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15th November 2012. Thank you!

**Principal Investigator**

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Discipline	Economics		
Role in team	PI/Economic Valuation		

**Project team**

Total number of people involved	Academics	15
	Non-academics	2
Of these, how many are	Natural scientists	6
	Social scientists	3
	Economists	4

**Project title (<120 Characters)**

Interdisciplinary methods to build a socio-ecological decision-making tool to inform marine governance and policy

**Project objectives**

- 1) Creation of a dynamic model representing marine ecosystem and coastal community which updates predicted values of all factors in the model with policy changes - capturing interactive relationships within the modelled ecosystem and community.
- 2) Overall "Integrated Ecosystem Value" based on equilibrium of social, economic and ecological performance in the model - capturing trade-offs within policy and allowing decision-makers to manipulate factors to predict effects on the Integrated Ecosystem Value.
- 3) Policymaker evaluation and debriefings to highlight strengths and limitations, to validate/improve methods and confirm first translation of valuation for dynamic marine ecosystems into valid tools directly informing coastal policy making.

## Summary

Please provide a **one page** plain language summary of your project, aimed at a non-specialist audience. Please address the following:

Human wellbeing is closely linked to the health of environments we live and depend on for food, water and jobs. Traditionally, environmental management has relied more on ecological information to inform policies that have had a bias towards supporting conservation goals. There is now a greater awareness of the need to integrate social well-being and cultural impacts with ecological and economic factors. It is now widely recognised that sustainable management that supports both people and the environments on which they depend can only be achieved through balancing economic, ecological and social goals. However to date policy makers lack tools to combine diverse data from these different disciplines. Slow progress towards achieving sustainability goals, especially in the marine environment has been further compounded by a lack of communication between academics and decision-makers. Thus an important part of this project was to create a participatory forum from the beginning that motivated scientists and those involved in policy advice to exchange knowledge so that a more practical and user-friendly management tool can be developed in the longer term.

This project has built the foundation for a management tool to assist decision makers in visualising how different management measures, for example, introducing a Marine Protected Area (MPA) to address overfishing can impact the ability of a fishing community to adjust to changes that influence income generating activities. In our study we brought together natural and social scientists using an interdisciplinary approach to apply their expert knowledge with empirical data collected from communities interviewed in the Western Indian Ocean. This region of the world provides an important case study because it is home to many communities socially and economically dependent on reef fisheries vulnerable to damage from climate change through rises in sea temperature leading to bleaching of corals, the home for many fish.

A 'model' was developed using a mathematical technique known as Bayesian Belief Networks to describe how the well being of a community can be impacted by the introduction of a management tool such as a MPA. The model is able to combine and integrate different types of information e.g. household socio-demographic data and non-market values for environmental changes, shared social and cultural values and marine ecological data, reflecting the linkages between them. The model shows how, when these different types of data are considered together (instead of separately, as is the norm), there are both negative and positive impacts of the MPA on the community. It therefore captures very well and makes clear to policymakers the trade-offs between marine health, economic development and community wellbeing that are inherent in policy they might consider implementing. These complex interactions were graphically communicated in an easily comprehensible format to academics and policy advisers. Experts involved in policy confirmed there is a gap and need for an environmental management tool that can facilitate policy making so that any proposed changes are considered in advance to implementation and explored in terms of how they might impact people that work, live and or depend on marine environments.

The project team has researched and developed the process to underpin improved policy making which considers environmental management from the three key pillars of sustainability, that is, economic drivers, social considerations and ecological indicators of environmental health. An exciting result from this project is the establishment of a new marine network that facilitates co-operation between both academics and policy advisers which is considered a key attribute towards building good marine governance, that is, the beginning of a more participatory approach in policy making.

Whilst this particular BBN was developed in the context of a representative fishing community in the West Indian Ocean, the members of our network from the marine policy and management community in the UK (Marine Management Organisation, Marine Scotland, DEFRA) indicated strongly that such an approach would be directly transferrable to a UK context, for example for the purposes of marine spatial planning. We also believe that, in principle, it also has the potential to be adapted for use by conservation groups or Non-Governmental Organisations with an interest in the sustainable management of marine resources.

## Your project and the Valuing Nature Network

Please provide up to **four pages** of detail regarding the following:

1. Your insights into which of the four VNN Key Challenges (Appendix A) you addressed, according to your proposal
2. How you have evolved the overall VNN conceptual framework (content of boxes and flows between) (see Appendix B)
3. Your thoughts on the future agenda for VNN research (following on from initial ideas in April's meeting)
4. Your recommendations regarding mechanisms to maintain and grow the network

### 1. The key challenges

Within this project we directly and unambiguously addressed Key Challenge 4 but also made substantive progress in respect of Key Challenge 1, due to an important characteristic and major strength of BBNs, namely flexibility in incorporating data of different types - for example qualitative vs. quantitative, good vs lesser quality and so on - from different sources and relating to different sectors e.g. marine ecology and household demography. We return to Key Challenge 1 at the end but at this stage consider our major focus, namely Key Challenge 4.

To illustrate, we present a brief description of the processes and outcomes of our project (a more comprehensive description can be found in Campbell *et al.*, 2012a (*VNN website, to be uploaded by 30<sup>th</sup> November, contract end date*). A Bayesian Belief Network (BBN) model was conceptualised by the interdisciplinary team after agreement that the BBN method offered a great deal of potential for policymakers to visualise the outcomes of the complex interactions between the different data. In an initial set of meetings, the academic members of the network worked together in small interdisciplinary groups to iteratively integrate information and data on the social and economic sectors of the marine community and physical environmental status data on the marine habitat. Integrated data was used to develop three separate conceptual models (for Marine Health, Economy and Social Wellbeing) reflecting the key within-sector components and relationships that would be likely to exist within them in the community. These sub-models were then taken to the second full team meeting in which the academic team were joined by stakeholder network members from the marine policy and management community. Here, the conceptual models were further refined and finalised and, most importantly, key inter-sectoral linkages were identified and agreed on e.g. to allow economic status to influence social wellbeing and environmental health, marine health/status to influence economic output and social wellbeing and, finally to allow social wellbeing to affect environmental health and economic output. The resultant BBN model was then trained and "populated" with data from expert knowledge and a dataset from communities in the Western Indian Ocean. The BBN model then used underlying probabilities to predict changes in all factors based on internal inter-linkages.

In our early meetings, following a series of discussions, we agreed that shared social and cultural values (e.g. many traditional fishing and management practices associated with the ecosystem generated by long-standing belief systems) could not be monetarised within the BBN, since many of these values cannot be quantified or captured using traditional economic methods. However, we retained individual household non-market values for environmental change within the BBN in a monetarised form, as they were consistent with the individual based socio-economic data available to us. We note here that actual data on non-market values was not present in any of the datasets, which required us to synthesise a customised dataset as opposed to relying on a conventional benefit-transfer exercise. We refrain from providing further details, which can be accessed in Campbell *et al.*, 2012b (*VNN website, to be uploaded by 30<sup>th</sup> November, contract end date*) and instead continue with our overall description of the project in the context of addressing Key Challenge 4.

Our objective was to develop a mechanism in which all these different types of values could be treated equally within the policy decision process, an aim supported by our stakeholder network members. This meant that any 'weighting' of outcomes was not integrated into the BBN- although, in principle, it could have been - instead, any weighting of outcomes is left to the policymaker. Our stakeholder members were strongly in favour of a separate presentation of the impacts on social well-being, economic status and environmental health, as opposed to integrating them into one final overall value which had been our initial intent. We note, therefore, that, in principle, BBN models such as the one developed in this project allow policymakers to compare predicted outcomes reliant solely on economic values (including or excluding non-market values) with predicted outcomes from models that include available data on social values.

We held two test-bed evaluation sessions with policy-makers and policy analysts to evaluate the potential for BBN decision tools (or similar) in the future. In these sessions, participants were shown testing and development of a marine management scenario, in this case the establishment of a “no-take” marine protected area (MPA). The potential to use the BBN to balance ecological, economic and social demands and to manipulate policy to fulfill community requirements while preserving ecosystem services for future use was demonstrated. They saw how such a model has the power to predict best practice for policy choice and policy implementation and to improve decision-making supporting the long-term sustainable management. Participants were very positive about the potential for BBNs as decision support tools and provided us with significant insights into where they might be best developed in the future, in particular in the area of marine spatial planning (e.g. Options Analysis, Co-location Analysis) into the potential for such models to support their work. Specific advantages of the BBN noted by participants included the graphical, visual identifications of factor impact/sensitivity, the possibility to simultaneously observe the strength of impact of the policy in each sector and the facility to include monetary, non-market values and social values, which they expect to have to include in their impact analysis in the near future, but currently lack reliable means to do so.

Thus, it seems fair to conclude that the potential exists for such a decision support tool to benefit marine communities by facilitating long term sustainable management based on a broader spectrum of considerations (natural environment, economic impacts and social wellbeing) than is currently the case.

Turning to Key Challenge one, when policymakers make their decisions they are, at least implicitly, valuing the alternative outcomes on behalf of society. Thus, if a policymaker implements an MPA for example, we can infer that they consider it to have an overall positive impact or value for society and, likewise, if they decide against implementation they must, implicitly at least have assumed that there would be an overall negative impact on welfare. It is likely that were it possible to take into account, at least to some extent, the structural complexity of a social ecological system a better and more informed decision would take place. A BBN allows us to do this. The conceptual modelling process formalises this structure and allows it to drive the output from the model. For a robust model for policy formation it is only necessary to ensure that the model reflects the key interactions between the three main sectors that are clearly impacted by the policy - it is not necessary to model all factors which affect social wellbeing and cohesion, an economic system or an ecosystem, making this approach viable and applicable in real world policy support.

## **2. Conceptual framework**

It would be possible to further evolve the current VNN conceptual framework by drawing on some of the principles embodied in our empirical BBN model which better reflects the dynamic and probabilistic nature of real-world human and natural systems. Our BBN respects the implicit equal weighting given to the various types of values in the conceptual framework, but overcomes limitations in the process and outcomes directionality of the VNN conceptual framework by incorporating causal links showing the direction of relationships between different variables. It also allows for iterative updating of variables and linkages. Furthermore, the debates within our early meetings led all interdisciplinary participants to conclude that the BBN model was adaptable and could be used at different levels (individual, group, and community) and at different scales of governance (local, national, regional) whereas the current VNN framework appears constrained in its adaptability to varying scales.

Manipulations of valuations and the goods and services affecting those valuations are immediately reflected by the BBN via changes in predicted outcomes and it is also possible to identify changes in the impact of key drivers of change. This is useful for allowing end-users to visualise different future management scenarios. Because of its flexibility and the iterative nature of a BBN, it is not restricted by positioning of decisions or implementation at the end of the conceptual model - essentially, the ‘end’ decision can be an input into the next iteration.

## **3. Future agenda**

We must of course continue to promote the marine environment as a key area that should remain supported by the VNN. We have been able to establish an interdisciplinary team with international reach and strong connections with user bodies, which shares common interests and goals in improving governance of marine socio-ecological systems proving that our particular science-into-policy

approach is of high relevance and value. The future of VNN research must reflect the significant value and priority many international research facilities and government institutions give to marine networks. In short, we believe that the VNN should ensure it retains a distinct marine element as the United Kingdom faces increasing challenges in future marine governance to ensure sustainability.

Nevertheless, one further issue became increasingly clear to us as we progressed within the project and talked to VNN members from other teams. Essentially, the skills base in academia is not well placed to support or exploit interdisciplinary opportunities and to develop interdisciplinary concepts. Interdisciplinary teams require additional time to learn multi-lingual disciplinary technical language. This initial project provided a participatory forum to begin this process by establishing new teams of committed natural and social scientists. We strongly believe that these teams/networks constitute one of the most valuable outputs of VNN thus far. Future VNN research must build upon the advances made in the past year and consolidate interdisciplinary process established among team members by allowing teams to build into their projects resources for tracking, reflecting and disseminating results on this aspect of the network.

Another valuable output from the 2012 agenda from our perspective is constituted by the new collaborative partnerships between academics and policy advisers. In our team, we were able to benefit from this directly as a number of marine policy and management stakeholders have become members of our network, participated in the construction of the BBN, evaluated its viability for policymaking and are keen to participate in any further developments. Thus, the working environment created within our network supported development of a truly interdisciplinary team which has established a common language and a common interest and goals in improving governance of vulnerable marine socio-ecological systems. VNNs future agenda should aspire to extending such experiences to the wider academic community.

#### **4. Maintaining and growing the network**

The Valuing Nature Network, if it wishes to be maintained and grow, must be supported by substantive research projects which apply the lessons and interdisciplinary process learned in the past year to collecting, analysing and evaluating real-world data. The existing network has been built upon mutual interest and common goals and has produced valuable results in the form of models, interdisciplinary process and above all interdisciplinary teamship. All members of the team for the current project have committed and given time in excess of that planned because of their strong commitment to the VNN principles. In future, however, the constrained key performance indicators of academic institutions will pre-require more substantive resources for this type of research and will be rewarded by outputs that can be published in high impact journals due to the unique and global appeal of valuing nature.

Network teams would benefit from continued opportunities to evaluate and comment on all other teams proposed or ongoing research. This may be facilitated by regular ‘Special Sessions’ at targeted conferences, both disciplinary and interdisciplinary.

The network would benefit strongly from a PI consultation process to share lessons learned and to generate ideas for future joint projects.

## Specific project details

Please provide brief details (**100 words** for each question) to address the following:

### Progress

There were no delays in this project.

*Was there any significant change in the research compared with the original proposal?*

One overall “Integrated Ecosystem Value” was replaced by three outcome indicators, one for each sub-sector of the conceptual model. A single value was considered less informative and likely to mask any decline in one sector by an improvement in another.

An independent evaluator reviewed our procedures (see Campbell *et al.* 2012a\*) allowing us to reflect on main challenges and positive and negative experiences generated by the interdisciplinary process\*.

Rather than present user body representatives with a ‘final’ end-of-project BBN, we instead invited them to become involved in constructing the BBN and held structured evaluation sessions with them on two occasions.

*\* uploaded onto VNN website by 30<sup>th</sup> November, contract end date*

*Were there any circumstances that aided or impeded research progress?*

*If YES explain how the work was affected and how any problems were overcome or opportunities exploited.*

The voluntary, or part-funded nature, of the network meant that some members found it difficult to simultaneously commit as much time to the project as they might have liked and fulfil other, funded commitments. Given this, a core team made a number of operational decisions and produced initial drafts of project outputs without wider consultation.

Stakeholders from user groups are very time constrained. By focussing on the Marine Management Organisation (based in Newcastle) and Marine Scotland (Edinburgh) we were able to exploit this local proximity and be flexible in timing meetings with them and they in turn found it easier to attend our full team meetings.

### Publications

*Dissemination of results.*

*To be uploaded onto VNN website by 30<sup>th</sup> November, contract end date*

Literature Review: Schuchert, P. (2012) Integrating Ecology, Economics and Social Sciences to improve policy making.

Project Review: Campbell *et al.* (2012a). Bayesian Belief Networks in combined analysis of economic and ecological health and community well-being – an interdisciplinary policy tool.

Manuscript: Campbell *et al.* (2012b). Synthesis of household non-market values for the ecosystem services from a marine resource. (*Targeted Journals: Journal of Economics and Policy; Journal of Agricultural Economics*)

## Results and outputs

*Have any significant datasets been generated from this research?*

No.

*Were there any circumstances that aided or impeded research progress?*

See above.

## Results exploitation and knowledge transfer

*Who do you think are the main users of this research?*

*Include any that apply:*

We envisage policymakers, regulators and decision makers (e.g. DEFRA, Marine Management Organization, Marine Scotland) to be the main beneficiaries of this research. However communities themselves can also benefit from a broader understanding of the processes underlying their interactions with the environment. We also imagine that the research could be of use to NGOs – mainly marine conservation organizations.

*Have any potential beneficiaries and/or users of the research outputs (in particular non-academic research users, such as private or public sector organisations) been involved at any stage in the research activity and/or been informed of the research outputs and achievements?*

Yes. As noted, policy and decision makers from DEFRA, Marine Scotland and Marine Management organizations were directly involved in the research activity from the outset as advisors and active stakeholders. A much wider network of policy and decision makers have been informed about research outputs and results in special workshops and personal communications.

*Has the research led to any further collaborations with potential users or other academics?*

The research team expanded throughout the project with additional collaborating academics from the social sciences and received interest for future collaborations with various policymakers, some of them became involved in more depth or joined during the progress. We also received additional queries from academics for future collaborations. There have been numerous requests for final outputs and reports and the outcomes of the research have been communicated to multipliers of interdisciplinary work in the United States of America, continental Europe and Africa.

## Science in society

*Has an opportunity arisen to promote the public understanding of the scientific results from this research?*

*Give details of work/activity undertaken*

No, although we envisage many opportunities for a BBN approach since members of the local community would be involved at the outset through the building of the conceptual model. This was impossible within the resource constraints of the current application. In the short term, we intend to report the results of this project to *marineNewcastle* network (<http://www.ncl.ac.uk/marinewcastle>), some of whom have active experience in outreach activities and public participation in research. We would consult with them on this aspect in any future marine governance project.

## **Interdisciplinary working**

*To what extent did the project enable new working relationships a) between different academic disciplines and b) with non-academics?*

*Please give details*

The project fostered new working relationships between interdisciplinary scientists with an economics focus and those with a landscape planning, marine science and governance focus. All core team members from Newcastle University, Queens University Belfast and Yale University developed close working relationships and strong mutual understanding and respect during the project - due to the integrated processes we deliberately adopted (Campbell *et al.*, 2012a). Existing informal relationships between academic staff and policy-makers were strengthened and new relationships were developed with the Marine Management Organisation and Marine Scotland also.

*What were the main challenges of working as a team consisting of people from different disciplines/sectors?*

*Please give details*

We underestimated the time required to develop a common interdisciplinary language, and hence much time was given over to determining and agreeing.

Disciplines differed in their initial goal definitions and these needed to be openly discussed and final, communal ones agreed.

The main approach - BBN - was unfamiliar to most members. Therefore, at first almost everyone imposed their own, incorrect interpretation of how it worked, although this was largely resolved over time, when people became involved in populating it and, at least in principle, began to understand its underlying principles. For a full review see the independent evaluator report.\*

*\*(uploaded to VNN website by 30<sup>th</sup> November, contract end date).*

*What methods did you use to successfully address these challenges?*

Terminology was harmonized where possible and members agreed to reduce their use of discipline-specific terminology in order to allow all members to grasp concepts quickly. Goal definitions were discussed and agreed, the strength of the BBN in allowing non-monetary valuation and equitable weighting of sectors was useful in helping overcome goal differences. The logic and underlying concepts of a BBN probabilistic model were presented and reiterated frequently to all team members

*Please give details and also include any recommendations for future VNN research.*

Future VNN research requires the use of glossaries to agree common language. Future valuations in VNN should make use of the strength of BBNs in offering probabilistic non-monetarised valuations of integrated factors across all economic, social and environmental sectors. VNN research must become problem-oriented as opposed to process oriented - the aims of the exercise immediately become clearer, more focused, more manageable and more achievable.

## **Anything else?**

*If there are any other outcomes from your project that have not been captured above, or if you have any further comments, please add them here*

Appendix A  
The four Key Challenges

1. How can the **complexity of socio-ecological systems** be incorporated into valuations of biodiversity, ecosystem services and natural resource use?
2. How can **stock sustainability** be incorporated within valuations of biodiversity, ecosystem services and natural resource use?
3. How can issues of **scale** be incorporated within valuations of biodiversity, ecosystem services and natural resource use?
4. How do we integrate natural and social science information on values for biodiversity, ecosystem services and natural resources into governance and so improve **decision-making** and implementation?

Appendix B

The conceptual framework

