Feed Strategies and Growth Performance of Florida Pompano Reared in Commercial-scale Inland Recirculation Systems

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United States Department of Agriculture
National Institute of Food and Agriculture

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Pompano Nutrition: Past to Present

- Goal of practical nutrition research is to provide information to support sustainable aquaculture production
  - Economic
    - Control feed cost with more ingredient choices
      - ⬇ Fish meal and fish oil
      - ⬆ Increase plant products
  - Environmental
    - Fisheries conservation, improved water quality in production environment, etc

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Pompano Nutrition: Past to Present

- Knowledge of nutritional needs of pompano can increase aquacultural success
  - Eliminate over-fortification of diets
    - Waste of resources, expensive
  - Improve nutrient balance
    - Better growth performance
  - Decrease use of products from reduction fisheries
    - Saves money, promotes eco-friendly image
  - Lower production cost
    - Maintain/improve profitability

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Pompano Nutrition: Past to Present

- 1970: Need for a species-specific pompano diet identified
  - Very little research followed
  - Pompano fed ground fish, commercial by-catch, any commercial diet available
  - Diets developed for other marine species also used for pompano
- Knowledge of pompano husbandry grew during next 25 years but knowledge of nutritional needs improved little

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Pompano Nutrition: Past to Present

- More detailed studies of pompano nutrition conducted in several laboratories from late-1990s to present
  - Alternative feedstuffs for low-fish meal diets
  - Some nutritional requirements
  - Availability of nutrients in common ingredients
- Focus in these areas of interest likely to continue in near term

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Background

- Natural diet is animal based
  - Pompano are selective grazers: opportunistic when small, more selective as they grow larger
    - Food habits vary with abundance of local prey
  - Young juveniles consume mostly planktonic organisms
    - Copepods, amphipods, polychaetes, gastropod larvae, insects , etc
  - Older juveniles and adults consume benthic organisms
    - Clams and crustaceans, primarily

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Background

- Feeding / Digestive anatomy
  - Rounded snout for digging in sandy substrate
  - Pharyngeal teeth for breaking hard material
    - Shells and exoskeletons of mollusks and crustaceans
  - Pyloric ceca (11) increase digestive/absorptive surface area
  - Short intestine (8/10 of body length)

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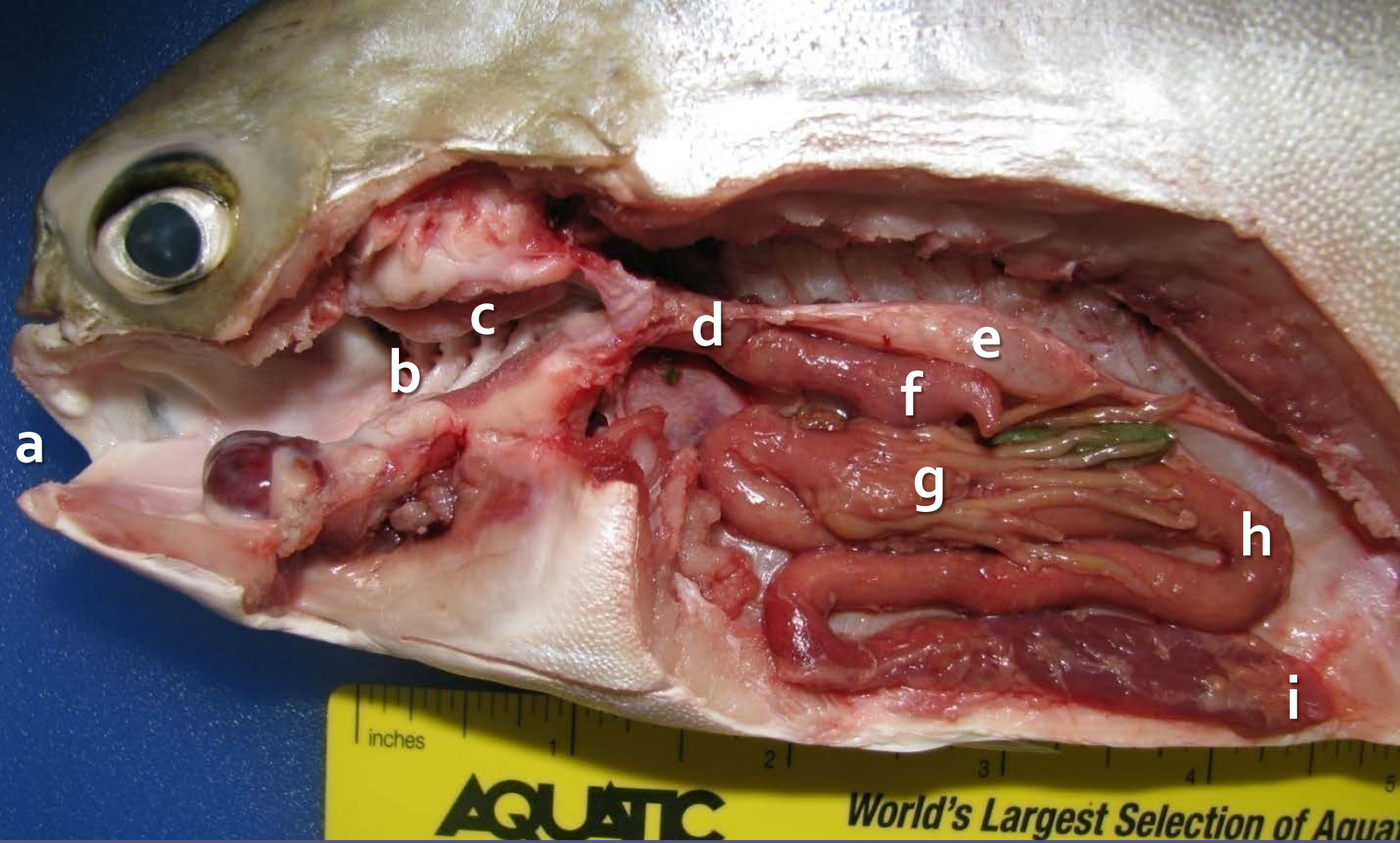
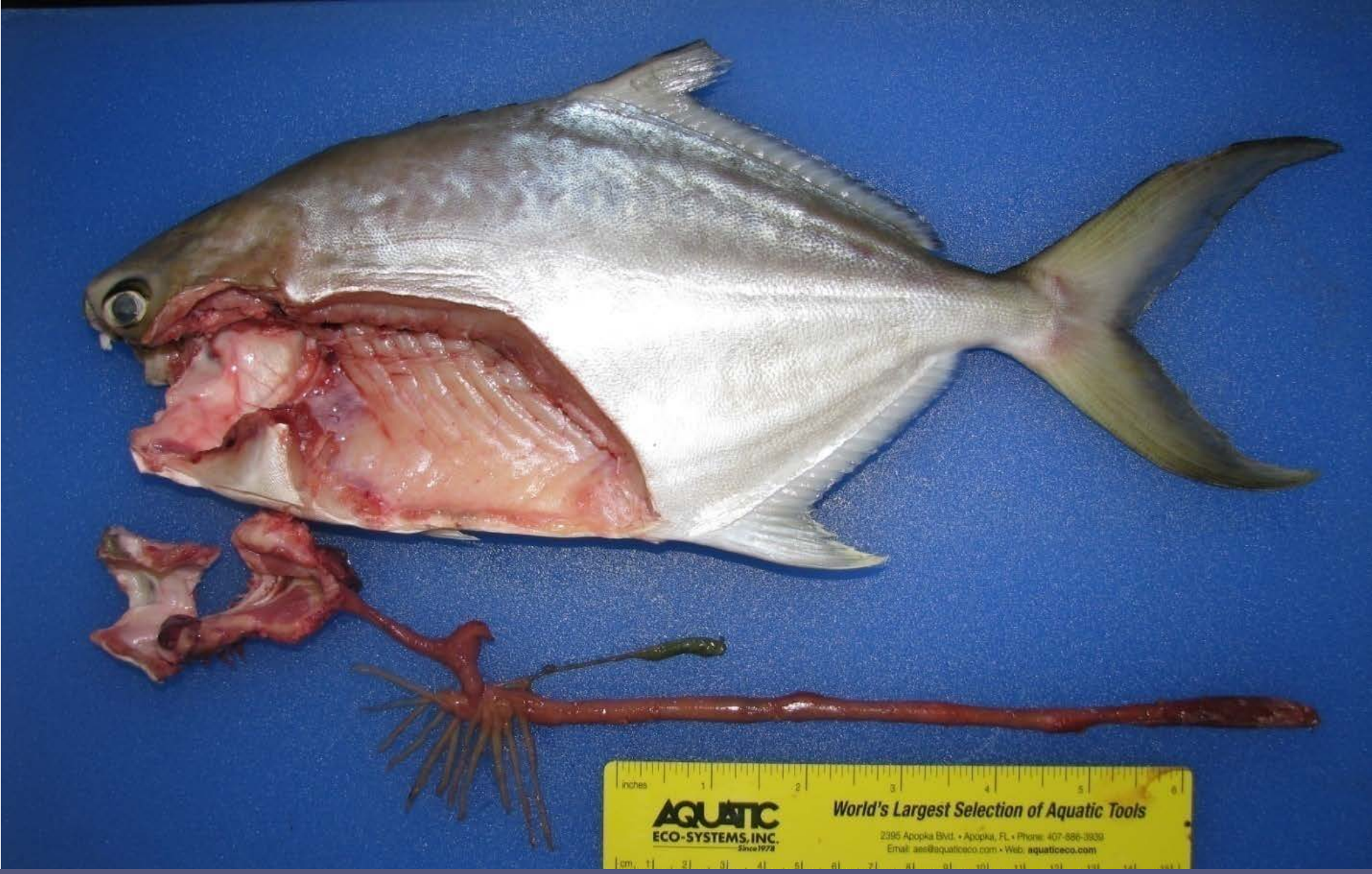
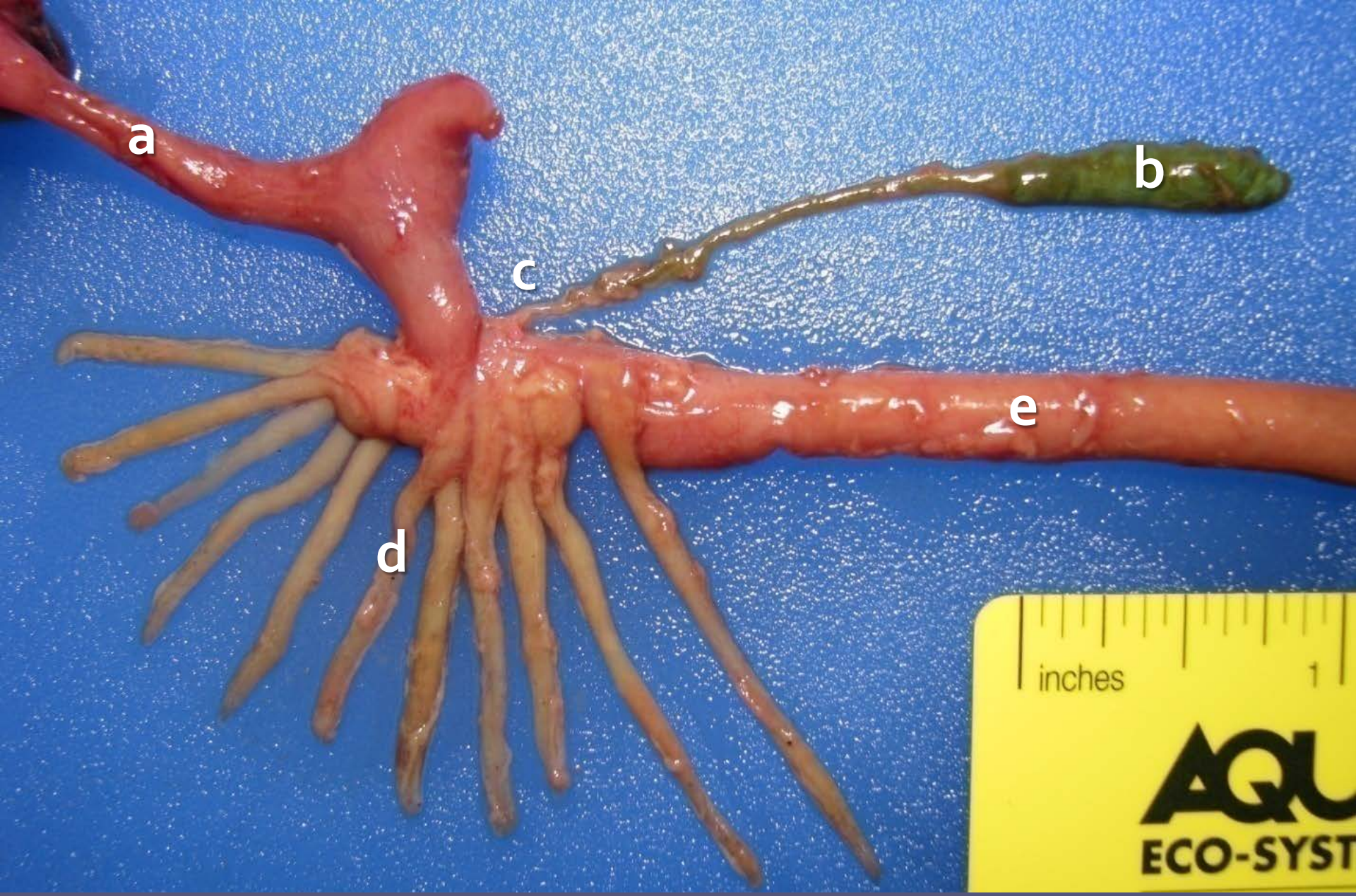


Dissected anterior portion of a sub-adult Florida pompano, with some organs removed, illustrating the general orientation of the GI tract inside the body cavity: (a) sub-terminal mouth, (b) gill arches, (c) pharyngeal teeth, (d) esophagus, (e) swim bladder, (f) stomach, (g) pyloric ceca, (h) intestine, and (i) anus. (Gothreaux, 2008)



GI tract of a sub-adult Florida pompano illustrating intestine length in relation to body length. Ratio of intestine length to body length is 0.80 ± 0.07 (n = 10) for fish ranging from 13.5 - 30 cm total length, a value typical of "carnivorous" fishes. (Gothreaux , 2008)



Close-up of GI tract from a Florida pompano: (a) esophagus, (b) gall bladder, (c) gall bladder insertion into intestine, (d) pyloric ceca, and (e) intestine. (Gothreaux, 2008)

Background

- Short GI tract produces short gut-retention time at optimal temperature (27-30 °C)
- Evacuation begins about 3 hours after feeding and proceeds quickly
  - Research with Plata pompano, *Trachinotus marginatus* (Cunha et al., 2009) — range: southern Brazil to northern Argentina
    - Fed 59% protein diet at 24°C and 33 ppt salinity
      - Oxygen consumption increased 34% within 30 min after feeding; returned to unfed rate in 2.5 hr suggesting digestion/assimilation completed in < 3 hr

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Background

- To maximize growth, a compounded diet should be easily digested (within 3 hours) and contain highly available nutrients
- We need digestibility information for a selection of feed ingredients to reliably predict nutrient availability in a diet formulation
- Digestibility typically determined with feeding trials
  - Digestible energy usually inversely related to fiber and carbohydrate content
    - Protein digestibility may or may not be affected

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Information Needed to Produce Good Diets

- 1) Nutritional requirements of pompano
  - Which amino acids, fatty acids, vitamins and minerals are needed and in what concentrations? Which ingredients can meet these requirements most cost effectively?
- 2) Availability of nutrients in a set of alternative ingredients
  - How much of the nutrient content of an ingredient is digested and absorbed by pompano? Which ingredients (or combinations of ingredients) offer good nutrition for a reasonable price?
  - Limited information is now available for some animal and plant products
    - Menhaden fish meal; meat and bone meal; canola; sorghum; assortment of corn, soybean and wheat products

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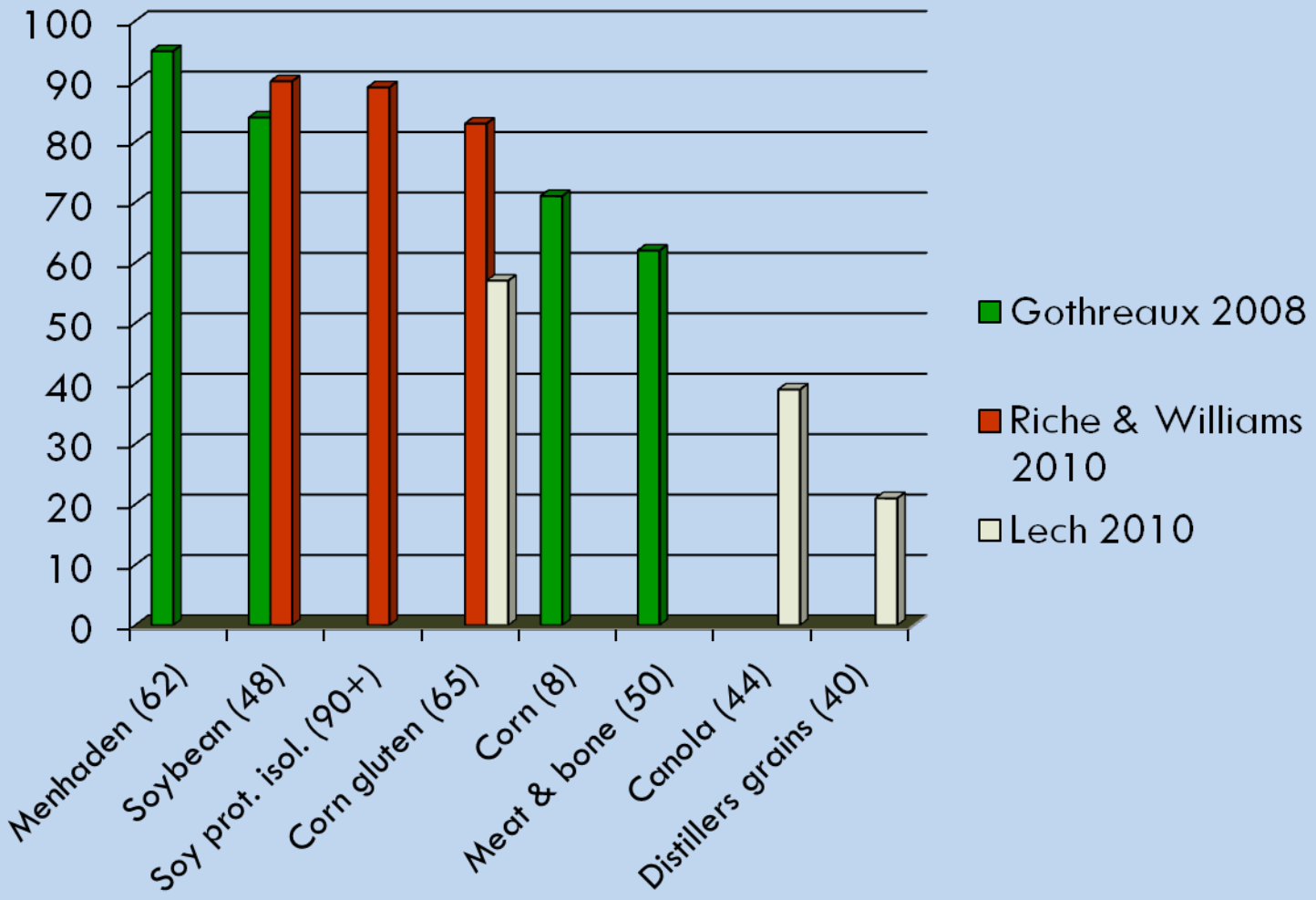
Apparent crude protein digestibility of ingredients used in Florida pompano feeding trials



Essential amino acid availability

(Gothreaux 2008; Gothreaux et al. 2010; Lech 2010; Patro and Reigh, unpublished data)

- Menhaden meal: 92-100%
- Soybean meal: 89-97%
- Meat and bone meal (porcine): 54-85%
- Corn, grain: 67-82%
- Corn gluten meal: 48-85%
- Canola meal: 45-92%
- Distillers dried grains with solubles: 30-91%

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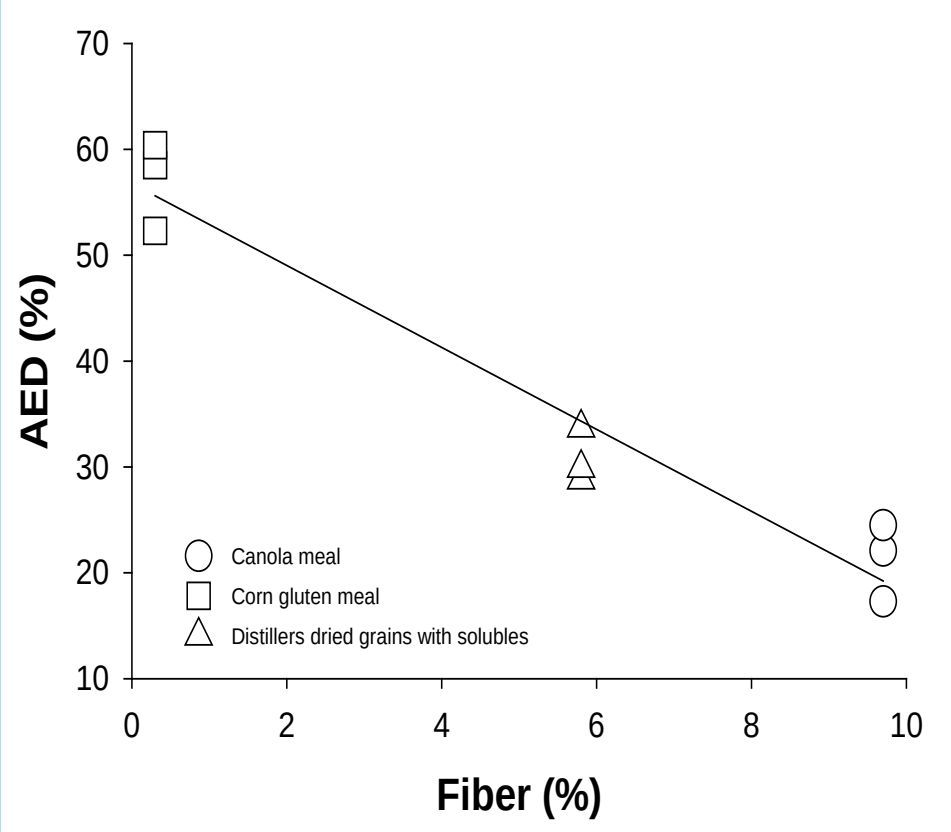
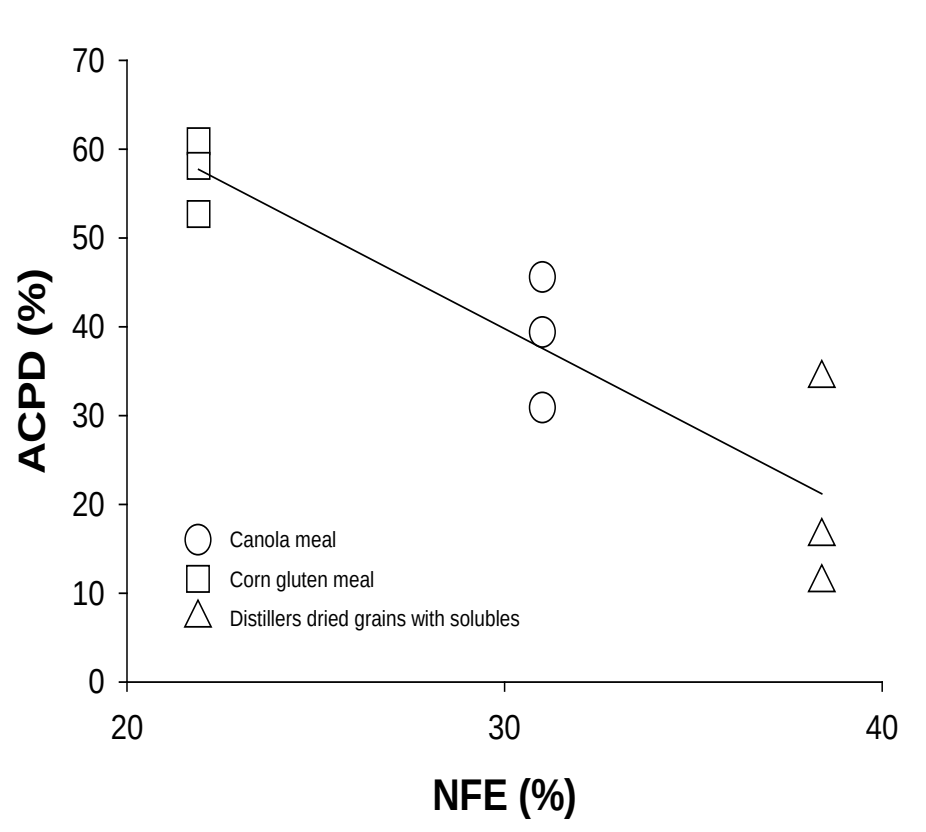
Feed composition affects digestibility





Energy digestibility inversely related to fiber content

Protein digestibility also affected by ingredient composition

What should be in a pompano diet?

- Protein
  - At least 40% protein from highly digestible ingredients with good amino acid profiles (e.g. fish meal, soybean meal)
  - Up to 25% of dietary protein can be provided as purified amino acids
  - Diet should be formulated to match the whole-body essential amino acid profile of pompano (ideal protein)
- Energy
  - 9-10 kcal digestible energy per gram protein appears to be sufficient
  - Oil rather than carbohydrate is preferred energy source
- Supplements
  - e.g. Taurine, present in animal tissue, can improve growth

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Commercial Diets

- Some commercial diets now available are good
  - High protein, high lipid diets can work well
  - Probably nutritionally over-fortified
  - More expensive than they need to be

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Future research needs

- Nutritional requirements
  - Establish dietary essential amino acid requirements of pompano at different life stages
- Alternative feedstuffs
  - Characterize nutritional value of as many practical feed ingredients as possible
    - Digestibility/nutrient availability
    - Levels/effects of anti-nutritional factors
    - Suitability as replacements for fish meal
- Palatability, taste preferences
- Feed schedules, night feeding potential
- Physical properties of diets

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Marine Research Team

Mote Marine Laboratory

Mote Aquaculture Research Park

- Dr. Kevan Main, Director
- Dr. Nate Brennan, UF
- Dr. Carlos Yanes, U. Stirling
- Michael Nystrom (MS, systems & fish production), Nicole Rhody (larval rearing, broodstock, Phd Student), Matt Resley (MS, broodstock), Carole Neidig (MS, fisheries and larval rearing), Paula Caldenty (Stock Enhancement, Phd Student)
- 12 student Interns: Clark Schnoover, Tim Mullin, Catie Orr, Jimmy Kilfoil, Phoebe Racine, Adam Collier, Duane Friedman, Sara Stevens, Nick Pearson, Andrew Angelos, Hayley Blumenthal, Drake Stevens

Integrated Recirculating Aquaculture System

Importance of feed technology

- Feed is one of the highest itemized costs in commercial aquaculture
- Aside from nutritional influences, physical attributes of the feed (e.g. pellet size, softness, buoyancy) and feed delivery schedules can strongly influence the amount of feed consumed and feeding efficiencies.
- Improvements in feed conversion efficiencies will directly contribute to commercial viability.
- Data generated from this study will be useful for economic feasibility studies.

Rising Feed Costs

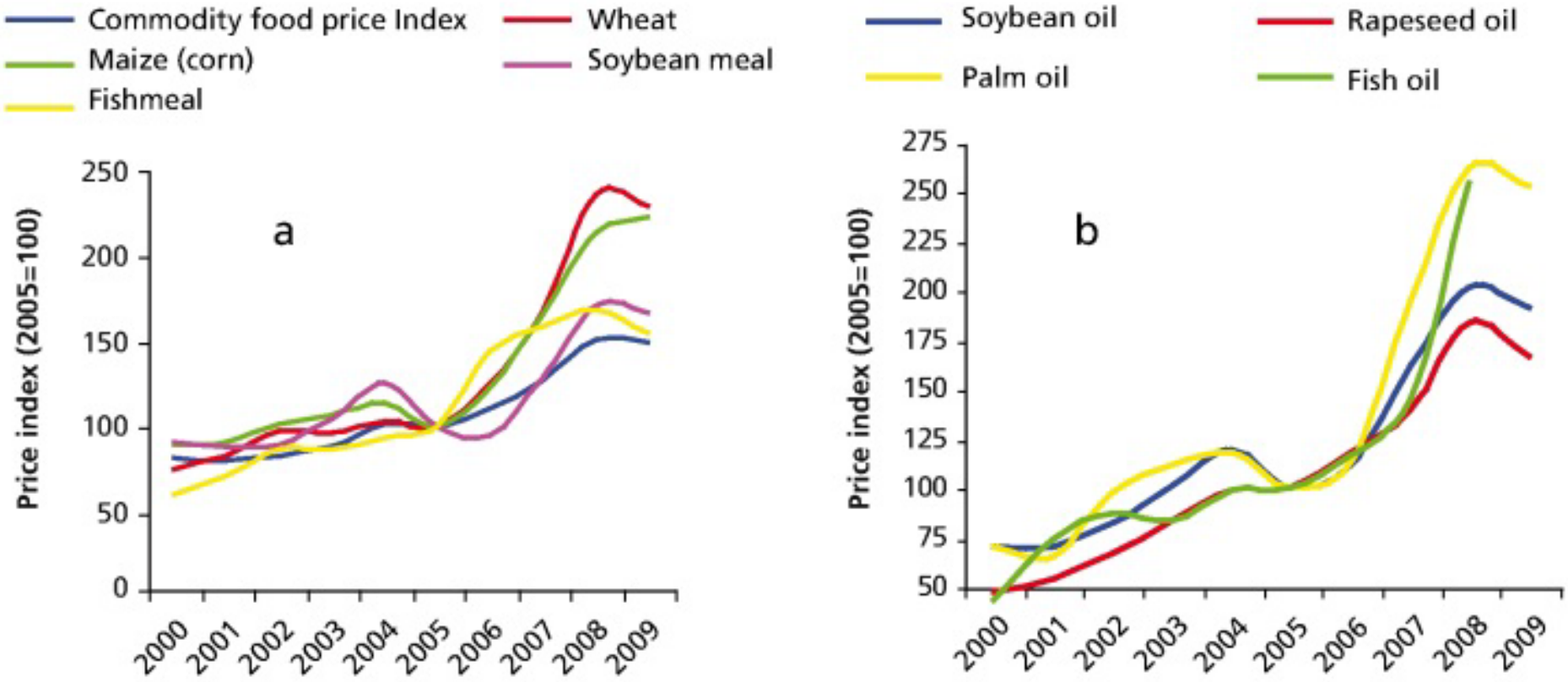
- *"Fish feed represents 50 to 70 percent of fish farmers' production costs, and the average price of the ingredients commonly used in fish feed jumped between 20 and 92 percent from June 2007 to June 2008"* FAO 2010

- Aquaculture feed generally consists of soybean, corn, fishmeal, fish oil, rice and wheat. Since 2005 prices of wheat, rice and fish oil have increased 180, 225 and 284 percent, respectively.

- Fishmeal makes up nearly 50 percent of the total feed cost. From 2000 -2008 the price has more than doubled.

- Another costly ingredient in fish feed is color — pigments/binders, which are less than 1 percent of the diet, account for 13 percent of costs.

Price index (2005=100) of key (a) food commodities and grains and fishmeal and (b) plant and fish oils, used for animal feeds and human consumption



Source: Adapted from International Monetary Fund (2009).

Research Goals and Objectives

Improve growth performance of Florida pompano by optimizing feeding strategies

- **Feed delivery schedule (daytime, day/night)**

- **Relative pellet size (10-20% mouth gape vs 25-45% gape)**

- **Feed buoyancy**
  Relates to amount of wasted feed in commercial system

Feed Delivery Schedule

700 L Tanks

Treatments

1. Daytime feeding only
   - 9% BWD (per 24H)
   - Belt feeders, loaded @ 8:30am
   - 4 replicates
2. Daytime feeding + night feeding
   - 9% day+ 3% night
   - Belt feeders, loaded @ 8:30am
   - Supplemental night lighting (1 lux)
   - 4 replicates

Diet

Otohime EP1, slow sinking
45% protein
18% lipid
2 mm pellet size

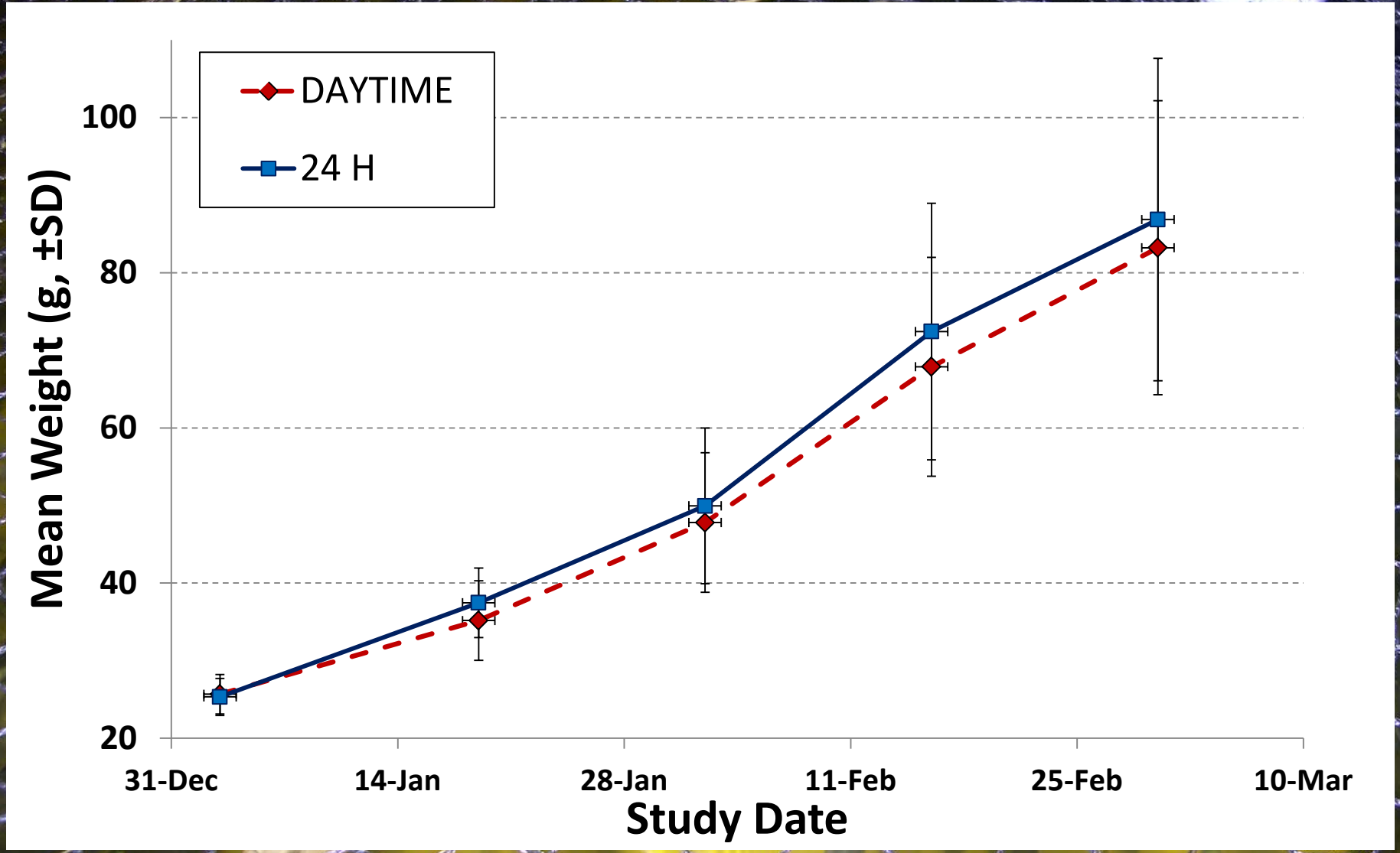
Stocking

25g mean wet weight
Used lower end of cohort's size structure
2 days acclimation before study start

Water quality

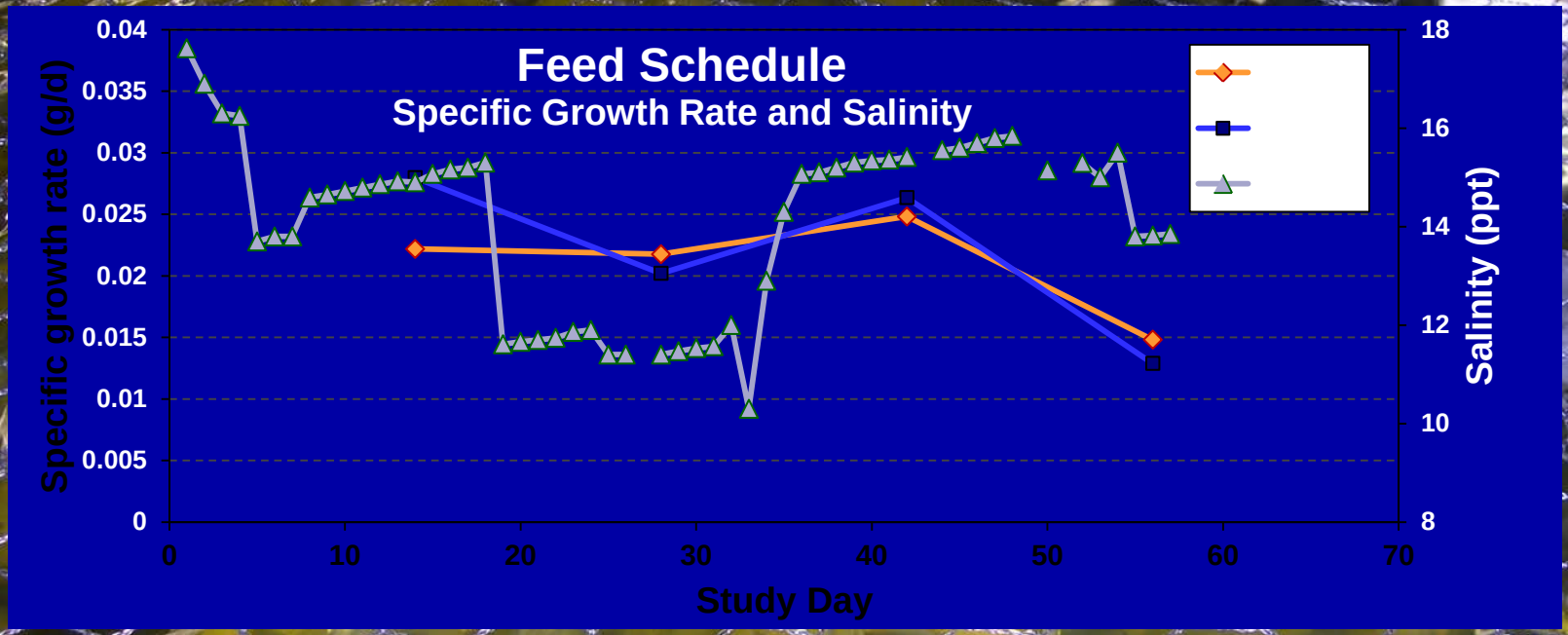
Brackish water (11-17 g/L)
Temperature 25^{o}C ±1.8^{o}C (SD)
DO mean 7.4 ± 2.3 mg/l
pH 7.9 ± 0.2

Feed Delivery Schedule



Other Effects…

A feed schedule trial showed a slight benefit to additional feed offered at night, but in this trial, pompano growth was more influenced by inadvertent changes in salinity.



- Tank Effects : shallow, light colored gel coat
- Skittish, shy behavior, likely high stress
- 2 week sampling interval; recommend longer sampling interval

Relative Pellet Size

700 l tanks

3 mm Pellet

- 6% BWD (per 24H)
- Belt feeders, loaded @ 8:30am
- 70% day / 30% Night
- 4 replicates

6.5 mm Pellet

- 6% BWD (per 24H)
- Belt feeders, loaded @ 8:30am
- 70% day / 30% night
- 4 replicates

Diet

Ziegler Finfish High Performance, slow sinking
45% protein
16% lipid

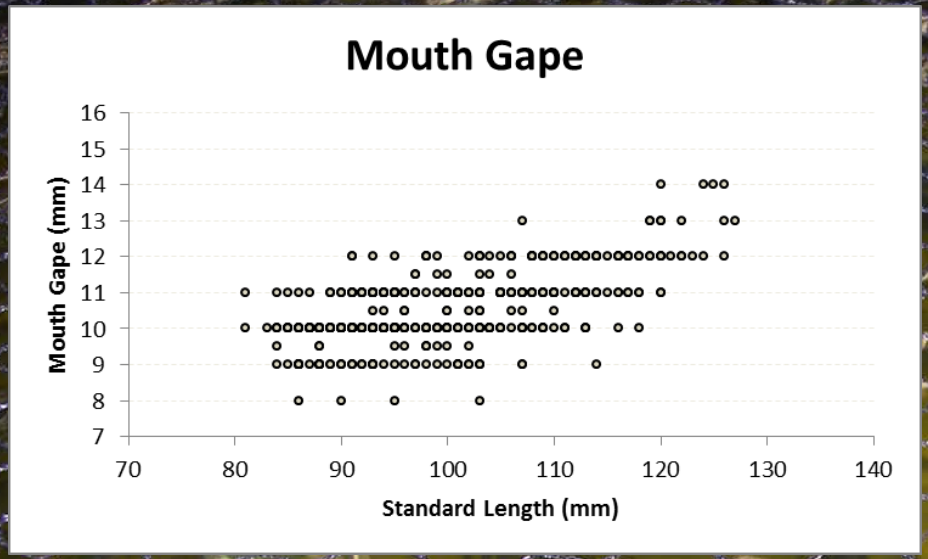
Water quality

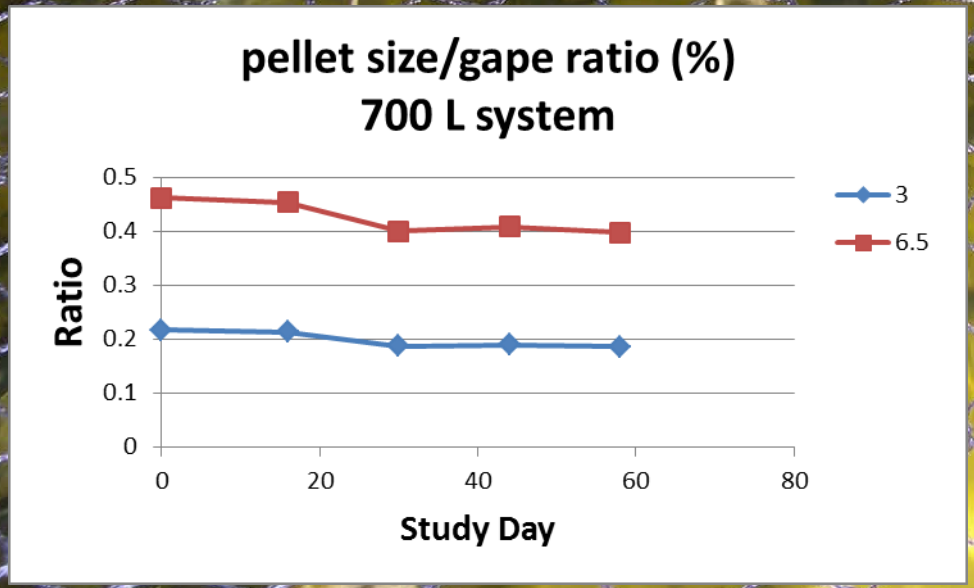
Brackish water (11-17 g/L)
Temperature 25°C ±1.8°C (SD)
DO mean 7.4 ± 2.3 mg/l
pH 7.9 ± 0.2

Stocking/Sampling

68 g Initial mean wet weight
Biweekly sampling
Wet weigh, TL, SL, Gape

Pellet Size and Mouth Gape





Relative Pellet Size
Commercial-Scale Rearing System

- **Culture Tanks**
  - Six 8.9m^3 tanks
    - 3m diameter
    - 1.5m depth
    - 1.2 m running water level
    - 4.7 m^3 volume
  - One 35.65m^3 tank
    - 6m diameter
    - 35 m^3 volume
  - Fiberglass with black gel coat and netting
  - 24 H Belt feeders
  - Vinyl mesh to contain fish
  - Fluorescent indoor lighting
  - Building insulation for temperature control

- **Filtration**
  - Drum filter
  - Biofilter (43m^3)
  - UV sterilization, ozone and foam fractionation
  - Wastewater cycles through denitrification system (geo-tube and plant raceways)

Relative Pellet Size
Commercial-Scale Rearing System

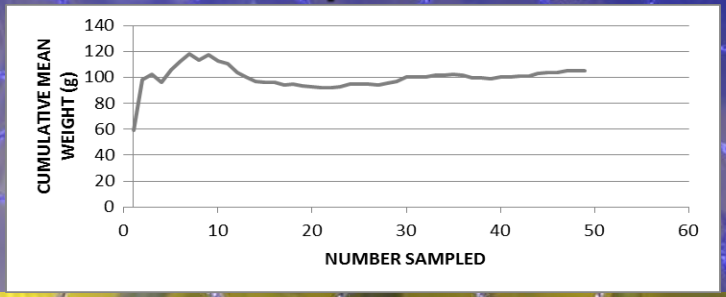
3 mm Pellet
- 4% BWD (per 24H)
- Belt feeders, loaded @ 8:30am
- Day delivery
- 2 replicates

5 mm Pellet
- 4% BWD (per 24H)
- Belt feeders, loaded @ 8:30am
- Day delivery
- 2 replicates

Diet
Ziegler Silver, Floating
40% protein
16% lipid

Water quality
Brackish water (14-16 g/L)
Temperature 25°C ±1.8°C (SD)
DO mean 7.4 ± 2.3 mg/l
pH 7.9 ± 0.2

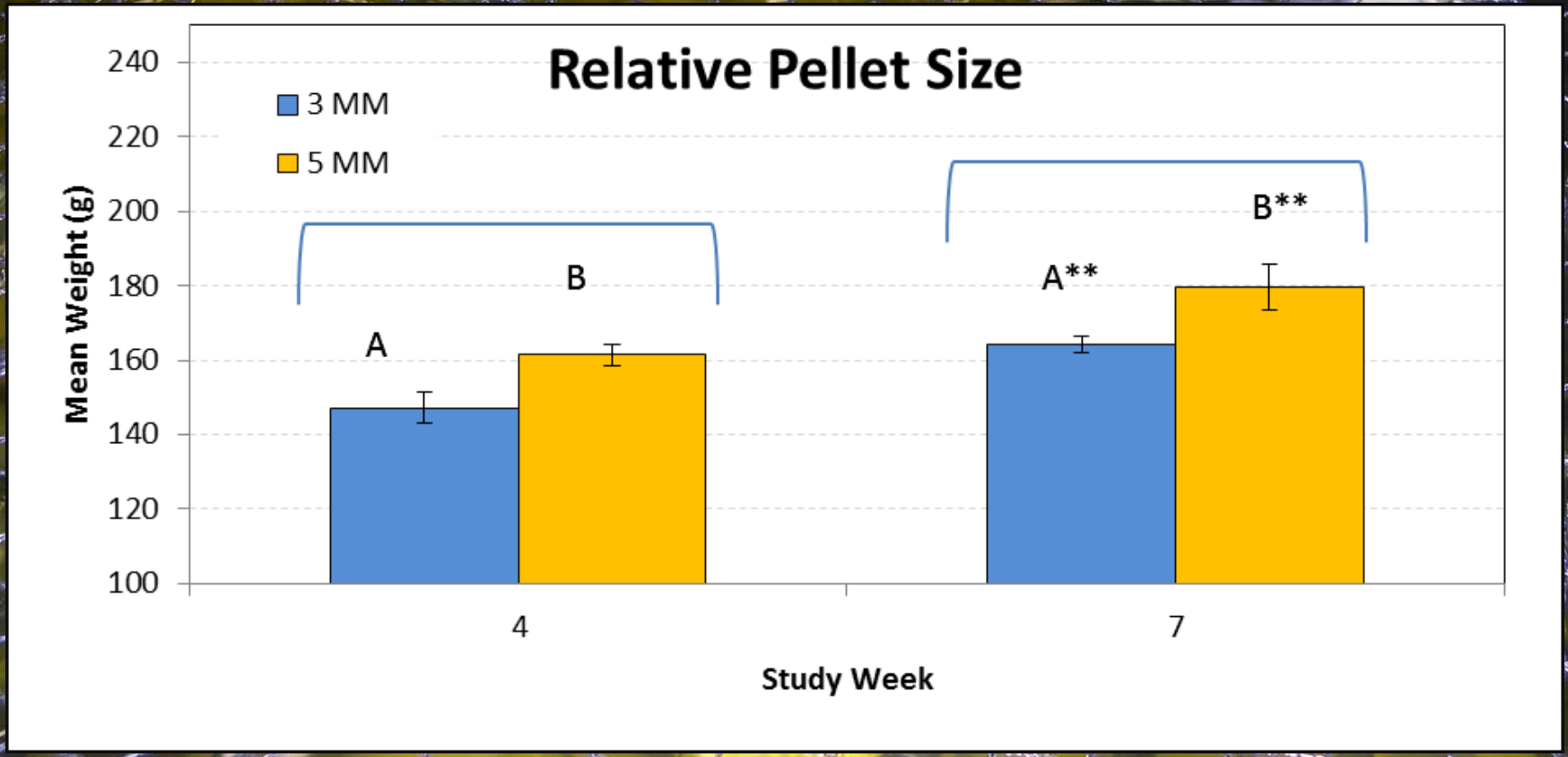
Stocking/Sampling
- 270 Florida Pompano stocked per tank
- Initial mean wet weight = 107 g (± 39g SD)
- Sampling: 0, 4, 7 weeks (wet weight, TL, SL, Gape)
- 80 fish sampled/tank/date



Pellet Size Results

Commercial System

- Larger pellets were more efficiently consumed and significantly improved growth rates of juvenile pompano. A 7 week trial delivering equal feed rates resulted in a 10% weight improvement in fish fed larger pellets



Pellet Size Results
Continued…

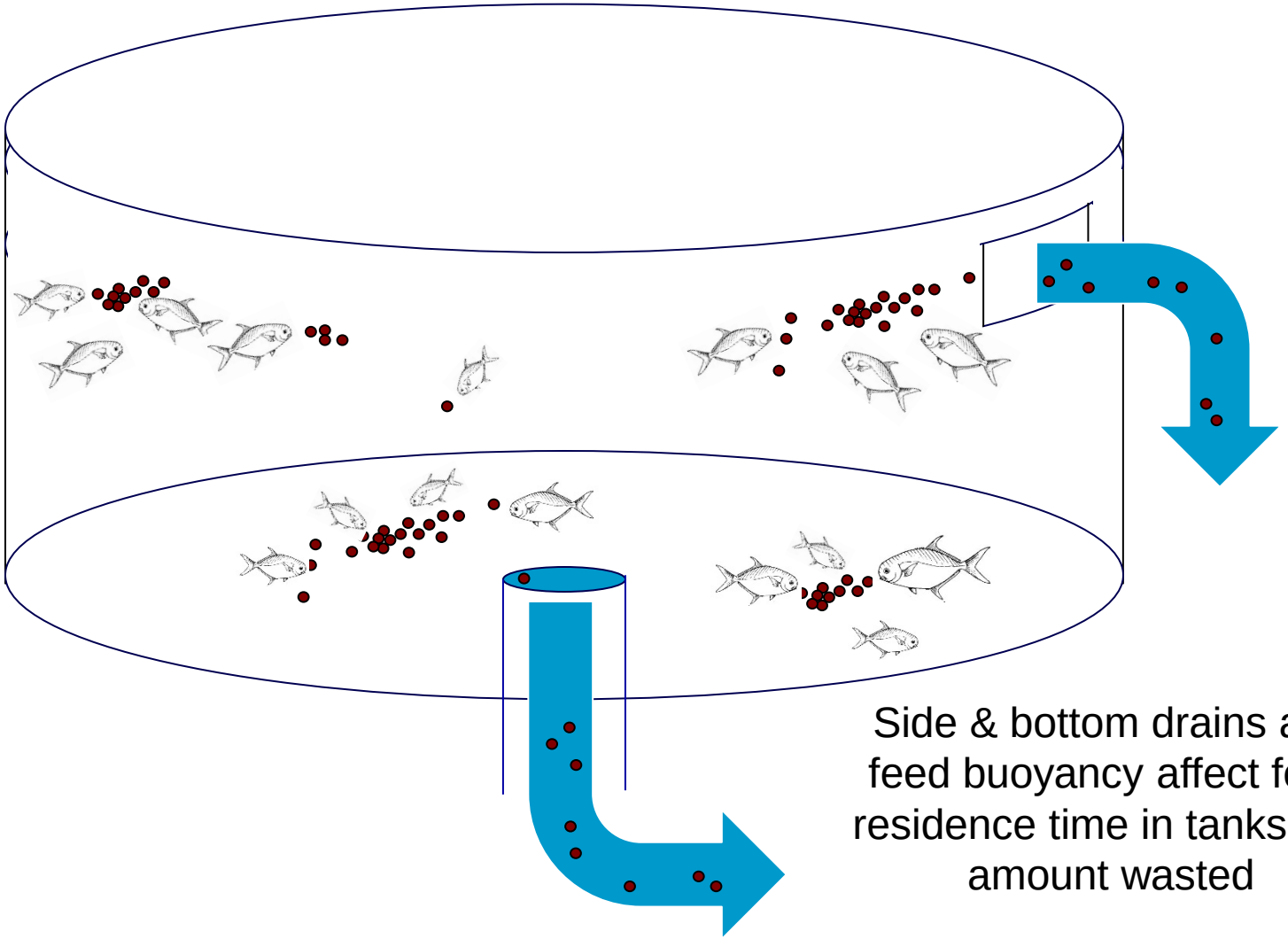
Within a given feed weight, how many pellets are available to the fish?			
Diet	# pellets	Sample wt (g)	Individual pellet wt (g)
5.0 extruded floating ziegler silver	52	5	0.0962
3.0 extruded floating ziegler silver	214	5	0.0234

- Foraging Theory: maximize feed intake while minimizing energy spent
- Soak time: If pellets soak for too long, they loose nutritional value and flavor
- Self cleaning tanks remove waste and uneaten food

Pellet buoyancy
in commercial-scale system (in progress)…

- Pellet buoyancy
  Slow sink vs. floating
  Quantify waste
  Quantify growth performance
- Feeding mechanics with high speed cameras
- Activity levels throughout day and night

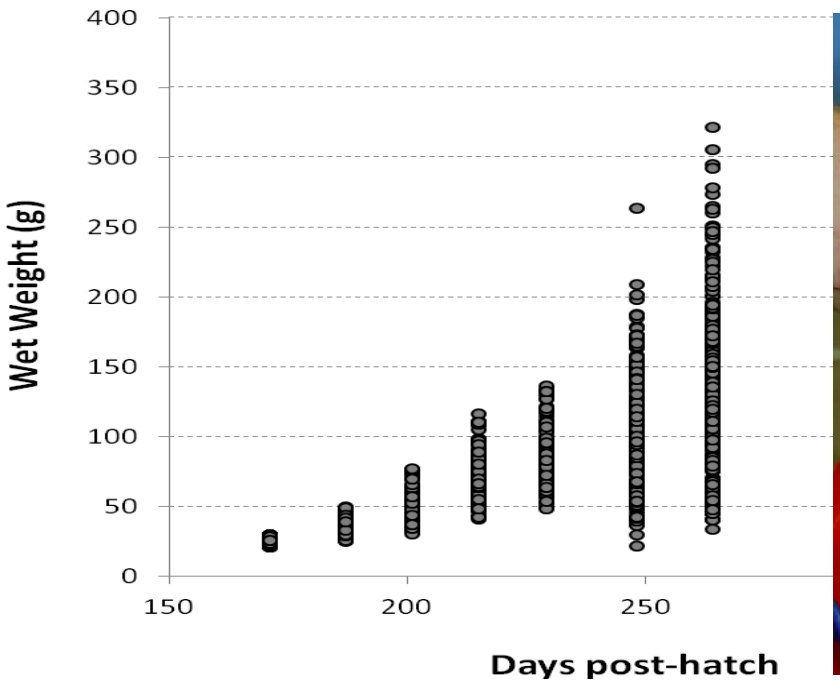
Pellet Buoyancy and feed waste management



Side & bottom drains and feed buoyancy affect feed residence time in tanks and amount wasted

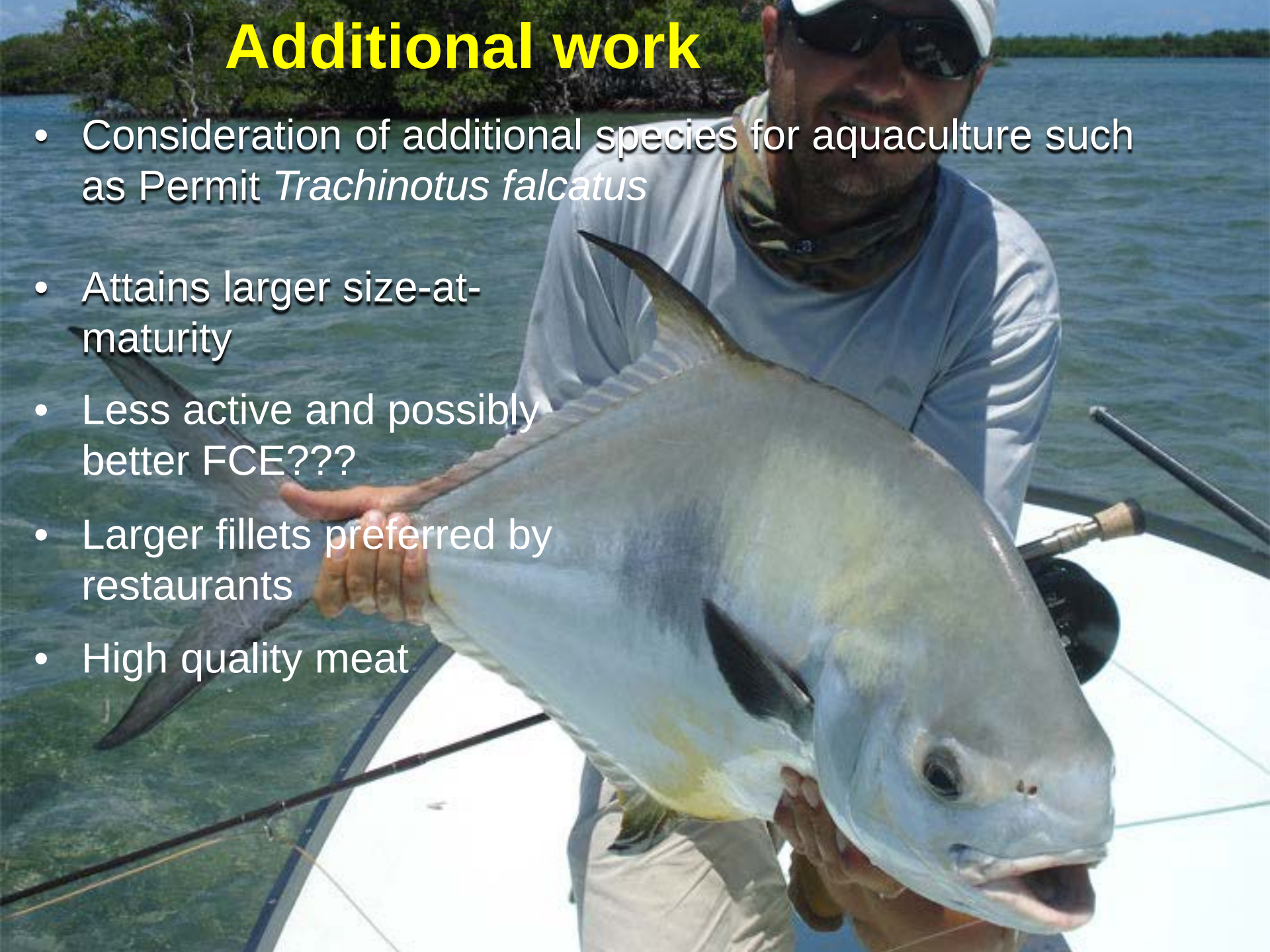
Additional work

- **Selective Breeding**: Natural variation in F1 pompano growth performance was very high and much of this is likely attributed to individual genetic variation.



Additional work

- Consideration of additional species for aquaculture such as Permit *Trachinotus falcatus*
- Attains larger size-at-maturity
- Less active and possibly better FCE???
- Larger fillets preferred by restaurants
- High quality meat



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