BIOENERGETICS OF COBIA AND MOI

APPLICATIONS TO OFFSHORE CULTURE AND MODELING

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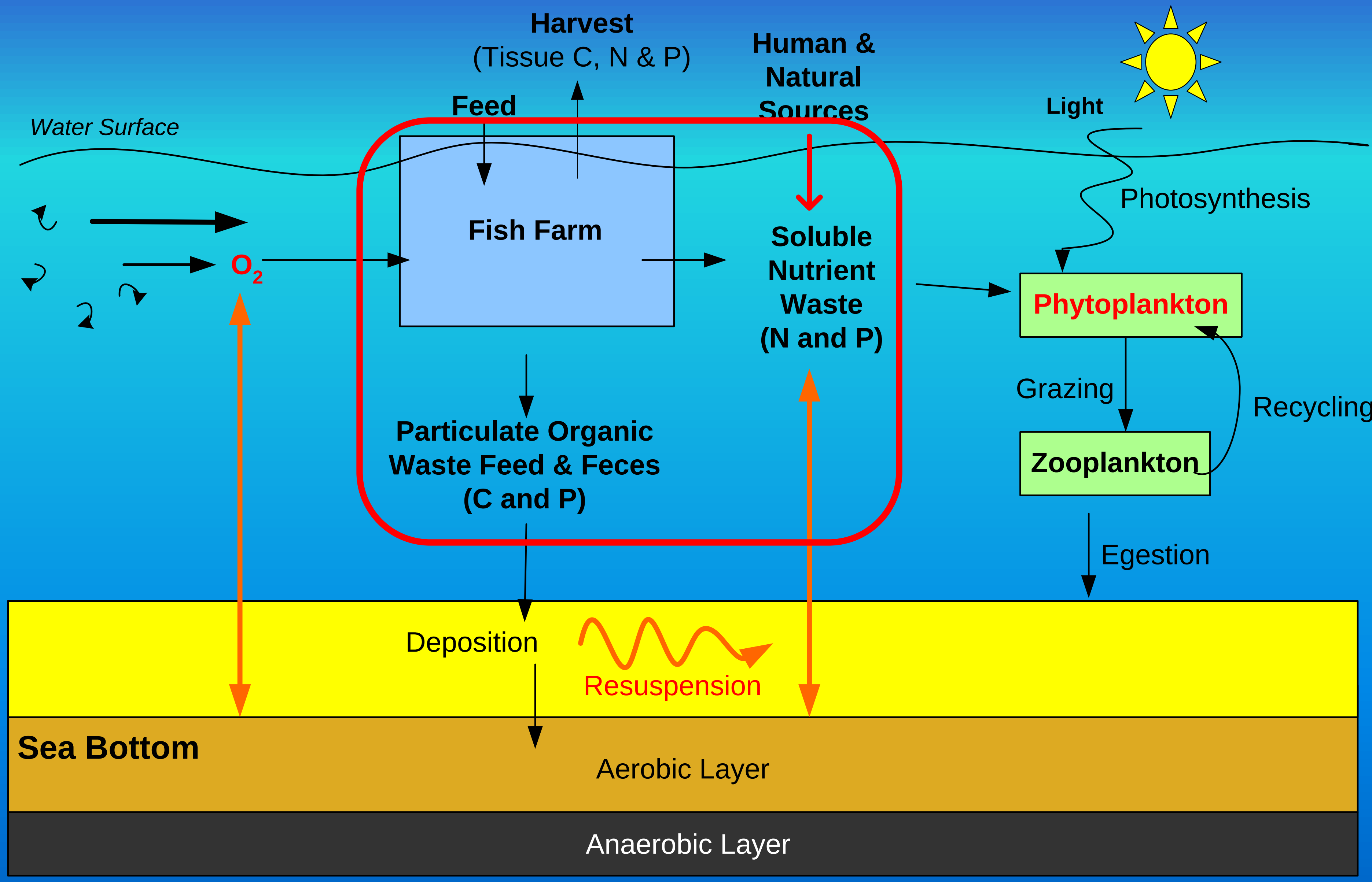
Overview

- Focus is juvenile & subadult moi & cobia: studies ongoing
- Few prior bioenergetic studies of larger fish for ongrowing
- Respiration, excretion and fecal settling rate
- Compare to salmon - benchmarks, factoring in temp. diff.
- Fish assimilation and fecal composition studies ongoing
- All work at NOAA NWFSC Seattle AquaLab ~ 26°C

AquaModel Components



Bioenergetics Component of AquaModel

- Virtual fish population living in “mass balance” system
- Fish eat, grow, swim, metabolize, respire, excrete, egest
- Carbon, nitrogen and oxygen stoichiometry
- Holistic water column + benthic system - interlinked
- “Submodels” salmon, striped bass, cobia, moi, sablefish
- Constants & rates vary – we use literature & empirical rates

Respiration: Oxygen flux

Goal: predict critical period oxygen minima for given farm – pen configuration, feeding cycle, flow rate

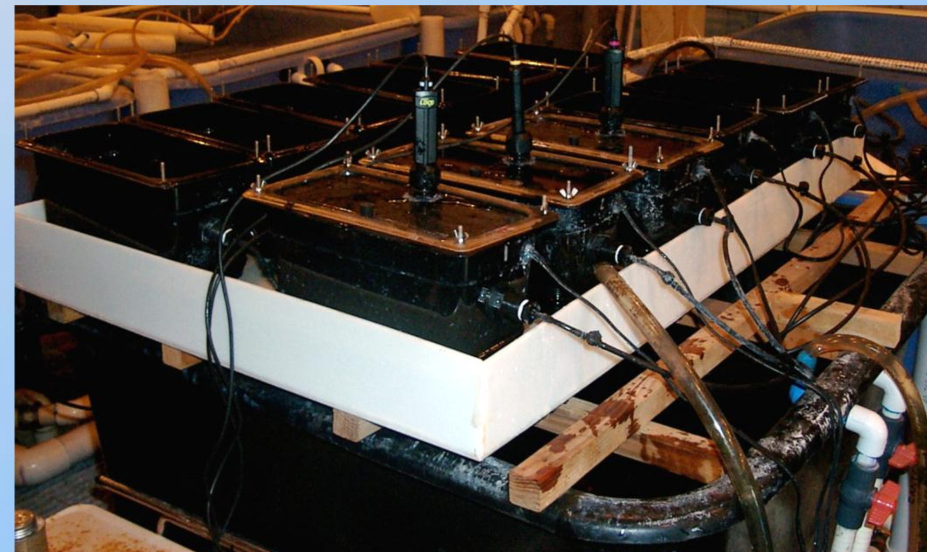
Avoidance of low DO =
healthier fish, faster growth

Respiration rate =
resting rate (basal metabolism)
+ active (swimming)
+ anabolic activity (growth)

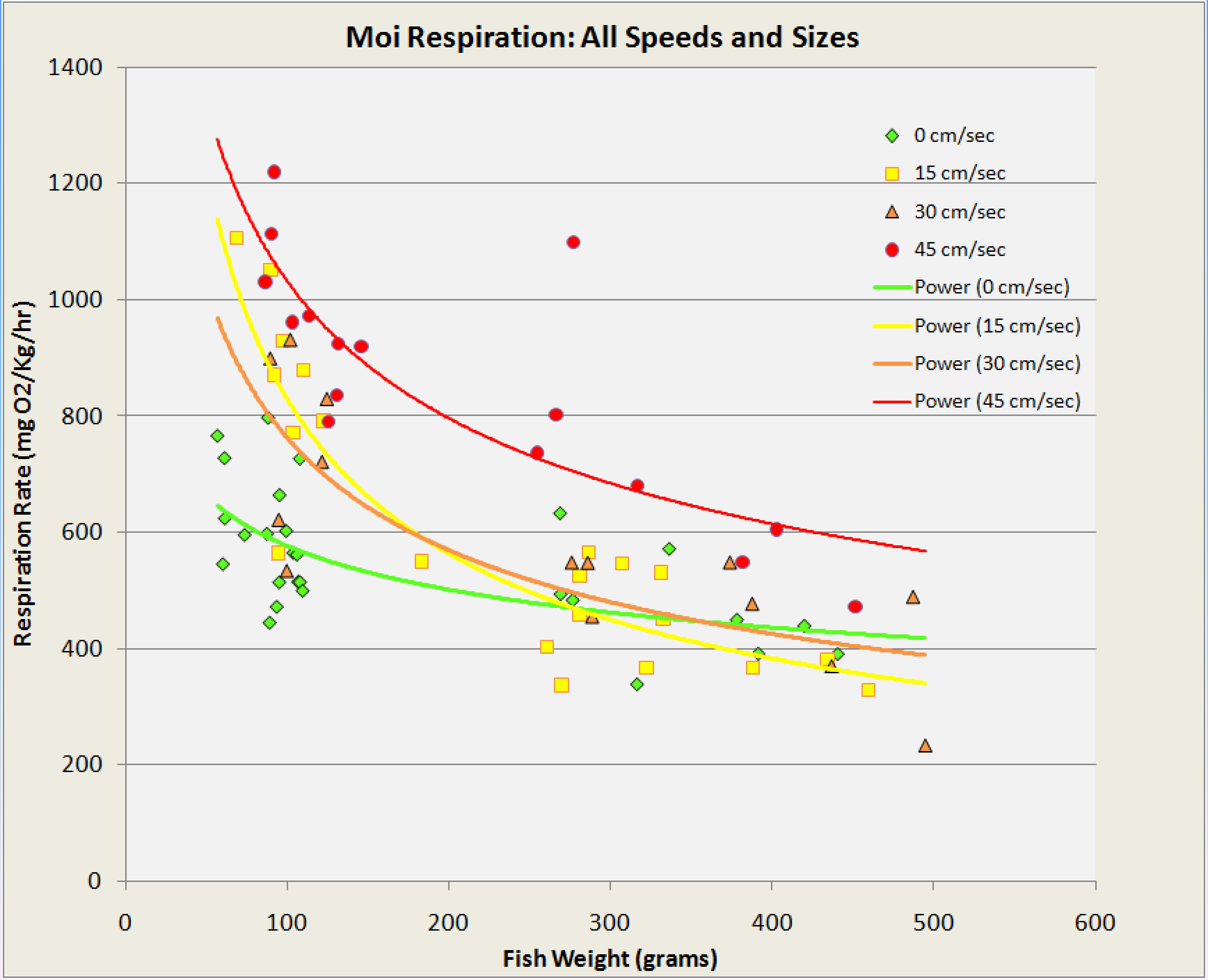
Closed system swim respirometers:
Acclimation and extended swim trials
Luminescent DO oxygen probes (LDO)

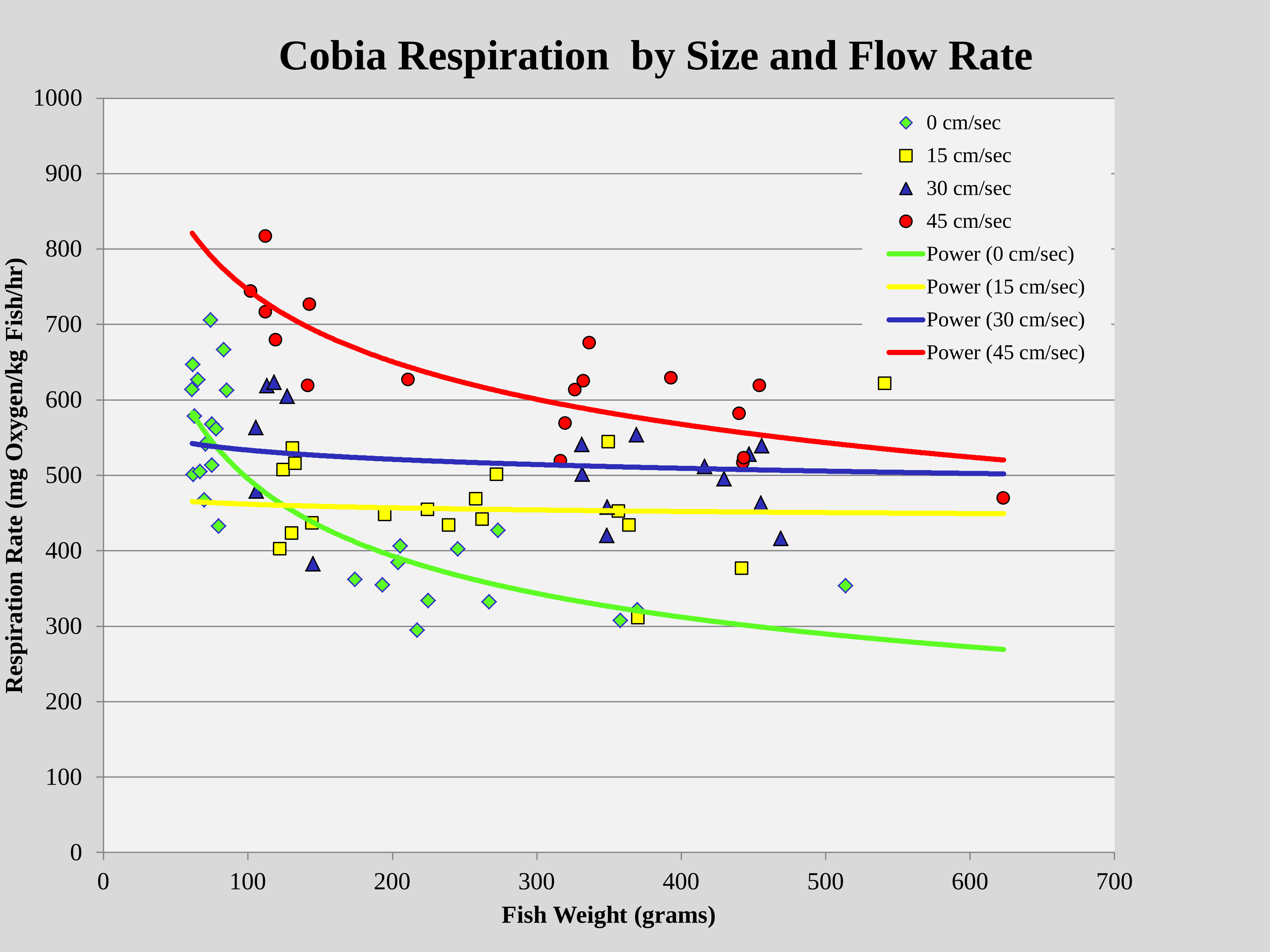
Fish swim respirometers

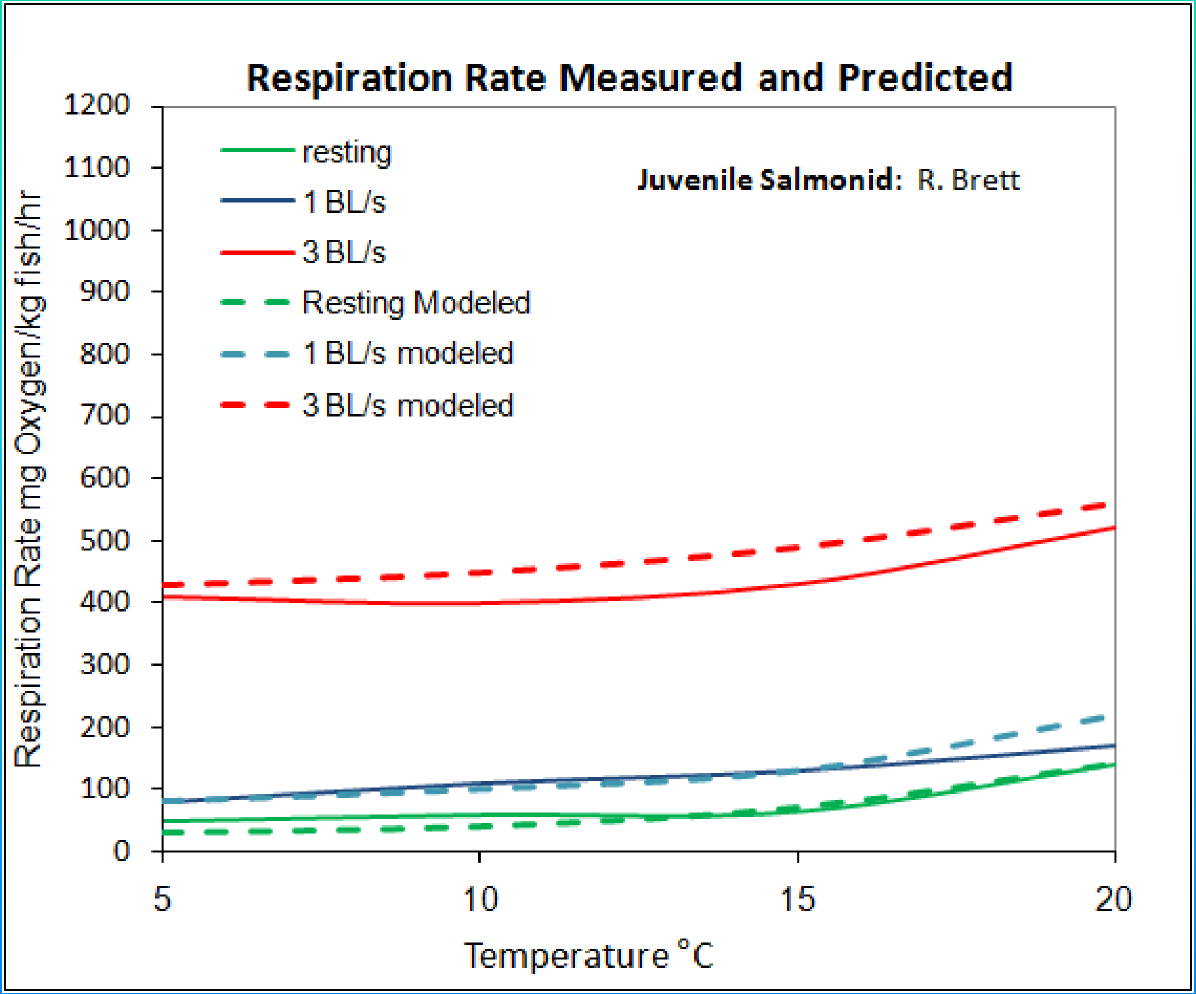
Fish static respirometers



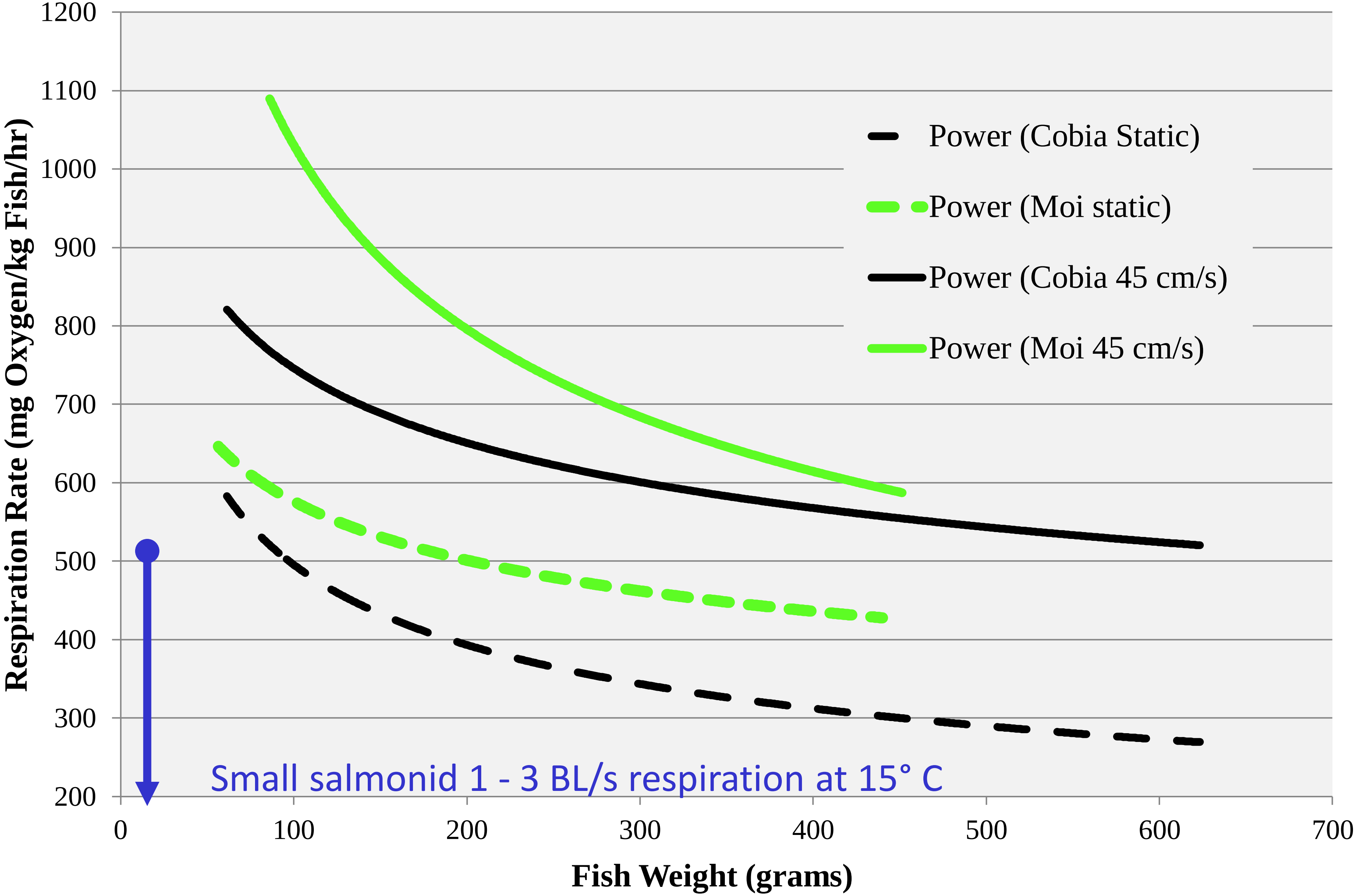
Hawaiian Moi
(Pacific Threadfish, *Polydactylus sexfilis*)


Moi Respiration: All Speeds and Sizes
Respiration Rate (mg O2/Kg/hr)
Fish Weight (grams)
0 cm/sec
15 cm/sec
30 cm/sec
45 cm/sec
Power (0 cm/sec)
Power (15 cm/sec)
Power (30 cm/sec)
Power (45 cm/sec)
0
200
400
600
800
1000
1200
1400
0
100
200
300
400
500
600


Cobia Respiration by Size and Flow Rate
Respiration Rate (mg Oxygen/kg Fish/hr)
Fish Weight (grams)
0 cm/sec
15 cm/sec
30 cm/sec
45 cm/sec
Power (0 cm/sec)
Power (15 cm/sec)
Power (30 cm/sec)
Power (45 cm/sec)
1000
900
800
700
600
500
400
300
200
100
0
0
100
200
300
400
500
600
700


Respiration Rate Measured and Predicted
Juvenile Salmonid: R. Brett
resting
1 BL/s
3 BL/s
Resting Modeled
1 BL/s modeled
3 BL/s modeled
Respiration Rate mg Oxygen/kg fish/hr
Temperature °C
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
5
10
15
20

Moi & Cobia Respiration: Static vs. Fast Swimming



Excretion Rate Bioassays

Goal: Predict nitrogen flux from pens – phytoplankton /zooplankton production

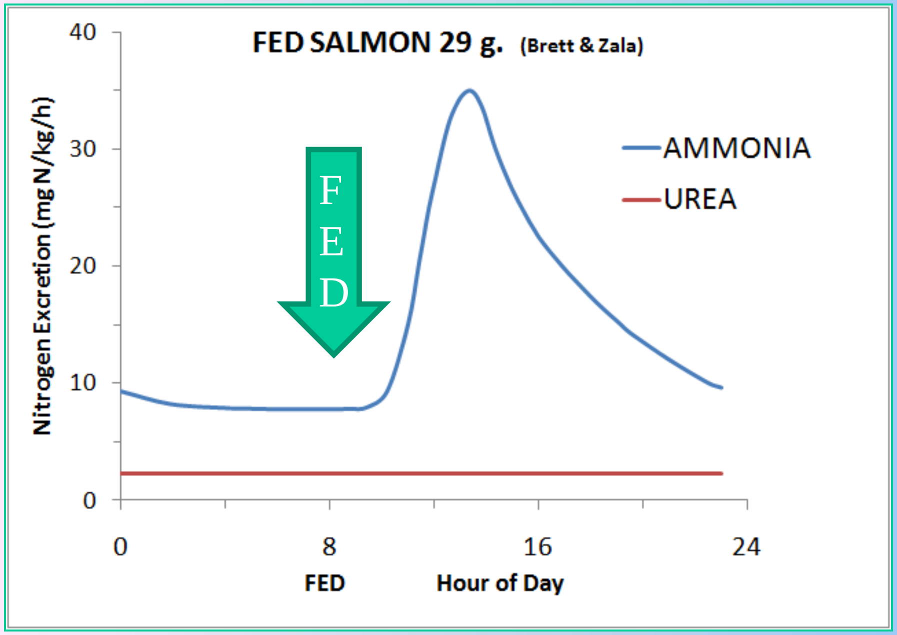
Dissolved nitrogen excretion rates = total ammonia N + urea N + other.

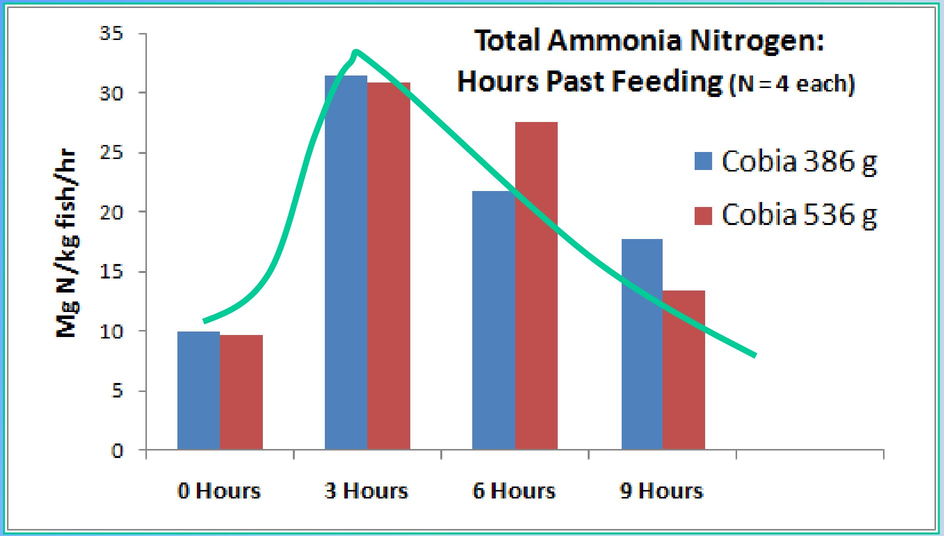
“Other” = unexplained fraction - can be significant ~ 20% in RBT

(e.g., Smith 1929 , Kajimura et. al 2004, McMaster Univ. Ontario)

Considerable variance of N excretion rate and components among species

Benchmark is salmon - best described species



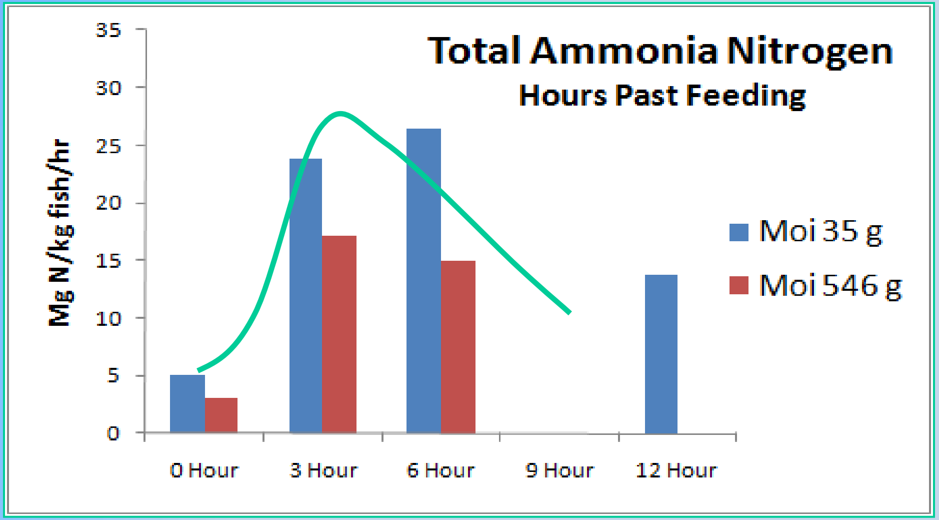


Cobia

-Not high compared to salmon despite higher temp & faster growth!

- Urea constant ~ 4 mg/kg/hr

- 17 to 45% of TN explained by TAN + urea (not shown here)



Moi

- Lower than cobia as expected
- Urea constant ~ 2 mg/kg/hr
- Stressed after 6+ hours
- 62% of TN explained by TAN + urea (not shown here)
- Stress related or normal?

- Ammonia rate increases with feeding
- Prior modeling or monitoring: only used TAN (or DIN).
- Dissolved total N excretion rates grossly understated with TAN only.

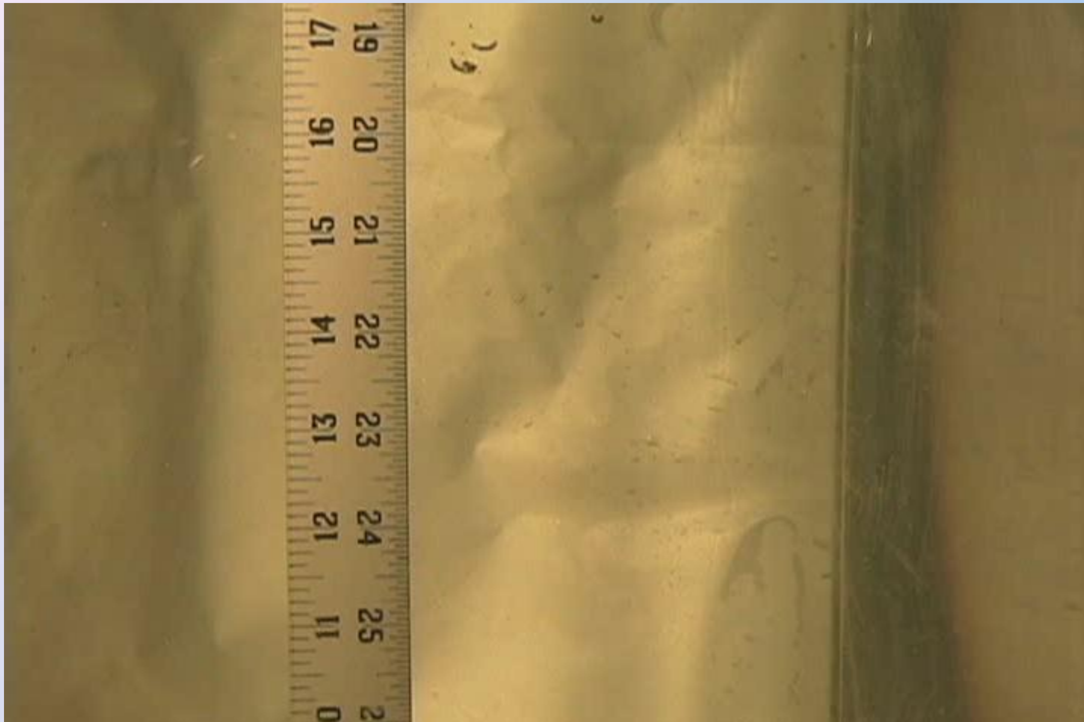
Fish Fecal Settling Rates

Waste Feed & Feces: Model tracks them separately

Sinking rates derived from anaesthetized, previously fed fish directly

Settling columns attached to Imhoff cones: measure volume/unit time

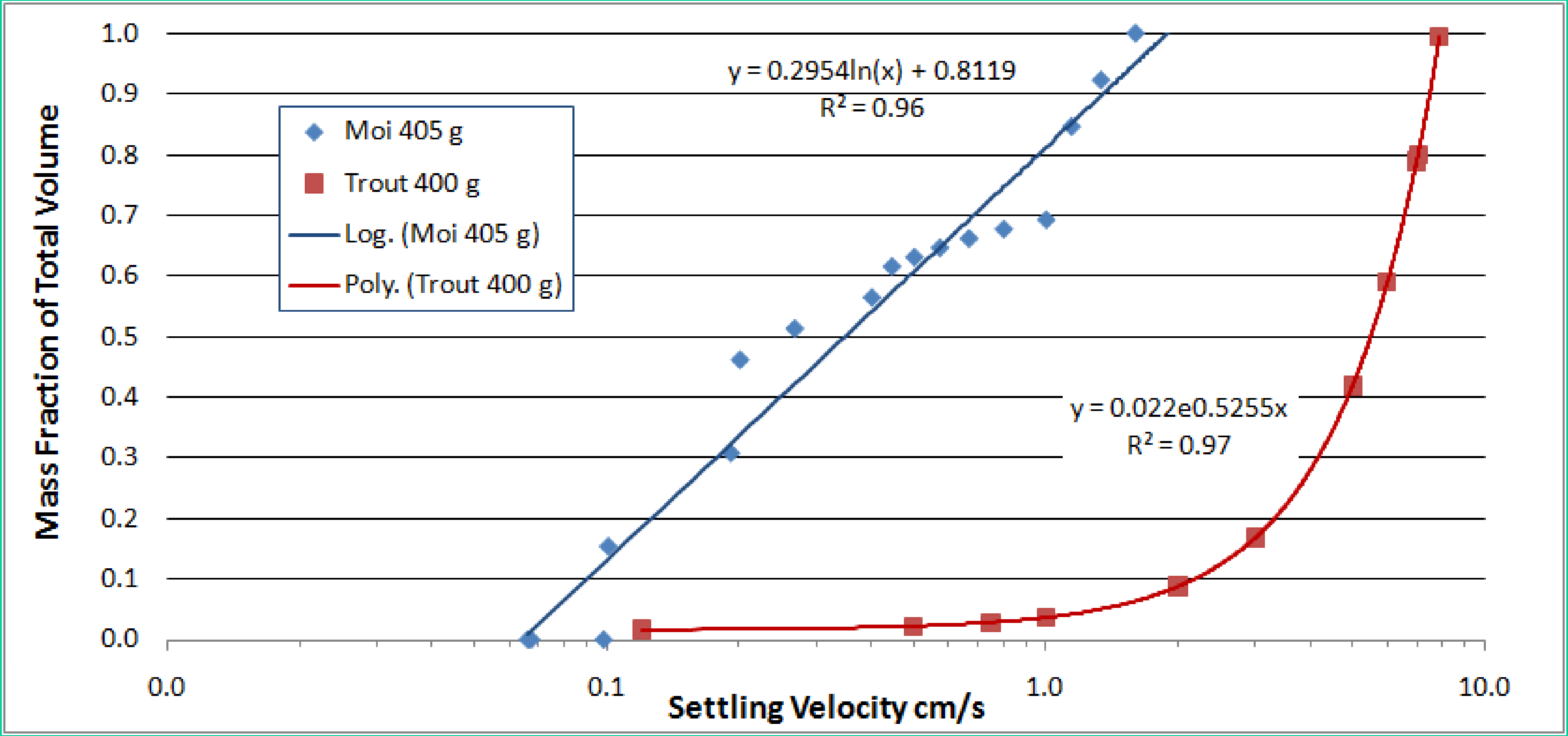
Marine Fish Feces



400 g Trout Feces

Six Inch (~15 cm) Dia.
Container width

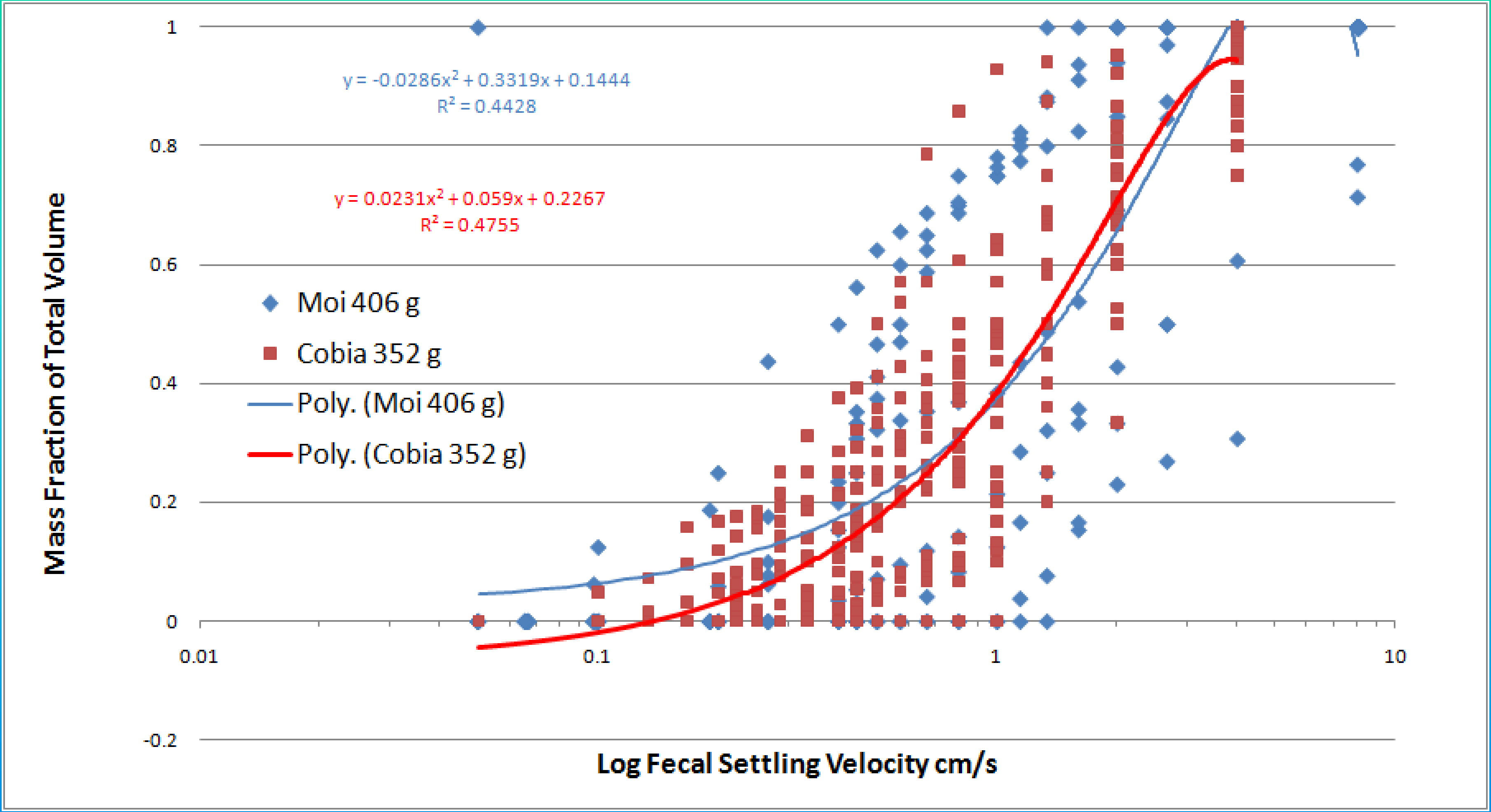
Our Motto: Feces Happens – Deal with it!



405 g Moi (example single fish)
Imhoff Cone - Column Method

400 g Rainbow Trout* (trend line)
Individual fecal pellet trials
Mean rate ~ 5.3 cm/s

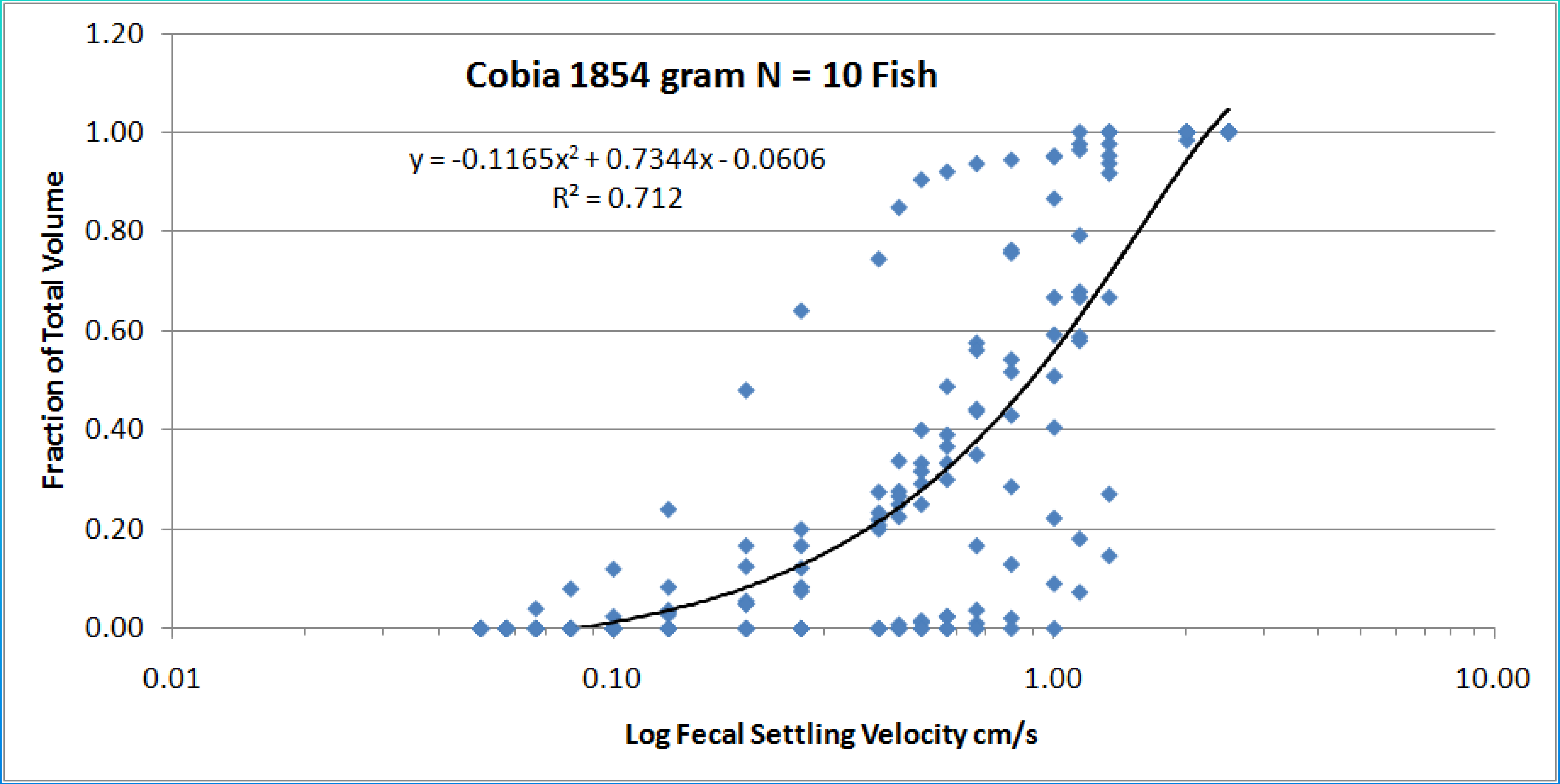
*Richard Moccia, David Bevan and Gregor Reid. 2007
Univ. of Guelph Aquaculture Center, with permission



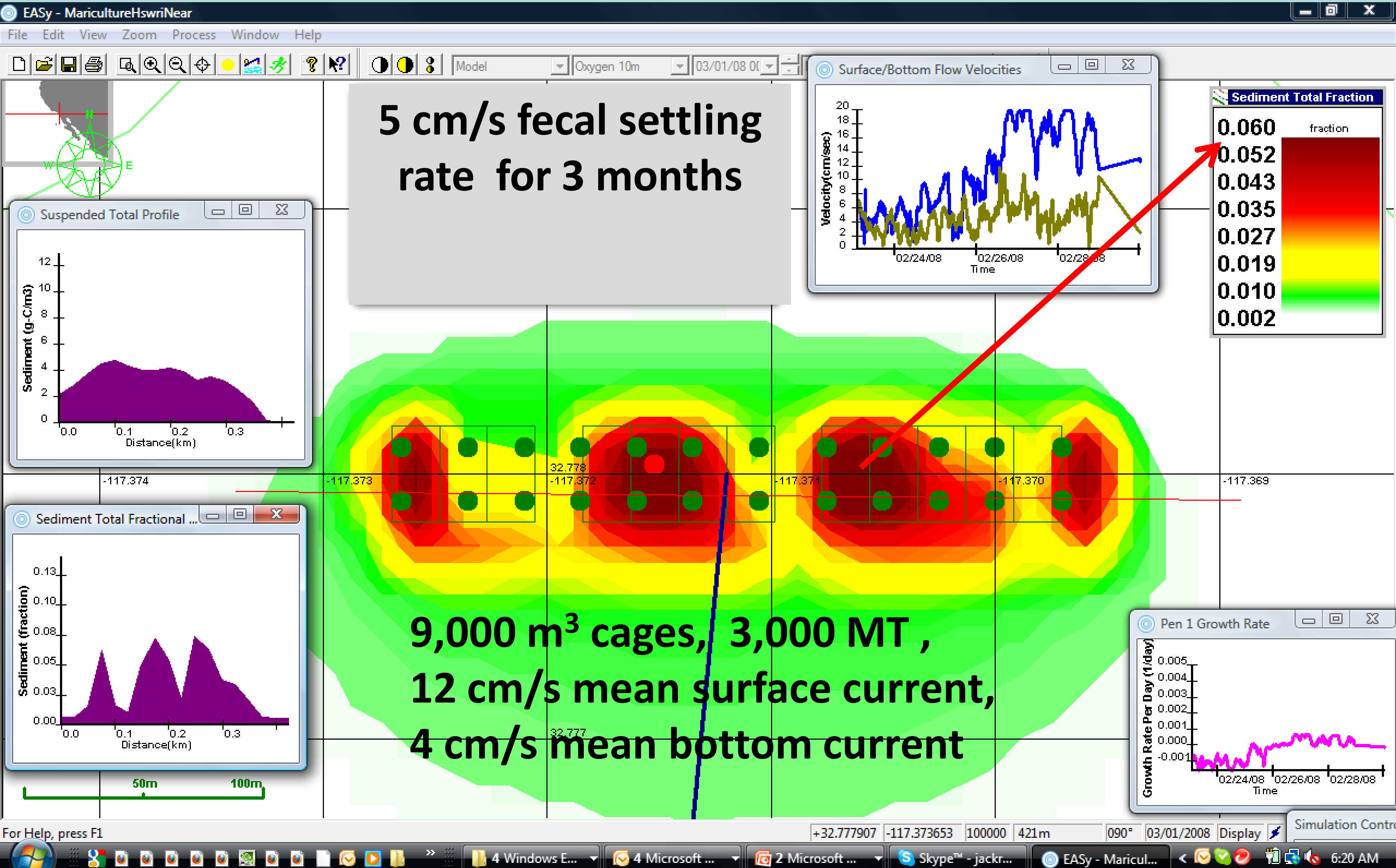
- Binomial Fit is very similar for moi and cobia
- Bimodal normal distribution may be more appropriate
- BUT, unlike salmon, nominal range is small
  (salmon~ 0.5 to 9 cm/s vs. marine fish ~ 0.1 to 1.2)

Does Size Matter?

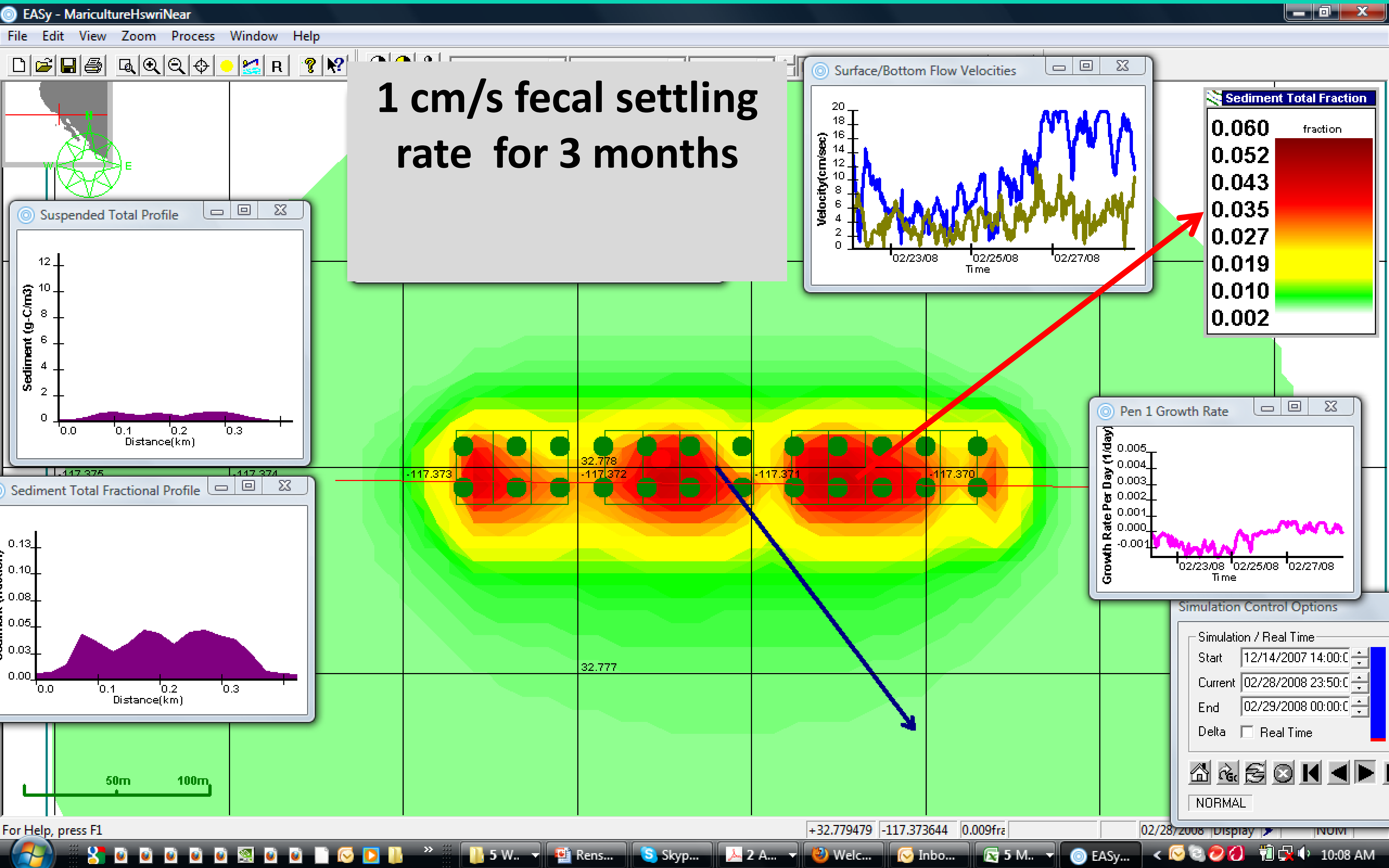
5 x larger fish, but rates are similar!
Up to 3 kg fish, no difference or slower

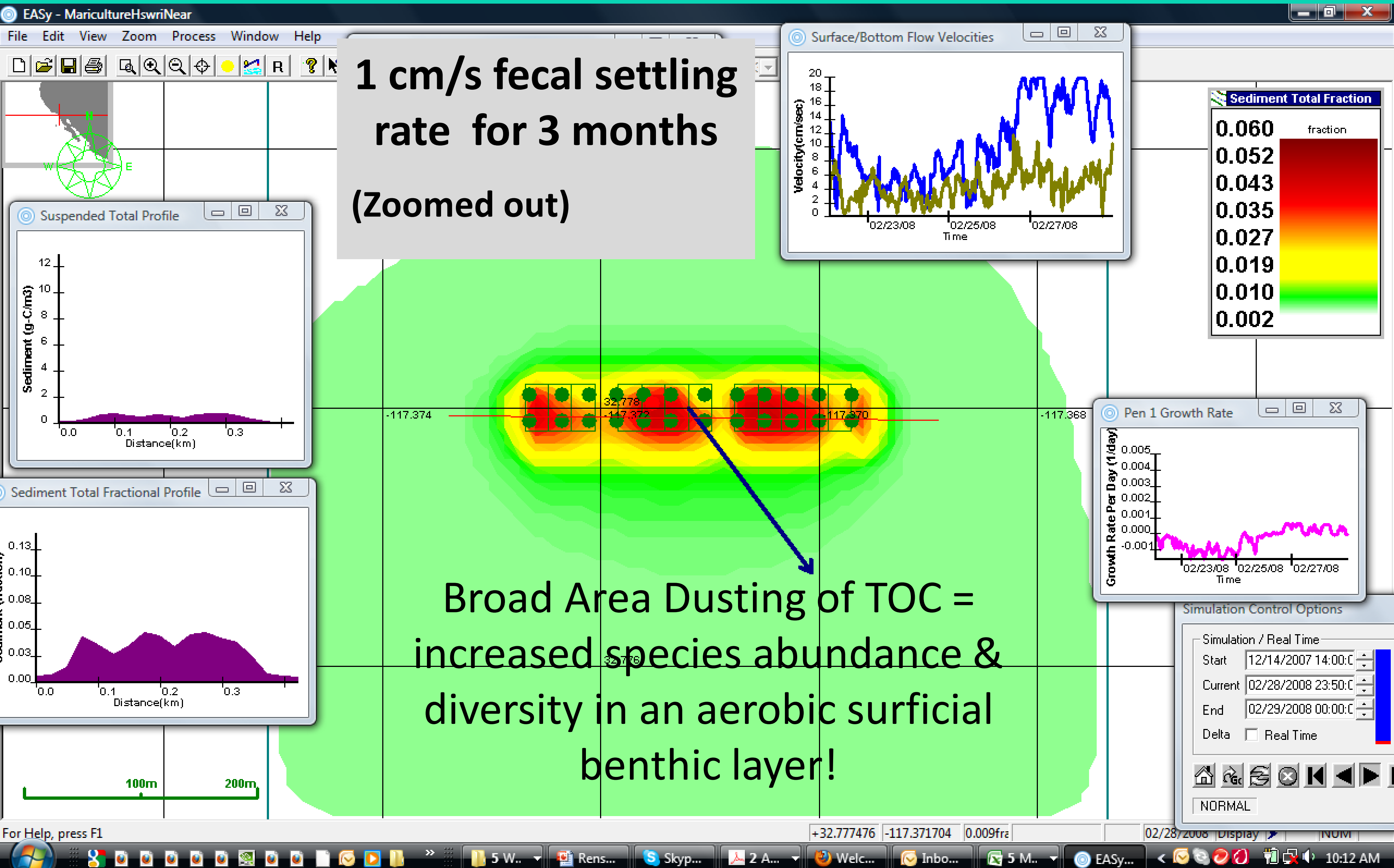


Waste Feed is huge factor for benthos, but what about waste feces?



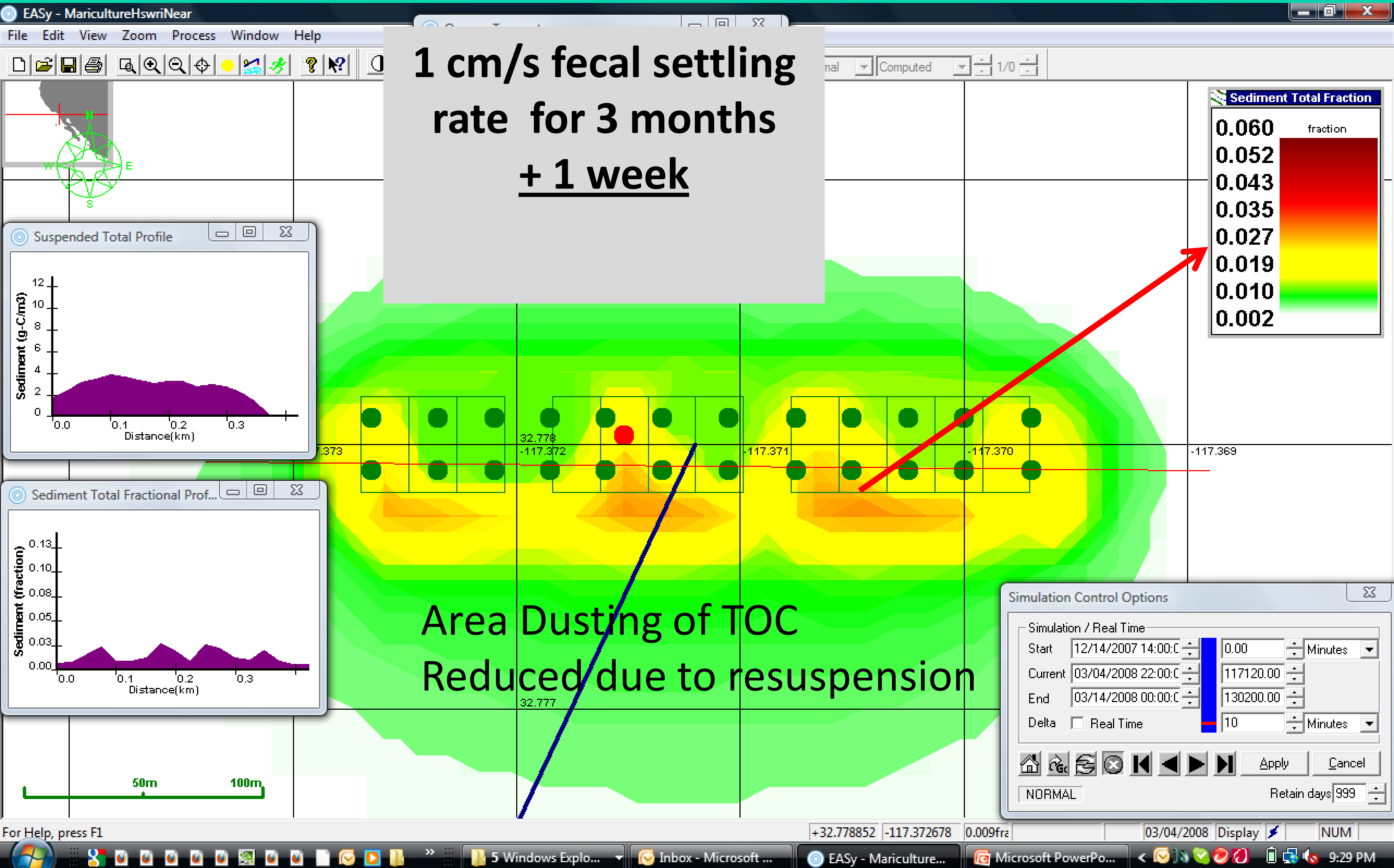
1 cm/s fecal settling rate for 3 months





1 cm/s fecal settling rate for 3 months
(Zoomed out)
Broad Area Dusting of TOC = increased species abundance & diversity in an aerobic surficial benthic layer!
EASy - MaricultureHswriNear
File Edit View Zoom Process Window Help
Surface/Bottom Flow Velocities
Velocity(cm/sec)
Time
02/23/08
02/25/08
02/27/08
Sediment Total Fraction
fraction
0.060
0.052
0.043
0.035
0.027
0.019
0.010
0.002
Suspended Total Profile
Sediment (g-C/m3)
Distance(km)
Sediment Total Fractional Profile
Pen 1 Growth Rate
Growth Rate Per Day (1/day)
Simulation Control Options
Simulation / Real Time
Start 12/14/2007 14:00:0
Current 02/28/2008 23:50:0
End 02/29/2008 00:00:0
Delta
Real Time
NORMAL
-117.374
-117.368
100m
200m
For Help, press F1
+32.777476
-117.371704
0.009fra
10:12 AM

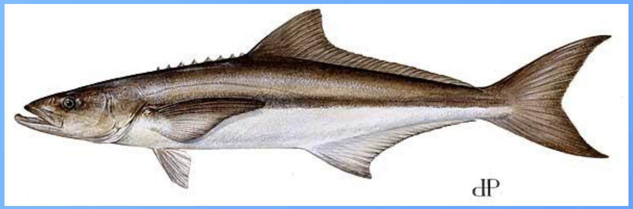
1 cm/s fecal settling rate for 3 months + 1 week



Area Dusting of TOC Reduced due to resuspension

Conclusions

- AquaModel team is building a bioenergetic database for several spp.
- Respiration rates: as expected, high for cobia, higher for moi
- Production rates of ammonia + urea surprisingly similar to salmonids
- Models based on TAN alone understate actual labile dissolved nitrogen
- Nutrient discharge is of little ecological consequence for a well-sited inshore or offshore farm (if avoiding nutrient sensitive sites)
- All water bodies have a carrying capacity for dissolved nutrients, effects can be pronounced (biomass/hypoxia blooms, HABs) in extreme cases.
- New, easier method for fecal settling rate determination developed.
- Fecal settling rates significantly effect benthic footprints <u>and</u> distribution of adverse vs. beneficial effects on the seabottom.



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Fish Stock Contributors & Collaborators

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Michael Schwartz, Virginia State University (juvenile cobia)

Hubbs Seaworld Research Institute, San Diego

Google: *AquaModel* or go to www.AquaModel.org