Nutrition of Hybrid Striped Bass
Importance of nutrition

• Maximize growth
• Maintain health & avoid deficiency diseases
• Minimize lipid deposition in product
• Minimize “off-flavor”
• Reduce cost of production
General comments on proximate composition and energy

• Live-weight composition of fish
  - Water (60-80%), protein (15-30%), lipid (2-12%) on a wet matter basis
  - Carbohydrates minimal, ~1%
  - Composition varies within and between
    • species, size, sex, genetics, reproductive stage, temperature, diet composition, activity regime, etc...
### Proximate composition and energy cont.

<table>
<thead>
<tr>
<th></th>
<th>Water (%)</th>
<th>C. lip. (%)</th>
<th>C. prot. (%)</th>
<th>CHO (%)</th>
<th>Ash (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet (%)</td>
<td>68</td>
<td>10.2</td>
<td>17.3</td>
<td>0.3</td>
<td>4.2</td>
</tr>
<tr>
<td>Dry (%)</td>
<td>--</td>
<td>32</td>
<td>54</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Kcal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12</td>
</tr>
</tbody>
</table>
Partitioning of dietary energy

- energy ingested must convert one form or another
- Basic energy budget is:

\[ I = M + G + E \] where

\( M \) includes standard, active, and feeding metabolism
\( G \) includes somatic and gonadal growth
\( E \) includes losses of urea, ammonia, feces, mucus, sloughed skin cells, etc.
Schematic of the “fate of dietary energy”

Intake energy (IE)

Excretory loss

Heat loss

Feces excretions (FE)

Digestable energy (ADC*)

Gill excretions

Metabolizable energy (ME)

Urine excretions

Basal Met., Activity, Heat increment

Net energy (NE)

Recovered energy (RE)

Maintenance

(growth, reserves, reproduction)
Development of fish feeds

- major fish culture advancement
- Started feeding natural foods, slowly progressed to prepared diets
  - Natural aquatic foods still important - e.g., plankton for juveniles and filter feeders
Early diets nutritionally deficient

- a lot of waste byproducts used
- used to supplement natural foods
- knew little about balanced diets for fish
- nutrition now most rapidly advancing specialty
Nutrient Groups

• Protein
  - Protein:energy ratio
  - Amino acids
• Lipids
• Carbohydrates
• Vitamins
• Minerals
Protein requirement

- Dietary protein that most closely approximates the amino acid requirements of the fish has the highest physiological protein “value”
- In general, animal better than plant
- Synthetic (crystalline) amino acids can be added
  - Question usability
  - Synthetics not absorbed from gut at same rate
  - Must be incorporated in diets at lower levels
- Fish meal usually needed to provide optimal diet
Protein

- Essential levels required to ensure:
  - Amino acid requirement
  - Growth and metabolic processes
- Energy:protein ratio important for protein synthesis (growth)
- Very costly part of feed, esp. fish meal

- HSB requirement
  - 40-41% of diet dwb
  - 8-9 kcal/g protein
Essential amino acids

Fish cannot produce 11 of necessary 23 amino acids
Ten are essential

Arginine (4.3%)      Phenylalanine
Histidine          Threonine (2.8%)
Isoleucine      Tryptophan
Leucine            Lysine (4%)
Methionine (2.9%)  Valine

Total sulfur amino acids (2-2.9%)

(% of protein, dwb)

Amino acid premixes used to supplement protein
Lipids & EFA

- Needed for energy, growth and assist in absorption of fat-soluble vitamins

- HSB requirements
  - Readily utilize dietary lipid
  - 5-17% (7-10% appears optimal) menhaden oil
  - E/P must be correct
  - 1% HUFA of n-3 series essential (20% of dietary lipid)
  - Lecithin - not required
  - Cholesterol - not required
Carbohydrates
\((C, H, O)\)

- Used for energy in mammals, but fish do not have a specific requirement
- Carnivorous fishes have more limited ability to use, but HSB have a simpler GI tract
- Energy mostly from proteins or lipids, but CHO can be used for protein sparing to some extent
- Some omnivores have intestinal microflora that allow them to use cellulose (e.g., chan. cat up to 40%)
- HSB appear similar to CC, utilizing up to 25% dextrin (as lipid replacement) in diets
Vitamins

- 15 considered essential
- 11 water soluble:
  - ascorbic acid (C), biotin, choline, folic acid, inositol, niacin, pantothenic acid, pyridoxine, riboflavin, thiamin, and B₁₂
- 4 fat soluble:
  - Retinol (A), cholecalciferol (D), tocopherol (E), and K
- Vitamins C, E and choline quantified
- Supplementation* based on several spp.
<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Amount/kg</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>4,400 IU</td>
</tr>
<tr>
<td>D</td>
<td>2,200 IU</td>
</tr>
<tr>
<td>E</td>
<td>55 mg</td>
</tr>
<tr>
<td>K</td>
<td>11 mg</td>
</tr>
<tr>
<td>C</td>
<td>376 mg</td>
</tr>
<tr>
<td>Choline chloride (70%)</td>
<td>550 mg</td>
</tr>
<tr>
<td>B(^{12})</td>
<td>0.09 mg</td>
</tr>
<tr>
<td>Folic acid</td>
<td>2.2 mg</td>
</tr>
<tr>
<td>Niacin</td>
<td>88 mg</td>
</tr>
<tr>
<td>Pantothenic acid</td>
<td>36 mg</td>
</tr>
<tr>
<td>Pyridoxine</td>
<td>11 mg</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>13 mg</td>
</tr>
<tr>
<td>Thiamin</td>
<td>11 mg</td>
</tr>
</tbody>
</table>
Minerals

• Up to 22 may be required for tissue formation, metabolic functions...
• Dissolved minerals and basic feedstuffs may contribute considerably, thus supplementation* may be minimal
• Macro
  - Calcium, chloride, magnesium, phosphorus, potassium, sodium, and sulfur (same as terrestrialis)
  - Phosphorus typically limiting in water
    • HSB reqt is about 0.43% of dry diet
Minerals

• Micro
  - Aluminum, chromium, cobalt, copper, fluorine, iodine, iron, manganese, molybdenum, nickel, selenium, tin, vanadium, and zinc
  - Selenium and zinc important for other fishes
  - Typically add trace mineral premix* to ensure adequacy
Mineral levels suggested for diets based on estimated or established requirements

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available phosphorus</td>
<td>0.5%</td>
</tr>
<tr>
<td>Copper</td>
<td>5 mg/kg</td>
</tr>
<tr>
<td>Iodine</td>
<td>2 mg/kg</td>
</tr>
<tr>
<td>Iron</td>
<td>30 mg/kg</td>
</tr>
<tr>
<td>Manganese</td>
<td>25 mg/kg</td>
</tr>
<tr>
<td>Selenium</td>
<td>0.1 mg/kg</td>
</tr>
<tr>
<td>Zinc</td>
<td>200 mg/kg</td>
</tr>
<tr>
<td>Protein</td>
<td>40-41%</td>
</tr>
<tr>
<td>----------------</td>
<td>--------</td>
</tr>
<tr>
<td>- Amino acids</td>
<td></td>
</tr>
<tr>
<td>T. sulfur aa</td>
<td>2-2.9% of prot</td>
</tr>
<tr>
<td>Lysine</td>
<td>4.0% “</td>
</tr>
<tr>
<td>Threonine</td>
<td>2.8% “</td>
</tr>
<tr>
<td>Arginine</td>
<td>4.3% “</td>
</tr>
<tr>
<td>Energy:protein</td>
<td>8-9 kcal/g prot.</td>
</tr>
<tr>
<td>Lipids</td>
<td></td>
</tr>
<tr>
<td>EFA</td>
<td>1% hufa n-3</td>
</tr>
<tr>
<td>Lecithin</td>
<td>NR</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>NR</td>
</tr>
<tr>
<td>Vitamins</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>26 mg/kg</td>
</tr>
<tr>
<td>E</td>
<td>28 mg/kg</td>
</tr>
<tr>
<td>Choline</td>
<td>300 mg/kg</td>
</tr>
<tr>
<td>Minerals</td>
<td></td>
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<tr>
<td>Avail. Phos.</td>
<td>0.43%</td>
</tr>
</tbody>
</table>
Summary

• Nutrient values obtained for chemically defined diets for small fish (20-150 g) under controlled conditions

• Current model diet formulations suffice for PI & PII*

• Specific nutrient requirements & additives for larval and broodstock diets are lacking
Feed manufacturers & distribution equipment

- www.aquafeed.com