Assessing Cumulative (Far-field) Effects of Aquaculture on Coastal Ecosystems

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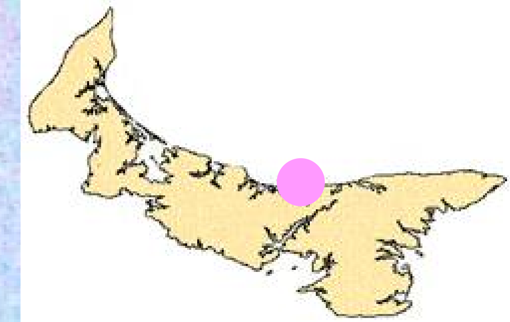
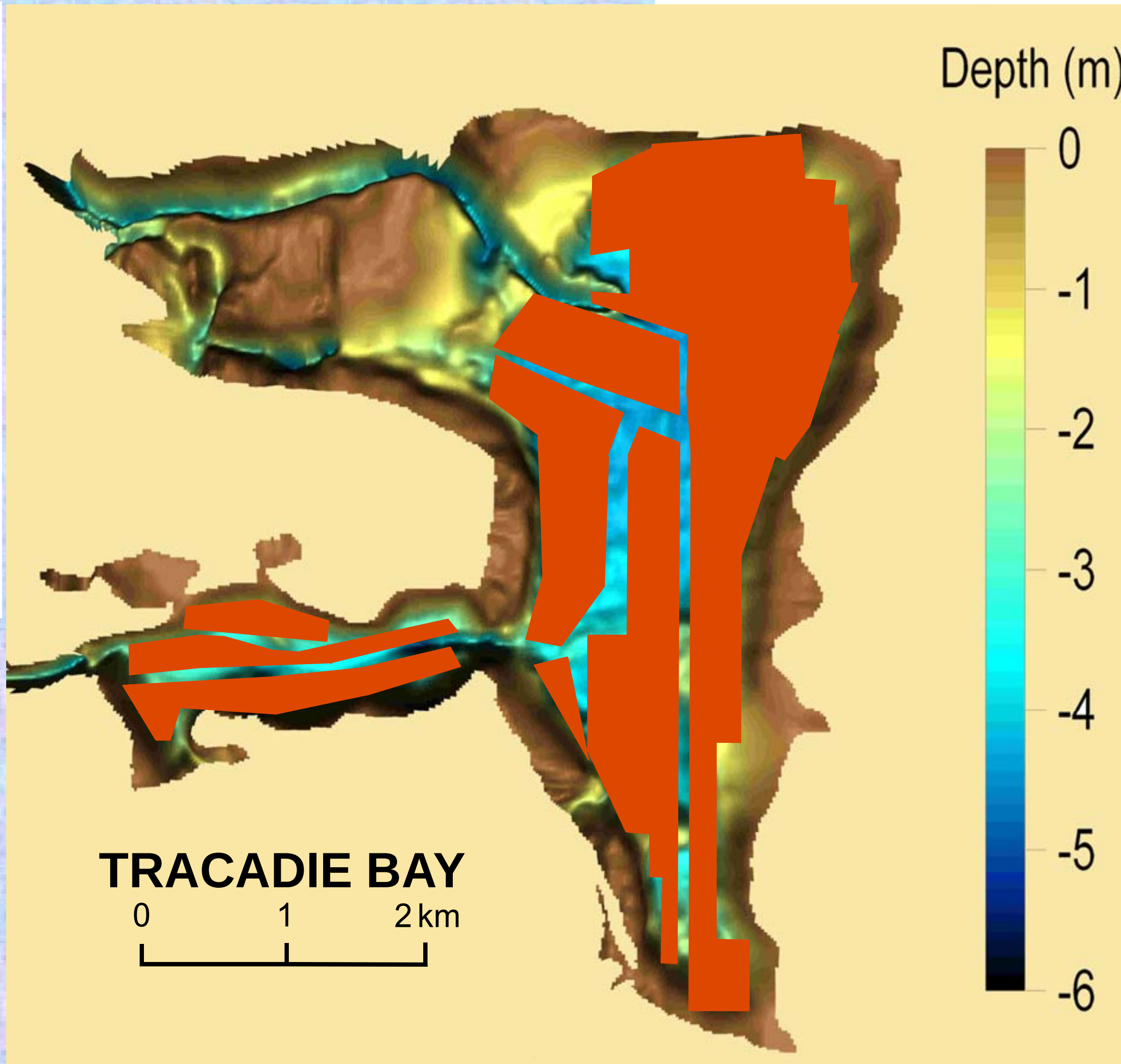
Purpose

- Identify a minimum set of variables monitored at the farm-scale that provide an integrated measure of site husbandry and regional environmental quality at the ecosystem level
- Apply observations/model results on a bay-wide basis to determine cumulative impacts of all aquaculture sites in an area

Tracadie Bay Case Study

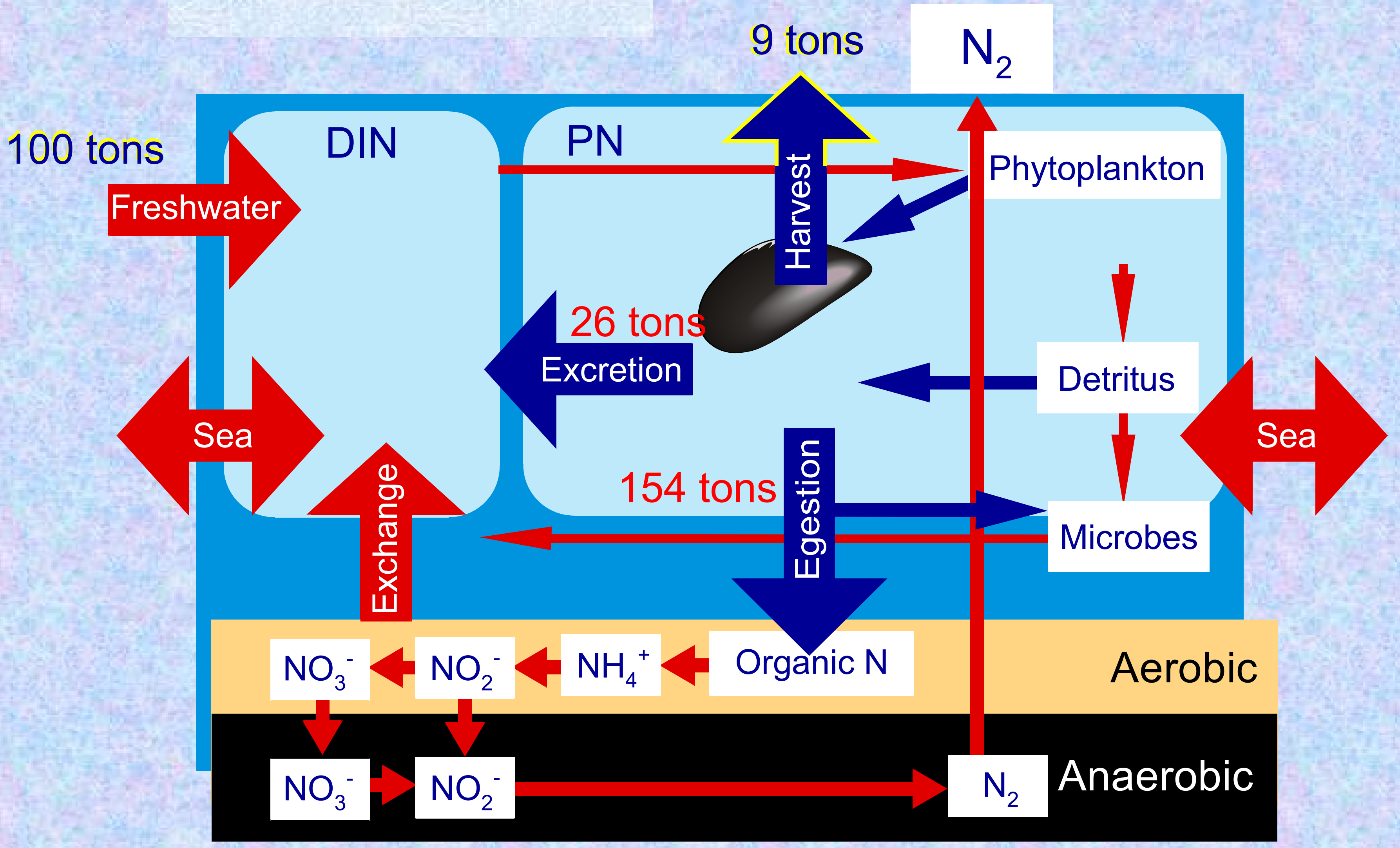


Area:	
Watershed (km^2)	117.4
Low tide (km^2)	14.0
Aquaculture (%)	50%
Mussel Culture:	
No. socks	~300,000
Biomass (tons)	~4,000
Harvest (tons)	~1,900
Value	$2.66M

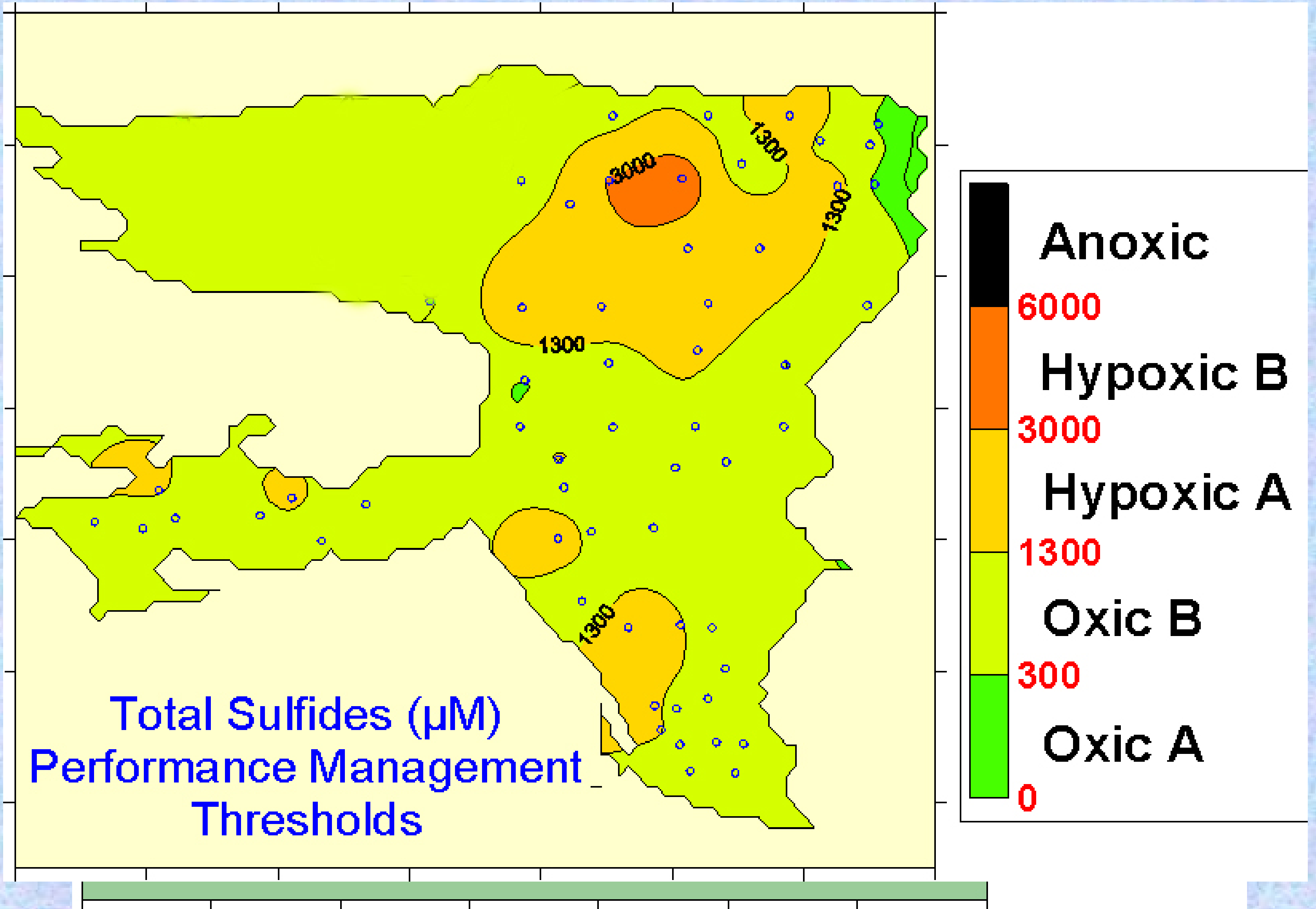


Mussels and other bivalves feeding on natural suspensions of particulate matter potentially affect pelagic and benthic ecosystem components

Effects on Nitrogen Cycle

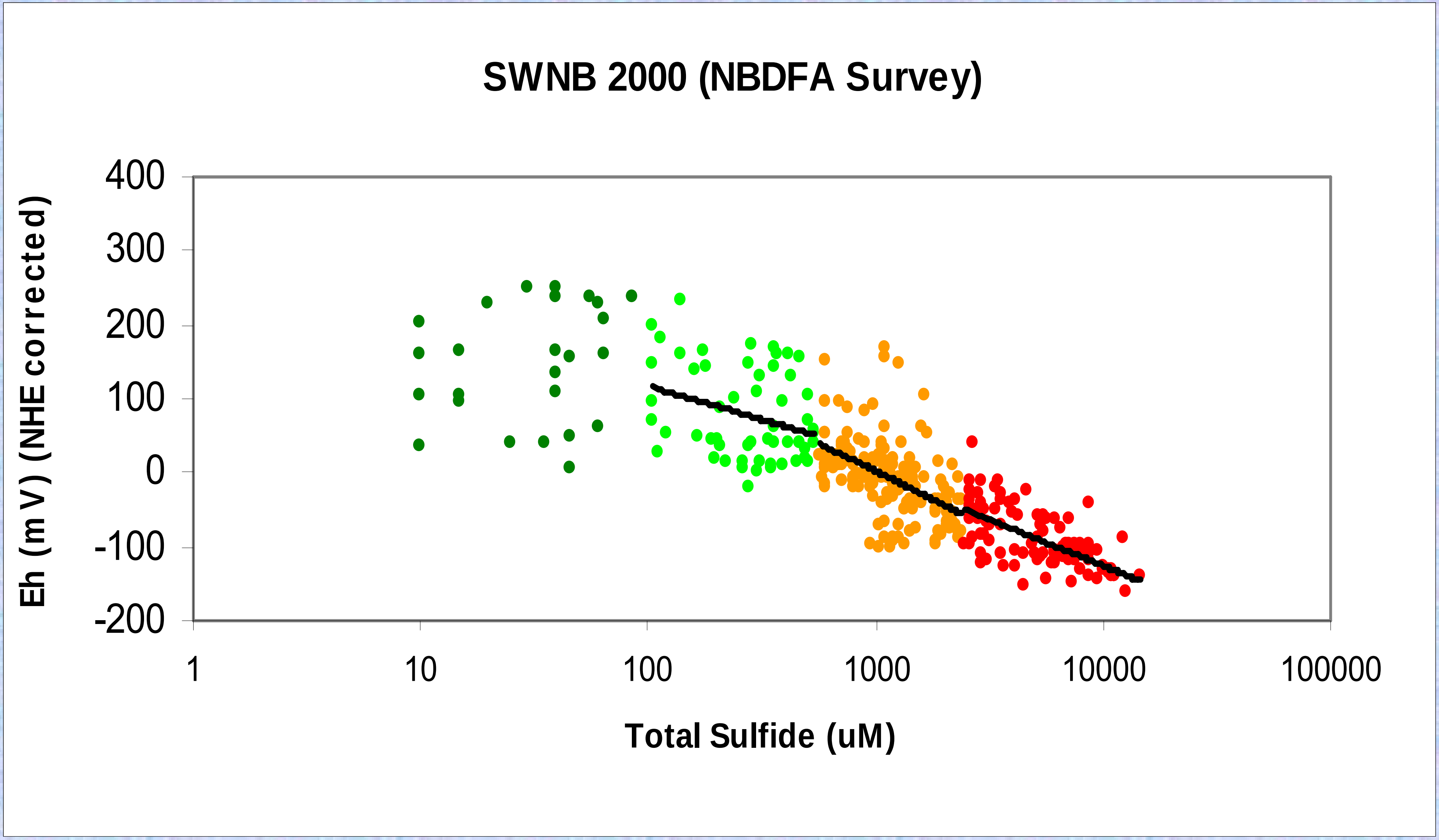


Sediment Biogeochemistry

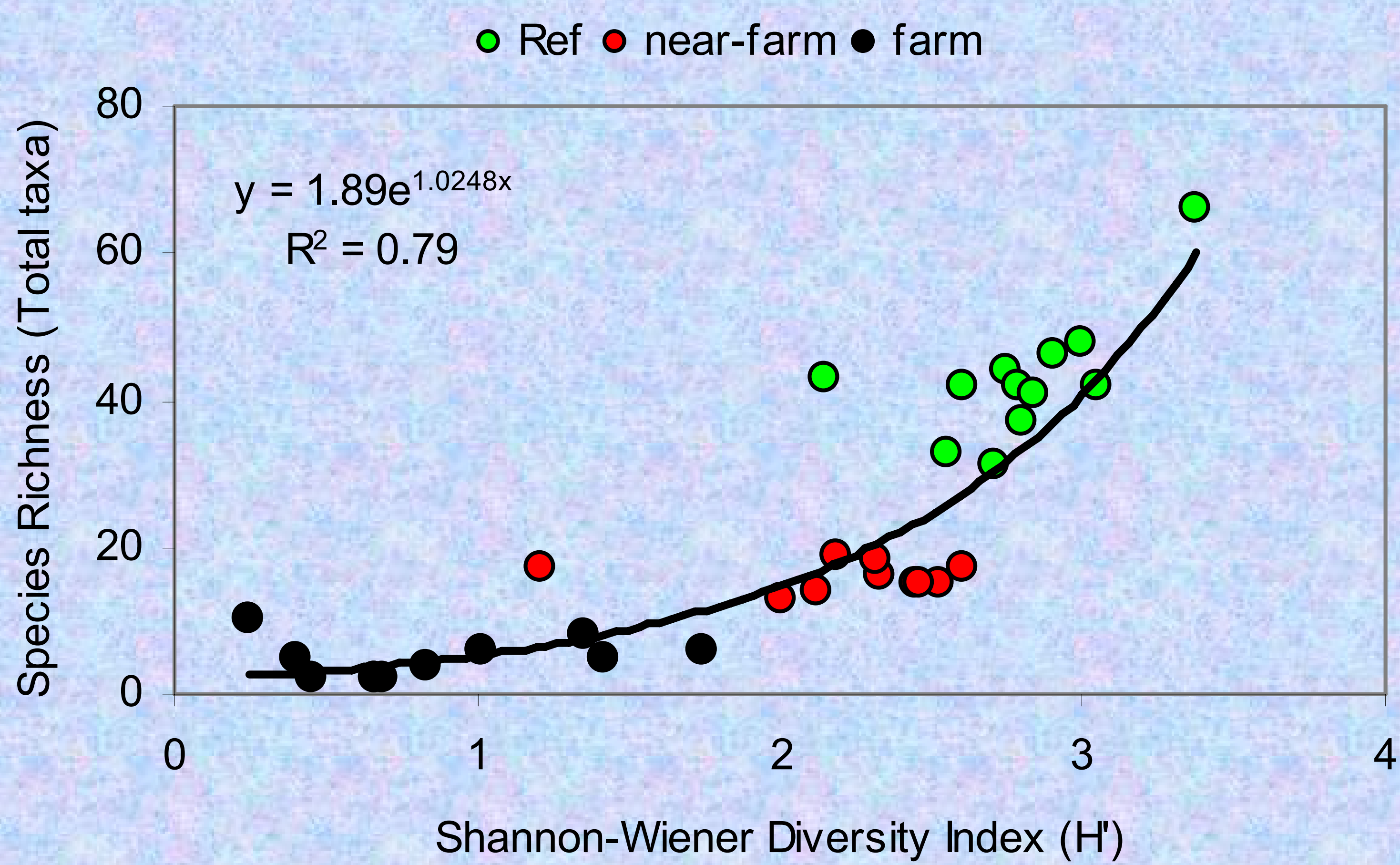


Salmon Aquaculture

- Addition of pelletized food creates the potential for localized effects due to sedimentation of waste feed. Impacts of organic loading may be localized as shown by model output (Depomod)
- Fecal matter settles more slowly and potentially moves away from a farm site



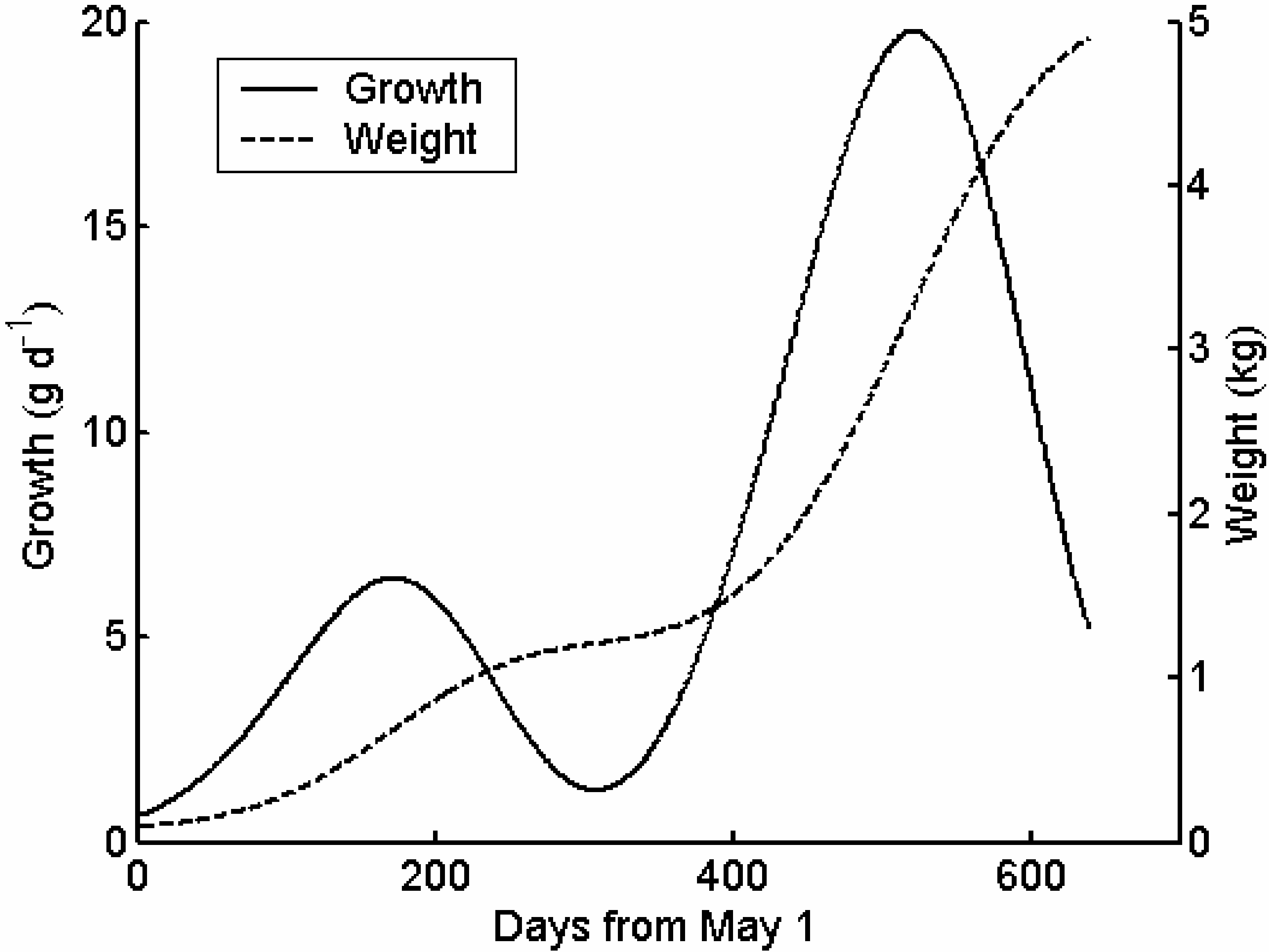
When reducing conditions (S>1500 uM) occur close to or at the sediment surface, negative Eh potentials are correlated with total free S



Data from Pohle et al. (2001), Wildish et al. (2001), Wildish et al. (2004)

Near and Far-field Waste Organic Matter and Nutrient Loading Due to Salmon Aquaculture

- Fish growth model (temperature, initial smolt size, grow-out cycle)
- Farm efficiency (FCR), nutrition data (digestibility and assimilation coefficients)
- Mass balance model (waste fraction released in particulate and dissolved forms, respired, buried)


Growth
Weight
Growth (g d^-1)
Weight (kg)
Days from May 1
0
5
10
15
20
0
1
2
3
4
5
0
200
400
600

Mass Balance Model for Waste Release*

Feed Use: feed = growth * FCR

e.g. Nitrogen $N_{feed} = N_{growth} - N_{waste}$

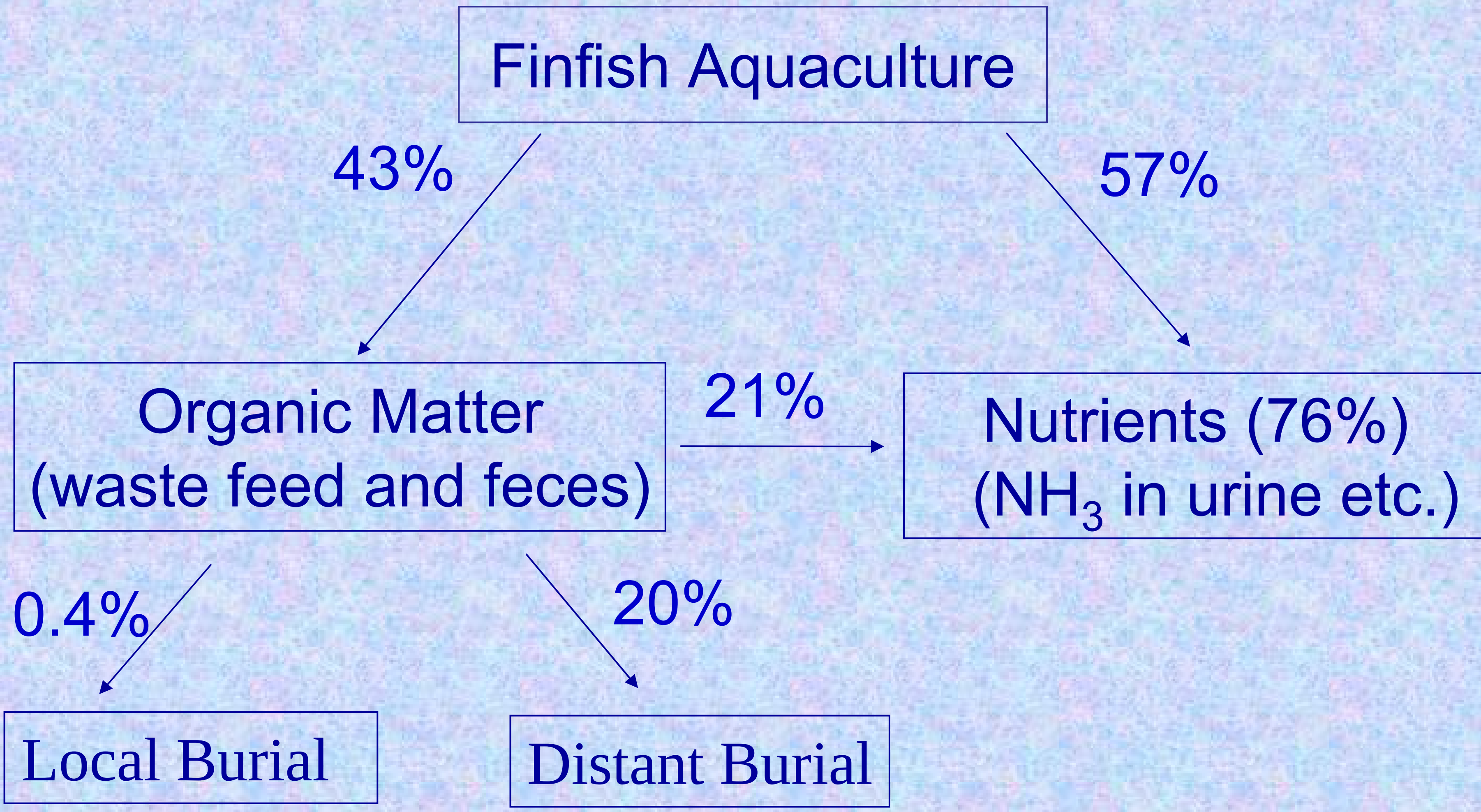
$N_w = N_{fd} - N_g$

$$N_w/g = (0.16 * f_{prot} + 0.02 * f_{fat}) * DM_{fd} * FCR - f_{Nfish}$$

*Strain and Hargrave (2005) Handbook of Environmental Chemistry (Springer)

Fate of N Discharged (SWNB)

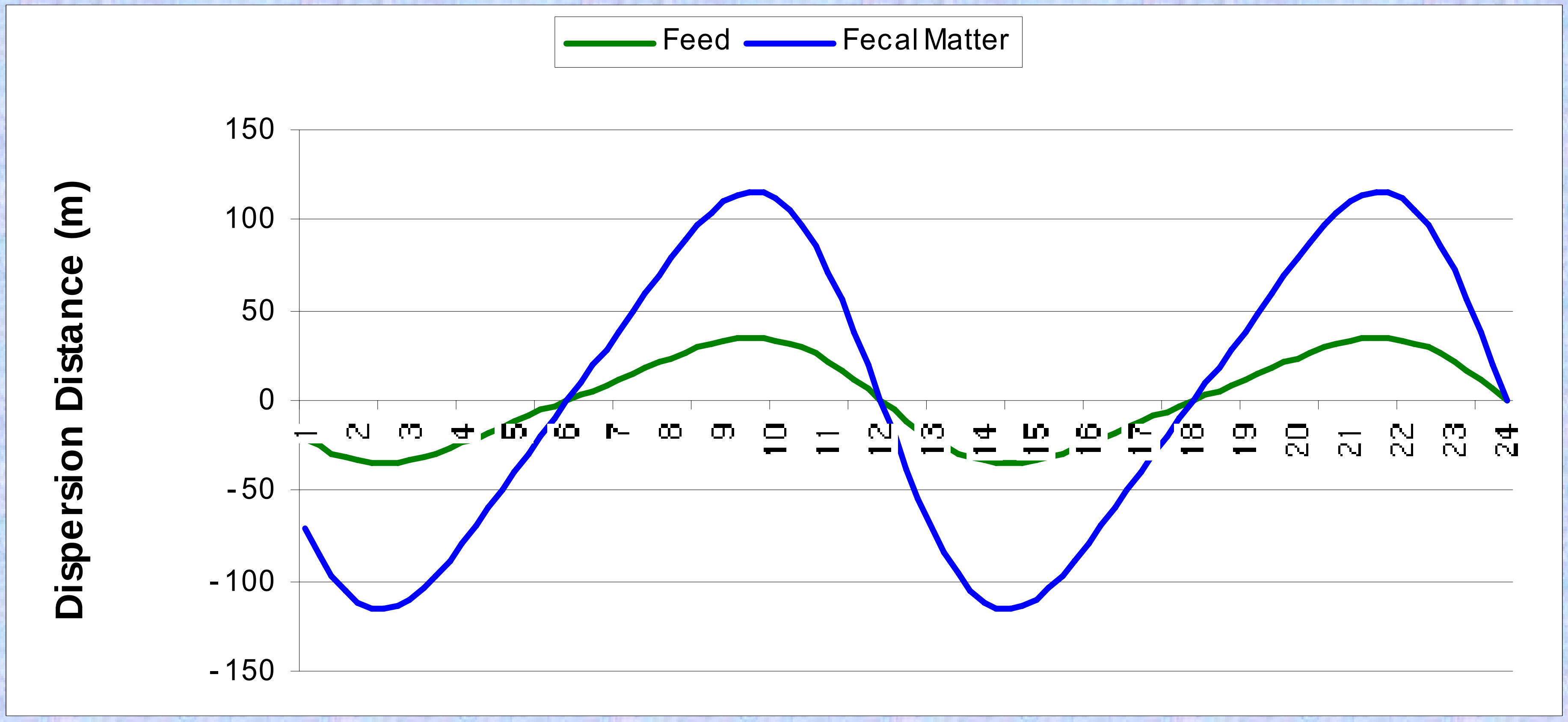
42 kg N t^{-1} production



Waste Feed and Feces Settling Rates

- assumed average settling rates for waste feed pellets (10 cm s^{-1}) and fecal matter (3 cm s^{-1}) used to determine dispersion distances (Depomod default values)
- distribution will be over an area at least as large as the total cage area in a farm

Dispersion distance calculations



Near-field dispersion distance over two tidal cycles for horizontal displacement (D) of particles with sinking rate (S) through depth (H) with depth-averaged current speed (Ū) (D-(H/S)=Ū). Here Ū=15 cm s^{-1}, H=15 m and S is 10 cm s^{-1} for feed pellets (green) and 3 cm s^{-1} for feces (blue)

Under-cage Waste Burial Rates

- The salmon physiological growth model showed that maximum carbon waste release occurred during the 2nd y
- For a stocking density 18 kg m^{-3}, C_{burial} ~20 g org m^{-2} d^{-1}
- correcting for density and OM, sediment accumulation at 3 farm sites in SWNB was estimated as ~0.25 cm y^{-1} (~0.4 g org m^{-2} d^{-1})
- burial of organic matter under pens is thus 50 times smaller than estimated waste mass discharge rate

Conclusions

Determining the proportion of off-farm waste transport produced during salmon aquaculture

- waste release calculated from the number and size (weight) of fish (growth model).
- FCRs, number, diameter, depth of fish and predator nets.
- water depth, current velocity and variability.
- benthic observations of sediment geochemical variables (Eh, S, porosity, OM).

Conclusions

- Debris piles may indicate increased local sedimentation under mussel lines and finfish pens.
- However, a large proportion of particulate wastes may be transported off-site, even in depositional areas with low current velocities.
- Mass balance and simple sedimentation models can be used to assess the magnitude of potential benthic organic enrichment.