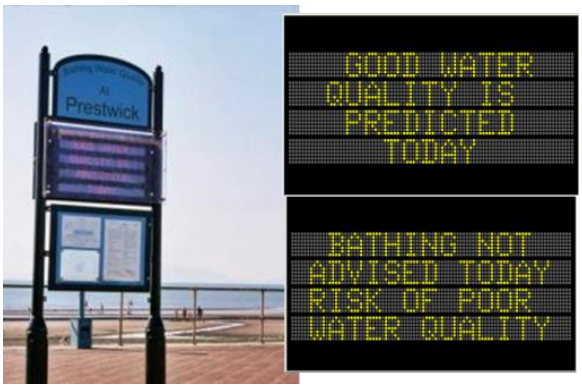
DELIVERING HEALTHY WATER

Delivering Healthy Water: building the science-policy interface to protect bathing water quality

Report from workshop 3

Stirling, 9th and 10th October 2012.



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Introduction

The third Delivering Healthy Water (DHW) workshop was held on the 9th and 10th October 2012 at the University of Stirling and focussed on the economic implications of changing the analytical methods used in the compliance monitoring of bathing waters.

As was the case for workshops 1 and 2 held earlier in the year, this workshop drew on the expertise of a wide range of academics, regulators, policy makers and other stakeholders. The aim was to facilitate the exchange of knowledge between these groups and to develop an understanding of the state of the art with respect to this inter-disciplinary subject and to identify the key questions and knowledge gaps that pertain to it.

Workshops 1 and 2

Workshops 1 and 2 were run consecutively on March 27th and 28th 2012. Workshop 1 set out to identify and prioritise regulatory, policy and other stakeholder needs with respect to evolving and emerging molecular technology for microbial parameter enumeration and tracking. The aim of workshop 2 was to evaluate how science providers can align with the needs identified in day 1 by the regulatory, policy and other stakeholder communities. It also attempted to identify pressing limitations or areas of uncertainty that may hinder meeting those needs now or in the near future. Information relating to the first two workshops and slides from all the presentations can be found at the DHW website: www.deliveringhealthywater.net .

Workshop 3 objectives

This workshop was organised in conjunction with Professor Nick Hanley of the University of Stirling. The aim of the workshop was to explore the breadth and depth of the economic implications that may arise in the future should there be a move towards the use of rapid and emerging techniques for regulating bathing water quality. Old methods (based on culture, or growing of colonies) are reliable but slow while new approaches (using molecular capability) are more rapid but not yet fully proven or accepted. There is growing momentum for more rapid approaches to inform on bathing water quality and thus alert the public to potential health risks should bathing water quality be poor and *vice versa*. With that comes a suite of associated economic, methodological and regulatory issues. The workshop investigated and drew attention to **the wider economic issues** of importance, including the management of health risk information, as the debate grows and moves forward. The workshop spanned three broad themes:

- Valuing coastal recreation linked to changes in water quality - The value of a day at the beach;
- Valuing changes in health risk relating to bathing water quality;
- The value of risk information.

The workshop was structured as a seminar series to debate the key issues from across the international community and was coupled with a break-out session drawing on material collected via a web-based survey in order to facilitate the inclusion of a wider audience. The survey protocol is included in Appendix 1.This report provides a review of each presentation from the workshop and a concise summary of the themes that developed over the day. It finishes with a table of research priorities identified by the participants based on responses from the online survey.

Workshop seminars

All presentations are available at www.deliveringhealthywater.net

Session 1

Two presentations were used to introduce the background to the DHW project and cover some basic economic concepts. The latter was important given the interdisciplinary nature of the audience with many of those present not being economists. **Dr David Oliver** from the University of Stirling and Principal Investigator for the project provided an overview of the DHW project and some background to workshops 1 and 2. David also set out the agenda for workshop 3 and explained how material gathered from all three workshops would be fed into

reports and briefing papers that would form the major project outputs. **Professor Nick Hanley** then introduced the workshop participants to some basic economic methods and tools for valuing improvements to water quality. This was for the benefit of the many non-economists among the participants and looked at the theoretical and practical differences between stated preference methods and revealed preference approaches. Nick summarised a range of methods that have been developed allowing us to estimate the monetary value of a change in environmental quality, health or recreational access based on the fundamental concept of Willingness to Pay (WTP). These methods formed key components of subsequent discussion material over the course of the workshop.

The next speaker was **Professor Sue Chilton** from the University of Newcastle who discussed **"Valuing risk reductions to human health"**. Sue highlighted that unlike other policy sectors, such as road safety, the environment often does not carry with it monetary values that can be incorporated easily into a modelling environment. However, if water-specific values are omitted it is likely that sub-optimal outcomes will be generated from impact pathway assessments.

Dr Sharyl Rabinovici (Mills College, California) gave a presentation on **"integrating valuations of the intangible and stakeholder participation into assessment of beach management alternatives"** Sharyl discussed the use of valuations to understand and compare beach management policy options. In particular Sharyl highlighted problems of source attribution, changing environmental conditions, the possibility of environmental sources of indicators that we thought were indicators only of faecal accidents and also the problem of what happens to the indicator bacteria in the environment. This results in a very complex system that we have little hope of being able to model with confidence and necessitates the use of techniques such as "transfer policy analysis". In this we take value, risk, cost and impact predictions from studies that were undertaken at places remote in space and time, or even policy issues remote in topic, and try to put together the best available integrated assessment. The advantage of transfer policy is that it is low cost, fast and it can estimate the value of collecting more information. The cons are that it is only as good as the original studies that are available and it is vulnerable to imprecision, inaccuracy or the propagation of error. Sharyl discussed examples of where she had applied this approach from three studies at two bathing sites in Illinois and California. In these she looked at:

- Implications of the 1-day lag testing compared to no testing;
- Potential improvement from using a predictive model compared to 1-day lag testing; and
- Potential improvement from rapid detection (qPCR) compared to 1-day testing lag and no testing.

The conclusions presented were:

1. Leaving beaches open may have the highest net benefit for swimmers.
2. Predictive models based on historic water quality records can outperform day-old data,
3. Net gains from rapid testing depend heavily upon the epidemiology assumptions used and their accuracy and precision relative to real world site conditions.
4. There is a need for more investigation into user-belief-behaviour and value studies.

5. Concerning experiments that are currently on-going in risk-participation and communication, we must be ready to evaluate them rigorously, eliminate the ones that are not serving us and promote and spread standardised models of the ones that are.

Dr Julie Hewitt (USEPA) spoke of **"The net benefits of rapid test methods at US coastal beaches"** explaining why it is appropriate to invest a lot of time and resources in this subject. A 1999 - 2000 national survey on recreation in the environment in the USA estimated that 22% of the population swims. Comparing culture and rapid methods in terms of opening and closing a beach, Julie pinpointed the net health benefits of rapid methods to lie in the period of time at the start of a pollution incident where we would be waiting on the results of culture tests but where, with rapid tests the information would be available to allow a decision to be made to close the beach. This early period was identified as the opportunity to realise health benefits because the beach would be closed and people would not be exposed to health risks. At the end of an incident the extra speed of rapid methods would also allow the beach to be opened sooner giving swimmers the recreational benefit.

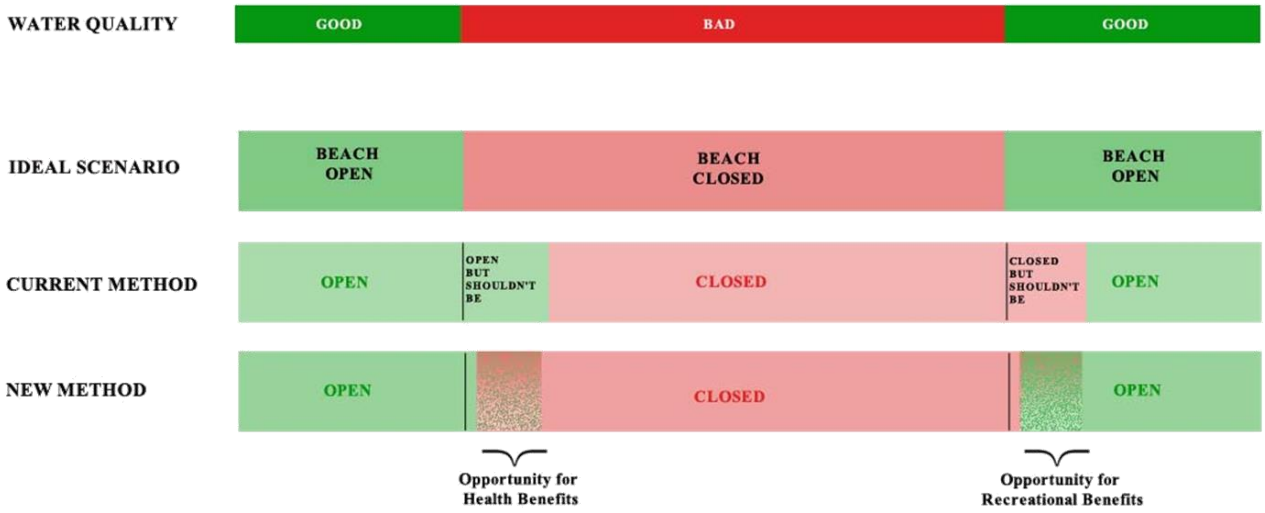

Figure 1. Comparison of different beach notification/closure scenarios linked to actual water quality when different methods are used (courtesy of Julie Hewitt)

This was used as the model for analysing the benefits (there is an argument that says that the latter recreational benefit could be cancelled out by the loss of recreational benefit at the start when the beach was closed early). Julie reported on a study using two beaches, one in Ohio and one in Indiana where both culture and qPCR methods were used. Based on the one year of data for the two beaches they estimated a health benefit, in terms of the 819 cases of gastrointestinal infections that would have been avoided had the beach closed early as a result of using qPCR, at $247 per case, of $202 000. For the same 15 days the recreational benefit of re-opening the beach early was calculated to be $62 000. Net costs were calculated for each method although Julie pointed out that better cost numbers are available now for qPCR. The net cost of qPCR at the two beaches was estimated at $2000. In total the net benefits at the two beaches amounted to $262 000 making it seem a positive prospect to move to qPCR. The next thing Julie discussed was how to extrapolate this to all coastal beaches and she highlighted the need for good visitation data and the challenges associated

with using data from the National Survey on Recreation in the Environment. Julie also drew attention to the dearth of information on how people respond to beach closures and advisory information and also the problems associated with measuring cost differences between the methods. In the discussion that followed Julie's talk, it was also pointed out that in reality any transition would need to include a phase of cross comparison whereby both methods were being used (increasing costs significantly). It is also worth mentioning that in England and Wales the potential benefits discussed by Julie would be difficult to realise because of the centralised laboratory situation for sample processing.

Session 2

Dr Klaus Glenk gave a presentation on "**Valuing risk of non-delivery of environmental outcomes".** This concept can be summarised by the question "what if it doesn't work?" There are many sources of uncertainty in environmental decision making for example when we try to predict what will be happening at some time in the future. These may be due to changes that might happen in the political, social or economic environment, or they could be external factors that change future relationships between supply and demand. Finally there is the fact that the models and predictions used may be based on current scientific knowledge and while the first two types of uncertainty may not be predictable, the latter could be. Klaus explained that with scientific uncertainty we can attach probabilities to the outcomes and describe them as "outcome related risk" rather than true uncertainty. Cost-benefit analysis can be undertaken with the outcomes and a sensitivity analysis applied by changing the assumptions or outcomes and predicting what the effects might be on the benefits and decision criteria.

Klaus explained that people tend to be risk averse and models that take into account this propensity fit the data better. Klaus then looked at the implications of this for willingness to pay values and found that values were lower when risk aversion was taken into account. An important point from this was that the results of these surveys always depend on how the question is asked, for example talking about the probability of success rather than the risk of failure.

Klaus then turned his attention to identifying areas of uncertainty in the field of technology choice – assessing costs and benefits:

- Culturable methods: variability in faecal indicator organism density over the course of the day, time and location of sampling can result in inaccurate beach closings and notifications (Tim Wade, US EPA & Dave Kay, CREH).
- 'EU-wide studies have suggested potential analytical problems with the precision and inter-laboratory reproducibility of qPCR-based enumeration'
- 'there is much uncertainty regarding the precision and accuracy of qPCR for microbial enumeration in the bathing zone'
- Predictive modeling: how accurate is prediction?

Klaus referred to work by Stidson et al. (2012) on Scottish beaches where they applied predictive modelling and produced four outcomes.

- Correct beach closure;
- Correctly keeping the beach open;
- Wrong to close it; or

- Wrong to keep it open.

Levels of probability can be assigned to each outcome and considered with each of the different techniques. Klaus suggested that the main concern was a false positive situation and that people may reveal a strong risk aversion to that situation. If people do tend to be risk averse they may not be so concerned about a false negative error.

A question was asked by Nick Hanley about whether people's preferences over environmental risks are similar to their preferences over other types of risk (road traffic or finance for example). Sharyl responded with a description of a study by Blais and Weber (2006)[1] that measures ones risk behaviour preferences in five different domains of life, for example health and social settings.

The risk preference parameter is likely to be unique to each choice situation so people would not assign the same risk aversion value to the probability of success for measures mitigation of climate change as to the probability of getting sick whilst swimming. Most evidence in this field is concerned exclusively with financial risks although some work has shown a correlation between attitudes to financial risk and attitudes to health risk in that they move in the same direction. However it was pointed out that people tend to be more risk averse with their health. Attitudes to financial risk may be used as a proxy for attitudes to environmental risk as a way of getting an objective measure of people's preferences in the context of health.

Dr Andy Vinten presented **"Testing the proportionality principle for pollution mitigation in the Irvine catchment and at a national scale".**

Andy used the Water framework Directive (WFD) standards to illustrate his approach and looked at the five standards of water quality and the economic costs of achieving them. Andy wanted to explore whether the proportionality principle, which is written into the WFD is upheld in the context of the BWD. He used work carried out in the Irvine catchment in southwest Scotland as an example. Storm event driven faecal indicator loads were monitored at various points downstream of the inputs. The information was fed into a bathing water prediction model that combined it with data relating to faecal indicator die-off rates, travel time to the sea and mixing processes between river and sea water. The information was scaled up to try to predict bathing water quality as a function of discharge. Epidemiological evidence and social benefits were fed into this biophysical risk model and it was calculated that annual benefits of around £400 000 could be realised for an 85 % reduction in faecal loads. Given that there were about 500 farms that could benefit from this, the health benefit amounted to about £1000 per farm that achieved mitigation. The Scottish Government funded projects to introduce steading and field measures in Ayrshire and Galloway spent about £40 000 and £10 000 per farm respectively on the measures. However this was based on faecal streptococci and when the impacts of *E. coli* O157 were included they found an infection rate of 41 per 100 000 in Ayrshire. This added a significant component to the benefit of about £200 000 over and above the £400 000 already mentioned.

[1]Blais, A.R; Weber, E.U. (2006) A Domain-Specific Risk-Taking (DOSPERT) scale for adult populations. JUDGMENT AND DECISION MAKING JOURNAL. 1(1) 33-47

The second example that Andy presented looked at the proportionality of pollution mitigation in the context of the WFD. It used a choice experiment with about 400 respondents who were asked to value the improvements in lake water quality following a pilot scheme. They incorporated a declining willingness to pay with a linear decline in the margin of willingness to pay as a function of the number of lochs mitigated. And they made some estimates in the context of mitigation of phosphorus pollution of the marginal costs and the total costs of achieving those improvements across about 550 lochs in Scotland. They found that mitigating up to 70 % of the total area of standing waters was seen as proportionate. This approach could be employed with bathing waters.

Session 3

Dr Dugald Tinch who is currently working on research looking at the environmental economics of the coastal zone gave a presentation on the "**Valuation of the upcoming revisions to the Bathing Water Directive (BWD)"**. Dugald designed choice experiments taking environmental goods, breaking them down into different attributes and identifying how people weight those attributes. Three attributes relevant to the BWD were health risk, health of seas and beach litter. Health risk was measured against a 10 % risk of getting a stomach upset. Health of the seas involved predicting how nutrient cycles would be affected by changing bathing water standards. Finally litter was seen by people as being important both on the beach and in the water. The choice alternatives for each attribute are shown in Figure 2. Three parallel surveys were carried out: General public (including non-use), General Public (direct use) and Active Recreationalists.

	Beach A	**Beach B**	**Beach C**
Benthic Health and population.	**Small increase** More fish, mammals and birds. Limited potential to notice the change in species numbers.	**Large increase** More fish, mammals and birds and an increased potential of seeing these species.	**No Improvement**
Health Risk (of stomach upsets and ear infections)	**Very Little Risk** – excellent water quality	**5% Risk** – good water quality	**10% Risk** – no improvement
Debris Management	**Prevention** – more filtration of storm water, more regular cleaning of filters and better policing of fly tipping.	**Collection and Prevention** – debris collected from beaches more regularly in addition to filtration and policing.	**No Improvement**
Additional cost of travelling to each beach.	£3	£9	£0
Please tick the **ONE** option you prefer.	☑	☐	☐

Figure 2 Example of choice card used for weighting attributes relating to a range of environmental goods

Dugald presented preliminary results of the Northern Ireland surveys. Among other things they found that active beach users pay less attention to cost in making their choices than the other users. More attention was paid to other attributes. Active users and illness sufferers were willing to pay more for a reduction in health risk than the general public or all respondents. Overall people were willing to pay between £7 and £14 to see a reduction in health risk.

Dugald briefly discussed some other willingness to pay results with Scottish surfers and people who were active on the day of the survey in Northern Ireland demonstrating the greatest willingness to pay for health impacts. Debris management was more important in Northern Ireland than Scotland. People in the "active but not today" category were more similar to the "never active" group then the "active" group in their responses. People taking part in a postal survey were most interested in debris management but also health risk. Among other results Dugald highlighted the lack of a significant difference between small and large increases in benthic health form the "never active" group. Dugald suggested that this was surprising as this group was likely to contain bird watchers who may be expected to be interested in the general fauna of the beach environment. To sum up the work so far Dugald indicated that the public were generally in favour of the provisions of the revised BWD when described through these attributes although it was unclear as to whether they would be willing to pay enough to meet the costs of compliance.

Dugald found consistency in the relative values placed on the attributes between groups. Absolute values varied depending on type of beach use, frequency of visits and whether there has been a previous illness.

Dr Sabina Shaikh discussed "**The value of beach visits and the effect of beach bans in Chicago".** Sabina reported the results of a study from 2004 that found inefficiencies in the programme of beach testing and beach ban policy. In 2005 changes were made to issue 'beach advisories' instead of bans. In 2012 predictive monitoring based on weather began. Sabina has been looking at identifying beachgoer characteristics, preferences and perceptions, the value of a day at the beach *to beachgoers*, lost value from swim bans and WTP to reduce swim bans. They used on-site in-person surveys, Travel Cost Method to estimate the demand for beach trips and the loss in consumer surplus from swim bans and Contingent Valuation Method to assess the willingness to pay to reduce swim bans and uncertainty. Over 50% of the people surveyed said they swam while at the beach but only 30% swam on that day. Of the reasons given for not going in the water, "too cold" and "water not clean" were the most popular. Sabina also discussed swim bans saying that the biggest predictor of certainty of when there would be a swim was after a big rainfall event. Most of the time when water quality was better than the required standard there was no swim ban. However when water quality was poor there were a lot of days when there was no ban but there should have been one. Nearly 60% of people would still visit the beach if a swim ban were in place and 70% considered the beach to be a valuable asset to Chicago even if a ban were in place. People used the radio and internet to find out about water quality before setting off for the beach. 70% of people did not want swim bans to be replaced by advisories. They did not want to swim at their own risk, often because they did not know how to assess the risk.

Alistair McVittie gave the final presentation looking at **"How information on different water quality measures can influence values"**. Alistair took the Environmental Valuation Reference Inventory database (EVRI) and interrogated it to find out how many studies it held relating to the term "bathing water". In total 22 were returned and this number was reduced to six when the filter of factors influencing people's values for water quality was applied. Alistair then proceeded to outline each of these six case studies.

Study 1. Machado & Mourato (1999) looked at health impacts and recreational benefits for 23 beaches on the Estoril coast in Portugal. They undertook two Contingent Valuation studies, the first of water pollution relating to health impacts. Gastroenteritis was identified as the most severe outcome by 60% of the sample and the WTP to avoid gastroenteritis was worked out to have a mean of US$ 44.39 and a median of US$ 14.26. From a contingent ranking where people ranked options on a choice card it was found that WTP to move from a beach category 'bad' to 'average' was just under US$ 11. Moving from 'average' to 'good' was US$ 7.94 and moving from bad to good US$ 18.90. The CV results were then used to forecast WTP to avoid gastroenteritis in the ranking sample to disentangle health and recreation benefits and adjusted to reflect risk. By combining the two surveys it was possible to work out how much of the overall value of a visit to the beach was due to a potential change in health effect and how much was due to recreational effects. The results were calculated on the basis of moving from either bad or average to good. They found the values for health to be much lower than those for recreation.

Study 2, Hanley et al. (2003). Based on a combined travel cost and contingent market approach looking at visits at 7 Ayrshire beaches where bathing water quality was often poor. The scenario being addressed by the evaluation was improving water quality to meet the mandatory standard. They found that the higher the perception of water quality the more trips people made to the beach. However, improving water quality so that the beach actually passes the standard only resulted in a 1.3 % increase in trips.

Study 3. Georgiou et al. (1996). This was a CV study of Lowestoft and Great Yarmouth. At the time of the study Lowestoft was achieving the BWD standard and Great Yarmouth was failing. This meant that for the former it was a willingness to pay to avoid the loss of water quality and for the latter it was a willingness to pay to gain in water quality. For Great Yarmouth the results indicated that local residents might not be willing to pay for an improvement in water quality. Also those people who spent more would be willing to pay more to avoid a loss than to accept a gain in water quality.

Study 4, Eftec (2002). This looked at the benefits of the revision to the BWD. It involved a choice experiment with 809 respondents considering 'the average beach in Britain' rather than a specific site. There were five attributes: water quality, an advisory note system, litter and dog mess, safety and amenities and finally additional water charges. For a 1 % reduction in risk of a stomach upset there was a £1.10 willingness to pay. Andy Cummins questioned how people understood the 1 % reduction i.e. if there is a 7 % risk would 7 out of 100 people get ill or does it mean that if I swim 100 times I should expect to get ill on 7 occasions? It was estimated that reducing unsafe to swim days by one day is worth 90 pence. Advisory notes were associated with a higher willingness to pay and other attributes such as dog mess were the most highly valued attributes of the beach trip.

Study 5. Brouwer R (2006). This study looked at the change in willingness to pay over time. 500 randomly selected Dutch households were surveyed in December 2002, outside of the bathing season. A further 500 randomly selected households were then surveyed in August 2003 during a very hot summer when there had been a lot of closures due to low river levels, algal blooms and botulism. Surprisingly the outcome showed no difference between the two sample sets in terms of willingness to pay for water quality improvements.

Study 6. Beharry-Borg N and Scarpa R (2010). This study looked at multiple beach recreation attributes in Tobago presented using either an increase or decrease in the risk of getting an ear infection. Andy Cummins highlighted the results from different classes of snorkelers and their willingness to pay for improvements in water quality. The preferences between groups varied from nature based attributes such as coral cover to litter on the beach.

To summarise the six studies Alistair said that the values for health impacts are often lower than for other water quality or beach attributes. There is some evidence that water quality information is more highly valued than the potential health risk, from the Eftec study where telling people if the water quality is good or bad was more important than the actual risk. Experience of illness and of water quality is often important-perceptions of water quality influence the value.

References used in Alistair's presentation

Machado F and Mourato S (1999) Improving the assessment of water related health impacts: evidence from coastal waters in Portugal, CSERGE Working Paper GEC 99-09

Hanley N, Bell D and Alvarez-Farizo B (2003) Valuing the benefits of coastal water quality improvements using contingent and real behaviour, Environmental and Resource Economics 24: 273-285

Georgiou S, Langford I, Bateman I and Turner RK (1996) Determinants of individuals' willingness to pay for reductions in environmental health risks: a case study of bathing water quality, CSERGE Working Paper GEC 96-14

Eftec (2002) Valuation of benefits to England and Wales of a revised Bathing Water Quality Directive and other beach characteristics using the choice experiment methodology, Final Report to Defra

Brouwer R (2006) Do stated preference methods stand the test of time? A test of the stability of contingent values and models for health risks when facing an extreme event, Ecological Economics 60: 399-406.

Beharry-Borg N and Scarpa R (2010) Valuing quality changes in Caribbean coastal waters for heterogeneous beach visitors, Ecological Economics 69: 1124-1139.

On Day 2, the workshop divided into four groups to carry out a brainstorming exercise relating to the three objectives of the workshop. The participants were asked to use responses from an online survey conducted before the workshop, and described in Appendix 1, and distil them into a set of key research priorities, questions and gaps. The outcomes of this exercise are summarised in Table 1 below. These priorities, questions and gaps have been organised into five areas: Questions relating to the measurement and communication of risk; how to value a day at the beach and the cost of illness; questions concerning the type of information relating to water quality that would be preferred; How to measure the economic impacts of changes to risk information; and questions relating to the economics of analytical method change and logistics.

In addition to these questions, the discussion allowed participants to identify ongoing or recent research and surveys that focus on some of these themes and which may serve to address some of the gaps recognized. These include:

MASTS (www.masts.ac.uk) - Disentangling of use and non-use value of coastal water quality

RNLI beach signage research (2010) http://www.dft.gov.uk/mca/rockpool_final_-_comments_updated.pdf

Research commissioned by the Scottish Government and SEPA (2005) “Assessing The Effectiveness Of Variable Messaging Signs To Inform Beach Users About Bathing Water Quality” http://www.scotland.gov.uk/Resource/Doc/37432/0011284.pdf

The Environment Agency is working with IPSOS-Mori consultants and carrying out local and national socio-economic research investigating likely attitudes and responses of visitors to signs that may be put up at beaches failing to meet minimum water quality standards in 2015 under the revised BWD. Results are expected to be published in 2013.

	1	2	3	4	5
How to measure and communicate risk	What are the risks to children and how best can we communicate effectively with their care givers?	How can uncertainty regarding health risk be better incorporated into valuation scenarios of bathing water quality?	Is there a common set of factors that explains variation in responses to risk information?	Which groups of recreationists would be most affected by 1) signs, 2) water quality changes?	What is the best way to present risk information ie risk of getting a GI infection as compared with risk of having an accident driving to the beach
How to value a day at the beach and the cost of illness	How to develop holistic regulatory approaches to avoid unintended outcomes. System-wide methods of assessment in order to understand the totality of benefits / trade-offs for valuations.	Do we know enough about the vulnerability / WTP of different user groups with regard to health risks?	What are the economic impacts of illness as a result of exposure to polluted waters? What are the economic impacts of posting warning signs at beaches to 1) users and 2) local economies?	Balancing the costs of improvements and benefits in light of other national priorities. What are the regional differences in attitudes and preferences regarding the impact of new regulations?	What drives demand for beach use, how heterogeneous is it, and what role does water quality play in it? How do people perceive substitutes and make those decisions?
Type of information on water quality	What quantity and type of information would beach users prefer to get? How quickly would they like to receive it and how would they like to access it?	Does the preference for a certain type of information or the way in which it is accessed differ between different user groups and if so how?	As a recreational water user would you value information on water quality before exposing yourself to pollutants?	What information would people respond to, to change the behavior or continue to go to the same bathing waters?	What are the differential impacts of the same information presented in different ways?
How to measure economic impacts of changes to risk information	What are the measures by which we can (and want to) evaluate beach management success?	What are the additional ($) benefits in terms of enhanced ecosystem services from actions to reduce health risks in bathing waters?	How would changes to the beach take shape (frequency/activities/ indirect and direct economic impacts) should water quality information be improved?	How do we capture the benefits to new users who do not currently use a beach due to poor water quality? Would some recreational users benefit from poorer water quality? (Savings from not testing?)	How do we distinguish the effects of changes in water quality compared to the effects of signs?
Methods and logistics	Would the use of new methods lead to more beach failures? If so what would be the economic costs?	Uncertainties in the scientific evidence base hindering economic valuations need to be addressed	What infrastructure and costs are needed to maximise the benefits of rapid methods? What would be the optimal location frequency of labs to facilitate qPCR?	Does prediction of water quality have more value to beach users than “real” water quality data?	How should investment be distributed between risk management (beach monitoring) and prevention (catchment management)?

Table 1 Research priorities identified from DHW survey and refined by breakout groups at workshop 3 grouped into broad themes

Review and Recommendations

The workshop brought together a range of expertise relevant to an assessment of research needs in understanding the economic implications and considerations associated with transitions in methods for monitoring bathing water quality. In total, the exercise resulted in 5 distinct priority research themes (see Table 1) that provide a valuable structure for the on-going process of identifying gaps and weaknesses in the current knowledge base. These priorities will also be useful as ‘seeds’ for the development of interdisciplinary approaches to future research in the field. The outcomes appear to complement well the findings of earlier workshops and link economics to concerns surrounding communication, modelling, catchment management and uncertainties in the scientific evidence base. Several areas already identified as science priorities were given further emphasis by identification as key to the information needs of decision-makers.

Appendix 1. The Delivering Healthy Water Survey

In advance of Workshop 3 we asked for contributions (from global experts) in the form of a list of challenging or unresolved issues, framed as questions for the academic and regulatory community to debate in terms of prioritising their importance and feasibility. The survey was embedded in the Delivering Healthy Water website and links to it were distributed widely over a period of several weeks before the workshop. In total 21 people completed the survey and Table 1 below gives a breakdown of the responses by stakeholder group. Each individual was able to identify as belonging to more than one group.

2. To which stakeholder group do you belong? You may select more than one option — Create Chart | Download

	Response Percent	Response Count
Research community	71.4%	15
Regulator	23.8%	5
Policy maker	9.5%	2
Recreational beach user	38.1%	8
Local authority	4.8%	1
Other (please specify) Show Responses	19.0%	4
	answered question	21
	skipped question	6

The questions were set out under the three workshop themes and examples of questions falling into each were provided for guidance. The responses could include broad areas of concern or specific questions or challenges relating to each theme.

Part 1. The value of coastal recreation linked to changes in bathing water quality

Examples of questions falling into this category:

1. How do we assign monetary values to a day at the beach?
2. Using molecular techniques for BW analysis may lead to a downgrading of the beach's EU classification. Would this change the value of a day at the beach? If so by how much? Ie what is the cost of losing "sufficient" status at a designated bathing water?

Part 2. The value of changes in health risk related to bathing water quality

Examples of questions falling into this category:

1. Which scenario would be preferred and how much would people be willing to pay for each?
    a. A lower risk – better quality BW, reported as it is done now (cost = x)
    b. No change in BW quality but the risk information is distributed more quickly and accurately (cost = y)
    c. Both a and b (cost = x + y)
    d. Neither – preserve the status quo (cost = 0)
2. Should investment be targeted at risk management (beach monitoring/information) or risk reduction and prevention (catchment management)?

Part 3. The value of risk information

Examples of questions falling into this category:

1. How would changes in trips to the beach take shape (frequency/activities/indirect economic impacts) should water quality information be improved?
2. How much extra would the public be willing to pay for information displayed by: 10am, Noon, 2pm, the next morning?

Part 4.

Please add any questions, areas of concern or key challenges relating to potential **economic implications** of using rapid methods to monitor bathing water quality that have not been covered by the three themes above.

Further information and contacts

This project has been funded by the Natural Environment research Council (NERC) and led by the University of Stirling. It is supported by Lancaster University and Aberystwyth University.

The core Working Group includes a membership of representatives from UKWIR, SEPA, EA, Defra, and Surfers against Sewage but has also drawn on a breadth of knowledge and experience from across the UK and the international community as well.

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