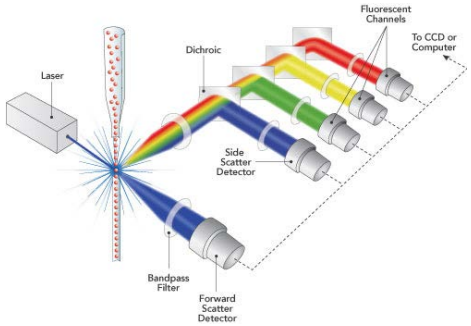
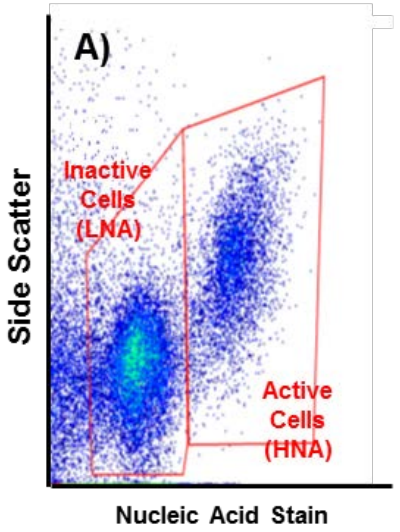
Flow Cytometry: A novel, rapid, screening and research tool for methylmercury production activity in aquatic ecosystems?





Collin Eagles-Smith[1], James Willacker[1], David Krabbenhoft[2]

[1]US Geological Survey, Corvallis, OR
[2]US Geological Survey, Middleton, WI

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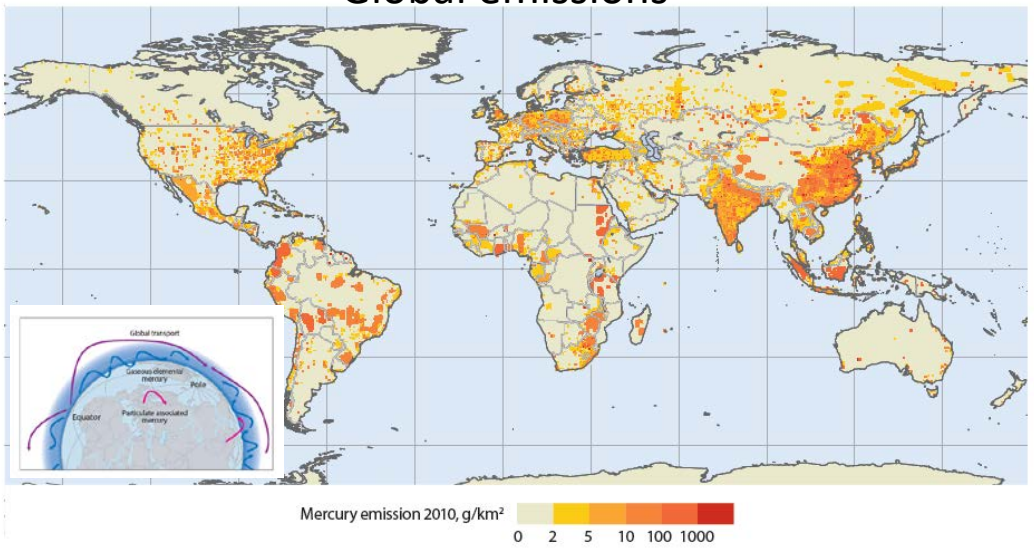
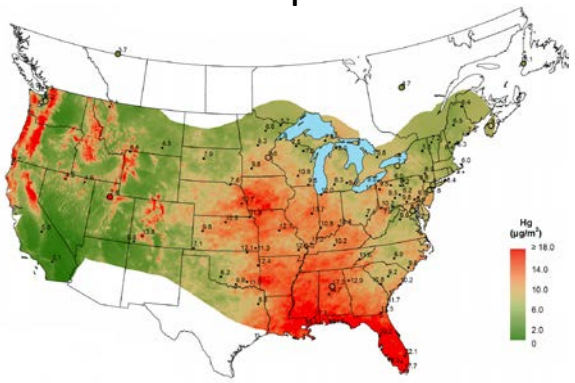
Mercury
A contaminant of global consequence

- Responsible for 80% of all fish consumption advisories
- Global burden of disease estimate 1.2-2.4 million years living with disability
  - Higher than hepatitis or Parkinson's
- Only element with its own international treaty

Global emissions

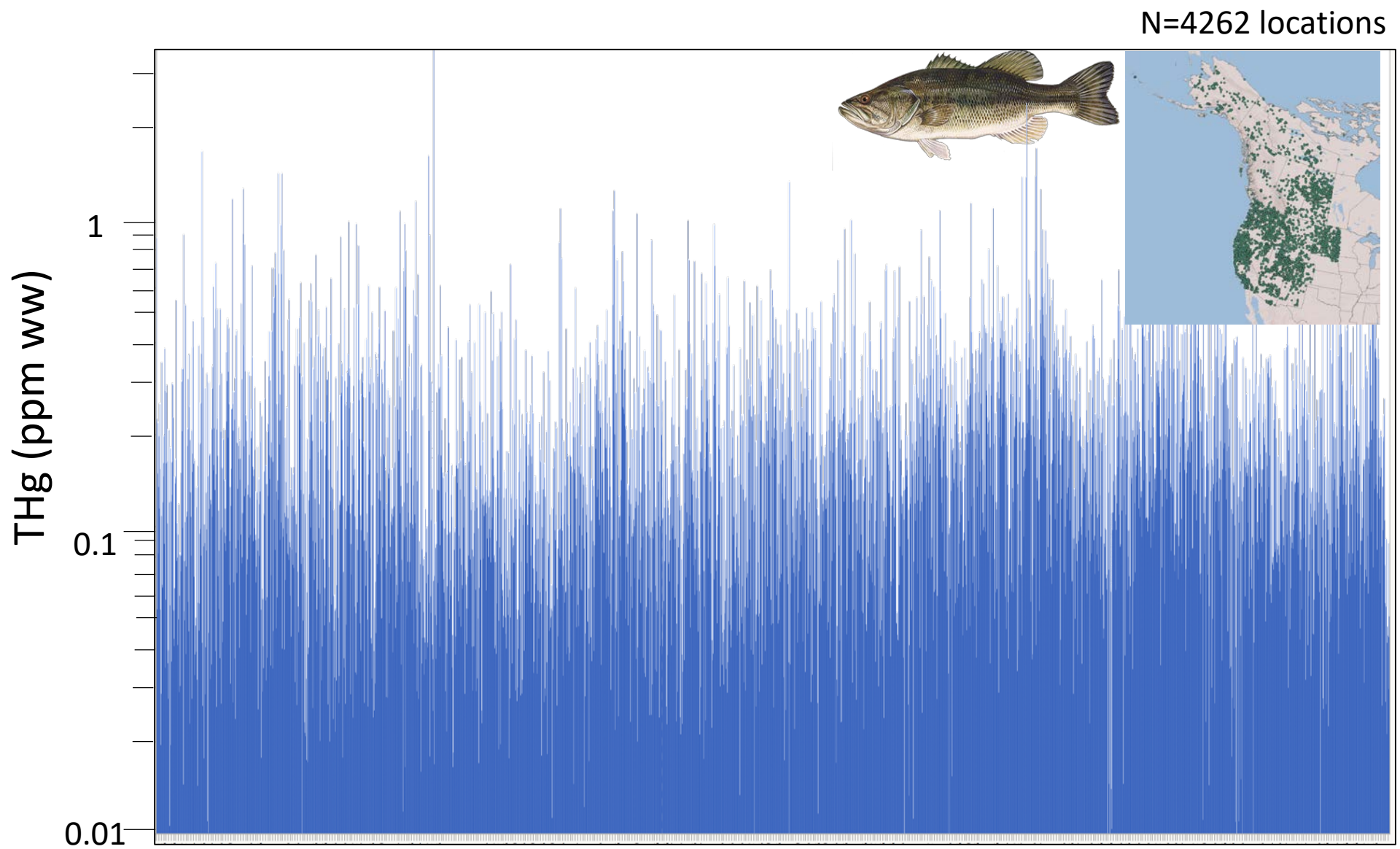


National deposition

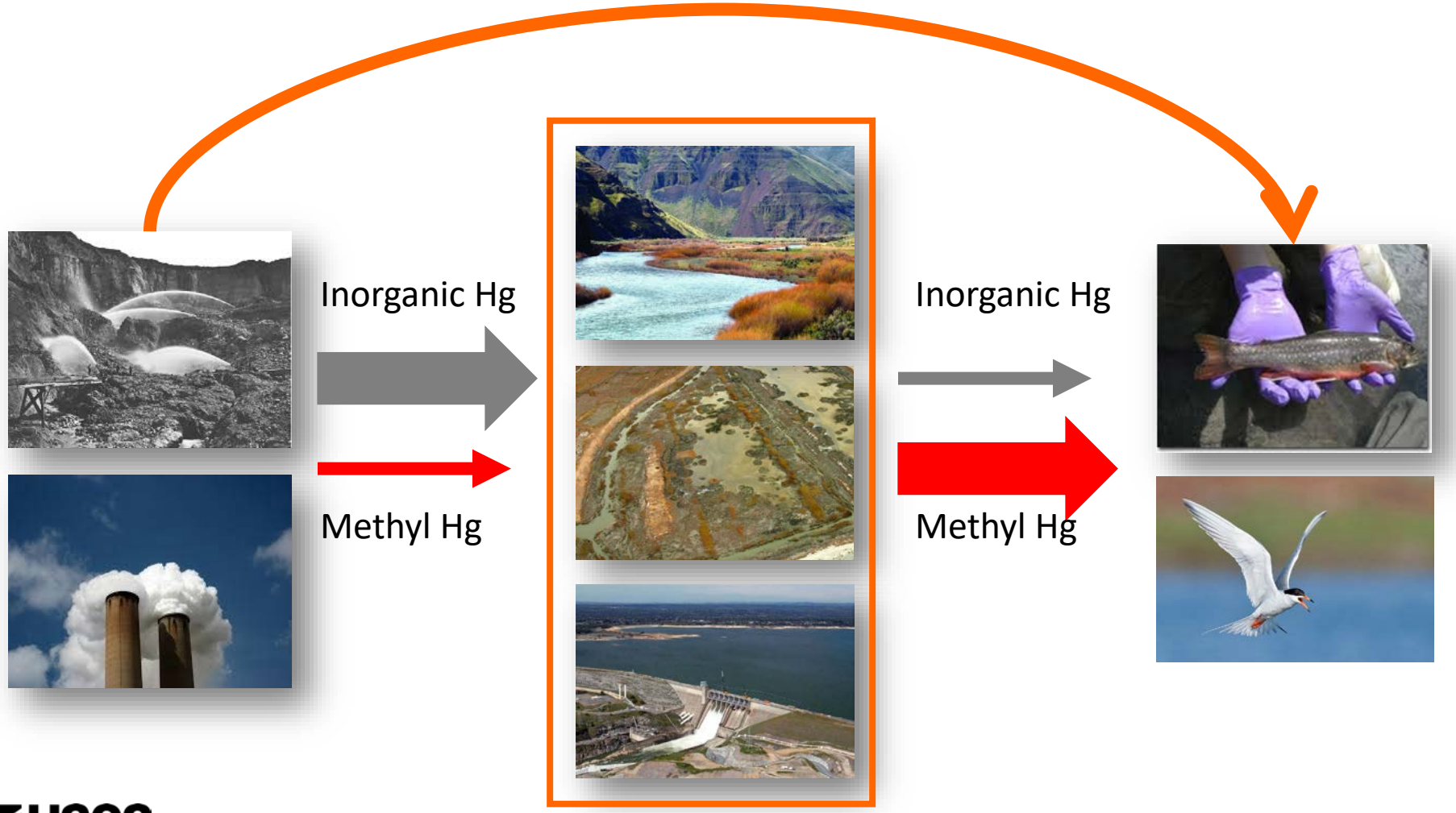


Consumption advisories

Variability of mercury in ecosystems



Pathways of inorganic Hg to bioaccumulation



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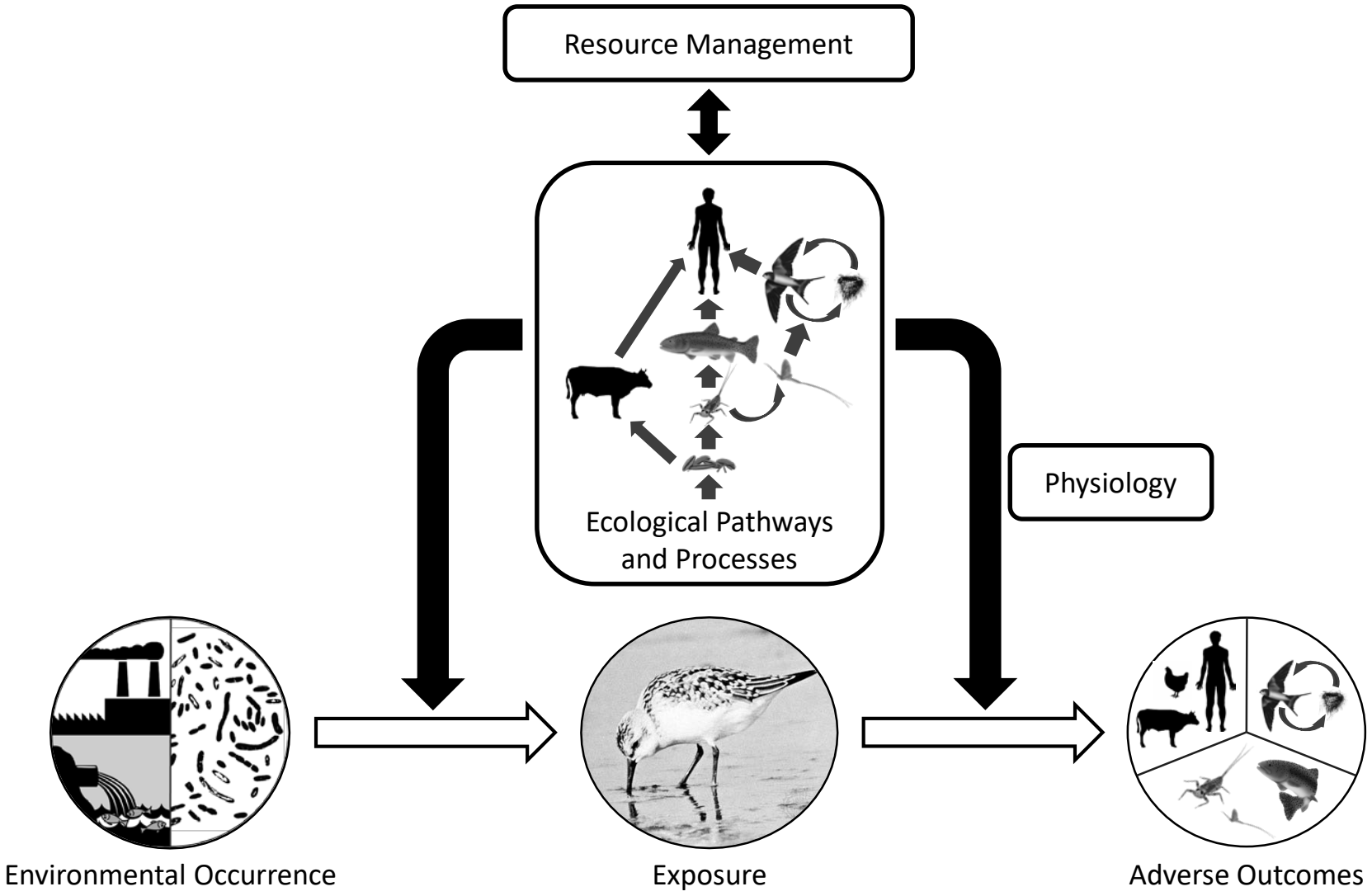
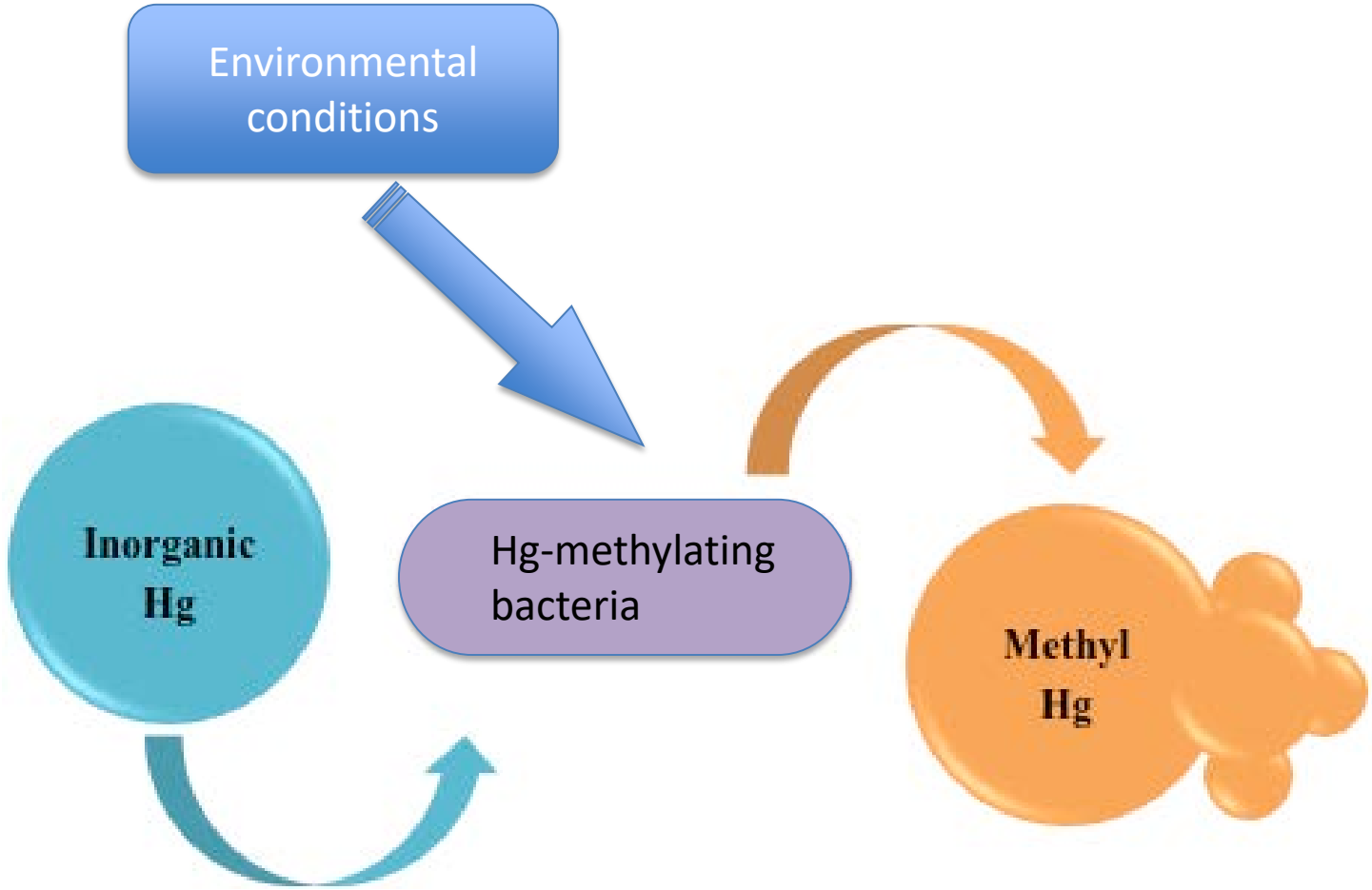
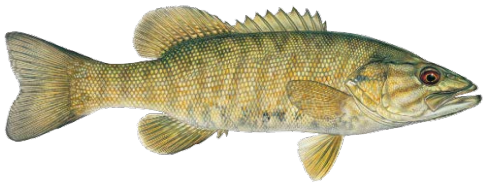
Ecological Pathways Conceptual Model

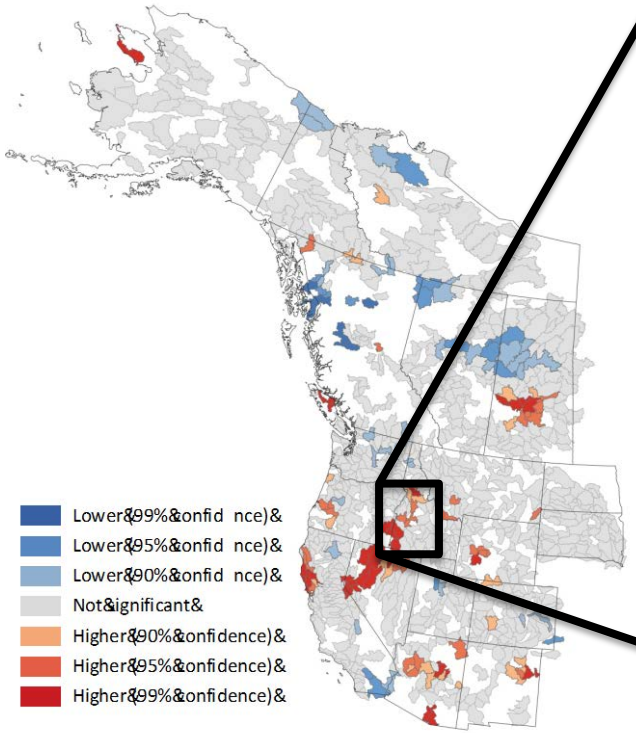


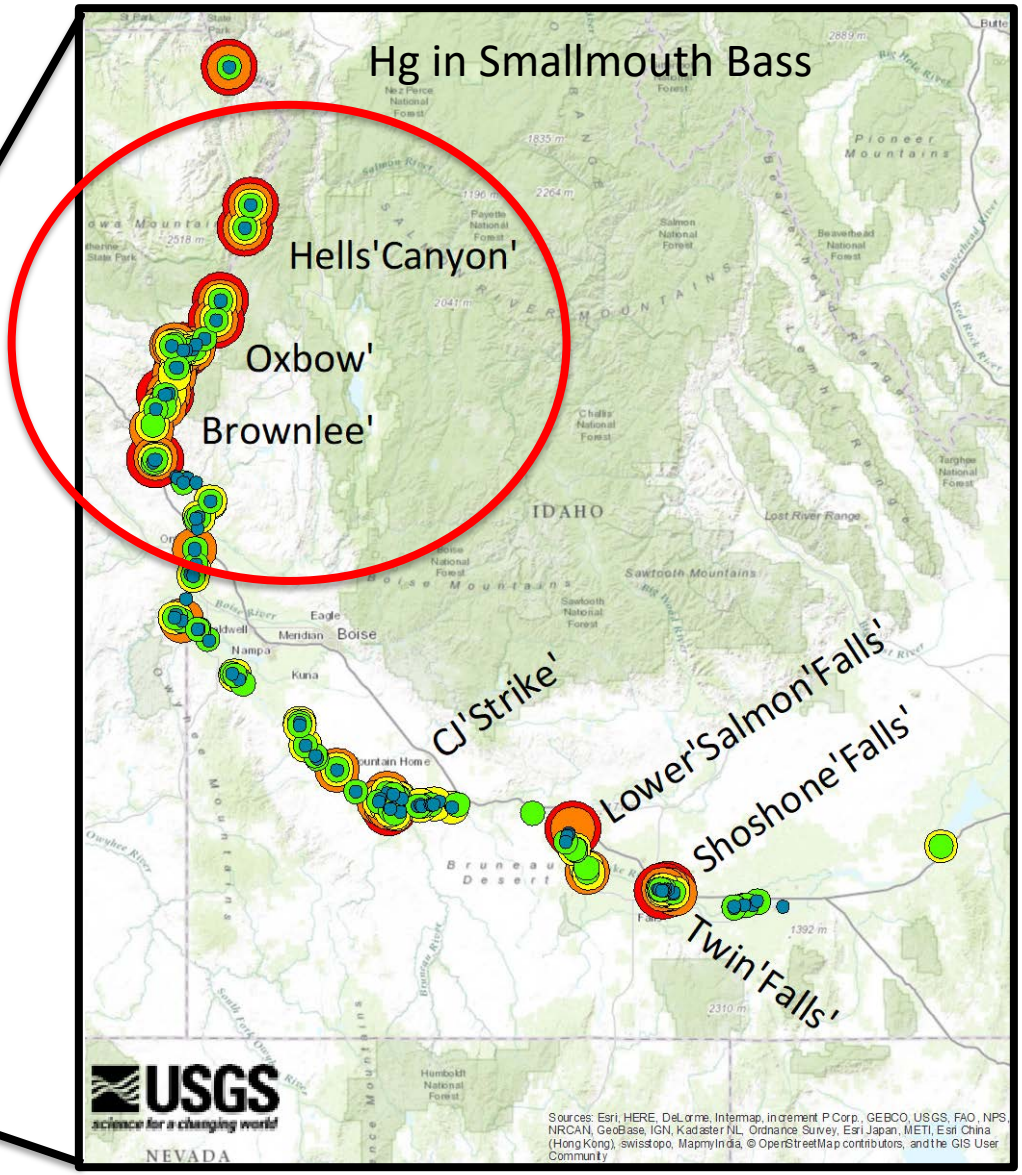
Methylmercury production – a microbial process



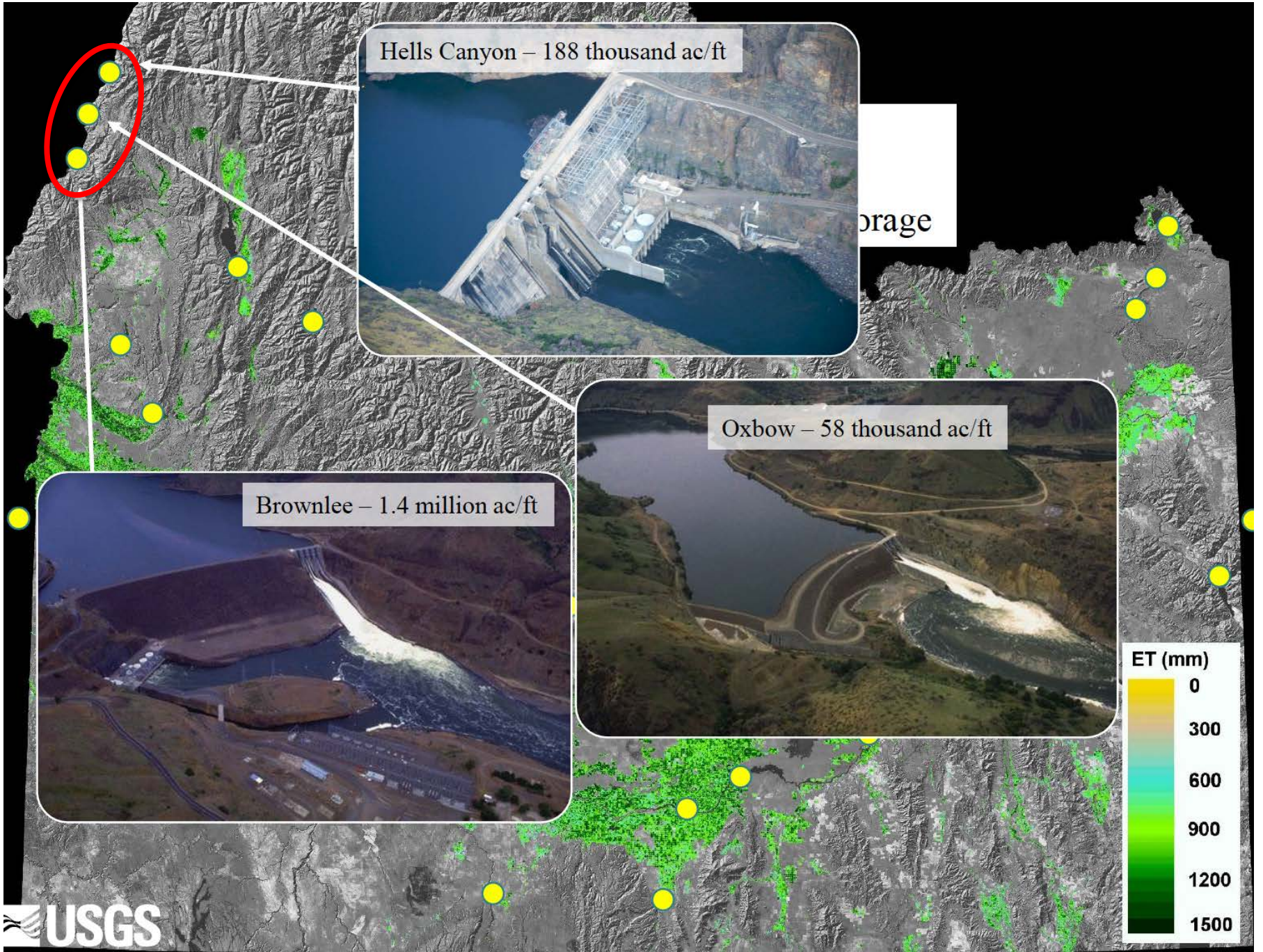
Hg in the Great Basin and Snake River Drainage



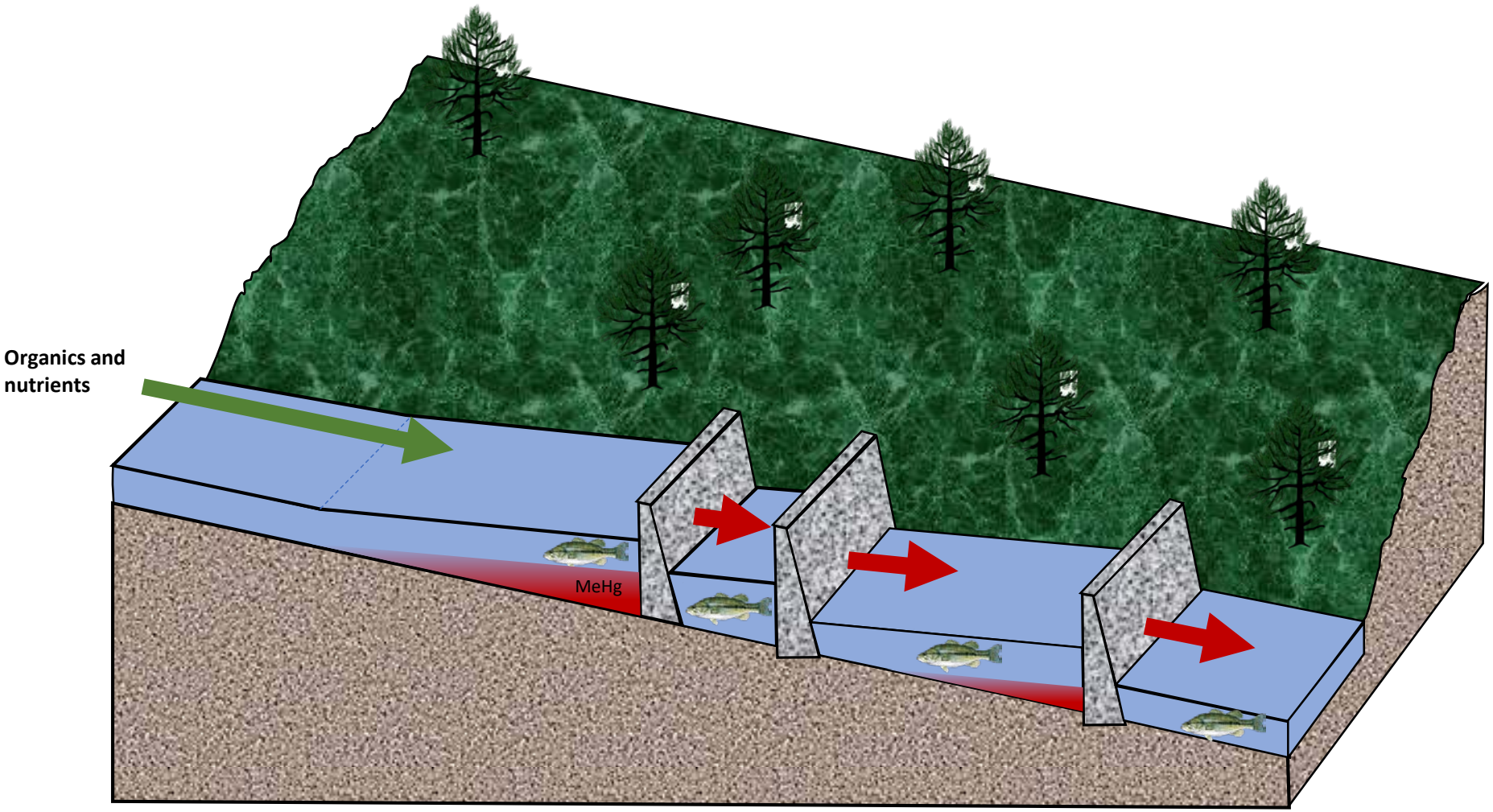




Eagles-Smith et al. 2016


Hells Canyon – 188 thousand ac/ft
Oxbow – 58 thousand ac/ft
Brownlee – 1.4 million ac/ft
ET (mm)
0
300
600
900
1200
1500
USGS

Mercury bioaccumulation through a three-reservoir complex



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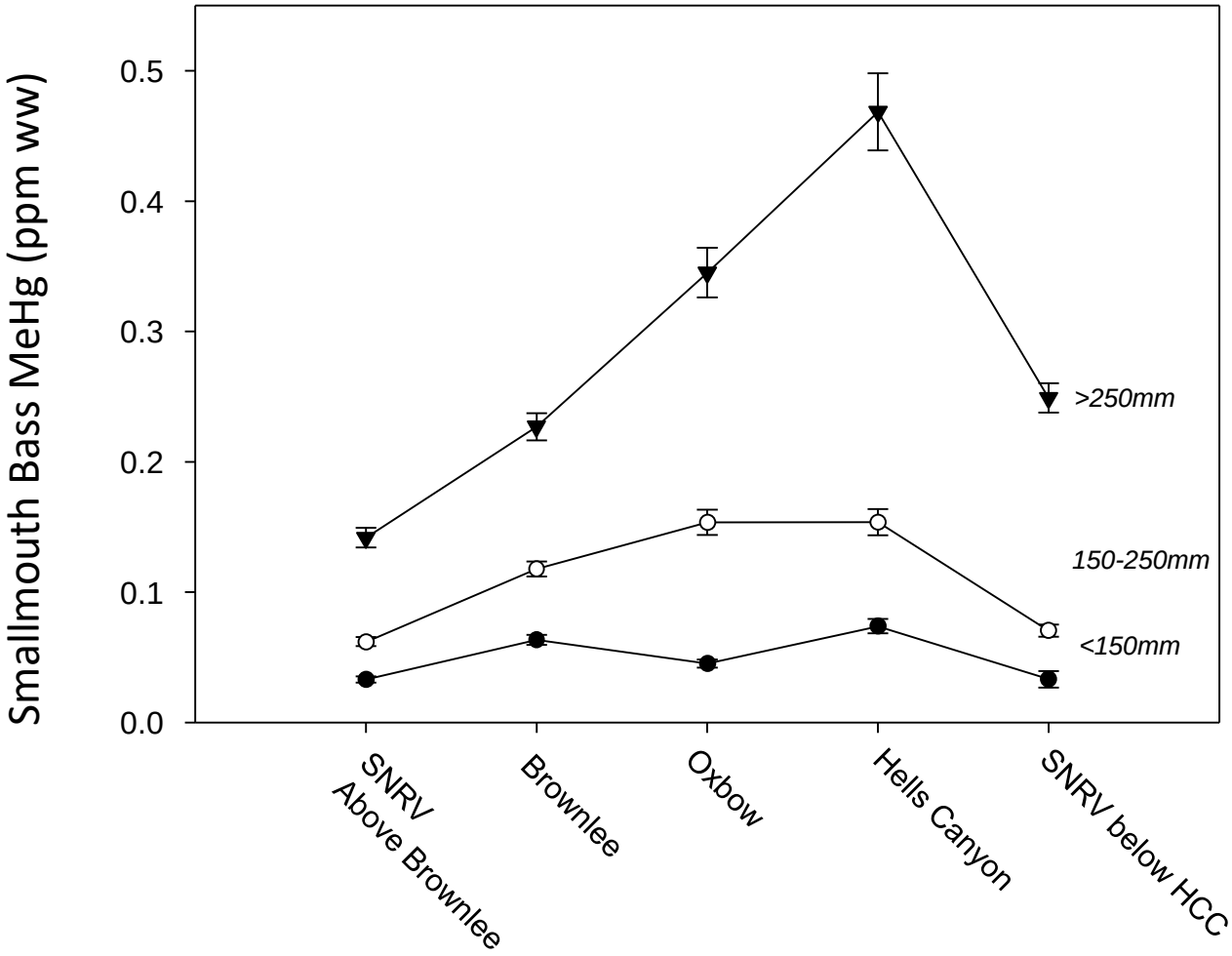
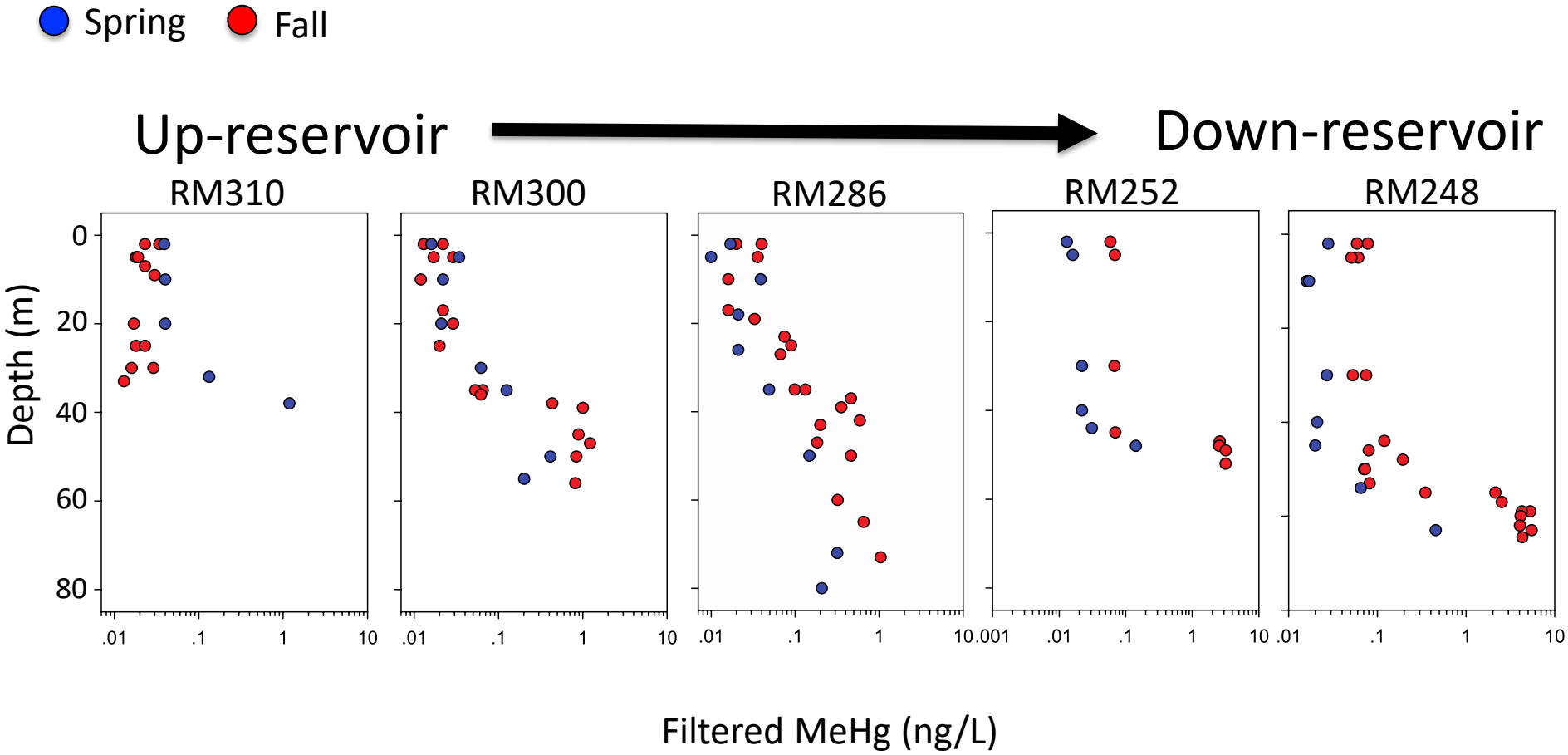
Slide courtesy of Reed Harris

Fish mercury concentrations increase through the complex

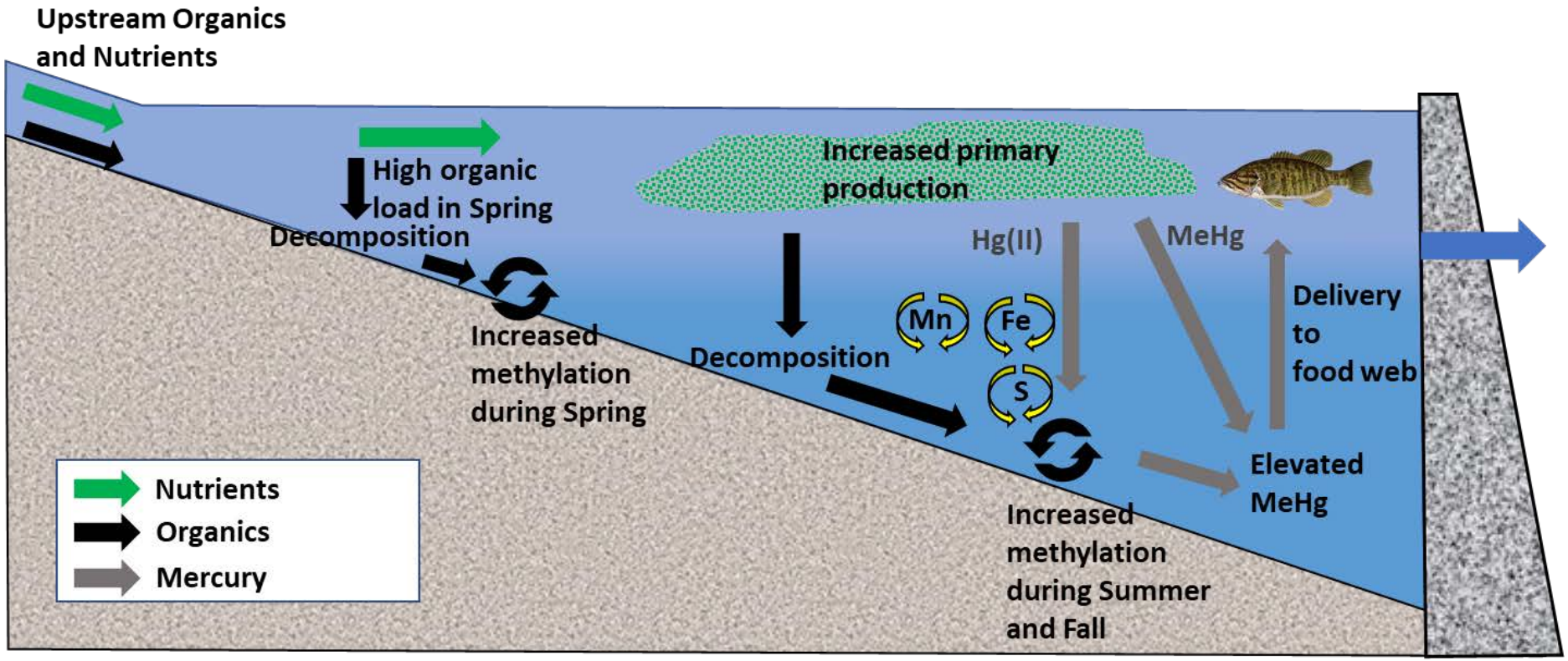


Aqueous MeHg concentrations through the complex



Variation greater within site (by depth) than across sites

Mercury cycling model for the complex



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Primary productivity as a driver of MeHg production

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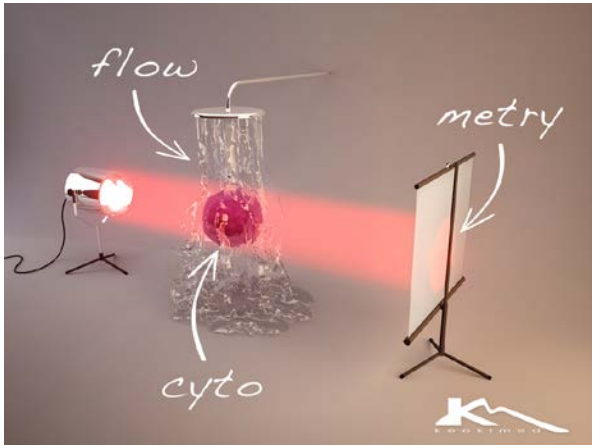
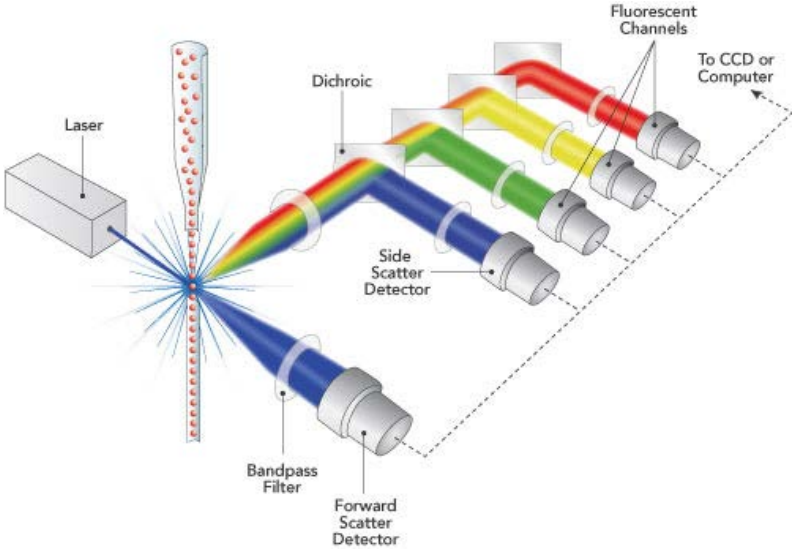
Flow Cytometry

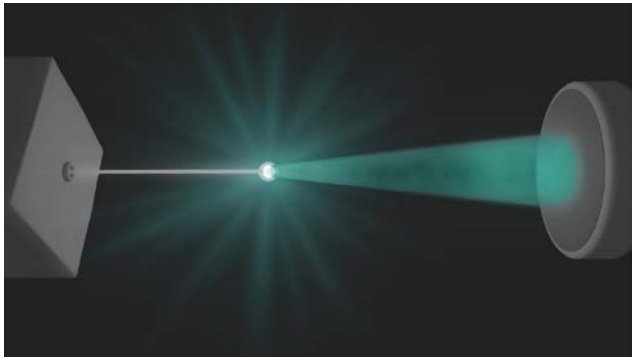
- Instrumented method for quantifying size and type of cells in a fluid
- Originally developed for medical uses (blood cells, etc.)
- Adopted by oceanographers and limnologists for algal cells
- Employed by microbiologists



Flow Cytometry

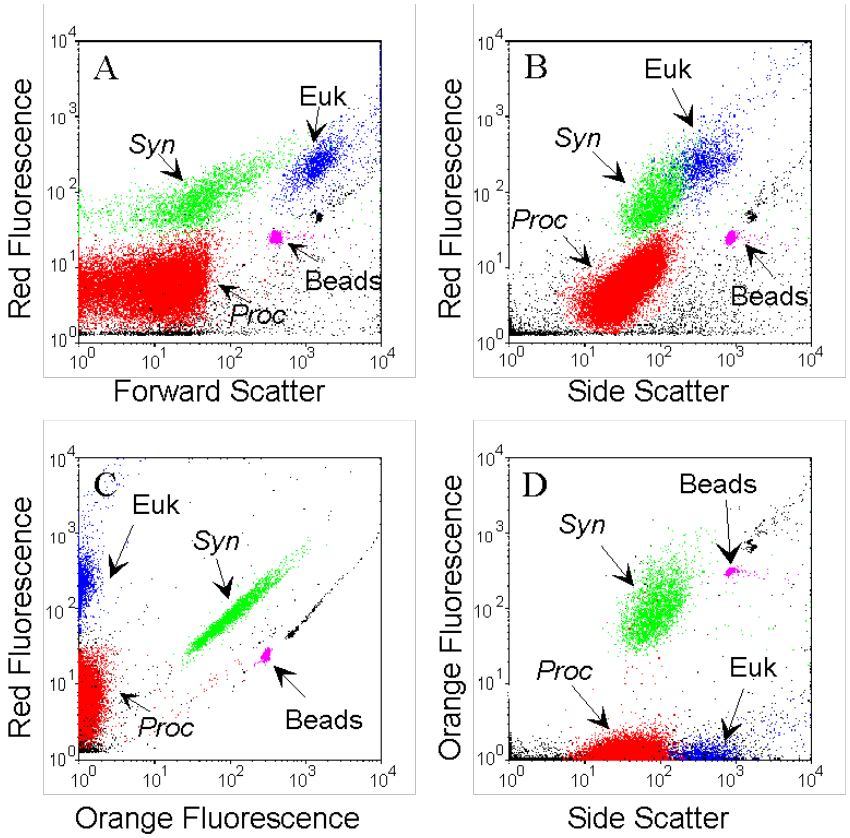
- Forward scatter estimates cell size
- Side scatter and fluorescence indicative of cell structure and granularity
- Measures light absorption and excitation





Flow Cytometry

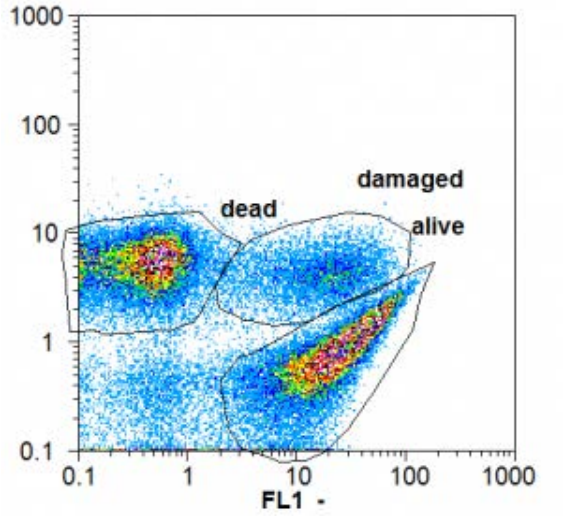
- Biplots of scatter and fluorescence allow for differentiation of different cell types

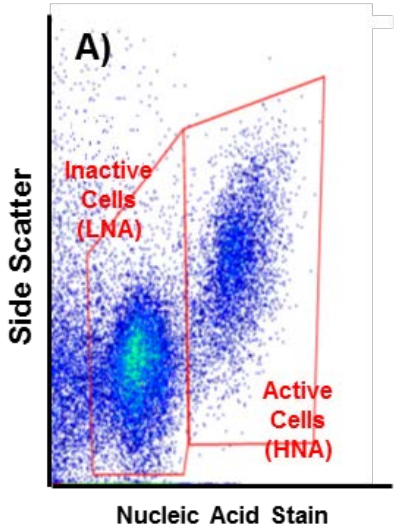


Marie et al.

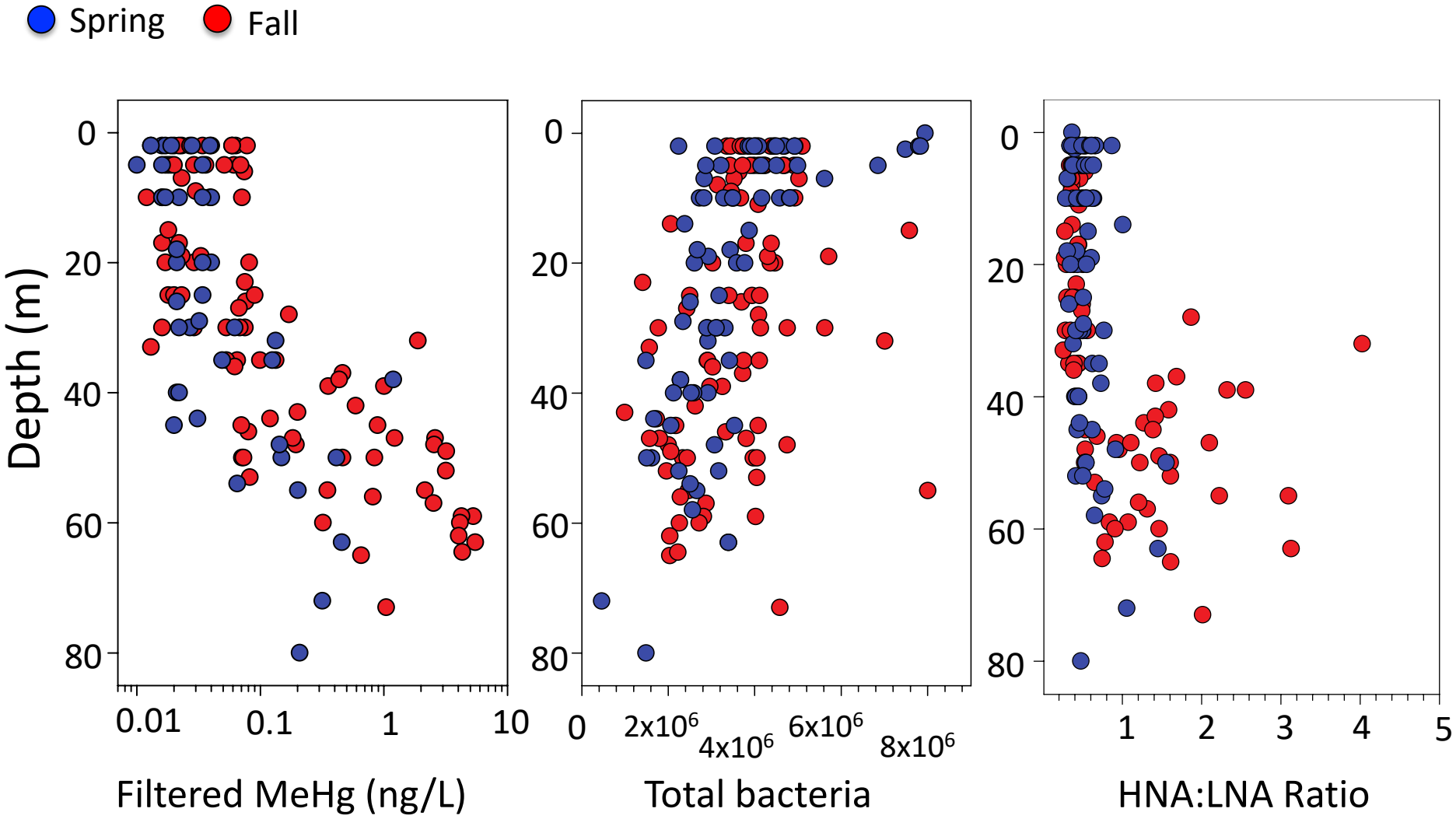
Flow Cytometry

- Bacteria determined by size and cell stains
- Coarse differentiation
- Nucleic acid stains differentiate two primary types
- HNA = High nucleic acid content (active cells)
- LNA = Low nucleic acid content (inactive cells)

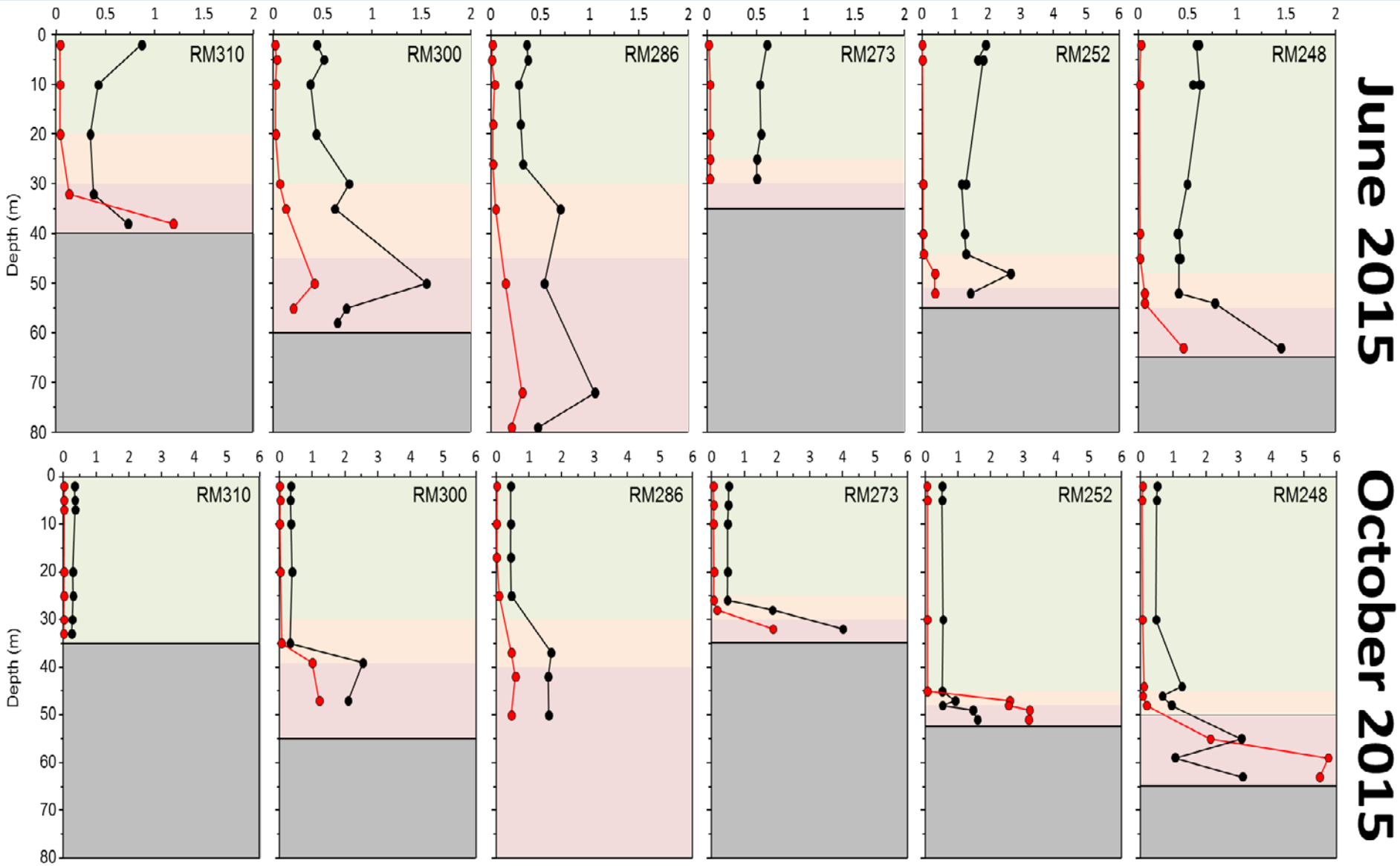




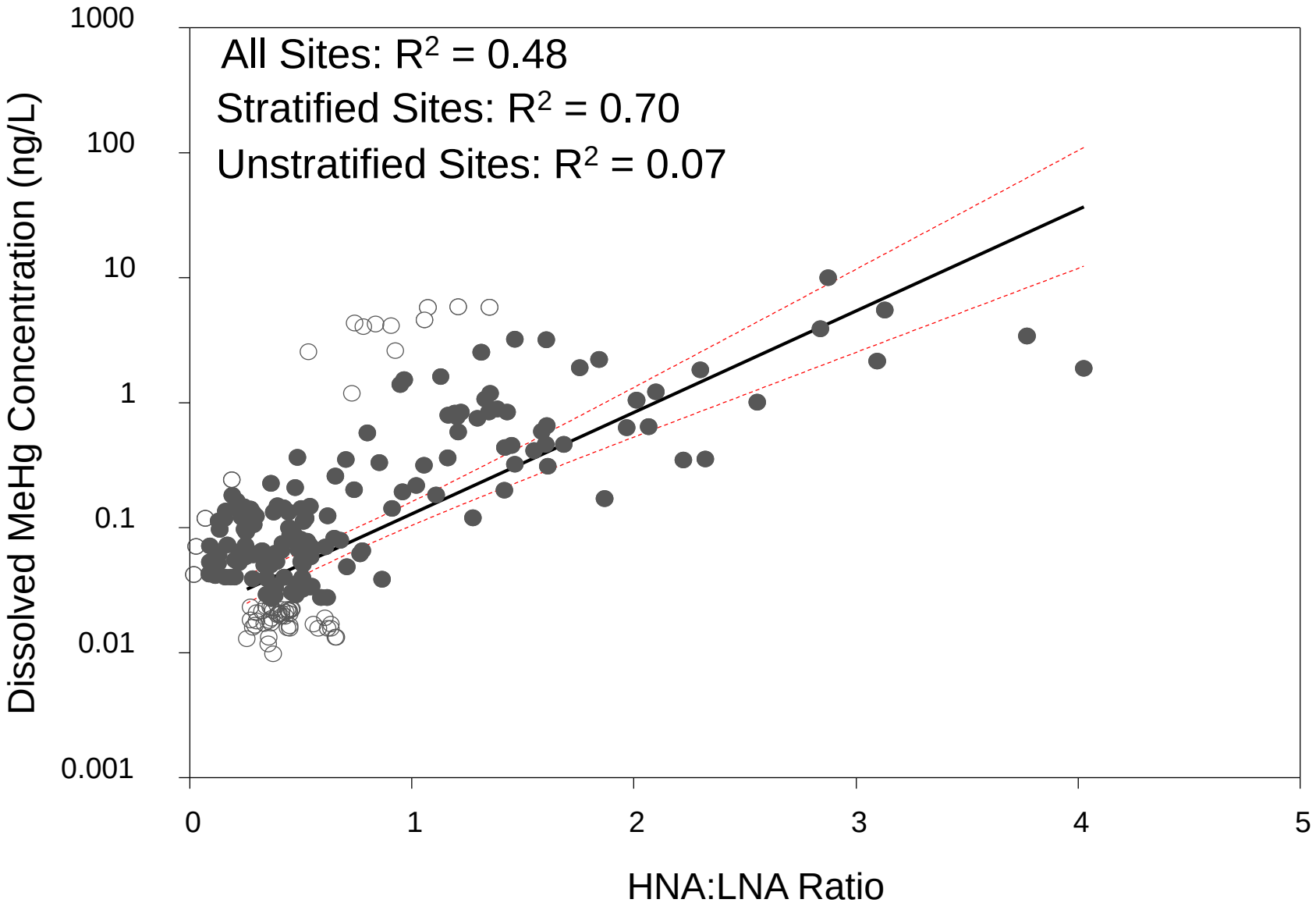
MeHg concentrations and microbial activity through the water column



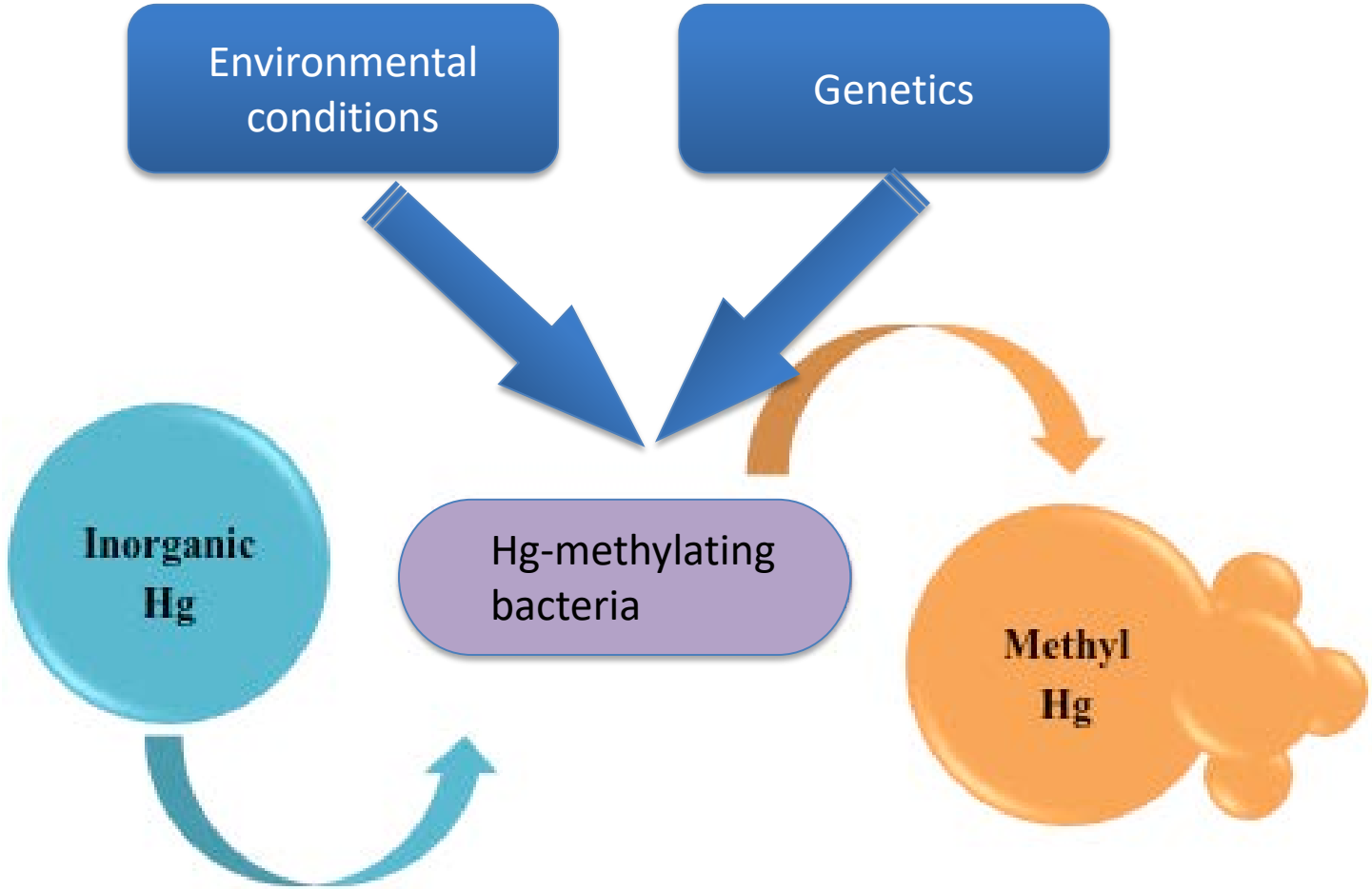
HNA:LNA ratio & Dissolved MeHg (ng/L)



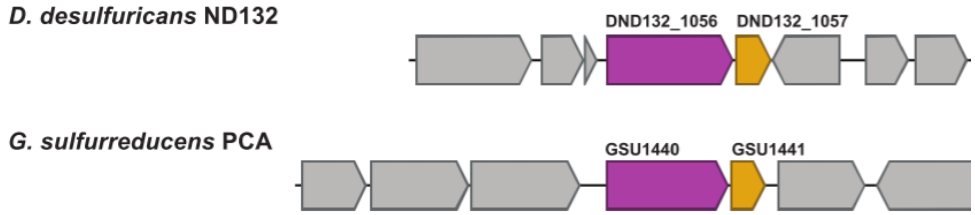
HNA:LNA ratio correlated with aqueous MeHg



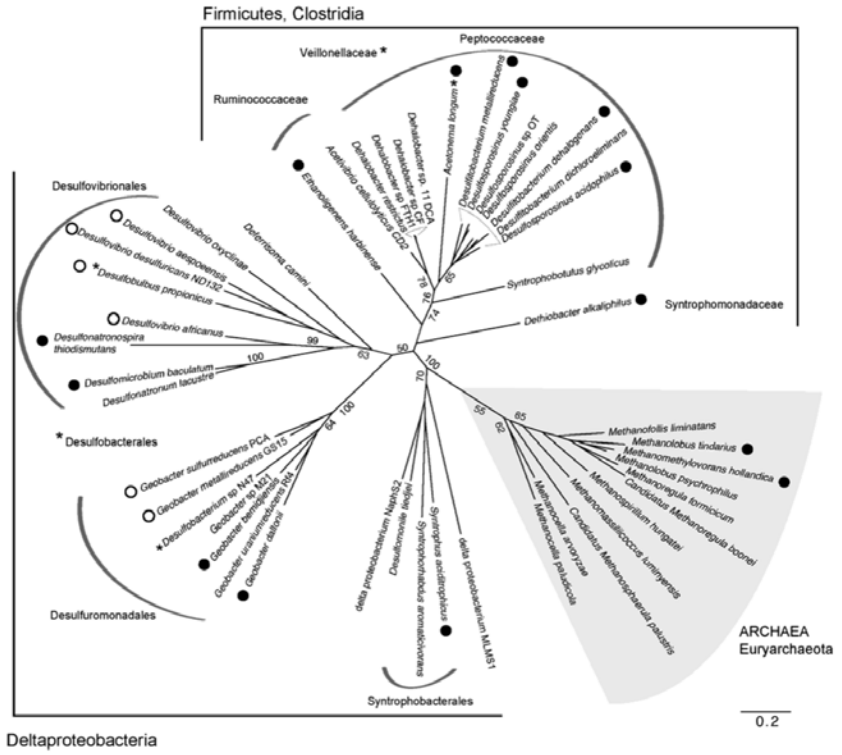
Methylmercury production – a microbial process



Discovery of hgcAB gene cluster (2013)



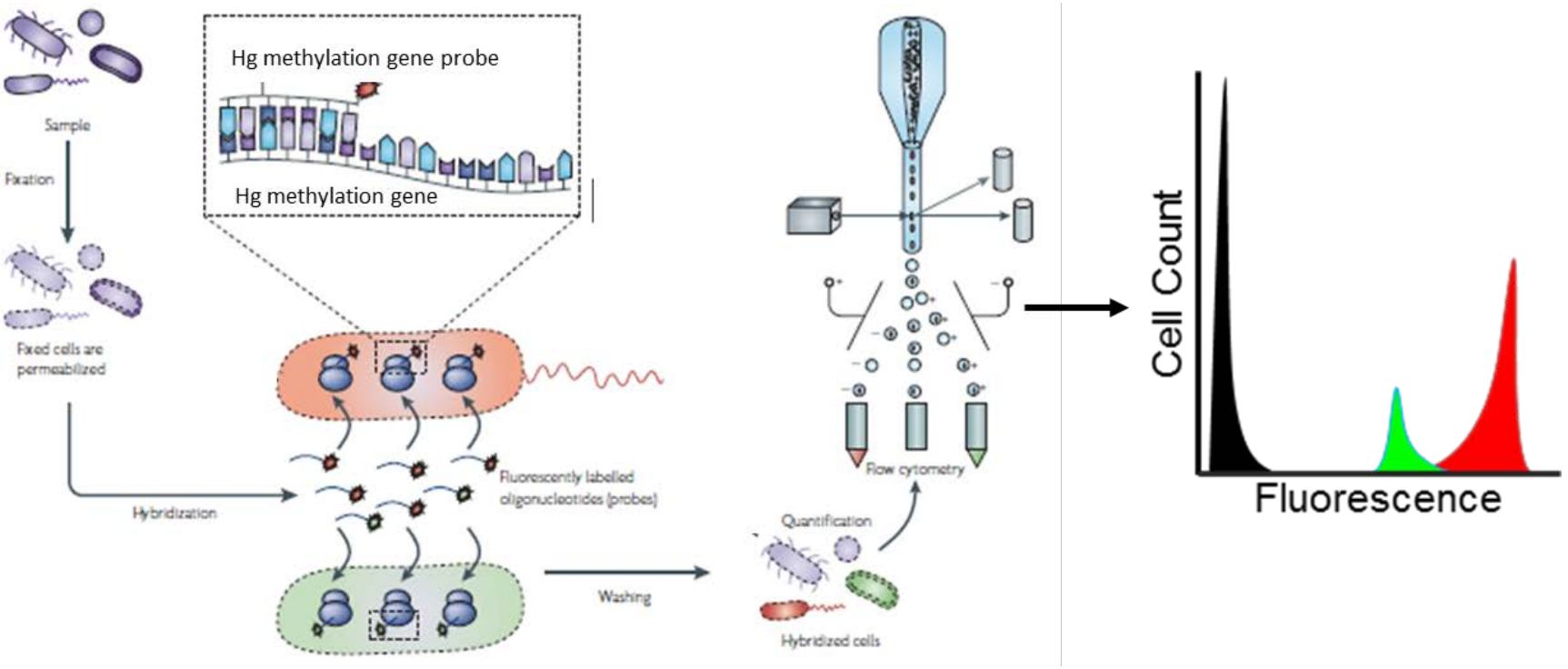
Modified from Parks et al, 2013



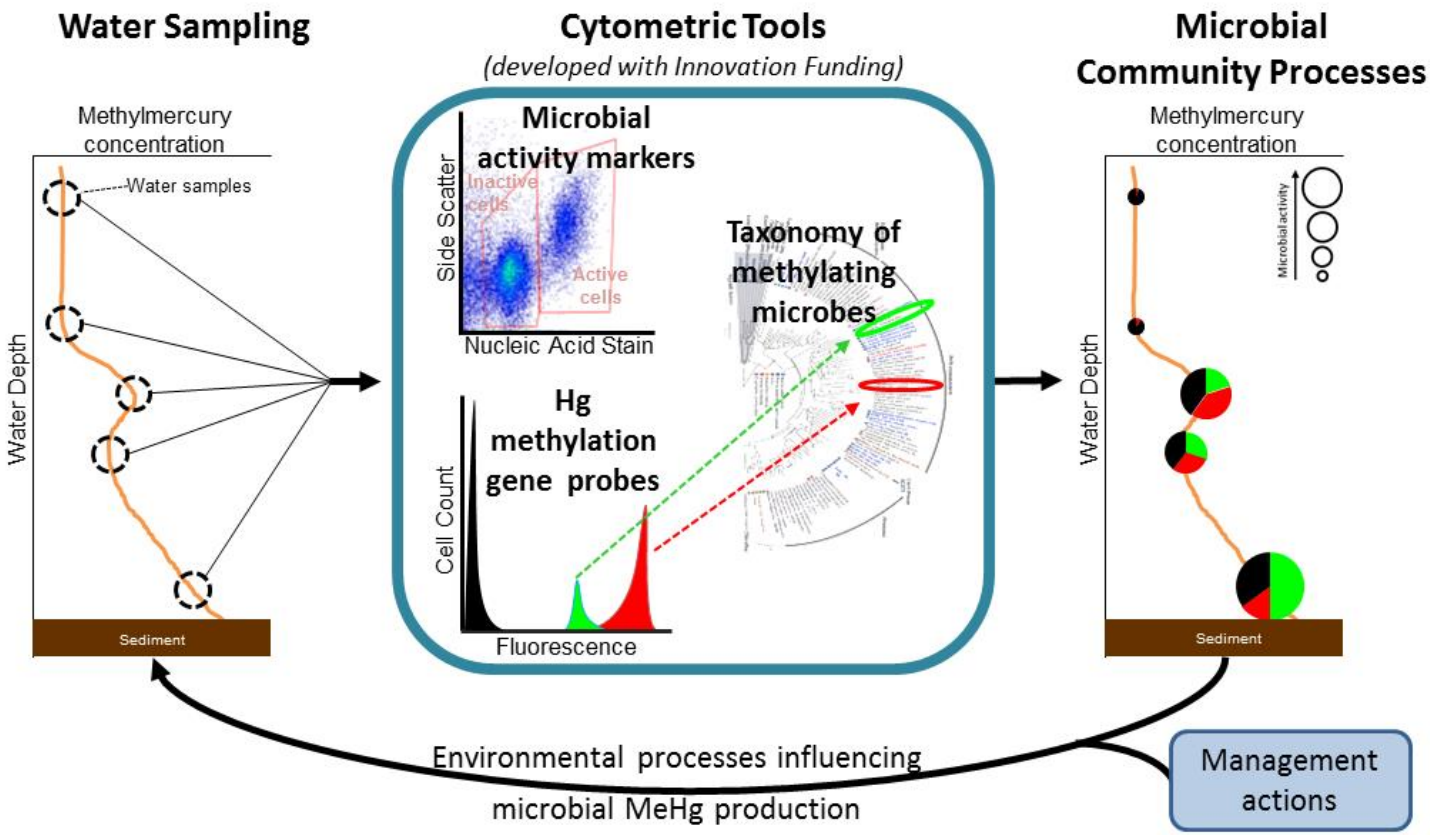
- Insights into molecular mechanisms
- Probing of existing cultures and genetic databases
- Environmental marker

Gilmour et al, 2013

Potential applications of flow cytometry in MeHg monitoring and research

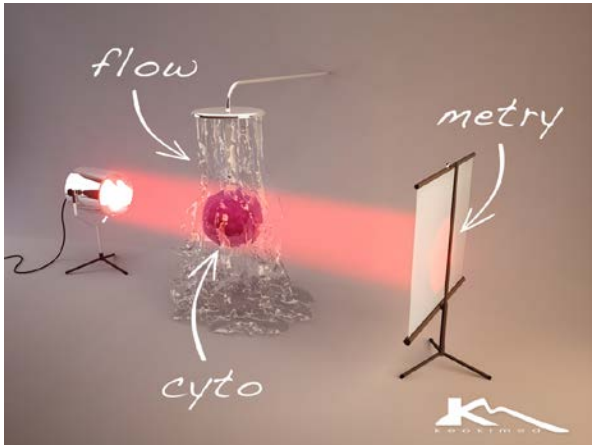


Incorporation of cytometric tools



Summary

- Flow cytometry provides a rapid, low-cost estimate of microbial community composition and activity
- Ratio of “active” to “inactive” bacteria profile closely matched aqueous MeHg profile
- Application to other systems?
- Development of molecular/genetic markers?



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Idaho Dept Env Quality

US Geological Survey

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