Nuclear Monitoring in the Post-Cold War Era: Technology to Support Unilateral Actions

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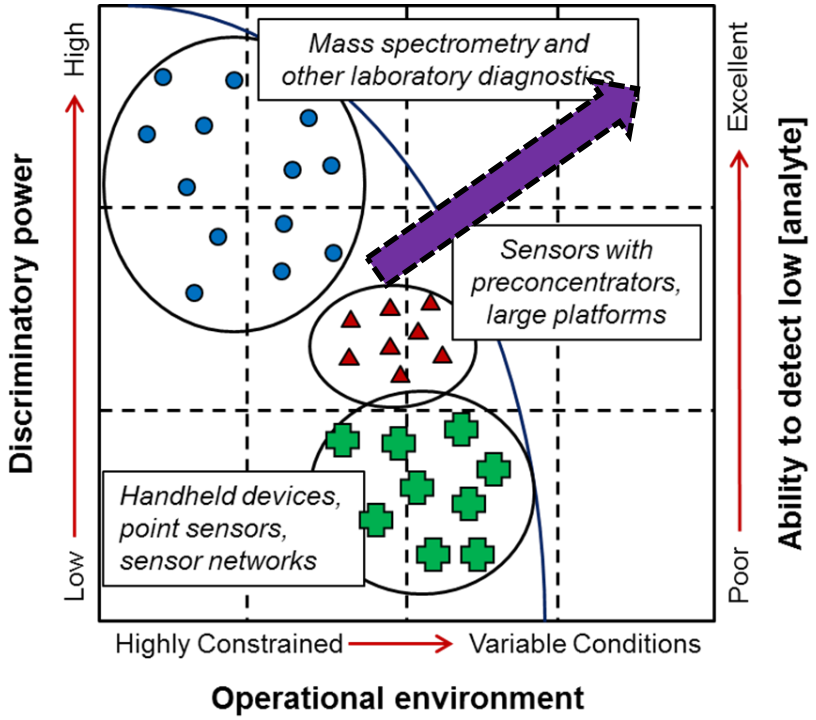
PONI Conference
9 – 10 December 2015

Overview

Monitoring Paradigm Shift: Outside of the Treaty Regime



"A Nuclear Future Unlike the Past"

Current technologies ill-suited for:

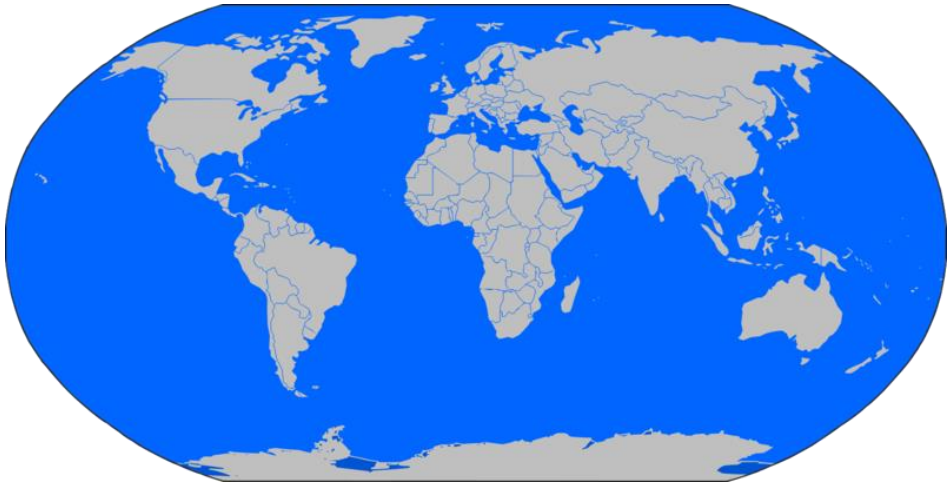
- **Non-permissive environments**
- Long periods of observation
- Large geographic areas
- Short duration events
- Masked signals

A new addition to the toolkit: Biosystems are highly responsive to presence of environmental contaminants and can produce tell-tale signatures that persist well past the exposure event.

The Challenge

"The nuclear future will not be a linear extrapolation of the past."

~ Defense Science Board Task Force Report (January 2014): Assessment of Nuclear Monitoring and Verification Technologies



- Motivations
- Capabilities
- Approaches

Unconventional threats demand unconventional tactics.

Current Monitoring Technologies

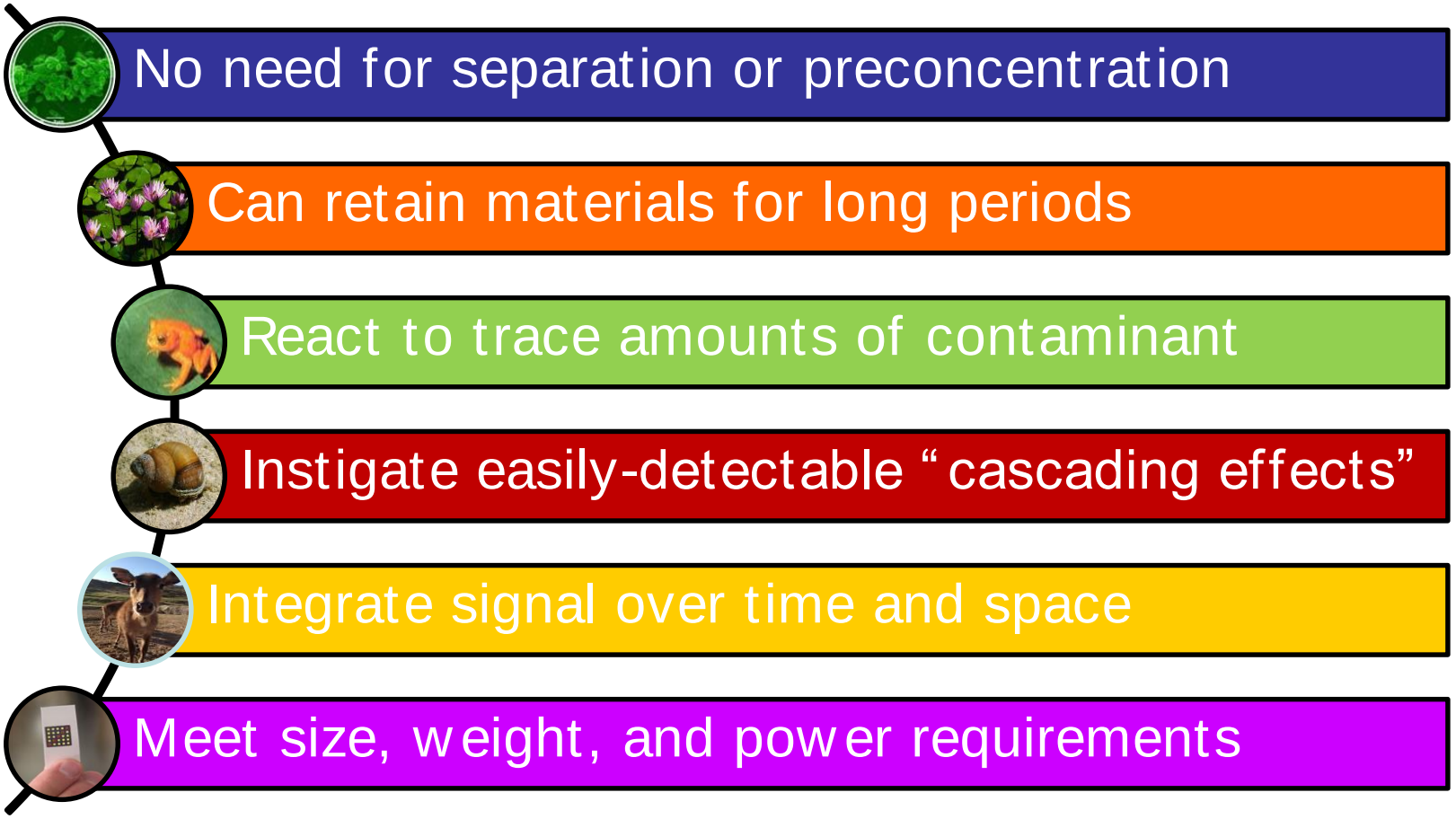
- Satellite imagery
- Detection technologies
- Collections

Environmental attenuation
Data processing
Signal:noise ratios
Single analyte selectivity
Human intervention
Supporting infrastructure
Loss of signature
Expertise/equipment

Detection of small inventories, covert operations, and use of non-traditional processes requires more descriptive data.

Advantages of Biosystems

Biology can help with ***really hard*** monitoring problems.

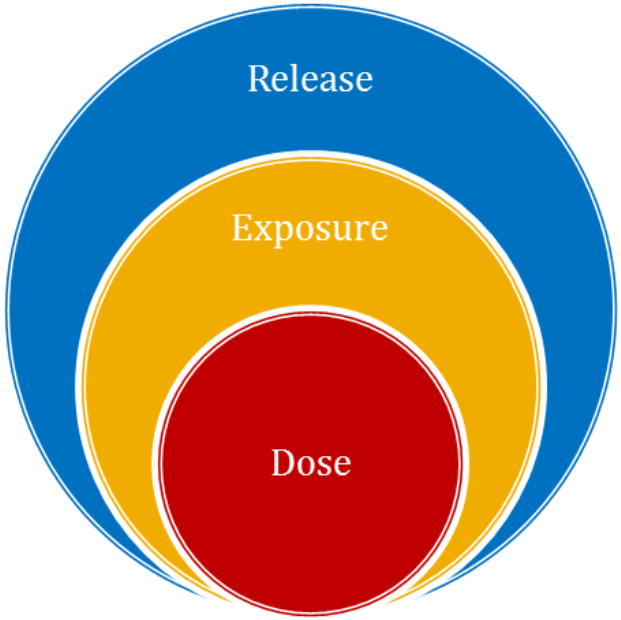


Biosystems are not the panacea.

…but, then again, what is?
Discernment is always necessary to match the capability to the CONOPs.

Issues to consider:

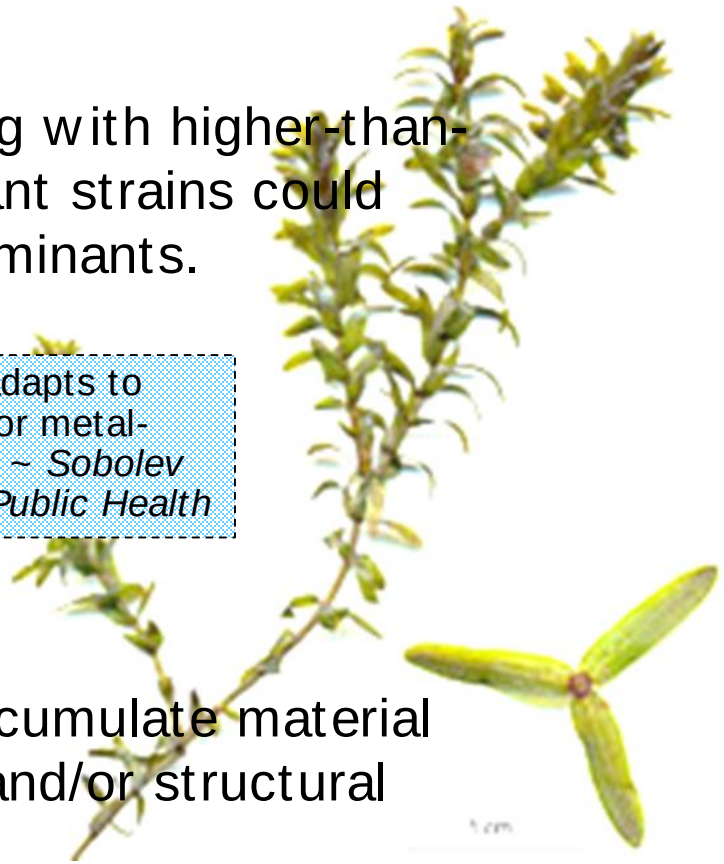
- Operational conditions
- Exposure-effect overlap
- Necessary dwell times
- Specificity of response
- Longevity of response



Best Use of Collections: Now

- Soil and sediment analysis
  - Changes to microbial diversity along with higher-than-anticipated concentration of resistant strains could indicate presence of specific contaminants.

Denitrifying microbial community adapts to elevated levels of Pb by selecting for metal-resistant forms of nitrite reductases. ~ *Sobolev and Begonia. 2008. Int J Environ Res Public Health 5:450-456*



- Informed collection
  - A wide range of flora and fauna accumulate material because of their natural ecologies and/or structural features.

Phytoaccumulation of U is enhanced by symbiotic association with specific fungal communities. ~ *Davies et al. 2015. Frontiers in Plant Science 6:1-6*

Best Use of Collections: Now

- Resource collections
  - Existing biorepositories could provide baseline information for analysis of environmental changes linked to nuclear activity.

Researchers found interspecific differences in benthic invertebrates collected from the Aleutians, site of three underground nuclear test shots. < *http://www.cresp.org*>

- Agri-food supply chain
  - Food radiation testing is common following radiation accidents and could be exploited for identifying suspected .

Foodstuffs from areas close to the Chernobyl Exclusion Zone and Daiichi Power Plant are routinely tested for contamination.

Something Different: Soon

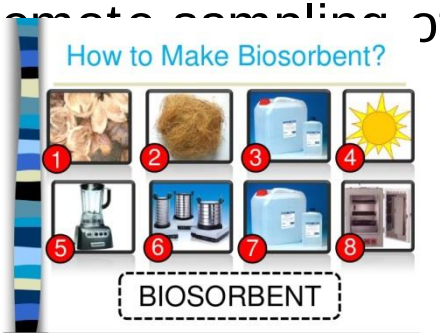
- Novel detection motifs
  - Stickers that exhibit color change upon exposure to radiation could be applied to packaging materials, vehicles, and clothing.

"Sterisure Gamma" is a small self adhesive label, 12mm diameter, which changes from yellow to red after exposure to gamma radiation.

http://www.siltechlimited.com/sterilisationindicators.aspx

- Biosorptive materials
  - Biosorptive materials could be used for remote sampling of stream discharges from suspect sites.

Several commercial biosorbents can remove heavy metal ions from industrial or mining wastewaters, including BIO–FIX, AMT–BIOCLAIM™, and AlgaSORB™, and have been evaluated in pilot tests for metals like Fe, U, Co, Cd, Pb, and As.



http://www.slideshare.net/annisaslide/pkt-61

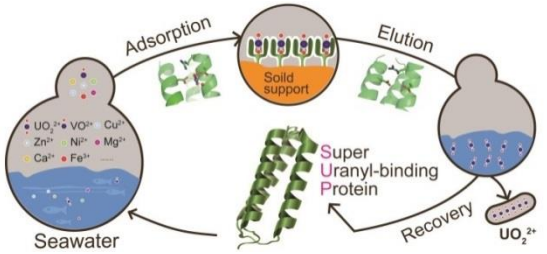
Something Wholly Different: In the Pipeline

- Remote detection via spectral reflectance
  - Changes in plants due to stress are detectable using combinations of hyperspectral and remote thermal sensing.

Identification of TNT-contaminated soils is possible by surveying differences in plant canopy reflectance on contaminated vs. uncontaminated sites.
~ Naumann, Rubis, and Young. 2010. SPIE Conference Proceedings

- Biologically-based sensor materials
  - A combination of computational screening and genetic engineering techniques allows rapid production of biological recognition elements with high affinity for specific targets.

Chinese researchers have developed "super uranyl binding protein", which binds uranyl cation at 10,000x greater affinity than other heavy metals.
~ Zhou et al. 2014. Nature Chemistry 6:236-241



Summary

- Need for strategic thinking to counter actual and potential threats
  - Disruptive technologies
  - Predictive power

The third revolution in life sciences will make possible development of revolutionary technologies enabled by living systems.

p.s. Remember the Sputnik? Many scientists declared that launching a satellite into space was impossible, too.