Assessing chemical threats to the environment through biomonitoring

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Why Biomonitor?

Characterise risk

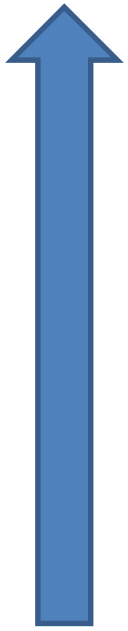
- understand fate and behaviour
- which species are exposed
- what is level of exposure [and potential effects]
- how widescale is exposure?
- does exposure/sensitivity vary within and between species?

Characterise variation in risk

- change over time?
- does exposure vary spatially?
- what are the sources?
- is mitigation working?
- Large scale drives (eg. global climate change)

What you might monitor for chemicals?

Food Chain Transfer



- Top Predators
- Secondary Consumers
- Primary Consumers
- Plants
- Soil / Water / Air

Choice of Matrix

- Honey/pollen/nectar
- Digesta/faeces
- Plasma/serum
- Liver and other organs
- Fat/blubber
- Eggs/juveniles
- Feathers/hair

Table 2 Number of published studies (identified from a literature review—see text for details) that analysed different pollutant groups in various sample types from raptor and owl species from Europe

	No/studies in which sample type analysed	No/studies measuring contaminant in each matrix type					
		POPs	PFASs	Lead	Mercury	Cadmium	Anticoagulant rodenticides
		$n = 137$	$n = 11$	$n = 71$	$n = 59$	$n = 48$	$n = 20$
Eggs	88	82	4	11	13	10	0
Feathers	45	10	4	15	21	11	0
Blood/plasma/serum	42	17	3	21	5	15	1
Liver	98	40	3	33	24	23	18
Kidney	40	11	0	21	19	17	0
Muscle	22	15	1	3	3	3	0
Bone	18	0	0	17	0	8	0
Brain	15	7	0	5	2	4	0
Fat	13	12	1	0	0	0	0
Preen oil	7	5	2	0	0	0	0
Regugitated pellets	4	0	0	3	0	0	1

n number of studies reporting concentrations of that compound group

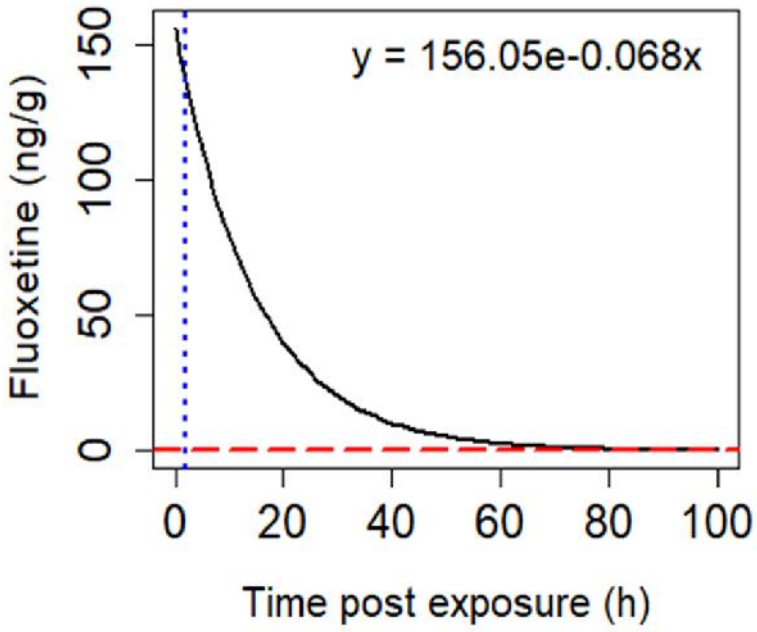
Total number of studies reviewed was 249, see S.I. Table 3 for references. Studies often analysed more than one sample type and multiple contaminant groups

Espín et al 2016 – review of pesticide biomonitoring in raptors:

- Blood (current) and livers (long-term) are most commonly used matrices to measure exposure
- There is no single optimal all-purpose matrix
- Utility of each matrix depends on aims and objectives

Suitable for All Chemicals?

- Persistence, bioaccumulate, bioconcentrate (define diffs)
- Depends on physico-chem properties
- Organic pollutants –lipid or protein bound
- Metals bioaccumulated not bioconcentrated (except Hg- honorary POP)



Whitlock et al., under review

Why use Predators for Monitoring?

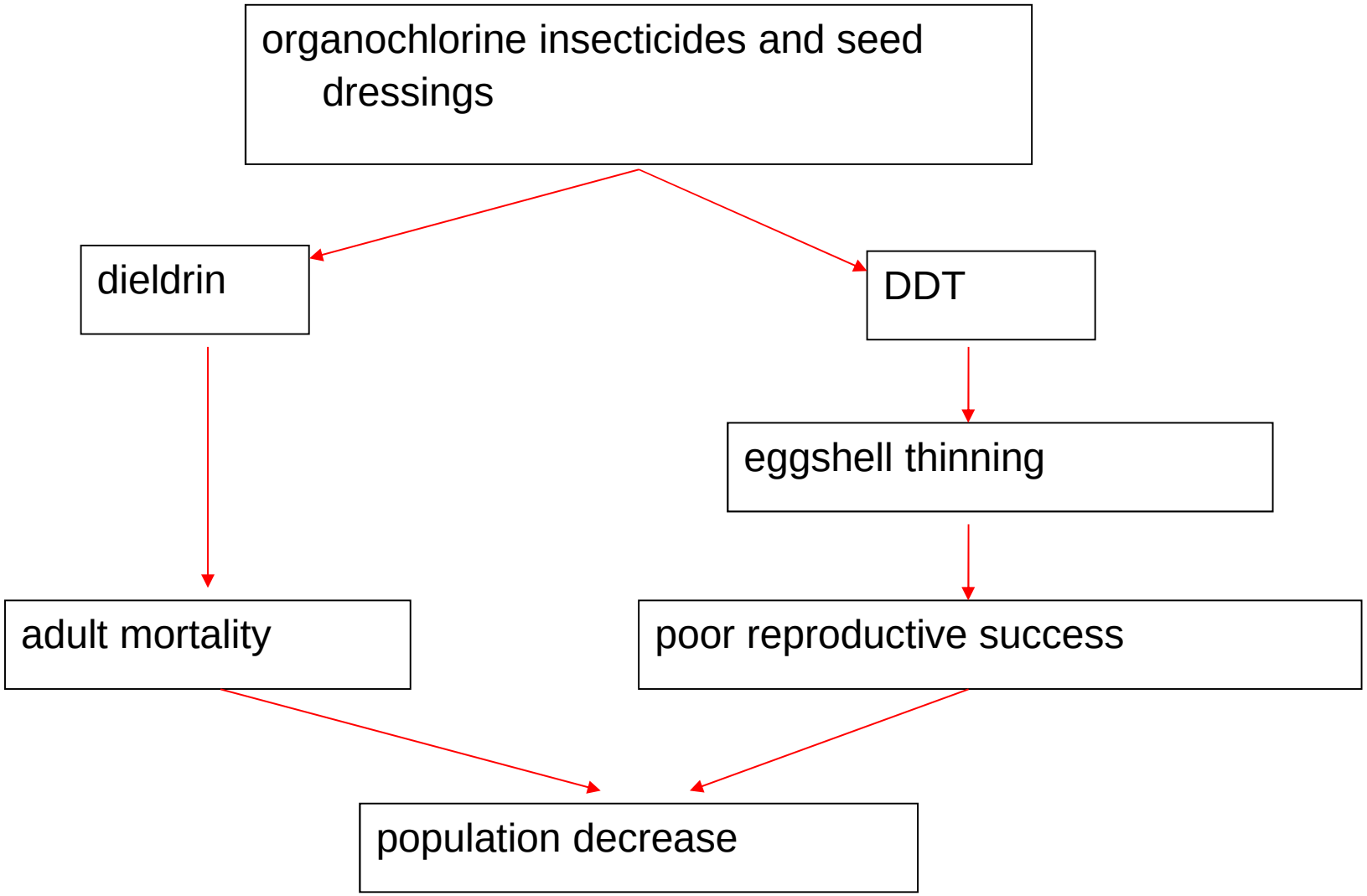
Most predators

- multiple food chains
- populations sensitive
- sentinels
- “rare” species
- charismatic

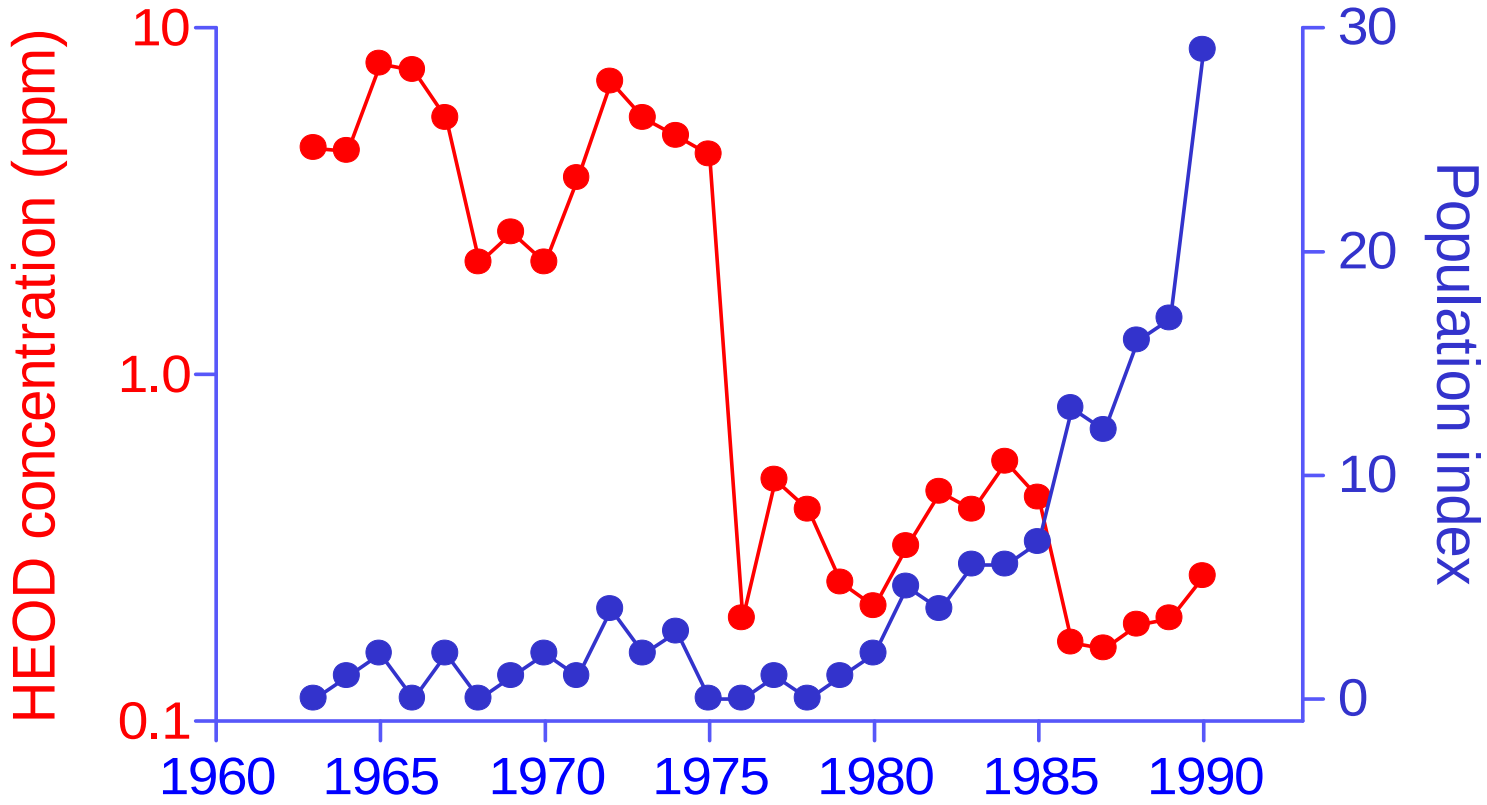
Predatory Birds

- integrators
- eggs and tissues
  –separate repro/ phase
- may use other receptors for inorganic compounds
- relatively easy to sample (incl. non-destructively)

Organochlorine insecticides



Dieldrin and sparrowhawk populations



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Newton & Wyllie 1992

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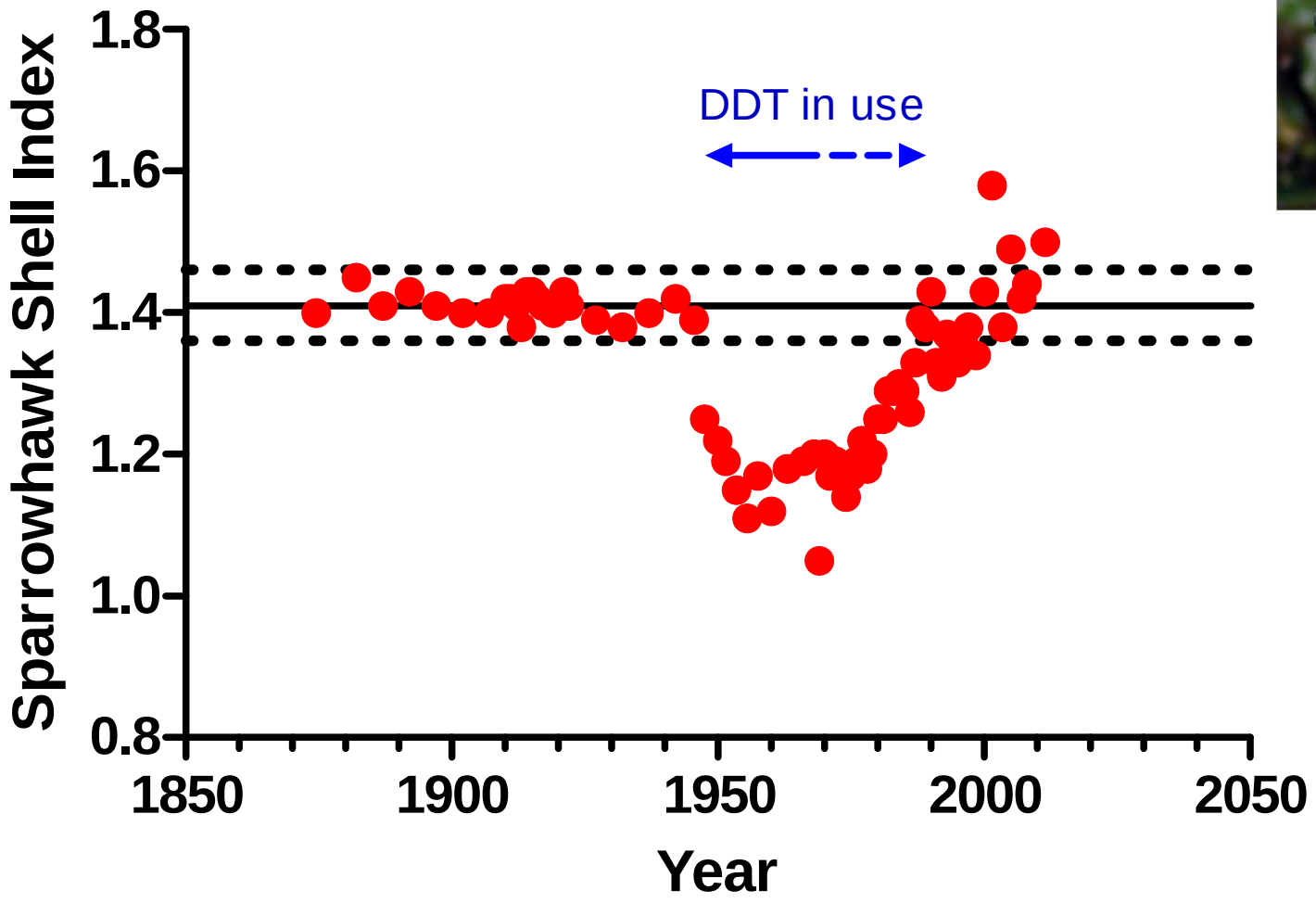
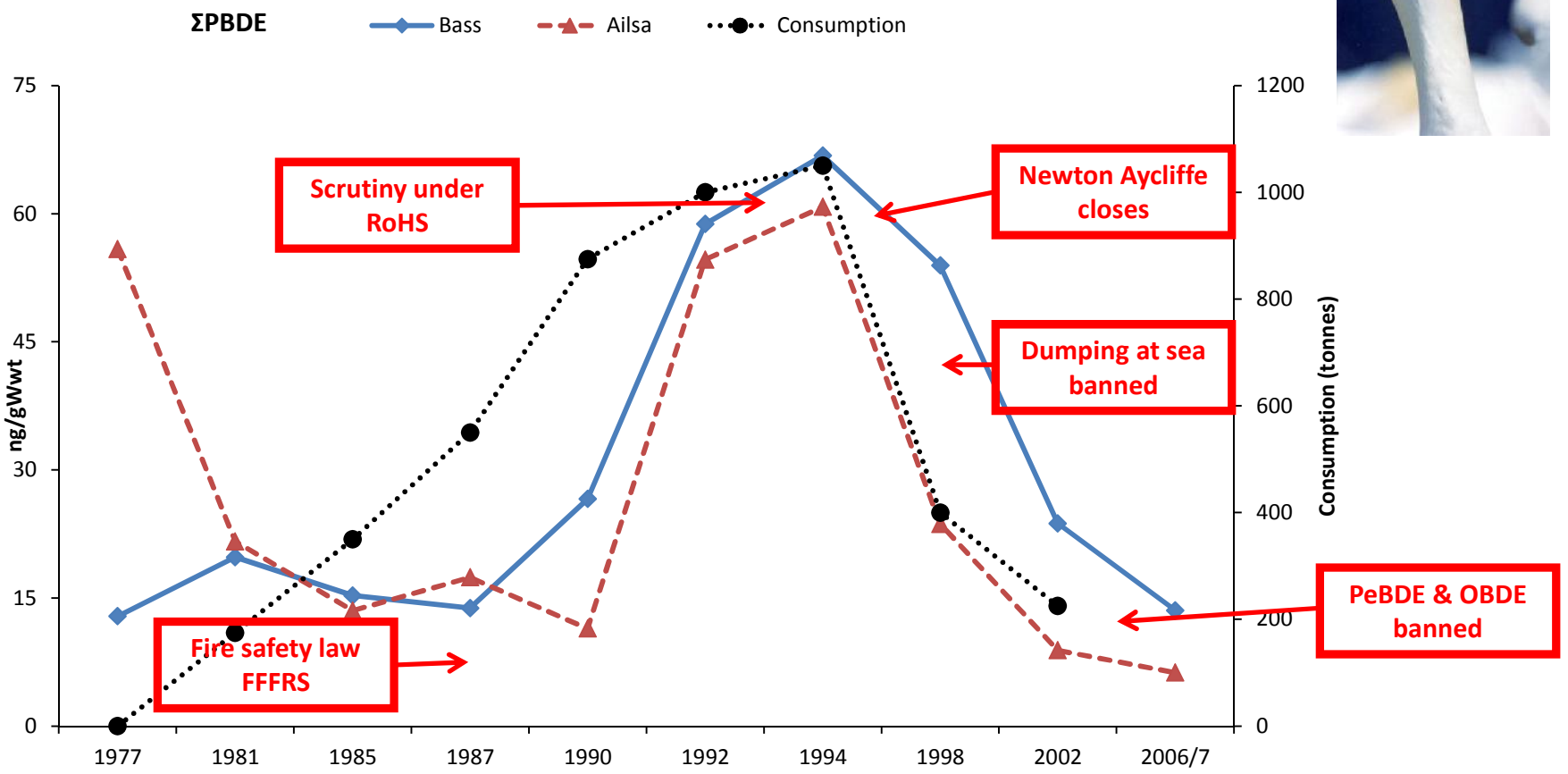
Charting Decline & Recovery



BDES: MITIGATION AND EXPOSURE

POLICY RELEVANCE: REACH, Stockholm convention, ACHS position paper, EA European lead for BDE209



Crosse et al., 2012 *Environmental Pollution*

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LANCASTER UNIVERSITY

Predatory Bird Monitoring Scheme
http://pbms.ceh.ac.uk/

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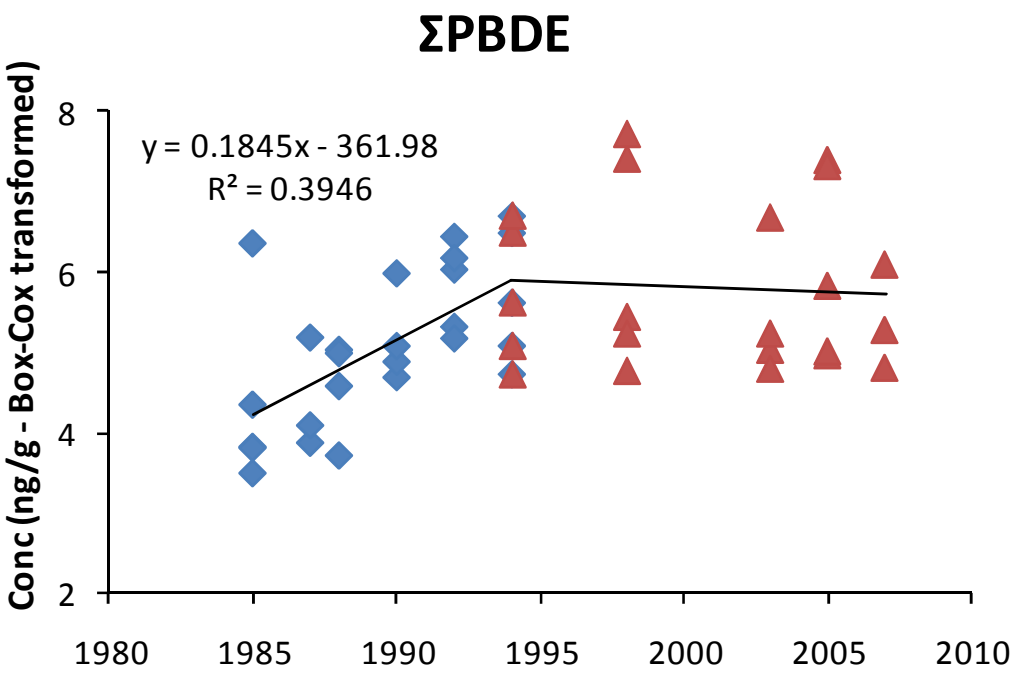
BDES: Terrestrial Environment

POLICY RELEVANCE: REACH, Stockholm convention, ACHS position paper, EA European lead for BDE209



- Linear increase of BDEs 47, 99, 100, 153, 154 and ΣPBDE concentrations until mid 1990's (ΣPBDE: R^2=0.39, $F_{1,42}$=17.5, P<0.001)
- BDE concentrations remained high from 1990s
- ΣPBDEs: 0.32-2.3 ug/g wet weight (wwt)
- Exceed the threshold for shell thinning and reproductive impairment found in other raptors (Fernie et al., 2009: Henny et al., 2009

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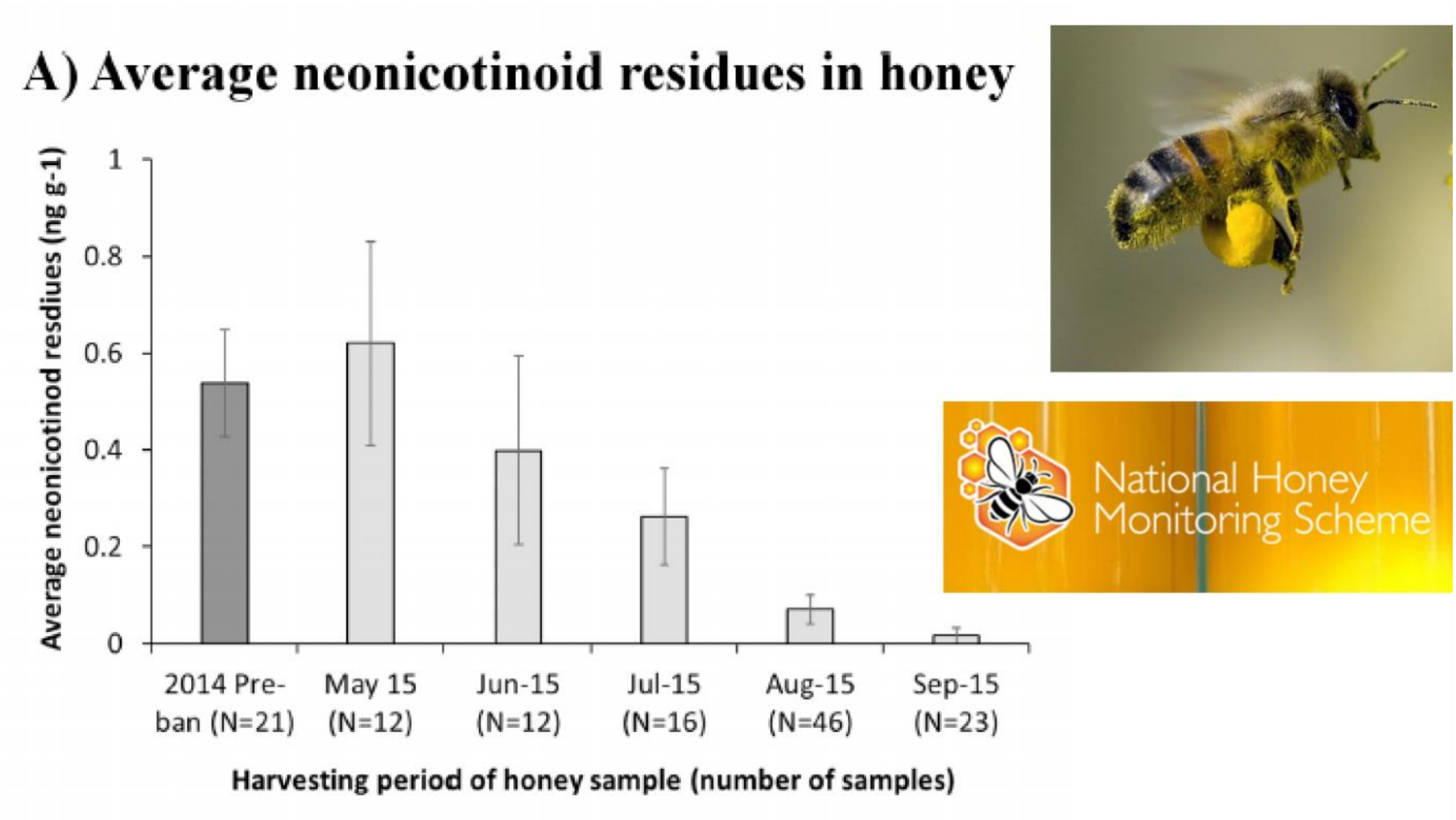
Crosse et al., *in prep*

Neonics and Honey



National Honey Monitoring Scheme

Woodcock et al. 2018 Plos One 13(1):e0189681

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Biomonitoring Life Cycle: eg. Rodenticides

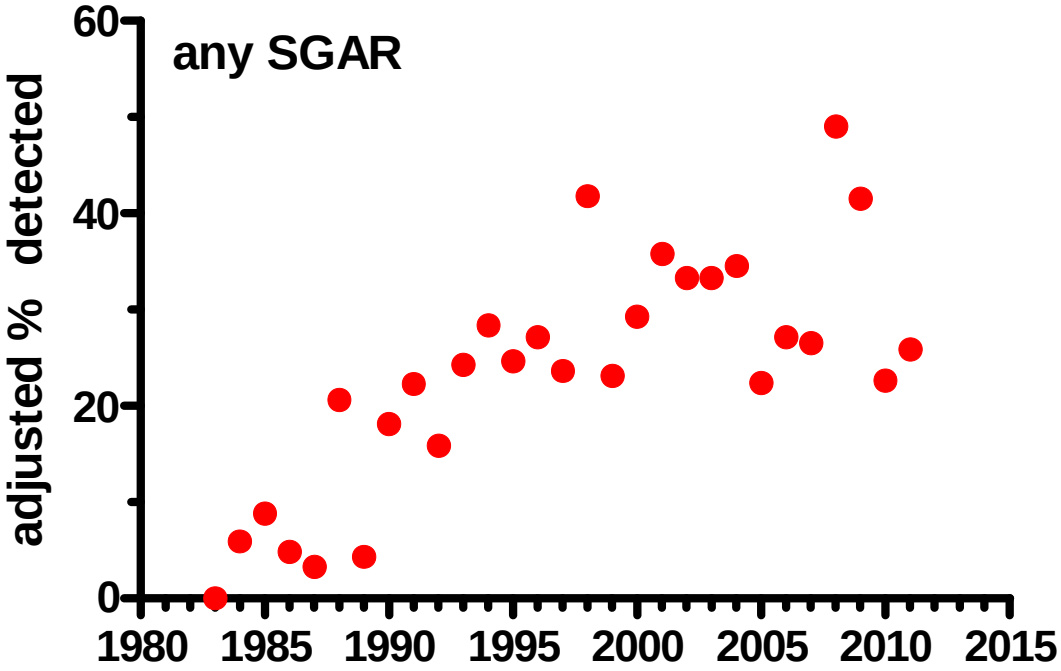
- UK large-scale use of SGARs
- Used on 80-90% of farms, millions lethal doses/yr
- Primary poisoning of non-targets

- Secondary exposure and poisoning of predatory birds and mammals, (some rare/protected) and possible impacts on populations

Life Cycle-1: Problem Identification

Predatory Bird Monitoring Scheme
http://pbms.ceh.ac.uk/

Early 1980s SGARs detected in owl species and long-term monitoring indicated rising exposure in owls



- Data adjusted for changes in analytical sensitivity

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Walker et al 2013. PBMS report on PBMS website http://pbms.ceh.ac.uk/

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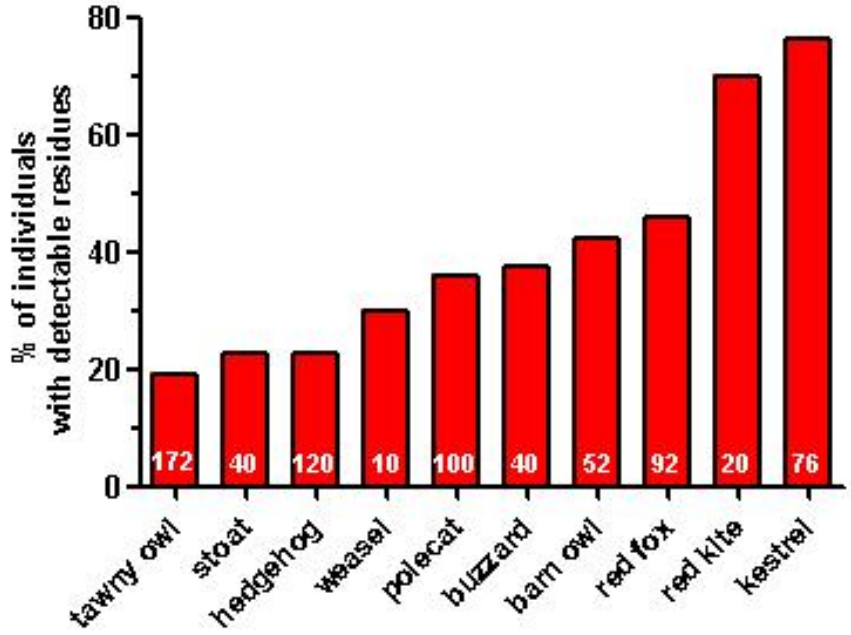
Life Cycle-2: Problem Characterisation

- various species exposed
- can be large % of population
- geographically widespread
- multiple food-chains
- indicates contamination of wider prey base (only some species eat lots of rats)
- *outdoor use*



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Life Cycle 3: Voluntary Initiative— Education Programme

New initiative to limit countryside poisons

Valerie Robinson

CONSERVATION groups have joined forces with an unexpected partner to help reduce the threat of rat and mouse poison to wildlife across the UK.

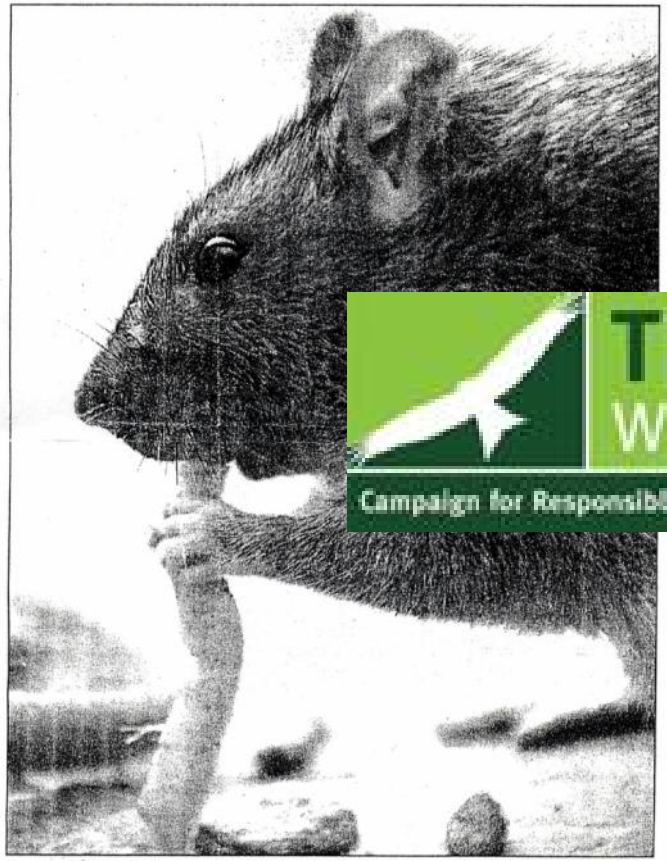
Pest control company Rentokil this week announced that it had implemented a new initiative to reduce the availability of its rodenticide in the environment by a minimum of 75 per cent.

The company has claimed that the move heralded a new era of environmentally responsible pest control that will reduce the number of birds and animals that die needlessly from poisoning.

For years the widespread use of rodenticides outdoors has been exposing wildlife in Ireland and Britain to the risk of accidental poisoning. The problem affects both the small mammals that unwittingly eat the bait as well as their predators.

Birds of prey that eat poisoned rodents are particularly susceptible to what is called 'secondary poisoning'. The issue is highlighted by the plight of the Red Kite, which is one of the UK's rarest birds with just 600 breeding pairs in the wild. Rodenticides have been implicated in high proportion of their deaths and analysis of Red Kite corpses revealed that 66 per cent had traces of rodenticides in their tissues.

Peter Newbery from the RSPB said: "Together with English Nature, Scottish Natural Heritage and a number of other partners including Forest Enterprise and Yorkshire Water, we have reintroduced Red Kites into six localities in England and Scotland since 1989. Despite considerable success with the programme, external



■ **UNWANTED PEST:** Long-term baiting of rats with rodenticide exposes wildlife to the poison long after the infestation has been dealt with

THINK WILDLIFE

Campaign for Responsible Rodenticide Use

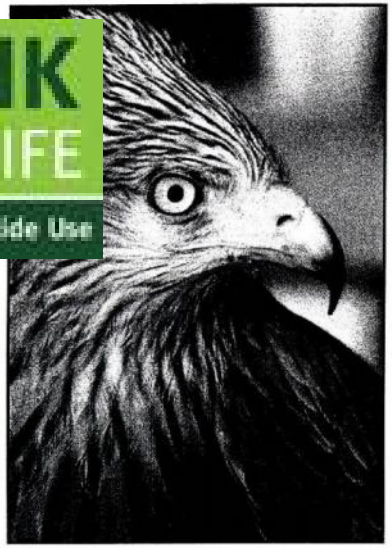
Rat poison firm vows to cut usage

A PEST control company has

In the News

Rentokil announce rodenticide restrictions

Quite coincidentally to the feature article on pages 4-7 of this issue regarding the possible effects of rodenticides on wildlife, Rentokil has announced its plans to reduce the availability of its rodenticide in the environment by a minimum of 75%. Rodenticides will continue to be used as part of Rentokil's armoury against unwanted pests, but from now on they will only be used when absolutely necessary.

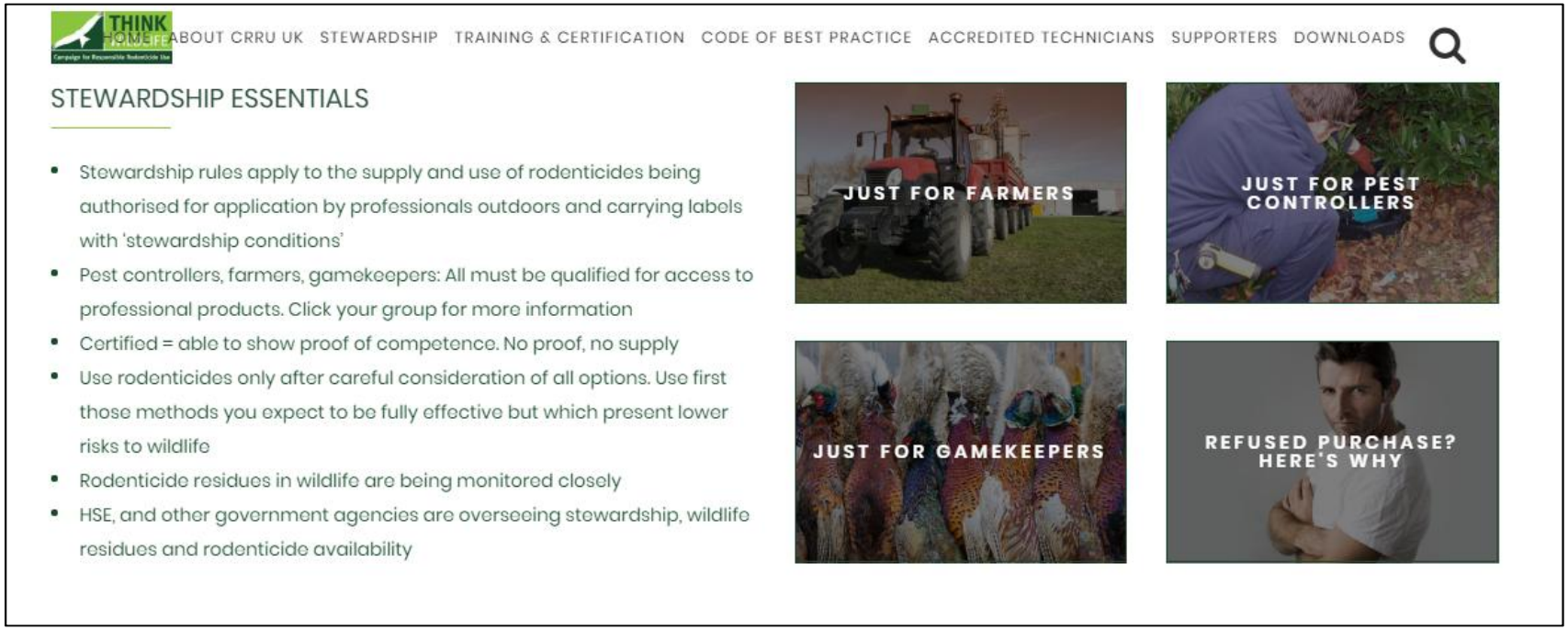


Red kites have particularly been affected by secondary rodenticide poisoning.

John Charlton, Rentokil's technical manager explained, "Traditional pest control methods have become over-reliant on rodenticides, exposing wildlife unnecessarily to toxins. For instance, if a factory had a rodent problem then the accepted practice

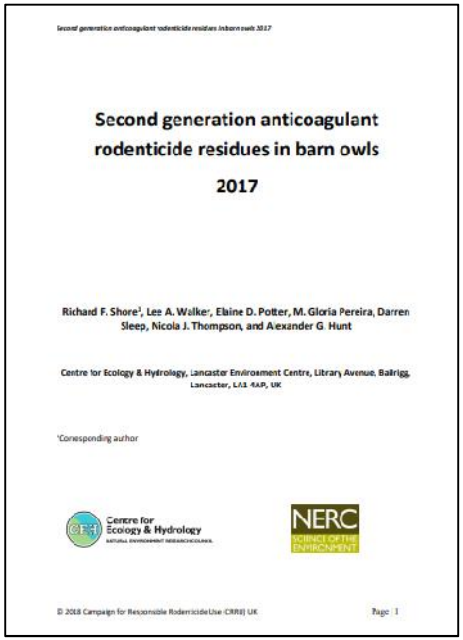
Life Cycle 4: Stewardship of Rodenticides

- Launched July 2015
- Rodenticides authorised for professional use in three main areas: Agriculture, Game Keeping, Pest Control & Local Authority
- Promotes best practice
- Changes in labelling to “in and around buildings”



How Sensitive/Powerful is Your Monitoring?

- To measure success of stewardship SGARs being monitored in barn owl livers
- Sentinel to track if exposure of non targets is decreasing
- Pre-Stewardship Baseline established


Second generation anticoagulant rodenticide residues in barn owls 2017

Second generation anticoagulant rodenticide residues in barn owls

2017

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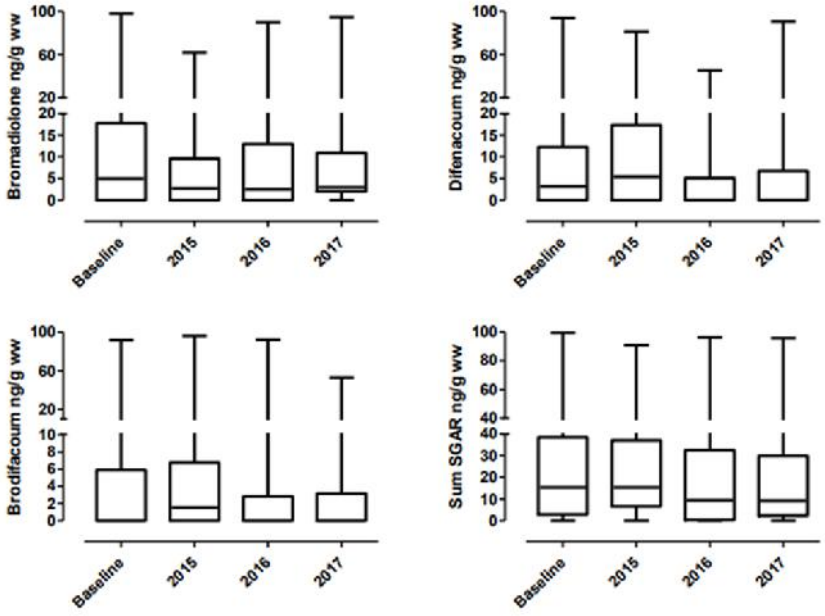

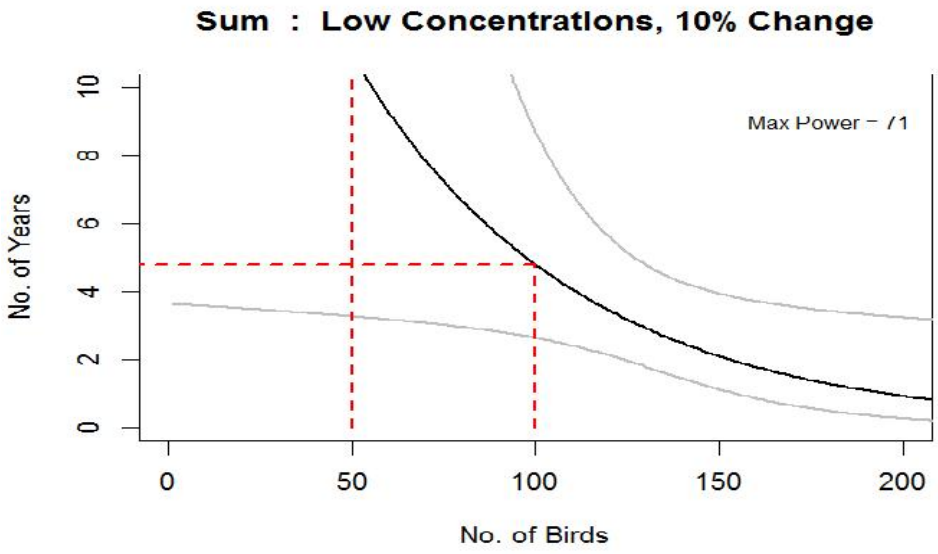

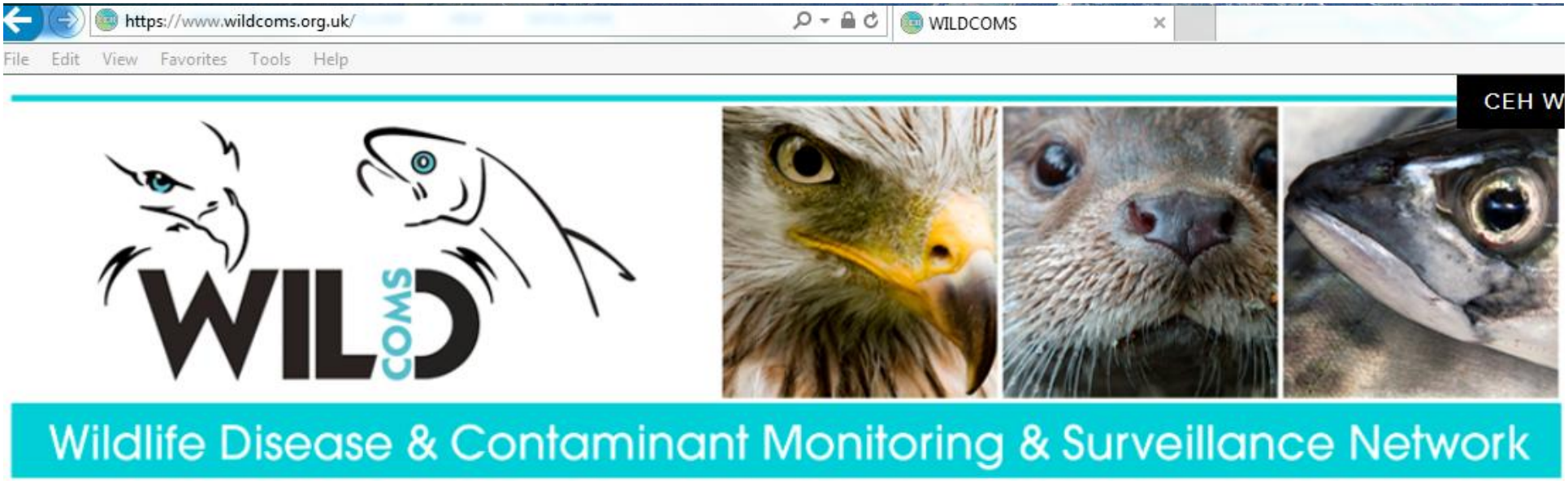

KE partnership linking national monitoring schemes

http://www.wildcoms.org.uk/

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Twelve Surveillance & Monitoring Schemes

Five aquatic schemes

- **Cardiff University Otter Monitoring Project- (CUOP)** run by Cardiff University and the EA
- **Clean Seas Environment Monitoring Programme-** run by CEFAS
- **Scottish Environment Protection Agency (SEPA) Lipophilic Monitoring Network** – run by SEPA
- **UK Cetacean Strandings Investigation Programme-** run by IoZ
- **National Fish Tissue Archive** run by CEH

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Twelve Surveillance & Monitoring Schemes

Seven terrestrial schemes

- **Predatory Bird Monitoring Scheme (PBMS)**- run by CEH
- **The Wildlife Incident Investigation Scheme (WIIS)-** run by Fera Science
- **Scottish Wildlife Incident Investigation Scheme** – run by the Scottish Agricultural Science Agency (SASA).
- **Scottish Raptor Health Study** run by Royal (Dick) School of Veterinary Sciences & SNH

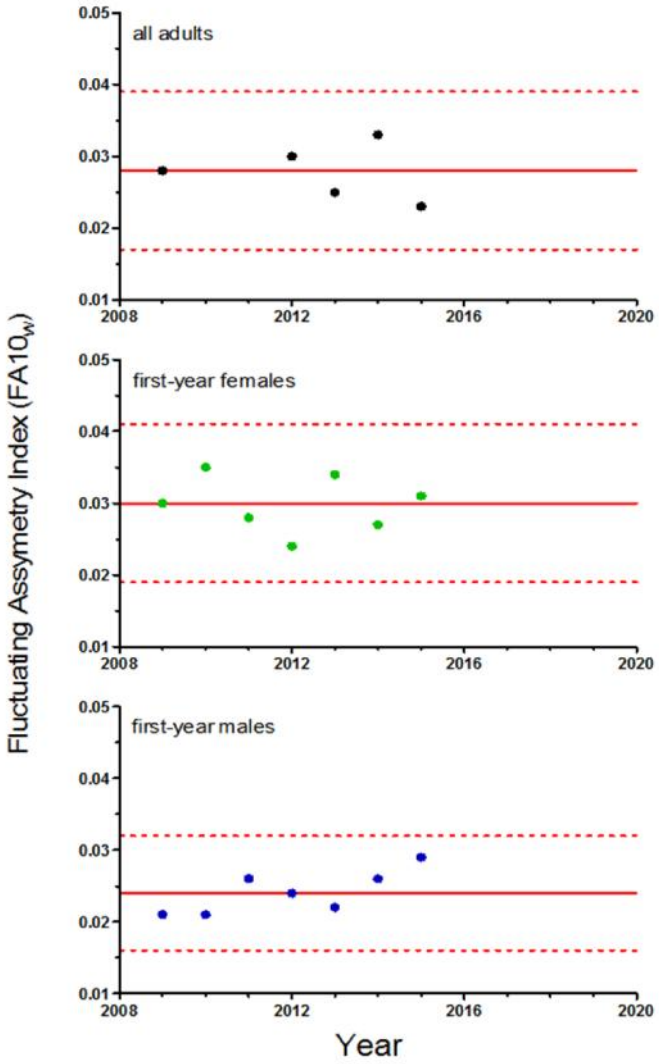
- **Animal and Plant Health Agency (APHA) Diseases of Wildlife Scheme**
- **Disease Risk Analysis and Health Surveillance Programme-** run by Institute of Zoology (IoZ)
- **Garden Wildlife Health (GWH)-** run by IoZ & BTO

Potential Biomionitoring for Chemical Risk

- Part of the 25 Year Environ. Plan
- Metrics for exposure and effects
- Range of measures
- Integrated across habitats/ compartments
- Mix biotic and abiotic to gain info
- Effects measures may not be chemical specific but give early warnings of things going wrong—one example of health metric indicator

Population Health Indices

- Post mortem examination observations
- eg. demographics, physiology, nutritional status
- Control charts to define current population statistics
- Deviation from control charts indicates change in status
- Positive/Negative?



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http://pbms.ceh.ac.uk/

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Future Challenges and Opportunities

- Understanding how monitoring can be integrated
- Identifying suitable spatial and temporal scales and having sufficient power
- Early-warnings—power of non-target screening but need to cope with large amounts of information
- Effects monitoring-source attribution, and what is important
- Move of endpoints to ecosystem services rather than protect everything everywhere

Questions?