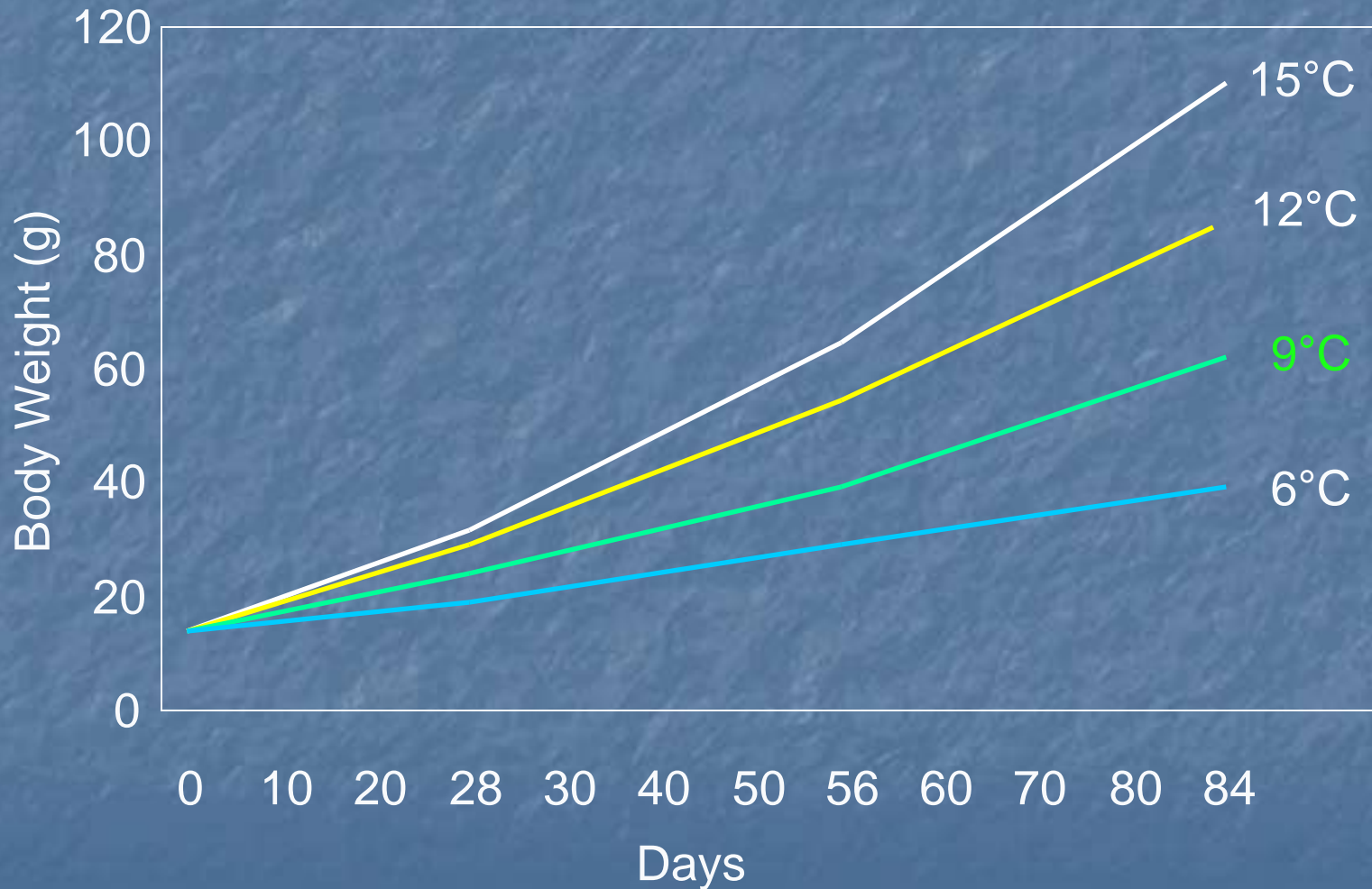
- ❖ Most systems will grow fish, but...
- ❖ The objective is to grow fish and make money.....



Key Factors in RAS

- ❖ Capital cost matters
 - These vary widely according to design and location
- ❖ Maximum daily feed ration is fundamental
 - RAS units are designed to process metabolic by-products
- ❖ It really doesn't really matter what kind of fish you're feeding
 - FCR
- ❖ Inventory turnover does matter
 - Time to reach market size
 - Number of cohorts per year
- ❖ Average annual selling price does matter
 - Atlantic salmon
 - Rainbow trout
 - Salmon smolts

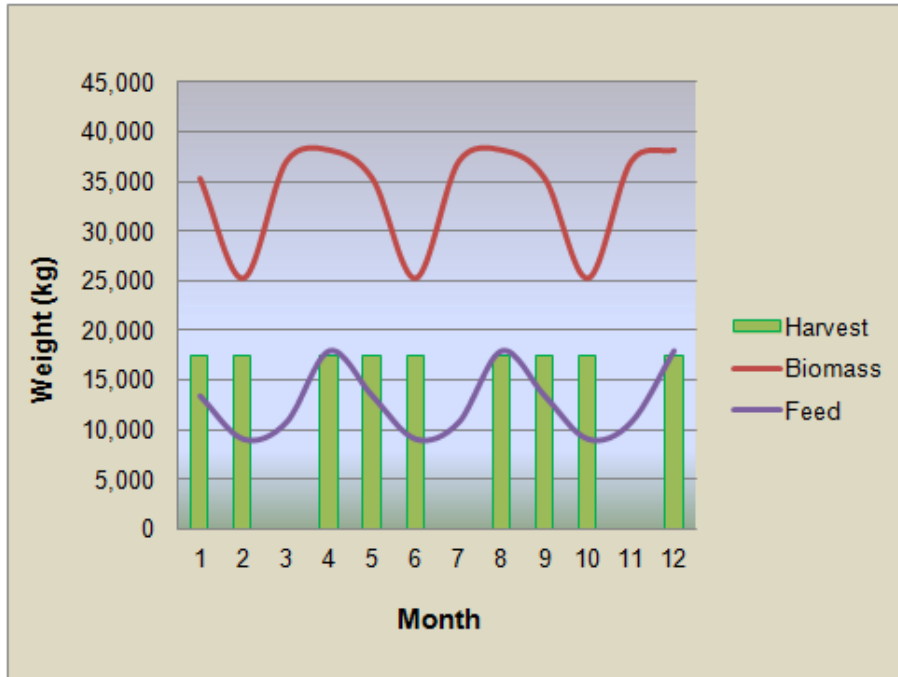
Trout Growth v. Temperature



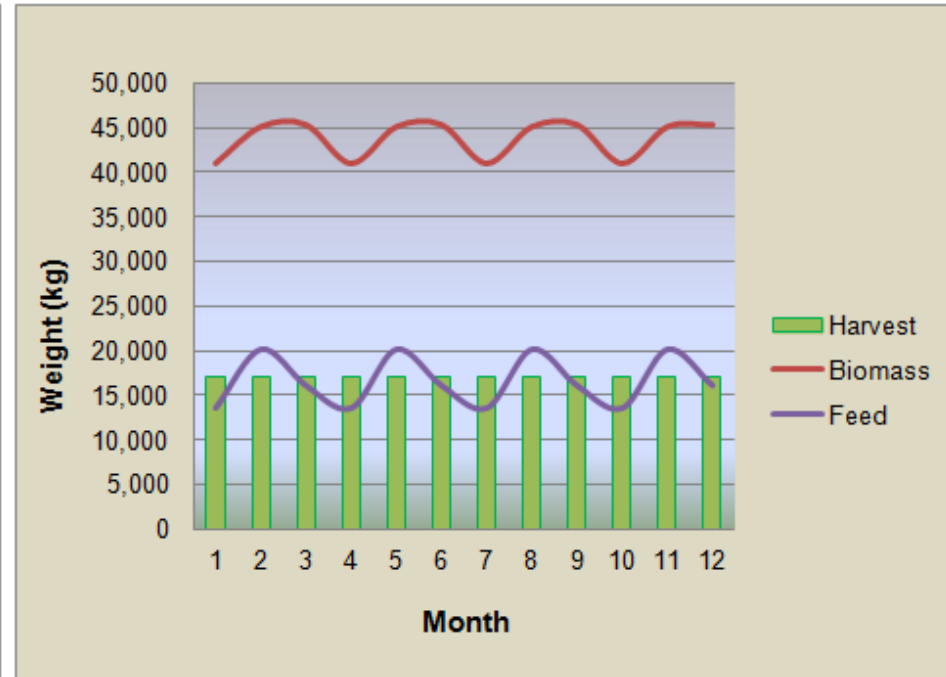
(Azevedo et al., 1997)

Production Modeling

- ❖ It is more productive and efficient to schedule multiple cohorts per year



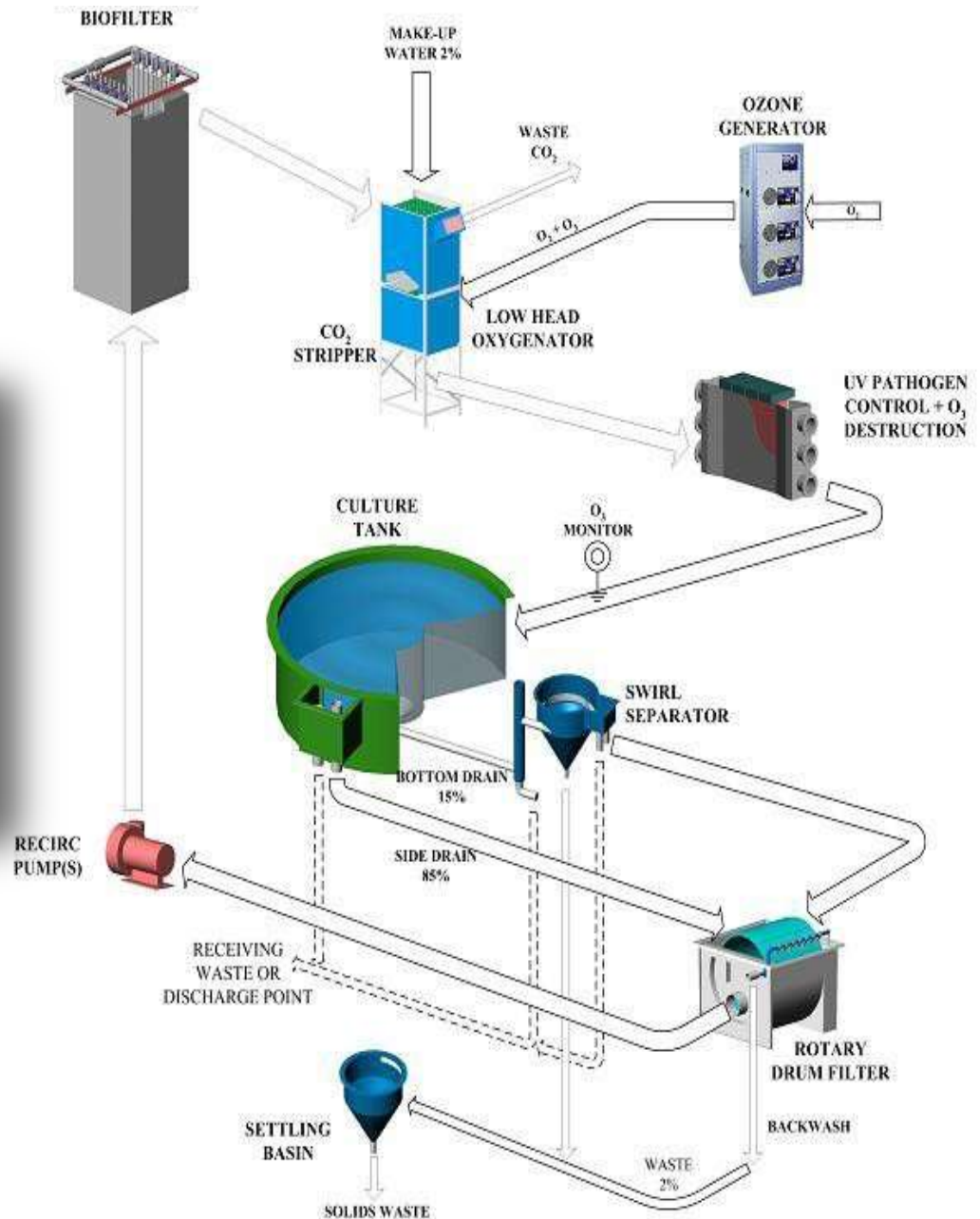
3 cohorts / year



4 cohorts / year

- ❖ Approximately 30% more production in the same system with 4 cohorts per year
- ❖ More stable loading on the systems

Recirculating Aquaculture Systems



Sand Plains AquaCulture

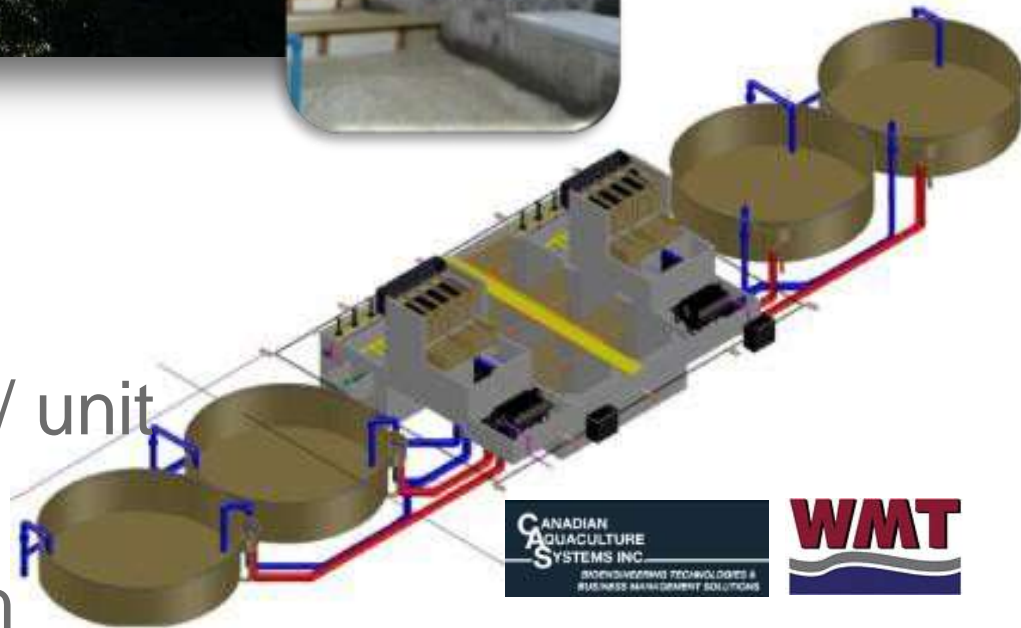


Smolt Production



Production

- ❖ 14 million smolts / year
- ❖ Up to 850 kg feed / day / unit
- ❖ 99% recirculation
- ❖ Simple, low-head design



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WMT

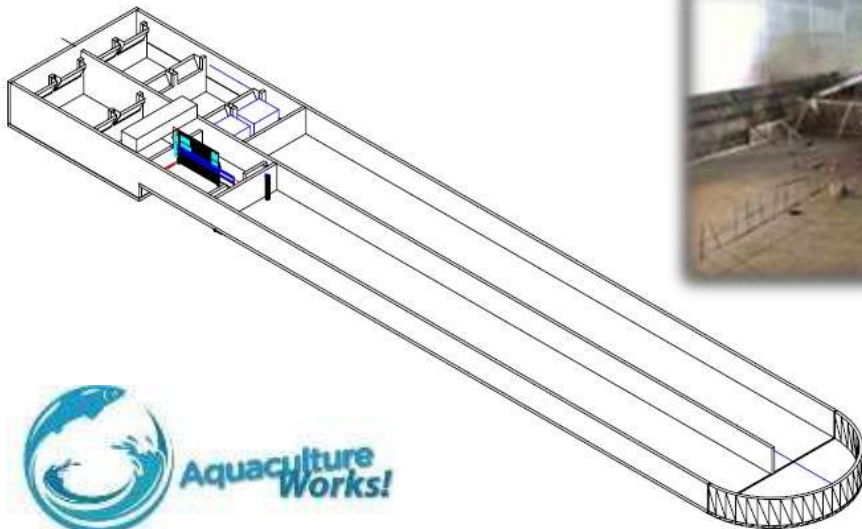
Danish Model Farm Program



Canadian Model Aqua-Farm Program

Production

- ❖ 130-tonne rainbow trout farm
- ❖ 99% recirculation
- ❖ Simple, low-head design
- ❖ 430 kg feed / day
- ❖ Capital cost = ~\$9,000 / mt



Canadian Model Aqua-Farm Program

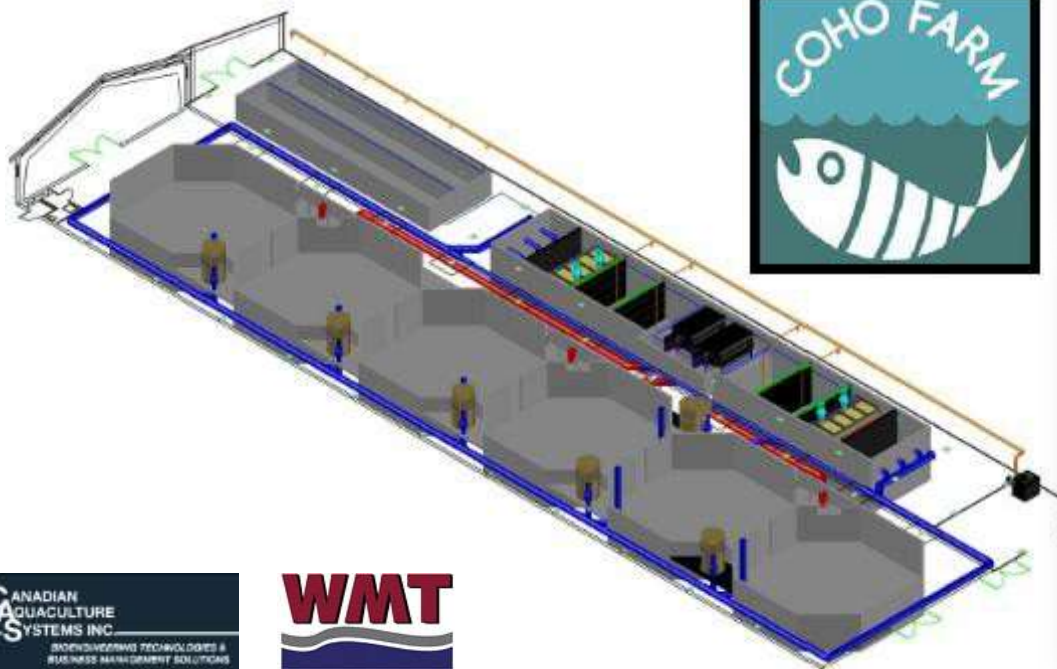


LITTLE
CEDAR FALLS

Coho Salmon Farm

Production

- ❖ 200 tonnes coho / year
- ❖ 725 kg feed / day
- ❖ Capital cost = ~\$13,000 / mt
 - ❖ Includes land, hatchery and 2 staff apartments

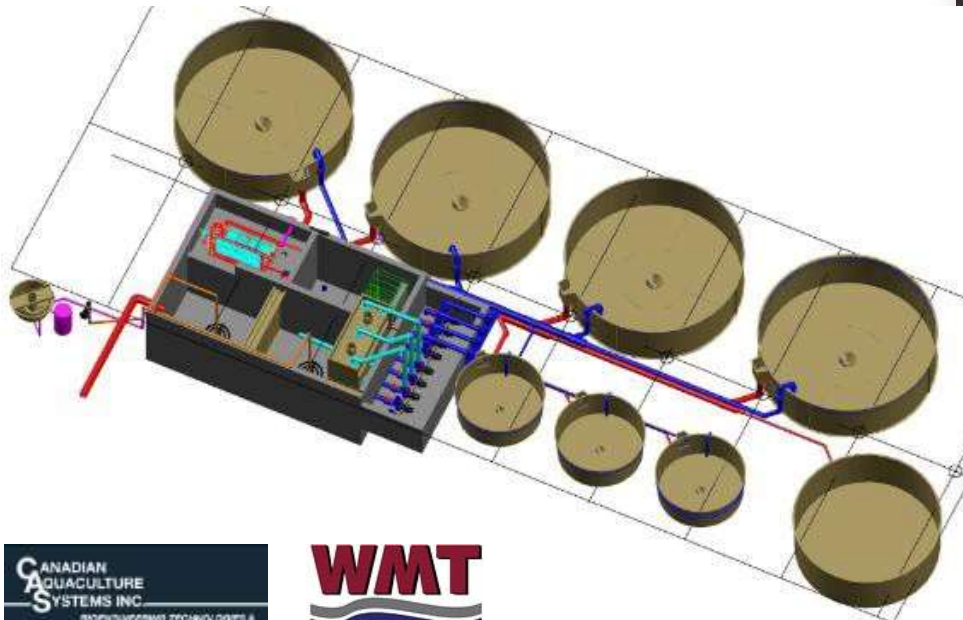


Trend AquaFresh



Production

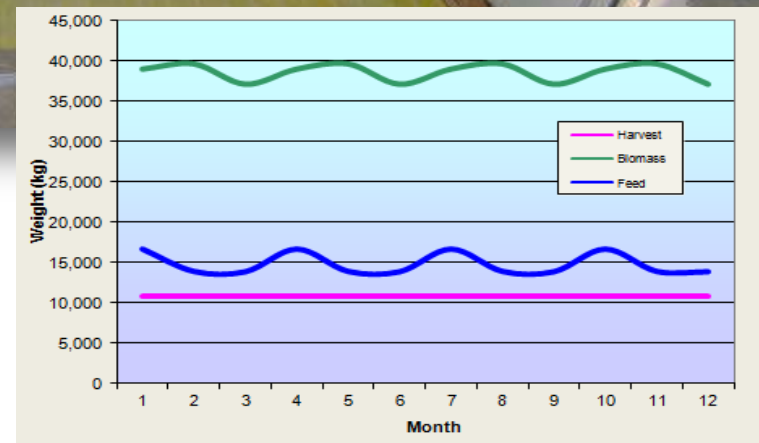
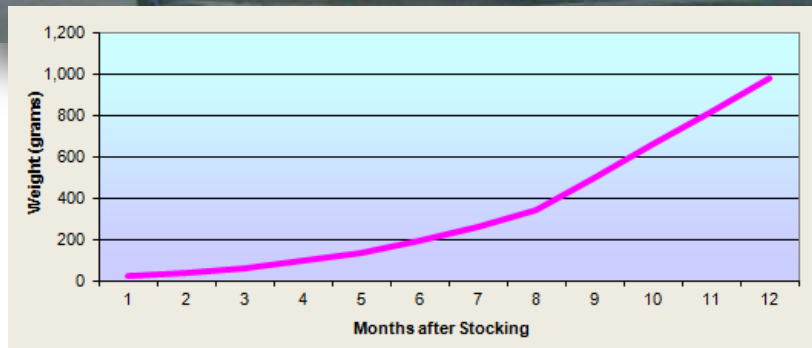
- ❖ 50 tonnes fish / year
- ❖ 200 kg feed per day
- ❖ Capital cost = \$9,700 / mt
 - Does not include land, greenhouse



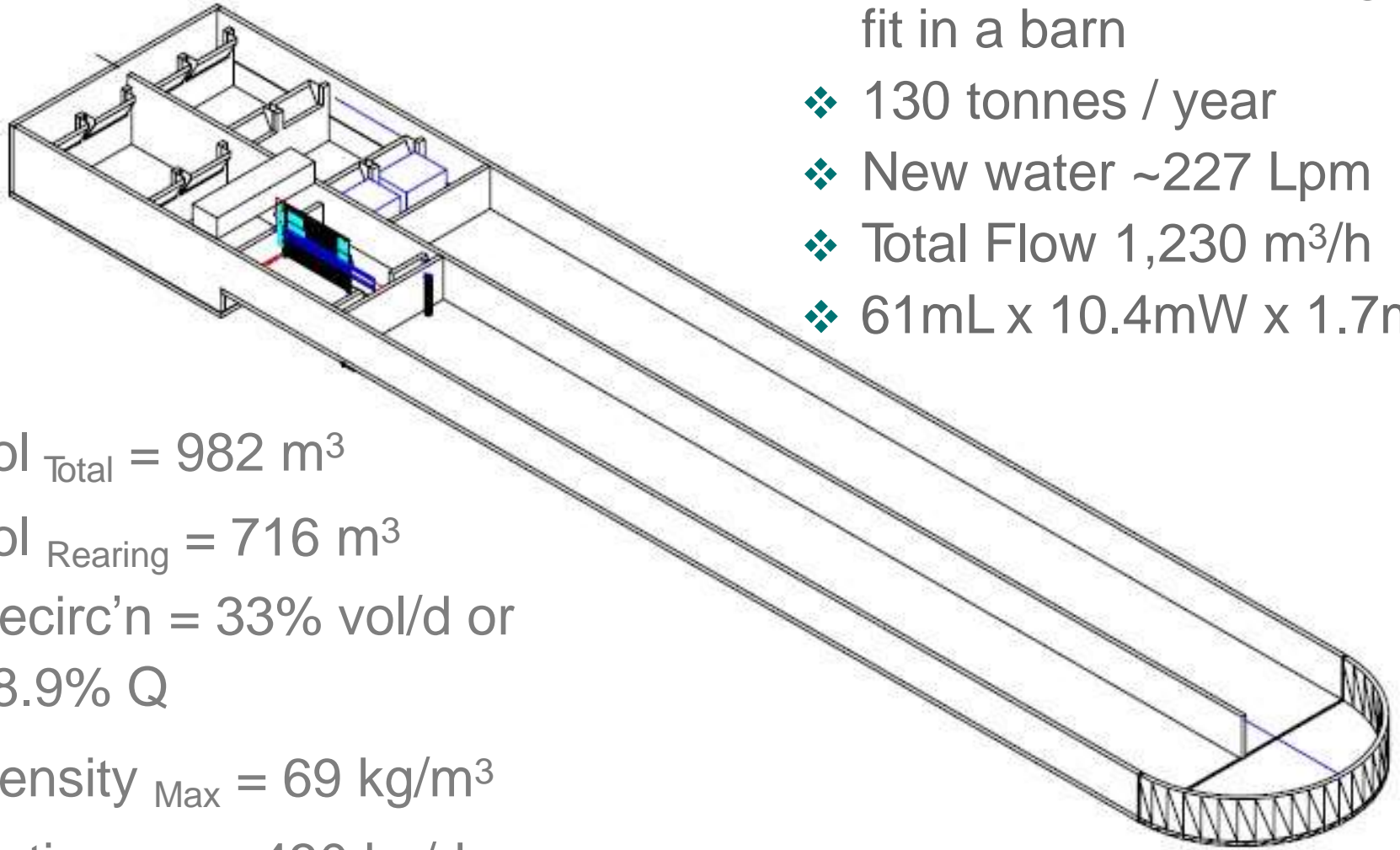
Canadian Model Aqua-Farm

❖ Year-round production

- 40,000 20g fry every 3 months
- 12 months to ~1200g @ ~10°C
- Harvest ~10,800 kg per month
- Harvest at 900 – 1000 g



Model Farm Layout



- ❖ Simple, efficient design to fit in a barn
- ❖ 130 tonnes / year
- ❖ New water ~227 Lpm
- ❖ Total Flow 1,230 m³/h
- ❖ 61mL x 10.4mW x 1.7mD

- ❖ Vol_{Total} = 982 m³
- ❖ Vol_{Rearing} = 716 m³
- ❖ Recirc'n = 33% vol/d or 98.9% Q
- ❖ Density_{Max} = 69 kg/m³
- ❖ Ration_{Max} = 430 kg/d