Coolwater Fry Culture in Ponds

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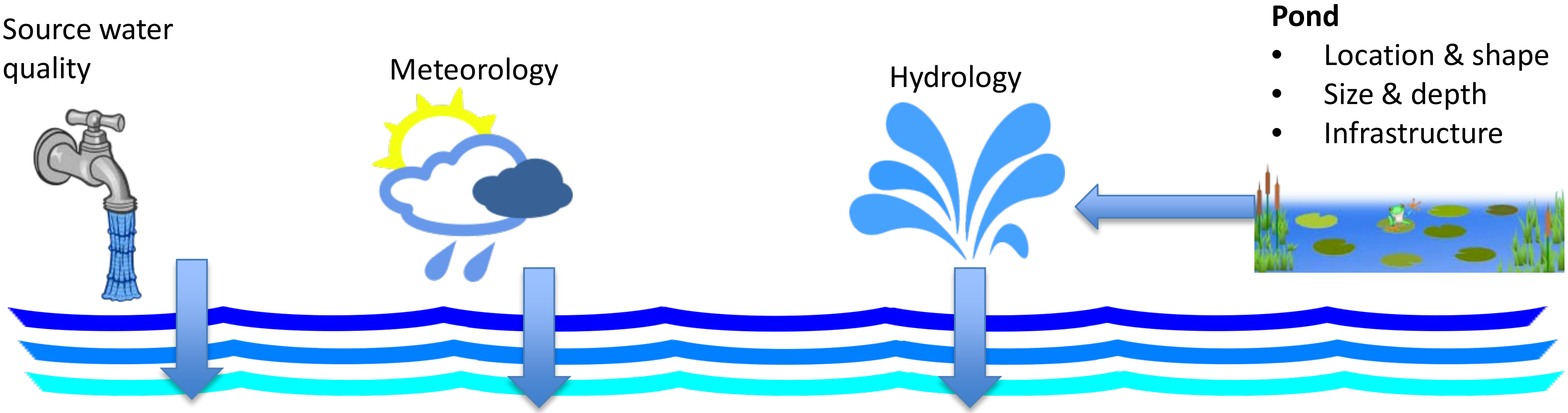
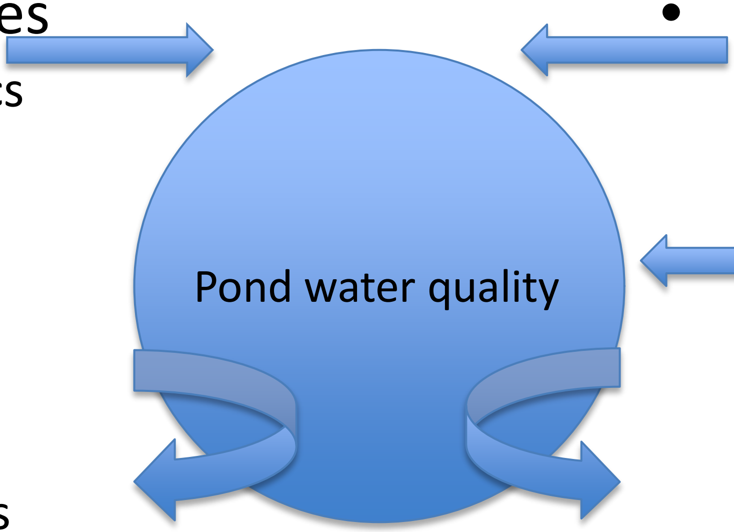
Pond Dynamics



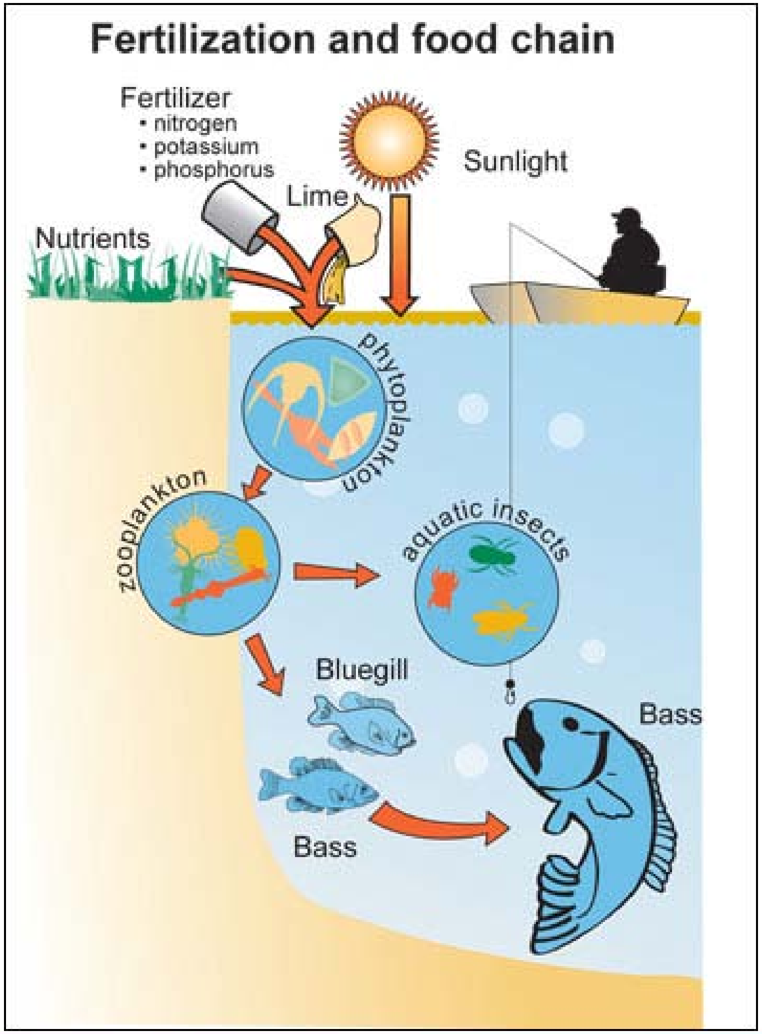
- Biological processes
  - Plankton dynamics
  - Photosynthesis
  - Respiration
  - Excretion
  - Decomposition
  - Nutrient cycling
  - Benthos dynamics



- Operation decisions
  - Fish
    - Species, size, density
  - Inputs
    - Fertilizers & feed
    - Energy (aerators)
  - Water management
  - Timing of operations

A. Milstein 2012, Aquaculture Pond Fertilization

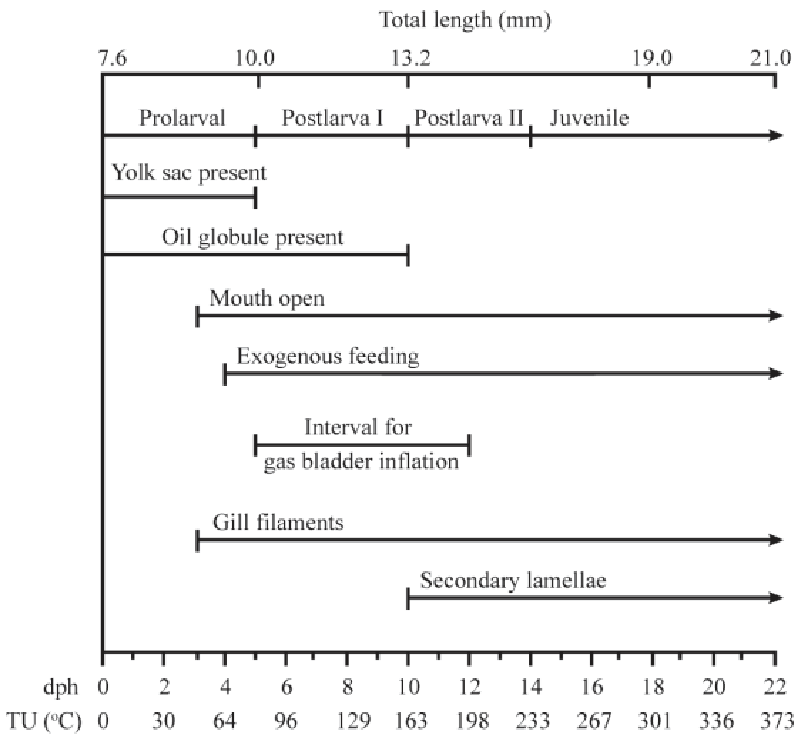
Food Chain



Fertilization and food chain
Fertilizer
• nitrogen
• potassium
• phosphorus
Sunlight
Lime
Nutrients
phytoplankton
zooplankton
aquatic insects
Bluegill
Bass
Bass

Natural and Artificial Spawn

Fry Development



Culture Practices

- Pond / Tank / Pond
- Step 1: Spawn Adults

Ponds

Habituation

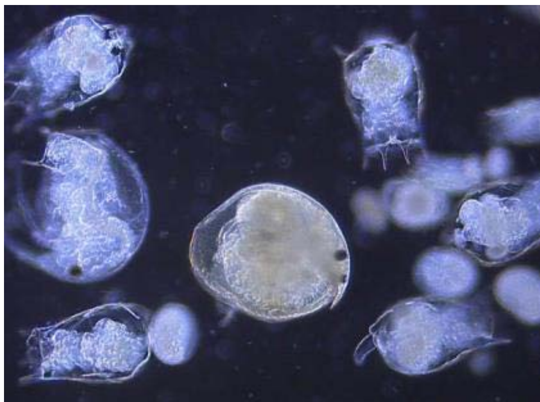
Growout

Culture Practices

- Step 2: Place fry in outdoor culture pond

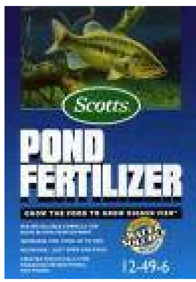
Culture Practices

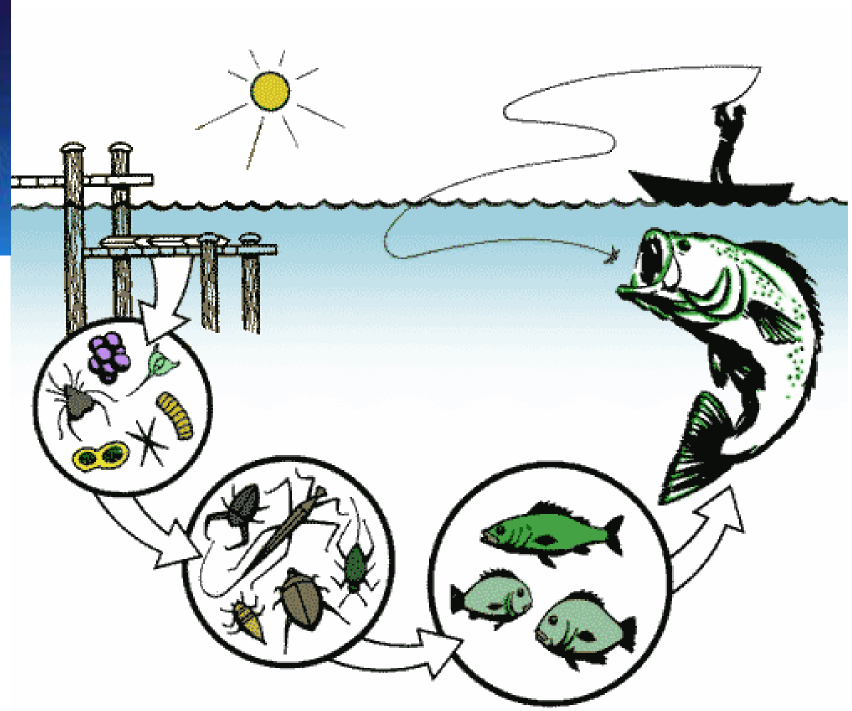
- Step 3: Larval fish feed on natural foods



Culture Practices

- Step 4: Fertilizers added weekly to enhance aquatic food web



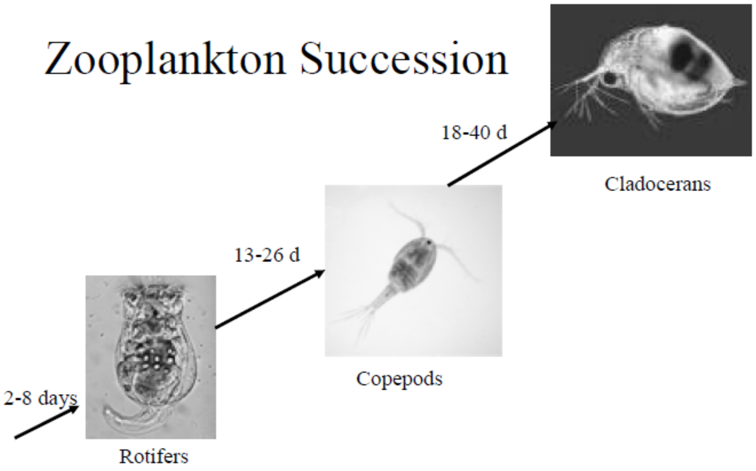


Culture Practices

- Step 5: Harvest and feed-train: habituate to formulated feed

Best Fertilizer

- Reduce costs
- Increase efficiency
- Increase survival rate
- Decrease the cost of fingerlings



Inorganic Fertilizer

- Primary components:
  - Nitrogen (N)
  - Phosphorus (P)
  - Carbon (C)
- Enhance autotrophic food webs

	Percentage		
Fertilizer	**N**	**P_2O_5**	**K_2O**
Urea	45	0	0
Calcium nitrate	15	0	0
Sodium nitrate	16	0	0
Ammonium nitrate	33-35	0	0
Ammonium sulfate	20-21	0	0
Superphosphate	0	18-20	0
Triple superphosphate	0	44-54	0
Monoammonium phosphate	11	48	0
Diammonium phosphate	18	48	0
Calcium metaphosphate	0	62-64	0
Potassium nitrate	13	0	44
Potassium sulfate	0	0	50

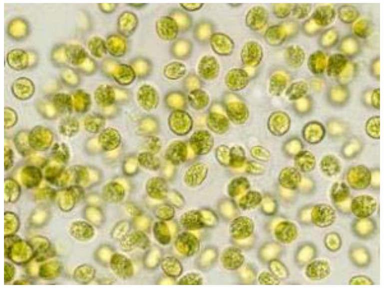
Organic Fertilizer

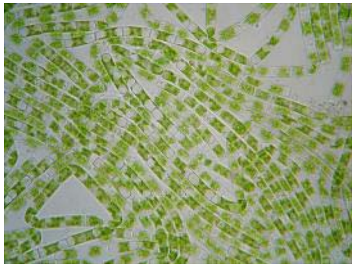
- Various types:
  - Animal manures (poultry, cattle, etc)
  - Plant material (hay, alfalfa, cottonseed, soybean meal, etc)
- Directly & indirectly enhance algae & zooplankton
  - Direct: Input of N, P, C stimulate autotrophic food web
  - Indirect: Stimulate heterotrophic food webs

	Average Composition (%)			
Material	**Moisture**	**N**	**P_2O_5**	**K_2O**
Dairy cattle manure	85	0.5	0.2	0.5
Beef cattle manure	85	0.7	0.5	0.5
Poultry manure	72	1.2	1.3	0.6
Swine manure	82	0.5	0.3	0.4
Sheep manure	77	1.4	0.5	1.2
Mixed grass, dry	11.0	1.12	0.48	1.44
Fresh cut grass	69.2	0.78	0.21	0.79
Oat straw	10.2	0.66	0.21	2.40
Peanut hulls	7.7	1.07	0.14	0.98
Rice straw	7.2	0.56	0.21	1.08
Potato peelings	79.8	0.34	0.09	0.0
Sugar cane leaves	74.3	0.21	0.16	0.91
Cottonseed meal	7.2	6.93	2.45	1.74
Soybean meal	9.7	7.31	1.44	2.30

Nutrient Ratio Manipulation

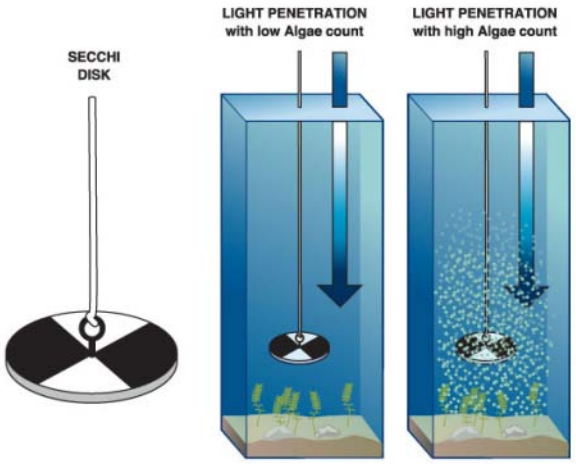
- Nutrient composition of phytoplankton biomass
  - 45-50% C, 8-10% N, 1% P
- Low N:P ratios = cyanobacteria
- High N:P ratios = non-cyanobacteria algae
  - 20:1 (N:P) [600 *u*g N/L and 30 *u*g P/L]
- Small green algae and diatoms = good
- Large filamentous and cyanobacteria = bad





Green Water Method (Visibility)

- Implies green water is nutrient rich water
- Uses visibility/Secchi disk to determine greenness
- Inexpensive, subjective, minimal accuracy
- Does not consider composition of algae, plankton, or impact of fertilizer on oxygen
- Difficult to establish consistent food web



Fixed Fertilization Rate Strategy

- Fertilizer is applied weekly at a selected quantity
- Requires prior knowledge of pond dynamics & fish production
- Simple; annual production of fish predictable
- Can lead to over-fertilization and is specific for each pond

Water Chemistry Measurement

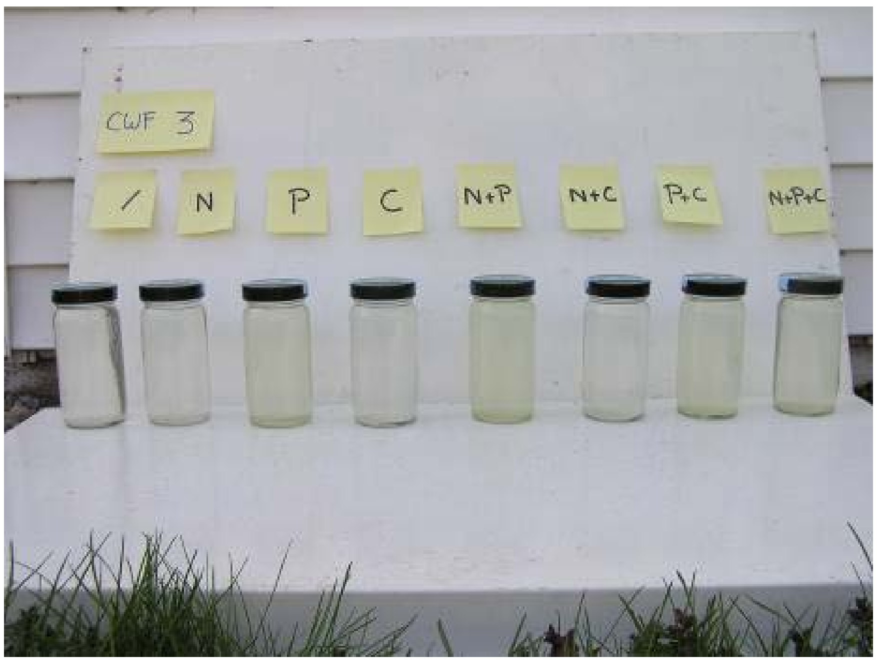
- Regularly collected water samples are measured for:
  - Total phosphorus & soluble reactive phosphorus
  - Ammonia-N, Nitrate-N, & Nitrite-N
  - Inorganic carbon
- Pond-specific & can precisely measure nutrient deficiencies
- Significant cost, technical, time consuming, & does not take into account daily fluctuations

Algal Bioassay Fertilization Strategy

- Based on algal nutrition limitation of N, P, & C
- Is pond & time-specific; utilizes ponds own algal community
- Uses a simple visual indicator
- Inexpensive, simple, & ecologically-based
- Water is collected weekly in clear sample bottles
- Each bottle is spiked with either N, P, C, or nothing (control), or a combination.
- Bottles are placed in sunlight for 2-3 days
- Water is filtered and compared visually and ranked as 100%, 50%, or 0% rate-limiting

Algal Bioassay Pond Samples

- Water samples showing nutrient spikes
- Filtered water showing limiting nutrient

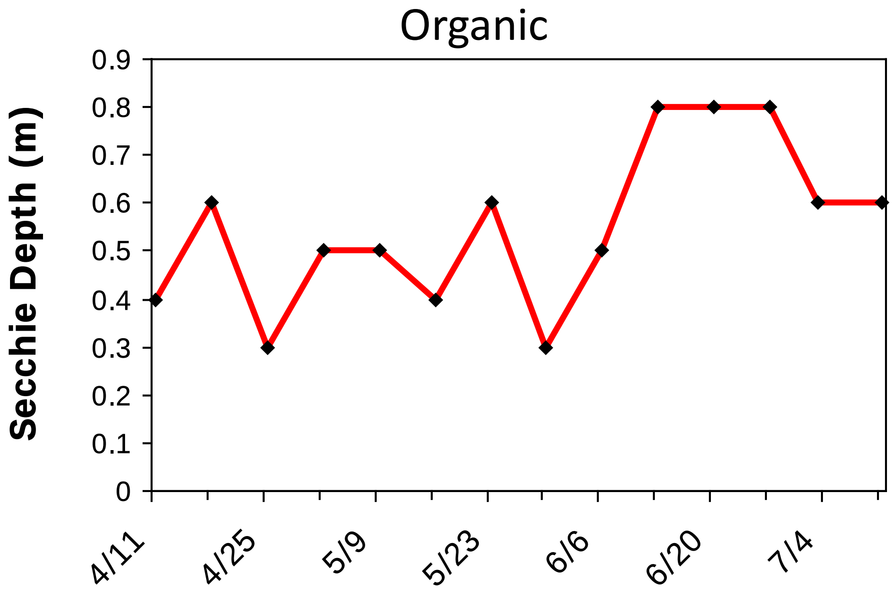


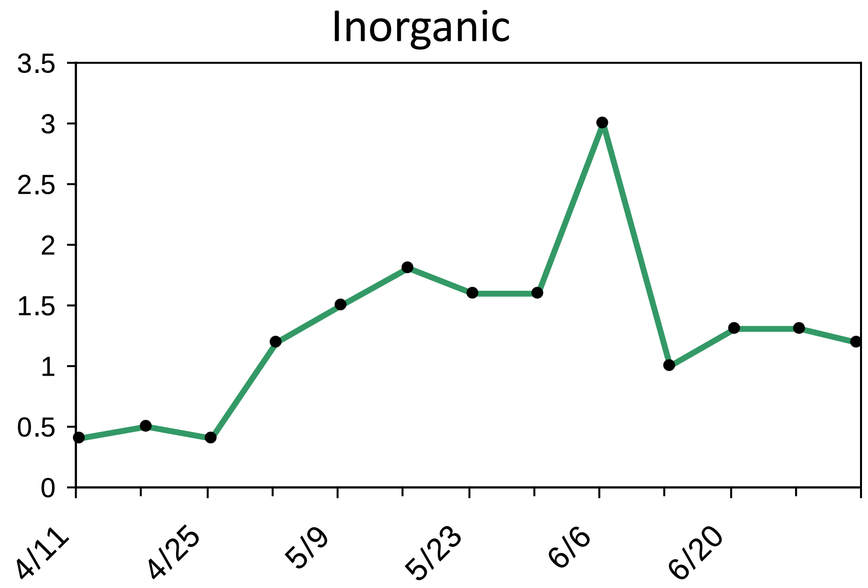
Yellow Perch Fry Example

- Methods
  - Year 1: Examine pond fertilization practices
    - Late April add organic fertilizer
    - Late April to mid-June weekly inorganic fertilizer
      - Urea-N and phosphoric acid (Desired Secchi depth 1.5 m)
  - Monitor water chemistry of culture ponds
  - Monitor phyto- and zooplankton
  - Monitor growth of yellow perch fingerlings
    - Stocked yellow perch fry (late April; 850,000 per ¼ acre)
      - Evaluate diet

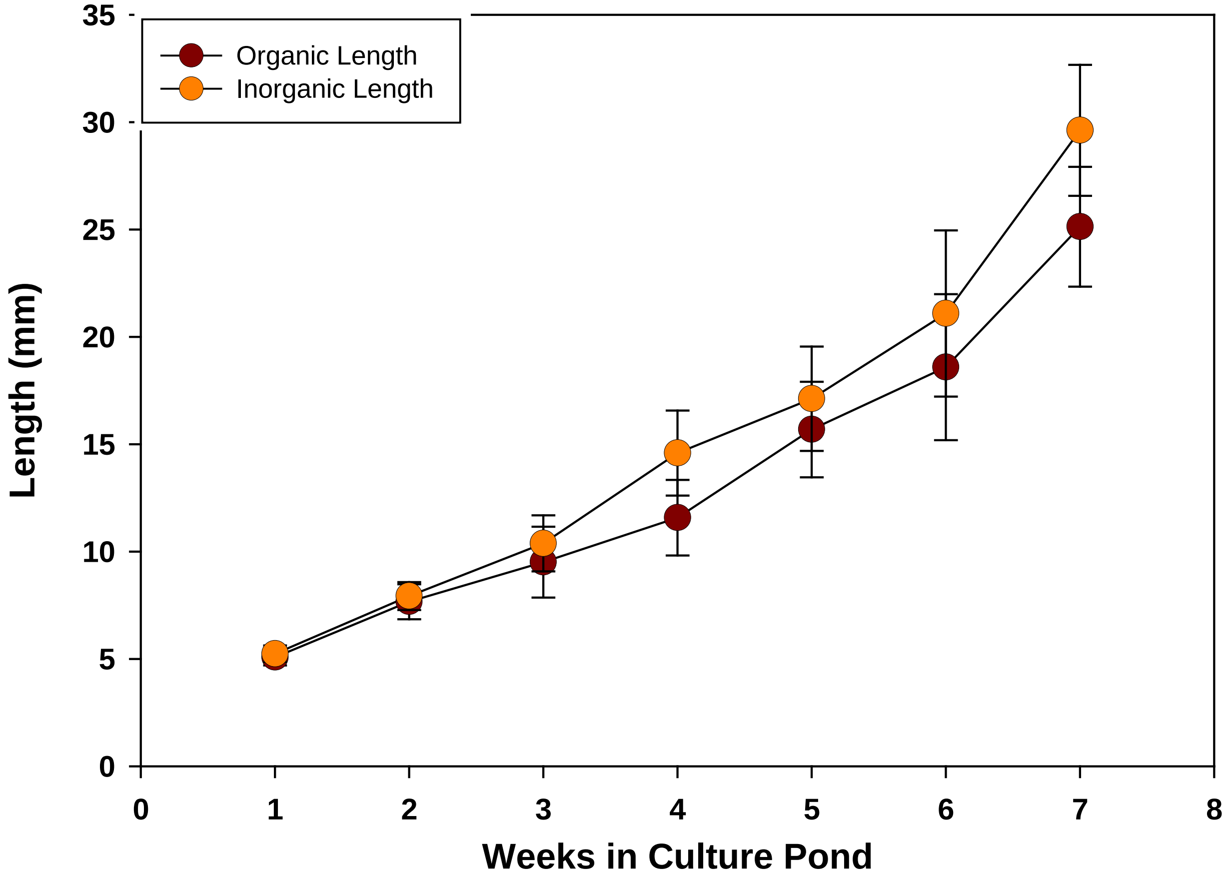
Water Chemistry and Visibility

- pH 8.46±0.26
- Alkalinity 156.5±13.2 ppm
- Hardness 248.2±26.7 ppm





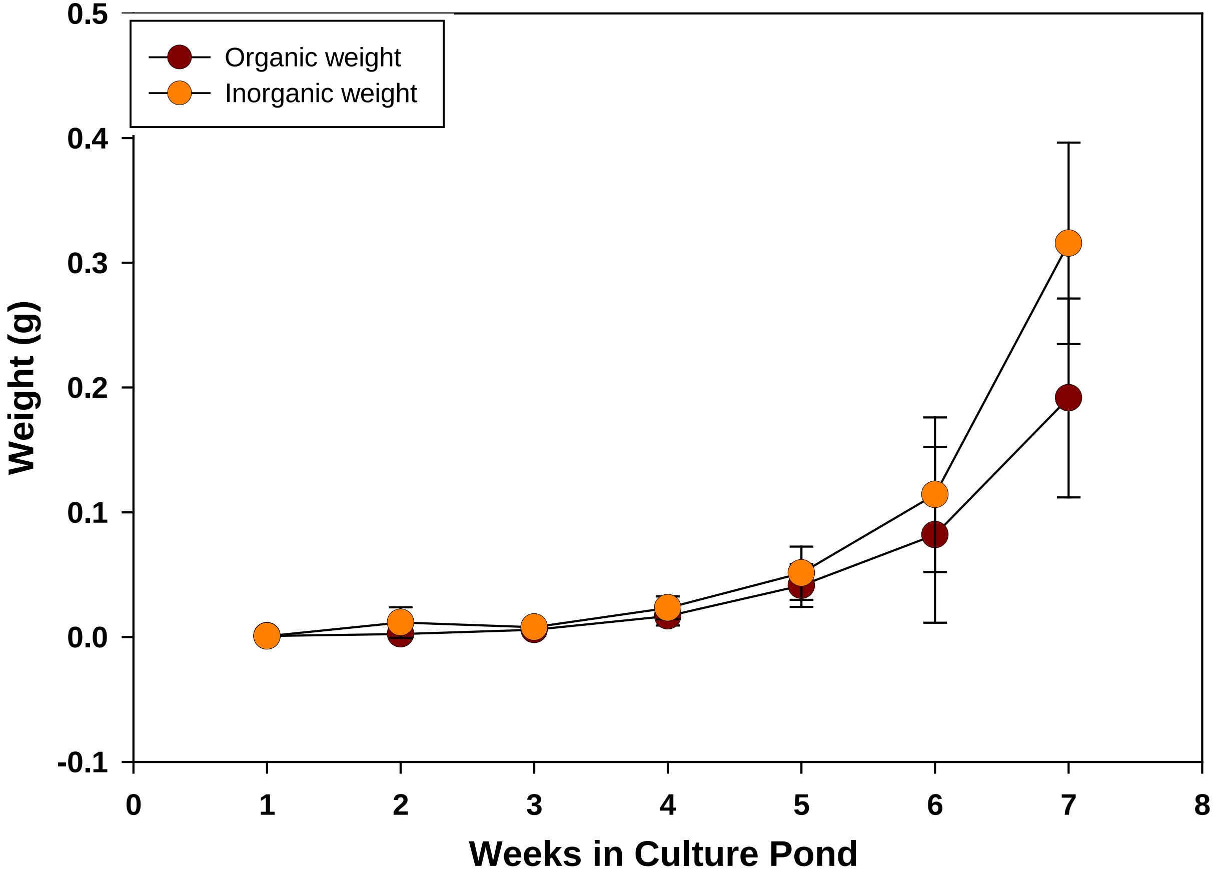
Growth



Mean Length week 7

- Inorganic: 29.62 mm ± 3.05
- Organic: 25.13 mm ± 2.79
- T-test: $p < 0.001$

Growth

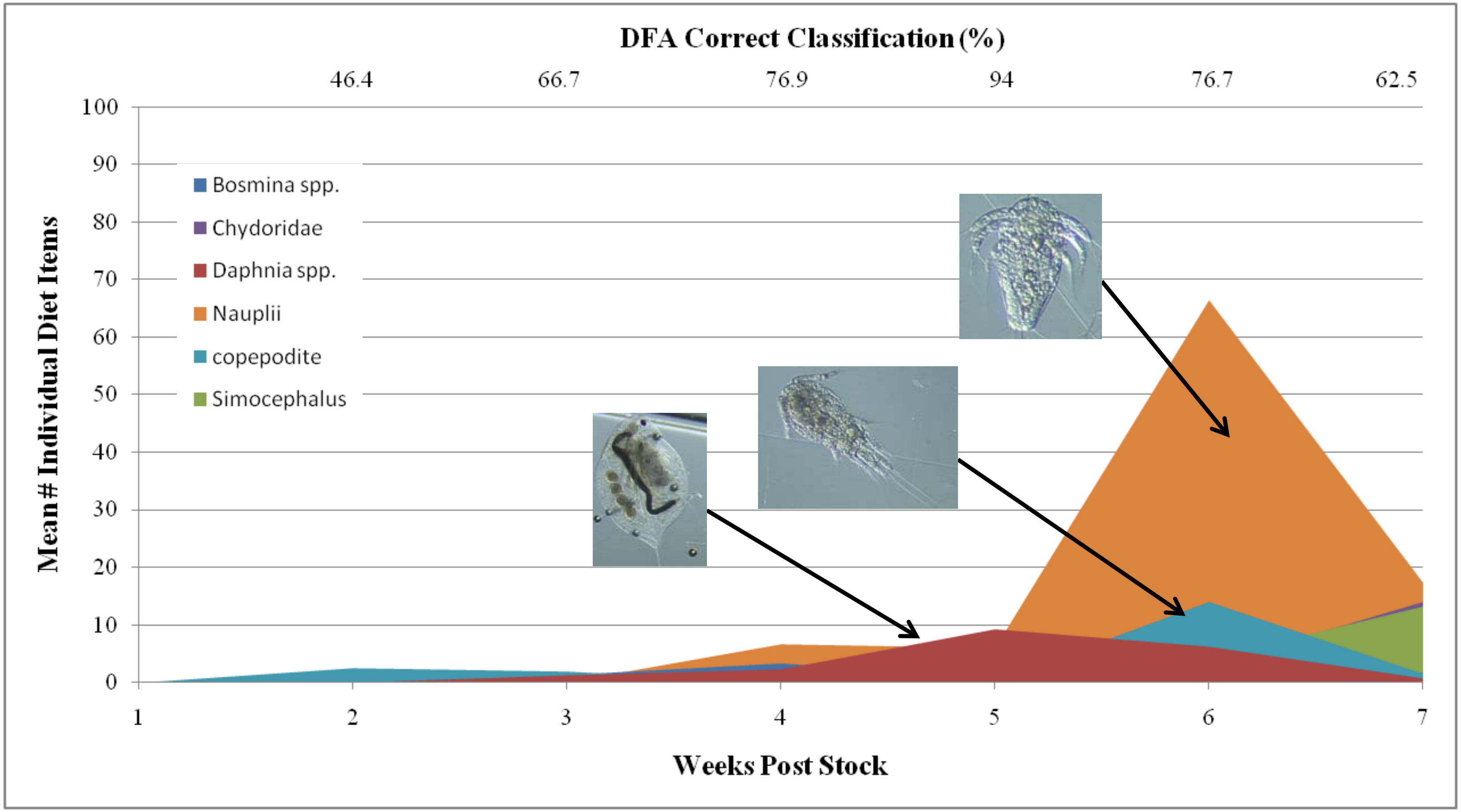


Mean Weight week 7

- Inorganic: 0.316 g ± 0.08
- Organic: 0.192 g ± 0.08
- T-test: $p < 0.001$

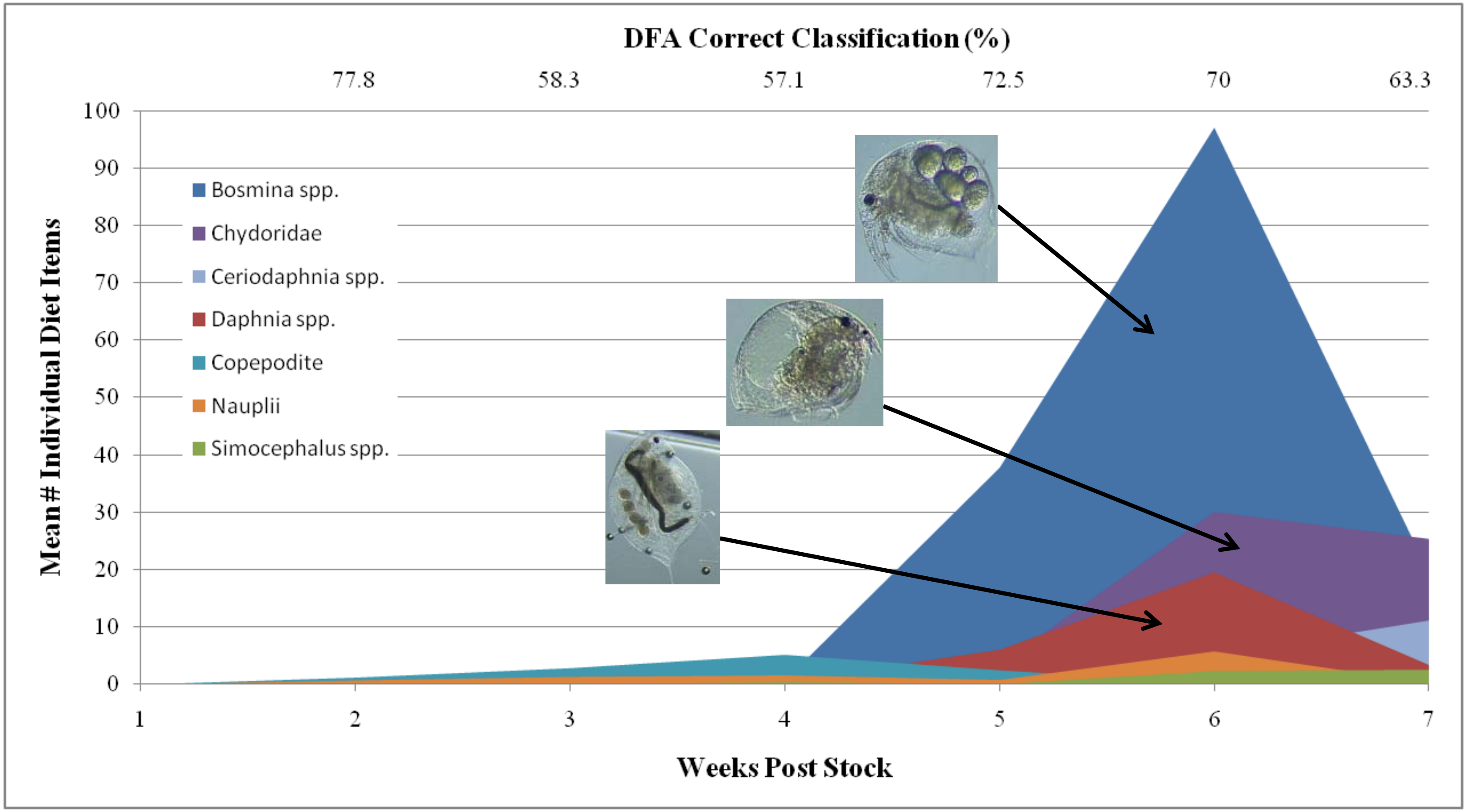
Results: Diet

Diet of yellow perch fry in the organic fertilized ponds



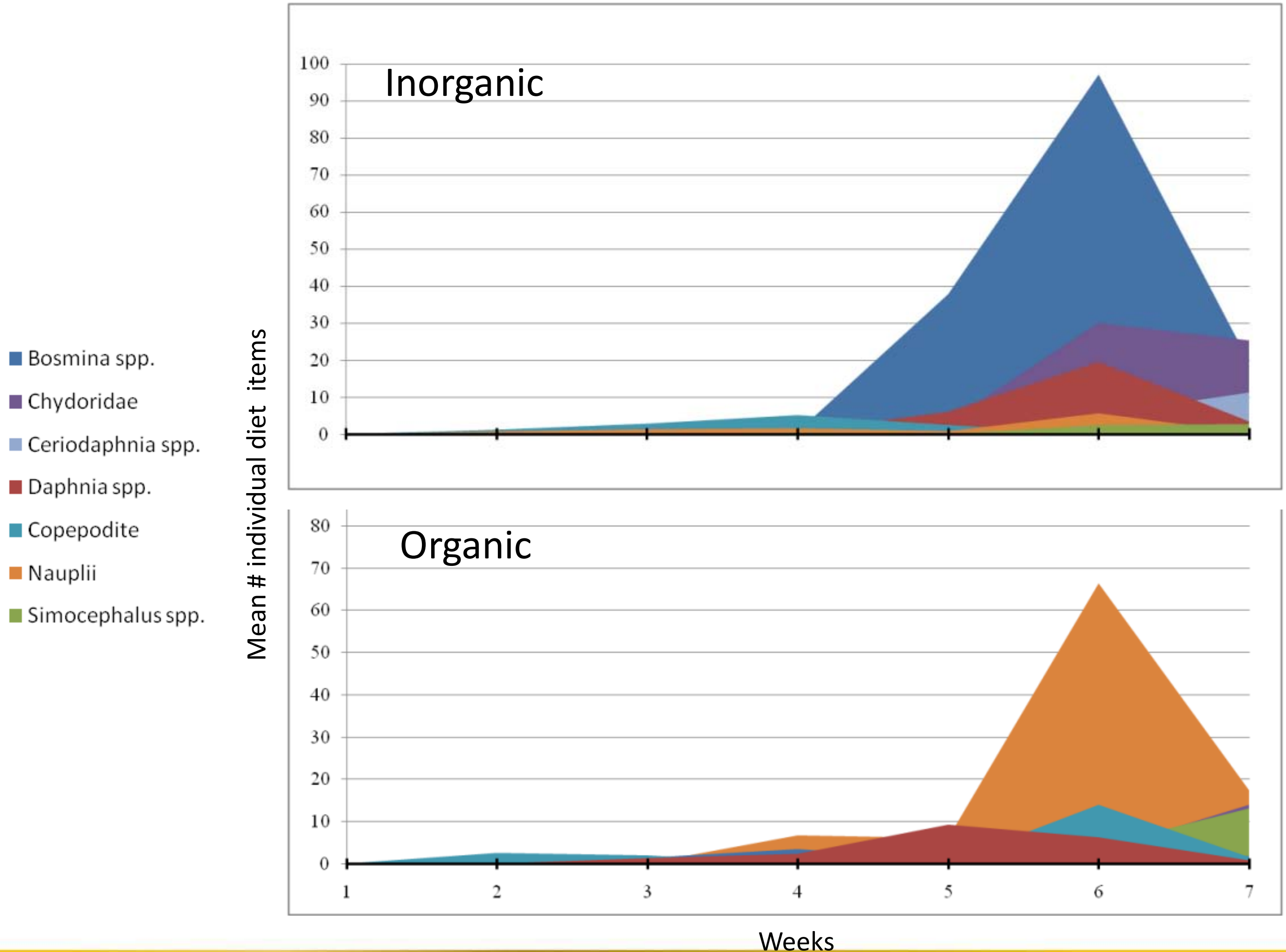
Results: Diet

Diet of yellow perch fry in the inorganic fertilized ponds



Results: Diet

Comparison of diets in inorganic and organic treatments



More food types in inorganic

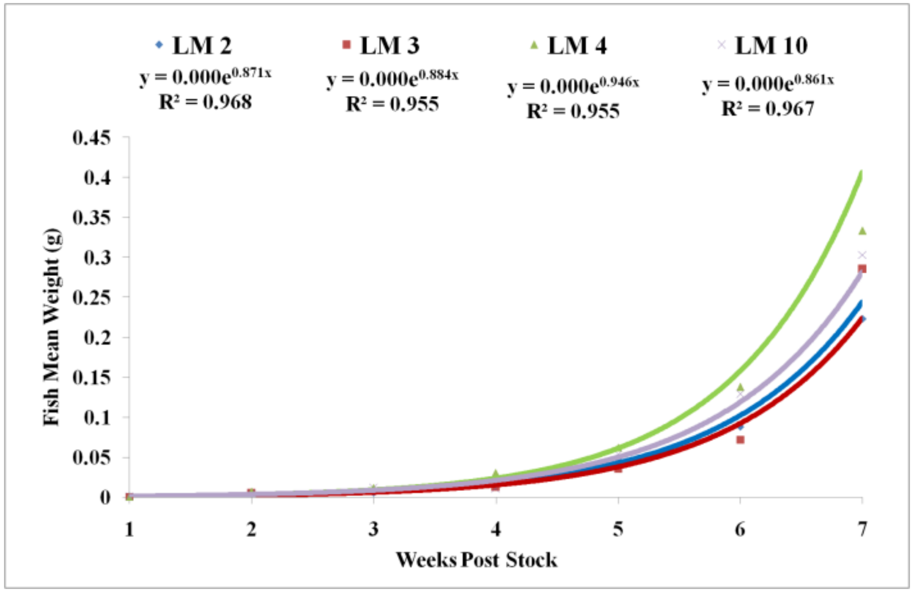
Bosmina spp. vs. nauplii

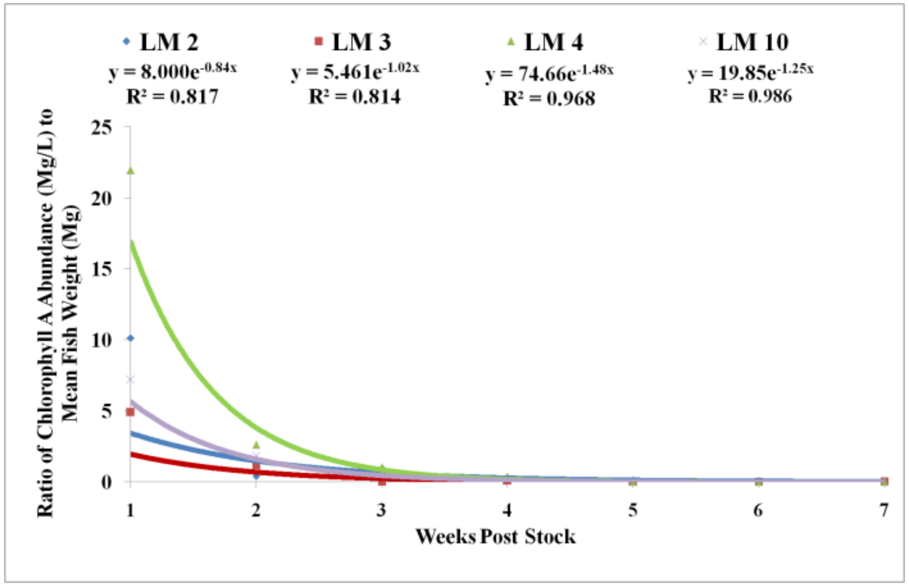
Inorganic treated ponds, fish eat more

Year 2: Four Fertilizer Treatments

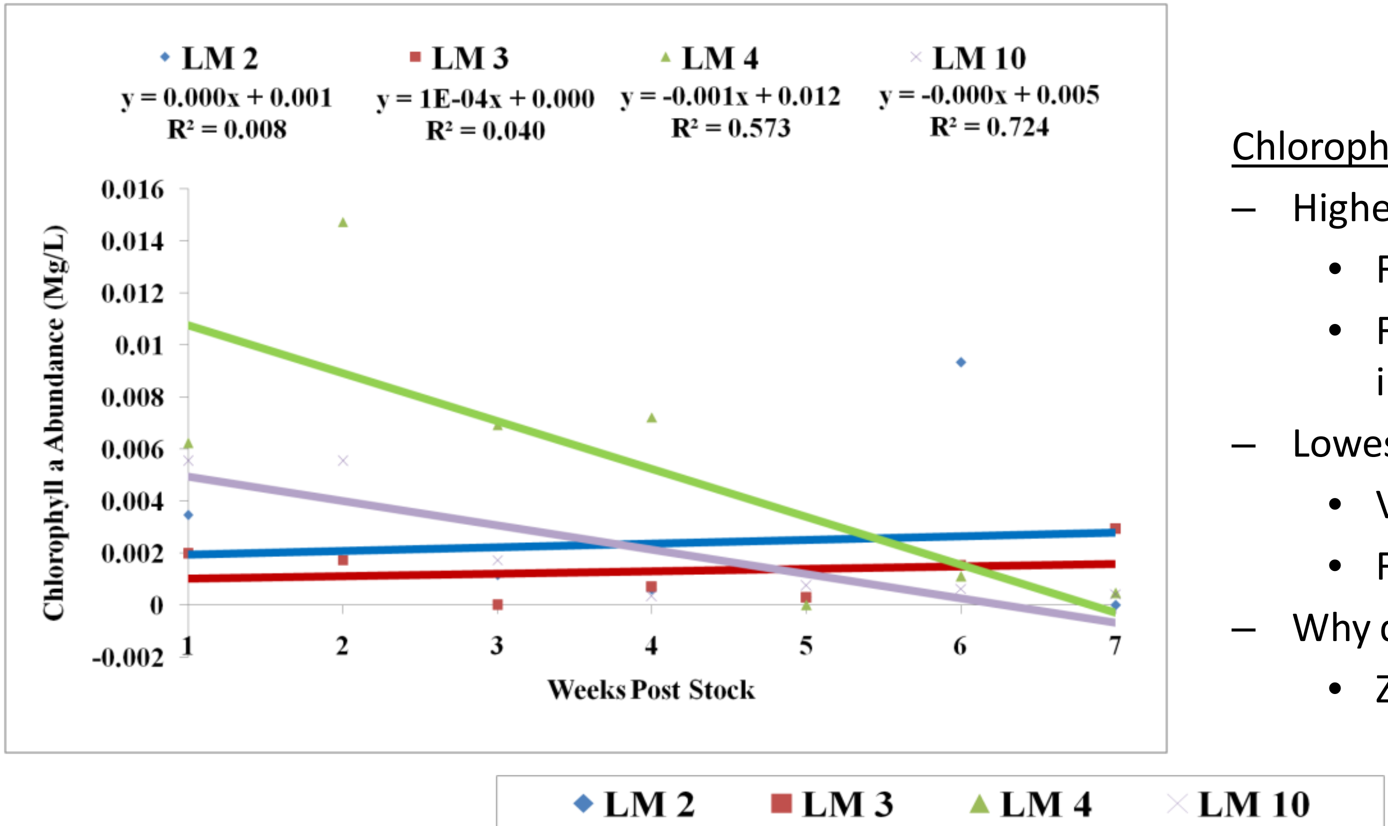
◆ LM 2 ■ LM 3 ▲ LM 4 × LM 10

LM 2: Lake Mills Pond 2 received fixed-input organic fertilizer
LM 3: Lake Mills Pond 3 received variable inorganic fertilizer
LM 4: Lake Mills Pond 4 received fixed-input inorganic fertilizer
LM 10: Lake Mills Pond 10 received fixed-input organic plus variable inorganic fertilizer





Zooplankton Attack

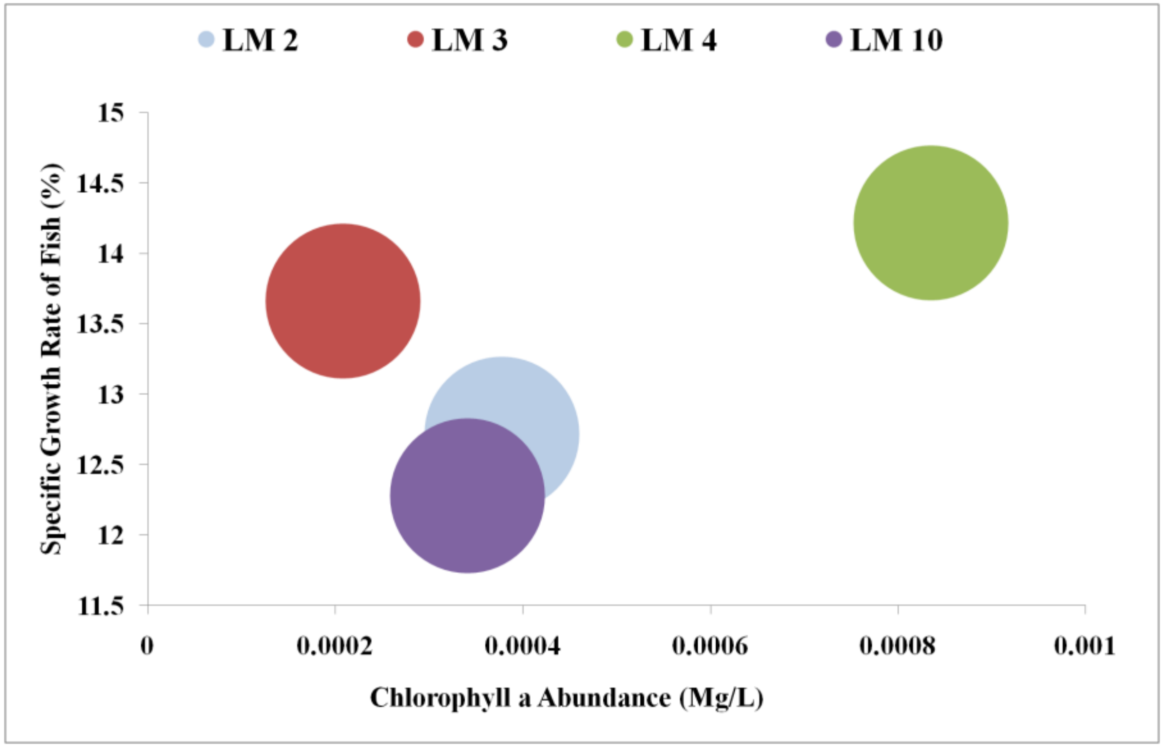


<u>Chlorophyll concentration</u>

- Highest but declines
  - Fixed input inorganic
  - Fixed input organic + variable inorganic
- Lowest but steady
  - Variable inorganic
  - Fixed input organic
- Why decline?
  - Zooplankton predation

LM 2: Lake Mills Pond 2 received fixed-input organic fertilizer
LM 3: Lake Mills Pond 3 received variable inorganic fertilizer
LM 4: Lake Mills Pond 4 received fixed-input inorganic fertilizer
LM 10: Lake Mills Pond 10 received fixed-input organic plus variable inorganic fertilizer

Temperature Effect



- Both inorganic fertilizer treated ponds showed highest yellow perch specific growth rate
- Both organic fertilized ponds showed lowest yellow perch specific growth rate

◆ LM 2 ■ LM 3 ▲ LM 4 × LM 10

LM 2: Lake Mills Pond 2 received fixed-input organic fertilizer
LM 3: Lake Mills Pond 3 received variable inorganic fertilizer
LM 4: Lake Mills Pond 4 received fixed-input inorganic fertilizer
LM 10: Lake Mills Pond 10 received fixed-input organic plus variable inorganic fertilizer

Conclusions

- Application of fertilizer based on transparency to establish "green water" not a good indicator of pond fertilization or trophic cascade.
- Early fry growth was strongly temperature dependent as was fertilizer effectiveness.
- Implications of diet selection based on fertilization:
  - Growth: Larger fish produced by inorganic treatment
  - Larger amount of prey and more varied diet
  - Bosmina spike in 5th and 6th weeks helpful for growth?
    - Zooplankton bloom effect
  - Possibility of gape limitation relaxation
- Poor survival related to low density of preferred prey.