Feeds & Feeding
Best Management Practices

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CONSIDERATIONS & CHALLENGES

Most fish don't chew their food well

- *Broad range of pellet sizes*
- *Milling particles to sizes from 500-50 micron*

Fish aren't fed in a trough on dry land

- *Different species/culture systems demand different pellet buoyancy profiles*
- *Pellets have to remain intact and not leach, even after extended soak time*
- *Feeding is the primary interaction between culturist and livestock*

Catfish and trout aren't the only cultured species

IDEAL PROPERTIES

Durable enough to withstand packaging, storage, transport, and on-farm distribution

Pellets aren't too hard or too soft

Hard pellets can cause gastric rupture, soft pellets fall apart and may cause digestive problems

Appropriate density and sinking velocity

Float, sink, slow-sink

Appropriate water stability

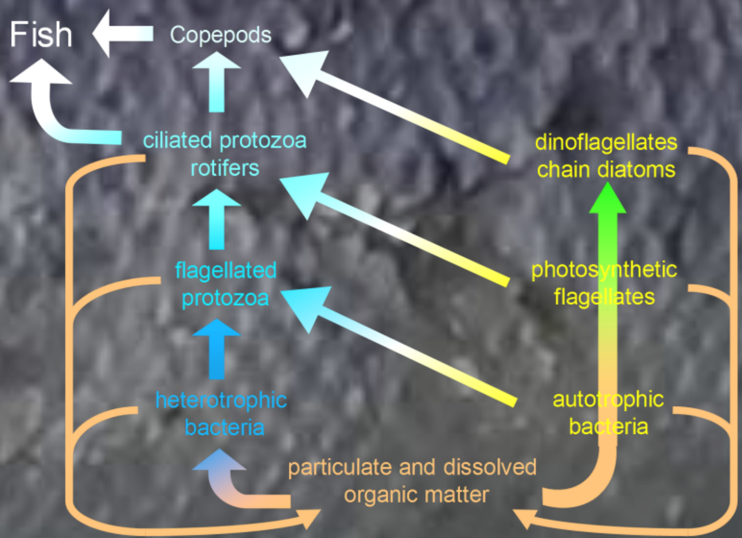
Longer stabilities for slow eaters

PROS AND CONS OF NATURAL VS. PREPARED FEEDS

Natural

Readily accepted

Proven performance



Prepared

Consistent product

Can be refined/adjusted

Year-round availability

Typically non-vector

Easy storage/distribution

Cost-effectiveness

FEED TYPES

CLASSIFICATION OF FISH FEEDS BASED ON ENERGY LEVELS & PROCESSING TECHNOLOGY

	High Energy (Carnivorous)	Medium Energy (Carnivorous)	Low Energy (Omnivorous)
Digestible Energy(MJ/kg)	15-22	14-18	13-15
Protein (%)	42-47	45-47	30-40
Fat (%)	22-35	12-23	8-12
Process technology	cooker extruder	extruder-expander pellet mill	pellet mill
Species	salmon eel trout	seabass seabream turbot	tilapia carp mullet

From: "Aquaculture feed manufacturing practice in EU Mediterranean countries", A. Martín

CHARACTERISTICS OF FEED TYPES

	Floating feed	Sinking feed
Diametric expansion (%)	1.2-1.6	0.98-1.02
Apparent Density kg/m3	350-400	520-820
Durability (%)	96-97	98-99
Rehydration after 8 min (%)	140-220	60-70

Adapted from Melcion 1999

Floating feeds are preferable for most applications

Crumbles will be less durable and more prone to leaching

The diversity of manufacturing options can yield a wide range of hybrid processes and product types

HOW DO I KNOW WHAT TO FEED?

Feed as little protein and lipid as needed

- *Minimize feed costs and effluents*

Nutrient requirement or demand studies

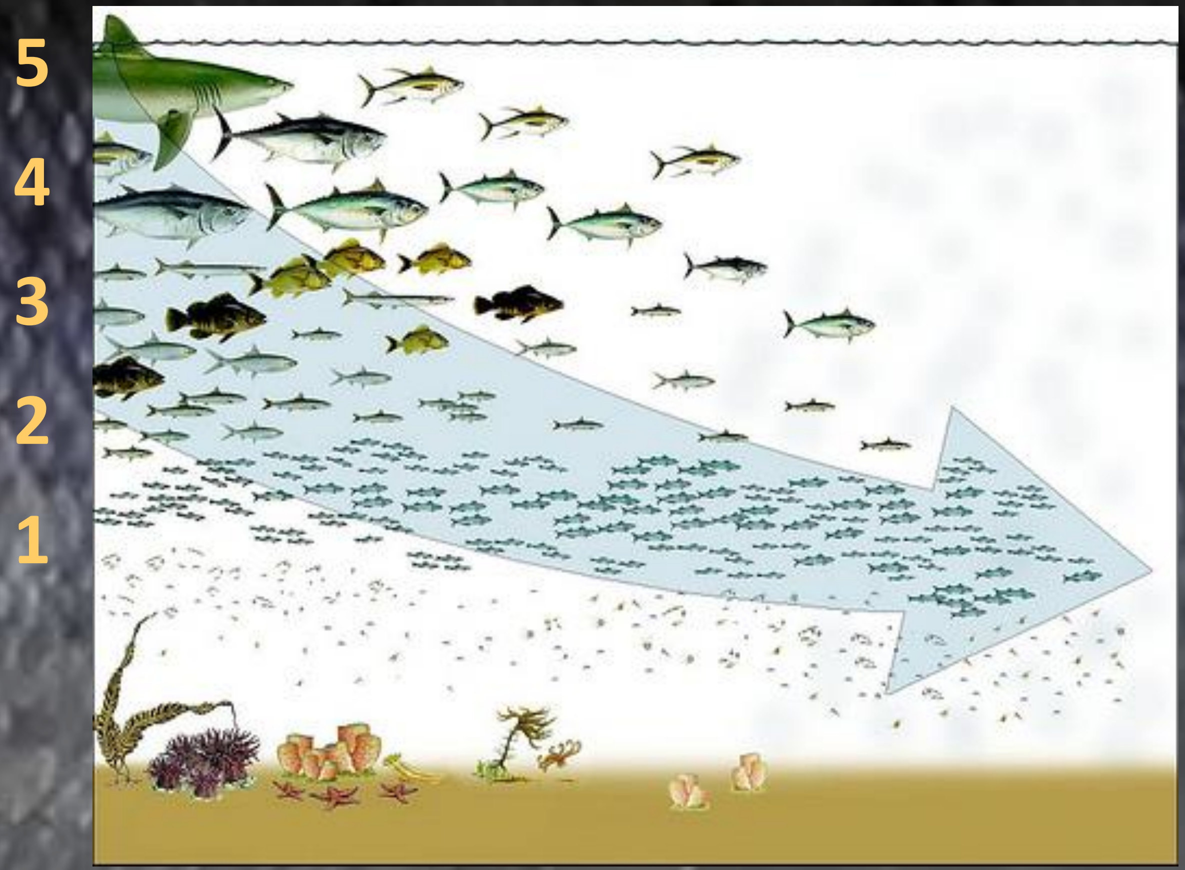
- *Published results*
- *Previous experience with different feeds*

Requirements of different lifestages or species

- *Carnivores vs. omnivores*
- *Effects of water temperature*
- *Larvae vs. juveniles vs. broodstock*

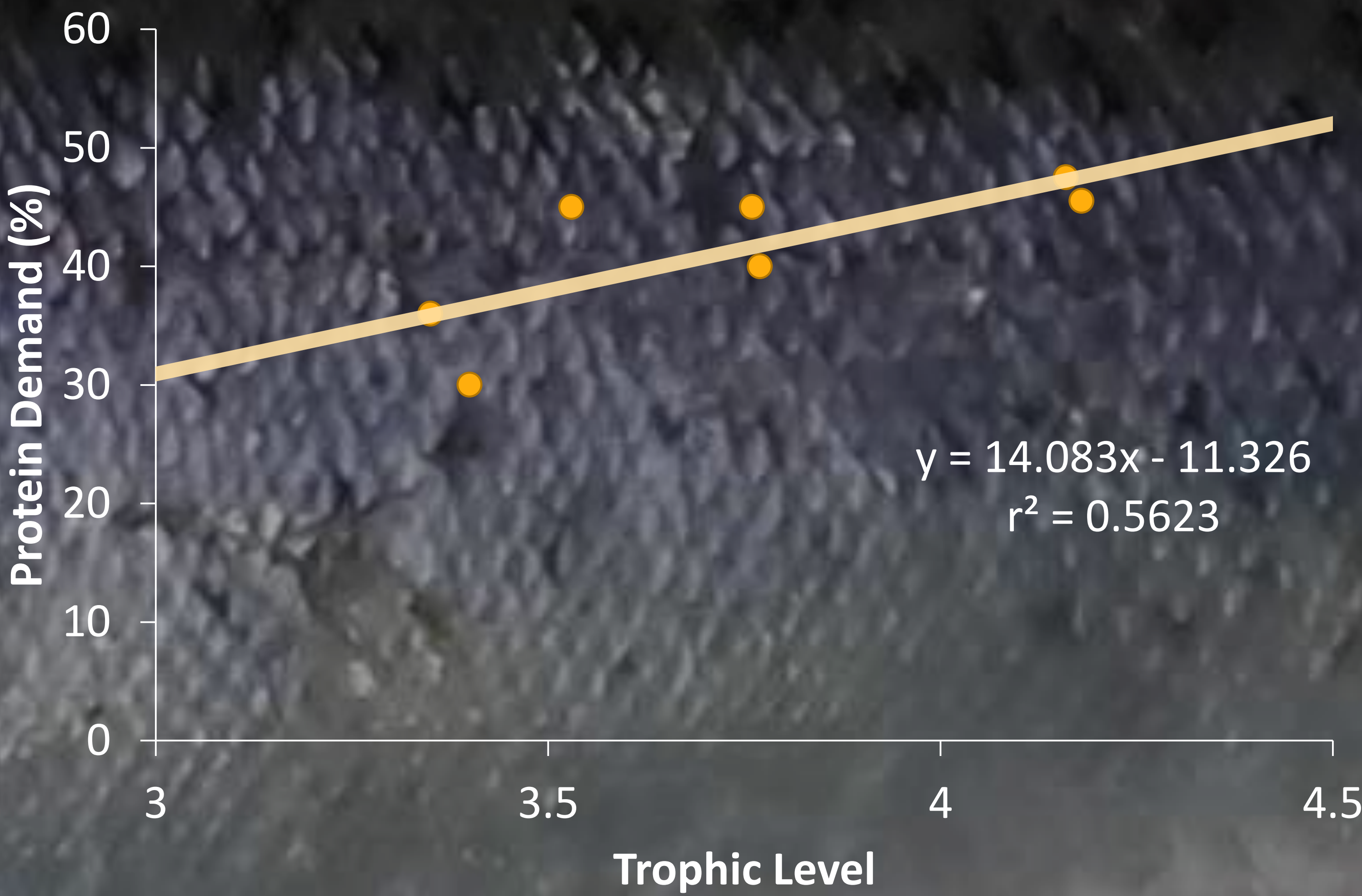
Pay attention to production costs, not just feed costs

USING TROPHIC LEVEL TO ESTIMATE NUTRIENT DEMANDS



1. Primary producers
2. Herbivores, primary consumers
3. Carnivores, secondary consumers
4. Carnivores, tertiary consumers
5. Apex predators

CARNIVORY PREDICTS PROTEIN DEMAND



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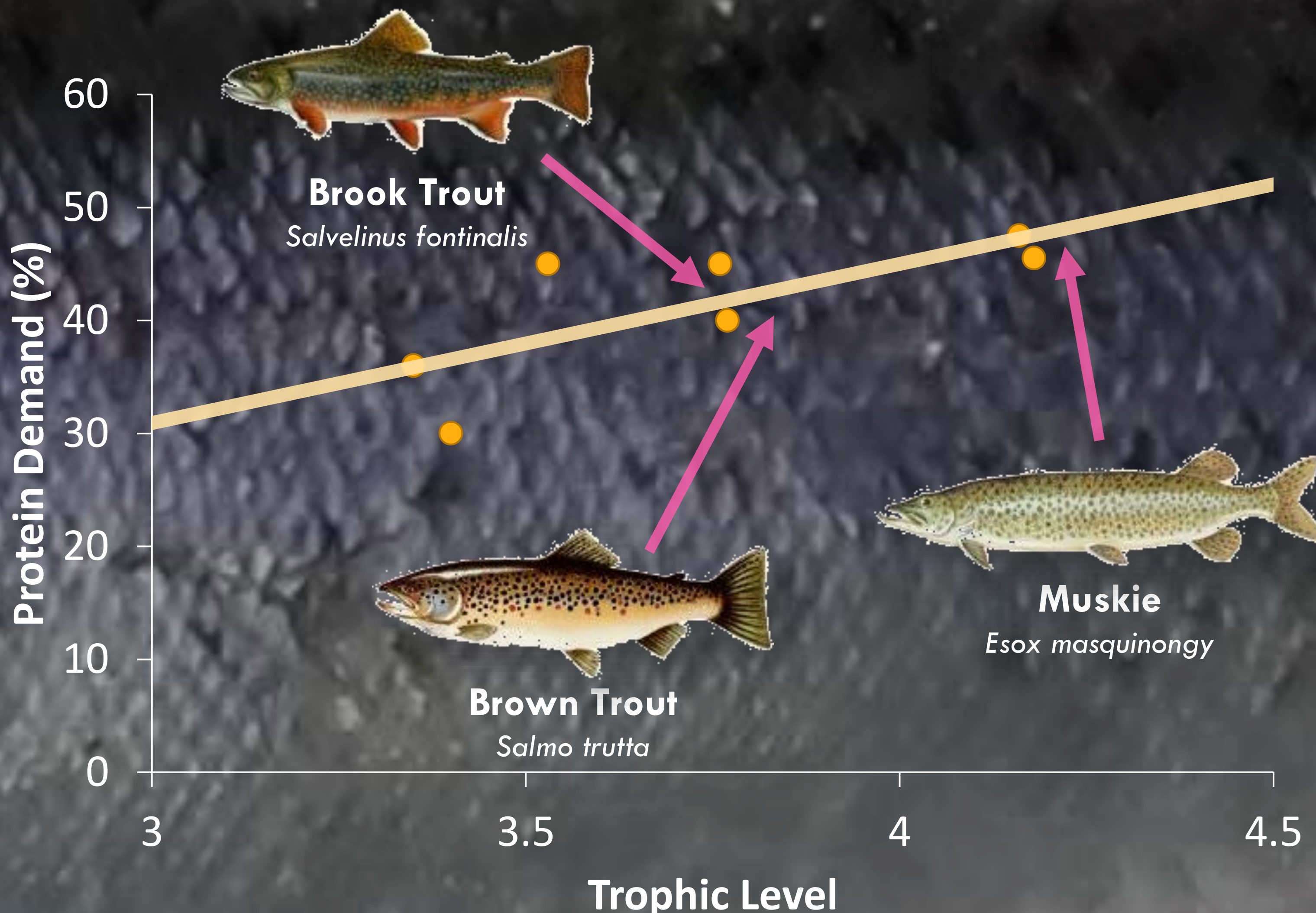
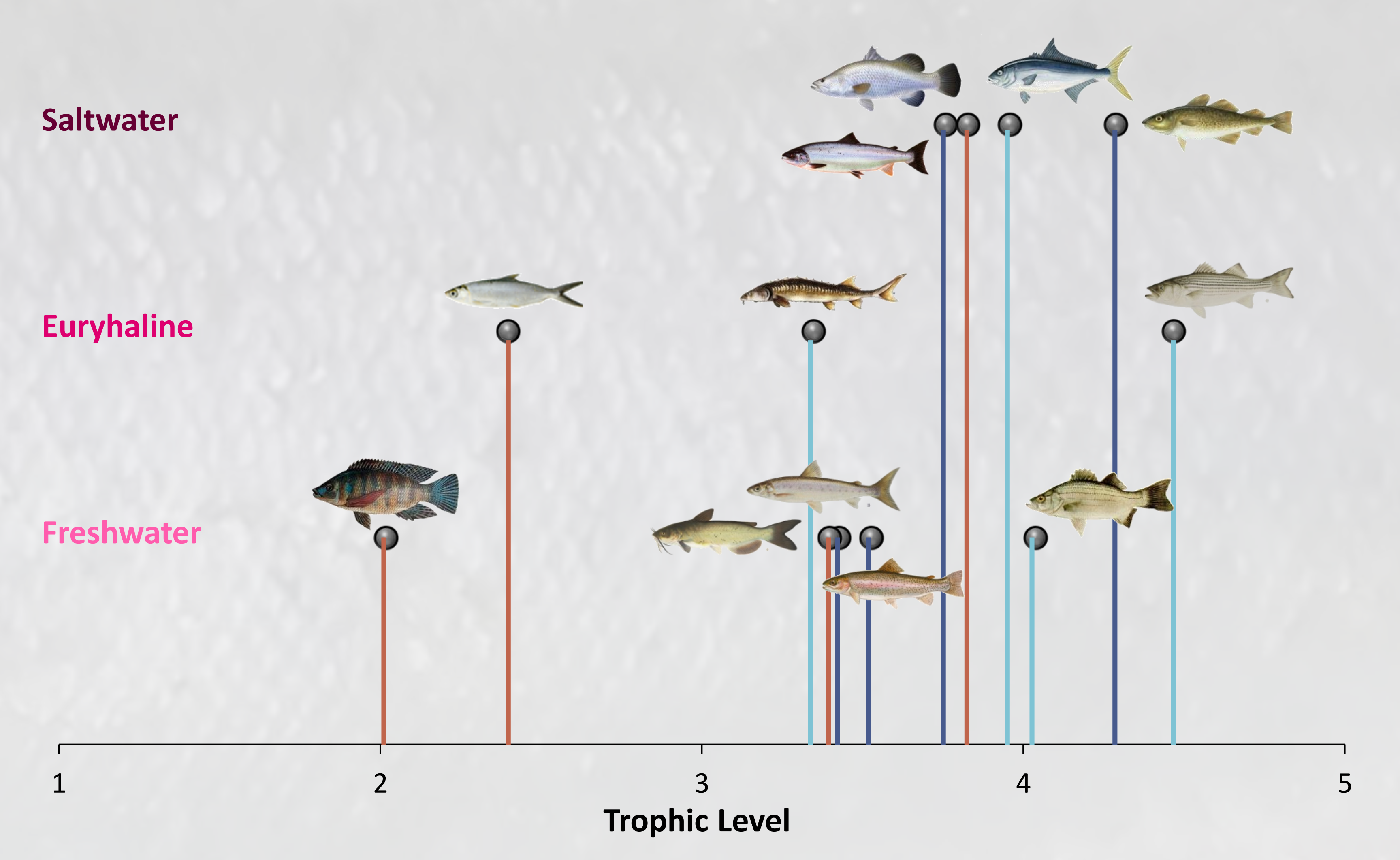


CARNIVORY PREDICTS FATTY ACID REQUIREMENTS, TOO



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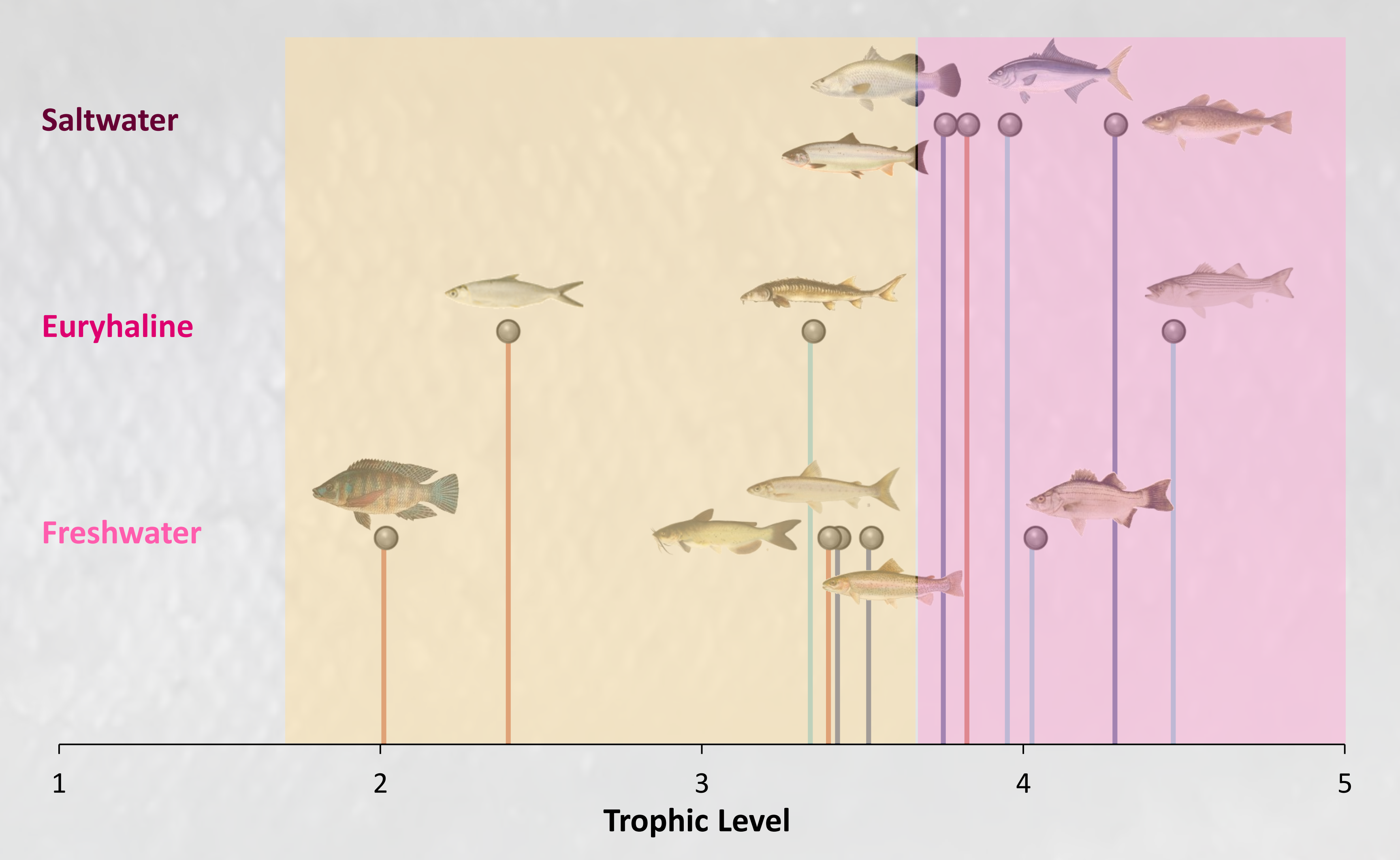


RECOMMENDED DIETARY PROTEIN LEVELS

Phase I

Phase II

Phase III

← ***36-55% Protein (Webster 2002)*** →

38-50% Protein
(Morris et al. 1999)
47% Protein
(striped bass, Millikin 1983)

35% Protein
(Nematipour et al. 1992)
41% Protein
(Brown et al. 1992)

32-40% Protein
(Wetzel et al. 2006)
40% Protein
(D'Abramo et al. 2000)

EFFECTS OF TEMPERATURE AND SIZE

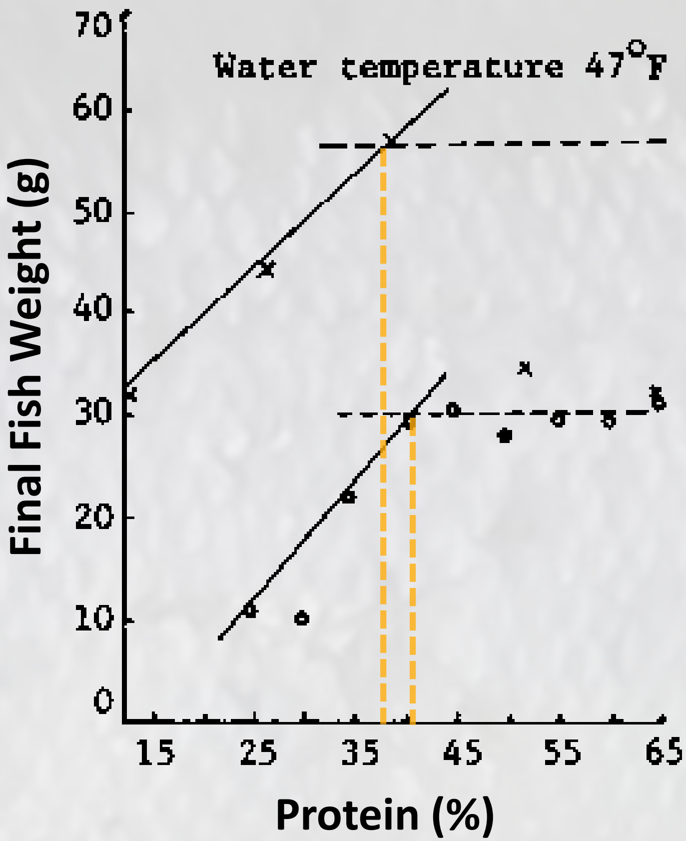


Figure 1. Protein demand of Chinook salmon at 47°F. Top curve: initial individual average weight of fish, 1.5 g. Bottom curve: initial individual average weight of fish, 5.6 g.

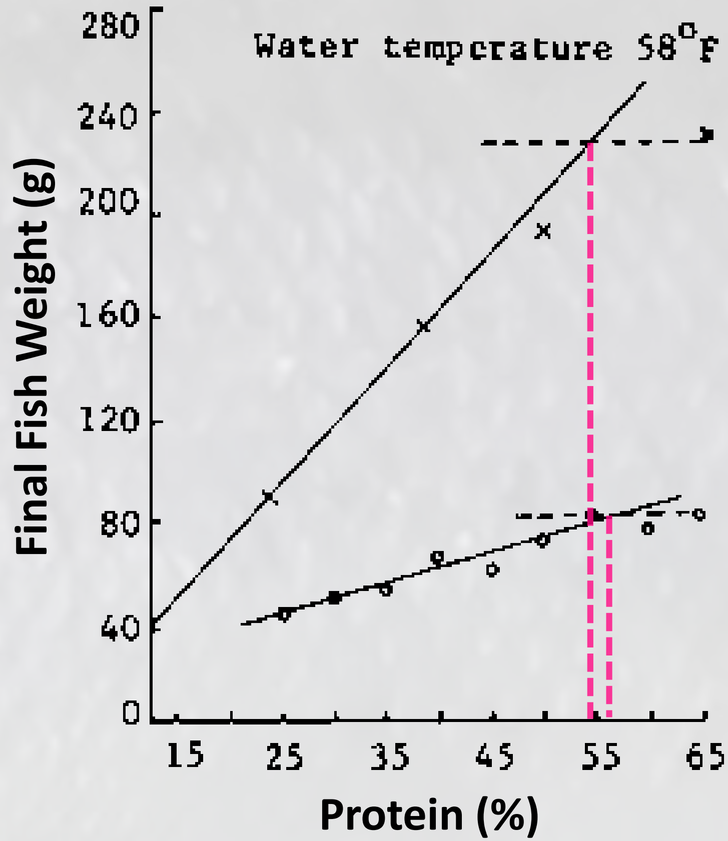


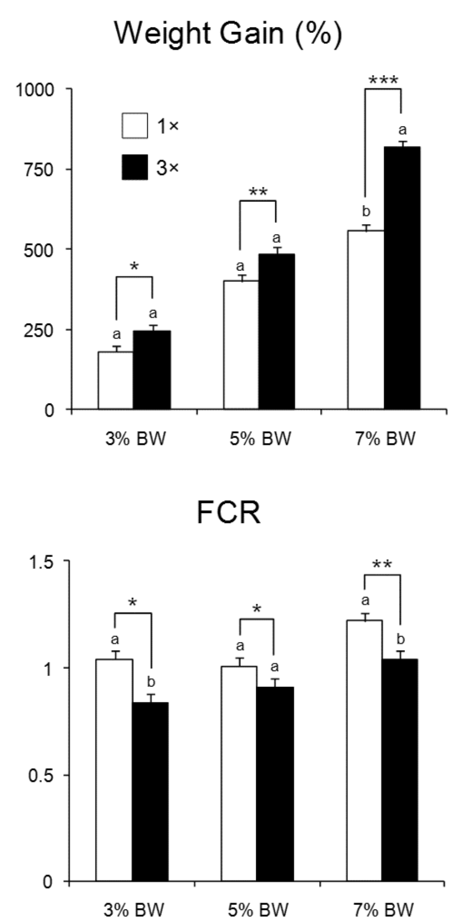
Figure 2. Protein demand of Chinook salmon at 58°F. Top curve: initial individual average weight of fish, 2.6 g. Bottom curve: initial individual average weight of fish, 5.8 g.

FEEDING RATES AND FREQUENCIES

If you feed it,
they will grow, but…

Increasing feeding rate too high can lead to inefficient growth, changes in body composition, etc.

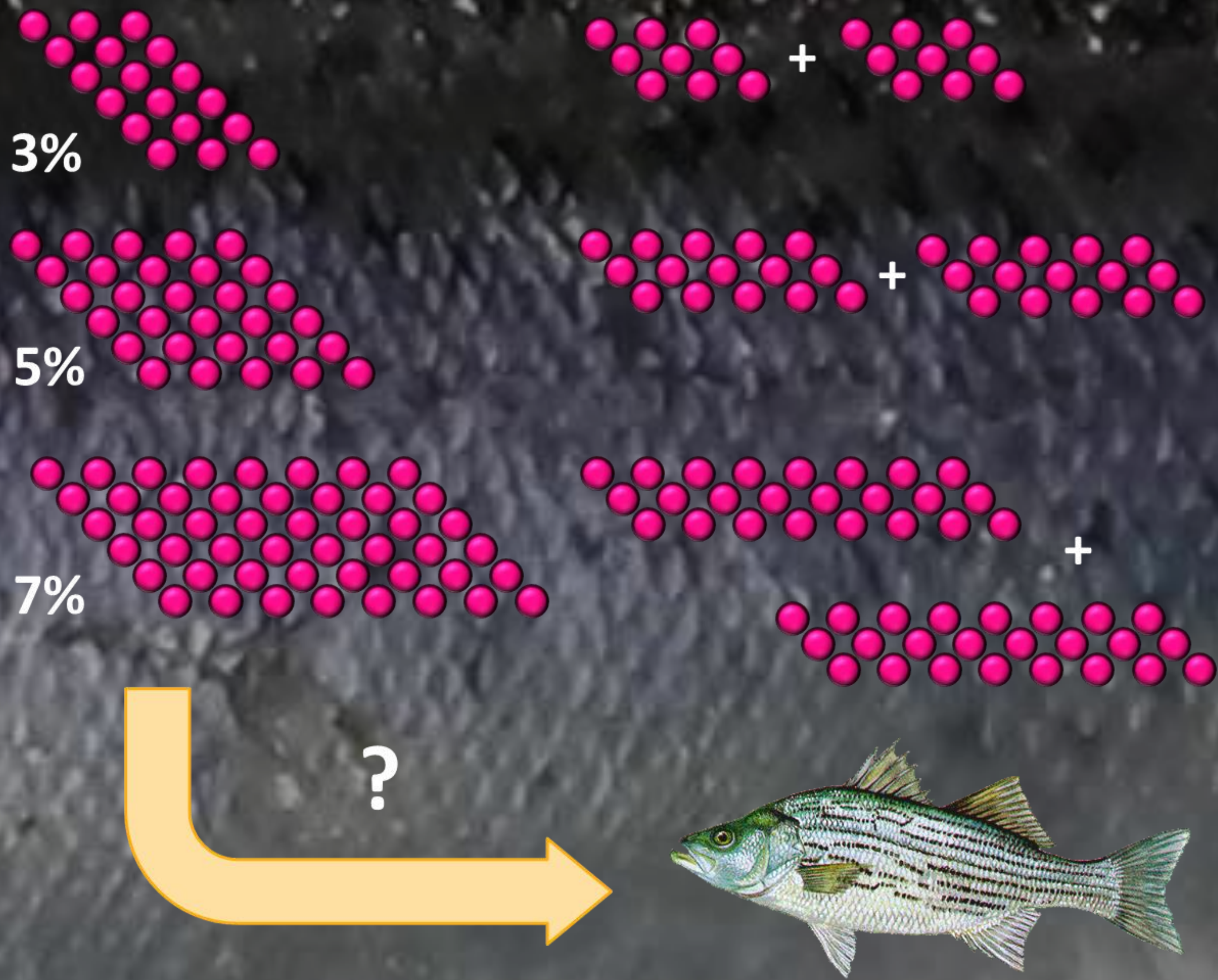
Feeding frequency is a Goldilocks balance between meal size, feeding event duration, and practicalities of farm/hatchery management



Trushenski et al. 2012

Fish fed more gain more weight

But gain can be less efficient, & weight gained might be mostly fat!


3%
5%
7%
+
+
+
?

Trout Feeding Table	5°C		10°C		15°C	
	Fish Wt (g)	Rate (% BW)	Fish Wt (g)	Rate (% BW)	Fish Wt (g)	Rate (% BW)
Week 0	1.0		1.0		1.0	
1	1.2	1.93	1.4	3.98	1.7	6.14
5	2.2	1.58	4.2	2.72	7.0	3.55
10	4.2	1.29	10.9	1.99	22.6	2.40
15	7.0	1.10	22.6	1.59	52.4	1.84
20	10.9	0.97	40.6	1.33	100.9	1.51
25	16.1	0.86	66.3	1.15	172.8	1.30
30	22.6	0.78	100.9	1.02	272.6	1.14
35	30.7	0.72	146.0	0.92	404.9	1.02
40	40.6	0.66	202.8	0.84	574.3	0.92

Adapted from Fauré and Labbé 1999

Suggested Feeding Rates for Hybrid Striped Bass Production

Production Phase	Fish Size (cm)	Fish Size (g)	Feed Size	Rate (% BW/day)
Phase I (30-35 days)	4	0.6	#1 crumble	15
	4.5	0.9	#2 crumble	10
Phase II (12 months)	5	1.5	#3 crumble	6
	6.5	3	#4 crumble	6
	7.5	5	2.4 mm	6
	13	23	3.2 mm	4
	19	77	4.0 mm	3
	24	143	4.8 mm	3
Phase III (6 months)	Market-sized fish	500	6.4 mm	3

Adapted from Atstupenas and Wright (1987) as reported by Morris et al. (1998)

Suggested Feeding Rates for Tilapia Production

Fish Size	Daily Feeding Frequency	Feed Size	Rate (% BW/day)
First feeding to 1 g	8	#00 or #0	10-30
1-5 g	6	#1	6-10
5-20 g	4	#1 or #2	4-6
20-100 g	3-4	#2, #3, or 3/32”	3-4
>100 g	2-3	1/8”	2-3

Adapted from Lim 1997 as reported by Shiau 2002, and Riche and Garling 2003

FOCUSING ON PRODUCTION COSTS

What to feed hybrid striped bass? And when?

Cooperative trial with Zeigler Bros., Inc. (Tim Markey and Scott Snyder)

21-week trial, June 3 – November 4, 2011

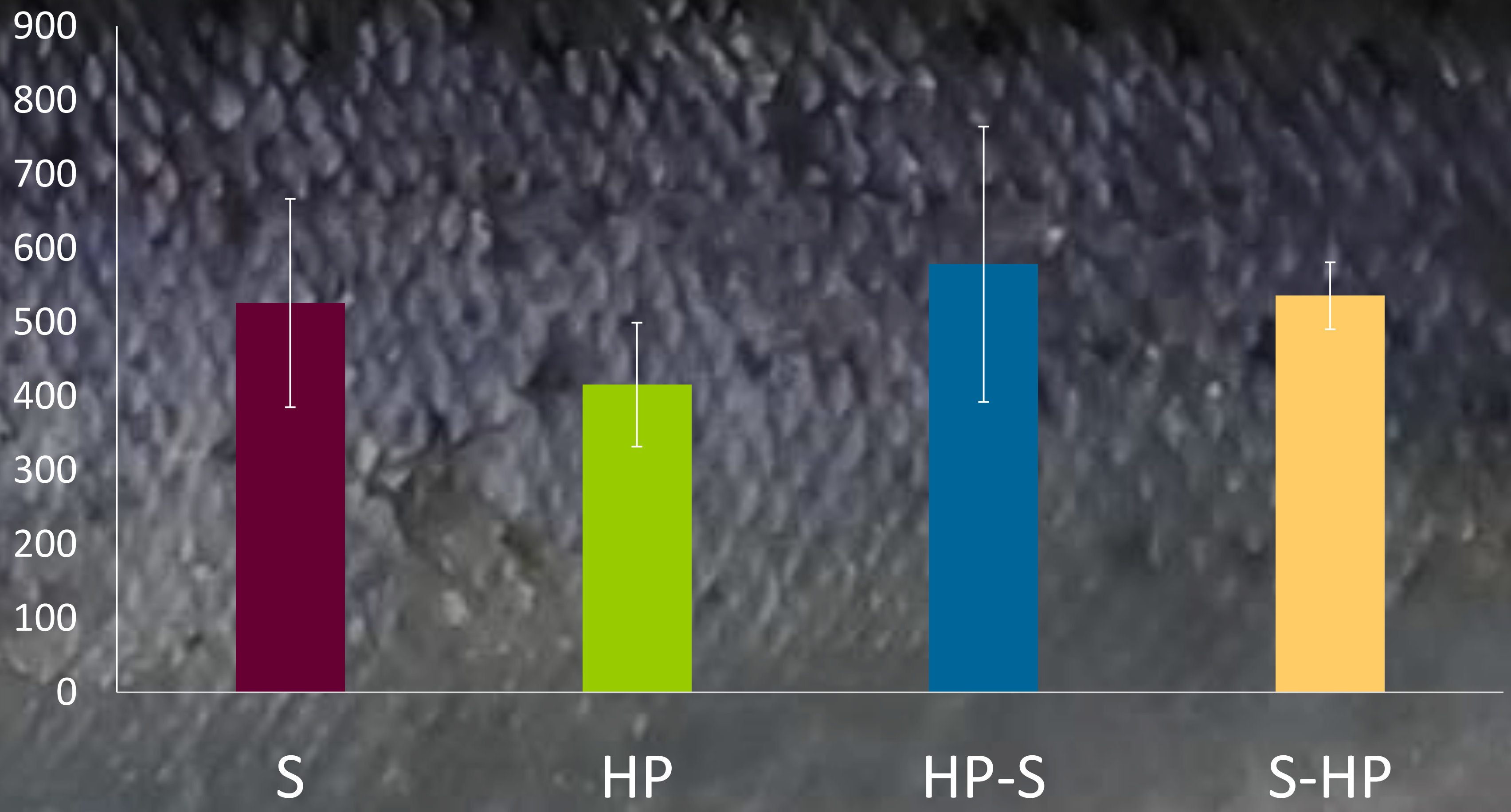
Factorial design –temperature-dependent feeding

- *All ZBI Silver 40-10 (S)*
- *All ZBI High Performance 45-16 (HP)*
- *High Performance (12 d) to Silver (89 d) to High Performance (45 d) (HP-S)*
- *Silver (12 d) to High Performance (89 d) to Silver (45 d) (S-HP)*
- *4 replicate ponds per treatment*
- *16 ponds stocked with 7.5 kg (approx. 150) 49.95 g/fish*

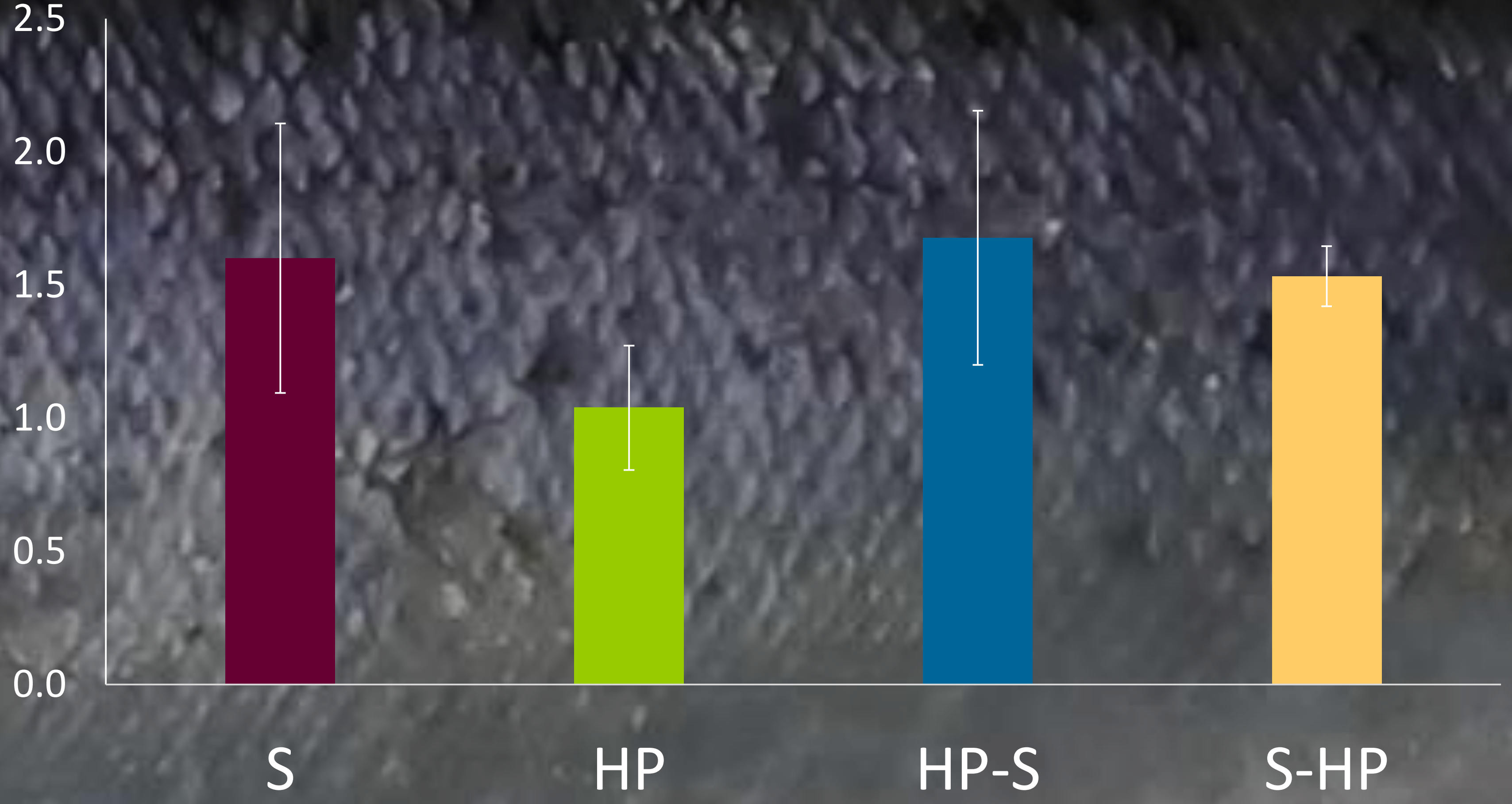
Collect standard growth performance data

Perform economic productivity analysis

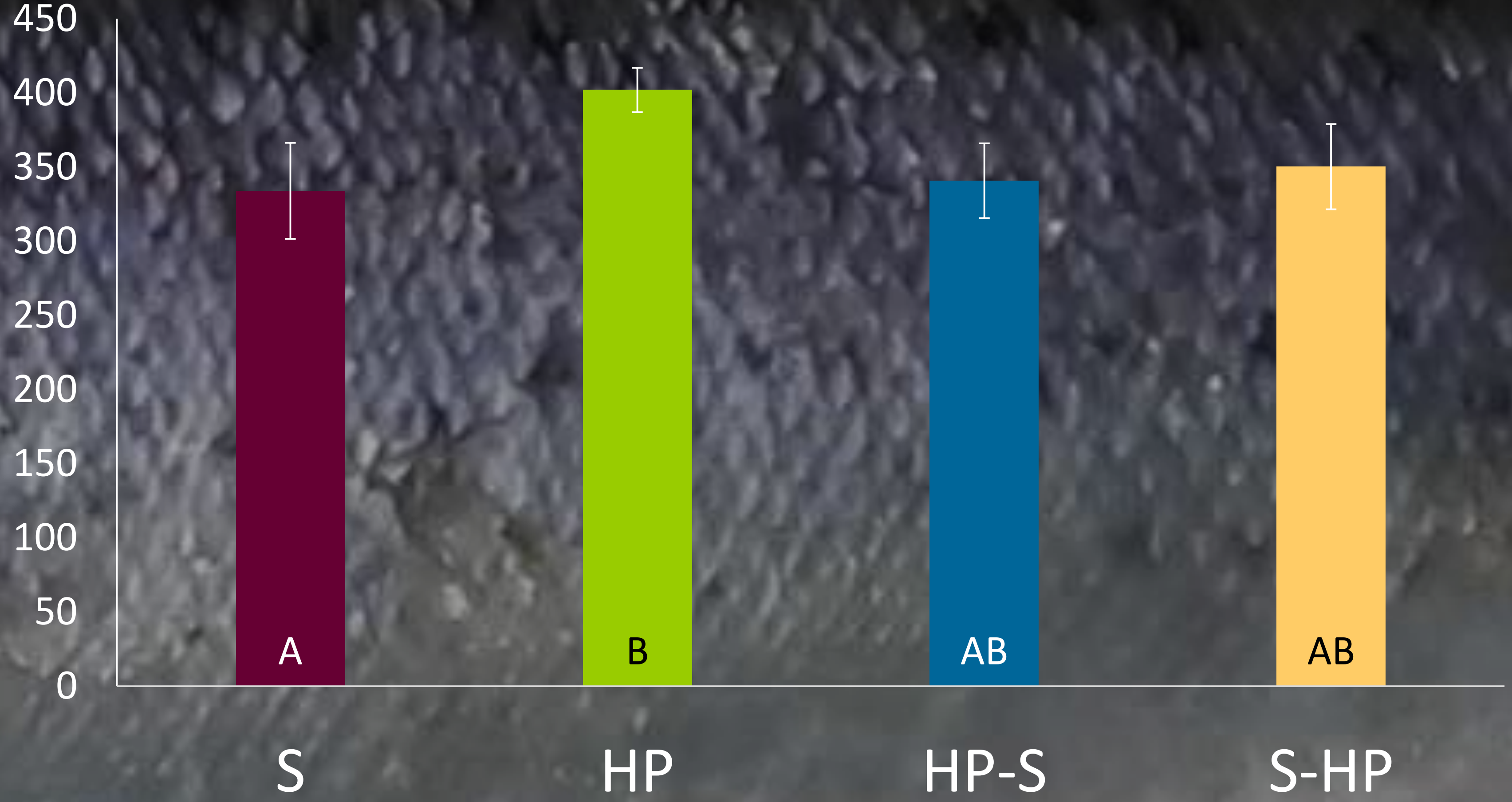
AVERAGE INDIVIDUAL CONSUMPTION (g)



FEED CONVERSION RATIO



AVERAGE INDIVIDUAL GAIN (g)



ECONOMIC PRODUCTIVITY ANALYSIS

Input Data	S	HP	Difference	
No animals stocked	600	600	-	0.0%
Gain/day (g)	2.29	2.75	0.46	20.1%
Avg wt at market (g)	450	450	-	0.0%
Survival/yield (%)	95%	95%	-	0.0%
FCR*	1.60	1.04	(0.56)	-35.0%
Fingerling cost, $	$ 0.09	$ 0.09	-	0.0%
Initial wt/animal (g)	50	50	-	0.0%
Market value ($/kg)	$ 6.60	$ 6.60	-	0.0%
Feed cost ($/kg)	$ 1.100	$ 1.320	0.220	20.0%
Overhead/day/fish ($)	$ 0.0040	$ 0.0040	-	0.0%
Calculatons			**Difference**	
No days in cycle	174.67	145.45	(29.22)	-16.7%
Total wt marketed (Kg)	256.50	256.50	-	0.0%
Value at market ($)	$ 1,692.90	$ 1,692.90	$ -	0.0%
Cost of fingerlings ($)	$ 54.00	$ 54.00	$ -	0.0%
Feed fed (Kg)	364.80	237.12	(127.68)	-35.0%
Cost of feed fed ($)	$ 401.28	$ 313.00	$ (88.28)	-22.0%
Overhead cost ($)	$ 419.21	$ 349.09	$ (70.12)	-20.1%
Results			**Difference**	
Fingerling cost/Kg marketed ($)	$ 0.211	$ 0.211	$ -	0.0%
Feed cost/Kg marketed ($)	$ 1.564	$ 1.220	$ (0.344)	-22.0%
Overhead cost/Kg marketed ($)	$ 1.634	$ 1.361	$ (0.273)	-16.7%
Results - Profit				
Income over fingerling, feed and overhead costs ($)	$ 818.41	$ 976.81	**Difference** $ 158.40	19.4%
Other Factors/ Adjustments				
Additional growth opportunity ($)			$ 63.64	
ADVANTAGE FROM HP			$ 222.04	27.13%

HP FCR is better

HP cost is higher

S Production cost is higher than HP

19% more profit with HP!

DOCUMENT, DOCUMENT, DOCUMENT!

Without accurate records, it is impossible to differentiate between feed-related issues and other factors

Feed manufacturer, brand, batch, etc.

Feeding rates vs. water temperatures

Feed conversion ratios

Keep samples of all feeds

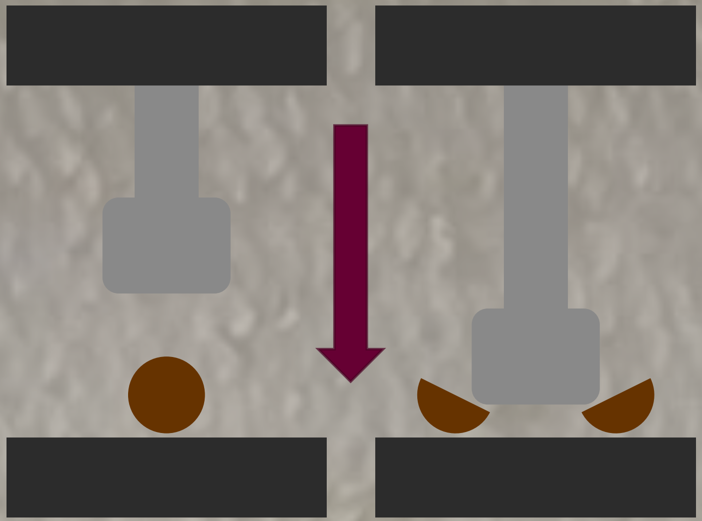
Store frozen

Complete batch information, delivery date, etc.

Third-party?

Store feed properly, and track pellet quality with simple, on-farm tests

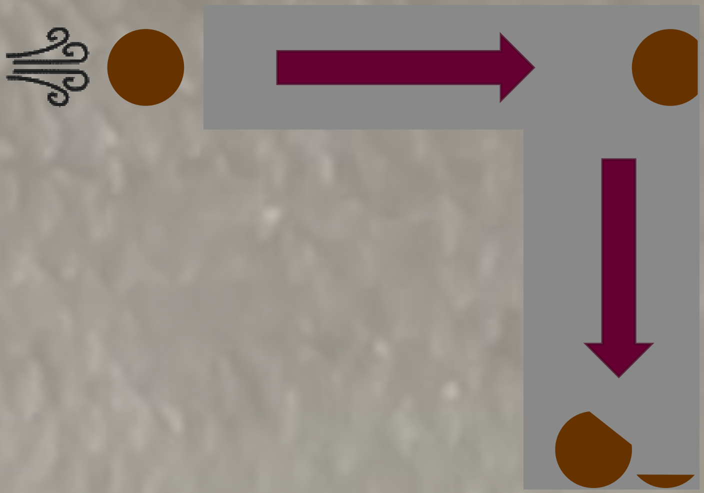
Hardness



Pressure is applied until the pellet breaks or is crushed

Hardness reported in terms of force needed to crack pellet

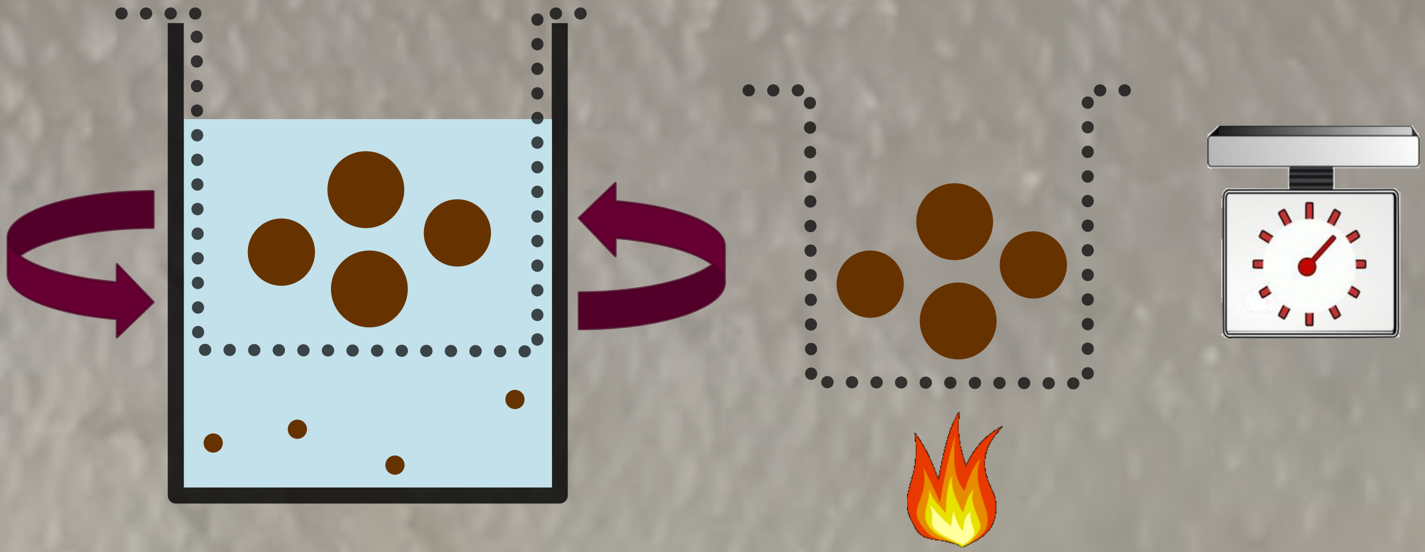
Durability



Pellets are air-driven against a series of right-angle pipe bends

Durability is reported in terms of the amount of fines produced

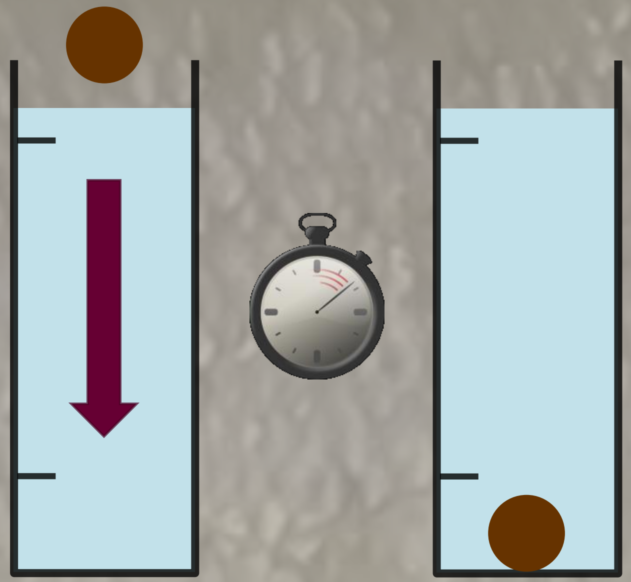
Water stability



Pellets are agitated in water, then dried and weighed

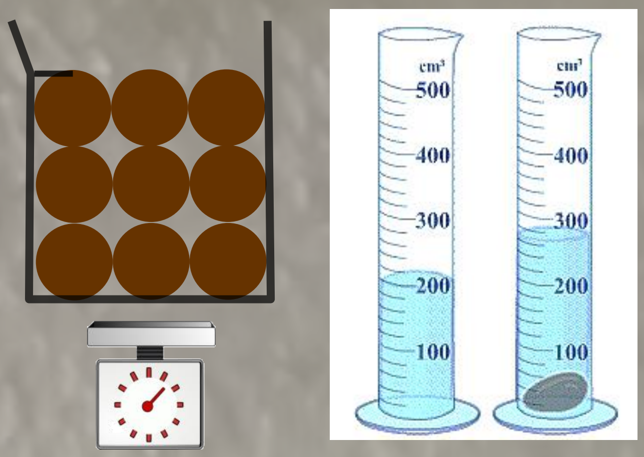
Stability is reported in terms of lost mass

Sinking Velocity

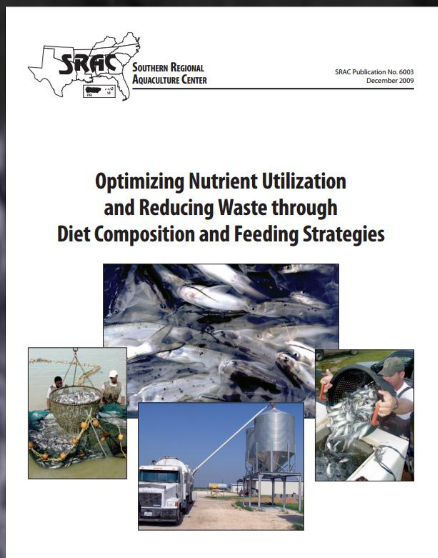


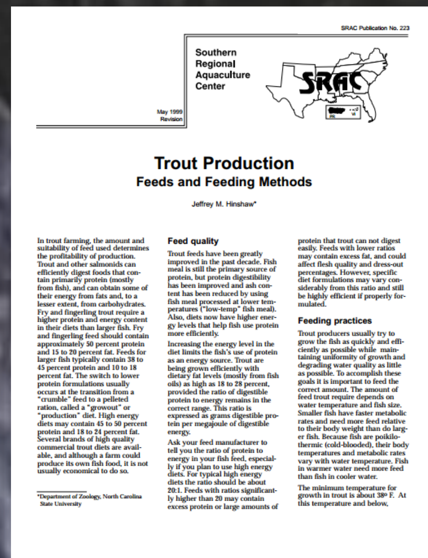
Pellets are dropped into a column of water and sinking through a distance is timed to calculate velocity

Bulk Density



Fill known-volume container with pellets then weigh contents, or determine volume by displacement then weigh pellets




SRAC Publication No. 223

Southern Regional Aquaculture Center

May 1999 Revision

Trout Production
Feeds and Feeding Methods

Jeffrey M. Hinshaw*

In trout farming, the amount and suitability of feed used determines the profitability of production. Trout and other salmonids can efficiently digest foods that contain primarily protein (mostly from fish), and can obtain some of their energy from fats and, to a lesser extent, from carbohydrates. Fry and fingerling trout require a higher protein and energy content in their diets than larger fish. Fry and fingerling feed should contain approximately 50 percent protein and 15 to 20 percent fat. Feeds for larger fish typically contain 38 to 45 percent protein and 10 to 18 percent fat. The switch to lower protein formulations usually occurs at the transition from a "crumble" feed to a pelleted ration, called a "growout" or "production" diet. High energy diets may contain 45 to 50 percent protein and 18 to 24 percent fat. Several brands of high quality commercial trout diets are available, and although a farm could produce its own fish food, it is not usually economical to do so.

*Department of Zoology, North Carolina State University

Feed quality

Trout feeds have been greatly improved in the past decade. Fish meal is still the primary source of protein, but protein digestibility has been improved and ash content has been reduced by using fish meal processed at lower temperatures ("low-temp" fish meal). Also, diets now have higher energy levels that help fish use protein more efficiently.

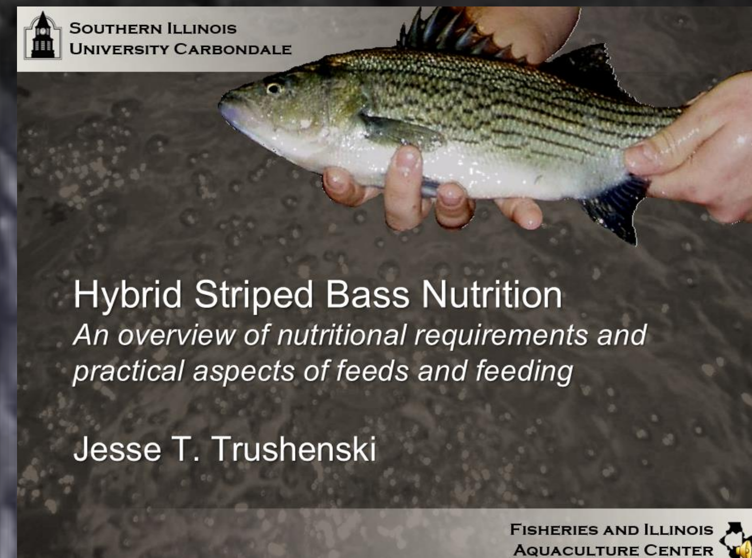
Increasing the energy level in the diet limits the fish's use of protein as an energy source. Trout are being grown efficiently with dietary fat levels (mostly from fish oils) as high as 18 to 28 percent, provided the ratio of digestible protein to energy remains in the correct range. This ratio is expressed as grams digestible protein per megajoule of digestible energy.

Ask your feed manufacturer to tell you the ratio of protein to energy in your fish feed, especially if you plan to use high energy diets. For typical high energy diets the ratio should be about 20:1. Feeds with ratios significantly higher than 20 may contain excess protein or large amounts of protein that trout can not digest easily. Feeds with lower ratios may contain excess fat, and could affect flesh quality and dress-out percentages. However, specific diet formulations may vary considerably from this ratio and still be highly efficient if properly formulated.

Feeding practices

Trout producers usually try to grow the fish as quickly and efficiently as possible while maintaining uniformity of growth and degrading water quality as little as possible. To accomplish these goals it is important to feed the correct amount. The amount of feed trout require depends on water temperature and fish size. Smaller fish have faster metabolic rates and need more feed relative to their body weight than do larger fish. Because fish are poikilothermic (cold-blooded), their body temperatures and metabolic rates vary with water temperature. Fish in warmer water need more feed than fish in cooler water.

The minimum temperature for growth in trout is about 38° F. At this temperature and below,



Questions?