

EEA Chemicals & Water Workshop, Copenhagen, 6-7 December 2010

Environmental Risk Assessment of Chemicals in the 21st Century: Optimizing the Use of Chemical & Biological Tools

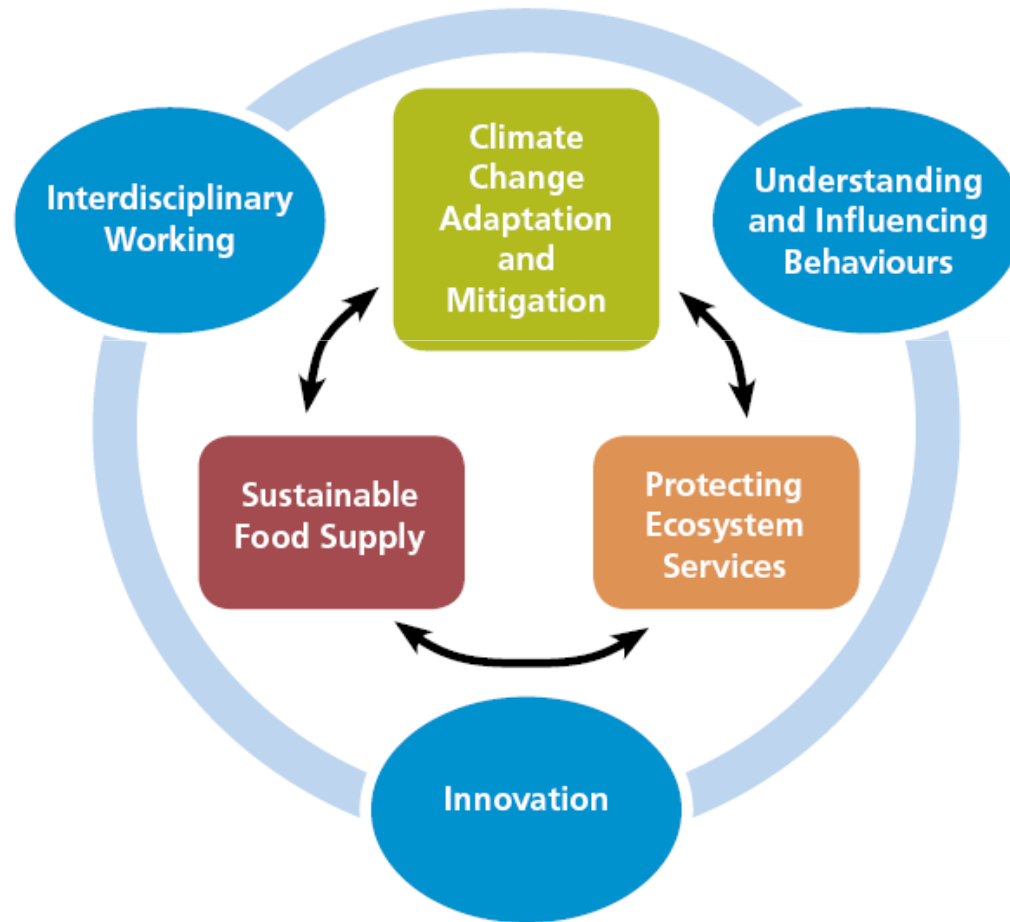


Professor Tom Hutchinson
Centre for Environment, Fisheries & Aquaculture Science
Weymouth
UK

CEFAS is an Executive Agency of Defra

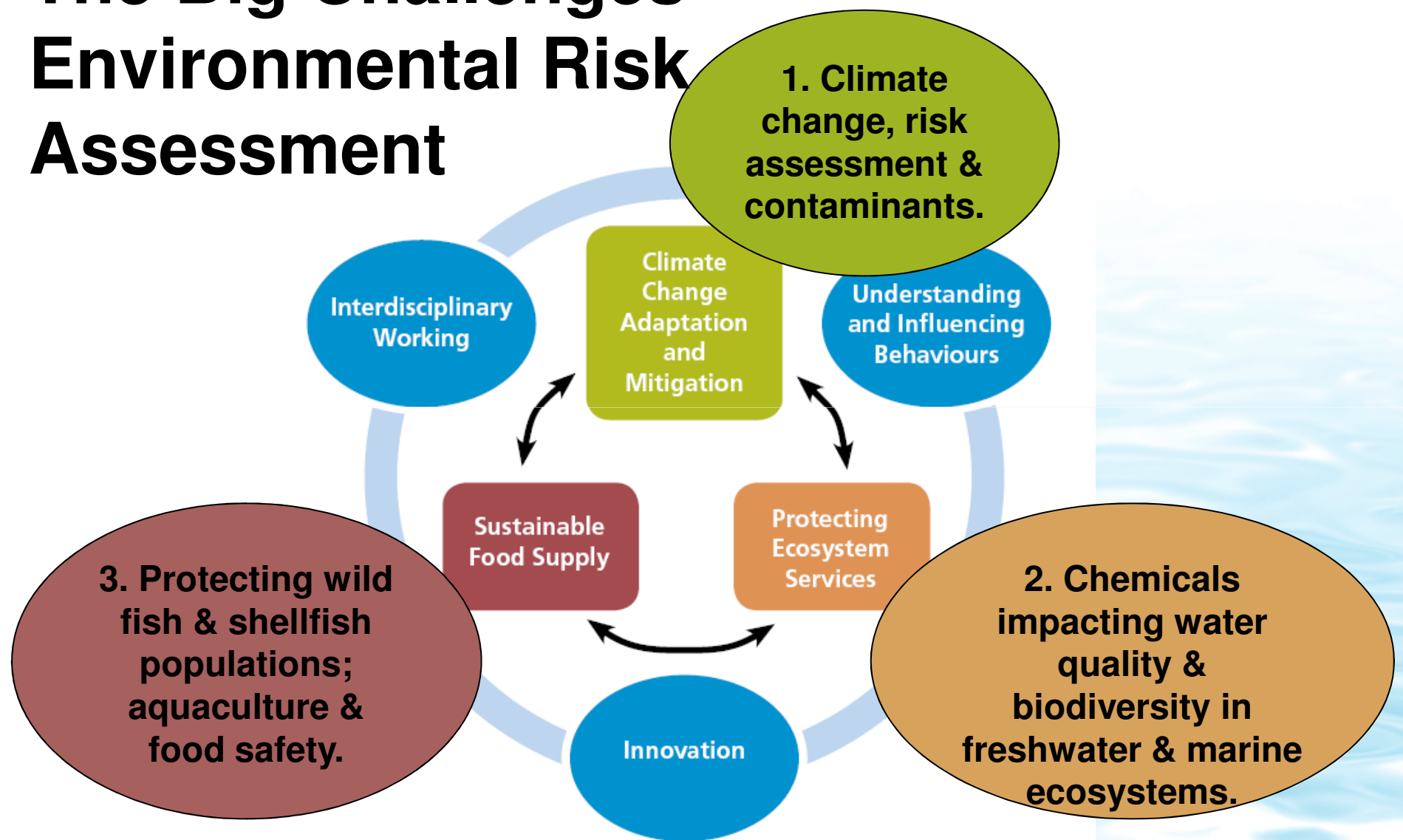


The Big Challenges: Defra Evidence Investment Strategy 2010+



Source: <http://www.defra.gov.uk/evidence/science/how/strategy.htm>

The Big Challenges - Environmental Risk Assessment



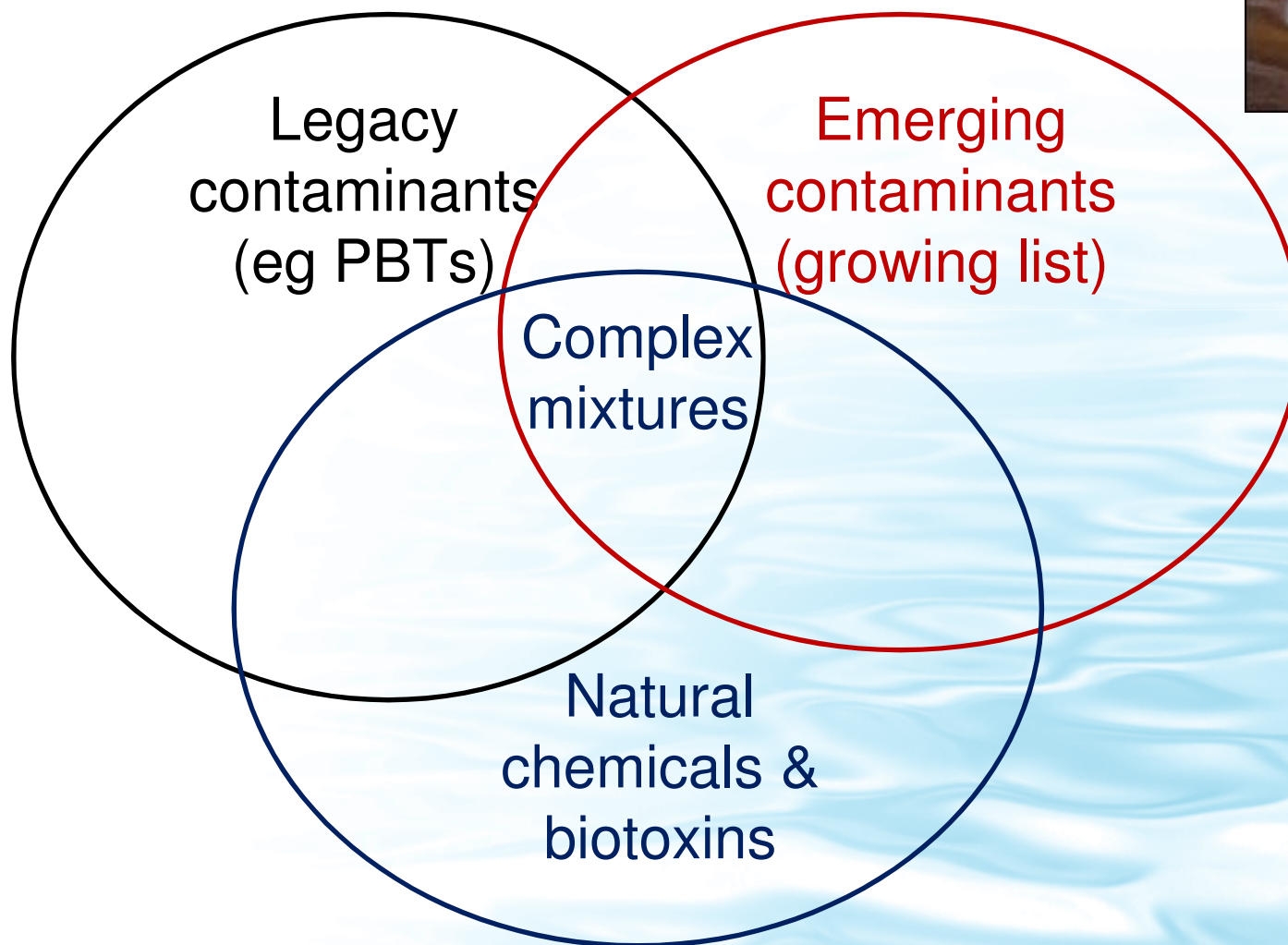
Adapted from: <http://www.defra.gov.uk/evidence/science/how/strategy.htm>

Economic Importance of Aquatic Ecosystems

Ecosystem types	Ecosystem services value (\$ US per ha per yr)
Grasslands	232
Evergreen pine forest	302
Evergreen broadleaf forest	2007
Permanent wetlands	14,785
Floodplains - Swamps	19,580
Estuaries	22,832

(Source: Martinez et al (2007) Ecol Economics 63: 254-272)

Chemicals & Water Quality



Looking back, looking ahead ...

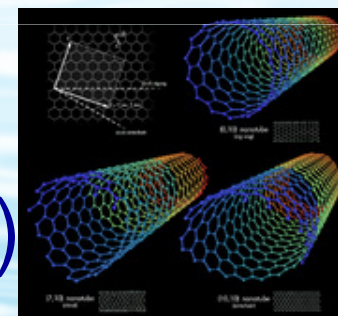
- Legacy contaminants
 - antifoulants (eg tributyltin)
 - heavy metals
 - polychlorinated biphenyls
 - polycyclic aromatic hydrocarbons



- Emerging contaminants
 - endocrine disruptors
 - flame retardants
 - fragrances
 - pharmaceuticals
 - plastics

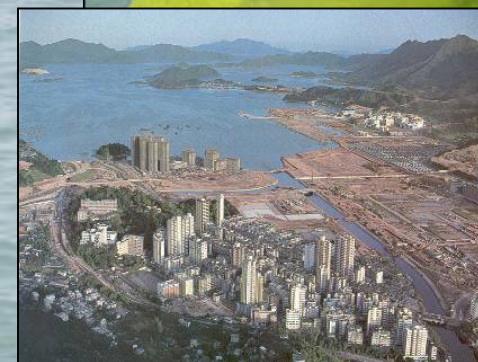
Emerging contaminants ...

- Endocrine disruptors
 - affect development & reproduction
- Flame retardants
 - eg fluorinated chemicals
- Nanoparticles
 - antimicrobials (eg silver)
 - antifoulants (eg carbon nanotubes)
- Pharmaceuticals
 - human & veterinary
- Plastics
 - microplastic + litter (MSFD)



More people, more chemicals

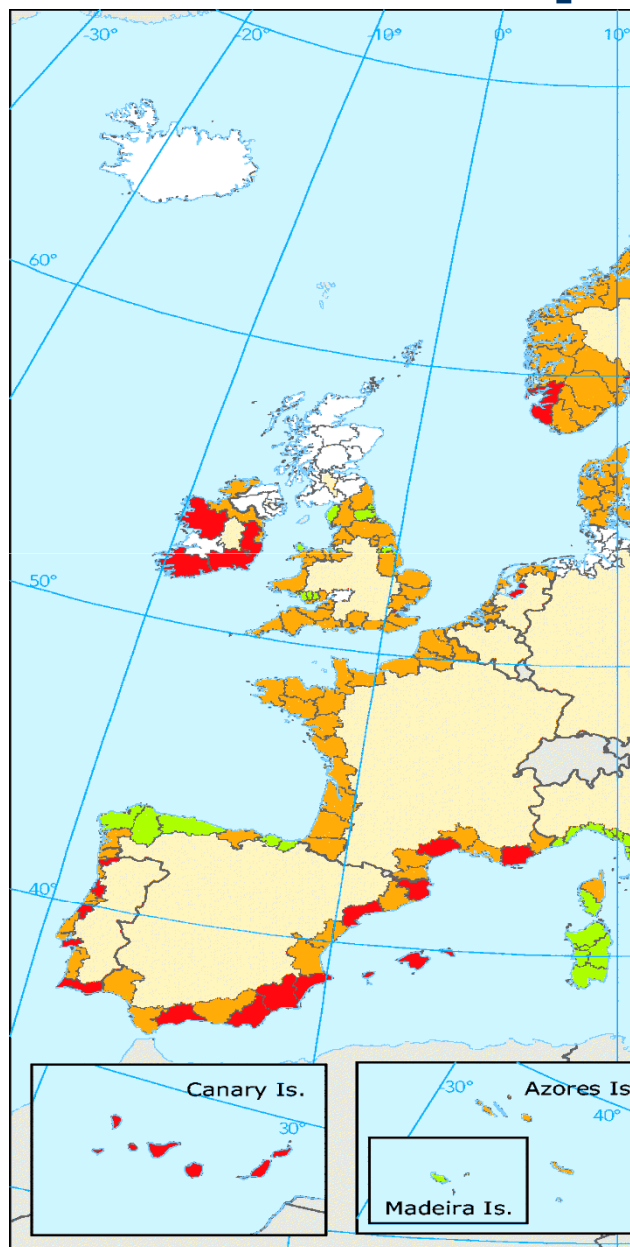
- 75% of the world's megacities are by sea
 - by 2010, >80% of global population estimated within 60 km of coasts
- synthetic chemicals likely to reach coastal ecosystems via sewage, unless rapidly degraded



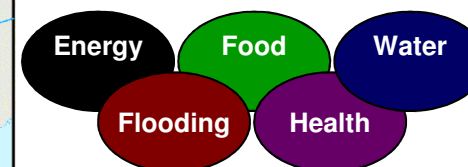
Refs: UNEP (2004)

Martinez et al (2007) Ecol Economics 63: 254–272

Pan-European

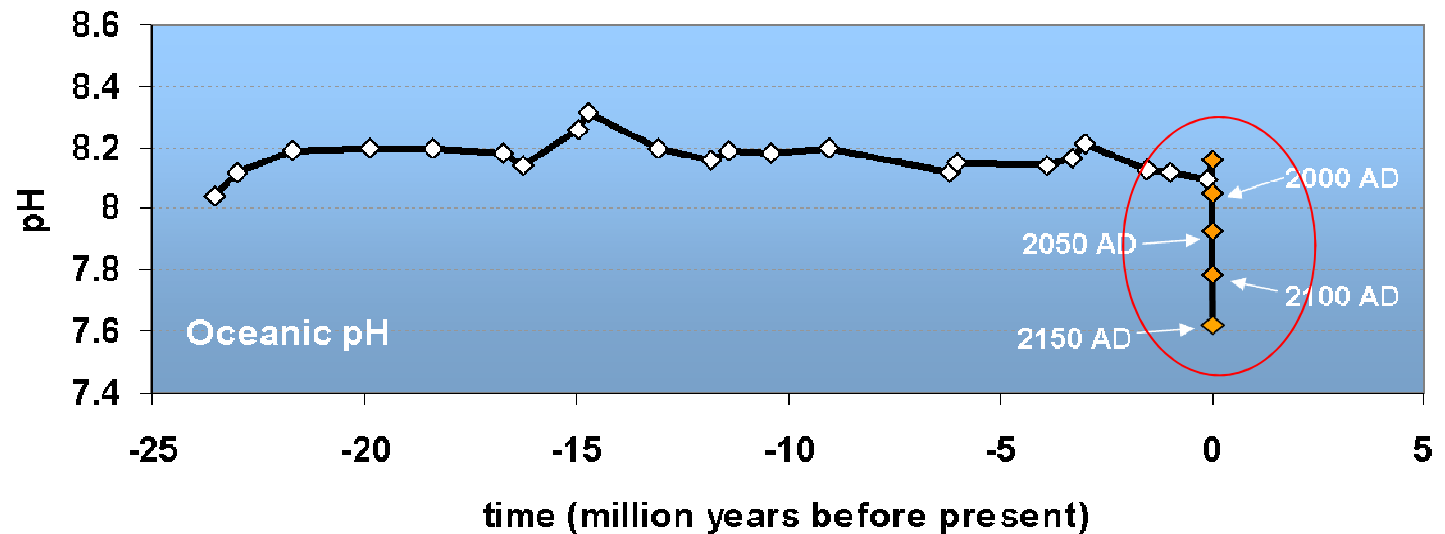
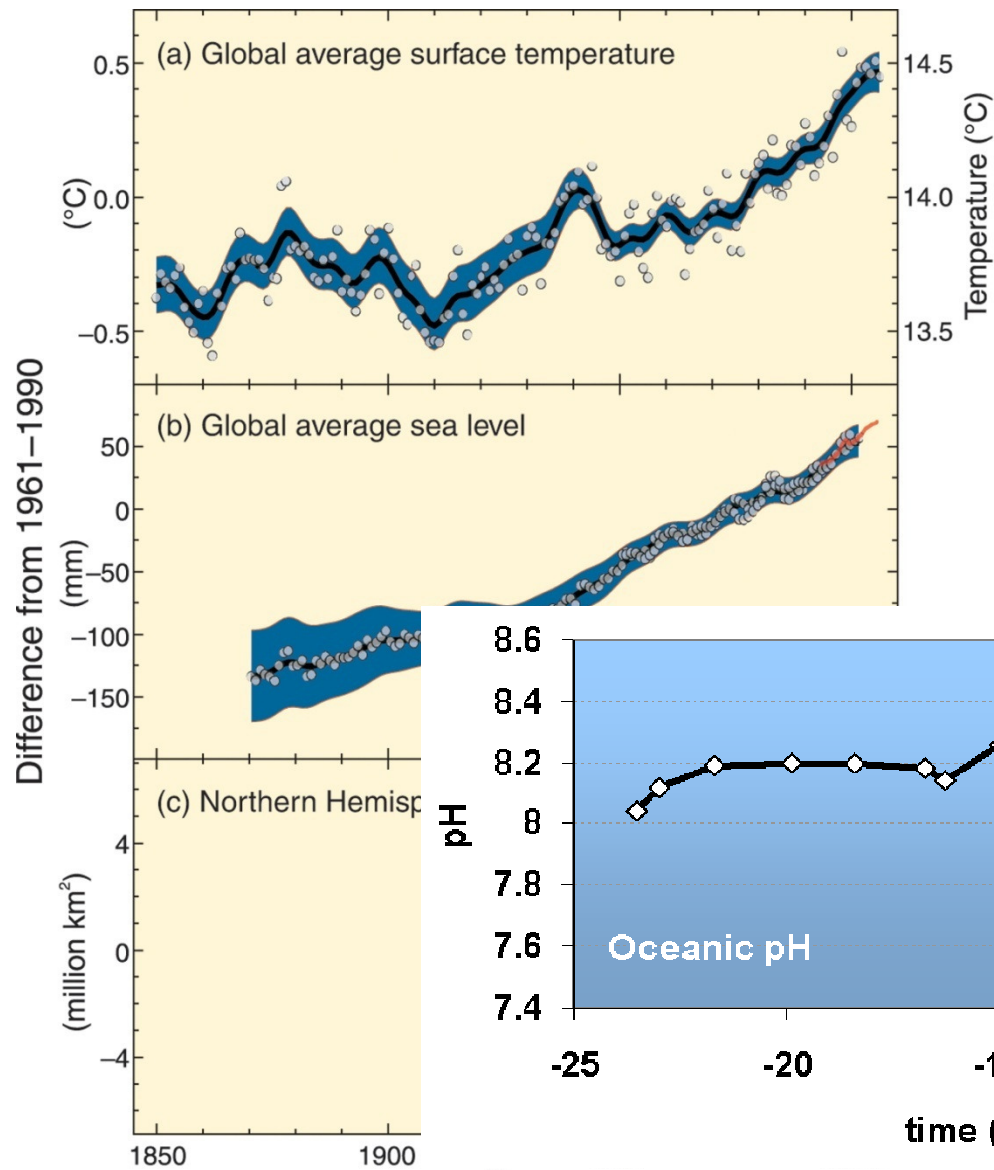


Country	Total population 2003 (millions)	Coastal population 2003 (millions)*	Coastal density increment (%) 2003-2015
Algeria	31.90	21.95	19.44
Egypt	71.30	37.86	23.70
France	60.00	23.76	3.83
Spain	42.10	28.59	5.46
Sweden	9.00	7.89	3.33
UK	59.30	58.47	3.54



Source: EEA & Martínez et al (2007)

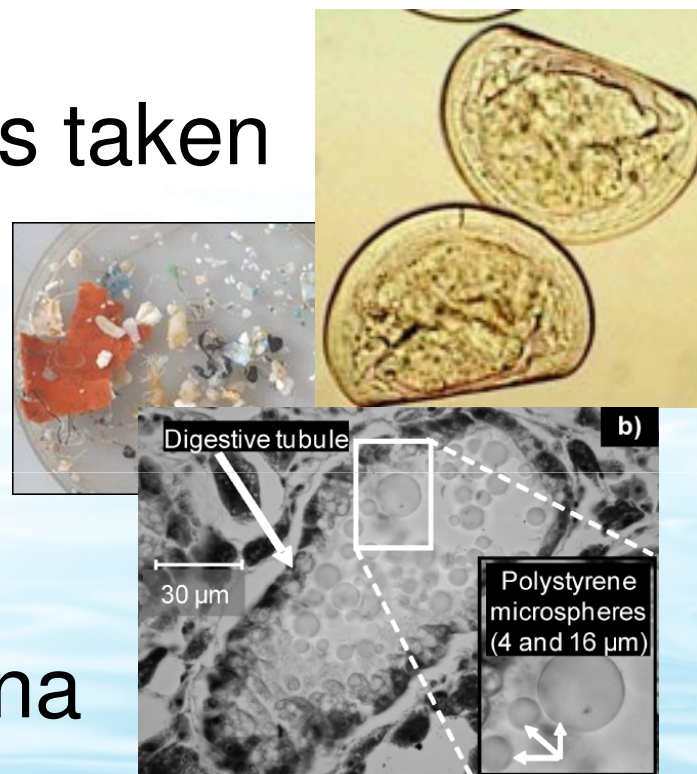
Climate change & the oceans



(Blackford & Gilbert 2007; Turley et al., 2008)

Bioconcentration a Critical Issue

- Nanoparticles – aggregates taken up by commercial shellfish species (filter feeders)
- POPs still a major concern
- Plastics – microplastics in shellfish & sediment fauna



Could *in vivo* invertebrate bioconcentration data be useful to strengthen traditional log Kow model for chemicals & nanomaterials?

Drugged Waters

Does it matter that pharmaceuticals are turning up in water supplies?

By JANET RALOFF

Treated municipal wastewater entering a Swiss stream. Treatment plants have not been designed to remove excreted drugs before releasing their effluent into public waterways.



BBC NEWS UK EDITION

Last Updated: Friday, 5 August, 2005, 12:28 GMT 13:28 UK

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science/technology

DRUGS DOWN THE DRAIN

Surprisingly little research exists on the potential environmental effects of pharmaceuticals and personal care products

Pamela S. Zurer
C&EN Washington

potential effects on aquatic organisms and other wildlife are virtually unknown.
"Pharmaceuticals and personal care

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Italian river 'full of cocaine'

Scientists have found large quantities of a cocaine by-product in a river in northern Italy - suggesting consumption is much higher than previously thought.

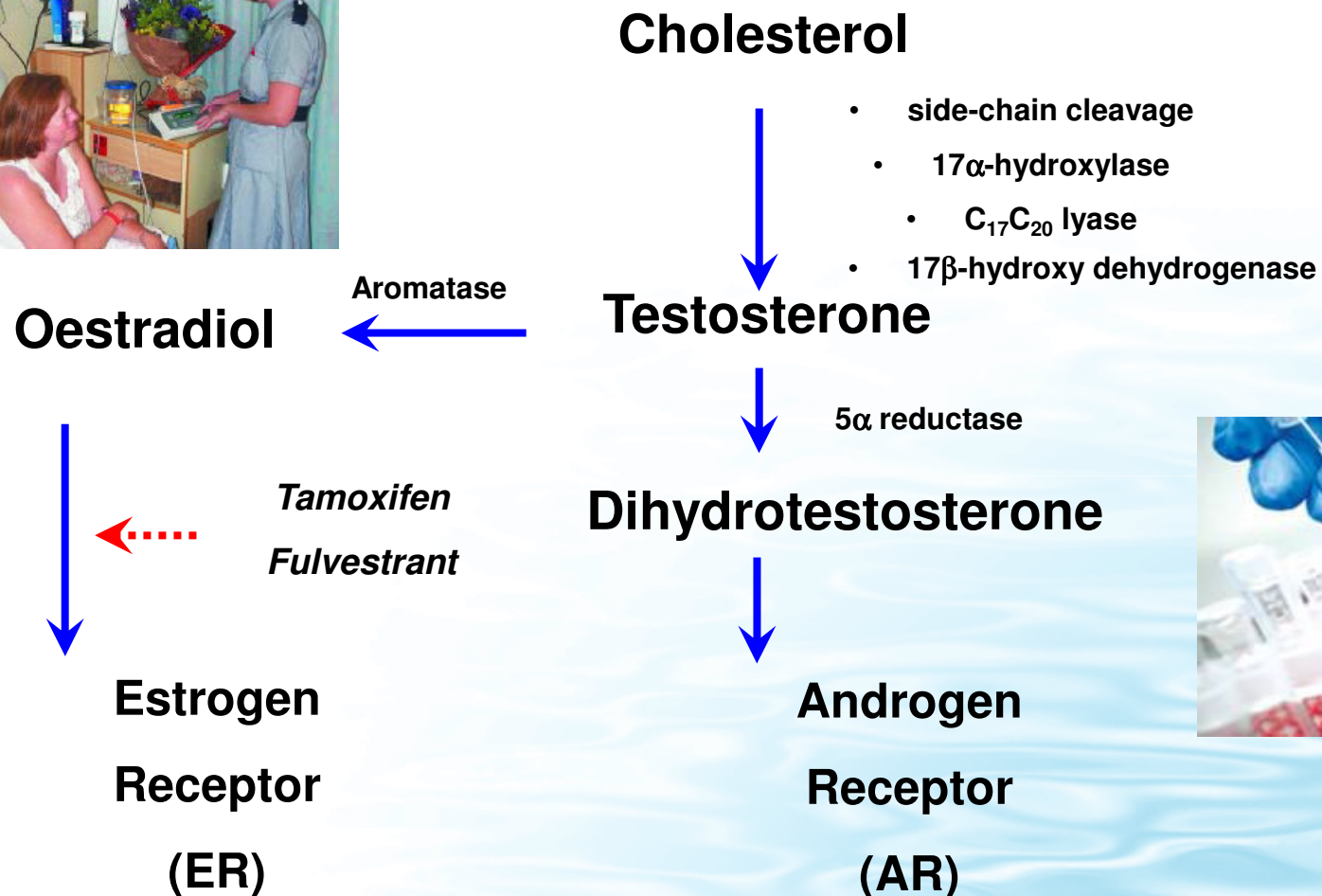
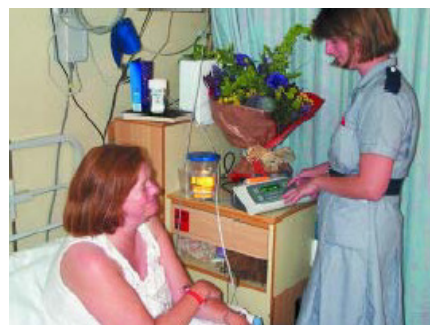
The River Po was found to be carrying the equivalent of nearly 4kg (8.8lb) of cocaine daily. The Po Valley is home to about five million people.

The study estimated daily consumption to be about 27 doses (100mg or 0.004oz each) per 1,000 young adults.

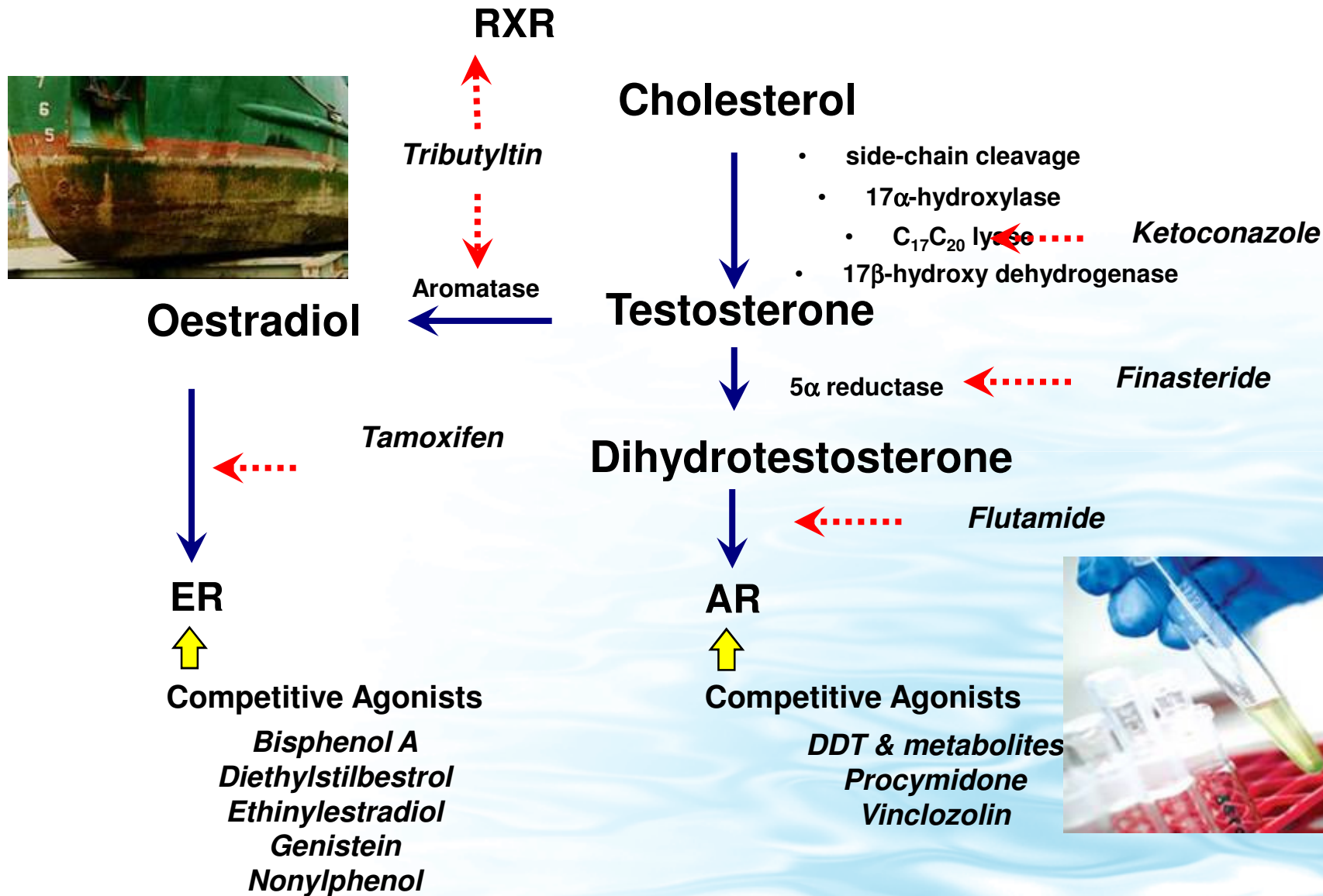


The results suggested cocaine was in regular use in the areas tested

Medical endocrine disruptors



Environmental endocrine disruptors

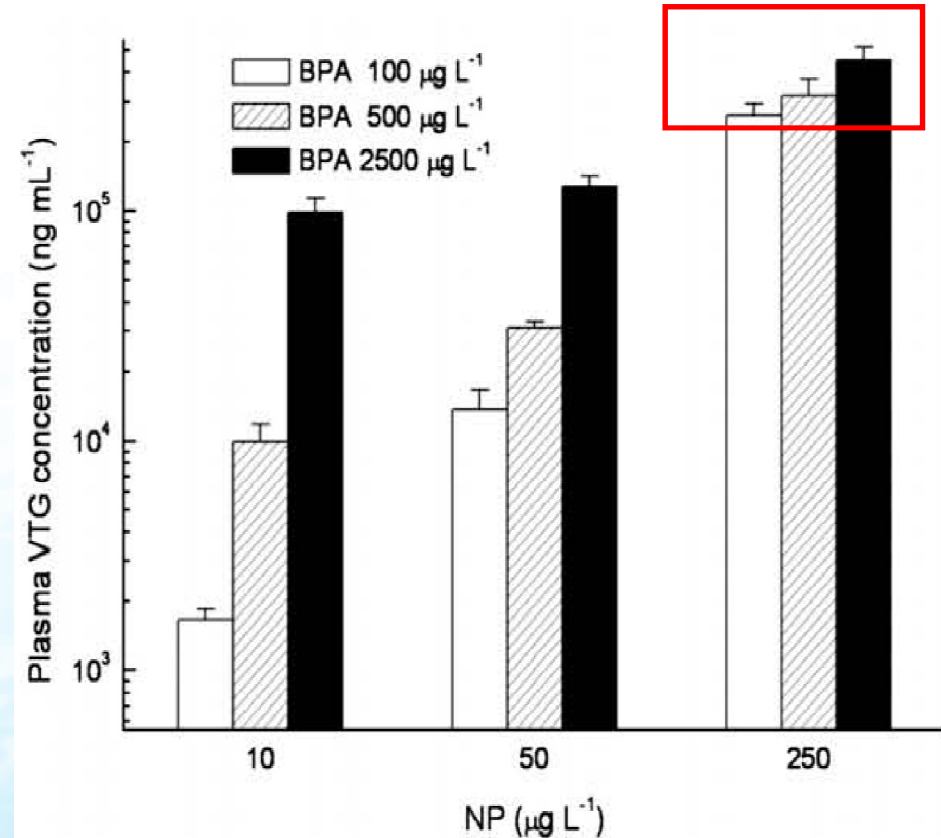
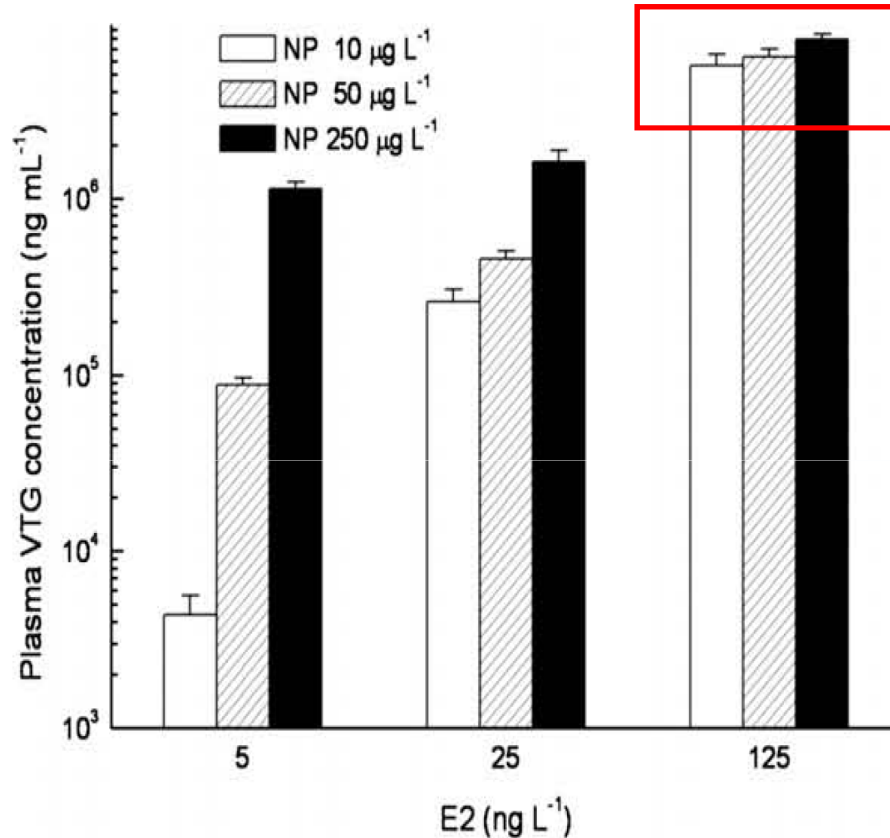


OECD Guidelines VTG validation

Organism	End point	Variable ^a	CV (%) ^b
Fathead minnow	Juvenile whole-body VTG	Reproducibility	55
	Female plasma VTG	Reproducibility	45
	Male plasma VTG	Reproducibility	38
	Plasma VTG	Repeatability	3–14
	Plasma VTG	Repeatability	16.4
	Plasma VTG	Reproducibility	18.6
	Plasma VTG	Repeatability	32
	Plasma testosterone	Repeatability	46
	Plasma estradiol	Repeatability	64
Medaka	Liver VTG	Comparability	52–863
	Whole-body VTG		100–1873
	Liver VTG	Repeatability	< 7
Zebrafish	Whole-body VTG	Comparability	70.2–269
	Whole-body VTG	Repeatability	14–18
<hr style="border-top: 1px dashed red;"/>			
Rainbow trout	28-day growth LOEC	Repeatability	—
	28-day growth LOEC	Reproducibility	19–58
Sheepshead minnow	Larval IC ₂₅	Repeatability	28–42
	Larval IC ₂₅	Reproducibility	44
Zebrafish	Survival NOEC	Repeatability	26–33
	Survival NOEC	Reproducibility	35–52
	Fecundity	Repeatability	26–63

**Ref: Hutchinson et al
(2006) EHP 114**

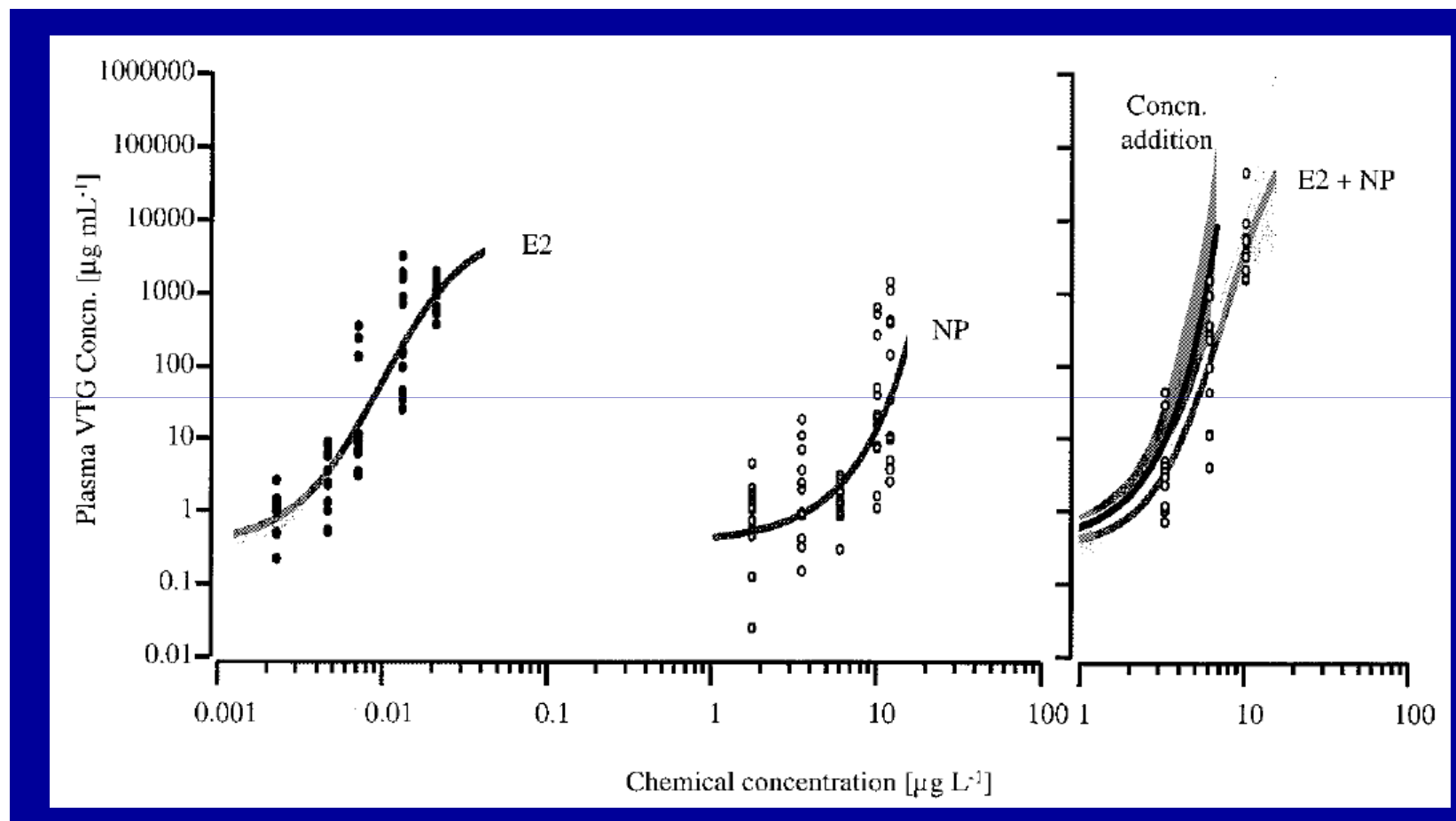
Health consequences *in vivo* - plasma VTG in male medaka (14d)



- Refs
 - Sun et al (2009) Chemosphere 75: 410-415
 - Länge et al (2001) Env Toxicol Chem 20: 1216-1227

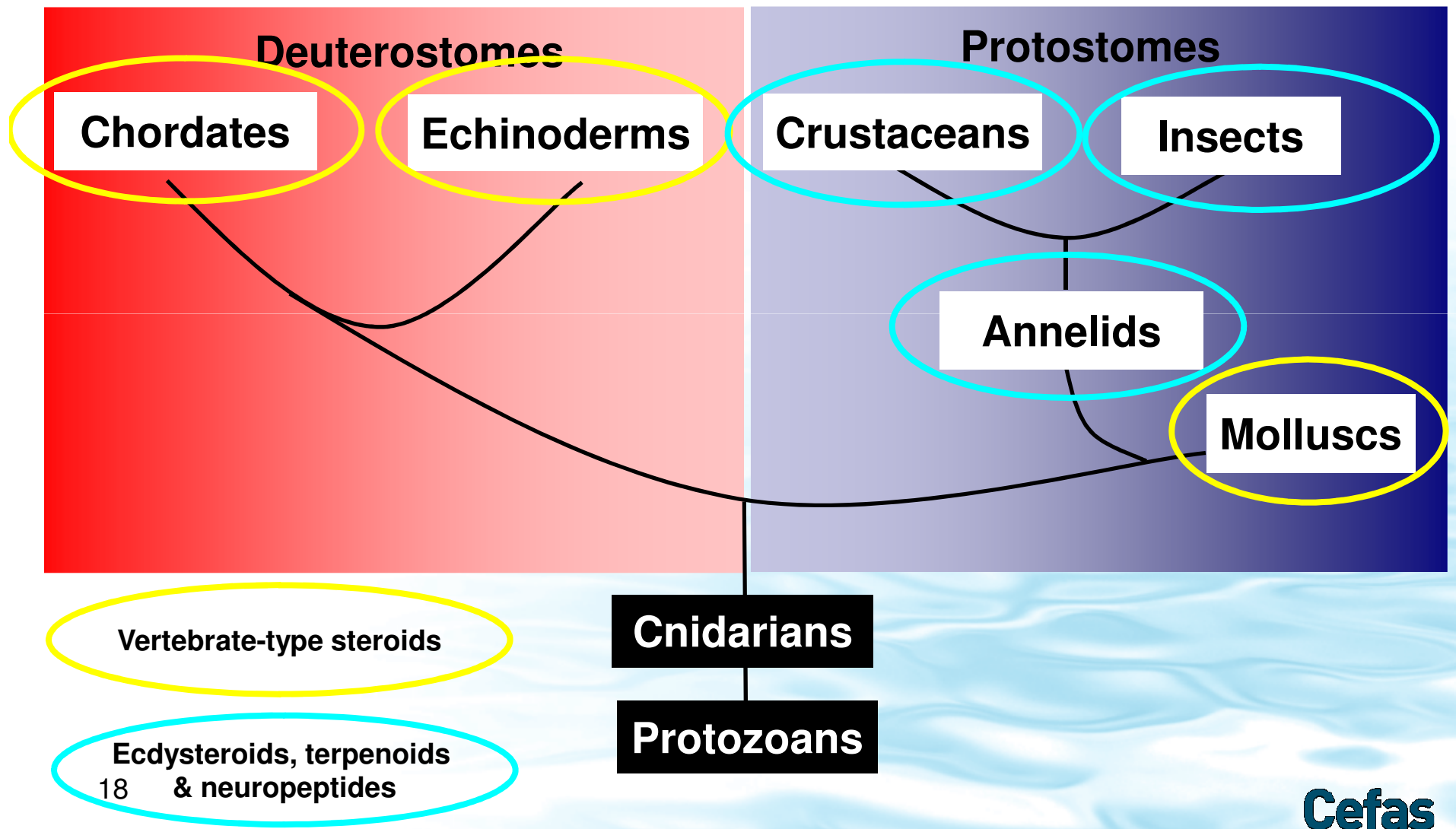
**High VTG levels
cause kidney
damage & death**

Mixtures *in vivo* fish VTG assay

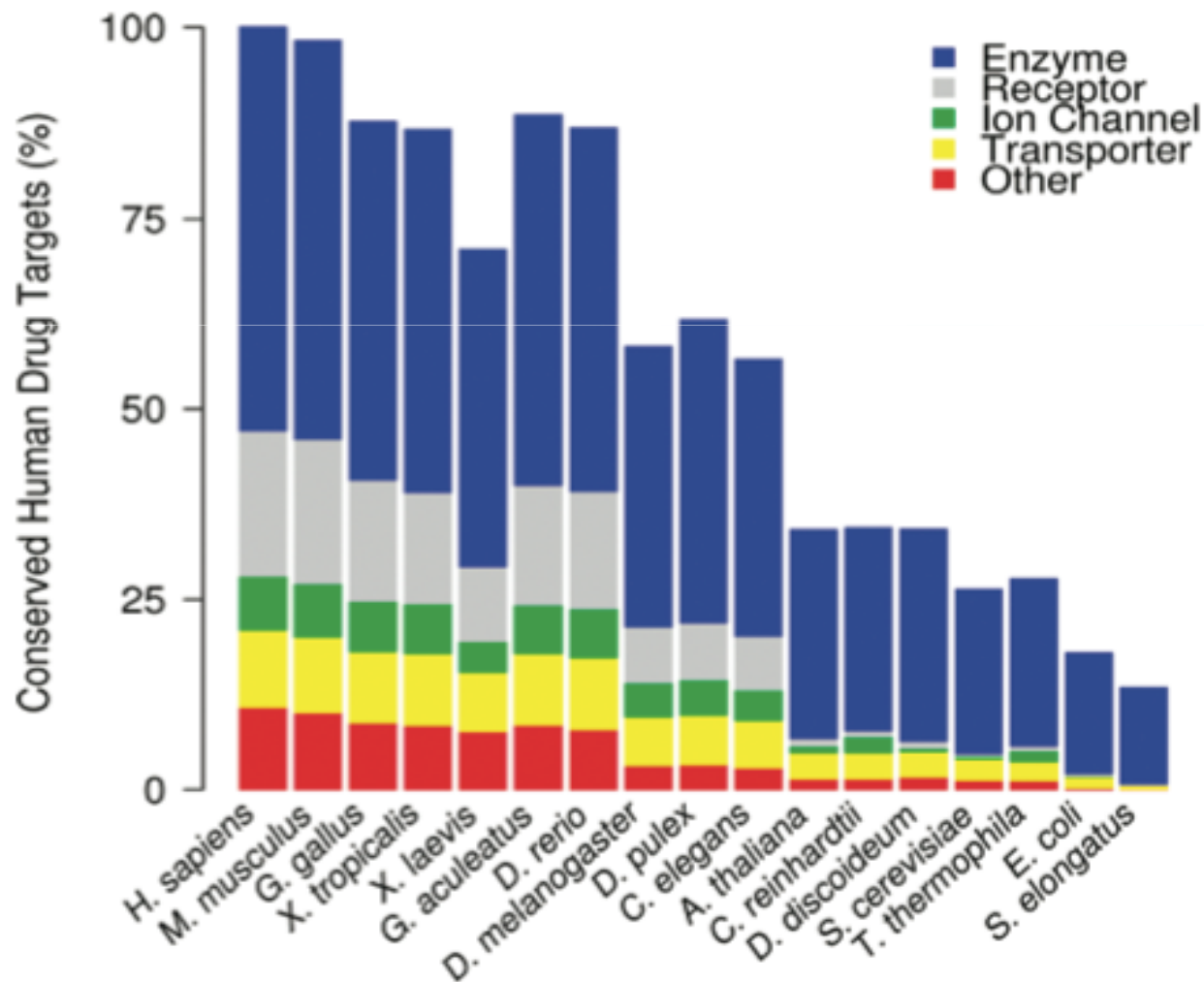
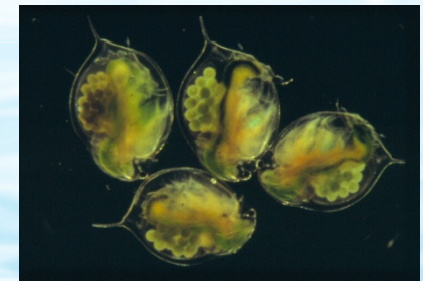


Mixtures of E2 and NP were additive at the concentrations; data presented illustrate that model of concentration addition accurately predicts VTG response (Thorpe et al (2001) ES&T 35: 2476-2481

Evolution of physiological systems .. knowledge from genomics



Gunnarsson et al - Bioinformatics Approach to Target Conservation



Source:
Gunnarsson et
al (2008)
Env Sci
Technol 42:
5807-5813

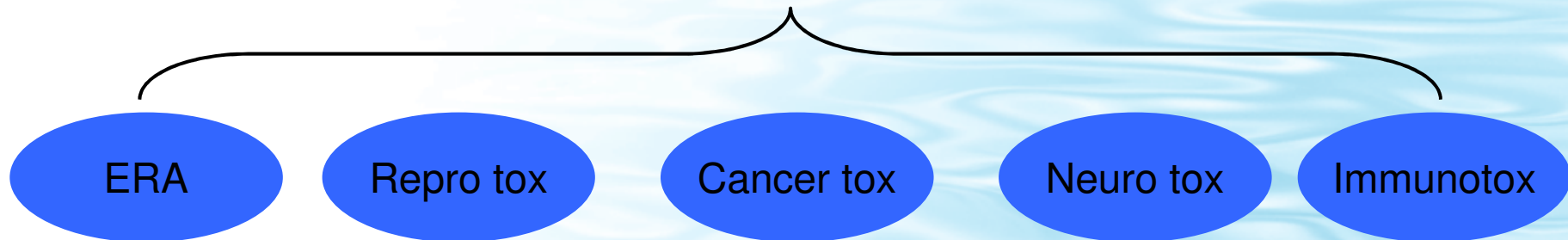
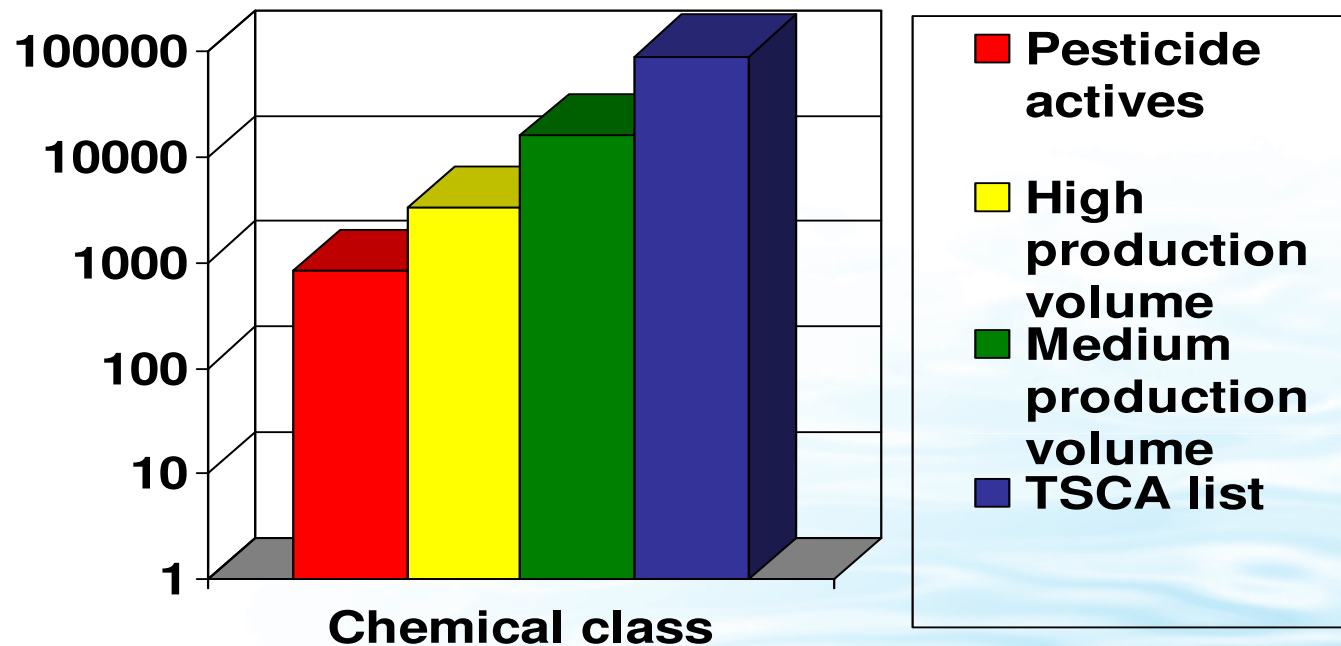
Insect cell line for hormone (ecdysteroid) binding

Substance	EC50 Values	Response (+/-)
Bisphenol A	$1.0 \times 10^{-4}\text{M}$	Active antagonist
Diethylstilbestrol	$1.0 \times 10^{-3}\text{M}$	Inactive
Diethylphthalate	$2.0 \times 10^{-3}\text{M}$	Active antagonist
Ethinylestradiol	$3.0 \times 10^{-5}\text{M}$	Inactive
Flutamide	$5.0 \times 10^{-5}\text{M}$	Inactive
Genistein	$1.0 \times 10^{-3}\text{M}$	Inactive
20-hydroxyecdysone	$7.6 \times 10^{-9}\text{M}$ (~4 ppb)	Active agonist
Lindane	$3.0 \times 10^{-5}\text{M}$	Active antagonist
Methoxychlor	$1.0 \times 10^{-3}\text{M}$	Inactive
Octylphenol	$1.0 \times 10^{-3}\text{M}$	Inactive
Tamoxifen	$1.0 \times 10^{-4}\text{M}$	Inactive
ZM189,154	$5.0 \times 10^{-5}\text{M}$	Weak antagonist

Dinan et al (2001) Environ Toxicol Chem 20: 2038-2046

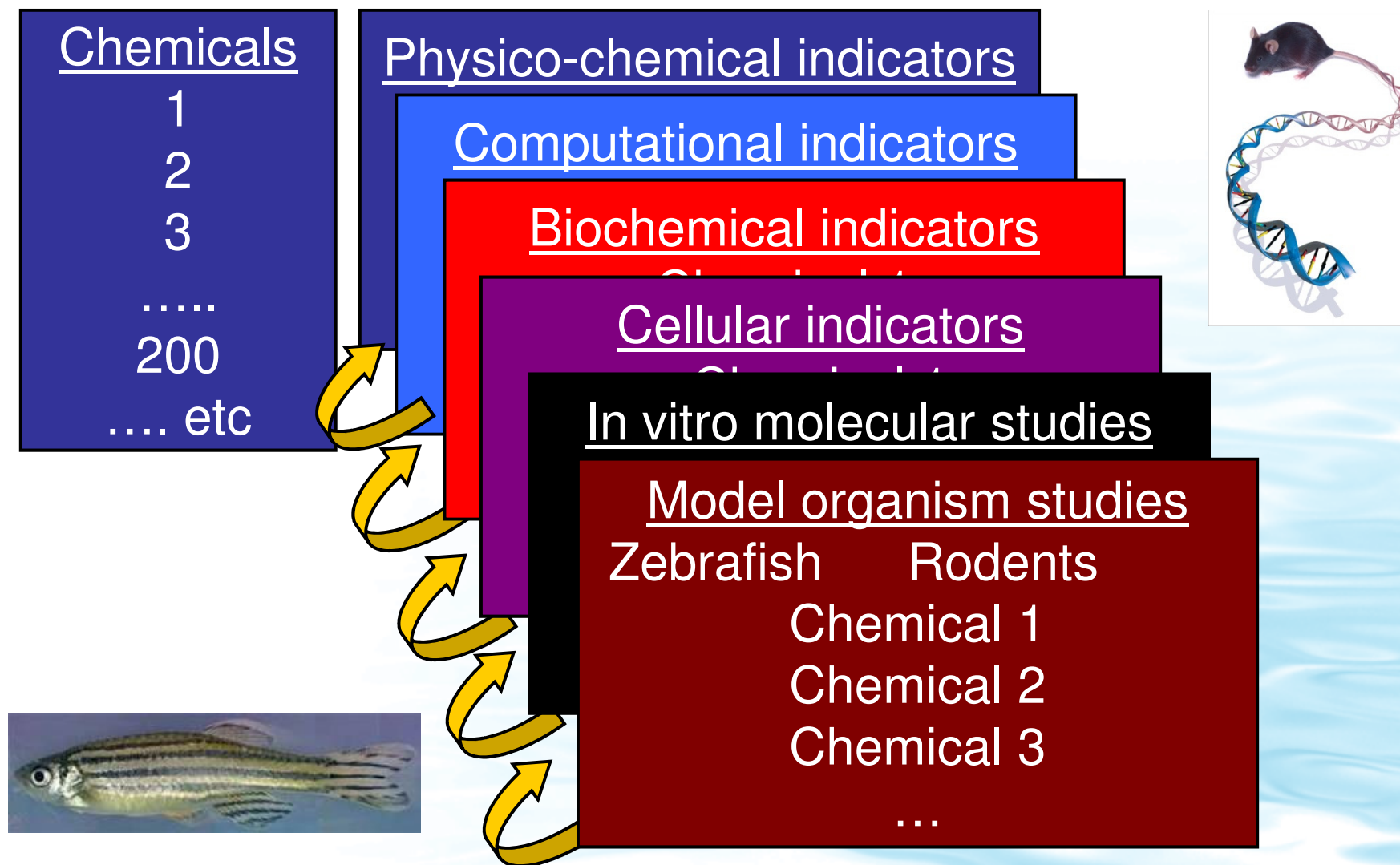
The ToxCast™ Challenge ...

- Large number of environmental chemicals to be assessed (ca. 90,000)



- Animal testing concerns & costs – millions £££

ToxCast™ - Systems Toxicology



Zebrafish in biomedicine



The Sanger Institute: Danio Rerio Sequencing Project - Microsoft Internet Explorer provided by AstraZeneca

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Back Forward Stop Home Search Favorites Print View Source

Address http://www.sanger.ac.uk/Projects/D_rerio/ Go Links

Sanger Home | Acedb | YourGenome | Ensembl | Trace Server | Library

Info | Databases | Blast | Genomics | Infrastructure | HGP | CGP | **Projects** | Software | Teams | Search

Data Release Policy | Conditions of Use

The Danio rerio Sequencing Project

In February 2001 the Sanger Institute started sequencing the
categories:
libraries and
assembly.

13th Oct 2005
ZFIN expression patterns mapped to Zv5
The expression pattern data hosted by ZFIN has been mapped to the Zv5 assembly. The data is visible as a ...
[more](#)

29th Jul 2005
Zv5 released in Ensembl
We are pleased to announce the release of a new Ensembl database based on the zebrafish assembly Zv5. This release ...
[more](#)

14th Jun 2005
Zebrafish Genome Resources Workshop
The Sanger Institute, ZFIN and NCBI organise the "Zebrafish Genome Resources Workshop" to be held concurrently with the 4th European ...

Annual zebrafish PubMed listings

Zebrafish in PubMed since 1980 ...

Total
32,188,827

Select

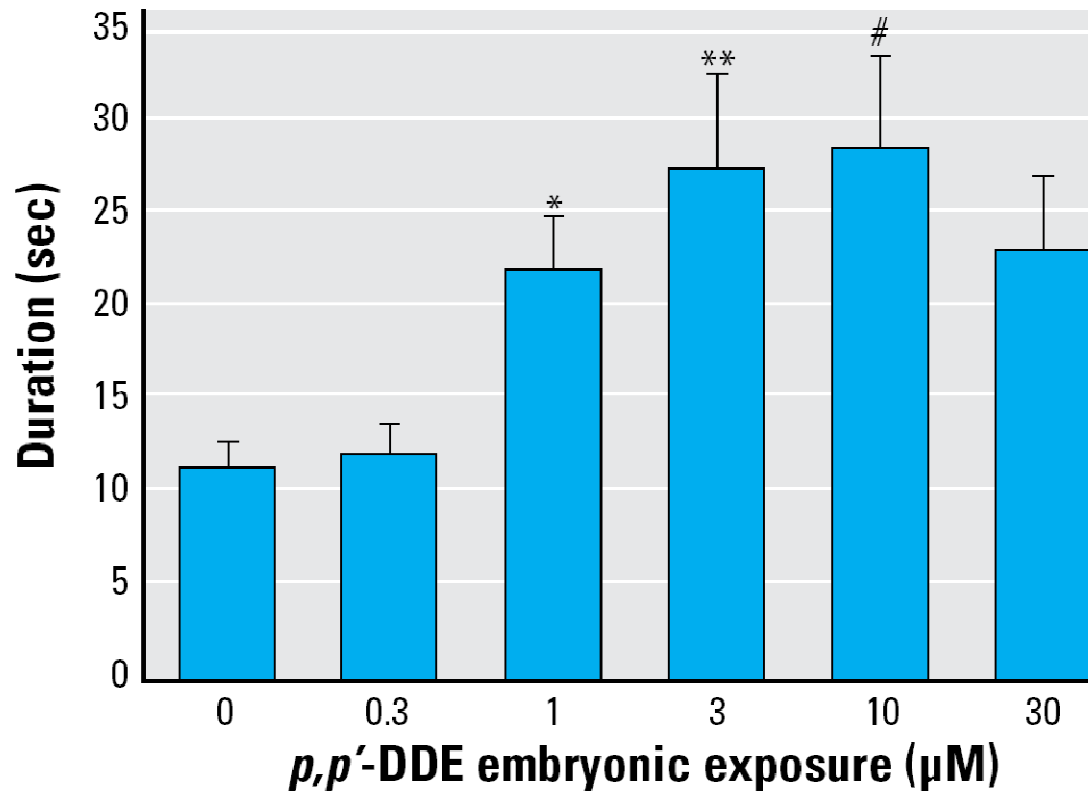
contacts

Select

- [Genome Resources Workshop Dresden 2005](#)
- [Sanger part of Madison 2004 tutorial](#)

Start Em... RE... ZF... fin... Ho... GS... RE... Th... Internet 12:52

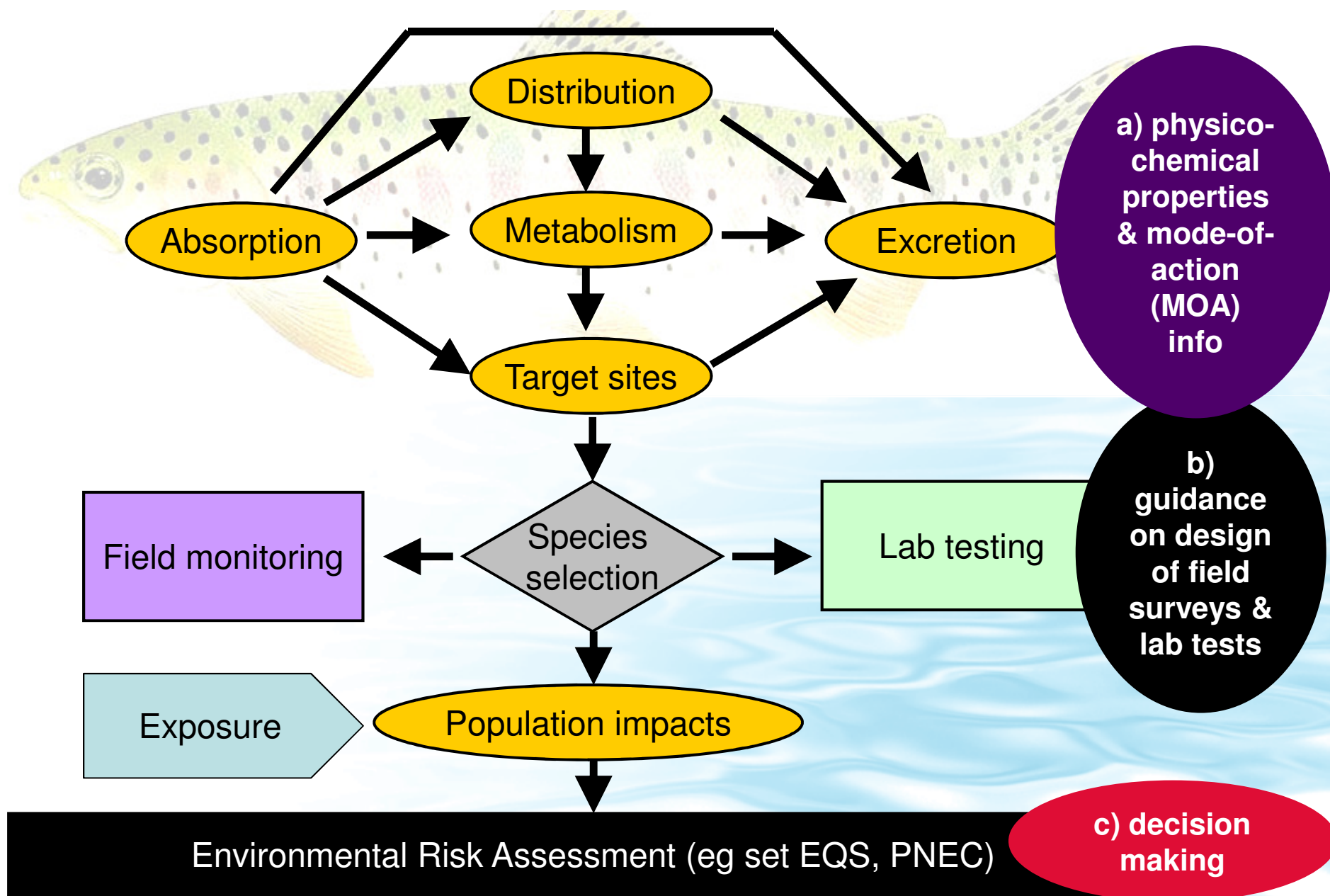
Zebrafish locomotor assay for biotoxin & p,p' -DDE interactions



- Domoic acid (neurotoxin)
 - p,p' -DDE alone did not induce seizures
 - p,p' -DDE body burdens close to levels found in foetal marine mammals enhance seizures due to domoic acid

- Duration of seizures in embryo-exposed p,p' -DDE larvae after exposure to 5 mM PTZ.

Targeted Hazard Assessment



Chemicals in Water Report: Ideas for Case Studies

1. Oestrogens & fish feminisation – integration of biology and chemistry using TIE approach, led to OECD test guideline with VTG biomarker;
2. Pesticides & pharmaceuticals – mode of action approach and PNECs for complex datasets;
3. Tributyl tin – a success story which spans ecological observations, in depth mechanistic studies & policy actions;
4. POPs (eg methylmercury, PCBs, PFOS) – levels in aquatic environment & human health

Future Investment Priorities

1. Smart assessment approaches needed for increasingly complex range of chemicals & nanoparticles;
2. Targeted ('intelligent') testing strategies needed to link population relevance + mode-of-action;
3. Need validated biological effects tools for multiple stressors (eg ocean acidification & contaminants)
4. Need to ensure EC supports training in essential pertinent to environmental risk assessment