INNOVATIVE TECHNOLOGIES TO QUANTIFY ENVIRONMENTAL CONTAMINANT BIOAVAILABILITY & EXPOSURE

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Why Bioavailable ?

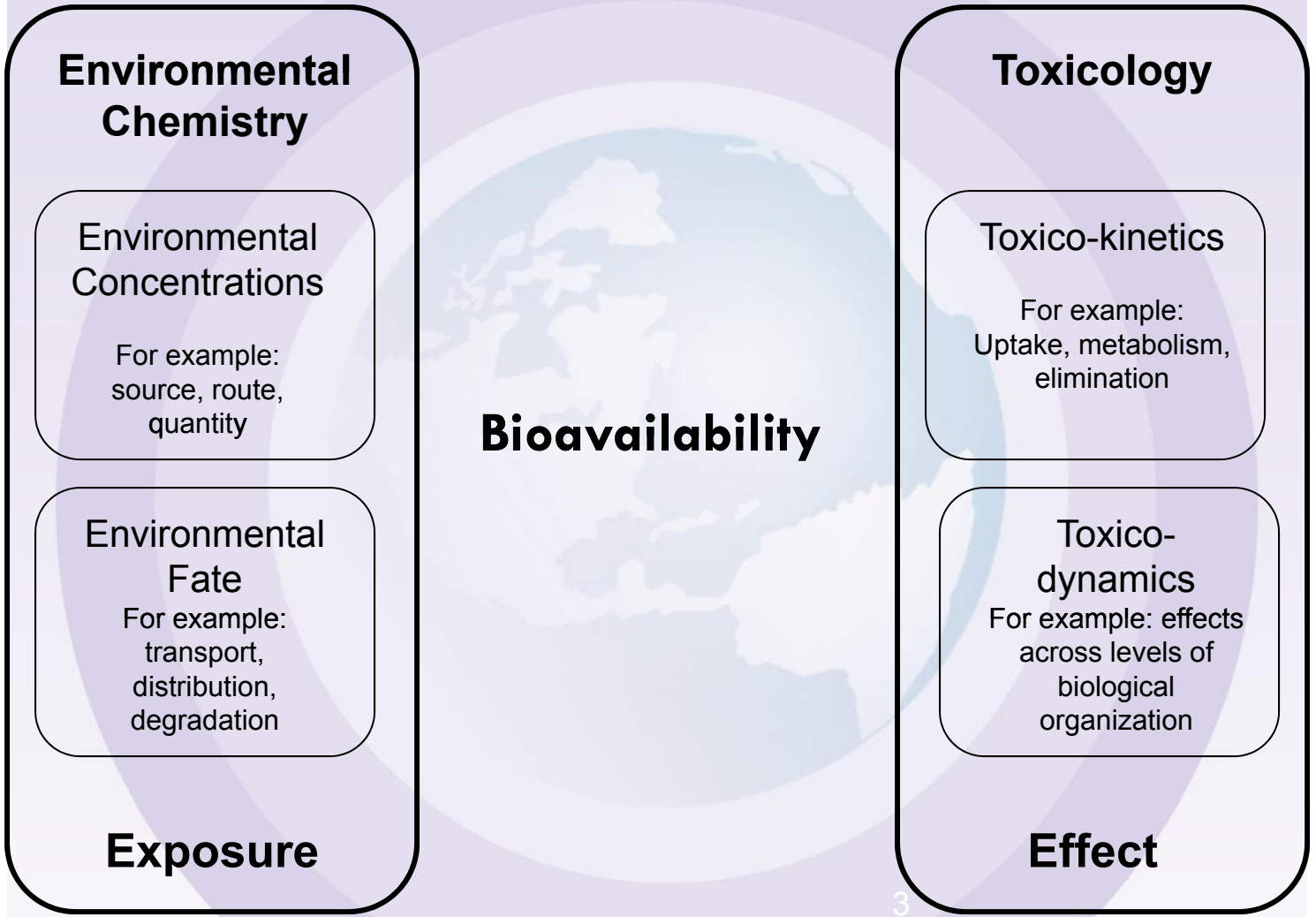
Environmental exposure and fate

- *Understanding environmental factors on diseases…*
  - Must develop new bio-analytical tools to measure exposure
    - L.S. Birnbaum, EHP, 2010

Thinking outside the sampling jar

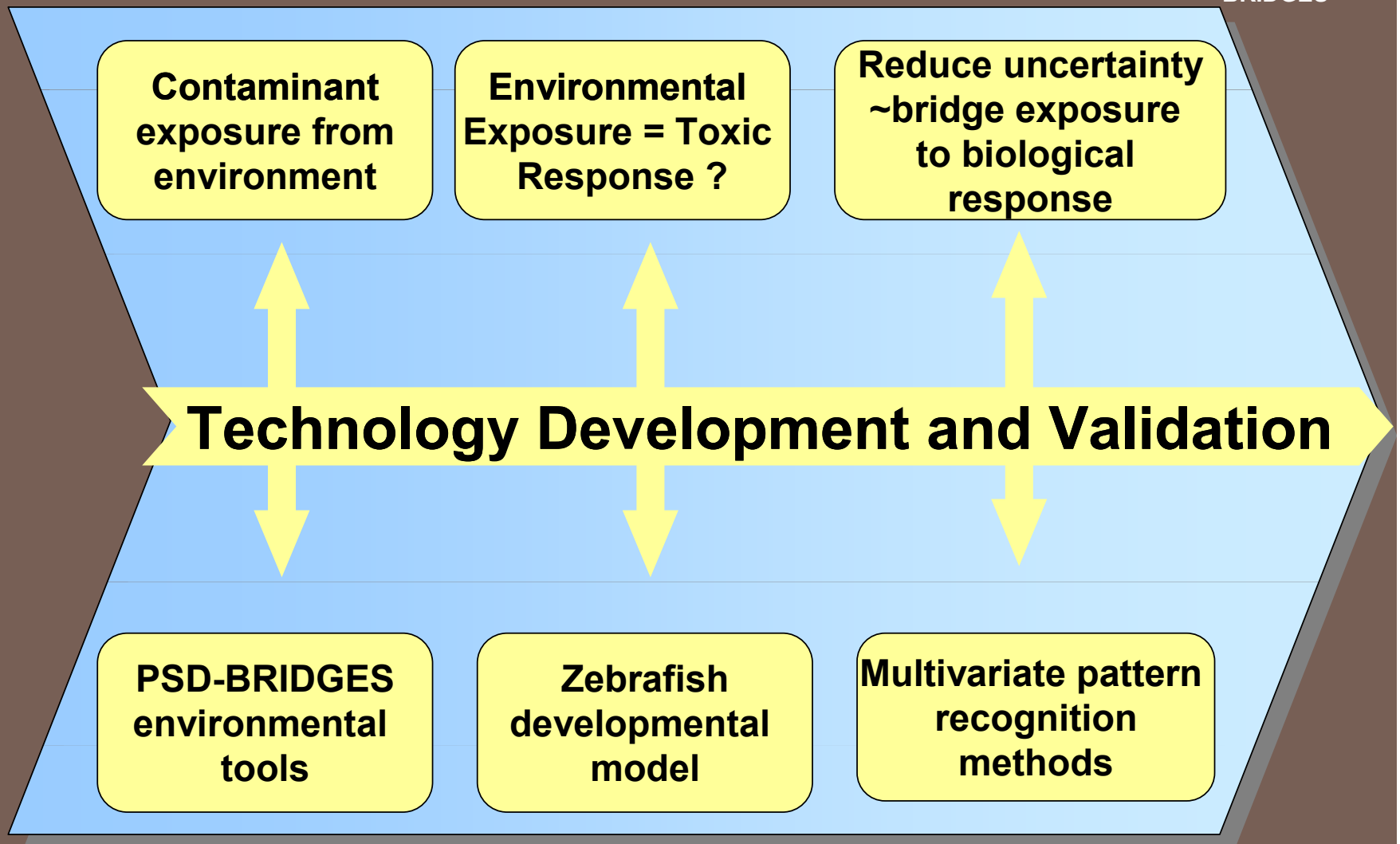
- Few advances
- Intelligent sampling
- Environmental exposure
- Bioavailability

BRIDGES

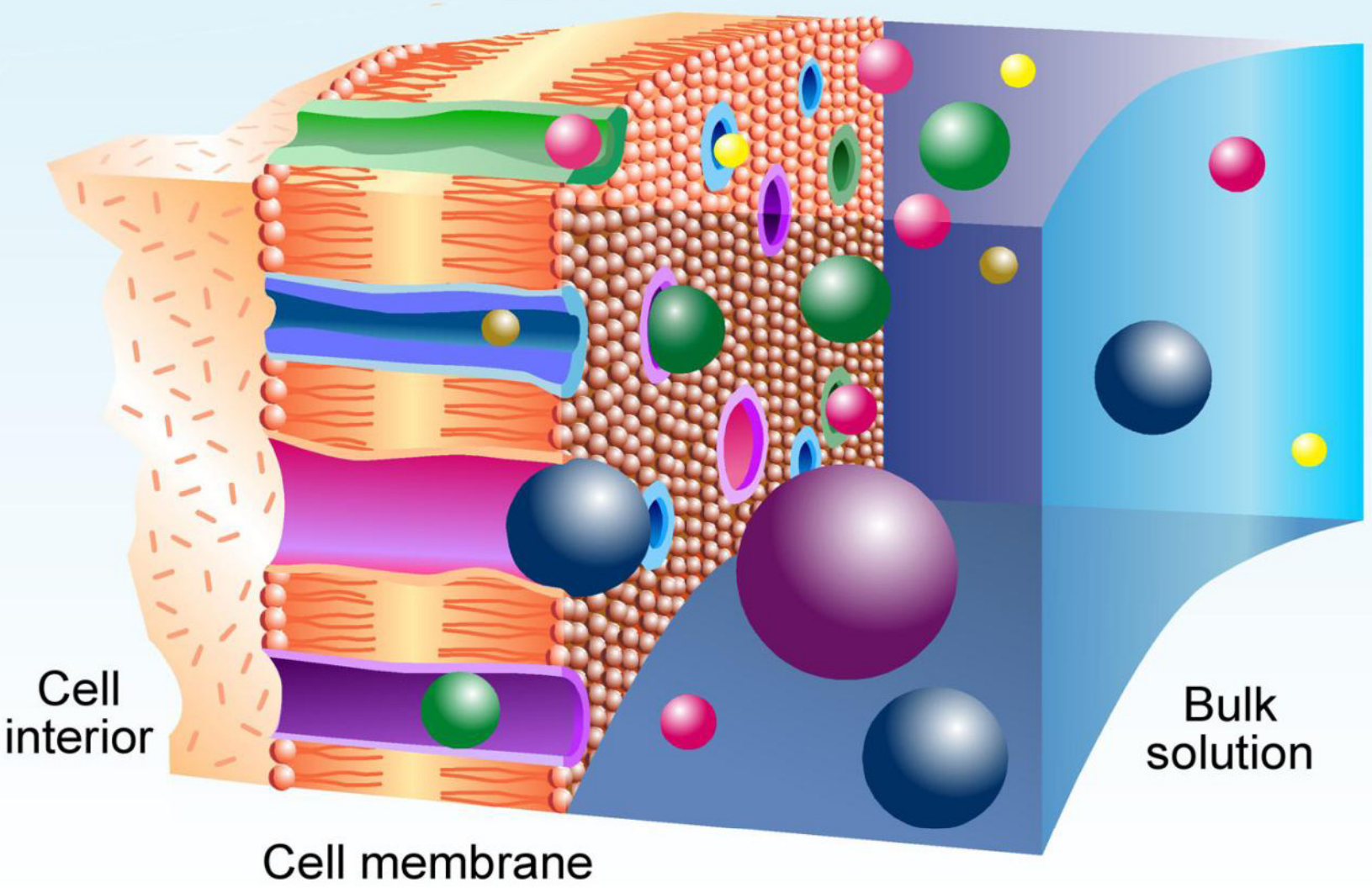


Adapted from: Anderson & Hillwalker, Ecotoxicology Bioavailability, Elsevier 2008

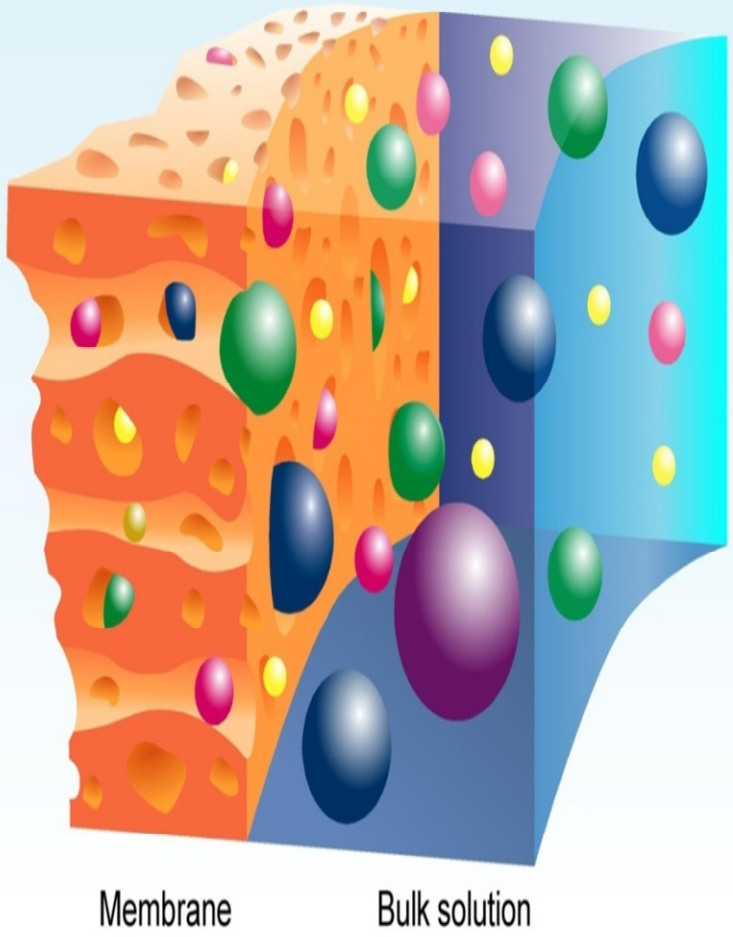
Adapted from: Schwartz, D.A., *et al*, 2005



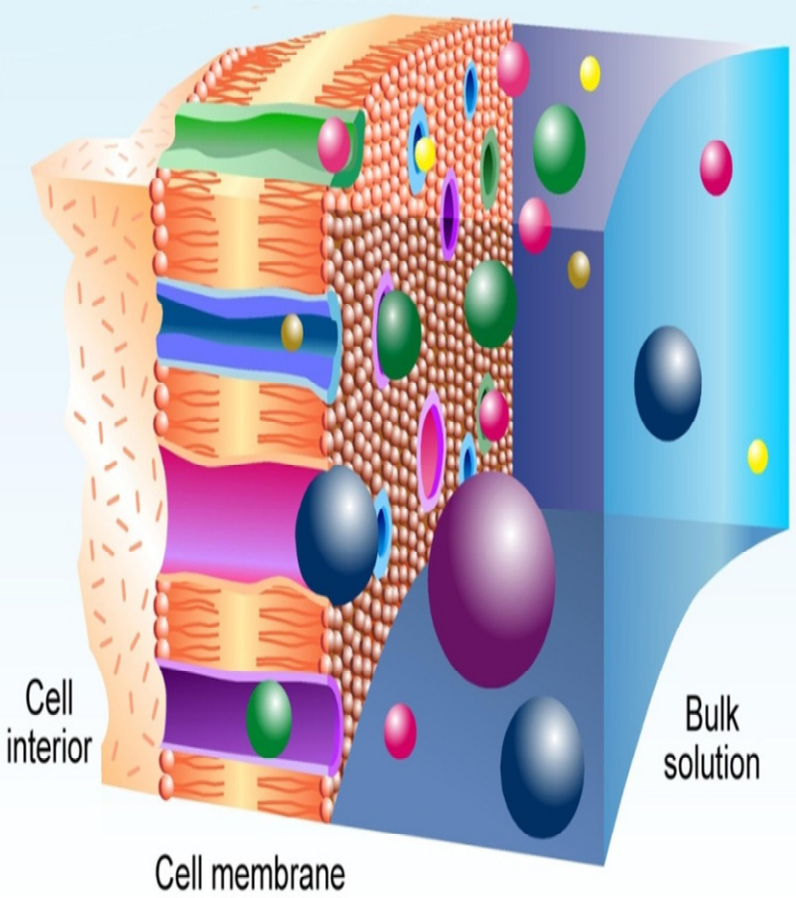
Bioavailability



PSD Membrane



Cell Membrane



BRIDGES

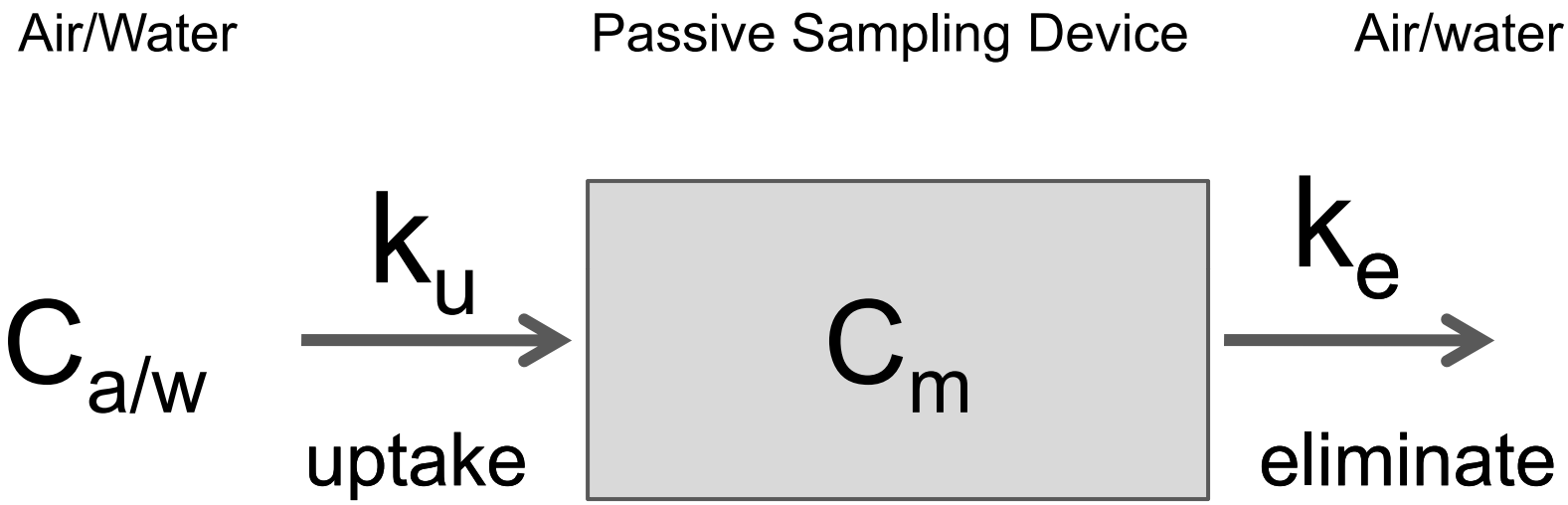
Biological Response Indicator Devices for Gauging Environmental Stressors

Passive sampling devices *quantitative* technology for deployment at Superfund sites

- **PSD theory:** PSD represent an organic lipid membrane. Like a membrane, PSDs discriminate against particulate bound material. As *in situ* time integrative passive samplers, PSDs may be deployed for extended periods of time to sequester contaminants. This **overcomes potential issues such as detection limits, bioavailable fraction collection and fluctuating contaminant concentrations.** ***In-situ*****, site specific calibration is through isotope labeled infusion into the PSD with performance reference compounds.**



Chemical Reaction Kinetics Model uptake and release of contaminant



Rate to change of the concentration:

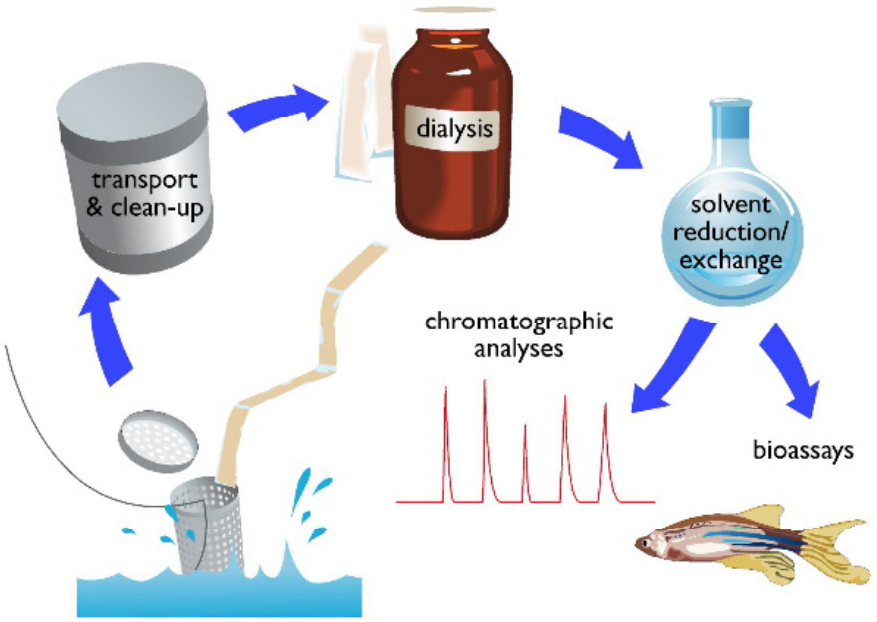
$$dC_m/dt = k_u C_w - k_e C_s$$

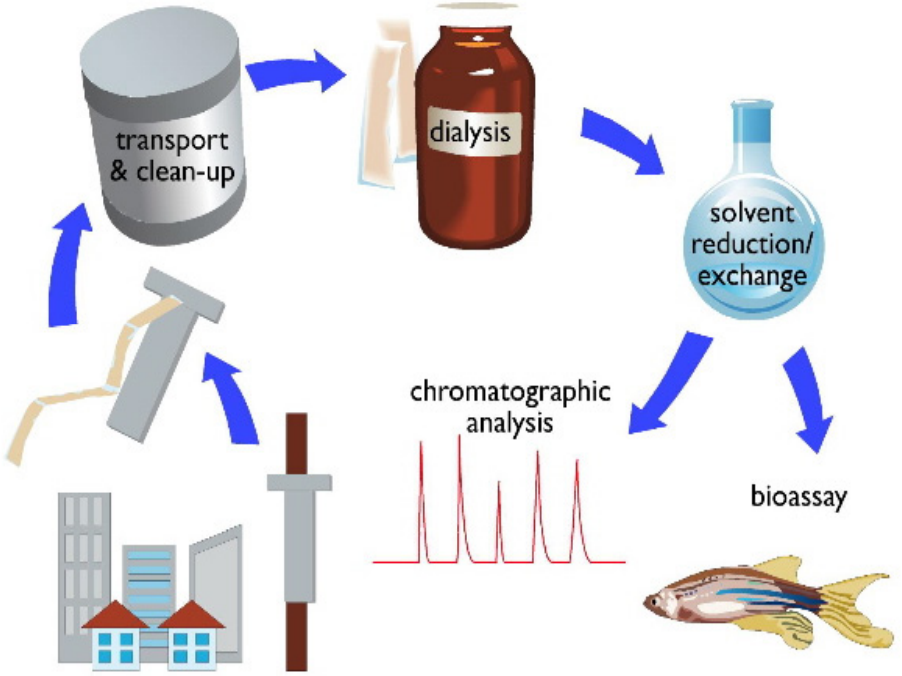
Conc at any *t* is determined by competing rates of uptake and release

Anderson, et al; ES&T, 2008

Holistic, Common Metric

same PSD used in water, air, sediment, personal

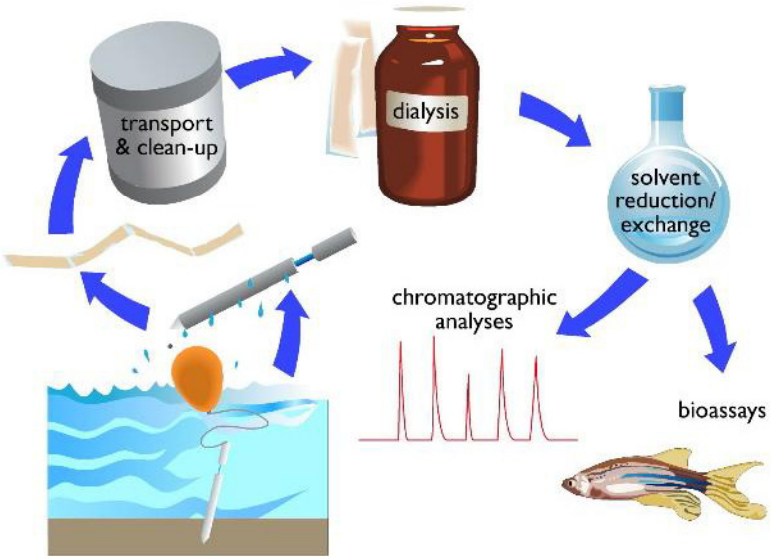




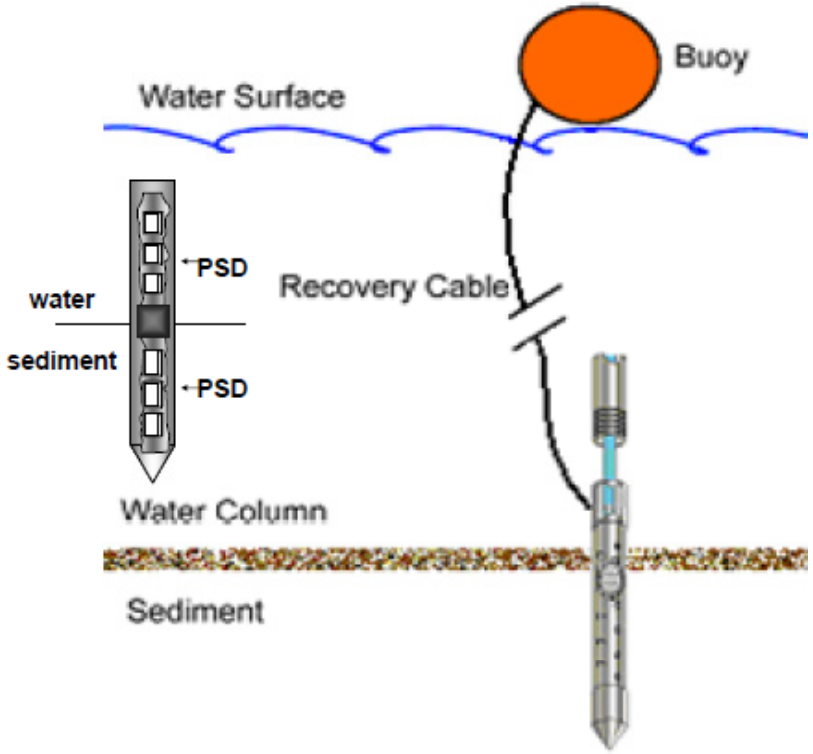
Anderson, et al; ES&T, 2008

Bioavailable Passive Samplers

Extraction and bioassays



In situ sediment deployments



Development of Bio-analytical Tools

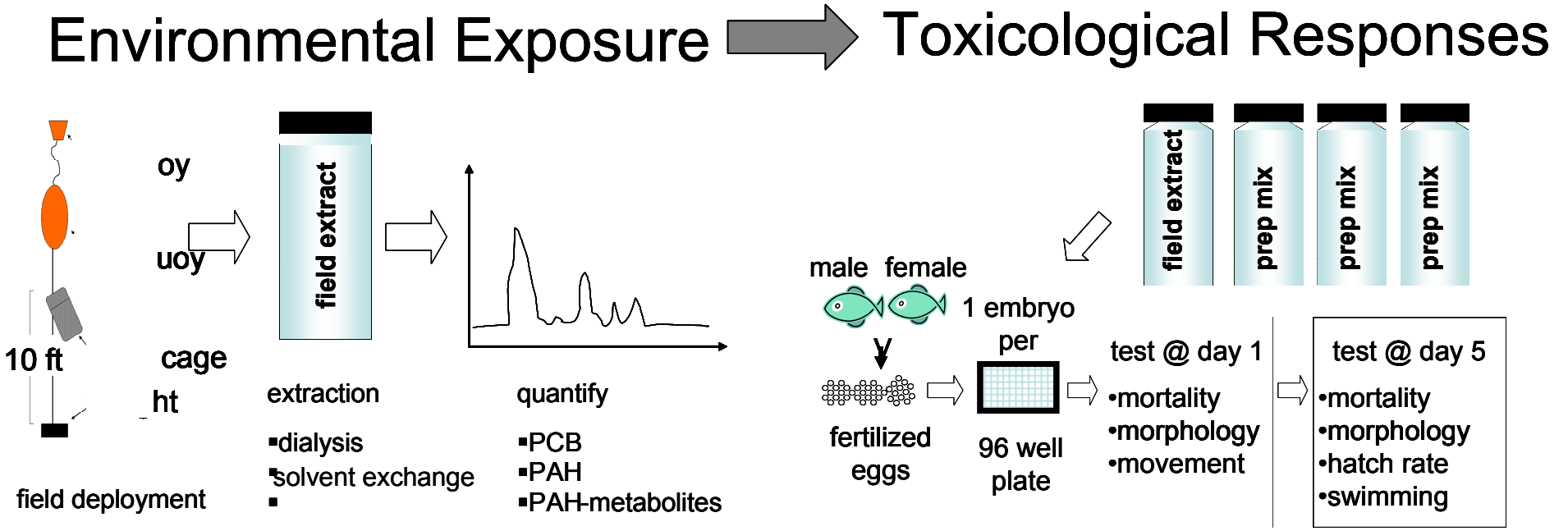
Integrated Sampling

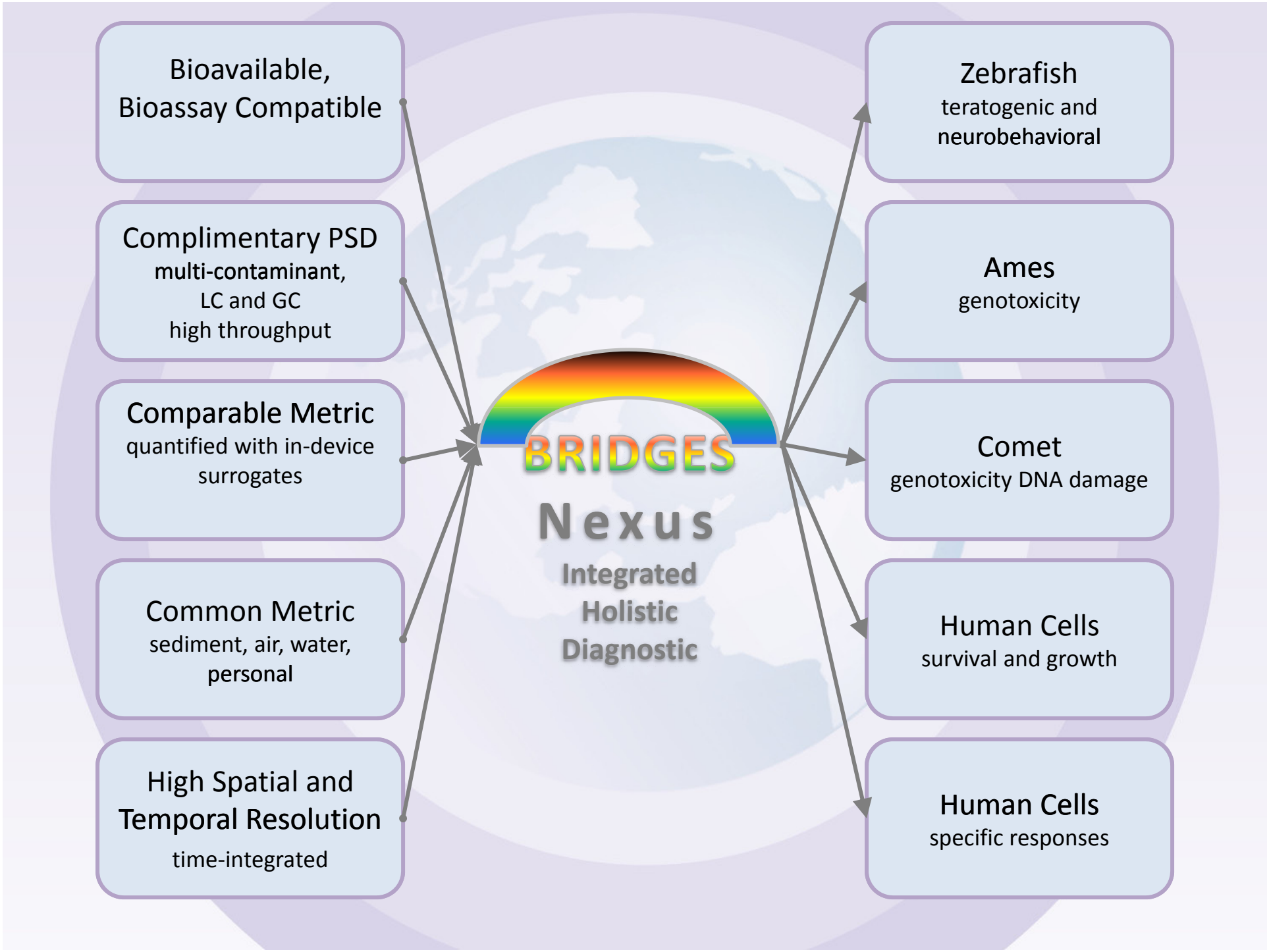
Broad range of contaminants

- Suitable to LC and GC
  - PAHs, PCBs, Pesticides
  - 1,200+ analytes screen
  - Oxygenated PAHs
    - Layshock *et al* ETC, 2010

BRIDGES: **Reduce exposure uncertainty by analyzing biological responses**

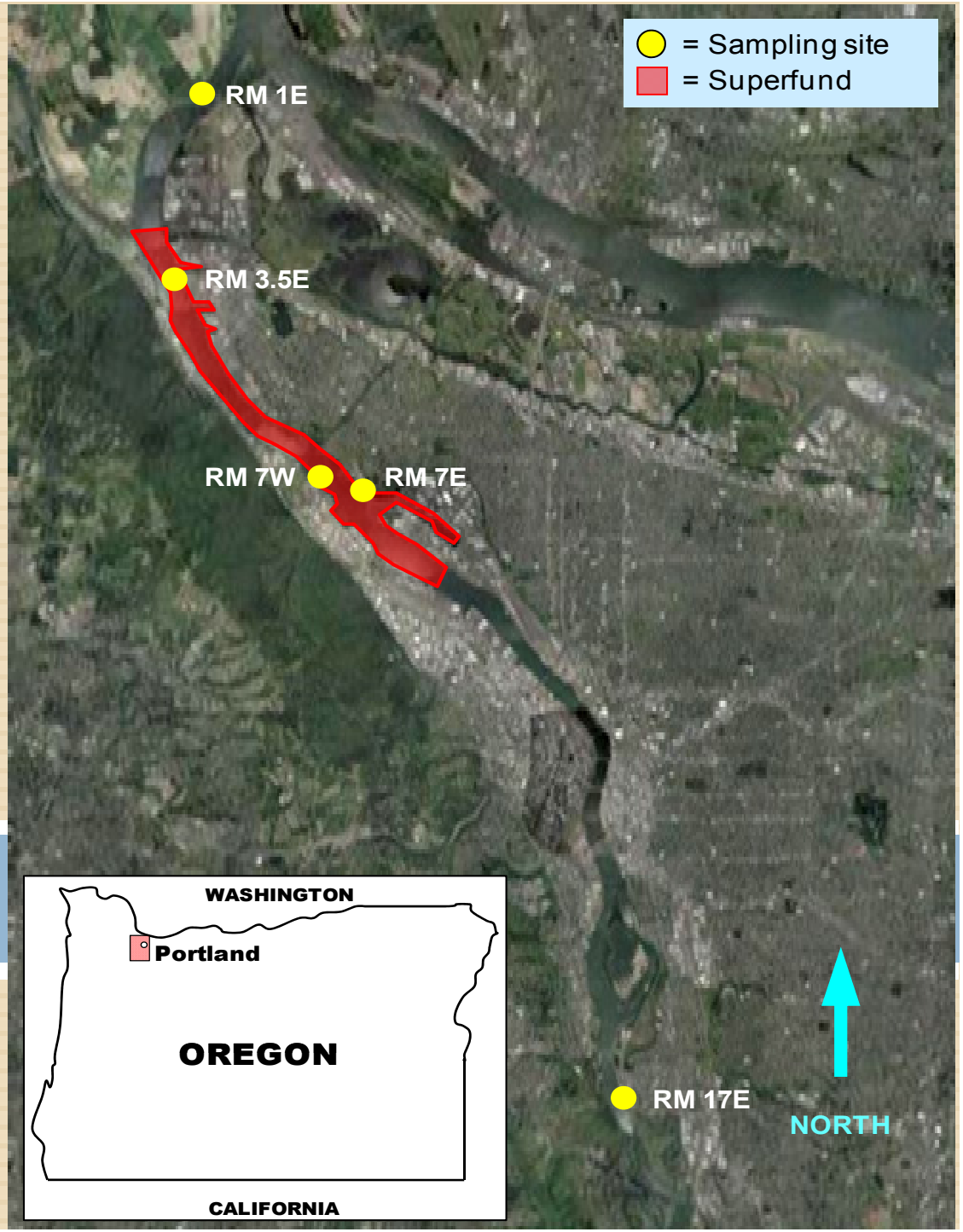
BRIDGES extracts with bioassay model (Zebrafish, Ames, etc) systems

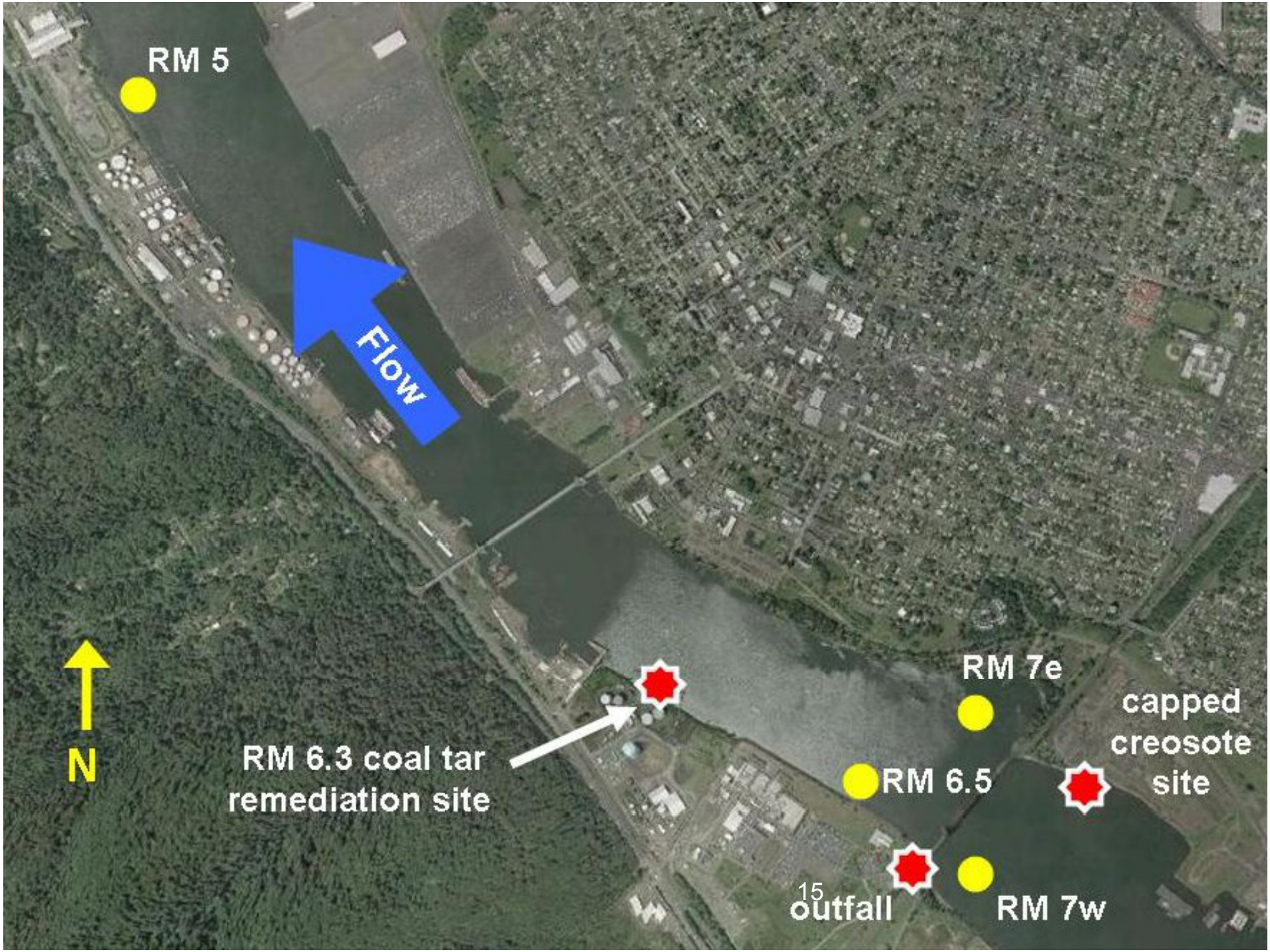



Bioavailable,
Bioassay Compatible
Complimentary PSD
multi-contaminant,
LC and GC
high throughput
Comparable Metric
quantified with in-device
surrogates
Common Metric
sediment, air, water,
personal
High Spatial and
Temporal Resolution
time-integrated
BRIDGES
Nexus
Integrated
Holistic
Diagnostic
Zebrafish
teratogenic and
neurobehavioral
Ames
genotoxicity
Comet
genotoxicity DNA damage
Human Cells
survival and growth
Human Cells
specific responses

Superfund Deployment Sites

BRIDGES



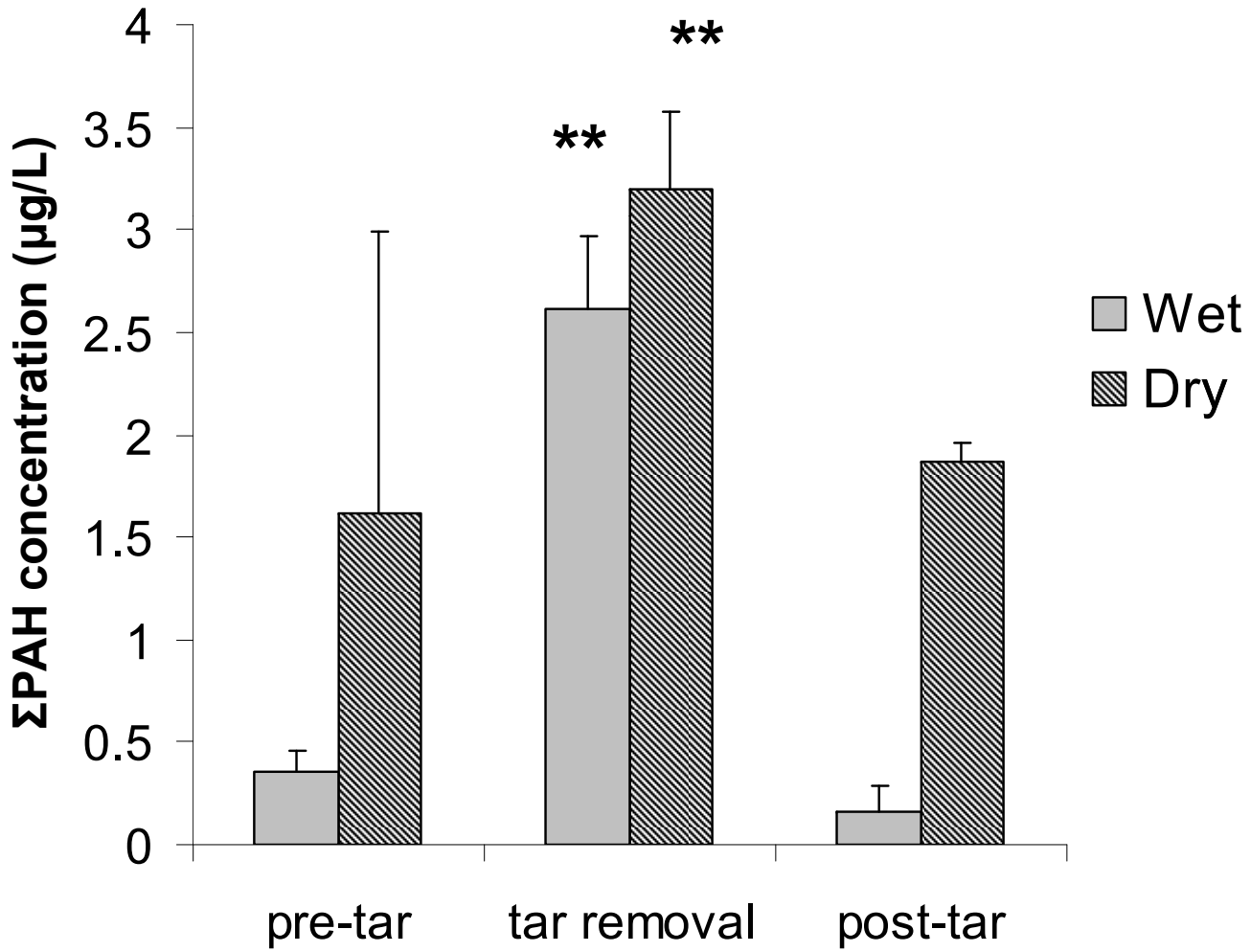

RM 5
Flow
N
RM 6.3 coal tar
remediation site
RM 7e
capped
creosote
site
RM 6.5
outfall
RM 7w

Extraction and Analysis of PSD

- Extract clean
- LC or GC compatible
  - HPLC, GCMS, GCMS-QQQ, LCMS
- **PAHs** (EPA) and b e y o n d 33 PAHs
- 302 mw, dibenzopyrene isomers PAHs
  - Layshock *et al* JEM, 2010
- Oxygenated PAHs (ketones, quinones)
  - Layshock and Anderson, ETC, 2010
- Pesticides, PCBs,
- **1,200+ analyte screen**

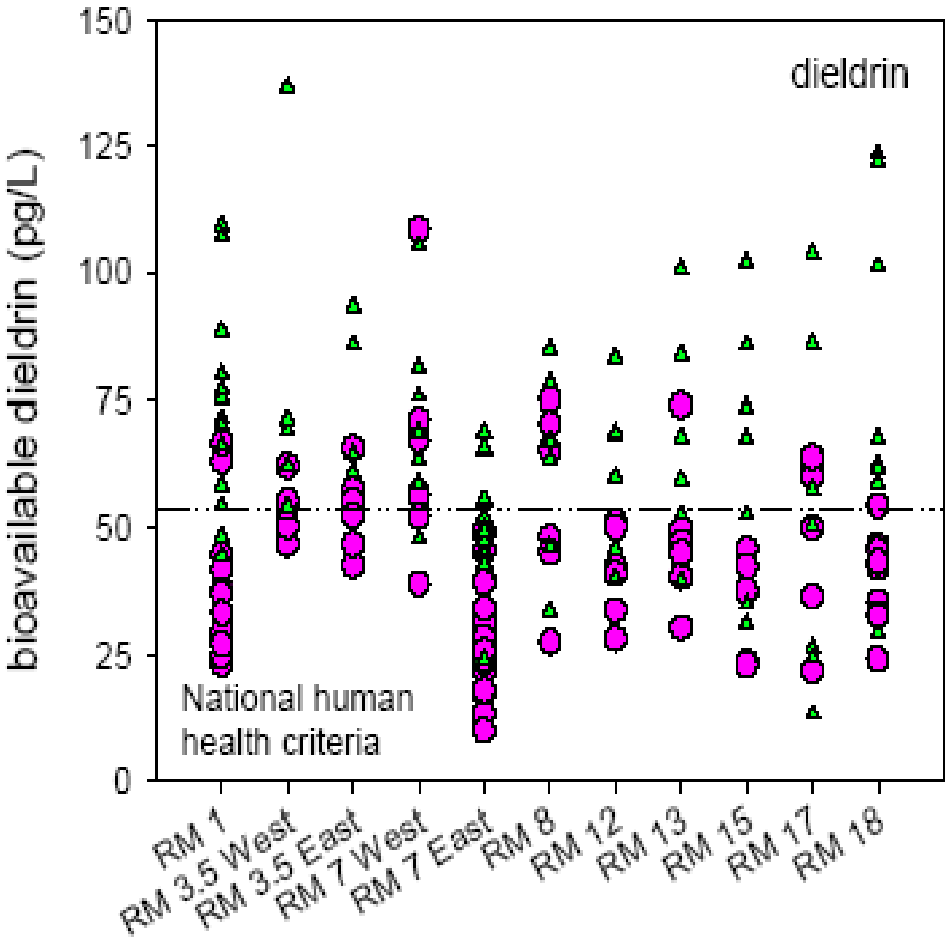
Effect of dredging at RM 6.3 on *bioavailable* PAHs at RM 7

n=3, each a composite of 5, p<0.05, in situ calibration with labeled PRC



Spatial and Temporal at Superfund sites

- Water quality data for the carcinogenic EPA PP PAHs.
- ▲/O = wet season
- ● = dry season
- The dashed lines represent the EPA Water Quality Guidelines for human health for consumption of water and organism.



N = 110, P<0.001, 3 week deployments

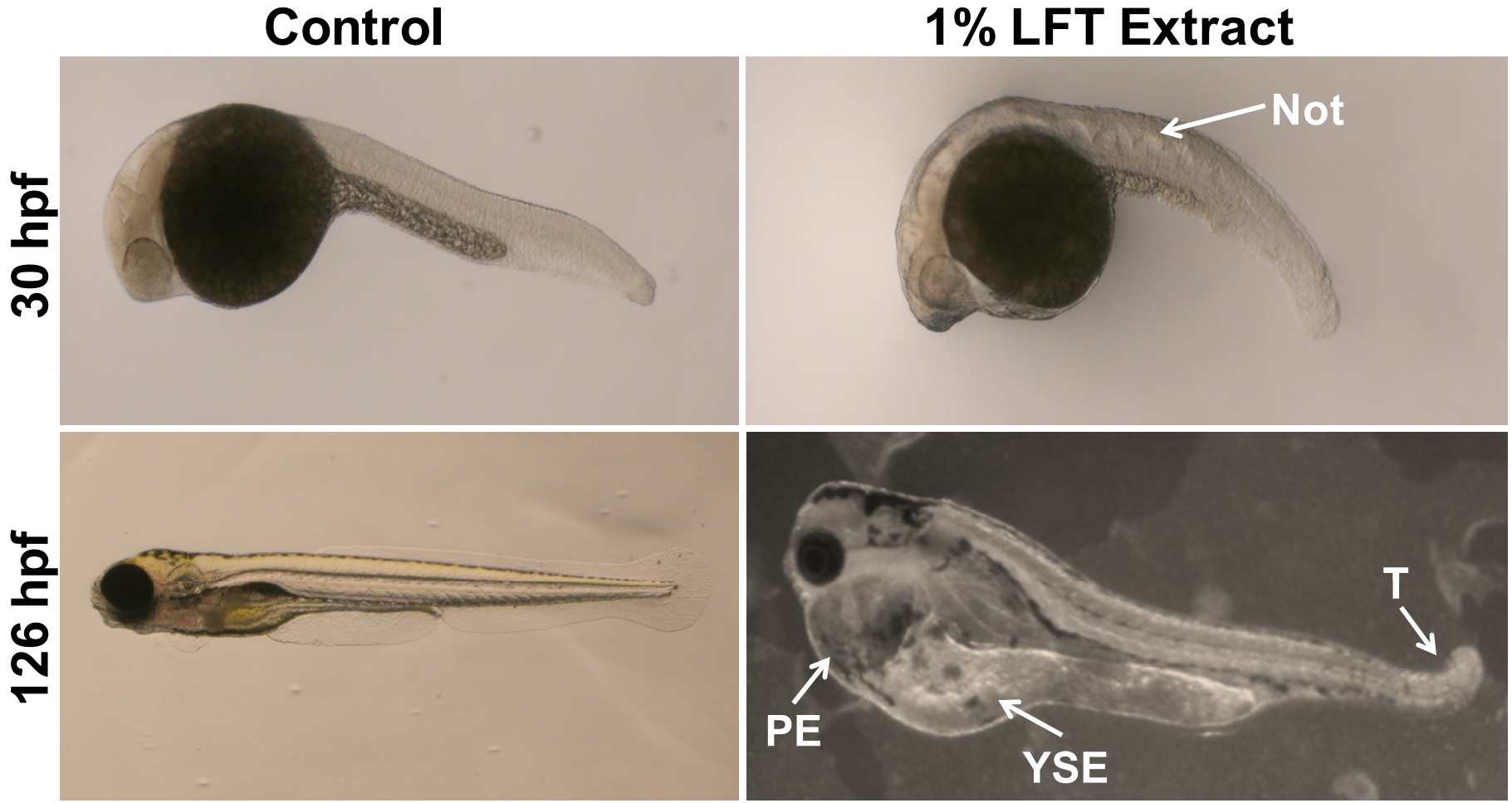
● = low flow (summer)

▲ = high river flow (>10,000 ft^3/s, >1 in rain)

Sower & Anderson, EST, 2008, Sethajintanin and Anderson, EST, 2007

Site-specific Biological Responses

Abnormal developmental morphological endpoints observed in embryonic zebrafish exposed to contaminant mixtures from extracts of LFTs deployed at Superfund sites.



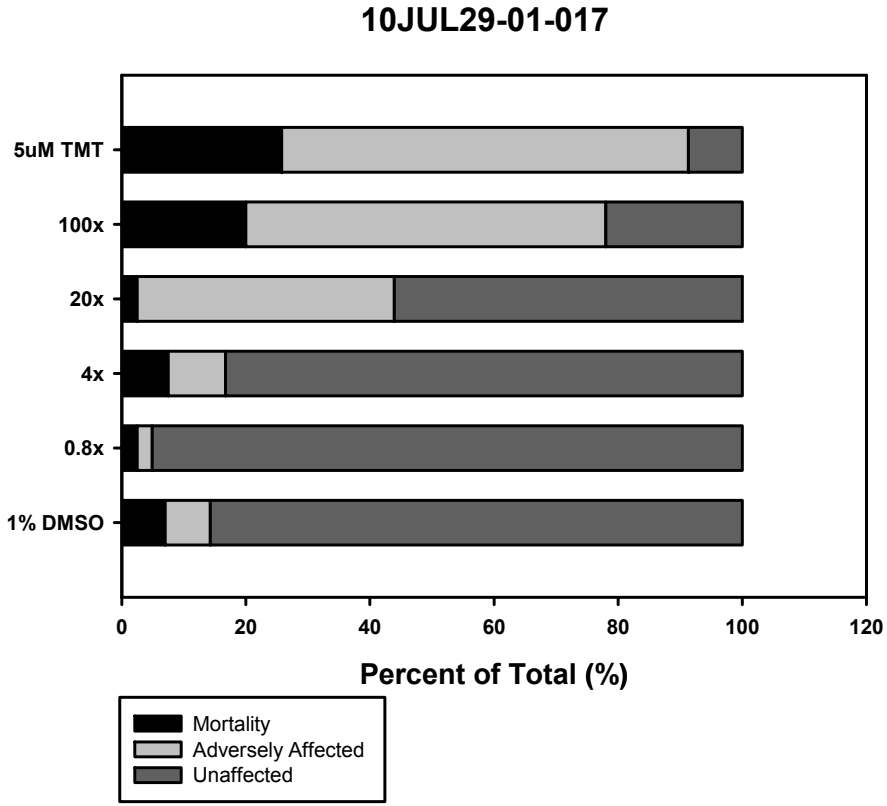
Not= notochord waviness; PE= pericardial edema; YSE= yolk sac edema; T= bent tail

PSD successfully bridged to *in vivo* full organism bio-assay

n=32 each dose, PSD dose response, 0.8x ≅ 8x river water

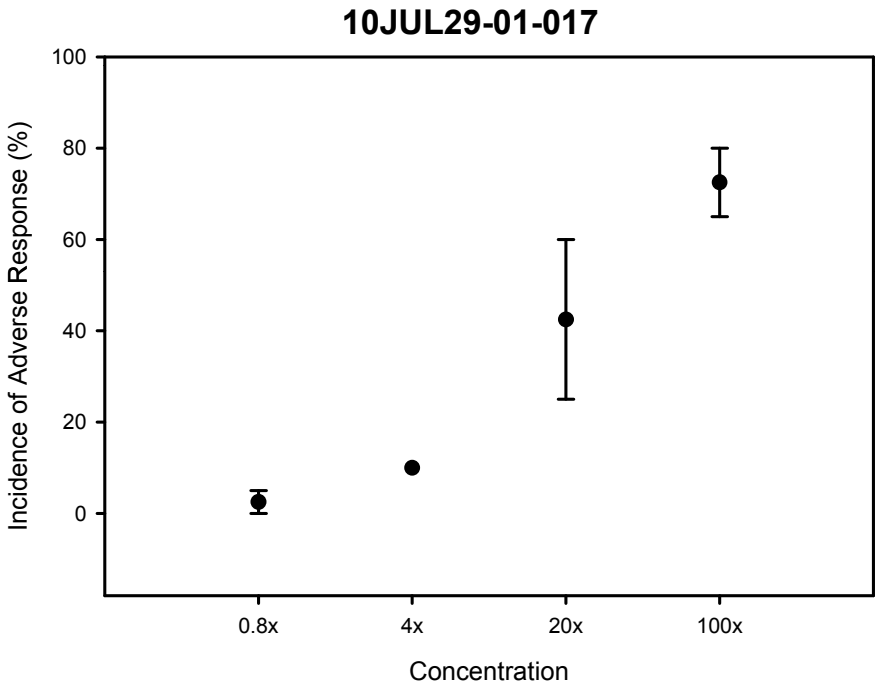
Positive control trimethyltin

Negative control 1% DMSO



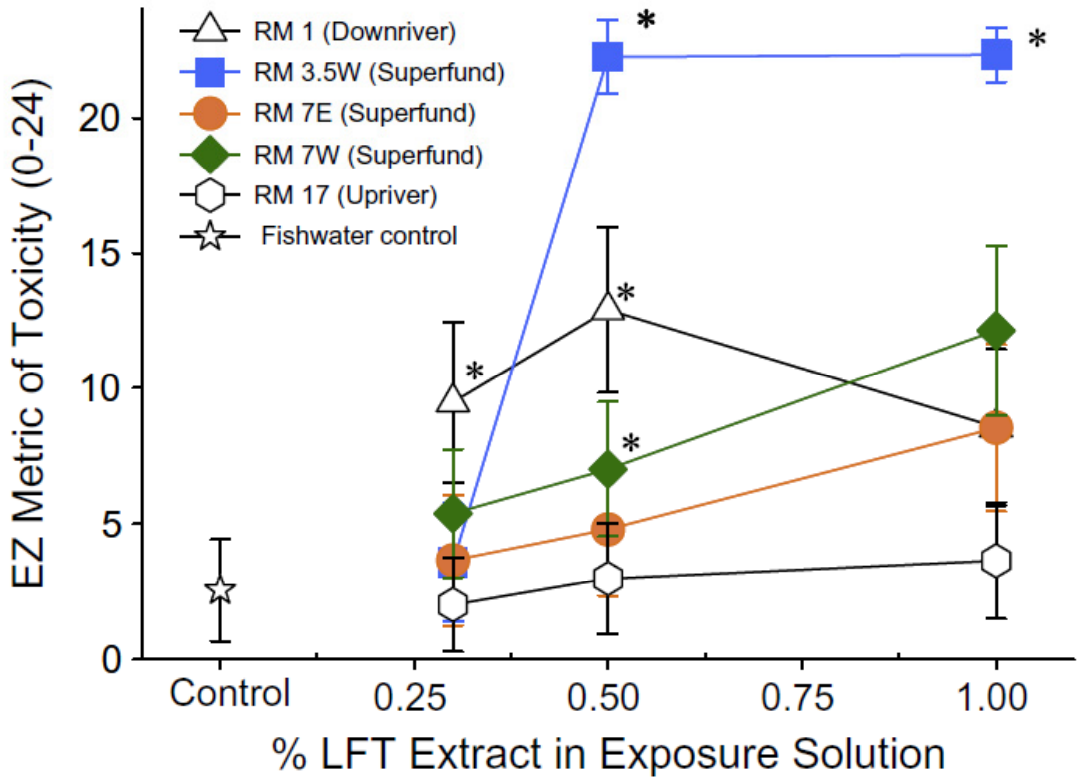
PH Superfund site river mile=3.5W

July 2010



PSD bridged to whole organism bio-assay

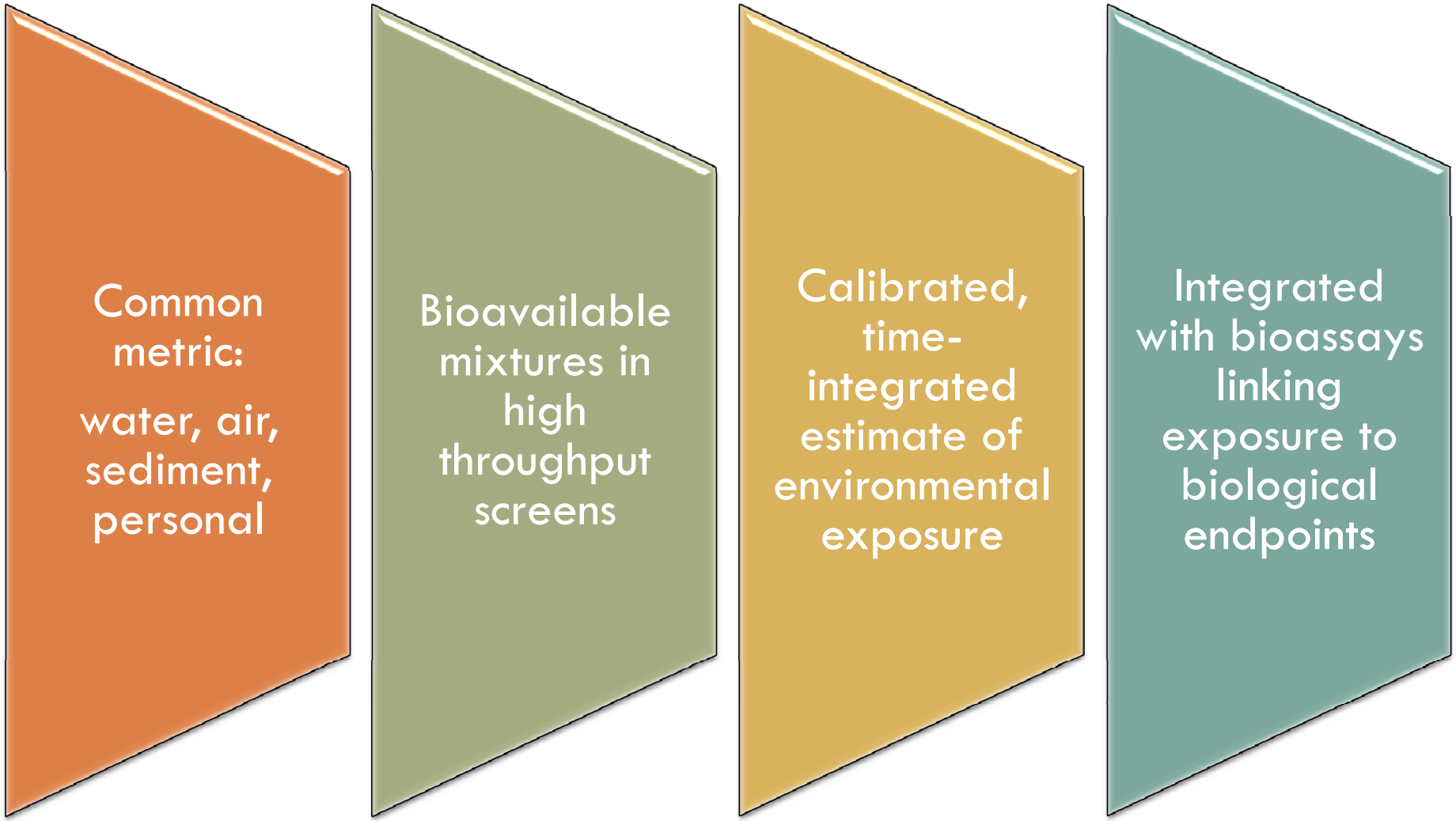
Comparison of the integrative EZM (mean ± 95% CI) of embryonic zebrafish exposed to different concentrations of extract solution obtained from LFTs deployed M&B and Portland Superfund sites.



n = 941, Asterisks (*) indicate significant differences relative to control embryos (1% DMSO).
Each dose total **n=72,** three different days 24 fish each day.

Hillwalker, Allan, Tanguay, and Anderson Chemosphere, 2010, 79, 1-7

Anticipated IMPACT



Innovation

- Sequesters dissolved-bioavailable fraction
- Sequesters a broad range of contaminants
- Bioavailability changes of new remedial technologies can be pre-tested in site-specific sediment created microcosm
- Has the ability to be use directly in bioassays
- Linkable with integrated bioassay from in vitro (mammalian cell) to in vivo vertebrate assays
- Has the ability to be used to explore mechanism-based understanding of bioavailability processes
- Same technology as used for water and air
- High spatial and temporal resolution possible
- In situ sediment depth profiles possible
- Captures episodic events
- Comparative data developing rapidly
- Composites without mechanical power
- No on-site power needed
- Very low detection limits with analytical ease
- Less expensive
- Greener technology
- *In-situ* assessment of contaminants most biologically relevant
- Discriminates environment from other exposures (e.g. diet)
- Easier to replicate spatially than organism
- Organisms in the environment are **not** sacrificed

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http://fses.oregonstate.edu

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http://oregonstate.edu/superfund/oilspill

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NIEHS Superfund Research Program

a hazardous waste research and training program

www.niehs.nih.gov/research/supported/srp/index.cfm

Superfund Research Program

Research

- Interdisciplinary
- Collaborative
- Solution-Oriented
- e.g. molecular tox, biomarker development, ecology, remediation

Network of:

- 19 university-based research centers
- 11 individual research grants
- 5 SBIRs/STTRs

Training

- graduate and post doctoral
- interdisciplinary

Products

- Over 6,000 publications
- 55 patents
- Enrichment materials, e.g., fact sheets, videos

Communication Tools

- Research Briefs
- Risk-e-Learning
- Workshops
- Conferences

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