Trusting emergence: Some experiences of learning about integrated catchment science with the Environment Agency of England and Wales

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Abstract

The recent context of managing water in the European Union has changed in response to the imperatives of the Water Framework Directive (WFD). To meet WFD obligations in a climate change context, there is now an urgency to develop adaptive integrated water management strategies. The challenges arising as WFD implementation proceeds pose, in our view, a fundamental and largely unaddressed question: are current scientific practice and scientific explanations able to meet the demands of doing effective integrated, adaptive water management? This paper explores some answers to this question drawing on two years of co-researching with an emerging community of practice (CoP) responsible for Integrated Catchment Science (ICS) Strategy within the Environment Agency, the main environmental regulatory body for England and Wales. Rather than attempting to define and pre-determine the direction and outcomes of the work, our methodological approach has been rooted in trusting the systemic notion of emergence. In collaboration with the CoP, the authors undertook a series of co-researching workshops in 2006 and 2007 using systems thinking and practice to enable social learning about ICS. The research suggests that current scientific practices and explanations are struggling to address more integrated and adaptive ways of managing water. Two key insights emerge from this work: 1) integration of catchment sciences is possible only at the level of policy (or practice) objectives

rather than at the level of scientific disciplines and research findings; 2) the main requirement of the WFD (e.g. no deterioration in good ecological status) can be understood as an emergent property of a system (for managing water) rather than an individual 'thing' or 'state' that exists. From our perspective, this realisation is sufficiently profound to require a concomitant shift in the use of language away from a reliance on Integrated Catchment Management as a discrete 'catch-all' noun towards Integrated Catchment Managing. This better describes the sets of purposeful activities and interactions among multiple stakeholders operating in situations of complexity which enable or constrain the emergence of integrated and adaptive practices.

I Introduction

In recent years, the context of managing water in the European Union (EU) has changed in response to the imperatives of the WFD (CEC, 2000). To meet the obligations of the WFD, there is now an urgency to develop more holistic approaches. Terms such as ICM and integrated water resource management (IWRM) are now firmly part of the debate. More recently, in response to the expected imperatives of climate change and concerns about uncertainty, there is an increasing emphasis on *adaptive* IWRM strategies.

On many levels, these developments in approaches to water management are to be welcomed since they provide opportunities for drawing attention to the complex dynamics of water catchments. In the EU, the focus is on 'good ecological status' as one of the principal goals and measures of success enshrined in the WFD legislation. This is increasingly dominating the science agenda and is a key driver in efforts for more integrated approaches to managing Europe's water.

Implementing the WFD is not without difficulty as it poses many challenges, not least resolving what constitutes good ecological status (SLIM, 2004a; CEC, 2007). To date, debates amongst policy makers and scientists have been focused on determining reference conditions and uncertainties associated with the effectiveness of Programmes of Measures to deliver good ecological status. The challenges arising as WFD implementation proceeds pose, in our view, a fundamental and largely unaddressed question: are current scientific practices and the resultant scientific explanations able to meet the demands of doing effective integrated, adaptive water management as part of an on-going process of climate change adaptation?

This paper explores some answers to this question drawing on two years of co-researching with an emerging community of practice (CoP) (Wenger, 1998) responsible for Integrated Catchment Science (ICS) within the Environment Agency (EA), the main environmental regulatory body for England and Wales.

We begin by exploring how ICM has been interpreted in the literature and relate it to traditional approaches to 'science management' (Section II). Our conceptual and methodological basis for introducing systemic and social learning approaches to ICS, rooted in trusting to the systemic notion of emergence, is then described (Section III). A summary of the evolving practices of the EA-based ICS CoP (Section IV) precedes an account of the emergent learning of the CoP as it tries to overcome the lack of a common conceptual framing of ICS and ICM (Section V). We then outline some of the opportunities and difficulties of building support and capacity for the development and sustenance of CoPs through a process of 'trusting emergence' within the prevailing cultures of natural resource management organisations (Section VI). Our concluding comments draw out some of the key threads relating to 'trusting emergence' for adaptive managing in situations of complexity and uncertainty.

II ICM – imperatives and traditions

ICM is widely considered as the cornerstone of attempts to bring about more adaptive management practices for managing water resources. The case for ICM is set out in recent major initiatives concerned with managing water resources more sustainably at global (World Water Forum, 2000, 2003), European (CEC, 2000) and national levels (see for example, DEFRA, 2002 in the UK). It has become the by-word to signify more enlightened approaches to managing rivers, catchments and basins.

Given its popularity, it is perhaps surprising that few commentators have devoted time to exploring the meanings associated with the constituent wording of ICM. 'Integrated' suggests that the links between different aspects of catchment functioning (such as rainfall, groundwater and runoff) are recognised, acknowledged and understood. The term 'catchment' can be variously interpreted, but even hydrological boundaries between surface and groundwaters are rarely clearly determined. 'Management' suggests that the knowledge and skills required for making sense of the full range of links between catchment components are known and available and are used in some form of accepted praxis (theory informed practice). The emphasis on management also suggests that the whole range of components relating to catchment functioning can be acted upon purposefully or at least orchestrated collectively to create a set of desirable outcomes.

The extent to which any of these imperatives, especially integration (see Dovers, 2005), are understood and used to critically inform policy and practice is debatable. In our view, the ubiquitous use of 'ICM' as a 'catch-all' policy imperative conceals some key conceptual and methodological underpinnings which have important implications for sense-making and practices associated with ICM. Thus, some interpret ICM from an ecological perspective (Edwards and Dennis, 2000; Wheater and Peach, 2004), others from hydro-geomorphological (Conacher, 2002) and/or socio-economic perspectives (Cameron, 1997), to name just a few of the many possible domains of knowledge and epistemology used to 'construct' ICM.

Equally, the 'traditions' inherent in different interpretations of ICM are not limited to particular science-based disciplines. Some authors note that for integrated catchment management to occur:

1. 'the legislation and policies that aim to achieve ICM must be combined with existing and future legislation and policies;
2. the science that is required to support ICM and provide the evidence base also needs to be integrated across natural and social science disciplines;
3. the management of catchments should be based on integrating land management with a wide range of stakeholder requirements, policies and scientific evidence base' (Macleod et al, 2007: 591; see also Dovers, op cit).

Following Margerum (1997), our assessment of ICM recognizes that the science of ICM is situated within and shaped by specific historical, cultural and policy contexts.

For example, in Australia soil erosion was the starting point for new ways of thinking about managing catchments:

> 'During the early to mid-1980s, the terms integrated catchment management and total catchment management began to appear more frequently in policy discussions by soil conservation professionals. ICM was seen as addressing the problem of fragmented approaches to land resource management' (Reeve et al. 2002:13).

In other contexts, ICM has emerged from concerns with flooding and soil erosion in pre and post war USA (see Margerum, op cit); and as part of an emerging national political agenda for managing water on a catchment basis in South Africa (see for example Ballweber, 2006; Lotz-Sisitka & Burt, 2006). In the EU, ICM is key to the WFD with its emphasis on integrated catchment management for achieving good ecological status (CEC, 2000).

ICM – the English and Welsh context

In the UK, catchment based management has been a feature of water policy for over 30 years. The UK government's high level strategy for water in England and Wales, *Directing the Flow* (currently under review) offers the view that the WFD-led imperative for integration will help avoid duplication of effort and contradictions between objectives and priorities of different plans; and lead to greater transparency for stakeholders, whilst ensuring that individual statutory obligations can still be met (DEFRA, 2002). Among many key challenges, will be the extent to which attempts at integration can deal with new hazards and new forms of knowledge:

> 'It is important that sufficient weight is put on scientific evidence in formulating water policies, both at national and EU level. This means, however, interpreting "science" on a wide basis, including allowing for systematic evaluation of social and economic evidence, as well as evidence from physical science' (DEFRA, 2002:57).

This broadening of the remit of science is reinforced in the River Basin Planning Strategy for England and Wales (EA, 2006a) which places great emphasis on the importance of integration of policies, practices and knowledge for integrated river basin and catchment management. As the designated competent authority, and to meet the challenge of a broader interpretation of science, the EA's Corporate Strategy for 2002-2007, *Making It Happen* (EA, 2002) highlights nine themes where it will focus its work. Three of these are particularly relevant to a more integrated approach to the management of the water and land environments at catchment scale: improved and protected waters; restored, protected land with healthier soils; and an enhanced environment for wildlife.

Below the level of the Corporate Strategy, the EA's Science Strategy, *Solving Environmental Problems Using Science* (EA, 2004) sets out the overall objectives and the organisational framework for delivery of the Corporate Strategy. It establishes five 'Thematic Programmes' covering: climate change impacts; environment and human health; flood risk science; sustainable use of resources; and integrated catchment science (ICS). The rest of this paper focuses on the ICS Thematic Programme and in particular, co-researching with the ICS Programme staff to develop a more integrated ICS Strategy for the EA and its stakeholders.

Co-researching for integrated catchment science

The vision, objectives and a high level structure for the EA's ICS Programme for the period 2006-2011 and beyond were set out in early drafts of the ICS Strategy. The aim of the Programme is to deliver high quality science outputs, which integrate understanding of environmental processes between air, land and water at the scale of river basin management and allows the development of evidence based policy and sound operational decision-making. Critically, the Programme is to be achieved by developing an integrated catchment modelling framework and associated decision-support tools using a social learning approach to build the capacities needed to tackle the key challenges of integrated river basin management at the catchment scale (EA, 2006b).

Situating the science to be done within a social learning approach was a new initiative on the part of the EA. According to anecdotal reports from EA staff, the individual Programmes within the Science Strategy would normally have been developed and managed as a set of largely separate projects. Groups of projects would be compiled on the basis of scientific interest and expertise to undertake or oversee a project, rather than a more systemic assessment of the Programme objectives as a whole and the potential for more integrated science. Hence most Programmes could be fairly described as collections of individual projects loosely grouped together under individual themes with integration being desirable, but rarely designed into the development of the Programmes.

The ICS group's desire for a different approach and the emphasis on social learning can be attributed to several interrelating factors such as the integrating imperative within the WFD; budget cuts within EA science; and a new EA policy to engage in social learning approaches for river basin planning (see EA, 2006a; Collins et al, 2005).

Of equal importance, however, was the growing recognition by the ICS manager and staff of the complexities and uncertainties associated with understanding catchment functioning; the difficulty of 'defining' ICS with any satisfaction and the difficulties of 'doing' ICS in relation to the WFD. The changing context led the ICS manager to note that 'doing science just because we are interested in it is no longer possible or acceptable' (Anon, pers comm., 2006). Awareness of previously helpful interventions in other areas of EA policy relating to river basin planning (see Collins et al, 2005), led to an invitation to the authors from the ICS staff to assist the group in the development of its ICS Strategy using systemic, social learning approaches based on trusting to emergence.

III Social learning and emergence

Our conceptual and methodological approach to working with the EA has been shaped by our earlier experiences (see Collins et al, 2005) in using systems thinking and practice (Checkland, 1981; Checkland and Scholes, 1999). Our theoretical approach to social learning is discussed in full elsewhere (see Blackmore et al, 2007; Collins et al, 2007).

There are many authors attempting to develop social learning theories (see for example Finger and Verlaan, 1995; Daniels and Walker, 1996; Woodhill & Röling, 1998; Pahl-Wostl et al, 2007). Blackmore (2007) notes that social learning theory is part of the tradition of 'adaptive management' (Holling, 1978) and is also reflected in Wenger's social theory of learning in relation to communities of practice (Wenger, 1998) defined as 'groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis' (Wenger et al, 2002:4-5).

Part of the requirement for adaptive or social learning approaches to managing water catchments is the growing realisation that catchments are situations more usefully experienced as being characterised by complexity, uncertainty, interdependency, having multiple stakeholding and often ongoing controversy (SLIM, 2004b; Ison et al, 2007a). In dealing with these kinds of situations, we suggest that social learning is significantly different in its epistemological assumptions from existing policy mechanisms. In our work, we interpret social learning as one or more of the following:

1. the **convergence** of goals (more usefully expressed as agreement about purpose), criteria and knowledge leading to more accurate mutual expectations and the building of relational capital;
2. the process of **co-creation** of knowledge, which provides insight into the causes of, and the means required to transform, a situation. Social learning is thus an integral part of the make-up of concerted action;
3. the **change of behaviours and actions** resulting from understanding something through action ('knowing') and leading to concerted action. Social learning is thus an emergent property of the process to transform a situation (SLIM, 2004c).

Rather than attempting to define and pre-determine the direction and outcomes of the work with the ICS CoP, our methodological approach has been rooted in trusting the systemic notion of emergence, not in any simplistic sense but in pursuing the purposeful design of learning systems which are not deterministic (Ison et al, 2007b), but create the circumstances for emergence.

Emergence is a key systems concept. A system can be described as an entity which maintains its existence through the interaction of its constituent parts or elements. The pattern of interactions or connections between the constituent elements gives rise to larger wholes. While there is some debate on definitions and interpretation, (for example see Goldsmith, 1999; Corning, 2002) we associate emergence with: new patterns arising from a set of interrelationships between the constituent and diverse elements of a system, these patterns or characteristics not being reducible to individual elements. From this perspective, rather than being a 'thing' that can be pre-defined and applied (often desired within the context of best practice), ICM can be understood as an emergent property of a set of practices for managing catchments which occur in particular contexts.

Following Bawden's (2004) approach to sustainability, managing for the emergence of ICM challenges our conceptual understanding of catchments, how they are managed and the policies and practices which become instituted over time. It also challenges the kinds of interventions employed to bring about more integrated approaches, such that the design of interventions must be rooted in trusting to emergence. It follows that a commitment to social learning and emergence within a CoP is facilitated by a parallel commitment to co-researching (see Reason and Bradbury, 2001). In our work, this commitment was based on earlier experiences with the EA and formalised in an internal written memorandum of agreement on how the co-researching relationship should be conducted between the researchers and the EA.

IV Co-researching in practice

Drawing on systems thinking and practice, social learning, notions of emergence and community of practice, our engagement with the EA in 2006 and the first half of 2007 was focused around designing and facilitating a series of 12 workshops with the ICS staff. Other practices, such as interim development and review meetings; telephone and email conversations with ICS managers; and presentations to senior EA management were also used to facilitate movement of the group towards a situation where they might be described as a CoP – both by themselves and by others.

While the specific aims of the workshops varied according to need, the overall aims of the co-researching activity were for the EA staff involved and the authors:

1. to develop a better understanding of ICS in the context of the ICS Programme;
2. to develop a common understanding among participants of the meaning and the purpose of the ICS Strategy and the practices associated with enabling ICM;
3. to experience ways of working as a CoP to provide mutual support for those involved in the ICS theme.

It is important to note that specific references to social learning and systems thinking and practice were not included in the aims, although the terms and their meanings were used explicitly throughout the various events during the co-research period. For reasons of space, the issue of 'silent' practice is not addressed in this paper.

The ICS staff numbered about 25, and on average 18-20 participants attended the main workshops. Each workshop was facilitated by the first author or the senior manager of the ICS group with support from his deputy manager. Significant work and design contributions were made by many in the ICS group during the process. An informal 'review group', comprising the ICS manager, deputy manager, several senior scientists and the facilitator/researcher met at various stages during the process to assess progress and review the work of the CoP in relation to organisational issues. Table 1 summarises the main activities over the period, outlines the design considerations and reports on the outcomes at each stage which were then used to inform the design and purpose of the subsequent event(s).

There is a danger in reading Table 1 that the impression is gained of a pre-determined, largely coherent pre-planned trajectory and associated timetable. In reality, the work with the EA evolved – the situation was often very uncertain with regard to the context, design, outcomes and the nature of discussions at any stage. Each workshop was designed on the experiences and learning emerging from the previous event(s) and were largely in response to the group's own sense of what was needed to progress the development of the ICS Strategy.

Although an often difficult and uncertain process, by July 2007, the ICS Strategy comprised five core workpackages (WPs) and two supporting WPs. Each of the five core WPs, some with sub-WPs, detailed projects around the broad themes of: chemicals; ecology; diffuse pollution; sediments; mining; and marine environments. Efforts to integrate the WPs and associated projects were focussed on the development and refinement of activity models for achieving particular policy objectives.

Table 1 – Summary of co-researching activities

Date	Event / Practice	Design Considerations	Outcomes (including shaping future events)
Mar 06	ICS Workshop 1 (2 days)	Exploring context: traditions of understanding; introducing notions of complexity; systems thinking, diagramming, social learning and co-researching. Identifying purposeful activity; trusting to emergence; meeting participants' and organisational needs	Awareness of context; agreements on overall purpose; commitment to co-researching and social learning; awareness of conceptual models within ICS; recognition of organisational constraints
May	ICS Planning Workshop	Exploring organisational constraints; being aware of language	Commitment to learning process
June	ICS Workshop 2	Identifying boundaries; identifying purpose; organising Workpackage (WP) and consolidate narratives	Developing systemic narratives for each WP
July	ICS Workshop 3	Identifying purpose, outcomes and measures of success for WP projects	Developing systemic narratives for ICS projects; simplifying language
August	ICS Review	Reviewing learning to date	Agreement to continue with the process and simplify
Sept	ICS Workshops 4 & 5	Integrating WPs at project level: dealing with failure; rethinking integration	Realisation that higher system level required: integration at policy rather than science level; realisation that understanding of policy could be improved; request for support of ICS Board to engage with Policy managers.
Oct	ICS Review	Review of learning about ICS	Implications of learning for project selection and financing
Nov	ICS Board Mtg ICS Board and	Communicating the process and learning to date to others; exploring new contexts and	Agreement for Policy engagement Support for process to continue

	Policy Mtg	ways of collaborating	
Jan 07	Research review of ICS	Review of research questions and framing	Validation of research questions
Mar 07	ICS Board Mtgs 1 & 2	Involving new people in the process; communicating findings; agreeing next steps	Further endorsement for process and engaging policy staff in specific WP areas; further engagement with Policy
Apr 07	ICS + Policy Workshop 1	Agreeing purpose; identifying interdependencies between science and policy	Agreement on key policies and science for soils and sediments
June 07	ICS + Policy Workshop 2	Agreeing purpose; identifying interdependencies between science and policy	Agreement on key policies and science for industrial pollution

While there were many aspects of the process that we could report on, the emergent learning about the nature of ICS through systemic diagramming techniques represents the most significant development in the thinking of the CoP about its own work and its learning about ICS. From this, three closely related insights emerged: 1) ICS as an organising notion is meaningless without reference to an agreed purpose in context; 2) purpose can be determined by reference to policy; and 3) integration of catchment sciences is possible and more meaningful at the level of policy objectives rather than at the level of scientific disciplines and research findings. The emergent learning relating to these elements are discussed next.

V Emergent learning about ICS

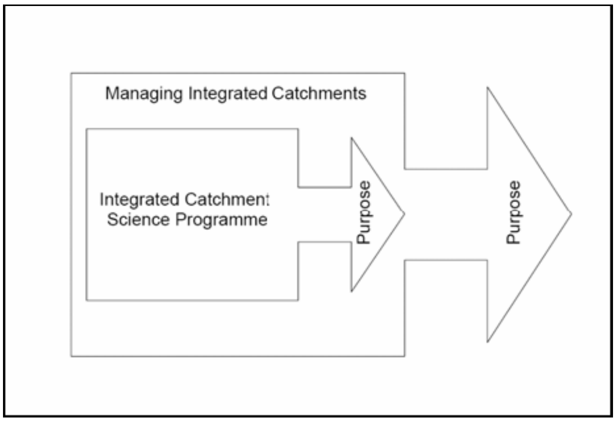
ICS – Agreeing purpose in context

As noted above, at the beginning of our co-researching with the EA, it was clear from pre-existing early drafts of the ICS Strategy that there were a number of policy and resource issues which shaped the thinking of the ICS group. Even so, up to the point of the first workshop with the authors, the policy imperatives were acknowledged, but not engaged with in great detail or the implications addressed directly. In this sense, ICS was being understood as a 'given': a rational and appropriate response to a generic body of policy and organisational requirements as understood by the ICS team and others within the EA. This position, almost by default, led to a general conceptualisation of ICS and ICM each as a single entity or 'thing' which could be identified, made coherent in a strategy document and, in some fashion, applied to address the policy issues in any situation. This perspective, although appearing to be sensitive to context in responding to a particular policy and practice environment, actually meant that ICS was decontextualised because it was initially viewed and understood in the abstract.

The precariousness of this position was highlighted in the first workshop in March 2006 when an explicit discussion about purpose revealed that members of the ICS group had different views on whether the purpose of the ICS Programme lay wholly within the boundary of managing integrated catchments or partially outside. Over the course of the two days of this first workshop, it was eventually agreed that the purpose of the ICS

Programme was wholly aligned with managing integrated catchments (see Figure 1).

Fig. 1 Integrated catchment science for integrated catchment managing



Even with this boundary agreement, discussion around the specific purpose of the ICS Programme in the context of integrated catchment management revealed many further different understandings among those present. Suggested purposes of the ICS Programme included:

1. provide the evidence base to support decision-making under the WFD;
2. help the EA improve the quality of the environment; understand and prioritise environmental risks;
3. increase co-operation and co-ordination within science;
4. understand the interactions, processes and change for technical and political solutions;
5. drive integration and organisational change – as much culture as science.

Eventually, the diversity of views were summarised using the soft systems expression of (Checkland and Poulter 2006): 'A system …to do P (what) by Q (how) because of R (why).

This systemic device was used in order to focus attention on determining the 'what', the 'how' and the 'outcomes' of the ICS Programme. The two main strands of thought within the group are reflected in the two system descriptions that were generated (Table 2).

Table 2 The ICS Programme seen as 'a system to…. '

… provide the evidence base to support decision-making by promoting understanding, developing tools and increasing stakeholder interactions in order to improve the quality of the environment.	…do integrated science that aids understanding of environmental risks and management options which achieves sustainable environmental goals within hydrological catchments.

These two statements of purpose reveal the differences in thinking even within the same group charged with the same task. Further discussion in the workshop eventually resolved these differences to arrive at a working statement of the purpose of the ICS Programme as a system to…*develop the appropriate scientific understanding by working in multi-disciplinary teams which enable us (the EA and others) to manage the environment at the river catchment scale*.

For the purposes of this paper, the precise details are not, of themselves important since the definition is dependent on the context of those involved to define its meaningfulness. However, the process of exploring purpose and refining the statements reveals the sometimes overt, sometimes subtle differences in the thinking about the purpose of the ICS programme, the nature of ICS and the context in which ICS is to be developed and applied. The explicit use of a systems methodology based on a methodological commitment to emergence enabled these diverse views to be surfaced and the emergence of some agreement within the ICS group about purpose in (their) context.

The subsequent workshops during the rest of 2006 then focused on developing each of the WPs (and sub-WPs) by outlining the projects within the WP and detailing, inter alia, the aims of the projects; outcomes; and criteria for success.

Purpose aligning from policy

Having developed drafts of individual WPs during the first half of 2006, in the July and especially the September 2006 workshops (see Table 1) the participants struggled to integrate the different WPs and their constituent projects with each other, particularly in relation to outcomes of the projects. For example, trying to make sense of the science and outcomes associated with a project on 'mine effluent pathways' in relation to a project on air pollution revealed that there were in many cases no direct links between different parts of the ICS workpackages and projects which could provide the locus or 'sites' for integration. How then to integrate?

Despite using several methodologies to attempt to link outcomes of projects with each other, these failed to lead to any sense of integration. It became clear that the WPs were often at different levels to each other (e.g. information; models development; pollution prevention) and the constituent projects were also specific to an individual WP or sub-WP. In other words, each WP, although having considerable internal 'vertical' coherence (an explicit purpose aligned with outcomes, and measures of success etc), did not mean that horizontal coherence could be assumed between projects in different WPs despite having agreed the overall purpose of the ICS Programme. Thus integration between some projects was not meaningful.

At the same time, a realisation emerged among several in the group that more generic or higher level outcomes needed to be developed which could be inclusive across several WPs. (In systemic practice terms this involves moving up a level of abstraction, or changing the boundary to the system of interest).

This realisation led to a suggestion by an individual EA staff member that progress on ICS could be made by adopting an explicit strategy of developing the science in relation to policy objectives. On the surface, this may sound a naïve realisation and something that should be self-evident. However, the implications of this perspective are profound in that it demands conceptualising a new, much closer, interdependent relationship between science and policy and by scientists and policy-makers. It prompted considerable debate in several subsequent workshops among the ICS group and with senior Science managers about the drivers, independence and time-scales of science in relation to policy-making processes. Should science drive or respond to policy? What other ways of conceptualising the science – policy relationship might be helpful?

It would be unrealistic to suggest that such discussions were resolved in their entirety in the workshops. However, that the workshops provided the space for such questions to emerge led to the request by the ICS team in September 2006, and subsequently supported by the ICS Board overseeing the development of the ICS Programme, to convene a series of meetings with EA Policy Managers to learn more about the policy perspectives on ICS and ICM. The first of these 'policy workshops' took place in November 2006, followed by more focused policy discussions in the first half of 2007.

Given the importance of policy as the 'mechanism' for integration, the aim of these workshops was to promote a high level of understanding between the ICS WP authors and their counterparts in policy sections of the

EA in order to integrate ICS through policy objectives. The emergent learning is discussed next.

Integrating science through policy objectives

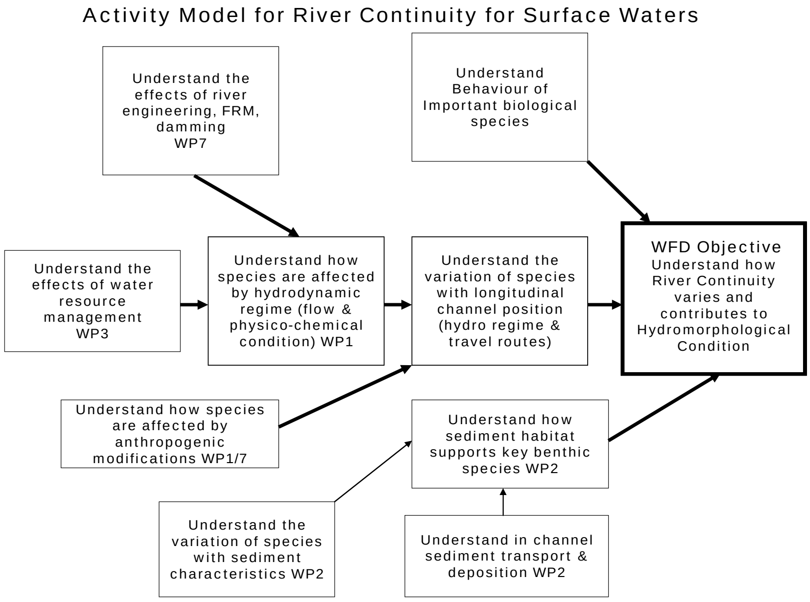
Just as integrating science proved complex, determining a set of policy objectives for integrating the science proved to be no easy task. In many respects EA staff responsible for policy were in a similar position to the EA scientists: many extant policies, but no ready mechanisms for integrating them. A process of reviewing the main international, national and organizational policy drivers for the EA revealed a myriad of objectives with many discontinuities, scales, areas of overlap and possible conflicting elements, all important, but each with little sense of relative priority.

In this light, in November 2006, the pragmatic decision was taken by the ICS group to adopt the 14 or so key policy objectives of the WFD as the most 'integrated' set of objectives currently extant and relevant to catchment management. An analysis undertaken by one member of the group suggested that meeting the objectives of the WFD would, by default, enable the work of the ICS team to contribute to obligations in other policy areas, such as flood control; habitat protection and pollution.

Having identified a set of policy objectives, a core team in the ICS group was asked to develop these further and identify the key activities required to meet them. Drawing upon soft system methodology, the result of several months' largely independent work by the core team was a suite of draft activity models setting out the key science activities required to meet each of the 14 key policy objectives in the WFD, thereby enabling integration between work packages in the ICS programme.

During the latter parts of 2006 and early part of 2007, the models were presented to the main group for further refinement. For each activity model, the specific projects within any WP could be assigned to any one activity. Several projects could be required, for example, to 'develop understanding of groundwater modelling' – in itself one activity among several required to achieve the WFD objective of preventing deterioration in groundwater-dependent terrestrial ecosystems. In this way, a visual 'map' was developed of the projects being proposed within the ICS Programme and how they contributed to the policy objectives in the WFD. A typical activity model is shown in Figure 2.

Figure 2 An example activity model for understanding how river continuity affects hydromorphological conditions relating to ecological status of surface water.



Although not strictly adhering to systems diagramming protocols, Figure 2 shows the main policy objective on the right hand side and a series of activities required to deliver the objective from the viewpoint of the ICS Programme (other programmes might contribute to these or other activities). Several WPs are identified for the activities (more detailed activity models permit cross referencing to individual projects). In this example, we can see that projects within WPs 1, 2, 3, and 7 contribute to understanding (the ICS group's shorthand for 'understanding, modelling and predicting') how river continuity varies and contributes to hydromorphological condition – a factor in determining the ecological status of surface waters.

Simply developing the activity model enables learning because it promotes inquiry and thinking about the key activities required to 'achieve' the policy objective. This requires clarity of understanding and rigour in thinking and, in a group setting, a commitment to engage in a social learning process. Once drafted, the activity model could be used in several ways: to show where there was a cluster of projects and thus possible opportunities for integration and efficiency; to show where current objectives were not being served by any or a small number of projects; to identify interdependent sequencing between projects to deliver policy objectives, and if required other potential suppliers of projects. As the pattern of emerging relationships between projects, WPs and policy objectives were revealed in the activity models, they became learning devices to promote further inquiry into the work of the ICS Programme and opportunities for integration. The activity models also became powerful communication devices for engaging EA staff in other Science Programmes.

While the development of the activity models as learning devices for ICS were undoubted benefits of trusting to emergence, the constraints posed on praxis of this type by the political realities of organisational cultures should not be underestimated.

VI Institutional and organisational constraints to systemic praxis

The approach outlined here and the theoretical and methodological commitment to trusting to emergence runs counter to the experiences of most management processes and is not without problems within organisational settings. Like many executive agencies, the EA's overall strategy is determined by reference to central government policy and statutory responsibilities which often require close adherence to pre-determined management and legislative protocols. This, along with a culture of project management predicated upon systematic approaches such as PRINCE2, tends to limit the scope for experimentation and a more critical perspective to project management where emergence might be fostered (see for example Hodgson and Cicmil, 2006) and understood as part of project design (Nocker, 2006).

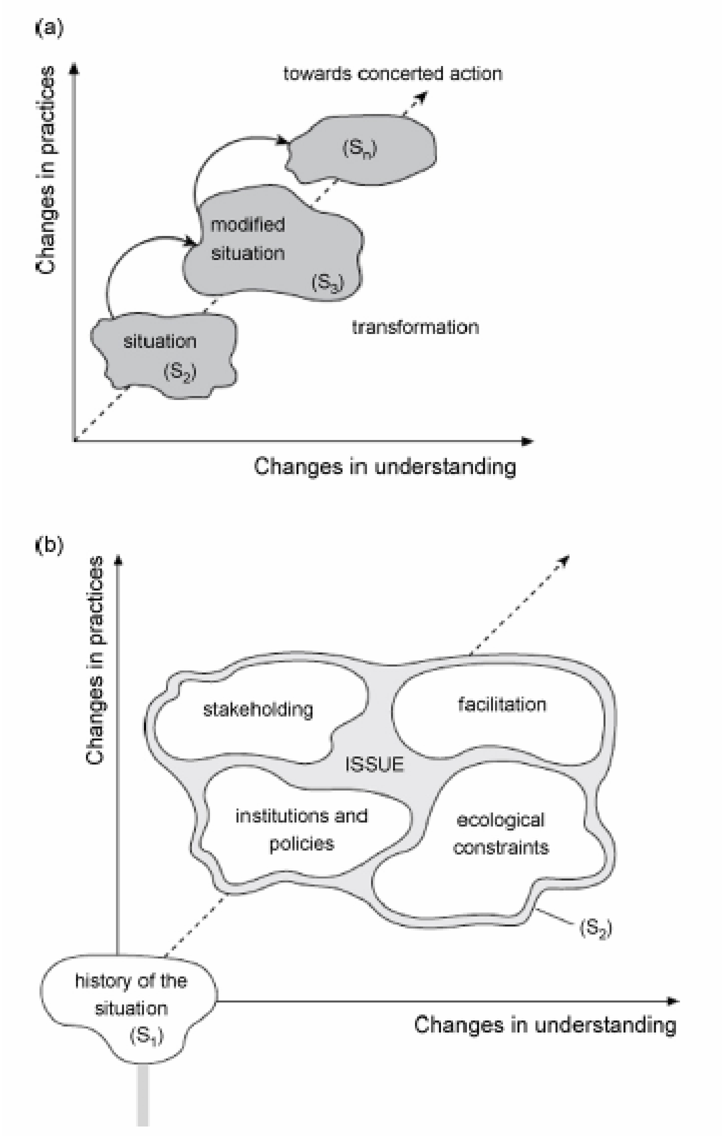
Our earlier experiences of using systems approaches with the EA (see Collins et al, 2005) were echoed in many instances during the process, with particular concerns around shifts in organisational goals, resourcing and personnel.

It is perhaps the loss of key relationships among individuals that has generated the greatest potential to undermine the resilience of the approach described in this paper in response to changes in the environment. Elsewhere we describe this as the breakdown of relational capital, the form of capital which subsumes all the others – natural, social, artificial and human (SLIM, 2004d; 2004e). Changes in the senior management of the ICS Programme and personnel responsibilities in the Science Programme during the first part of 2007 has led to considerable uncertainty about the direction and longevity of the embryonic CoP – a situation which remains to the present. The future of the CoP will largely depend on the willingness of new managers to endorse the experiences of those involved to date and, critically, retain the space for emergence. This is easier said than done and will require effort on the part of the CoP to bring about a situation where new managers are able to engage in experiential learning with the CoP such that they come to value trusting in emergence.

The opportunities presented by CoPs for organisations are significant and, increasingly, self evident as the complexities and uncertainties of natural resource management situations become more and more apparent. In our experiences with the EA, the CoP has generated a new perspective on ICS and ICM through engaging in a learning approach and trusting to emergence. This has led to a new way of thinking about the situation and the tasks at hand, even if the continuity of the CoP remains in some doubt. The research reported here can be understood through the lens of the SLIM heuristic (Figure 3; SLIM, 2004c; Steyaert and Jiggins, 2007). Through the research process the participants understandings and practices have changed aided by facilitation (through an individual who took a facilitative role as well as through the generation of activity models, which through their construction became epistemic devices facilitating changes in understanding), an increased stakeholding in their 'joint project' and changes to the epistemological commitments held by those involved. The decision to adopt a social learning approach from the start was a break with the history – with 'the EA way of doing things' - and thus served to create a different set of initial starting conditions for the process. However, as with earlier work the SLIM 'variable' most constraining to working in these new ways is that of 'institutional and organisational' constraints.

We thus caution against efforts to engineer and hard wire processes for CoPs since to do this would be traditional project management by another name. The essential quality at the heart of CoPs is trusting emergence and this needs organizational space which is flexible and expansive rather than rigid and closing.

Figure 3 Heuristic for exploring the dynamic change, understood as change in practice with changes in understanding in complex uncertain natural resource managing situations (S), such as integrated catchment management (S1-3, situation one, two or three etc. (Source: SLIM 2004c and see also Steyaert and Jiggins, 2007 for further explanation.)



VII Concluding comments

This paper set out to explore whether current scientific practices and the resultant scientific explanations are able to meet the demands of doing effective integrated, adaptive water management, using some learning arising from co-research work with the EA in England and Wales.

It is clear from our engagement with the EA that current scientific practices and explanations are struggling to address more integrated and adaptive ways of managing water. The major contribution of the co-research work reported here is that a social learning approach based on systemic ideas of emergence has helped the ICS group deal with and make sense of a situation they experienced as highly complex and progress their understanding of the meaning of ICS. Within a conducive organisational and management setting this clarity of purpose has the potential to significantly enhance effectiveness and efficiency. However, as in earlier research, we have found a number of factors associated with the organisational life of large agencies all too often undermine the building and sustenance of relational capital.

Despite this, a way forward for making sense of ICM is offered by the key advance made by the ICS team. They have begun to understand the main requirements of, for example, the WFD (e.g. no deterioration in good ecological status) as an emergent property of a system rather than an individual 'thing' that exists. Conceptualising ICS and ICM as an emergent property of a set of activities or elements when combined has opened up questions about science and scientific practice. In our experience, the explicit framing conditions associated with a community of practice combined with systems thinking enabled learning about ICS which had not been previously possible.

Our experiences of working with the EA also highlight the problem of spanning organisational boundaries effectively: the working cultures, remits and priorities are very different at each level even within the same organisation. It is also apparent that there are few systemic conversations occurring between policy, science and operations.

The development of a CoP has not been an overt objective in the work with the ICS team because it is generally acknowledged that CoPs cannot be engineered. Instead, it was hoped that a CoP might, of itself, emerge from an increased awareness and realisation of a need for different ways of working among members of the ICS team. As a result of the facilitated workshops there has been a marked development amongst participants of a sense of 'community' (marked by the shift from the term 'group' to 'team' to describe themselves); significant advances in understanding among the team about ICS and a shift in some of their practices in working collectively. However, funding, personnel and organisational changes in mid-2007 within the Science Programme and the ICS team itself mean the status and longevity of the embryonic community is in some doubt.

In trying to develop the ICS Strategy, the ICS team has become aware of the need for a more sophisticated conceptualisation of the science and policy relationship. Doing science 'because it is interesting' is no longer acceptable within the culture of the EA. It needs to be seen to be policy-relevant. The problem is that there is little agreement on what the key policy priorities should be (even within policy). Debate also hinges on whether science should be driving or responding to policy. The search for the 'right relationship' between science and policy is further complicated by the 1-3 year horizons of policy and the 5-15 year horizons of science.

At root, many of the difficulties arise because of the ubiquitous imperative for ICM in policy and science for catchments. This obscures the differing scientific traditions and context-dependent nature of ICM, creating the largely false impression that ICM is a widely accepted set of theory-informed practices.

From our perspective, the work of the EA CoP has revealed the emergent nature of ICS and ICM. Such a realisation is sufficiently profound to require a concomitant shift in the language we use away from singular reliance on ICM as a discrete 'catch-all' noun to Integrated Catchment *Managing* (ICMg). In our view, this term better describes the sets of purposeful activities and interactions among multiple stakeholders operating in situations of complexity which enable or constrain emergence of integrated practices. In other words, ICMg is not some 'thing' that can be done by any individual or pre-determined. Instead processes are needed which pay attention to the context, stakeholders, the key changes required in particular catchments and the epistemological perspective of those involved in managing catchments.

It is not yet possible to assess the extent to which this shift is recognised or being progressed at operational level with stakeholders at River Basin District or catchment levels. Anecdotal evidence suggests experiences are at best, mixed. For example, Stakeholder Liaison Panels (LPs), established as part of River Basin planning and management for WFD implementation in England and Wales, are performing well in terms of establishing networks of stakeholders, but there are ongoing problems relating to how the LPs approach, and manage for, scientific uncertainty and integration.

In terms of the types of learning systems and networks required at RBD and catchment levels, we conclude that those involved in catchment managing need to engage in conversations around notions of ICM as an emergent property of a process of ICMg. Based on our findings, the extent of this shift in scientific practice and the resultant scientific explanations will determine the extent to which water management strategies will be adaptive and integrated and the good ecological status of water sustained through a deliberative, adaptive, co-evolutionary approach better fitted to living in a climate-change world.

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