Innovation in Monitoring: satellites, citizens and sequences

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Laurence Carvalho UK Centre for Ecology & Hydrology (UKCEH Edinburgh) @LacLaurence

Why Monitor?

Collecting actionable data on quantity, quality and use

Surveillance

- What is the health of the wetland?
- Can we detect changes in biodiversity?
- Can we see changes in wetland functioning?
- Are we seeing any changes in wetland use?

Operational

- What is the impact of specific pressures?
- Are management measures having any impact?

Investigative

- What is the cause of changes in quality?

Different questions require different monitoring design



many sites, many subjects to monitor, many questions to answer

VS

demands: reduce monitoring budgets!

Scope for innovation in:

- 1. Design of surveillance networks
- 2. Enhancing coverage and effectiveness of monitoring
- 3. Reducing costs of monitoring





Design of Surveillance Network: Status

Scotland River Surveillance Network



O'Hare et al. (2020) Fewer sites but better data? Optimising the representativeness and statistical power of a national monitoring network. *Ecological Indicators*, 114, 106321.

Fewer sites but more representative picture?

Surveillance to Detect Change



Need long-term monitoring of "Sentinel sites" to detect change

Frequent sampling to provide sufficient confidence

Carvalho et al. 2013. Hydrobiologia, 704, 127-140

Enhancing coverage and confidence

- Earth Observation (EO)
- Remote sensing (hydroacoustics & drones)
- Citizen science
- Environmental DNA



Satellite Earth Observation



high spatial and temporal coverage with consistency in measurement

- Wetland extent
- Emergent and Floating vegetation
- Water quality (chlorophyll-a & Harmful Algal Blooms)
- Riparian zones
- Temperature & turbidity

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Vanz		htc	h
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TheceoWa	ater Qual	ity Initia	tive



Component	Parameter	Source	Spatial resolution	Temporal resolution (with 2 satellites in orbit)
EO – optical	Chl-a	S2	10 – 60 m	10 days (5 days)
		S3	300m	2-3 days (daily)
EO – optical	TSM	S2	10 – 60 m	10 days (5 days)
		Landsat-8	30m	16 days
		53	300m	2-3 days (daily)
EO – optical	Transparency (K _d)	S2	10 – 60 m	10 days (5 days)
		Landsat-8	30m	16 days
		S3	300m	2-3 days (daily)
EO – optical	PC	S3	300m	2-3 days (daily)
EO – optical	CDOM	S3	300m	2-3 days (daily)
EO – optical	Floating layers (e.g. oil, cyanobacterial scum)	S2	10 – 60 m	10 days (5 days)
		Landsat 8	30m	16 days

Remote sensing: Hydroacoustics



Macrophyte abundance and composition (life forms) Source: Ray Valley, BioBase



https://www.cibiobase.com/



Fish abundance and size class Source: Ian Winfield, CEH

- Rapid, quantitative, non-invasive
- Combine with limited biological survey to identify species
- Passive sampling by boat owners

Citizen Science

- Public engagement
- Cost-effective
- Improved spatial and temporal coverage
- Quality of data
- Bias in recording effort
- Reliant on volunteer experts for verification



Pocock et al. (2014) Choosing And Using Citizen Science: A Guide To When And How To Use Citizen Science To Monitor Biodiversity And The Environment.

Citizen monitoring: smartphone apps



Invasive Alien Species in Europe



River Obstacles



Bloomin' Algae



FreshWater Watch Earthwatch

Bloomin' Algae











58% Accepted

cepted 11% Rejected

31% Plausible

- 151 site records in 2020
- 69% don't need further checking big savings to monitoring costs
- Direct early warning notification to Scottish EPA & Local Authorities
- Rapid feedback to public and landowners

environmental DNA (eDNA)

Meta-barcoding approach where DNA is extracted from the environment

e.g. a water or sediment sample





Useful where:

- Identification is difficult
- Labour-intensive sample analysis
- Sampling poorly represents community (e.g. rare species)





Status of rare fish

Recommendations

Innovation can enhance monitoring coverage, increase confidence in assessments and reduce monitoring costs



- Optimal design of monitoring networks related to purpose
- Expand monitoring programmes through EO, sensors and citizen science
- Maintain taxonomic expertise but consider automated and DNA methods to reduce costs

Monitoring is cheap compared to restoration - ensures you target management measures more cost-effectively



Laurence Carvalho laca@ceh.ac.uk @LacLaurence



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