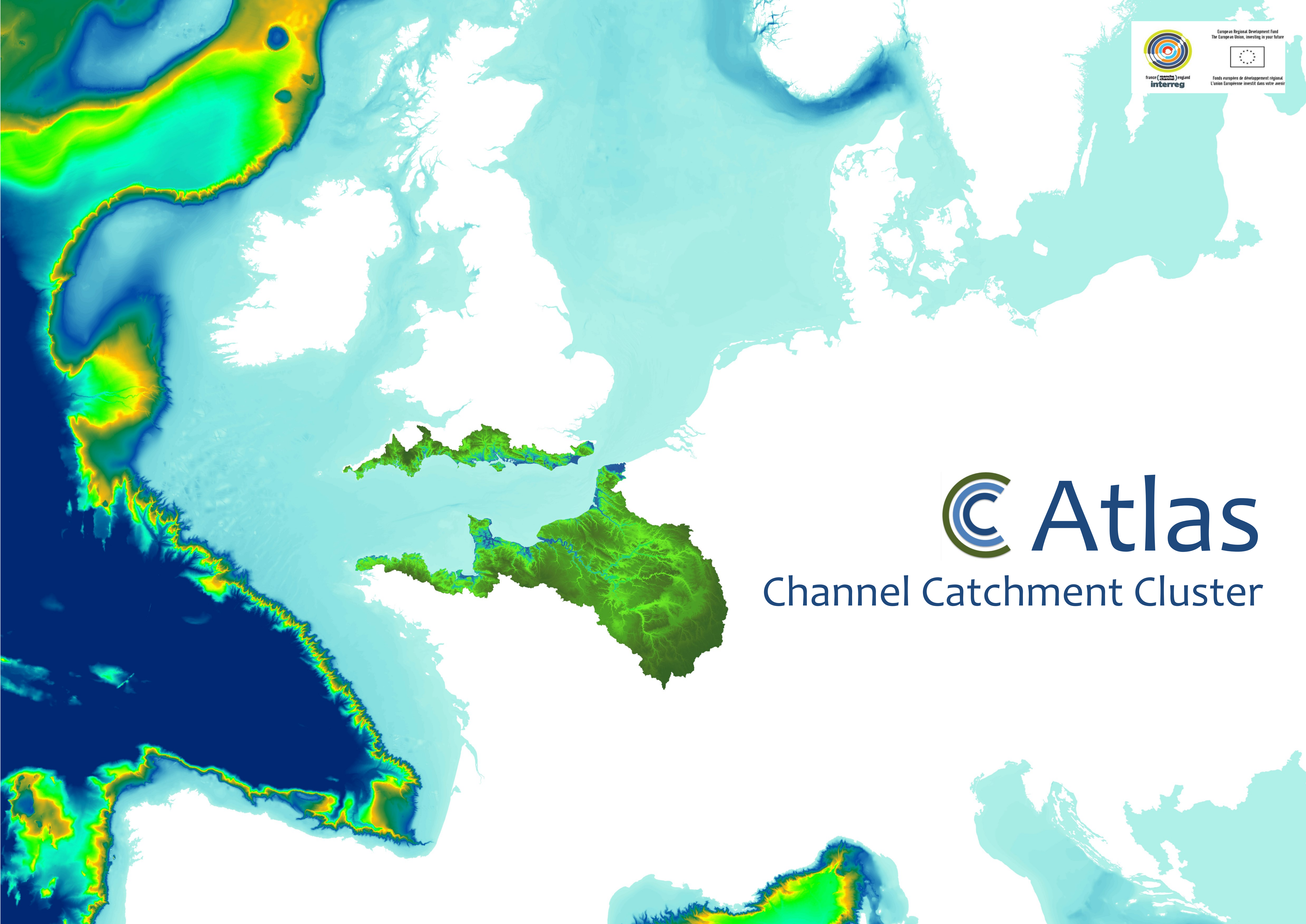

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CATCHMENTS DRAINING INTO THE CHANNEL

Lucy Morris, Westcountry Rivers Trust

A Recent History of the Channel

20,000 years ago the world was at the peak of the last Ice Age and much of northern Europe was covered in sheets of ice up to 3 km thick. The ice was formed mainly from water that had evaporated from the oceans and condensed into snow, which was then deposited as ice across the polar regions. The overall result was a fall in global sea levels by about 120 metres.

This fall in sea level was big enough to expose the landmass, known as 'Doggerland', under the southern North Sea, connecting the British Isles to mainland Europe across a low-lying tundra. The 'uplands' of Doggerland, known today as the Dogger Bank, were situated off the east coast of East Anglia and extended towards the Netherlands. These uplands formed the northern watershed of a large river system that flowed South West across the tundra (now the sea bed of the Channel) as a wide, slow river, out into the Atlantic Ocean.

During this time, the rivers of current day northern France and southern England were mere tributaries of this historic river system, until the ice started to melt and sea levels began to rise once again.

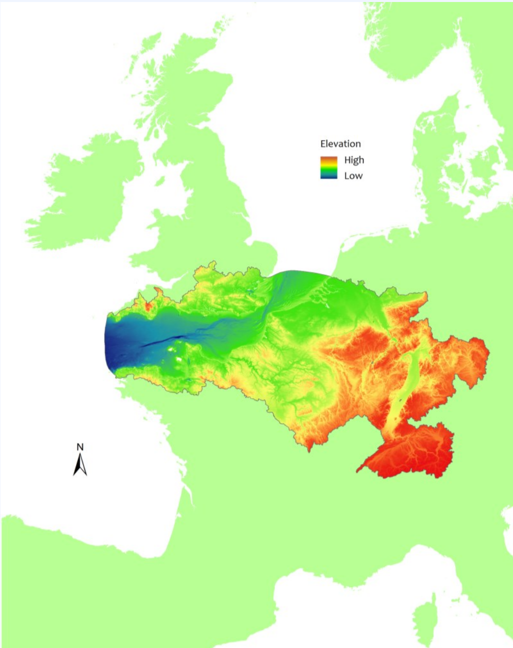
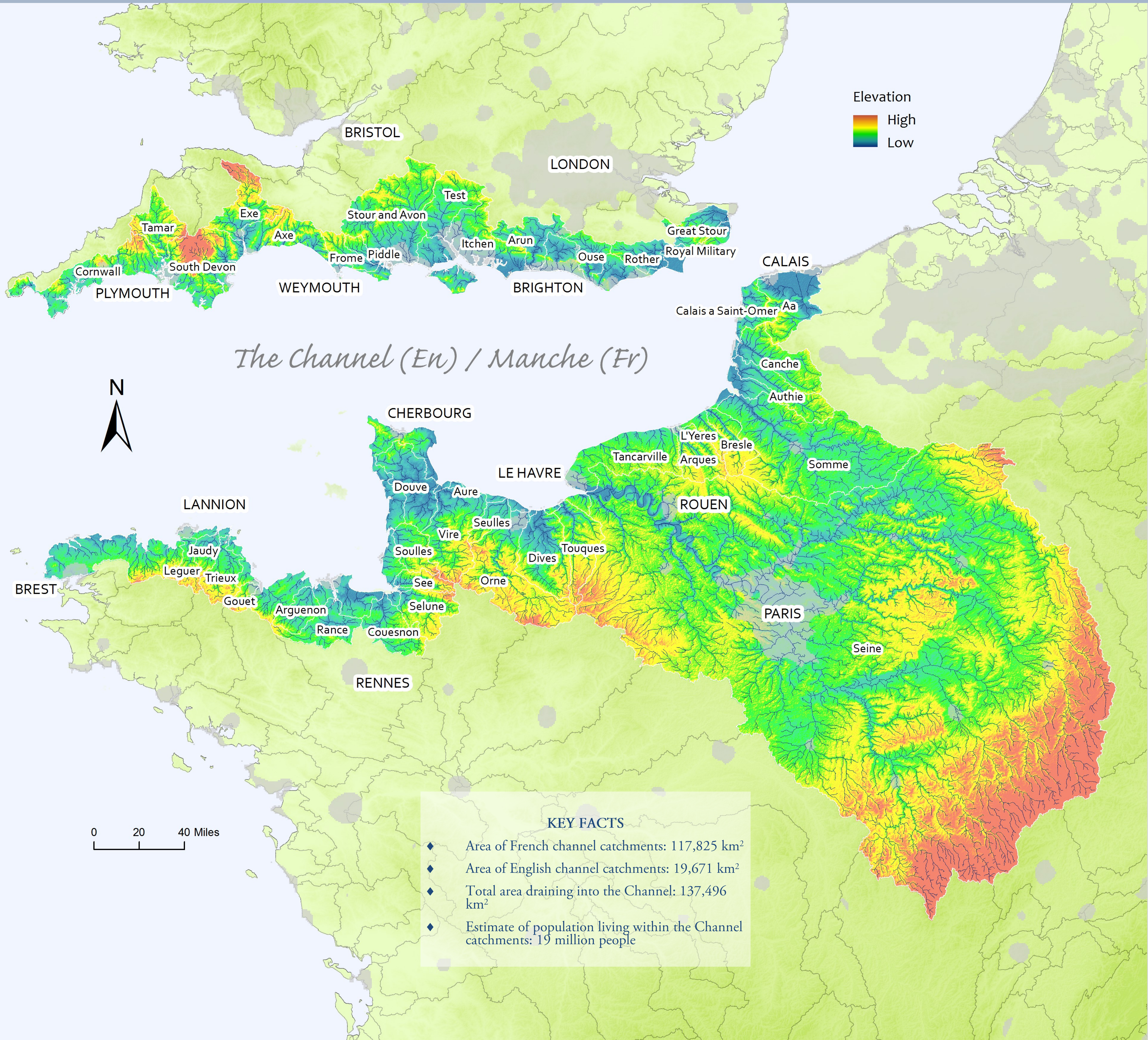


Illustration of the catchment area that drained out into the Atlantic ocean across the channel tundra approximately 12,000 years ago.



KEY FACTS

- Area of French channel catchments: 117,825 km²
- Area of English channel catchments: 19,671 km²
- Total area draining into the Channel: 137,496 km²
- Estimate of population living within the Channel catchments: 19 million people

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METAL PROFILES OF ESTUARINE SEDIMENTS

Nick Pope, Marine Biological Association, Plymouth

Metals in Estuarine Sediments

Trace metals commonly found in river systems, such as arsenic, cadmium, chromium, copper, mercury, nickel, lead and zinc, can be found either dissolved in the overlying water or in their solid phase as suspended particulate material and in bed sediments. Due to their chemical characteristics, the concentration of metals within sediments are usually several orders of magnitude greater than in the overlying water. Therefore, an understanding of sediment metals is essential to an overall assessment of trace metal contamination.

Trace metals in our estuaries are derived from a range of sources. The underlying geology of an area, together with natural weathering, will provide a proportion of the total load and is particularly significant in metal-rich regions, such as Devon and Cornwall in the UK. Historic and current metal mining in these areas has accelerated this process with sediments in many estuaries being particularly enriched with metals. However, in other estuaries, industrial activities, shipping, domestic waste and many other human activities have all increased metal loadings above natural levels.

Despite regulation and control of anthropogenic metal inputs in recent decades, and due to their ability to sequester metals, estuarine sediments act as a record of historic inputs and also as a potential long-term reservoir for future re-mobilisation. Re-mobilisation can occur through many processes. Changes in chemical or physical conditions (physical disturbance, changes in pH or redox potential) can act to alter the equilibrium partitioning such that dissolved metals are released. This process may also occur due to the physical activities of burrowing fauna (bioturbation) or human activities such as dredging in ports and harbours.

There is no universally applied assessment of risk for sediment metals, although in the absence of such a standard the Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (Canadian Council of Ministers of the Environment) have been adopted as a *de facto* standard in many countries. These guidelines are are based upon a range of synoptic biological and chemical data for sediments and have been used to calculate two assessment thresholds; the Threshold Effects Level (TEL) and the Probably Effect Level (PEL). Evaluation of sediment metal concentrations at any location may then be assessed relative to these levels (further explained in the subtext to the map).

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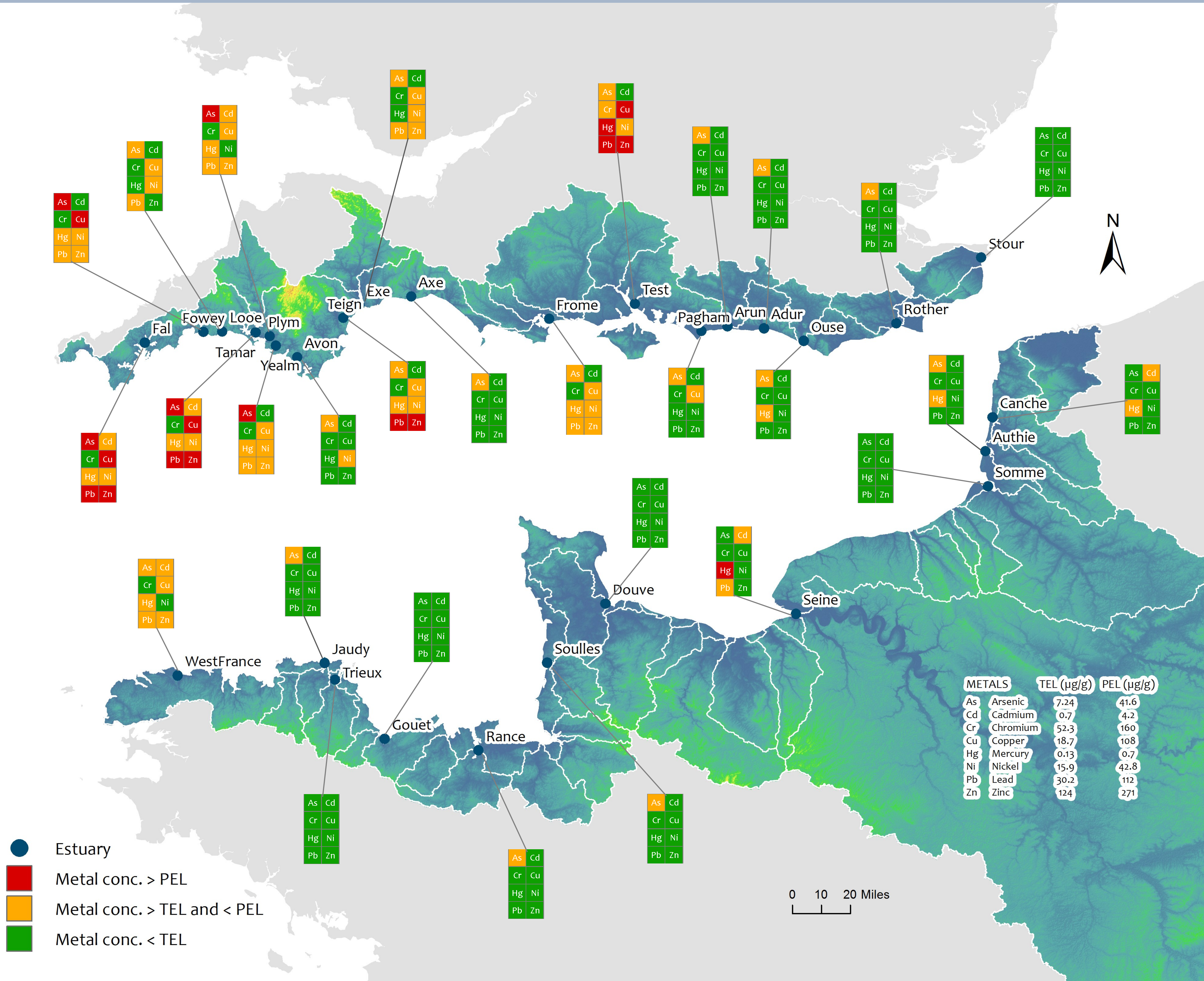

The 'Threshold Effect Level' (TEL) and 'Predicted Effect Level' (PEL) are sediment quality guidelines, where the TEL is the concentration below which sediment-associated contaminants are not considered to represent significant hazards to aquatic organisms and the PEL is the lower limit of the range of concentrations associated with adverse biological effects.

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ANALYSING SPATIO-TEMPORAL CHANGES IN ESTURATINE SEDIMENTS

J. Richir, J. Pini, S. White and G. Watson, Institute of Marine Sciences, University of Portsmouth

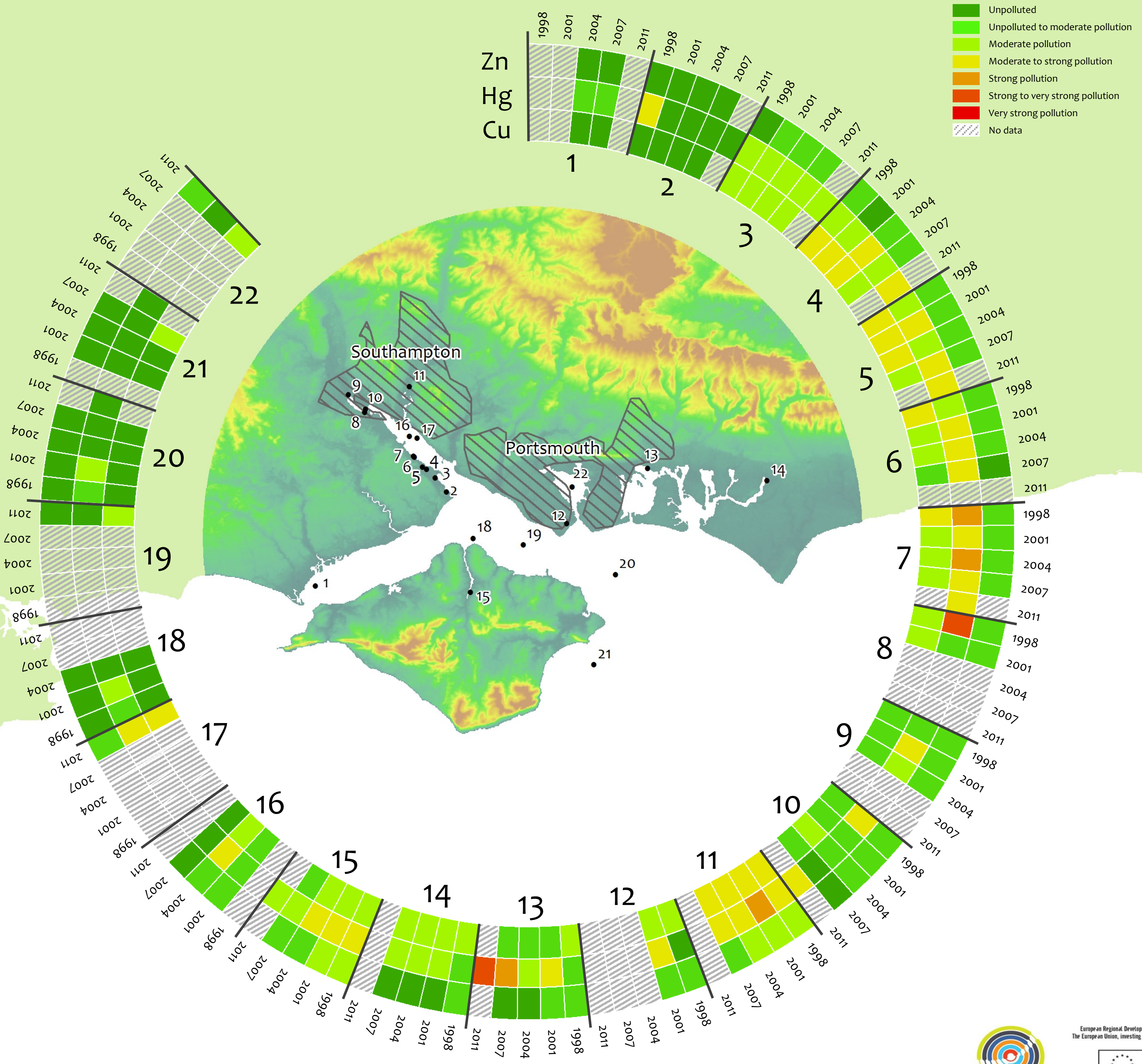
Sediment Trace Element Contamination

Among the variety of contaminants that threaten the marine environment, trace elements are of concern because of their toxicity, their ability to highly concentrate in biota and persistence in sediments. Large spatiotemporal surveys are thus performed in the UK to monitor their environmental occurrence. But the resulting databases generated remain underexploited. This research work therefore aims to investigate the long term changes in trace element (As, Cd, Cr, Cu, Fe, Pb, Hg, Ni, Zn) contamination in the sediments along the coasts of South England, using the 2 main marine environmental UK databases of the Environment Agency and the MERMAN project.

The risk assessment of the sediment pollution requires the comparison of contamination values to reference levels. The 7-level Geoaccumulation Index (Igeo) pollution scale (see table below) classifies the sediments from unpolluted to very strongly polluted. Igeo scale levels correspond to given enrichment factor (EF) values; the EF of a trace element is the ratio between its concentration in the sediments and its natural background concentration. These two indices thus give qualitative and quantitative information on the natural and human-induced contributions to the observed sediment contamination.

The map on the right shows the changes in the levels of Zn, Hg and Cu contamination in the < 63 µm sediments in the Solent area, from the late 1990s till recently. The sediment contamination in the Solent displays an important spatial variability, presumably linked to the spatial distribution of pollutant anthropogenic sources, *e.g.* around Southampton. The contamination levels generally decrease during the survey time interval, although this downward trend cannot be generalized to all the monitored sites. Mining of existing environmental databases is a relevant (and cost effective) way to monitor the spatiotemporal evolution of the pollution, and to transfer relevant information to managers and policymakers on the efficiency of the implementation of European environmental directives.

Pollution Level	EF	Igeo
Unpolluted	< 1.5	0
Unpolluted to moderate pollution	1.5 - 3	0 - 1
Moderate pollution	3 - 6	1 - 2
Moderate to strong pollution	6 - 12	2 - 3
Strong pollution	12 - 24	3 - 4
Strong to very strong pollution	24 - 48	4 - 5
Very strong pollution	> 48	> 5



PASSIVE SAMPLING PESTICIDES IN THE RIVER TAMAR

South West Water, University of Portsmouth, Natural Resources Wales and Westcountry Rivers Trust

Passive Sampling to Detect Acid Herbicides

Spot sampling, carried out by South West Water (SWW) at their abstraction point at Gunnislake on the River Tamar, reveals episodic spikes of acidic herbicide pollution. However, these spikes are rarely observed in spot samples collected infrequently (once a month) throughout the catchment by statutory bodies, as acidic herbicides are typically flushed through the system extremely quickly at the onset of rain.

Acidic herbicides include mecoprop, MCPA, 2,4-dichlorophenoxyacetic acid (2,4-D) and other related compounds, all of which are widely used across the South West, principally for the control of broad-leaved weeds in permanent and temporary grassland. Concentrations often exceed the 100ng/l limit for an individual pesticide in treated water, as specified by relevant drinking water legislation.

The Chemcatcher™ passive samplers used in this study were developed by the University of Portsmouth and the methods for identifying and quantifying specific acidic herbicides were developed by SWW in collaboration with Natural Resources Wales.

For this passive sampling study, Chemcatcher™ samplers remained in the water for two weeks. The study aimed to:

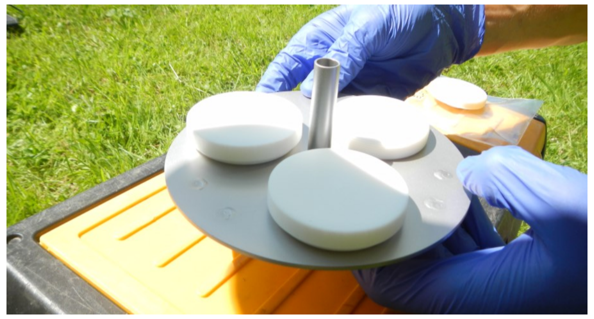
i. identify the tributaries primarily responsible for input of acidic herbicides,

ii. Provide an indication of the specific pesticides arising from each area and

iii. Provide evidence to inform targeted management advice

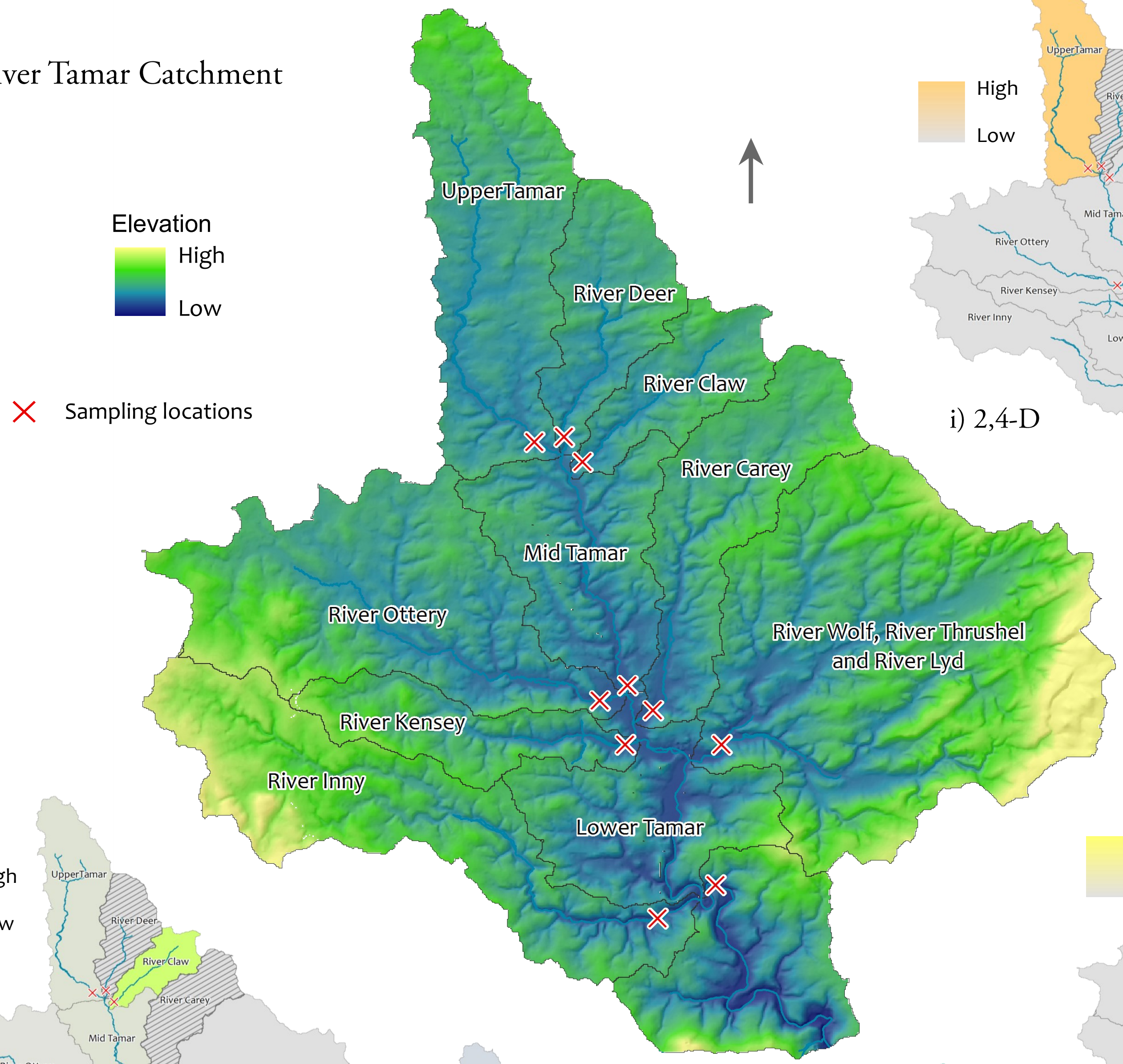
A range of herbicides were detected in the system and key source areas were identified. This study emphasised the capability of the technique to account for short-lived spikes in pollution, which were not detected using the traditional spot sampling method.

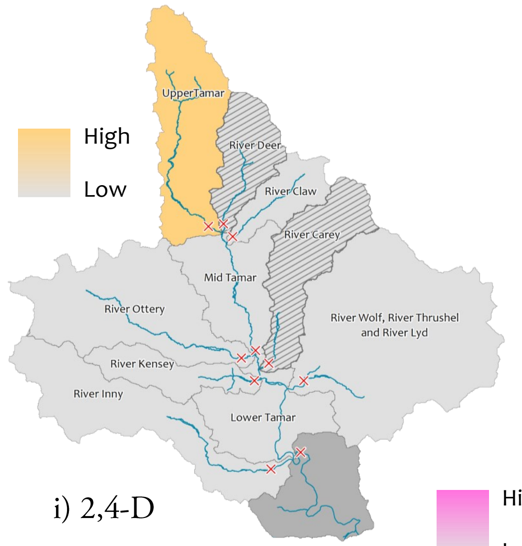
This passive sampling method is currently being developed for detection of a range of additional pollutants.



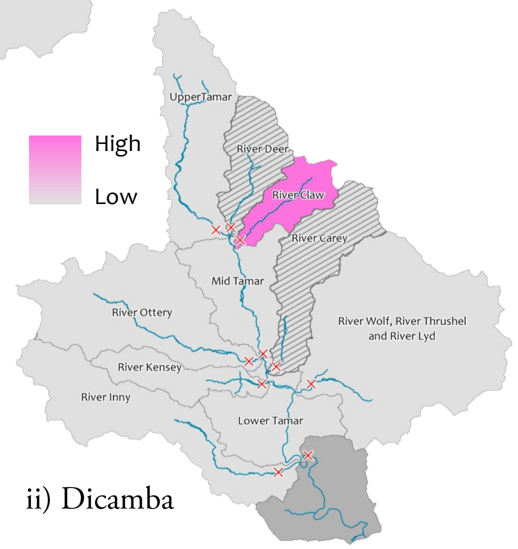
Three Chemcatcher™ receiving discs ready for deployment.

River Tamar Catchment

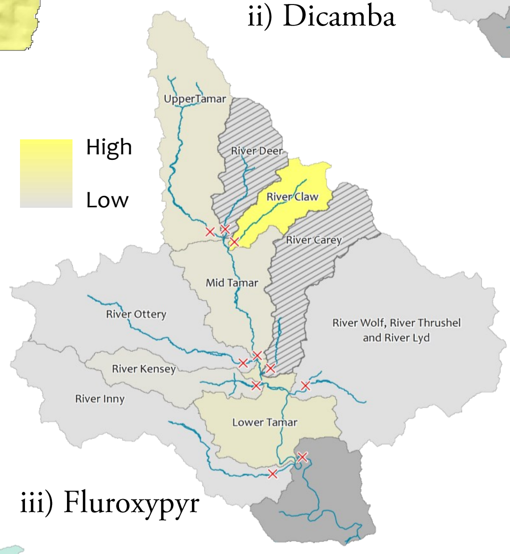




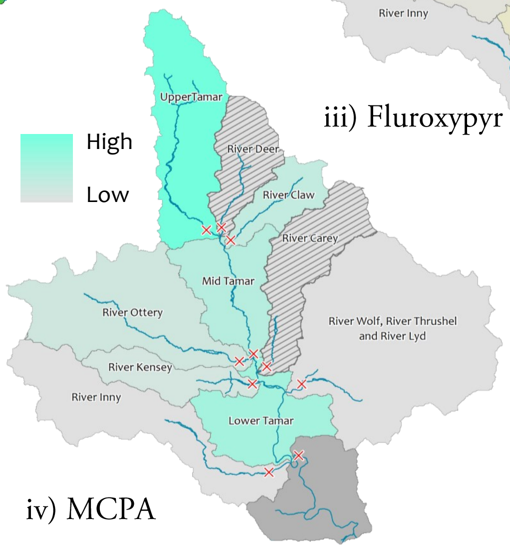
i) 2,4-D



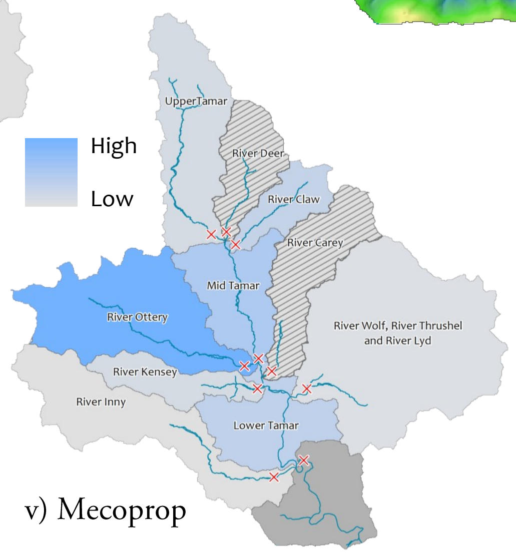
ii) Dicamba



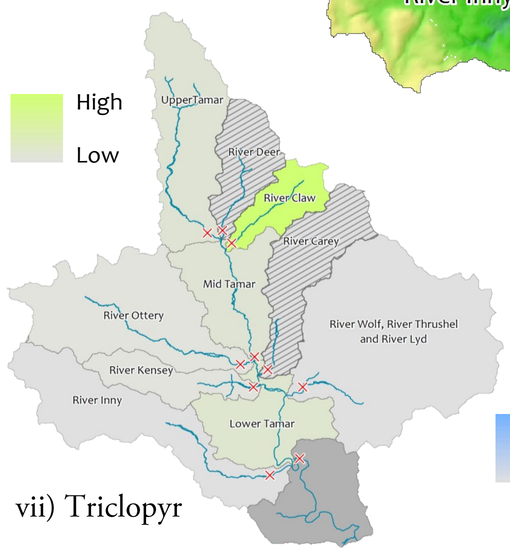
iii) Fluroxypyr



iv) MCPA



v) Mecoprop



vii) Triclopyr

No Results

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COMPARATIVE PAH CONTAMINATION AND BIOLOGICAL EFFECTS IN THREE ESTUARIES

Awantha Dissanayake and Awadhesh N. Jha, University of Plymouth

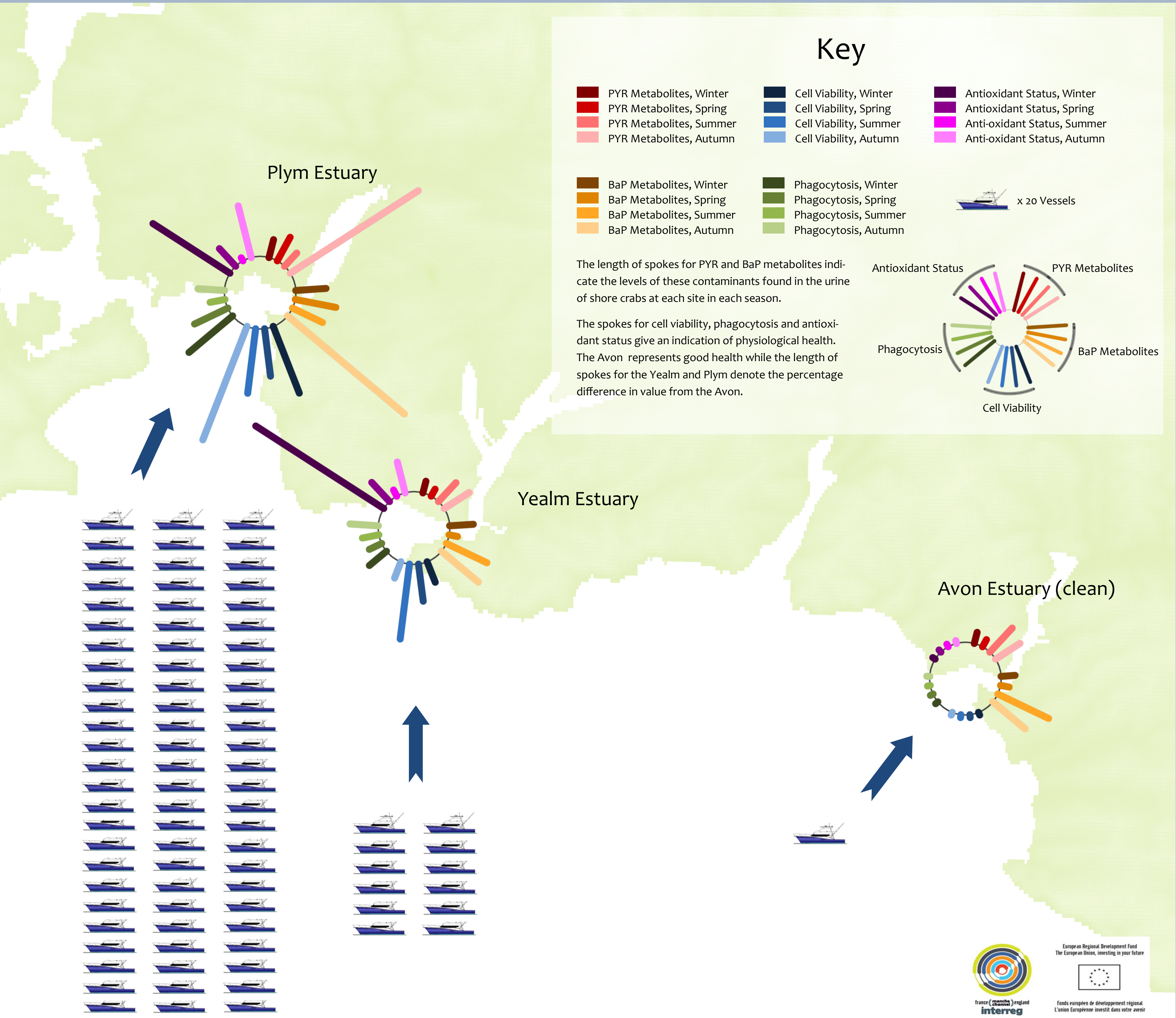
PAH Contamination and Biological Effects

Coastal marine waters and sediments, including estuaries, continually receive contaminants from human activities that are potentially toxic to aquatic organisms. The recent emphasis of marine environmental monitoring has been to develop biological measurements of anthropogenic impact, including physiological assessments of the 'health' of chosen test species. Unfortunately, implementation of such an approach is impeded by a lack of understanding of the basic biochemistry of test organisms, such as the natural seasonal variation in physiological ranges for specific chemicals.

Here, we present biological effects of polycyclic aromatic hydrocarbon (PAH) exposure in the shore crab, *Carcinus maenas* which is a common inhabitant of various coastal habitats throughout Northern Europe and widely employed as a bioindicator species. This example demonstrates how biological responses may be implemented as indicators of water quality (Dissanayake et al. 2011). PAHs present in the water column can be detected in urine collected from shore crabs. Fluorescence detection of PAH metabolites (PYR and BaP) was developed to signal PAH exposure in both fish and crustacea. Crabs from all estuary sites demonstrated levels of PAH metabolites in the urine, indicating that crabs had been exposed to hydrocarbons from the water column. The different PAH metabolite levels reflect the varying anthropogenic input from maritime and confirm that the Avon Estuary is a relatively clean site while the Plym Estuary is relatively high in PAHs. As the Avon was taken to represent the clean site, physiological differences between the Avon and Plym crabs were apparent throughout the year, irrespective of season, highlighting that Plym Estuary crabs displayed biological effects due to PAH exposure.

Physiological impacts include lower viability of haemocytes (oxygen carrying blood cells) in summer and decreased ability to deal with oxidative damage as shown by antioxidant capacity in autumn. Repercussions of such biological impacts mean crabs are vulnerable in these times of the year and may act as 'windows of sensitivity' to contaminant exposure.

A major goal of the Eu Water Framework Directive (2000/60/EC) (European Commision 2009) is the protection, improvement and sustainable use of aquatic environments. In order to achieve and maintain 'good environmental status* (i.e. chemical levels) and good ecological status (species biodiversity) would be to monitor biological impacts in the biota which would signal chemical exposure and act as early warning signals prior to any ecological impacts such as loss in biodiversity.



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OCCURRENCE OF NON-INDIGENOUS SPECIES IN CHANNEL HARBOURS, PORTS AND MARINAS

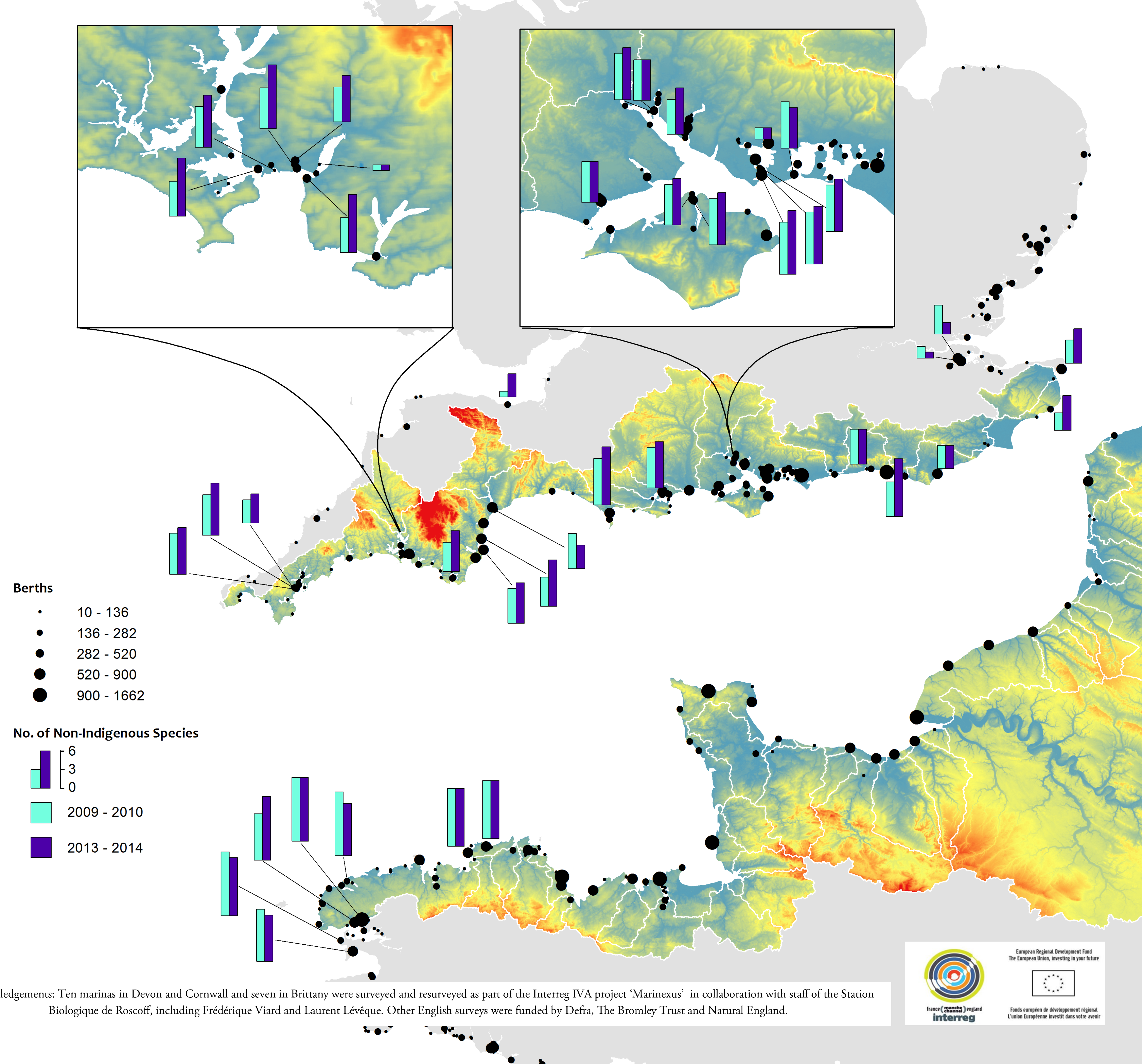
Christine Wood, Anna Yunnie and John Bishop, Marine Biological Association, Plymouth

Coastal Non-Indigenous Species

Coastal ports, harbours and marinas are prime sites for the arrival and establishment of non-indigenous species (NIS), which are a potential threat to native biodiversity, human health and ecosystem services. These sheltered artificial habitats are frequently located in transitional waters of river mouths and estuaries, from where introduced aquatic species can spread seaward or into river systems, according to their environmental requirements. Marinas are priority sites for monitoring, being 'hotspots' for the occurrence of NIS, and their floating pontoons allow access to shallow subtidal biota at any state of tide. The map shows the results of standardised searches ('Rapid Assessment Surveys', RAS) of marinas on the English Channel coast in 2009-10, repeated in 2013-14, and relates to sessile animals - those that live as adults attached to a solid surface, and generally feed on organic particles, including plankton, suspended in the surrounding water. (Examples include barnacles, oysters, sea-squirts and moss animals.)

The total of species recorded on each occasion from a suite of thirteen sessile animal NIS is shown. At English sites, numbers of NIS generally increased between surveys, but a similar increase was not evident at the marinas in Brittany, where numbers were already higher in 2009-10 than those in 2013-14 in England. Despite this, the lists of NIS present on the two sides of the Channel are very similar. The difference is that in 2009-10 most of these species were already widespread in Brittany - present in the majority of marinas - whereas in England most species were infrequent, present in only some or a few marinas. This seems to be because a suite of relatively recent introductions to NW Europe are longer established in France, and have thus colonised most of the available marina sites, whereas they are more recent arrivals in England and are still spreading from site to site. It therefore seems that the recent flux of NIS across the Channel within this category of organism has been predominantly northwards.

Also shown is the approximate number of marina berths or moorings per site, emphasising the very substantial (and increasing) scale of the infrastructure associated with leisure boating on the Channel coast and the presence of clusters of boating activity such as in the Solent and along the Devon coast.



Acknowledgements: Ten marinas in Devon and Cornwall and seven in Brittany were surveyed and resurveyed as part of the Interreg IVA project 'Marinexus' in collaboration with staff of the Station Biologique de Roscoff, including Frédérique Viard and Laurent Lévêque. Other English surveys were funded by Defra, The Bromley Trust and Natural England.

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ECOSYSTEM SERVICES MAPPING IN EAST DEVON

Nick Paling and Sarah Wigley, Westcountry Rivers Trust

Ecosystem Services Mapping

The Westcountry Rivers Trust, in collaboration with DEFRA and the Rivers Trust, has developed a method for undertaking stakeholder-led spatial visualisation of ecosystem services provisioning areas across a catchment landscape. During this participatory process, stakeholders from all sectors, including private businesses, public bodies, charities and other local interest groups, and technical specialists, work with a broker/facilitator to collate and scrutinise all of the data and evidence relating to environmental infrastructure and ecosystem services provision for their area of interest.

Once the evidence has been evaluated, the partnership then works to develop a series of conceptual models or 'rules' that can be used to define areas of the catchment most likely to play a critical role in the provision of the different ecosystem services, singly or in combination. These priority areas are locations where a programme of measures may realise the greatest enhancement in the provision of multiple ecosystem services.

Fundamentally this is a data visualisation and evidence exploration process that facilitates the development of a shared vision and language in a catchment group. The Westcountry Rivers Trust believes that this approach could be of great utility to other partnerships engaged in DEFRA's Catchment-Based Approach, which has been established in catchments across the UK to help effectively target efforts to meet standards set out under the EU's Water Framework Directive. The Trust has developed a manual to enable other organisations to simply and effectively adopt this Ecosystem Services approach in their catchments if required.

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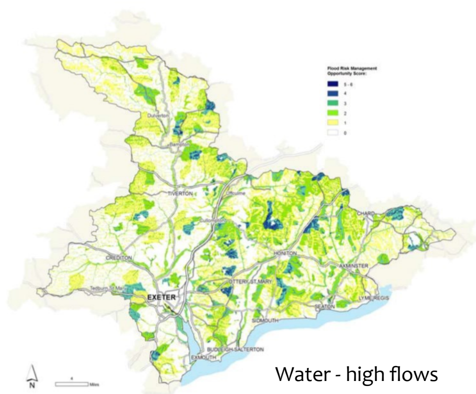
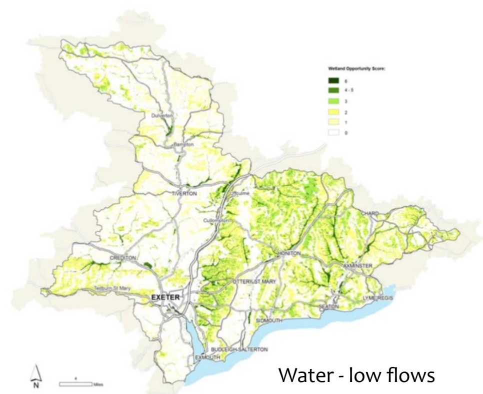
Multifunctional Ecosystem Services Opportunity Areas

These maps illustrate the final synthesis of the conceptual models / data exploration exercises where they have been combined to identify areas important for the provision of multiple ecosystem services. Locations where areas of high opportunity in the individual services coincide can be considered to be important targets for measures to enhance the provision of multiple ecosystem services.

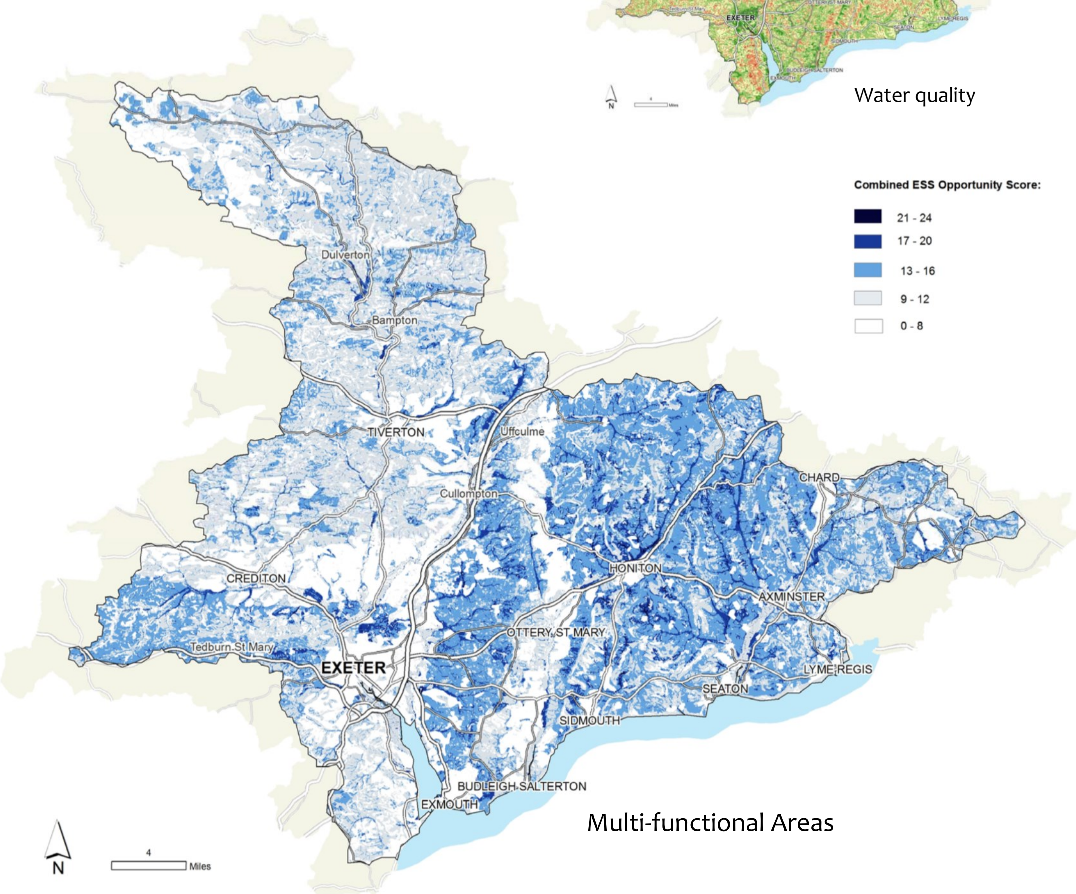
Water quality



Water - high flows

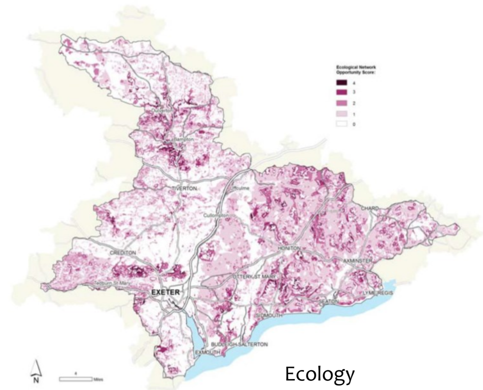


Water - low flows

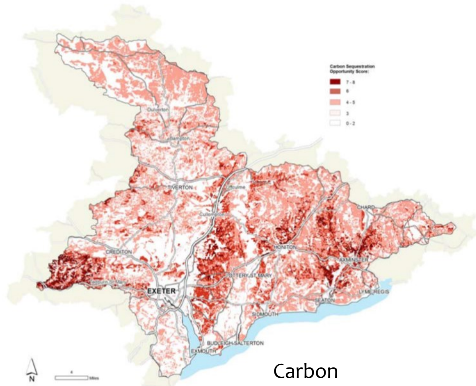


Multi-functional Areas

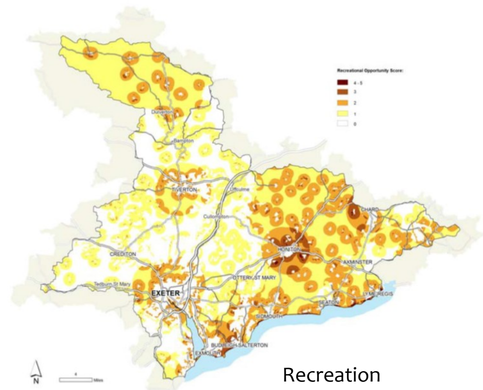
Map created from cumulative scores:
WATER QUALITY = 0-5pts
BASEFLOWS = 0-5pts
FLOOD RISK = 0-5pts
ECOLOGICAL NETWORKS = 0-5pts
CARBON SEQUESTRATION = 0-5pts
RECREATION = 0-5pts
MAX SCORE = 30pts



Ecology



Carbon



Recreation

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CATCHMENT RISK MAPPING, RIVER OUSE, SUSSEX

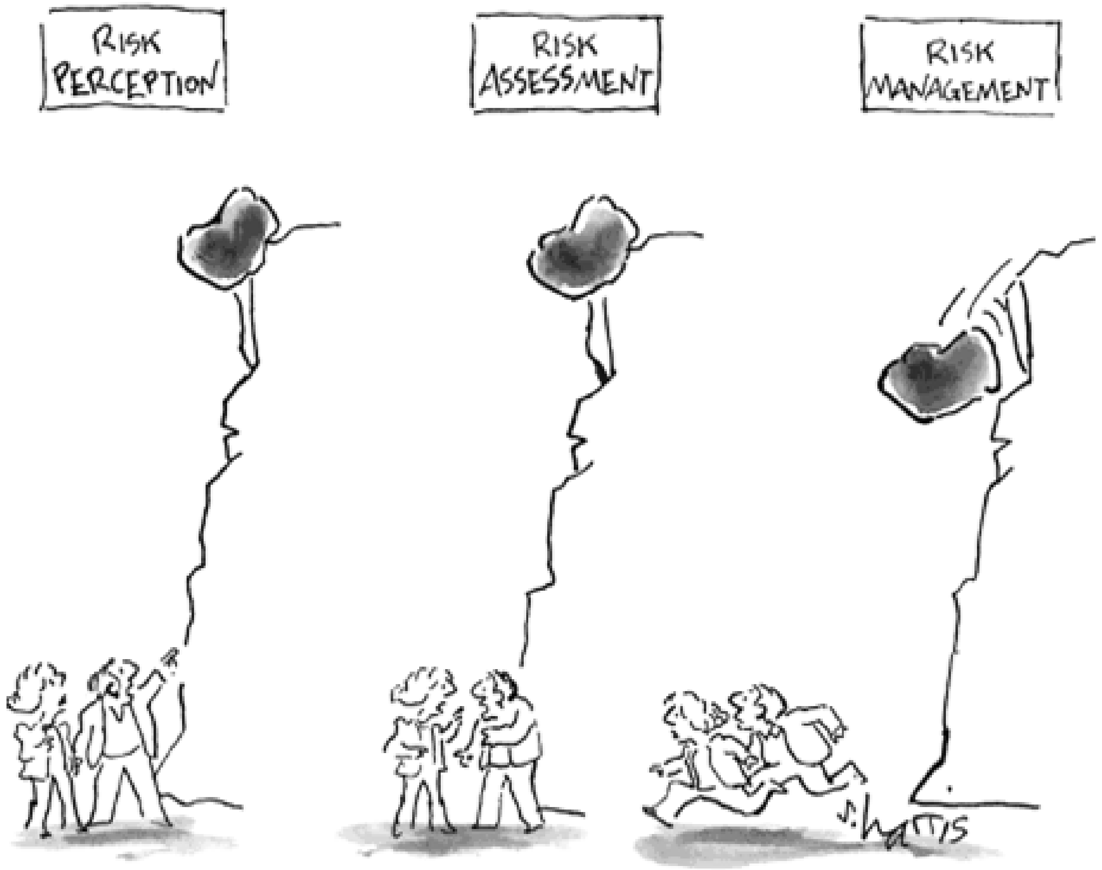
Sarah Purnell, University of Brighton

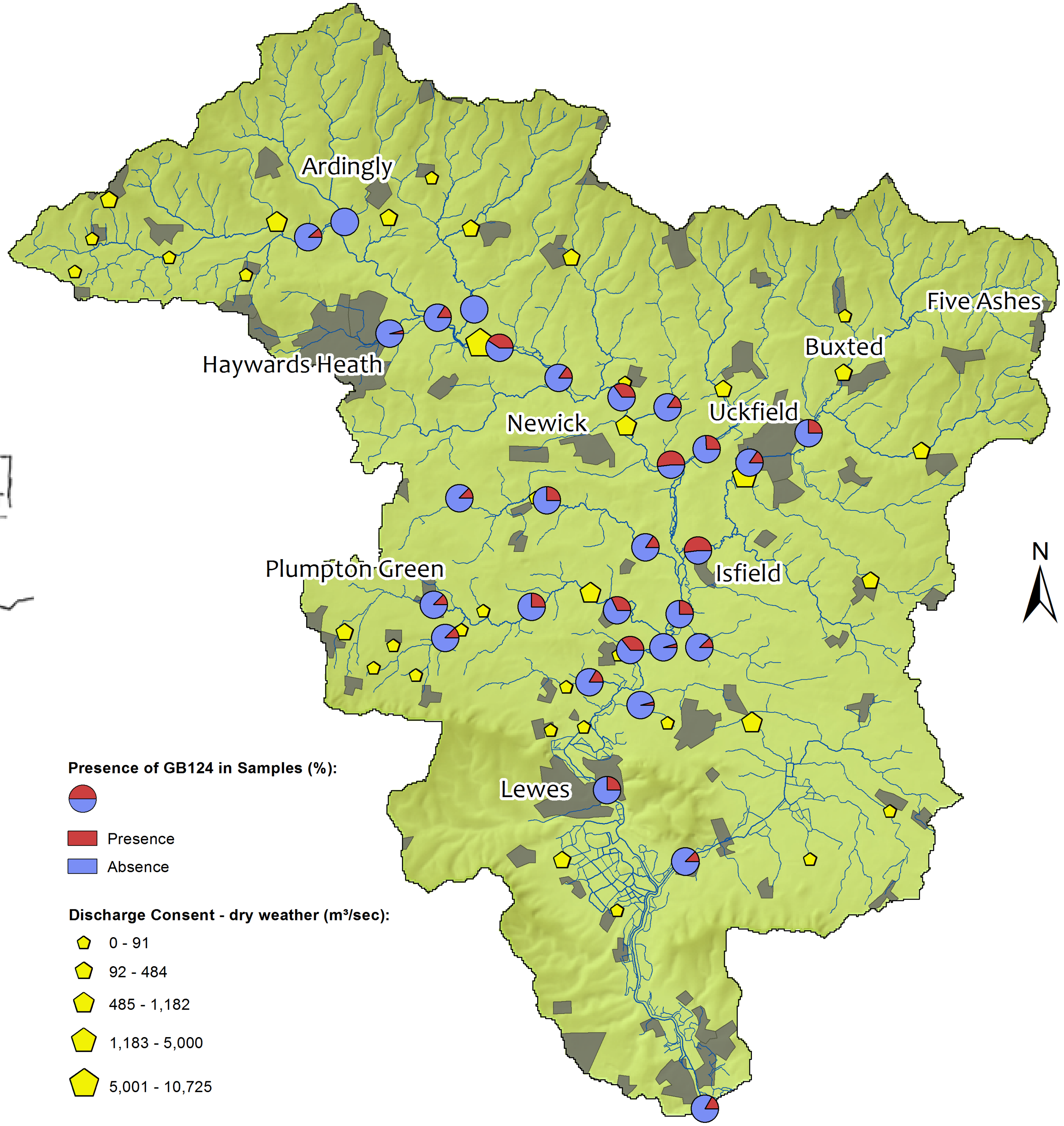
Catchment Risk Mapping

The AquaManche aquatic risk management toolbox (ARMT) brings together monitoring, microbial source tracking and modelling tools which may offer risk prediction and inform future management within river catchments.

The ARMT is designed to provide information to a wide range of stakeholders and will provide a web-based source of information for interested groups.

This catchment risk map for the River Ouse catchment in Sussex illustrates the results of microbial source tracking and the percentage of samples that tested positive for human faecal contamination. This is measured by testing for the human specific Bacteroides host strain (GB124) in samples taken from locations throughout the catchment.





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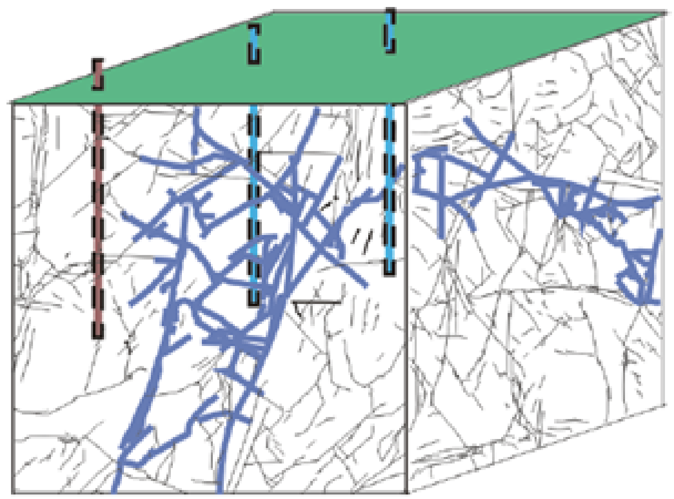
DISTRIBUTION OF CHLORIDE IN GROUNDWATER IN BRITTANY, FRANCE

Paulina Lopez, Universite de Rennes, France

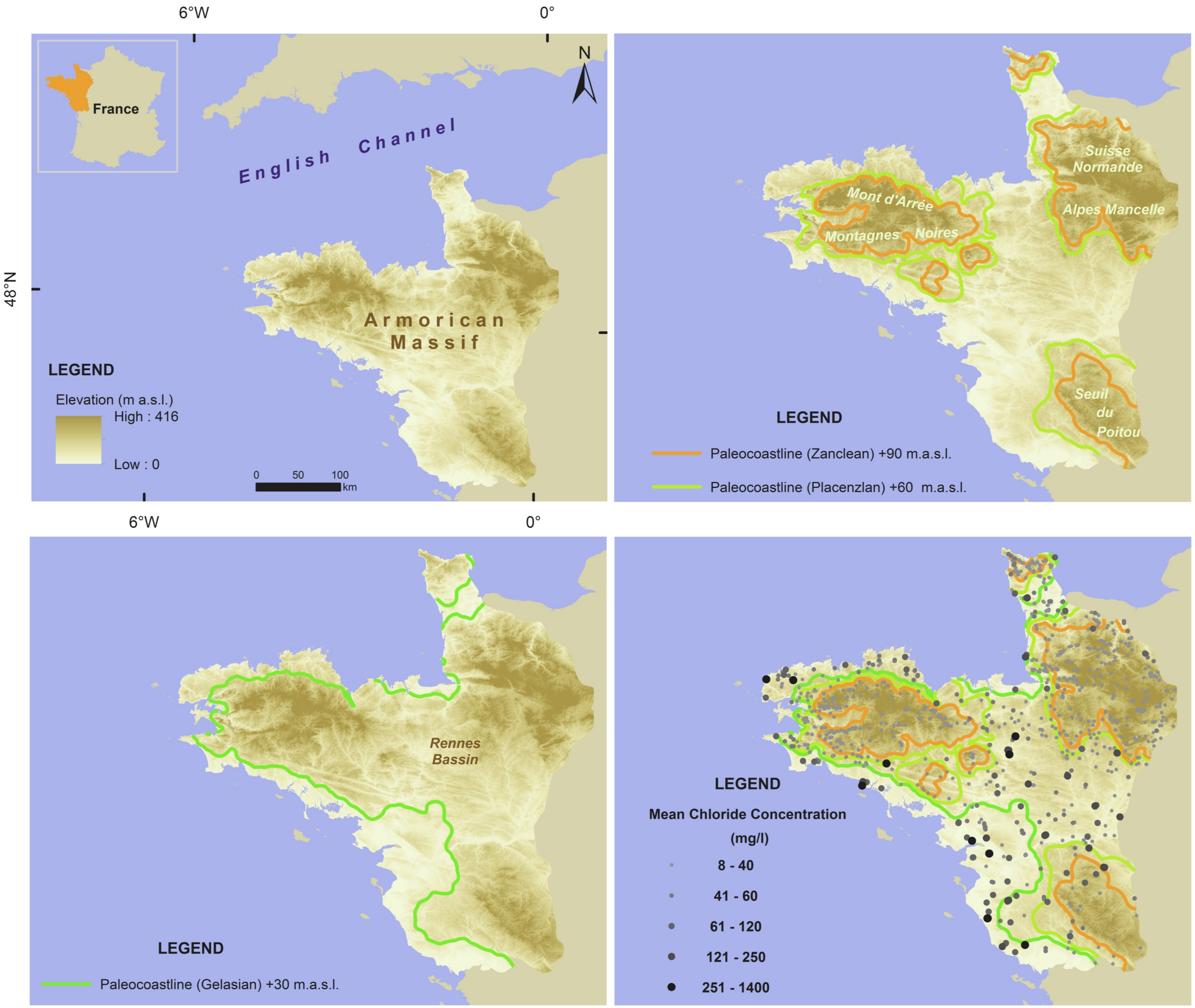
Distribution of Chloride in Groundwater

During the last 5 million of years, the geomorphology of Brittany Region has been completely modified, mainly as a result of marine transgressions. Over the Last Tertiary Period, in three opportunities the sea level increased of 90 m (6-4.6 My), 60 m (2.7My) and 30 m (2 -1.6 My) above the actual level on the coast of the Armorican Massif. The consequence of the described marine intrusions was the land submersion and the transformation (two times) of the region in an island or peninsula. For the first two transgressions, only higher relief remained emerged: Mont d'Arrée, Montagnes Noires, Suisse Normande, Alpes mancelle and Seuil du Poitou. Rennes basin was still emerging during the last marine transgression which rises to 30 meters high and penetrates not as far as the others inland.

The distribution of the actual concentration of chloride in groundwater (except from polluted sites) of the Armorican Massif is the witness of the Geological history of Brittany.The areas which have never been immerged during the last 5 My show chloride concentration less than 40mg/L meanwhile in submerged areas chloride concentration can exceed 1g/L and thus limits water abstraction for tap water.



3D representation of a fractured heterogeneous aquifer.



ENDOCRINE DISTRUPUPTION IN THE CHANNEL REGION

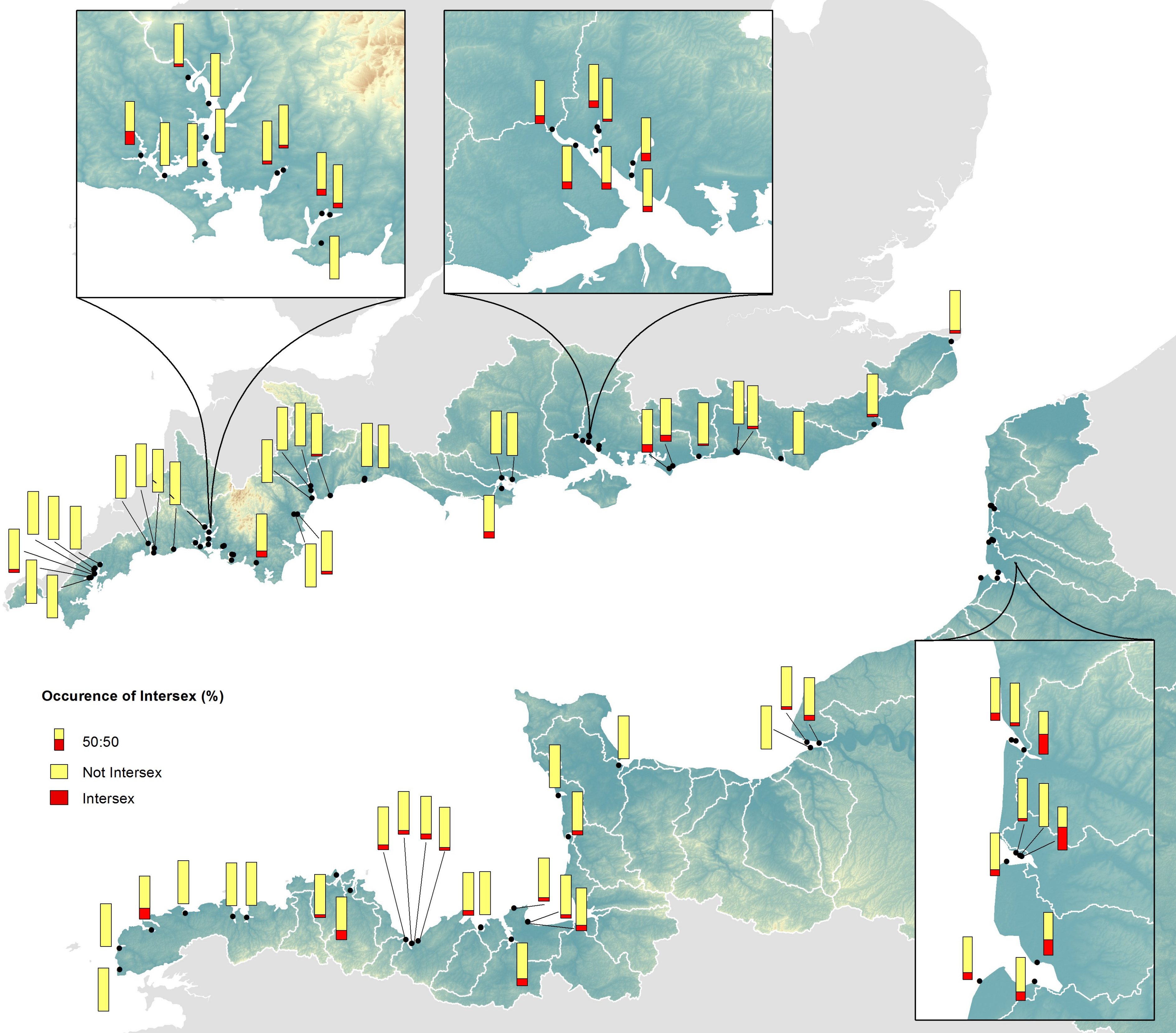
Nick Pope, Marine Biological Association, Plymouth

Endocrine Disruption in Clams

Endocrine Disruption (ED) is of growing concern. Feminisation of male fish in rivers occurs extensively and has been linked with environmental exposure to endocrine-disrupting compounds (EDC's) including oestrogens and oestrogen mimics. However, it is uncertain whether invertebrates, which comprise 95% of all animal species and are central to ecosystem function, are also susceptible. It is therefore important to develop practical tools to screen for ED effects in marine systems. Given previous ED problems in marine snails, the question of whether anthropogenic activities can influence the secuality and reproduction of shellfish populations is especially important within the Channel region.

Populations of the estuarine deposit-feeding bivalve, *Scrobicularia plana*, usually have equal numbers of male and female individuals but appear susceptible to some EDC's. Intersex, in the form of ovotestis (presence of eggs in the male gonad) occurs in some populations and is inducible in the laboratory by natural oestrogens such as 17D-oestradial and hormone mimics such as alkylphenol. The susceptibility of *S. plana* coupled with its extensive distribution and central role in ecosystem functioning makes it a valuable biomonitor for determining ED effects together with broader threats from other contaminants.

The field campaign incorporated sampling of clams, sediments and environmental parameters including grain size, organic matter, organotins and metals. To determine effects on sexuality of clams, several easy-to-use indices were developed: sex ration, frequency and severity of intersex and oocyte size. This map illustrates occurrence of intersex at sites on both sides of the Channel: 37 of 71 UK populations were affected (52%) and 26 of 37 French populations (70%), giving an overall total of 63 out of 108 (58%). Whilst intersex was mostly at a low level (10% or less of males affected) there are sites where frequency is well above background (50% of males affected) and the severity of intersex is elevated. At a small number of sites, population sex rations were significantly skewed from 1:1, most likely as a result of anthropogenic influence.



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