DIETARY MODULATION OF PUBERTY AND MATURATION PROCESS IN FISH

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Conference and Workshop on Age and Size at Maturity of Chinook Salmon and other Pacific Salmonids

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University of Guelph | Ontario Ministry of Natural Resources
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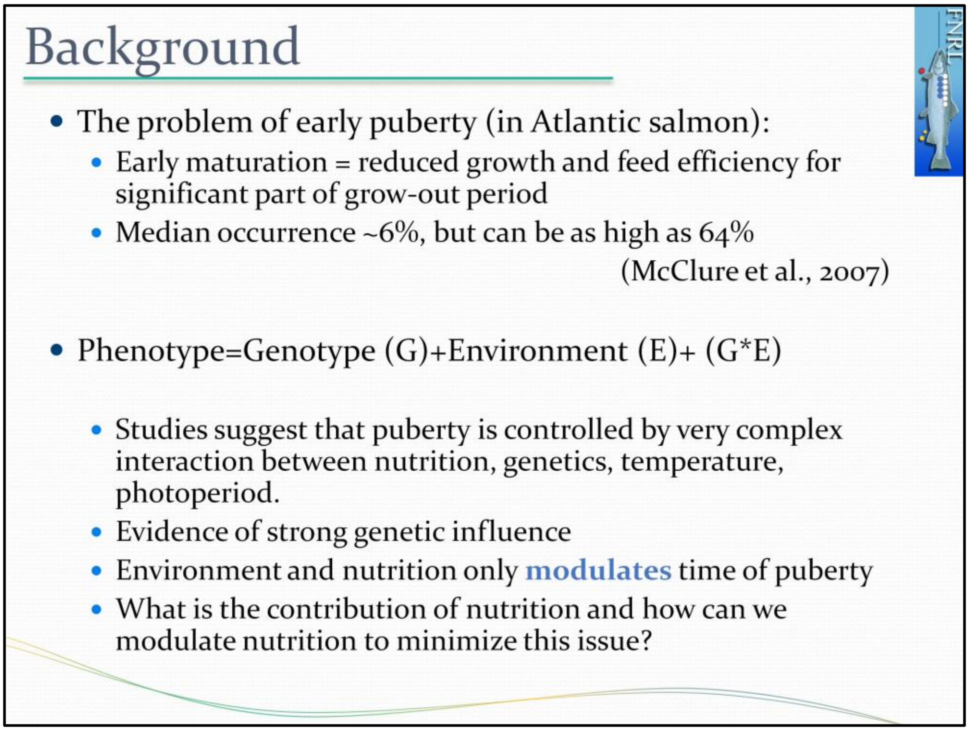


Smaller fish produce fewer eggs. Chinook salmon reproduce only once in their life-time, thus precocious puberty results in lower fecundity, and fewer fingerlings released in the river. In the context of aquaculture for food fish species (Atlantic salmon or rainbow trout), precocious puberty reduces growth and feed efficiency, thus causing significant financial losses.

Nutrition and puberty

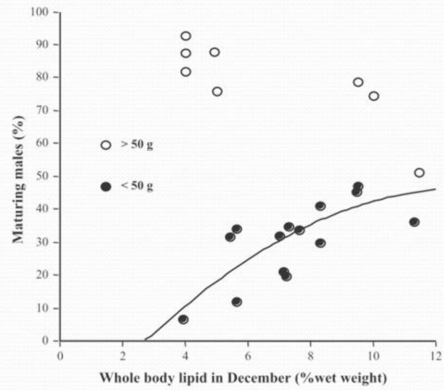
- Number of studies is very limited
  - Shearer et al., 2006. Aquaculture 252:545
    - Chinook salmon
  - McClure et al., 2007. Aquaculture 272:370
    - Atlantic salmon
  - Taranger et al., 2010, Gen. Comp. Endocr. 165:483
    - Atlantic salmon, Atlantic cod, Atlantic halibut, European seabass
- Incidence of early puberty correlated with high body weight (BW) at an early age
  - High BW on Aug in SW for Atlantic salmon or December for Chinook salmon
  - High incidence following relatively warm winters
- Lipid reserves have been suggested as having a potential impact.

FNRL

The correlation between body weight and body lipid content months before sexual maturation shows the existence of a critical, species-specific, time window during which the fish "makes the decision" to mature of not (see Penny Swanson's presentation).

Body lipids & puberty

- Early puberty in Chinook salmon:
  - Main effect = body weight in December
  - Also significant effect of whole body lipid
  - Lesser occurrence of puberty in "leaner" fish with low / average weight?



Shearer et al., 2006

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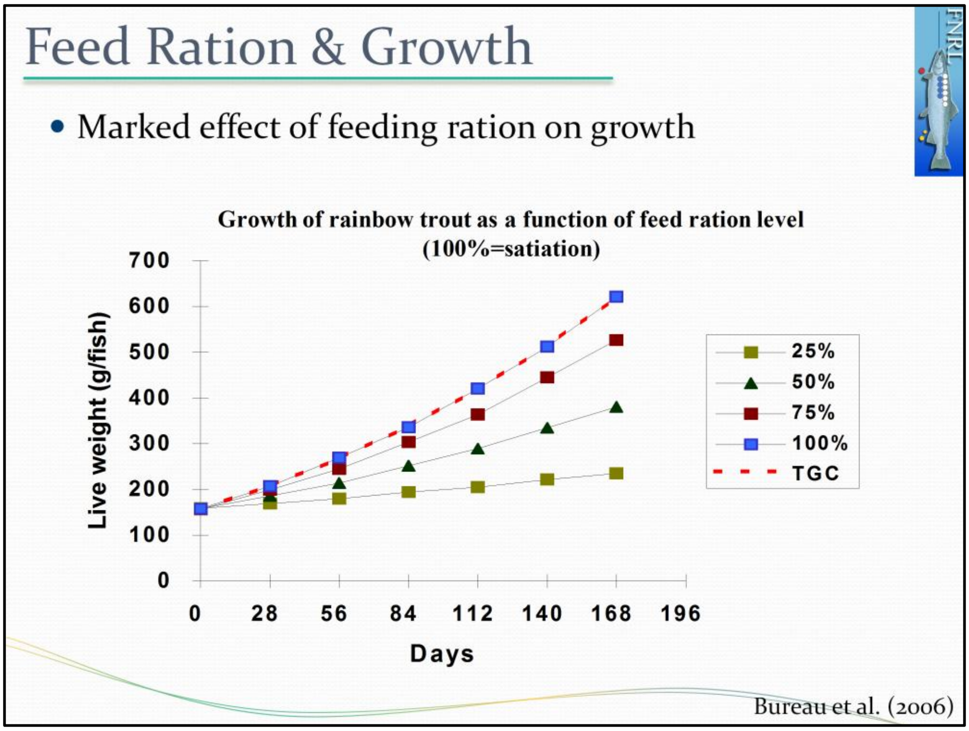
Nutrition, Growth and Body Composition

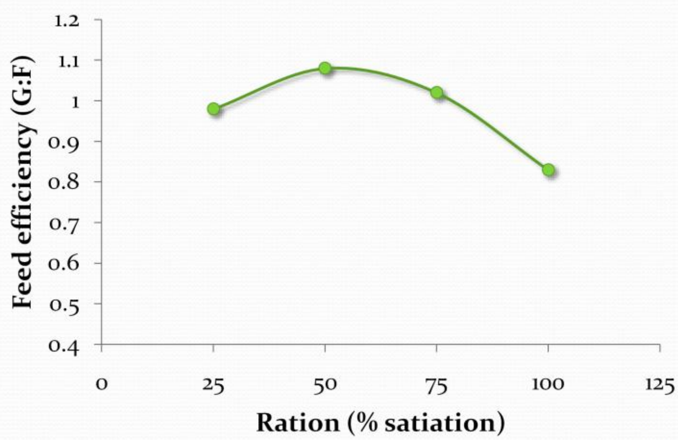
Assessing the impact of nutrition



As expected, restricting feed ration reduces the growth of rainbow trout.

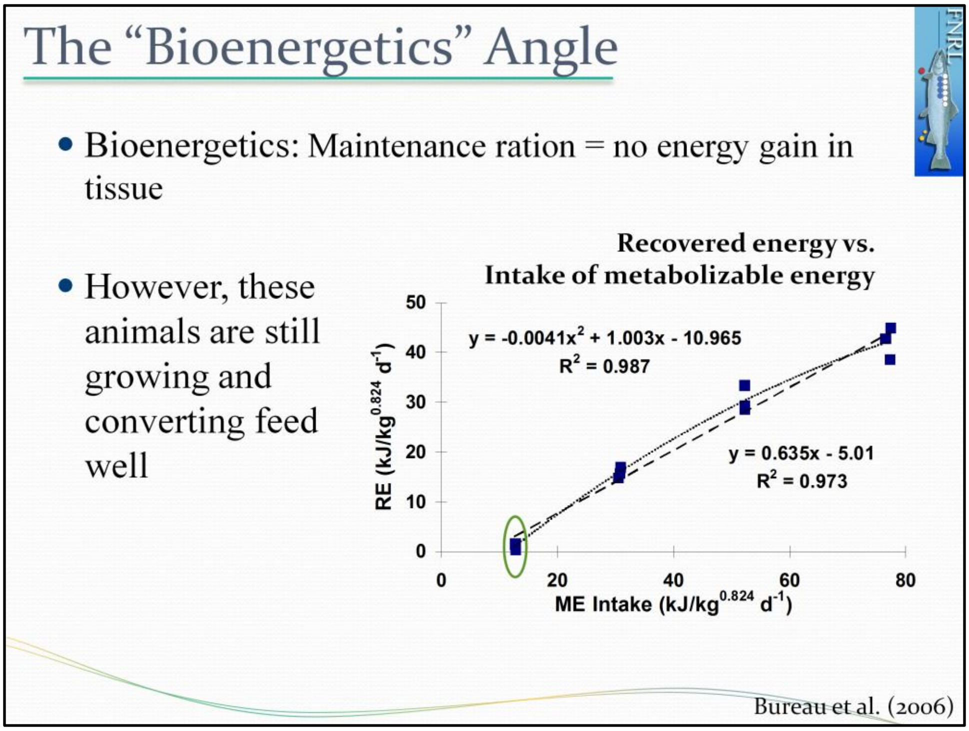
Feed ration & FE

- High FE maintained unless fish fed high rations

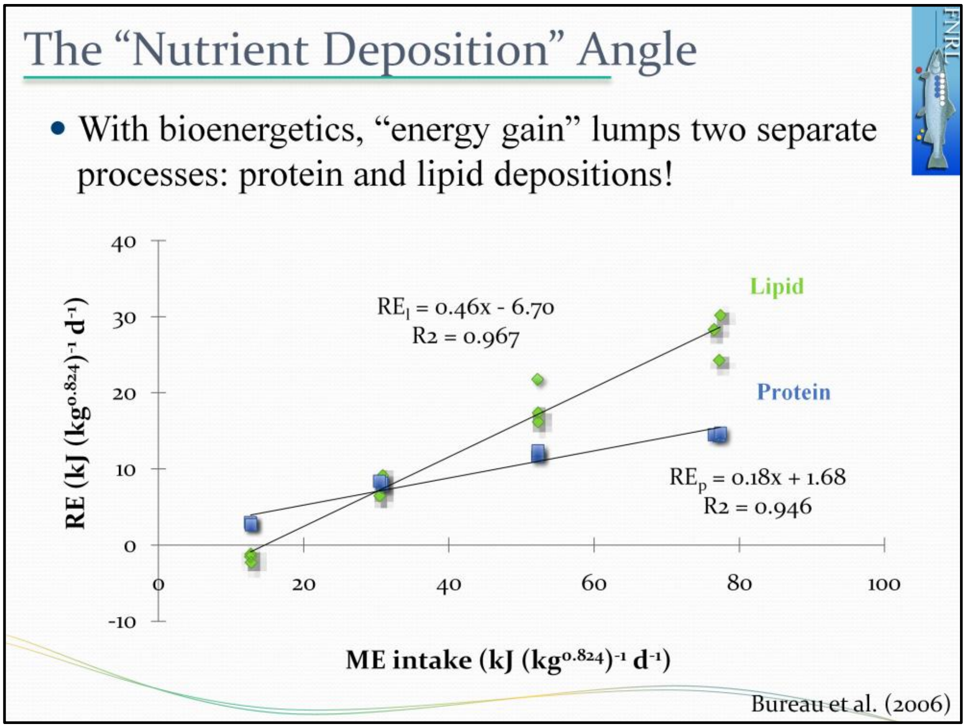


Bureau et al. (2006)

However, feed efficiency remains high even at very low feeding levels, and is only reduced at very high feeding levels.



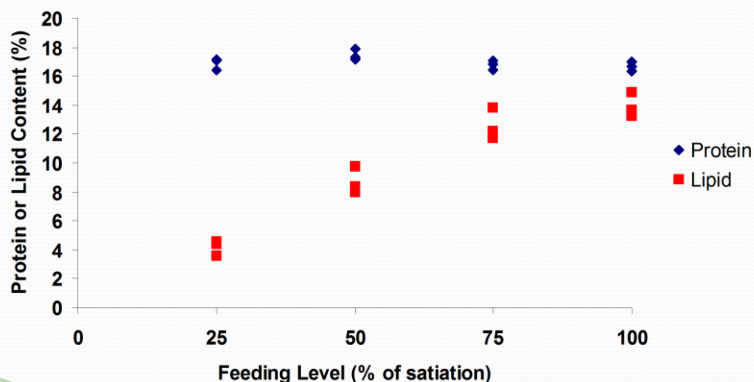
Bioenergetic is the traditional approach in nutrition modeling, where all diet and body nutrients are summarized into their energy value. Energy intake is linearly correlated with deposited energy on a metabolic body weight-basis. However, based on previous slides, fish fed 25% satiation still grow and convert feed well, thus showing some limitation of the bioenergetic approach.



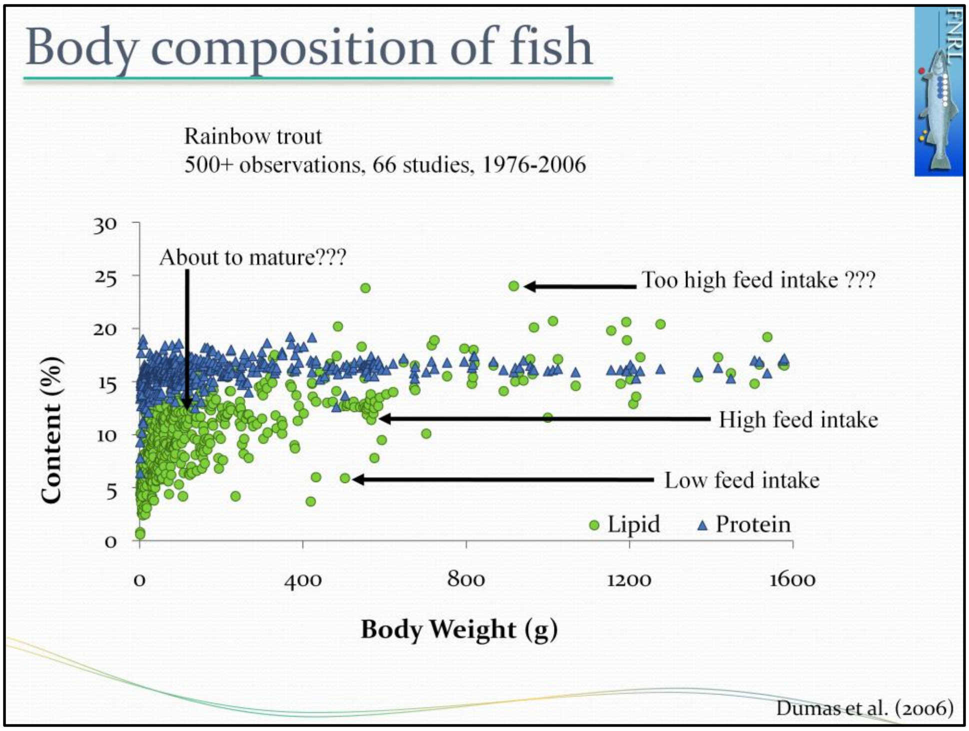
Nutrient-based modeling is an alternative approach, where deposition is considered for each nutrient separately. Interpretation of the previous data according to this model shows that lipid deposition rate is much more sensitive to feed ration than that of protein.

Ration & body composition

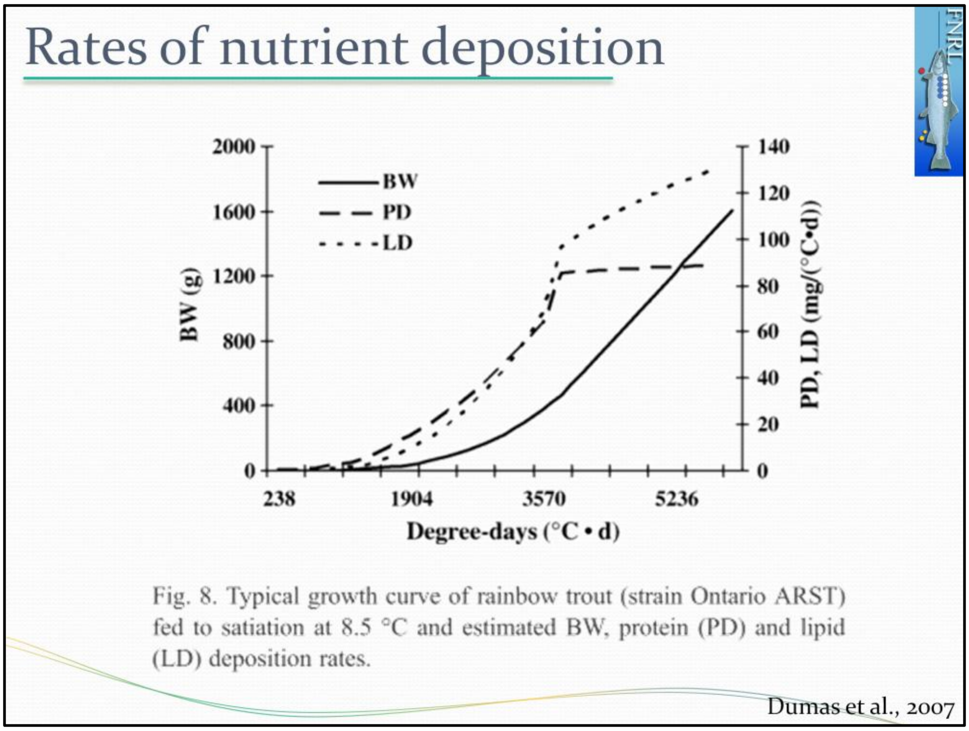
- Protein concentration remains pretty constant despite feed restriction
- Lipid concentration very significantly affected by feed restriction



The previous result is verified in the body composition: protein content of the whole fish is unchanged by feeding levels, while lipid content increases with feeding level.



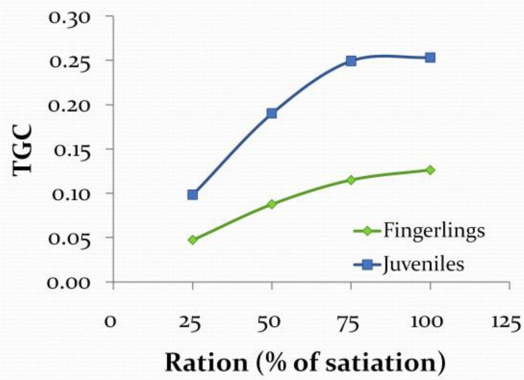
Meta-analyses of 66 studies in rainbow trout covering a wide range of body weights shows that protein content starts low in young individuals, and stabilizes around 18%, regardless of body weight. Contrarily, lipid content is highly variable and remains plastic across all life stages. Therefore leaner fish may be obtained at the critical time for onset of puberty by manipulating feed rations.



Around 400g body weight, the deposition rates of protein and lipid switch from an exponential increase pattern to a linear pattern. Protein deposition rate stabilizes while lipid deposition rate continues to increase, although more slowly. The link between this switch in nutrient deposition dynamics and time of puberty has been suggested. However, this switch occurs much later after the critical decision window (see slide 3).

Feeding level vs. TGC

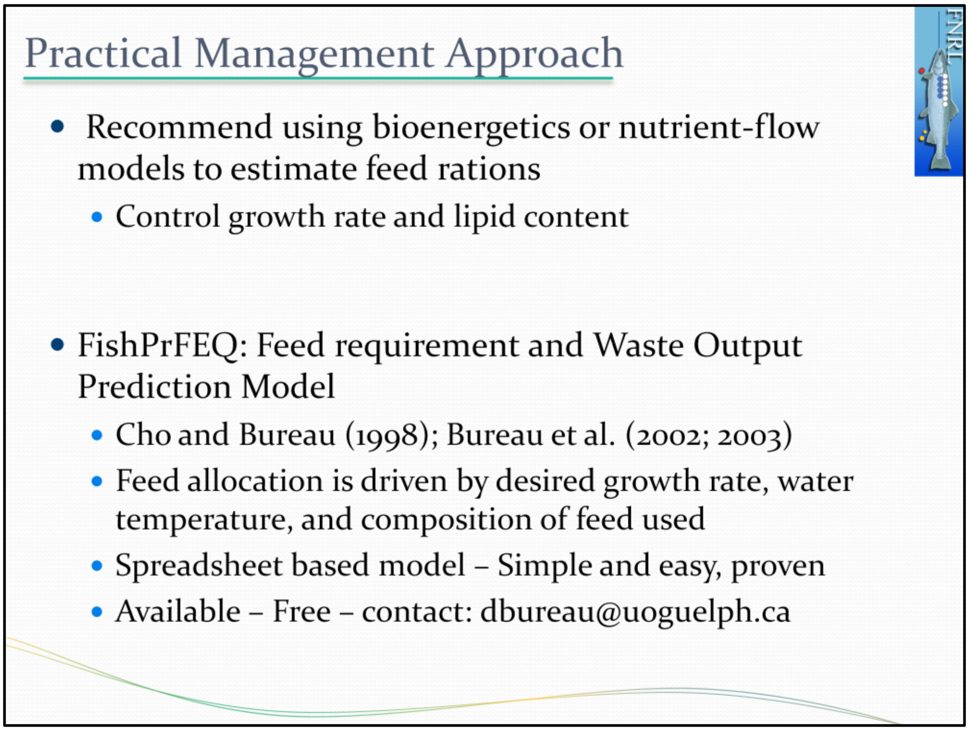
- Rainbow trout can overfeed at certain life stages
- Moderate feed restriction may be useful to minimize lipid deposition



The effects of overfeeding are life stage-dependent in rainbow trout: feeding at 100% satiation did not result in higher growth rates in juvenile, while it did in fingerlings. Therefore, feed ration can be used to limit lipid deposition while maintaining growth rates.

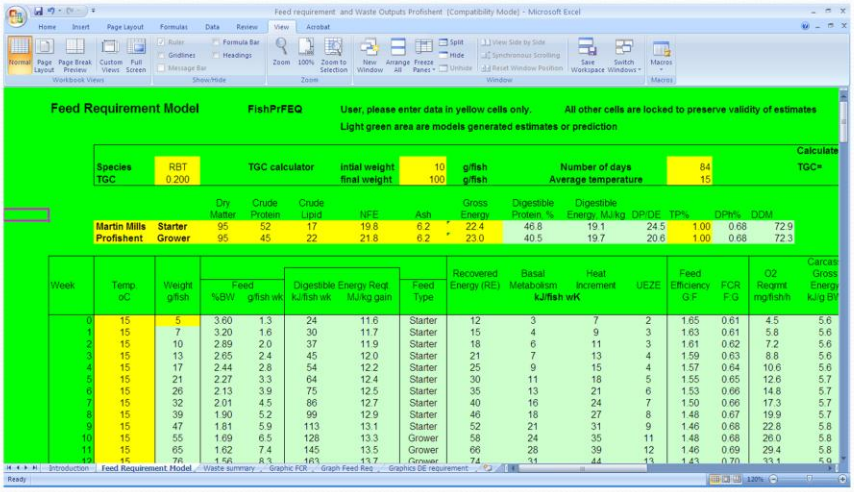
Control of growth and body composition

- Live weight gain, protein and lipid depositions rates are driven/controlled by numerous factors:
  - Exogenous: nutrition, temperature, etc.
  - Endogenous factors: genetic, life stage, sex, etc.
- Body protein content (%)
  - Determined by genetic and live weight of the animal
  - Very strong association of protein and water gains= highly stable protein content regardless of nutritional status
- Body lipid content (%)
  - highly affected by nutritional status and many other endogenous and physiological parameters (genetics, sex, ploidy, season, etc.)
  - Weight gain and lipid concentration very easily manipulated by nutrition (notably ration level)



The key is to find the right balance between 1) controlled growth and lipid deposition in order to limit precocious puberty and 2) attain the farm/hatchery objectives, especially in term of fish size for economical viability or practical constrains for tagging. Using a model can be used as a scenario-testing tool as well as a management tool to achieve the intended target.

Fish-PrFEQ Model



Feed requirement and Waste Outputs Profishent [Compatibility Mode] - Microsoft Excel

Feed Requirement Model **FishPrFEQ** **User, please enter data in yellow cells only.** **All other cells are locked to preserve validity of estimates**

Light green area are models generated estimates or prediction

Species	RBT	**TGC calculator**	**intial weight**	10	**g/fish**	**Number of days**	84
TGC	0.200		**final weight**	100	**g/fish**	**Average temperature**	15

Calculate TGC=

		Dry Matter	Crude Protein	Crude Lipid	NFE	Ash	Gross Energy	Digestible Protein, %	Digestible Energy, MJ/kg	DP/DE	TP%	DPh%	DDM
Martin Mills	**Starter**	95	52	17	19.8	6.2	22.4	46.8	19.1	24.5	1.00	0.68	72.9
Profishent	**Grower**	95	45	22	21.8	6.2	23.0	40.5	19.7	20.6	1.00	0.68	72.3

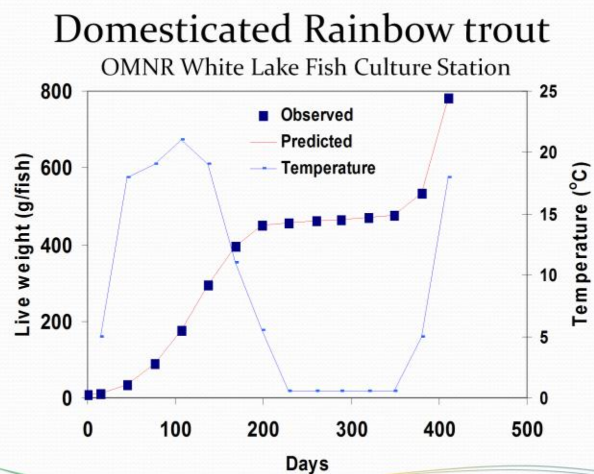
Week	Temp. oC	Weight g/fish	Feed %BW	Feed g/fish wk	Digestible Energy Reqt kJ/fish wk	Digestible Energy Reqt MJ/kg gain	Feed Type	Recovered Energy (RE) kJ/fish wK	Basal Metabolism kJ/fish wK	Heat Increment kJ/fish wK	UEZE	Feed Efficiency G:F	FCR F:G	O2 Reqrmt mg/fish/h	Carcass Gross Energy kJ/g BW
0	15	5	3.60	1.3	24	11.6	Starter	12	3	7	2	1.65	0.61	4.5	5.6
1	15	7	3.20	1.6	30	11.7	Starter	15	4	9	3	1.63	0.61	5.8	5.6
2	15	10	2.89	2.0	37	11.9	Starter	18	6	11	3	1.61	0.62	7.2	5.6
3	15	13	2.65	2.4	45	12.0	Starter	21	7	13	4	1.59	0.63	8.8	5.6
4	15	17	2.44	2.8	54	12.2	Starter	25	9	15	4	1.57	0.64	10.6	5.6
5	15	21	2.27	3.3	64	12.4	Starter	30	11	18	5	1.55	0.65	12.6	5.7
6	15	26	2.13	3.9	75	12.5	Starter	35	13	21	6	1.53	0.66	14.8	5.7
7	15	32	2.01	4.5	86	12.7	Starter	40	16	24	7	1.50	0.66	17.3	5.7
8	15	39	1.90	5.2	99	12.9	Starter	46	18	27	8	1.48	0.67	19.9	5.7
9	15	47	1.81	5.9	113	13.1	Starter	52	21	31	9	1.46	0.68	22.8	5.8
10	15	55	1.69	6.5	128	13.3	Grower	58	24	35	11	1.48	0.68	26.0	5.8
11	15	65	1.62	7.4	145	13.5	Grower	66	28	39	12	1.46	0.69	29.4	5.8
12	15	76	1.56	8.3	163	13.7	Grower	74	31	44	13	1.43	0.70	33.1	5.9

Introduction | Feed Requirement Model | Waste summary | Graphic FCR | Graph Feed Req | Graphics DE requirement

Ready

Modeling fish growth

- TGC can accurately predict fish live weight in time and with varying temperatures



TGC is a practical growth model, especially when water temperature is not (cannot be) maintained constant.

Plant feedstuffs: Emerging Issue?

- Plant feedstuffs (e.g. soy or corn products) contain phyto-oestrogens
- Feeding soybean-based diet vs. commercial trout diet to 1.5 y-o juvenile Siberian sturgeons for 15 weeks increases 10 fold vitellogenin plasma levels
  - Similar results with rainbow trout but lower sensitivity
- When feeding diet with graded levels of genistein (isoflavone, phyto-oestrogen) to rainbow trout (IBW = 40 g)
  - Males: faster testicular development, decreased sperm motility and concentration
  - Females: increased VTG, spawning delayed at 500 ppm, but not 0 or 1000 ppm

Bennetau-Pelissero et al., 1998, 2001

Also see Ann Gannam's presentation.

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Thank you!