Give a man a fish and feed him for a day.
Teach a man to fish and he will

...sit in a boat and drink beer all day.
A World in Crisis?

Number of hungry people in the world 2010

- Total = 925 million
- Developed countries: 19
- Near East and North Africa: 37
- Latin America and the Caribbean: 53
- Sub-Saharan Africa: 239
- Asia and the Pacific: 578

Source: FAO.
FAO Projections 2050

HUNGER RAMPANT HIGH FOOD PRICES POPULATION CLIMBING FAST

ONE WAY TO MAKE A DIFFERENCE IS BY ENSURING HEALTHY SUSTAINABLE FOOD SUPPLIES
World population will grow from around 7 billion people today to 8.3 billion people in 2030.

The number of hungry people in developing countries is expected to decline.
- from 777 million today to about 440 million in 2030.

Patterns of food consumption are becoming more similar throughout the world, shifting towards higher-quality and more expensive foods such as meat and dairy products.
At global level there is enough water available, but some regions will face serious water shortages.

- Libyan Arab Jamahiriya and Saudi-Arabia, are already using more water for irrigation than their annual renewable resources.

- In large areas of India and China, ground-water levels are falling by 1 to 3 meters per year.
Meat production is growing fast in the developing countries...

Source: The State of Food and Agriculture. Livestock in the balance (FAO 2009)
### Protein Source Carbon and Energy Costs

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Carbon Footprint (Kg CO2/kg edible)</th>
<th>Energy Use (MJe/kg edible)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pork, Sweden</td>
<td>5.9</td>
<td>41</td>
<td>“ “</td>
</tr>
<tr>
<td>Chicken, Sweden</td>
<td>2.7</td>
<td>29</td>
<td>“ “</td>
</tr>
<tr>
<td>Salmon, Norway</td>
<td>2.9</td>
<td>40</td>
<td>Winther et al (2009)</td>
</tr>
</tbody>
</table>
Protein Conversions and Efficiencies

**Protein conversion from grain (protein to protein)**

- 1 kg fish – 13.5 kg grain
- 1 kg pork – 38 kg grain
- 1 kg beef – 61 kg grain

**Protein efficiency values for major food commodities (%)**

![Bar chart showing protein efficiency values for various food commodities.](source: Hall et al. 2011, Blue Frontiers)
## Protein Nutrient Emission Expenditure

### Nitrogen and Phosphorus emissions

*(kg/tonne protein produced)*

<table>
<thead>
<tr>
<th></th>
<th>N emission</th>
<th>P emission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>1200</td>
<td>180</td>
</tr>
<tr>
<td>Pork</td>
<td>800</td>
<td>120</td>
</tr>
<tr>
<td>Fish (avg)</td>
<td>360</td>
<td>102</td>
</tr>
<tr>
<td>Chicken</td>
<td>300</td>
<td>40</td>
</tr>
<tr>
<td>Bivalves</td>
<td>-27</td>
<td>-29</td>
</tr>
<tr>
<td>Salmonids</td>
<td>284</td>
<td>71</td>
</tr>
<tr>
<td>Shrimp</td>
<td>309</td>
<td>78</td>
</tr>
<tr>
<td>Catfish</td>
<td>415</td>
<td>122</td>
</tr>
<tr>
<td>Carp</td>
<td>471</td>
<td>148</td>
</tr>
<tr>
<td>Tilapia</td>
<td>593</td>
<td>172</td>
</tr>
</tbody>
</table>

Source: Hall et al. 2011, Blue Frontiers
Health Risks -vs- Benefits
Press Releases

2006 Releases

New Study Shows the Benefits of Eating Fish Greatly Outweigh the Risks

For immediate release: October 17, 2006

Boston, MA – Many studies have shown the nutritional benefits of eating fish (finfish or shellfish). Fish is high in protein and omega-3 fatty acids. But concerns have been raised in recent years about chemicals found in fish from environmental pollution, including mercury, PCBs and dioxins. That has led to confusion among the public—do the risks of eating fish outweigh the benefits?

Researchers from the Harvard School of Public Health (HSPH) tackled that question by undertaking the single most comprehensive analysis to date of fish and health. In the first review to combine the evidence for major health effects of omega-3 fatty acids, major health risks of mercury, and major health risks of PCBs and dioxins in both adults and infants/young children, the results show that the benefits of eating a modest amount of fish per week—about 3 ounces of farmed salmon or 6 ounces of mackerel—reduced the risk of death from coronary heart disease (CHD) by 36%. Notably, by combining results of randomized clinical trials, the investigators also demonstrated that intake of fish or fish oil reduces total mortality—deaths from any causes—by 17%.
News at HSPH

Eating Fish May Lower Stroke Risk

Eating fish a few times a week may be beneficial in lowering stroke risk, according to a new meta-analysis. Researchers examined results from 15 previous studies to summarize the evidence linking fish consumption and stroke risk. According to the Swedish study, published online Sept. 8, 2011 in the journal Stroke, eating three extra servings of fish each week was linked to a 6% drop in stroke risk. And the people in the study who ate the most fish were 12 percent less likely to have a stroke than those who ate the least.

Harvard School of Public Health’s Dariush Mozaffarian, whose research with HSPH colleagues was included in the meta-analysis, told Reuters, ”I think, overall, fish does provide a beneficial package of nutrients, in particular the omega-3s, that could explain this lower risk.”

In their study, which drew on data from close to 400,000 people, co-authors Susanna Larsson and Nicola Orsini of Sweden’s Karolinska Institutet wrote that omega-3 fatty acids in fish might lower stroke risk through their positive effects on blood pressure and cholesterol. Mozaffarian added that Vitamin D, selenium and certain types of proteins in fish may also have stroke-related benefits.
News at HSPH

Omega-3s Tied to Lower Risk of Irregular Heartbeat

People with higher-than-average levels of omega-3 fatty acids in their blood may be roughly 30 percent less likely than those with the lowest levels to develop atrial fibrillation, according to new Harvard School of Public Health research. Atrial fibrillation is a dangerous condition that tends to strike the elderly and can lead to stroke or heart failure.

“..."A 30 percent lower risk of the most common chronic arrhythmia in the United States population is a pretty big effect," Dariush Mozaffarian, associate professor in the Department of Epidemiology and senior author of the report, told Reuters.

The study, led by epidemiology department research fellow Jason Wu, was published online in the journal Circulation, Jan. 26, 2012. The researchers took blood samples from more than 3,300 adults over age 65 and tracked their health over 14 years to see how many developed atrial fibrillation.

The omega-3 fatty acids measured in the study are found in oily fish, fish oil supplements, and in some enriched foods, like eggs. While many health experts recommend eating fish at least twice a week, Mozaffarian told Reuters that most Americans don’t meet those goals. But he said the new study “should change people’s motivation.”
Fish oil supplements don't prevent heart attacks, study says

By Elizabeth Weise, USA TODAY

Taking fish oil pills rich in omega-3 fatty acids doesn't appear to have a significant effect on heart attacks, strokes or death, a study published today in The Journal of the American Medical Association finds.

The news comes even as sales of fish oil supplements are booming. In 2011 Americans spent $1.1 billion on them, up 5.4% from 2010, according to the Nutrition Business Journal.

The researchers reviewed 20 well-designed clinical trials that looked at the health outcomes of people taking omega-3 polyunsaturated fatty acid supplements derived from fish oils. The trials dated from 1989 to 2012 and included 68,680 people who were studied for at least a year. They found no statistically significant association.

“The message Americans may not want to hear is that eating healthy foods, not taking pills, is what helps heart health, says Richard Karas, director of the preventive cardiology center at Tufts Medical Center in Boston.”
Attributes of Fish as Food Source

• High-value protein.

• High in Polyunsaturated omega-3 fatty acids (docosahexaenoic acid -DHA and eicosapentaenoic acid - EPA).

• Low in saturated fats, carbohydrates and cholesterol.

• Contains a wide range of essential micronutrients (vitamins A, B, D) and minerals (calcium, iodine, zinc, iron and selenium.)

Small quantities of fish can have a significant positive nutritional impact by providing essential amino acids, fats and micronutrients that are scarce in vegetable-based diets.
Evidence of beneficial effects of fish consumption in relation to:
- coronary heart disease
- stroke
- age-related macular degeneration
- mental health
- growth and development, in particular for women and children during gestation and infancy for optimal brain development of children.
## Problems associated with seafood

<table>
<thead>
<tr>
<th>Problem category</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overfishing</td>
<td>cod, halibut, yellow fin tuna, shark (dozens more), limitations on fishmeal</td>
</tr>
<tr>
<td>Environmental degradation</td>
<td>bottom trawling</td>
</tr>
<tr>
<td>Seafood safety</td>
<td>chemicals and toxins (mercury, PCBs, banned substances)</td>
</tr>
<tr>
<td></td>
<td>shellfish poisoning, cyanotoxins, foodborne illness</td>
</tr>
<tr>
<td></td>
<td>Import inspection</td>
</tr>
</tbody>
</table>
FAO 2006:
Not enough fish in the sea
Levels of wild fish captures have remained roughly stable since the mid-1980s, (~ 90-93 million tonnes)

“There is little chance of any significant increases in catches beyond these levels” (FAO).

Global assessment of wild fish stocks 600 species group
- 52% are fully exploited
- 17% overexploited
- 7% depleted
- 1% recovering from depletion
- 20% moderately exploited,
- 3% underexploited.

77%

1980: 9 percent of fish consumed from aquaculture,
2010: 47 percent = 57.2 million tonnes
World capture fisheries and aquaculture production

Million tonnes

160
140
120
100
80
60
40
20
0

50 55 60 65 70 75 80 85 90 95 00 05 10

Aquaculture production
Capture production

11%/yr

FAO SOFIA 2012
## Worldwide Aquaculture (2009 Data)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Quantity (million MT)</th>
<th>% of Total</th>
<th>Value ($billion)</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>China</td>
<td>45.279</td>
<td>62.0</td>
<td>57.095</td>
<td>51.8</td>
</tr>
<tr>
<td>2</td>
<td>Indonesia</td>
<td>4.713</td>
<td>6.5</td>
<td>5.648</td>
<td>5.1</td>
</tr>
<tr>
<td>3</td>
<td>India</td>
<td>3.792</td>
<td>5.2</td>
<td>4.820</td>
<td>4.4</td>
</tr>
<tr>
<td>4</td>
<td>Viet Nam</td>
<td>2.590</td>
<td>3.5</td>
<td>4.783</td>
<td>4.3</td>
</tr>
<tr>
<td>5</td>
<td>Philippines</td>
<td>2.477</td>
<td>3.4</td>
<td>4.190</td>
<td>3.8</td>
</tr>
<tr>
<td>15</td>
<td>U.S.</td>
<td>0.480</td>
<td>0.7</td>
<td>0.937</td>
<td>0.9</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Rank</th>
<th>Country</th>
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<td>4.190</td>
<td>3.8</td>
</tr>
<tr>
<td>15</td>
<td>U.S.</td>
<td>0.937</td>
<td>0.9</td>
</tr>
</tbody>
</table>

World Total: 73.045, World Total: 110.149

Source: FAO Fishstat Plus Version 2.30
2010 Value Aquaculture Worldwide

Source FAO 2013 database

Total $119 Billion USD

- China: 49%
- Asia (w/o China): 32%
- Europe: 8%
- Americas (-US): 7%
- US: 1%
- Africa: 2%
- Oceania: 1%
# Worldwide Aquaculture

(2009 Data; Total = 73.045 million MT)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Taxa</th>
<th>Quantity (million MT)</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Carps, barbels, &amp; other cyprinids</td>
<td>22.228</td>
<td>30.4</td>
</tr>
<tr>
<td>2</td>
<td>Red seaweeds</td>
<td>8.031</td>
<td>11.0</td>
</tr>
<tr>
<td>3</td>
<td>Brown seaweeds</td>
<td>6.725</td>
<td>9.2</td>
</tr>
<tr>
<td>4</td>
<td>Miscellaneous freshwater fishes</td>
<td>5.310</td>
<td>7.3</td>
</tr>
<tr>
<td>5</td>
<td>Clams, cockles, arkshells</td>
<td>4.438</td>
<td>6.1</td>
</tr>
<tr>
<td>6</td>
<td>Oysters</td>
<td>4.303</td>
<td>5.9</td>
</tr>
<tr>
<td>7</td>
<td>Shrimps, prawns</td>
<td>3.496</td>
<td>4.8</td>
</tr>
<tr>
<td>8</td>
<td>Tilapias &amp; other cichlids</td>
<td>3.097</td>
<td>4.2</td>
</tr>
<tr>
<td>9</td>
<td>Miscellaneous aquatic plants</td>
<td>2.565</td>
<td>3.5</td>
</tr>
<tr>
<td>10</td>
<td>Salmons, trouts, smelts</td>
<td>2.458</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Source: FAO Fishstat Plus Version 2.30
## Worldwide Aquaculture
### (2009 Data; Total = 110.149 $billion)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Taxa</th>
<th>Value ($billion)</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Carps, barbels, &amp; other cyprinids</td>
<td>29.399</td>
<td>26.7</td>
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<tr>
<td>2</td>
<td>Shrimps, prawns</td>
<td>14.647</td>
<td>13.3</td>
</tr>
<tr>
<td>3</td>
<td>Salmons, trouts, smelts</td>
<td>11.407</td>
<td>10.4</td>
</tr>
<tr>
<td>4</td>
<td>Miscellaneous freshwater fishes</td>
<td>9.963</td>
<td>9.0</td>
</tr>
<tr>
<td>5</td>
<td>Freshwater crustaceans</td>
<td>8.705</td>
<td>7.9</td>
</tr>
<tr>
<td>6</td>
<td>Tilapias &amp; other cichlids</td>
<td>4.830</td>
<td>4.4</td>
</tr>
<tr>
<td>7</td>
<td>Clams, cockles, arkshells</td>
<td>4.336</td>
<td>3.9</td>
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<tr>
<td>8</td>
<td>Miscellaneous coastal fishes</td>
<td>3.431</td>
<td>3.1</td>
</tr>
<tr>
<td>9</td>
<td>Oysters</td>
<td>3.343</td>
<td>3.0</td>
</tr>
<tr>
<td>10</td>
<td>Red seaweeds</td>
<td>2.531</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Source: FAO Fishstat Plus Version 2.30
2010

At single species level,

- most produced animal species by quantity **grass carp**
- highest value (USD11.3 billion) **white leg shrimp**
- Most cultivated algae species (5.1 million tonnes) **Japanese kelp**
Global Aquaculture

Africa, Americas, Asia, Europe, Oceania

Value in USD billion

Aquatic plants  Marine fishes  Diadromous fishes  Molluscs  Crustaceans  Freshwater fishes

Annual Increase
6.3% by weight
14.3% value

Source FAO 2013 database
Total Aquaculture Production

Source: FAO 2013 database
Global production of major species or species group from aquaculture in 2010

**MARINE FISHES**

- Marine fishes unidentified
- Seabream
- Jacks, pampanos, mackerels
- Drums and croakers
- Mullets
- European seabass
- Various marine fishes
- Japanese seabass
- Groupers
- Other flat fishes
- Turbot
- Cobia

**Thousand tonnes**
Global production of major species or species group from aquaculture in 2010

DIADROMOUS FISHES

- Atlantic salmon
- Milkfish
- Rainbow trout
- Other salmonids
- Barramundi
- Other Diadromous fishes
- Sturgeons
- Eels
- Coho salmon

Million tonnes

![Bar chart showing the production of various diadromous fishes in 2010](image)
Global production of major species or species group from aquaculture in 2010

FRESHWATER FISHES

- Silver and bighead carps
- Indian major carps
- Grass carp
- Tilapia and other cichlids
- Common carp
- Goldfish and crucian carp
- Other cyprinids
- Other freshwater fishes
- Catfish
- Pangasius catfish
- Perches and basses
- Snakeheads
China: Feeding the Beast

Worlds Economic Center of Gravity

Source McKinsey Global Institute
China’s Future Seafood Demand

*Increase of 6 to 65 million metric tons*

Metric Tons Whole Weight

- Seafood diet*
- Diet change
- Increased calories*
- Population growth
- 2005 total

2005 08 09 2025

*Source: Int’l Institute for Applied Systems Analysis

Growing *per capita seafood* consumption

FAO, Seafood summit.org
Aquaculture - Status

- Aquaculture accounts for 50% of all seafood consumed in the World, and the proportion is growing quickly!

- Global Aquaculture Production is valued at $100 - 120 Billion.

- US Aquaculture production is currently just under $1 Billion.
Aquaculture - Status

- US Consumers eat an average of 15 lbs. of fishery products per capita.

- 2010 USDA Dietary Guidelines for Americans recommends 26 lbs seafood annually per capita.

- Global per capita consumption of seafood is 17kg (34 lbs)

- Americans consumed 4.7 billion pounds of seafood in 2011, 91% of which was imported (86% in 2010).
Global Exports

- Shrimp continues to be the most important commodity traded in value terms.
- The other main groups of exported species were salmon and trouts (14 percent)
- Groundfish (10 percent e.g. hake, cod, haddock and Alaska pollock)
- Tuna (8 percent).
- In 2010, fishmeal represented around 4 percent of the value of exports and fish oil 1 percent.
Emerging/ Non Traditional in US

- Caviar/roe
- Cobia
- Sea Bass
- Meagre
- Sea bream
- Grouper
- Pompano
- Yellow and Bluefin Tuna
Emerging

- Algae
- Sea Vegetables
  - Sea cucumbers
  - Kelp
  - Nori
  - Dulse
Hot Research Areas

- Breeding for Omega-3s
  Norway

- IMTA  Integrated Multi-Trophic Aquaculture

- Nutrition Nutrition Nutrition
Global Trends

- Increasing seafood consumption
- Increasing seafood production
- Increasing pressure from environmental groups
- Regulations – health and importation
- Animal Welfare
- Aquaculture and seafood certification programs “Eco-labels”
  - Examples, MSC, GAP, Whole Foods
US Aquaculture

Source FAO 2013 database

1.9% Annual Increase
Global Aquaculture  Africa, Americas, Asia, Europe, Oceania

14.3% Value Annual Increase

Value in USD billion

Source FAO 2013 database
“Aquaculture will be the most likely source of food fish going into the 21st century. With increasing seafood demand and declining capture fisheries, global aquaculture production will have to increase by 500 percent by the year 2025, to meet the projected needs of a world population of 8.5 billion.”
The current US trade deficit in fisheries products is $10.8 Billion.
US Aquaculture

- World Aquaculture Value ($100 Billion)
- US Aquaculture Value ($1 Billion)
U.S. Economic Impact

- Farm-gate value: $0.94 Billion
- Total value: $5.6 Billion
- 181,000 full-time jobs
- One of the fastest growing sectors of U.S. agriculture since 1980’s

Source: FAO Fishstat Plus Version 2.30 & Economic-wide impacts of U.S. aquaculture
Source: 2007 USDA Census of Agriculture
Includes State, Federal and Tribal Hatcheries

2007 Production Value by Species

US

- Catfish 33%
- Other Foodfish 14%
- Trout 15%
- Crustaceans 4%
- Mollusks 17%
- Ornamentals 4%
- Baitfish 1%
- Sport/Game 6%
- Other non-food 6%

NCR

- Catfish 6%
- Other Foodfish 8%
- Sport/Game 35%
- Other 3%
- Baitfish 19%
- Trout 28%
- Ornamentals 1%
- Crustaceans 0%
- Mollusks 0%

$1.4 Billion

$57.6 Million
Value of Aquaculture Products Sold by Region

- Southern: 65.2%
- Northeastern: 13.0%
- North Central: 17.0%
- Western: 3.1%
- Tropical/Subtropical: 1.7%

Source: 1998 Census of Aquaculture, USDA-NASS
Value of Aquaculture Products Sold by Region

Source: 2005 Census of Aquaculture, USDA-NASS
US Consumption Share

Per capita availability (lbs)

- Beef
- Pork
- Chicken
- Seafood

Minimum seafood recommended by FDA

Source USDA (2010)
US Hot Issues

- Shellfish industry
  + 12.8% annual increase 1998 - 2008

- Catfish industry
  - 32% 2007 to 2011

- AIS / ANS
  - Asian Carp
    - Grass carp (most states sterile only)

- Regulations Regulations Regulations Regulations
Time series of non indigenous species introductions in Great Lakes since 1840

- **Welland Canal** 1829
- **Chicago Sanitary Canal** 1848
- Purple Loosestrife 1879
- Alewife 1873
- Sea Lamprey Upper GL 1920
- Curly leaf Pondweed 1946
- Eurasian Water milfoil 1970
- Zebra Mussel 1988
- Quagga Mussel 1989
- Eurasian Water milfoil 1970

Source: NOAA
US public laws and acts for invasive species

- Lacey Act 1900
- Executive Order 13112 1999
- National Invasive Species Act (NISA) 1996
- NANPCA 1990
- Asian Carp Prevention and Control 2010
Number of AIS entering Great Lakes by pathway (1840-2006)

- Ballast Discharge
- Deliberate Release
- Unintentional Release
- Unknown
- Canals
- Solid Ballast
- Aquaria
- Bait Release
- Ballast Water Hull Fouling
- Railroads and Highways

Source: NOAA
US Hot Issues

- Aquaponics
- Sustainability
Sustainable Aquaculture

Long Term

Growth

Current (e.g.)

Short Term

Environmental Conservation

Social Benefits

Economic Viability

Perception -vs- Science
US Hot Issues

- Aquaponics
- Sustainability
- Energy Energy Energy Energy
- IMTA  Integrated Multi-Trophic Aquaculture
Integrated Multitrophic Aquaculture

Feed Addition

Harvested fish

Dissolved Nitrogen (NH4)

Harvested Macroalgae

Phytoplankton

Seston and fouling organisms

Uneaten food

Fish feces

Harvested Bottom Grazers

Harvested Bivalves

Decomposition, Denitrification, Remineralization
Increased/Decreased Benthic Biomass and Diversity

Source: S. Belle Maine Aquaculture 2013
IMTA

Source: Japan International Research Center
UVI Aquaponic System

Graphic: UVI Aquaculture Program
Trends RAS

- Denitrification
- Microbial flocs
- De-phosphorus flocculation
- “Zero discharge”
US Hot Issues – Locally Grown

- Consider advantage to local grown in terms of energy and carbon footprint, transport costs...etc

- Is it in the national interest to significantly increase aquaculture production?
Aquaculture in the North Central Region
Addressing Concerns for Water Quality Impacts from Large-Scale Great Lakes Aquaculture

August, 1999

Roundtable Habitat Advisory Board of the Great Lakes Fishery Commission,
Great Lakes Water Quality Board of the International Joint Commission

• Caged aquaculture operations in the Great Lakes are currently limited by available technology and suitable sites.

• Neither caged nor land-based aquaculture is expected to grow substantially.

• The aquaculture industry is interested in achieving economically-viable and environmentally-sustainable operations.

• Both the aquaculture industry and governments want to limit water quality and habitat impacts.
Ontario Cage Culture
- 10 Facilities in Lake Huron Manitoulin Islands
- 10 million lbs per year
Aquaculture

- Aquaculture is a growing industry in inland waters of the Great Lakes basin, but lake-based cage culture of salmonids, which began in the mid to late-1980s, occurs only in Georgian Bay and North Channel of Lake Huron.
- Aquaculture is the farming of aquatic organisms. In cage-based systems, cages are suspended in the water, allowing water to pass through. The water brings oxygen in and carries away waste products including feces, uneaten food, and medicines.
- Aquaculture is the fastest growing food production sector in the world. In Ontario, aquaculture produced 4500 tonnes in 2005.
- Rainbow trout is the dominant species produced in Canadian aquaculture systems.
- Approximately 75% of the production comes from eight freshwater cages located in Georgian Bay and North Channel of Lake Huron.
Stressor (GLEAM)

- Any substance, condition, flux or organisms that alters the characteristics of the lakes, including their biology, from natural or desired conditions.
- May be currently operating on the lakes or may be considered likely to do so in the future.
- May be physical, chemical, or biological.
- May adversely affect specific aquatic plants and animals, key characteristics of natural resources, or entire ecosystems.
- Can also have some positive effects.
Human Benefits Interactive Map

The majority of solids settle to the lake bottom within hundreds of meters of cage locations. Ammonium levels have been reported to return to background at distances of 0.5 to 12 km.

Water circulation patterns will substantially influence the extent of flushing as well. Water quality impacts from cage aquaculture as local, dissipating to 10% of their initial value within 5 km and to 1% within 10 km.
Local Trends

Less fishing

Fishing Licenses (million)

Michigan

Local Trends

- Less fishing
- Do not see much of PETA influence
- Strong momentum for aquaponics
- More opportunity for locally grown products
- Rising concerns for safe and healthy seafood
- BUT – also overwhelming influence of cheaper available seafood
Local Trends

- Continued slow progress towards becoming a major producing seafood sector.
- Live food sales, mainly tilapia from MN, SD appear to have largest market share of regional raised seafood.
- Demands for trout cannot be met by producers in region, and only a few farms (mainly WI and MI) are actively pursuing this market.
- Demands for yellow perch and bluegill appear strong but consistent supply of fingerlings and better growth are needed.
Local Trends

- Production cannot keep up with demand
- Major producers tend to be older in age and highly productive new facilities are rare
- Increased burden due to restrictive regulations
- Financing through lenders extremely difficult to obtain
Regulatory Trends

- Regulation through restriction rather than promotion

- Increasing use of regulations,
  - especially Lacey
  - Complex and redundant

18th International Conference on Aquatic Invasive Species (ICAIS 2013) special session proposed:

*Preventing Aquatic Invasive Species through Management of the Live Bait Vector*
Figure 3.
Change in State Poverty Rates for the United States and Puerto Rico: 2010 to 2011

Statistically significant change by state:
- Increased
- No change
- Decreased

MI Water Discharge

See the MADA Act of 1996, List of Species – Appendix C

Discharge outlet

To a private or municipal water treatment facility

No State/DNR permitting needed, proceed to discharge load arrangement with your discharge

Ground discharge

Advance to Groundwater Discharge

Irrigation of effluent on cropland

???? Can we address in Irrigation GAAMP???

To “Waters of the State”

NPDES Process

Advance to NPDES Permit Application, via the DEQ Surface Water Assessment Section

Yes

Free to operate without NPDES discharge permit

No

No State/DNR permitting needed, proceed to discharge load arrangement with your discharge

See www.michigan.gov/d eq/0,4561,7-135-3313_4117---,00.html

http://www.michigan.gov/deq/0,4561,7-135-3313_3686_3728---,00.html - see Part 4 & Part 8 Rules – bottom right

See http://www.michigan.gov/deq/0,4561,7-135-3313_3686_3728---,00.html

Note – unresolved is the question about if the addition of treatment chemicals will require NPDES permitting

This process/rule could benefit from an assessment tool

Projected Facility production of >100,000 lbs of fish or > 20,000 lbs coldwater fish of aquatic species

Yes

Advance to NPDES Permit Application, via the DEQ Surface Water Assessment Section

Free to operate without NPDES discharge permit

No

Note – unresolved is the question about if the addition of treatment chemicals will require NPDES permitting

Free to operate without NPDES discharge permit

See http://www.michigan.gov/deq/0,4561,7-135-3313_3686_3728---,00.html

This process/rule could benefit from an assessment tool

No
Trends in US commercial aquaculture and baitfish sectors

- Bunker survival mode / under the radar??

- Waiting to see what the next regulation to be proposed is going to be

- Food fish production being seriously outpaced by other countries

- Trends towards decreases in recreational fishing likely to add additional burden to baitfish sectors
Trends in commercial aquaculture and baitfish sectors

- Seeking legitimacy
  - Certifications
Certified baitfish means ...

An official AAD certificate accompanies each load of Arkansas certified baitfish. On the certificate, you can find the farm name, the species, the size and weight of the load, the date the certificate was issued and when it will expire. The certificate is tamper-evident.

These farm-raised fish are certified free from:
- Spring Viremia of Carp (SVCV)
- Infectious Pancreatic Necrosis (IPNV)
- Viral Hemorrhagic Septicemia (VHSV)
- Infectious Hematopoietic Necrosis (IHN)
- Eurasian watermilfoil (Myriophyllum spicatum)
- Giant salvinia (Salvinia molesta)
- Hydrilla (Hydrilla verticillata)
- Zebra mussel (Dreissena polymorpha)
- New Zealand mud snails (Potamopyrgus antipodarum)
- Red-rimmed melania (Melanoides tuberculata)
- Sticklebacks (Family Gasterosteidae)
- Rudd (Scardinius erythrophthalmus)
- Orfe (Leuciscus idus)
- Silver carp (Hypophthalmichthys molitrix)
- Bighead carp (Hypophthalmichthys nobilis)

Trends in commercial aquaculture and baitfish sectors

- Seeking legitimacy
  - Certifications
  - Best Management Practices
  - Biosecurity Plans
  - AIS HACCP
AIS-HACCP is a process to help identify and control the critical pathways for spread of aquatic invasive species or other non-target aquatic species. The process provides for self-monitoring, verification, and record-keeping systems to help ensure that your activities don’t spread these hazards.

Potential Invasive Hazards
- Fish & other vertebrates
- Invertebrates
- Aquatic plants
- Aquatic diseases and parasites

For Who?
- Resource managers
- Researchers
- Graduate students
- Technicians
- Consultants
- Enforcement officers
- Fish farmers
- Baitfish producers

Why HACCP?
Natural resource professionals can spread invasive species during field work. Risks associated with their activities are diverse and a one-size-fits-all approach is often inappropriate or ineffective. AIS-HACCP is a flexible approach that manages diverse activities to prevent the spread of invasive species or provide AIS-free certification.

How HACCP Works
1. Conduct hazard analysis
2. Identify critical control points (CCP)
3. Establish control measures
4. Monitor each CCP
5. Establish corrective action to be taken when a problem occurs
6. Verify that the HACCP plan and control measures work
7. Establish a record-keeping system

Selected Outcomes & Impacts
- Over 500 private, state, federal, and tribal representatives from over 25 states, and the province of Ontario have been trained through workshops held in 18 states
- The U.S. Fish & Wildlife Service has adopted AIS-HACCP and developed 90 AIS-HACCP plans in over 16 states
- The Great Lakes Indian Fish & Wildlife Commission has developed AIS-HACCP protocols for their resource management work
- Fish farmers and baitfish producers have developed plans to help prevent the spread of invasive species in many Great Lakes states
- The Bait Association of Ontario will be training all bait producers in AIS-HACCP
- The Fish and Boat Commission in Pennsylvania stopped planting Lake Erie emerald shiners in inland lakes as a result of risks revealed through AIS-HACCP training

Sea Grant conducts 1-day training workshops! Curriculum manual, instructional video, and many training resources available.
Trends in commercial aquaculture and baitfish sectors

- Seeking legitimacy
  - Certifications
  - Best Management Practices
  - Biosecurity Plans
  - AIS HACCP
    - Certification?
      - e.g. certifiable body /3rd party

- Industry asking/should have a seat at the table
Which brings us to....
Director of Agriculture, Robert Boggs

- Update 2001 Ohio Aquaculture Plan
- Goal for Ohio is to be #1 in aquaculture production in the U.S.
- Make net small jars
- Tandem production
  - Hard systems
  - Balanced circulating systems
Thanks!
Aquaculture Information Lists Serves

Aqua-Ohio
contact: Laura Tiu, tiu.2@osu.edu

NCR Fish Culture:
http://www.ncrac.org/
NCR Aquaculture Roadmap