Proper Fish Feeding

- Doug Sweet
- Superintendent
- London State Fish Hatchery
- Ohio Division of Wildlife, ODNR
Fish are what they eat

- What is in their food is what is incorporated into their bodies.
- Many fish are carnivores/piscivores and eat other fish.
- Most fish feeds incorporate fish meal as their base ingredient.
Why do we feed our captive fish “fish food”?

- Convenient
- Reasonably cheap
- Easily stored
Shouldn’t we feed our fish exactly what they eat in the wild?

- Cannot do
- Too diverse
- Too expensive
- Too time consuming
- Inconvenient
- Difficult to store
- IMPOSSIBLE
Food habits of twelve inshore species of fish inhabiting the St. Mary’s River, Sault Saint Marie, Michigan, 1982

Focus on just lake whitefish fingerlings
Variety can be incredible in Natural Habitat!

- Lake whitefish fingerlings in the St. Mary’s River, on the morning of July 6, 1982 were feeding on the following:
- 14 different genera or families of zooplankton and insects including:
  - Six different daphnia (Cladocerans) – Ceriodaphnia, Bosmina, Eurycercus, Alona, Daphnia and one unidentified
  - Seven Insect Families or Orders – Chironomids (midges), Trichoptera (caddisflies), Corixids (water boatmen), Aphids (semi-aquatic aphids), Callibaetis (one genus of mayfly), Hymenoptera (a parasitic wasp), and Diptera (aquatic flies)
- One copepod – Eucyclops

CONCLUSION – Forage is immensely more variable in the natural habitat than it can ever be in captivity.
Fish Feeds – Natural habitat vs. captivity
Another consideration

- Freedom and Choice – fish can choose what to eat, when to eat it, and perhaps what is needed, in the wild. They can choose other factors governing nutrition like the optimal temperature to digest their food. In captivity this is not possible, nor is it practical but its implications are strong.
What do we know?
Early years of fish culture was a lot of trial and **error**

- Come a long way since feeding ground horse meat to trout
Scientists have developed complete and successful diets for various aqua-cultured species (through trial and error and many years of research)

- Trout
- Salmon
- Channel catfish
- Tilapia
- Carp, goldfish, koi
  - Mahi mahi
  - Mediterranean sea bass
  - Yellowtail
  - Barramundi
  - Etc.
Where do we want to go?
- Culture more species intensively!
Crash course in fish nutrition:

- Fish need same nutrients as any vertebrate animal including humans!
  - Protein
  - Fats and Oils (Lipids)
  - Carbohydrates
  - Fiber
  - Vitamins
  - Minerals
Classes of Nutrients needed by fish:
First Class - Protein

Protein – composed of amino acids and makes the structure of the body and enzymes. Also an energy source. Fish need more protein and better quality than humans (30% to 60% of diet).

Fish utilize animal protein better than plant proteins.
Second class of nutrients needed by fish: Fats and Oils

- Lipids (Fats and Oils) – extremely important for cell membranes, immune function, hormone production, nervous system development
- Very important energy source and for energy storage
- Omega -3 essential fatty acid source needed by most fish, especially marine species (source is fish oil or algae).
- Omega – 6 essential fatty acid also important (sources include vegetable oil, seeds, algae, terrestrial plants)
- Lipids should compose 5-10% of diet
- Fish do not utilize “hard fats” like tallow very well. Oils are preferred lipid source in fish feed.
Lipids (Fats and Oils) – special considerations

- Feeding too much fat, or the wrong kind, or too much feed in general, can result in fatty liver disease. Very common in captive fish. A leading cause of mortality either directly or indirectly.

- Fats (especially oil) turn rancid very easily. Important to store feed correctly, use anti-oxidants and/or preservatives in feed (Vitamin E, BHT, BHA, or ethoxyquin)
Importance of the right oil in the diet – Mediterranean sea bass cultured on normal aquaculture feeds grow and behave normally. This is on feed manufactured using cold-water capelin or herring oil.

- However, these same fish are sterile or have very low fertility when they are bred.
- Experiments substituting different exotic oils (especially tuna orbit oil) returns these fish to normal fertility levels.
- Further experiments found they are deficient in DHA (decosahexanoic) and AA (arachidonic) acids. Two essential fatty acids (one an omega-3 the other an omega-6)
- Diets using warm water marine fish oil (porgie) returns fertility too.
Third Class of Nutrients needed by fish: Carbohydrates

- Includes sugars, starches, dextrin, etc.
- Not as important for fish as it is for humans
- Fish do not utilize carbohydrates as well as land animals.
- Normally fish diets contain minimal amounts
- Sparing effects (some carbohydrate will spare protein usage for growth rather than energy.)
- Fish diets 5-30%
Fourth Class of Nutrient - Fiber

- Not defined as necessary for fish
- Omnivorous or herbivorous fish may benefit to keep bulk in long intestinal tract.
- Fiber is usually found in plant components of a feed.
- Sometimes used as a water stabilizer or binding agent to hold feed pellets or flake together and make it water stable.
- Example: carboxymethyl cellulose, locust bean gum, etc.
- Very small component of diet usually a couple percent
Fifth Class of Nutrient – Vitamins

- Essential molecules needed in enzyme reactions and in very small quantities.
- Spark plug analogy
- Fish need same as humans
- Fat soluble vitamins (A,D,E,&K)
- Water soluble (B’s, C, etc.)
- Easily destroyed in diet by heat, long term storage, oxidation, or processing and handling.
- Very common problems with fish feed – vitamin C (ascorbic acid), E (tocopheryl acetate), thiamine, folic acid.
- Supplement in diet with vitamin mix.
Vitamin C Deficiency in fishes: Common in feed allowed to go stale with long term storage and exposure to air. Causes broken back syndrome. Spinal degeneration from cartilage break down - scurvy
Vitamin C deficiencies can be avoided by: incorporation of vitamin C, or stabilized vitamin C (L-ascorbyl-2-polyphosphate) into diet and correct storage of feed.
Sixth Class of Nutrient: Minerals

- Examples include Calcium, Magnesium, Manganese, Iron, Phosphorus, etc.
- Builds bones and needed in many enzymes/co-enzyme functions.
- Not critical in fish diets, compared to terrestrial animals, because fish can extract many of their needs directly from the water.
- Still beneficial to have supplements in the food in case your water supply is deficient in certain minerals or trace minerals.
How do you optimize your fish feeding practices?

• Proper quantity and “size”
  • (for salmon and trout –size is 1/40 length)
• Selection of quality prepared or designed feed for the appropriate species
• Proper feed storage and handling
• Knowledge that there is always room for improvement.
• If it “Isn’t broke, don’t fix it.”
How much do you feed?

- Validity of the five minute rule. Feed only as much food as fish will clean up in five minutes vs. to “satiation”
- Is this enough?
Fish Nutrition and Feeding Tips:

• Fish eat to meet their energy needs! Daaah? This means that they will eat, if palatable and acceptable, whatever you put in front of them whether or not it is nutritionally complete and balanced.

• Quantities to Feed?
  • Rule of thumb, most fish can eat up to 4% of their body weight per day in DRY feed (that are 95% dry matter or more).
  
  - 1% to 2% or less for slowly growing or mature fish may be adequate

  - Equates to expanding the five minute rule to twenty minutes or slightly more as long as water quality allows.
Quantities to feed on a commercial basis:

- Know the number of fish you are feeding
- Know their weight
- Calculate out daily ration by the 1% to 4% (10% for very small fry) dry feed/day
- Sample fish periodically to get change in weight to adjust feed rate
- Use published feed tables, cross reference temperature, feed rate, to size of fish
- Use Haskell’s formula (for trout), or adopt a similar one for other species, to predict feeding rates for a specific time period with an expected increase in size.
### Comparative Recommended Feeding Levels for Rainbow Trout from Various Sources

(Some Interpolation Was Necessary)

<table>
<thead>
<tr>
<th>Fish size</th>
<th>Amount to Feed at 15°C (% of BW/Day)</th>
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* From Hilton and Slinger, in NRC-NAS (1981b).
‡ From Rangen, Inc., feeding chart, Buhl, Idaho.
* From G. W. Klontz, in Silver Cup Suggested Feeding Levels, Murray Elevators, Salt Lake City, Utah.
* From Buterbaugh and Willoughby (1967).
‡ Calculated according to formula p. 26.
‡ Expected specific growth rate in percent per day.
# Freshwater Feeding Guide for Salmonids

Figures give the feeding rate in percent of body weight per day.

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<tr>
<th>Feed Pellet size</th>
<th>0.5 gr</th>
<th>0.7 gr</th>
<th>1.0 gr</th>
<th>1.0 mm</th>
<th>1.5 mm</th>
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**NOTE:** This chart is meant as a guide only. Actual feeding percentages may vary with specific site conditions.
Haskell’s formula
(assumes trout increase in size at constant rate, constant temperature, with the same food and conversion factor)

- % body weight to feed daily = \frac{Conversion \times 3 \times \Delta L \times 100}{L}

  - \Delta L (delta L) = daily increase in length in inches
  - L = Length in inches at the present time
  - Conversion = number of pounds feed to gain number of pounds of fish
  - (for example, could be 1.2 lbs. fed to 1.0 lb. gained)
  - The numerator in the above equation becomes the Hatchery Constant
  - HC = Conversion \times 3 \times \Delta L \times 100L

- Limitations of Haskell’s is the amount to feed is based on the expected conversion ratio BUT the conversion ratio is dependent on the feeding rate. Therefore, the estimate is based on a variable which is dependent on the estimate.
Nutrition Tips Continued:

- Shopping for quality fish feeds -
  - Adequate protein levels – 30% - 60%
  - Animal source proteins used preferentially to plant based proteins (like soy)
  - Oil as lipid source (fish oil, or fish oil combined with a plant oil like soy bean oil is O.K.) If all animal fat, probably not good
  - Minimal Carbohydrate – main ingredients should not be high carbohydrate plant sources like corn, wheat, potatoes, other grains, etc.
  - Fiber – minimal
  - Vitamins – vitamin mix or pack should be added (especially vitamin E and C, thiamine and folic acid, etc.)
  - Feed attractants – can be added to increase acceptability – fish oil, anise oil, beet extract, wheat gluten, algae, etc.
  - Color enhancers – astaxanthin, canthaxanthin, zeaxanthin, roxanthin red, lutein, carotene, guanine, algae (chlorella or spirulina)
  - Want preservatives like ethoxyquin, BHT (Butylated hydroxy toluene), BHA (Butylated hydroxy anisole) etc. to prevent rancidity.
Use well known brands – reputable sources
Nutrition Tips Continued: Proper feed storage

- Dry food must be kept dry, cool, out of sunlight.
- Dry food can be frozen for longer term storage (some controversy) in sealed containers (bags with air removed).
- Buy modest quantities that you use up between one and three months.
- Dry feeds must be kept dry! If damp, and not frozen, mold grows causing aflatoxins to form.
- Be conscientious about where you buy feed, turnover rate, storage temperature, etc.
- Watch for spoilage: bad colors, bad odors, bad taste, odor of crayons or acetone (fingernail polish remover) are signs of rancidity.
Other new fish nutritional developments:

- Probiotic incorporation into feed
- Growing push to replace animal protein (i.e. fish meal) and fish oil with vegetable sources. This is O.K. for certain omnivorous species but is seriously pushing the envelope for carnivorous fish. (However many new developments are allowing this with great success.)
- Novel new manufacturing processes like cold extrusion, micro-extrusion marumerization (MEM) and particle assisted rotational agglomeration (PARA).
- More exotic fish oils for optimal fertility of brood-stock and larval survival like tuna orbit oil, krill oil, squid oil, etc.
It’s a fish eat fish world