

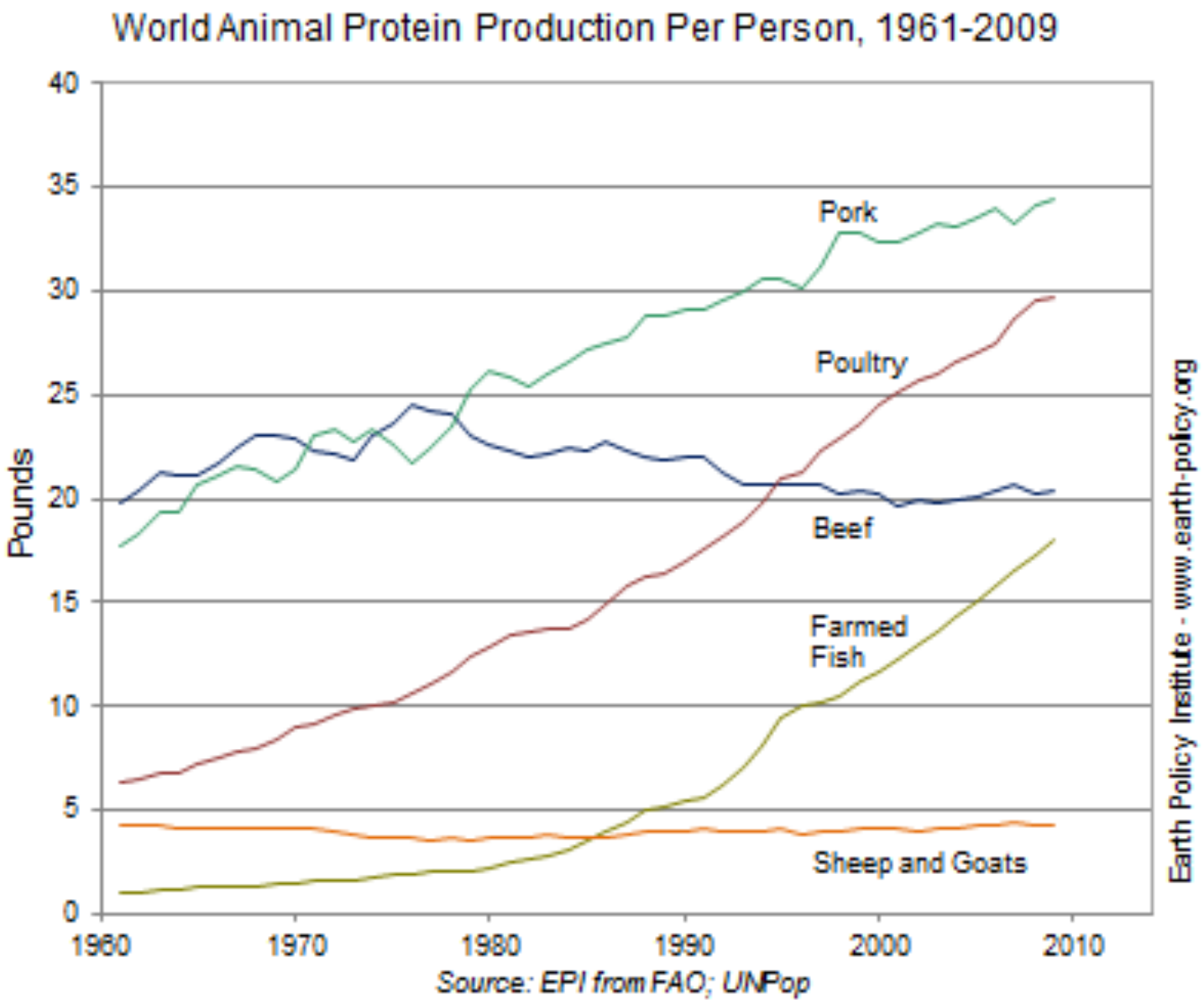



Ethical and Stewardship Considerations in Aquaculture

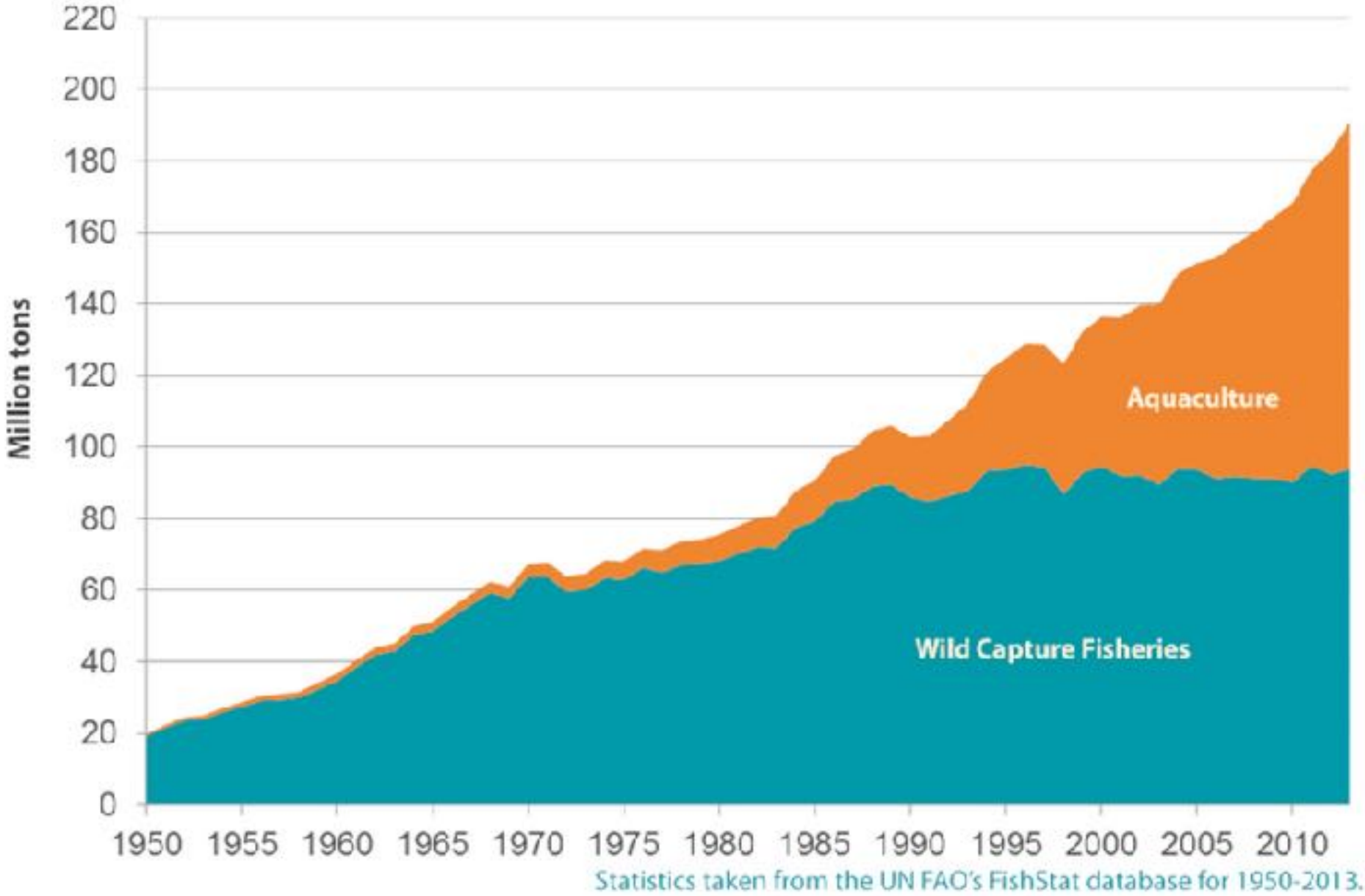

Steven Hall shall5@ncsu.edu
ASA July 2017

"The Earth is the Lords" Ps 24

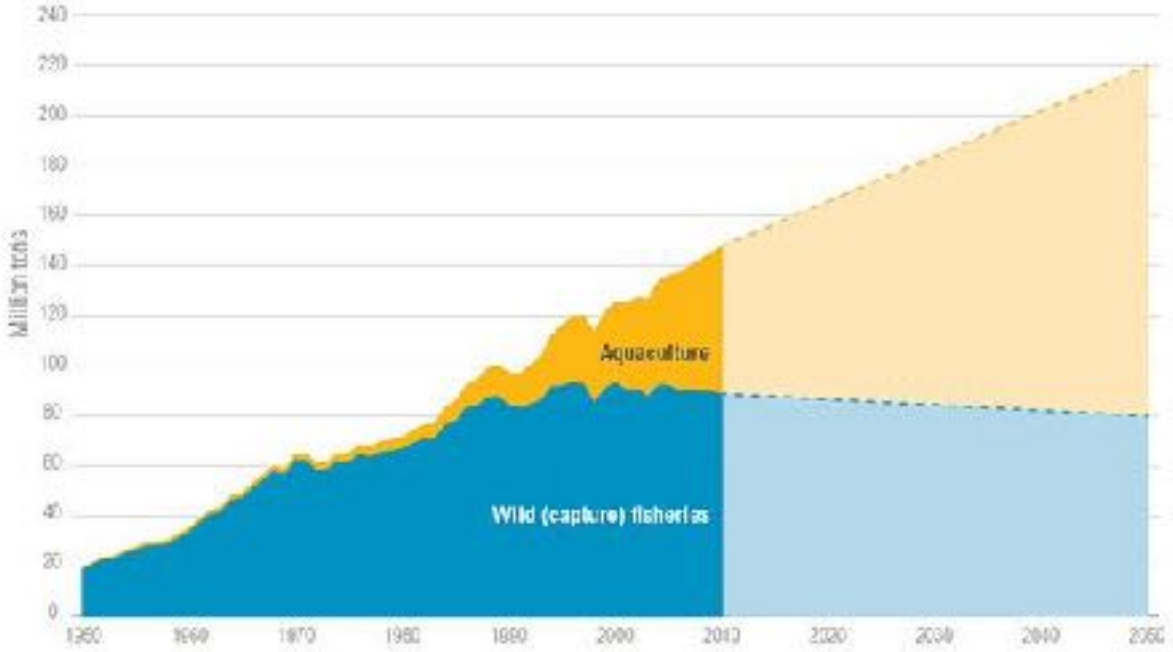




World Animal Protein Production Per Person, 1961-2009
Pounds
40
35
30
25
20
15
10
5
0
1960
1970
1980
1990
2000
2010
Pork
Poultry
Beef
Farmed Fish
Sheep and Goats
Earth Policy Institute - www.earth-policy.org
Source: EPI from FAO; UNPop

Global Seafood Production



Aquaculture Is Expanding to Meet World Fish Demand



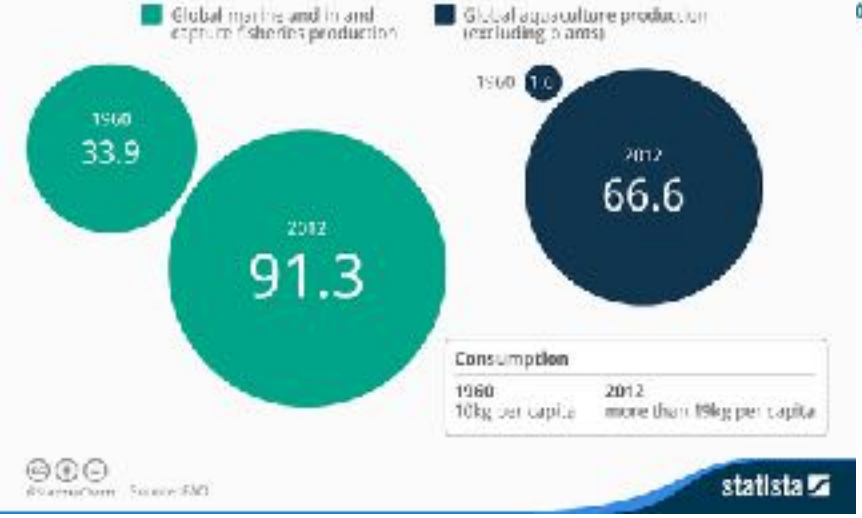
Data 1950–2010: FAO. 2014. "FishStatJ." Rome: FAO. Projections 2011–2050: Calculated at WRI, assumes 10 percent reduction in wild capture between 2010 and 2050, and linear growth of aquaculture production at an additional 2 million tons per year between 2010 and 2050.

org/publication/improving-aquaculture for full paper.

WORLD RESOURCES INSTITUTE

The Global Fish Farming Industy Is Booming

World fisheries and aquaculture production (in million tonnes)



What is Aquaculture? (vs. Terraculture)

Culture of Animals, Plants, Bacteria… in/with Water

Examples: Finfish (Fresh or Marine); Reptiles, Molluscs, Crustaceans; Microalgae; Macroalgae (seaweed); Plants (wetlands…); Bacteria…

Who/where grows it now?
(China: 50+%) (US: $1B <1%)
Trade: US Imports ~$20B
Who needs it (now/future)?

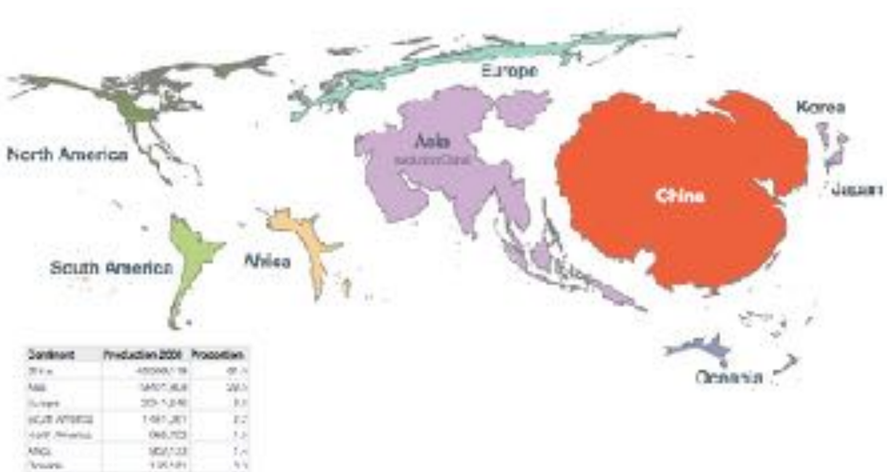
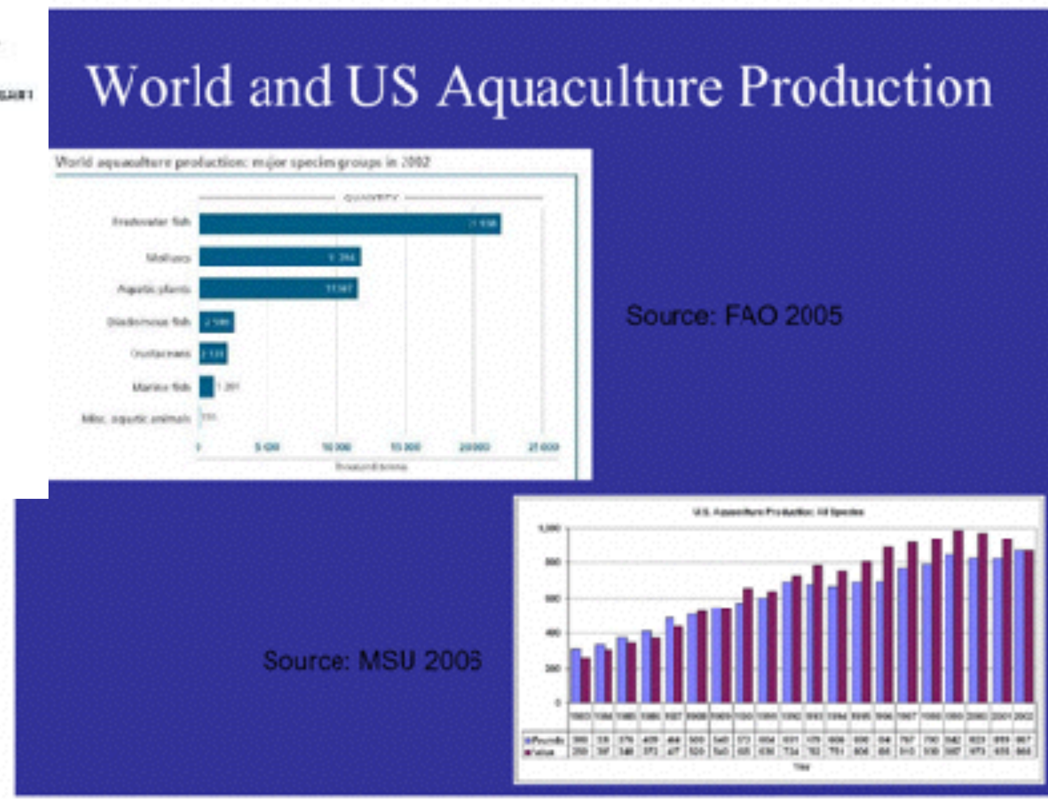


Figure 1.1 World aquaculture production by continent in 2006 (China located separately). Land areas are adjusted proportionally to reflect production volumes.



Ethical/Stewardship Issues in Aquaculture

Rich vs. Poor (tilapia vs. carnivorous)
Creation Care (Environmental Ethics – water)
Economics (energy/resources)
Human/Animal Health
Genetic Issues (Bio-resources)

Gen 1:26 … dominion… over the fish…
Gen. 2:15 … shmar and abad…
Matt. 25:40 ...for the least of these…
Rev 22: … river of water of life… (city/fruitful/heal/th)

Rich vs. Poor

Aquaculture **can** have FCRs of 1-2 (0.3-5)
Compare to Chicken 2-3; Pork 3-4; Beef 6-20
Rich desire “high trophic level”
e.g. salmonids (carnivorous);
sturgeon/caviar
Feed World: Low trophic level
Efficient production
Very cheap: tilapia, catfish, carp…
…to the least of these…

Creation Care (Environmental Ethics – water)

Recirculating Aquaculture Systems (RAS)

Recycle water: efficient water use (90-100%)

High capital costs

Energy costs: e.g. pumps

Energy efficient: e.g. LHO

Multi-raceways (18x = 94% recirc)

Possibly improved environmental impacts

… *shmar and abad*… Gen 2:15

Efficient production ->

Natural stocks can recover

Economics

Rich vs. Poor (tilapia vs. carnivorous)

Efficiency: Water; Energy; P; N; C

Externalities (accounted?)

High Protein Food

High Value Products (tilapia/skin… health)

Ecological Services (e.g. P/N/C efficiency/conversion/ sequestration)

… least of these…

(use talents given you)

Key Market/Environment/Technology Issues in Aquaculture

Lower Trophic Levels
More Plant Based Feeds
Waste Management
Disease Management
Local/Global Advantages
Stewardship
Social Issues

Human/Animal Health

IACUC Protocols (Animal Care)

Better control in RAS/Ponds

Safer food (less metals, etc.)

“Natural?”

Ethical Treatment of Animals

Genetic Modification in Fish

AquAdvantage Salmon (J. Buchanan et al.)

Atlantic/Chinook/Pout 11x growth rate (y1)

“Frankenfish?”

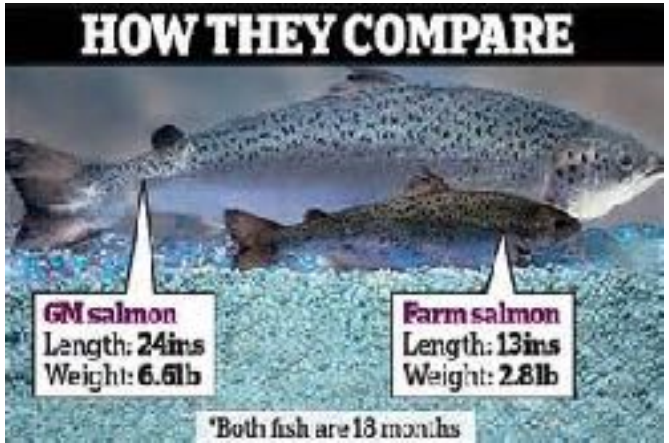
Possible competition (less efficient swimmer)

Triploid females (sterile 98.9%)

FDA: “highly unlikely… environment”

“as safe as… conventional”

(US 2010-15; Canada 2016)



NC Species/Work

Trophic Levels:

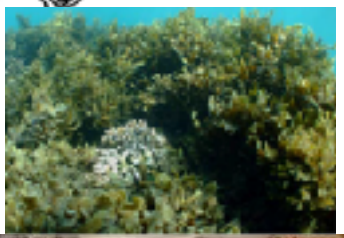
Lower: Algae, Macroalgae, Oysters, Tilapia

Higher: Salmonids; Bass (Sturgeon)

MOUNTAINS

PIEDMONT

COASTAL



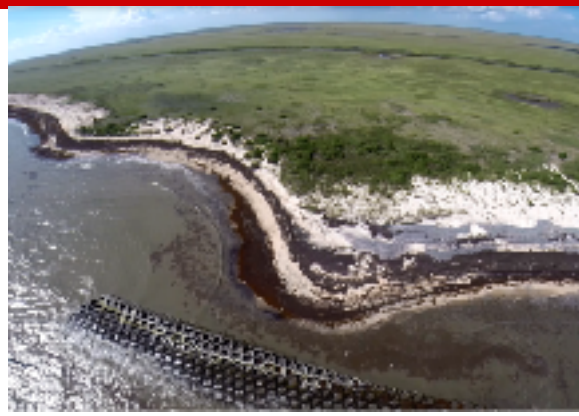
Lower Trophic Levels
More Plant Based Feeds
Waste Management

Marine Aquaculture Research Center (MARC)

- Advantages
  - Unique access to coast/salinity capabilities
  - Custom built; independent systems
  - Under our control
  - Good backup power/water
  - Neighbors with Marshallberg Farm (sturgeon)
- Disadvantages
  - Rural/access to visitors (3h Raleigh; 30min Morehead)
  - No dorms/minimal offices/meeting rooms
- Unique Features
  - Solar/Wind; Marine; Waste Treatment; 7 species

Marine Aquaculture Research Center (MARC)

Summary



Fish efficient at growing: FCR can be <1
Work to be done: Trophic; Resources; Efficiency; Economics; Social; International

Engineering for Production
Engineering for Sustainability
Engineering for Growth, Ethically

Grow the successes; invent new winners

shall5@ncsu.edu

Hungry to Grow

Research/Discovery (MARC/FishBarn) Collaborators (LaPaz)

Water Quality: Biofiltration, Constr. Wetlands, Resource Use

Q1: How to approach zero discharge (animal/plant/algae)?
Q2: How to add/extract value from "waste"?
Q3: How to produce aquaculture and protect coast/water?

Larval/Reproductive Techniques: Sturgeon

Q1: How to use ultrasound to ID egg quality ("smart" caviar)?
Q2: How to allow/enhance reproduction for long-lived finfish (Sturgeon, Black Drum, Porgy/Bream…)?
Q3: Larval diets for large finfish? (w Peter Ferket, Harry…)

Harvest/Postharvest (Food safety)

Q1: How to produce safer foods? (w D. Green)
Q2: How to market/engineering/packaging?
Q3: Culture microorganisms (bioproc/bioreactors)? (w Ben Reading et al.; Jon Bell)

Research Goals

PhD: D. Smith, M. Greensword, S. Oladi (LSU)

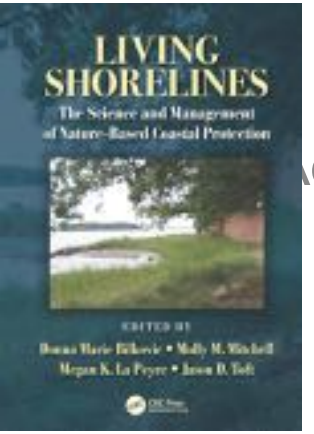
NCSU RA: Ryan Kelly, Marine Aquaculture Rsch Ctr (MARC) (Hybrid Striped Bass, Sturgeon, Marine Species, Oysters)

PhD: Melody Thomas (Water Quality/Constr Wetlands and Gators); Matt Campbell (Coastal Aqua/Protection)

MS: Alex Geddie (Sust. Development/Sust Aqua)

Senior Design: Kelly, Alexi, Ben, Andrew, Natalie

Aquaculture and Ecosystem Services: CO2/N sequestration



Grant$: Multistate (funded/approved): Vehicles/Wate

SBIR: NSF/NOAA (Coastal bioeng. tech.)

SeaGrant (Water/Aquaculture; Process…);

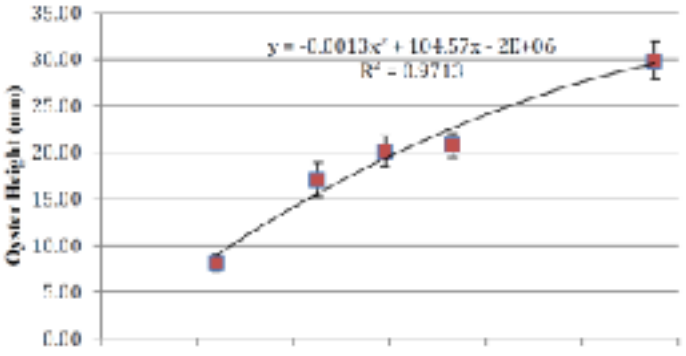
NIFA: Macroalgae w Cheng, Dubbs et al.

Pubs (16-17): Living Shorelines Chapter; Vehicles pubs: plant harvest/water quality; oyster pubs (Melody…); Coastal (Matt…); Alligators (C. Malveaux); Sturgeon, finfish upcoming

Conserve AND Grow

Long-Line and Boom Systems; Bioengineered Oyster Reefs

Artificial Cultch



Research Goals (Sustainably)

Grow NC Industry→ 2016→2020→2025

"Large" value: ($50M → $100M+)

- Trout →$9M →$10M→15M ($21-50M+, WQ)
- HSB → $11M → $15M+ ($50M, Market/Growth)
- Catfish→$5M →($17-20M+, Proc; Value)
- Tilapia→$3M, Extension/Expansion

"Special/small" value: ($1M → $90M?)

- Oysters $350K → $1M+ → $5M+ ($20M)
- **Sturgeon** $800K → $1M+ → $5M+ ($50M)**
- Crayfish → $40K → $200K → $1M+ ($10M)
- Alligators → $0 → something → $1M+ ($10M)
- Plants/Algae/Macroalgae $small →$1M+

file:///C:/Users/shall5.SHALL5-LAPTOP/Desktop/2015aquaNCADCUpdate.pdf

Extension

Learn Industry, Serve Industry

Grow Industry

Currently ~$58M

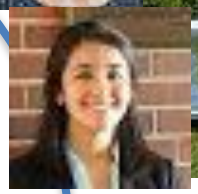
Goal: >$100M by early 2020s

Enhance Sustainability/Responsibility

BOTH/AND

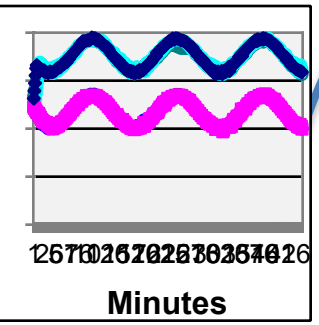
Production AND Eco/Env

“Have your fish and eat them too”



Teaching
Students
Classes
Online
Web

Research Papers
Undergraduate Research
Extension Pubs



Research
Graduate Students
Univ/Govt/Industry
Grants/Contracts
Research Pubs/Books
Online
Web
Grow Industry
Sustainable/Env

$$\theta_{calc} = -1355\phi\cos\left(\frac{\pi t}{12}\right) \quad (6)$$

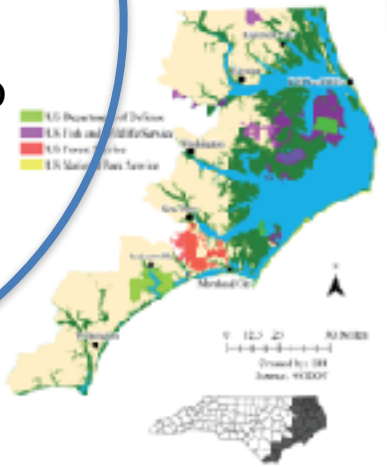
where ϕ is the percentage of solar radiation varied in the trial runs (Table 1). Eq. (5) becomes:

$$\rho c_p V\frac{dT}{dt} = 1355\phi\cos\left(\frac{\pi t}{12}\right) - \sum q \quad (7)$$

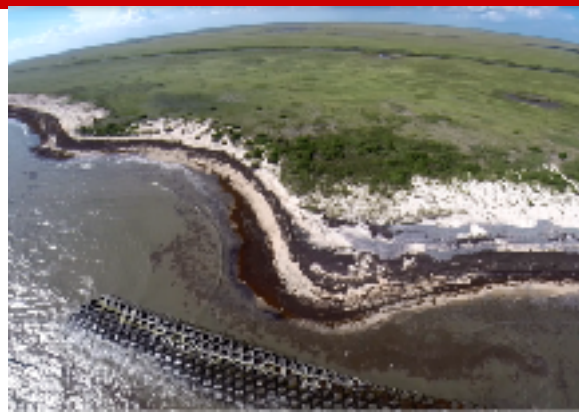
Integrating Eq. (7) for $t = 0$ to some time t between 6 and 18 h gives:

$$T = T_i + \frac{1626\phi}{\pi\rho c_p V}\left(\sin\frac{\pi t}{12} - 1\right) + \int_0^t \left(\sum q\right) dt \quad (8)$$

Extension
Life-long learners
Field Days/Demos
MARC/FishBarn
Aquaponic$ Club
Youth (SOS)
Grow Industry
Online
Web



Summary



Work to be done

Engineering for Production

Engineering for Sustainability

Engineering for Growth

by 2020's

Grow the successes; invent new winners

Hungry to Grow