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Article

Understanding Science in Conservation: A Q Method Approach on the Galápagos Islands

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Abstract

The variety of perspectives that conservation practitioners and scientists from different disciplinary backgrounds have towards the role of science in conservation add to the already complex nature of most contemporary conservation challenges, and may result in conflict and misunderstanding. This study used Q method (a form of discourse analysis with roots in psychology) in order to uncover the range of perspectives on the science/conservation interface currently held by scientists and conservation managers working on the Galápagos Islands. The aim was to facilitate mutual understanding and communication between proponents of the various viewpoints, as well as to expose the subjective values, assumptions, and interests on which these opinions are constructed, to critical scrutiny. Twenty-seven people from a range of disciplinary and professional backgrounds carried out a Q test consisting of a sample of 34 selected opinion statements. Four statistically different perspectives emerged from the analysis, emphasising different concerns and highlighting different understandings of science and conservation. The perspectives have been labelled as: 1) Science for management; 2) Freedom of science; 3) Limits of science; and 4. Separation of science and conservation. The similarities and differences between the perspectives are discussed in depth, and the implications for conservation practice are explored in light of the current literature.

Keywords: Q method, discourse analysis, conservation management, social perspectives, Galápagos

INTRODUCTION

A solid base of scientific data is often cited as one of the fundamental components of successful conservation practice (e.g., Tracy and Brussard 1996). However, there are many divergent opinions as to what exactly this implies for scientists working at the science/conservation interface, and the exact role that science and scientists should play in conservation is still a matter of some disagreement (Giller et al. 2008). There are a number of on-going debates around this issue, each emphasising different concerns and priorities, and simultaneously highlighting different conceptions of the nature of both science and conservation.

At the level of conservation management, the debates often focus around the divide between scientists or academics on one hand and managers on the other (e.g., Roux et al. 2006). There are concerns that the types of science often carried out in natural areas has not been able to provide managers with the data they need for effective management (e.g., Santander

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2007), and furthermore, that traditional disciplinary boundaries have been unable to rise to the challenge of addressing problems with the levels of complexity characteristic of contemporary conservation issues. These types of concerns have propelled the development of frameworks such as the integrated 'socio-ecological systems' model (Berkes et al. 1998; Folke 2006) for studying societies and ecosystems, fed calls for the development of a 'post-normal science' (Funtowicz and Ravetz 1994) as well as resulting in increasing calls for interdisciplinary studies and, in general, a broader integration of different disciplines within conservation programmes and institutions (e.g., Tapia et al. 2009b).

Within academic conservation biology circles, the science in conservation debates have tended to focus around the degree to which individual conservation biologists and conservation institutions should become involved in advocating for particular conservation policies on the basis of their scientific findings (see for e.g., Marris 2006). In these debates, the focus is on the nature of conservation biology as a discipline, whether or not it is inherently normative (e.g., Barry and Oelschlaeger 1996), and therefore whether or not advocacy on behalf of these norms should be allowed and encouraged. Related ethical debate in this area hinges on the question of the degree of certainty required before a policy prescription can be made, with some scientists (e.g., Noss 1986) arguing that in situations of ecological uncertainty, the ethically preferable path for researchers is to risk making type-I errors (i.e., false positives) while others (e.g., Simberloff 1987) argue that risking type-II errors (i.e., false negatives) over type-I errors is more conservative and therefore preferable [for an overview of the ethical arguments on both sides see Shrader-Frechette (1994)]. Others (e.g., Lackey 2007) highlight what they see as the need for scientists working within conservation to be vigilant about maintaining a distinction between what he calls 'policy neutral' science and what he refers to as 'normative science' (Lackey 2007: 12), the latter being science that is imbued with implicit policy preferences evidenced in the use, for example, of 'value-laden' words such as 'degradation', 'good' or 'poor' to describe scientific findings. According to Lackey, there is a tendency within conservation biology and ecology towards 'normative science' masquerading as 'policy neutral' science, which (he argues) risks corrupting science as an institution (Lackey 2007). These debates touch on the science-policy literature (e.g., Pielke 2004; Sarewitz 2004), on philosophy of science critiques of positivism (e.g., Longino 1990), and to a degree, on the Science and Technology Studies (STS) literature concerning the plausibility of a separation of the domains of objective science from policy making (e.g., Jasanoff 1987).

From a more critical angle, research under the broad heading of political ecology has raised concerns about the role of science and scientists from environmental disciplines such as ecology and conservation biology, in generating and perpetuating so called orthodoxies or 'myths' about environmental change that may not only be bio-physically inaccurate, but may also have detrimental consequences on local livelihoods. Work in this field is concerned with critically examining the ways in which social and political framings are "woven into both the formulation of scientific explanations of environmental problems and the solutions proposed to reduce them" (Forsyth 2003: 1). Such research draws on Science and Technology Studies literature about the social nature of science and policy, rejecting a simple distinction between the two, understood not as essential and universally understood categories but as "constellations of component practices and procedures enacted by people and institutions" (Fairhead and Leach 2003: 17). Research in this area (e.g., Leach and Mearns 1996; Stott and Sullivan 2000; Fairhead and Leach 2003; Thompson 2006) tends to draw on diverse methodological and theoretical traditions such as discourse analysis, ethnography and practice theory.

The variety of debates around the role of science in conservation can be 'bewildering' for scientists working at the conservation policy interface (Lackey 2007), and lead to confusion and miscommunication between different practitioners that do nothing to further conservation aims. And yet it has been argued that collective thinking and problem solving in a cross-disciplinary area such as conservation "depends on the facility with which collaborators are able to learn and understand each others' perspectives" (Pennington 2008: 1). This study therefore aims to use Q methodology as a tool in order to better understand the variety of perspectives on the role of science in conservation as they are played out in the Galápagos Islands.

The Galápagos Islands (to a large extent internationally synonymous with both science and conservation) provide an ideal arena within which to examine the detail of some of these debates. On Galápagos, the science and conservation sectors have not only been the site of heightened social tensions and even outright conflict with other local people (see Ospina 2004), but also the subject of various vocal academic critiques (e.g., Grenier 2007; Orduna 2008), and in recent years, the site of heightened internal (i.e., inter and intra-institutional) tensions generated by debates and disagreements about the most appropriate and necessary types of science on the islands (e.g., Tapia et al. 2009a). The aim of this study was to critically examine some of the subjective values and assumptions underlying debates in Galápagos with a view to facilitating dialogue and more transparent collaboration between proponents of the various positions.

Q METHODOLOGY

Developed by psychologist and quantum physicist William Stephenson in 1935 (Stephenson 1935), Q methodology provides a tool which enables exploration of subjective attitudes and points of view. The emphasis of the method is on understanding "why and how people believe what they do" (Addams and Proops 2000: 34). As its focus is on subjectively held opinions, a Q study can be used to explore viewpoints towards any topic that can be socially contested or debated. In recent years, Q methodology is increasingly being applied to the analysis of conflicting views of environmental issues such as climate change (Dayton 2000), sustainable forestry (Swedeen 2006), conservation conflict (Mattson et al. 2006), and ecosystem management (Ockwell 2008). In a Q study, a relatively small number of purposively selected participants (usually between 20 and 40 people) are asked to rank order a number of opinion statements about the topic in question. Outcomes are statistically analysed using factor analysis in order to look for patterns or shared attitudes towards the topic. The resulting 'factors' or discourses are interpreted with the aid of interview data from the participants.

Q differs from many other quantitative techniques for studying perspectives and attitudes (such as surveys and questionnaires) known collectively as 'R' techniques (after Pearson's r coefficient in statistical analyses), in that it does not attempt to correlate subjective opinions with other objective factors, such as wealth, gender or skin colour (which are not considered to make subjective attitudes comprehensible), but instead looks to understand the structure of subjective opinions according to the subject's own internal frame of reference. Q method thus takes an anti-essentialist approach to subjectivity, which is seen as observable as an expression of one's behaviour. In Q method, subjectivity is considered measurable by examining how participants express their views in the active process of rank ordering opinion statements according to subjective or self-referential criteria.

Due to the way in which a Q study does not impose a priori categories onto the data, but allows categories to emerge from the data, it holds the potential to reveal subtle differences between perspectives in situations of conflict, when nuances in the debate may become obscured by simplistic generalisations. Furthermore, Q's 'quali-quantitative' nature (drawing on both statistical analyses and more interpretive discourse analysis) provides a helpful bridge between the natural and social sciences (Sell and Brown 1984), and is thus a useful tool for facilitating dialogue between these divergent research traditions.

Study site: the Galápagos Islands

For natural scientists from a number of disciplines, the Galápagos Islands have an iconic status matched by few other sites in the world. They have been called a 'Mecca' (Sauer 1969) for ecologists and natural historians, and are famously known as a natural laboratory for the study of evolution. The volcanic archipelago is situated in the Pacific, straddling the equator, 1,000 km from the coast of Ecuador by whom they are governed. Credited with inspiring Charles Darwin to develop the theory of evolution by natural selection, the islands are home to a range of charismatic endemic species such as the Galápagos giant tortoises (*Geochelone elephantopus*), the only sea going lizard in the world, the Galápagos marine iguana (*Amblyrhynchus cristatus*), and the endangered Galápagos penguin (*Spheniscus mendiculus*). They are also home to a (less celebrated) human population of approximately 25,000 people, inhabiting 4 of around 18 islands[1].

The Galápagos National Park (GNP) was created in 1959, covering all of the areas of the islands that had not yet been colonised (an area amounting to approximately 95% of the islands' terrestrial surface). Also founded in 1959 was the Charles Darwin Foundation (CDF) with headquarters in Brussels and a remit enshrined in a written agreement with the government of Ecuador, to carry out scientific research and provide advice to the national authorities on how best to conserve and manage the islands (CDF 1993). The inauguration of the Charles Darwin Research Station in 1964 signalled the start of conservation operations and the beginnings of a permanent infrastructure to support scientific investigation on the islands. It can also be seen as the start of an on-going phase of heightened international involvement in the governance of Galápagos (Grenier 2007).

Conservation challenges on Galápagos are often framed in terms of how best to balance the development needs of a growing human population with the isolation needs of the flora and fauna. The Galápagos economy has been growing rapidly over the past few decades (Kerr et al. 2004) as the result of a booming tourism industry (Taylor et al. 2003, 2006; Epler 2007), and there are fears that on-going immigration from mainland Ecuador in order to service the economy is 'continentalising' the islands through the creation of ever stronger transport and trade links to and between islands (Grenier 2008). These processes increase the risk of introduction of non-native and invasive species, whose potential to out-compete, predate upon, or infect already vulnerable native or endemic species has been labelled as the greatest threat to the biodiversity of the islands (Causton et al. 2006). As a result of these fears, in 1998, the Galápagos Special Law (GSL) was passed by the Ecuadorian government. The GSL granted special status to the province of Galápagos, and imposed strict migratory regulations in an attempt to curb population growth. It also lead to the founding of the inspection and quarantine service, Agrocalidad (formerly SESA-SICGAL) to limit the entry of non-native species, and founded the Galápagos Marine Reserve (GMR) to provide protection for an area of 40 nautical miles around the islands (Heylings and Bravo 2007). The Galápagos Special Law can be seen as the first attempt by the Ecuadorian government to deal with the problems facing Galápagos in their entirety (González et al. 2008). However, a decade later, the problems were felt to be persisting, and as a result, in 2007 the archipelago was placed on UNESCO's list of World Heritage in Danger[2].

Ever since Charles Darwin's visit aboard the HMS Beagle in 1835, science has occupied a central place in the international image of the islands as well as the local reality, and the islands are the site of an enormous and ever growing number of scientific investigations. A bibliographic analysis carried out by Santander (2007) suggests that there had been at least 4,884 publications about Galápagos up to 2007, of which 1,392 were scientific publications in high impact academic journals. Several authors have documented the various scientific endeavours that have taken place on Galápagos since the publication of Darwin's Origin of Species (e.g., Larson 2001; Quiroga 2009) and there have also been efforts to catalogue the scientific output from the islands by a number of people (Snell et al. 1996; Ospina and Falconi 2007; Santander 2007), as well as more critical texts regarding the links between particular types of science, conservation and tourism (Grenier 2007). These histories will not be summarised here, but for the purposes of illustrating the context of science on Galápagos today, a number of recent events and publications can be highlighted as particularly relevant.

Firstly, there is an increasing drive (in line with international trends) towards incorporating a human dimension within conservation's remit. This is manifest, for example, in the latest Galápagos park management plan (2006), which adopts for the first time the framework of Galápagos as a 'socio-ecological system' and maintains that "the future of the archipelago depends on the integration between the conservation of the ecosystems and sustainable development of the community that lives on the islands" (PNG 2006: 1). Related to this, there have been efforts to incorporate social sciences within scientific and conservation institutions and programmes. For example, in 2008, the Charles Darwin Foundation hired its former critic, Christophe Grenier, to lead the first ever social sciences department of the organisation.

There have also been various calls for changes to the ways that research is carried out. Thus for example, in 2006, the first strategic plan of the Charles Darwin Foundation suggested that as "research results have begun to affect policy decisions that have increasingly greater impact on the human population… the traditional method of research and management while successful in the early years is no longer appropriate" on Galápagos (CDF 2006: 16). Calls for changes to the nature and focus of research were reiterated again in 2009 in the National Park's publication *Ciencia para la Sostenibilidad* (*Science for sustainability*), which highlighted historical tendencies towards the production of 'pure' natural sciences, and called for 'new types of science' (Tapia et al. 2009a: 10) to be produced on Galápagos, and stressed the need for closer links between science and conservation management.

In the midst of these developments, the science sector on Galápagos is becoming more complex. Traditionally, the Charles Darwin Foundation was the dominant institution responsible for carrying out science, or facilitating science being carried out by international researchers, while the National Park was responsible for managing the protected areas; however, currently, the National Park is running approximately 45 investigation projects (Tapia pers. comm. 2010) and collaborating with a wide variety of national and international institutions. Furthermore, Ecuadorian institutions, such as the University of San Francisco in Quito, are rapidly developing their research programmes on the islands, evidenced by for example, the inauguration in 2011 of the University's new multi-million dollar science centre on the island of San Cristobal, part funded by the University of North Carolina at Chapel Hill. As one interviewee put it, in terms of science, "the CDF are no longer the only kid on the block." The increasing complexity of the science sector on Galápagos, with a growing number of institutions and individuals involved, and an ever increasing array of disciplinary approaches to research being employed, mean that there are arguably greater possibilities for miscommunication and conflict than ever. Simultaneously, in this changing context, interdisciplinary research and collaboration is increasingly being highlighted as being of crucial importance in rising to the challenges of conservation (e.g., Tapia et al 2009b: 161). There is thus a clear need for work that may help to facilitate this process.

MATERIALS AND METHODS

There are four distinct phases of data collection and analysis in a Q study: 1) a concourse of statements is developed and refined into a 'Q sample'; 2) a diverse range of purposively selected participants are asked to sort the statements in the Q sample along a scale of 'most like my point of view' to 'least like my point of view'; 3) the results are statistically analysed in order to allow the extraction of a number of 'typical' q sorts or 'factors' representing generalised opinions or discourses present in the population; and 4) the factors are interpreted using additional comments made by the participants and recorded at the time of carrying out the Q sorts.

Concourse development

A concourse can be defined as 'the volume of discussion' on a given topic (Brown 1986: 58). In this study, the volume of discussion is that which is related to science in conservation on Galápagos. A concourse would normally be expected to contain several 'discourses' or distinct "way[s] of seeing and talking about something" (Barry and Proops 1999: 338), and a Q study is interested in analysing a concourse and "resolving it into its component discourses" (Dryzek and Berejikian 1993: 87).

The concourse in this study was constructed through a 'semi-naturalistic approach' (Robbins and Krueger 2000), whereby opinion statements were gathered from a combination of document review and semi-structured interviews with scientists and conservation managers on Santa Cruz Island, Galápagos, between May and June 2010. Secondary sources included academic literature, grey literature (e.g., pamphlets, technical reports, annual reports, and management plans), websites of NGOs working in Galápagos, proceedings of events held by conservation NGOs, and clippings from the local and international press. The aim of this approach was to reveal the diversity of opinions about the topic of science in conservation on Galápagos. A total of 200 opinion statements made up the original concourse, written in both English and Spanish. At this point, the concourse was considered complete, as the addition of extra statements did not add any new opinions. In line with standard practice in Q methodology, some statements in the concourse were 'deliberately ambiguous' (Dryzek and Berejikian 1993: 51), or contained 'excess meaning' (Brown 1970, cited in Webler et al. 2009: 9). Given that participants are not being measured against an external scale imposed by the researcher, this ambiguity is not problematic as it would be in a questionnaire design. The statements themselves do not have just one objective meaning with which participants either agree or disagree. Rather, the participants put meaning into the statements as they sort them, and it is this subjective meaning that is of interest in Q method. Thus, statements act as stimuli to reveal the internal frames of reference of the participants, and the ways in which the participants interpret the statements is resolved and made comprehensible by the way in which they place them in relation to all the others, and by the comments made during sorting.

The concourse is subsequently refined down to a manageable number of statements (the Q sample) in order to be sorted by participants. As a rule of thumb, an appropriate size for a Q sample is between 20 and 60 statements (Webler et al. 2009: 15). There are two methods for reducing the concourse down to a manageable number for sorting—a structured method using a matrix design developed from existing theory (e.g., Dryzek and Berejikian 1993), or an unstructured approach that aims to search for themes that emerge from the concourse and uses these themes to ensure that the variability of the concourse is captured by the Q sample (e.g., Dayton 2000). Since this study was not aiming to test a particular theory, the latter approach was felt to be optimal.

The final Q sample was made up of 34 statements, written in Spanish or English, and a professional translator was used to translate the entire Q sample into both Spanish and English. The translations were then checked by a bilingual Galápagos resident in order to ensure that the language was appropriate to the Galápagos context. Finally, statements were printed on individual cards in both Spanish and English.

Selection of participants

Participants for a Q study are not randomly sampled from a population, but are deliberately chosen for their relevance to the topic in question (Brown 1980). The most important principle of participant selection is diversity of opinion; however, it is also important that the participants are familiar with the topic and have 'well formed opinions' (Webler et al. 2009: 9). In general, the number of participants in a Q study ranges from 20 to 40 individuals (Brown 1980), but Q studies have been shown to yield results with as few as 12 participants (Barry and Proops 1999). The author's existing knowledge of the science and conservation sectors in Galápagos was complemented by the ethnography of Ospina (2004) in order to identify potential participants. In addition, a 'snowballing' approach was adopted whereby participants were asked to identify other possible recruits with opinions that might vary from their own. In total, 27 individuals completed Q sorts on the islands of Santa Cruz and San Cristobal, Galápagos, between June and July 2010. Table 1 gives a list of the institutional affiliations of the participants. No claim can be made that the subjects who participate in a Q study are statistically representative of the population at large, but this is not the aim of a Q study. Instead, in so far as the concourse is 'representative' of the breadth of opinion on the topic, each factor described should "prove a genuine representation of that discourse as it exists within a larger population" (Dryzek and Berejikian 1993: 52). Thus, although it cannot be asserted that the factors uncovered by this study are the only viewpoints that exist on the topic, the discovery of factors other than those described (for example through the participation of an additional individual with a unique point of view) will "in no way influence description" of the existing factors (Brown 1980: 67, cited in Addams and Proops 2000: 34).

Completion of the Q sorts

Participants were asked to sort the statements in the Q sample into a grid with the form of a quasi-normal distribution (from -4 to +4) according to the following sorting instruction: "Please sort the cards onto the chart according to how like or unlike they are to your own point of view, with +4 being most like your point of view and -4 being least like your point of view."

The distribution chart is shown in Figure 1. The imposition of a forced normal distribution is the preferred approach in Q studies as it encourages participants to reveal their preferences more thoughtfully (Webler et al. 2009: 19). However, it should be noted that the imposition of a normal distribution is not necessary for the technique to work, having no noticeable

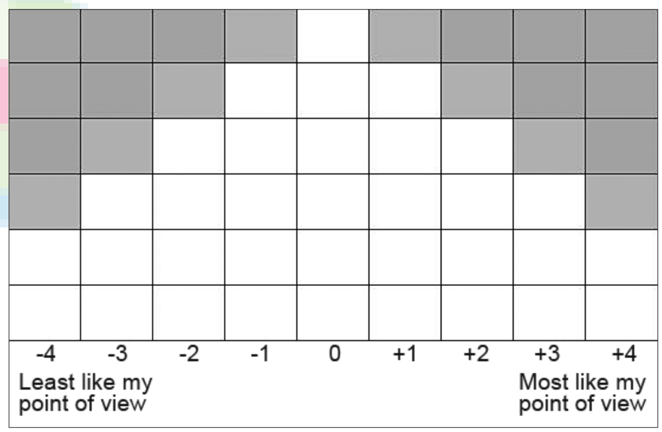

Figure 1
Distribution chart onto which participants ranked the opinion statements

Table 1
Institutional affiliations of the participants

Institution	Number of participants
Parque Nacional Galápagos	5
Fundación Charles Darwin	10
FUNDAR Galápagos	1
Conservación Internacional Galápagos	1
Universidad San Francisco de Quito	2
Universidad Andina Simón Bolívar	1
Pontificia Universidad Católica del Ecuador	1
Motu (New Zealand)	1
Universidad de Missouri – St. Louis (USA)	1
Instituto Mediterráneo para estudios avanzados IMEDEA (Spain)	1
No institutional affiliation	2
Total	**27**

effect on the factors resulting from a study (Brown 1971). The majority of the Q sorts were carried out face-to-face in a recorded interview process lasting between 30 minutes and one hour, during which participants were encouraged to 'think aloud' and to comment on the rationale behind the positioning of particular statements as they sorted them. In four of the 27 cases, where a face-to-face interview was impossible, participants were sent a copy of the Q cards to carry out the sort in their own time, and a comments sheet was provided to allow them to elaborate on the reasoning behind the positioning of any of the cards. The transcripts of the interviews and comments from the postal participants were subsequently used to aid interpretation of the discourses emerging from the statistical analysis, in an effort to minimise researcher bias (Gallagher and Porock 2010).

Statistical analysis

The resulting 27 sorts were factor analysed using the free software package PQmethod 2.11 (Schmolck 2002) specifically designed for the analysis of data from Q studies. Principal Component Analysis was carried out on the 27 x 27 matrix of statement responses, and the resulting factors were rotated using a varimax rotation that aimed to find the simplest structure in the data that explained the greatest amount of variance, and to rotate the factors such that each individual tended to be associated with just one factor.

Within Q method, there is not necessarily one 'objectively correct' or 'mathematically superior' final solution regarding the number of factors that emerge from the analysis (Watts and Stenner 2005: 80), and the final solution also needs to consider the criteria of simplicity, clarity, distinctness, and stability (Webler et al. 2009: 31). In this study, a solution was sought which aimed to maximise the variance explained, and the number of participants whose sorts correlated significantly with just one factor, minimise the number of 'confounders' (participants whose sorts correlated with more than one factor) or 'non-loaders' (participants whose sorts did not correlate with any factor), and ensure that each factor contained at least two sorts that correlated with that factor alone (Watts and Stenner 2005: 81). Based on these criteria, a four factor solution was felt to be optimum.

Individuals whose sorts correlate significantly with a given factor are called loaders[3], and the weighted average of the loaders' sort patterns for a particular factor are used to calculate an idealised sorting pattern for that factor along the original response scale (i.e., -4 to +4). The idealised sorts for each factor are illustrated in Table 2.

Table 3 gives details of the correlation between factors, the percentage variance explained by each factor, and number of sorts loading on each factor alone at $P < 0.01$. The degree to which each participant's sort was correlated with each factor is given in Table 4. It is important to note that while Q method is searching for the underlying patterns of understanding, as Table 4 shows, each individual will usually hold "aspects of several discourses in varying degrees" (Addams and Proops 2000: 33).

RESULTS

The following narrative descriptions are based on the distinguishing statements for each factor that emerged from the statistical analysis, i.e., those statements whose positioning by one factor was significantly different to one or more of the other factors (at the $P < 0.05$ or 95% confidence level). A more detailed interpretation and discussion of the differences revealed by the factors will be given in the following section. The numbers in square brackets in the factor descriptions refer to the number of the statement on which the analysis is based (see Table 2). Quotes are from interviews with participants who loaded significantly on that factor, and those marked with an asterisk [*] have been translated from the original Spanish.

Factor 1: Science for management

This perspective considers that research priorities on Galápagos should be clearly tied to conservation management needs [11], which should be put before the needs of scientists. As one Ecuadorian researcher for a conservation NGO put it: "Take away the interests of the scientists. Some scientists are just interested in publishing."* This viewpoint is optimistic about the contribution of science to the development of conservation policies [28] and considers that there is thus a need for more science of all types on Galápagos [9, 10, 22]: "You are never going to finish investigating a place, new things come up all the time."* Proponents of this view believe that in order to ensure it meets conservation needs, science should be closely controlled by an institution such as the National Park [23]. Conservation management and scientific research are considered similar tasks and should be carried out together [19]. Galápagos is conceived of as an 'integrated socio-ecological system' whose societies and ecosystems should be managed as one, by experts with recourse to the best available scientific and technical data [8]. In line with this understanding, the responsibilities of science and scientists are understood in a broad way, encompassing such activities as 'working out ways of building an island culture of conservation' on Galápagos [5]. Statements regarding the line between political advocacy and science [3], and whether or not scientists should 'voice opinions' about conservation issues [15] received neither strongly positive nor strongly negative scores for this factor.

Factor 2: Freedom of science

From this perspective, science is considered to be 'like art', requiring freedom if its full creative potential is to be realised [14]. The distinction between pure and applied science is felt to be unhelpful: "You never know when pure science becomes applied, most of the great findings start usually with pure science, and then you find out, wow this is going to help me with doing something." Thus there is only really 'good science and bad science' [17]. Proponents of this view are in mild disagreement with the idea that research priorities of science on Galápagos should be beyond the research interests of individuals or

Table 2

Statements that made up the Q sample with idealised sort patterns for each of the four factors. Factor scores are given in terms of the original sorting scale (-4 to +4)

Statement	Idealised sort patterns for each factor			
	1	2	3	4
1. A disciplinary approach to science focusing only on the threatened and endangered species and problems with the natural ecosystems of Galápagos is no longer appropriate on Galápagos.	0	-1	4	3
2. The solution to many of Galápagos' problems lie in the application of scientific investigation.	2	2	0	-1
3. Getting involved in politics threatens the reputation and legitimacy of scientists as providers of objective facts—scientists on Galápagos should focus on providing facts about the archipelago and leave the advocacy work to campaigning organisations like Sea Shepherd.	0	-1	-2	2
4. It doesn't matter who does the science as long as what's being done is high quality and useful to conservation.	4	3	0	4
5. We (scientists) need to be working out ways of building an island culture of conservation on Galápagos.	2	0	0	-2
6. People are the worst invasive species in Galápagos.	1	2	-3	0
7. We already know what the problems are—we don't need to do any more science, what's lacking is the political will to make changes.	-2	-3	2	-1
8. Ecosystems and societies should be conceptualised and managed as a single, integrated unit, a socio-ecological system.	2	0	-2	2
9. Despite the large amount of research that has been carried out on Galápagos, there are still big gaps in some areas of basic biology and ecology, and it is crucial that scientists continue to work to fill these gaps.	3	4	0	2
10. More social science would be useful on Galápagos but only as long as it helps to provide practical knowledge and suggestions to deal with particular problems.	1	1	0	0
11. Research priorities of science on Galápagos should be beyond the research interests of individuals or institutions and favour investigations that are directed to solving the most urgent management and conservation problems.	3	-1	1	1
12. My primary motivation for doing science here is that there are things here that you can't study anywhere else.	0	0	-1	-2
13. The scientists need to do their work, they aren´t the Department of Social Services, there are other institutions whose role it is to take care of the community.	-1	1	-1	2
14. Science to me is a little bit like art, and in order to be a good scientist you need to be creative. People will only be creative if they have a certain liberty to do what they enjoy and what they want.	0	4	2	1
15. I think we scientists should voice our opinions, take an active interest and play a political role in steering conservation policy.	1	-1	2	-2
16. One of the main weaknesses of a lot of the science that's being carried out here is that it's not communicated to decision makers and managers.	1	0	3	4
17. I don´t like the distinction between pure and applied science. I actually think there are only two types of science, good science and bad science, and all good science can be transferred to the decision makers if it's put in the right context.	-1	3	3	-1
18. Trying to play the roles of scientist and conservationist at the same time is a contradiction.	-3	-2	-2	1
19. Conservation management and scientific research really are different tasks, and trying to carry out both together is not possible.	-4	-2	-1	-4
20. The Darwin Foundation needs to become a social development organisation, otherwise it will become irrelevant.	-3	-4	-3	-4
21. The practise of science here should be geared towards improving life for the people who live here.	-1	-4	1	0
22. I don´t think the Ecuadorian government should be spending money on pure research in Galápagos.	-4	-3	-1	-2
23. The park needs to have control over the science that is carried out on Galápagos.	3	-2	-1	-3
24. At the end of the day, the opinions of the owners of the big tour companies count much more to the Ecuadorian government than those of a scientist or even a scientific institution.	0	2	4	3
25. Developing collaborations with international experts in conservation science is vital to building a sustainable Galápagos.	2	2	1	3
26. Different elements of the Galápagos human-ecosystem can be quantified in terms of capital: natural capital, socio-economic capital, cultural capital, etc. Their flows and interactions can thus be modelled in order to provide integrated information to managers and decision makers, and to steer research priorities.	1	1	-3	1
27. Researchers play an important role in Galápagos: they have the responsibility not only to practice what they preach but also to provide integrated and complete information to decision makers.	4	3	3	1
28. The idea that scientific data is the basis for policy making is simply not true.	-3	0	1	0
29. ¨Ecologism" is the new colonialism of the 21st century.	-1	-2	-2	-3
30. These islands are too important to be left in the hands of Ecuador alone: external NGOs, scientists and the international community have to assume some responsibility.	0	1	1	0

Table 2

Contd...

Statement	Idealised sort patterns for each factor			
	1	2	3	4
31. One of the main reasons that I work here is just because it's Galápagos, and I think that plays a large role in why many scientists are here.	-2	1	0	-1
32. It is the role of the scientists to find ways of reducing the loss of diversity (be it biological or cultural) or to encourage the creation of new diversity.	-1	0	2	-1
33. Science shouldn´t be driven by gringos coming down and telling the Ecuadorians what to do.	-2	-1	-4	0
34. Really, I´m quite oblivious to the political issues, I just want to focus on my scientific work.	-2	-3	-4	-3

institutions and favour investigations that are directed to solving the most urgent management and conservation problems[11]. Thus, several participants who loaded on this factor pointed out that if science had been constrained by management priorities in 1835, "Charles Darwin wouldn't have done the work he did." This view is also in mild disagreement with statement [1], suggesting that this factor believes that the traditional disciplinary approach to science focusing on the threatened and endangered species and problems with the natural ecosystems of Galápagos continues to be appropriate on Galápagos. Despite the large amount of research already carried out, this view maintains that there is still a lot to be done on Galápagos [9, 7]. This perspective appears cautious about scientists 'voicing opinions' on conservation issues [15], in the words of a participant: "When scientists start to give opinions it's total chaos… and trying to produce conservation policies, even worse!"*. Similarly, it is not the role of science or scientists to be 'improving the lives of people' who live on Galápagos [21]. This view is neutral or perhaps unfamiliar with the idea of humans and ecosystems conceptualised as an integrated 'socio-ecological system' [8], as one participant put it, "I don't understand what they mean by socio-ecological system, show me a socio-ecological system, I don't know, does it exist?"* Or in the words of another, "I don't think so, I think they should be kept separate." In fact, from this perspective, far from being considered as integrated in the ecosystem, people are (to a modest extent) considered as an 'invasive species' on Galápagos [6].

Factor 3: Limitations of science

This perspective is more cynical about the power of scientific data to have an effect on policy for conservation [24, 28]. According to this view, it is not science that is lacking, but the political will to make the necessary changes, thus more science on Galápagos is not really considered necessary [7, 9]. However, better communication of existing science is important [16]. The traditional disciplinary approach to science focusing on threatened and endangered species is considered inappropriate and ineffective on Galápagos today [1], and although the distinction between 'pure' and 'applied' science is felt to be false [17], this perspective agrees with the idea that scientists should be focusing on finding ways to reduce loss of diversity, both biological and cultural [32]. From this

Table 3

Factor correlations, % variance explained by each factor, and number of sorts loading on each factor alone

	1	2	3	4	% variance explained	Number of sorts loading on this factor alone at $P<0.01$
1	1.00	0.53	0.27	0.52	20	9
2		1.00	0.32	0.46	17	6
3			1.00	0.40	12	4
4				1.00	10	4

point of view, according to one participant, science should be "at the service of humanity, of its wellbeing, the development of its greatest potential". This perspective is also defined by its opposition to certain concepts, including: the quantification of different elements of Galápagos in terms of capital [26]: "It's intellectually satisfying, these models with arrows and numbers ... but where are the power relations, where are the lifestyles?"*; the idea of the Galápagos as a 'socio-ecological system' [8]: "Societies are not embedded in nature, not explainable nor managed by 'natural laws'"; and the idea that humans are an invasive species [6]: "That has a lot of implications for how you perceive people and our role on the planet and I don't agree with those implications."

Factor 4: Separation of science and conservation

While all the other perspectives appear to consider the roles of scientist and conservationist as complimentary, proponents of this view are mildly positive for statement [18], suggesting that they may feel a contradiction between the roles. In the words of one participant, the role of a conservationist is understood as "more activist maybe...more political", which is considered different from that of a scientist as a provider of 'objective facts'. Thus, scientists shouldn't be voicing opinions [15], and doing so in political forums threatens the legitimacy of science [3]. As one participant put it, "I'm not a conservationist, I'm a scientist...a pragmatist. I have to be that way otherwise it just gets too confusing my role in life." One of the main weaknesses of science on Galápagos is not whether there is an appropriate balance between so-called 'pure' or 'applied' investigations, but that all science is currently not communicated effectively to decision makers [16]. Thus, this perspective only agreed mildly with statement [27] regarding the important role played

Table 4
Loading of participants on each factor

Professional/disciplinary self identification and institutional affiliation of participants	Nationality (Local/ international)	Degree of correlation with each factor			
		1	2	3	4
Factor 1					
Ecologist (INGO)	Local	0.5655*	0.3512	0.0429	0.1594
GNP biologist	Local	0.6914*	0.1878	0.2112	-0.1313
GNP Conservation manager	Local	0.8526*	0.1551	-0.0063	0.0139
Botanist (INGO)	Local	0.5757*	0.3117	0.0256	0.0828
GNP biologist	Local	0.5448*	0.2619	-0.1676	0.1335
GNP conservation manager	Local	0.7633*	0.1736	0.0686	0.3525
GNP ecologist	Local	0.7779*	-0.0505	0.1888	0.3050
Conservation professional (INGO)	Local	0.6916*	-0.1010	0.1037	0.0284
Visiting scientist (biology), Ecuadorian university.	International	0.4903*	0.3521	0.2763	0.3858
Factor 2					
Ecologist (INGO)	Local	0.0773	0.6899*	-0.3822	0.1313
Independent hydro-geologist	International	0.0844	0.5303*	0.0994	0.1265
Ecologist (INGO)	International	0.0712	0.8045*	0.1135	0.2513
Visiting scientist (social science), Ecuadorian university	Local	0.0989	0.5791*	0.3278	0.0716
Visiting scientist (ecology), Ecuadorian university	Local	0.2883	0.7221*	0.2638	-0.2383
Visiting scientist (ecology), international university (P)	International	0.1316	0.6976*	-0.1462	0.2031
Factor 3					
Social scientist (INGO)	International	0.0145	0.0908	0.7749*	0.1555
Social scientist (INGO)	International	0.1397	0.0587	0.7464*	-0.0813
Visiting scientist (social science), Ecuadorian university (P)	Local	0.3431	0.1164	0.6032*	0.1440
Visiting scientist (social sciences), international university	International	-0.1597	0.0152	0.7589*	0.3641
Factor 4					
Ecologist (INGO)	International	0.0290	0.3652	0.2376	0.5178*
Conservation professional (INGO) (P)	International	0.3255	0.0590	0.3544	0.4977*
Visiting scientist (ecology), international university	International	0.0965	0.0028	0.2891	0.6385*
Conservation professional (local NGO)	Local	0.1366	0.3990	-0.0904	0.6966*
Participants loading on more than one factor					
Ecologist (INGO)	International	0.4994*	0.6690*	0.1589	-0.0008
Biologist (INGO)	International	0.3374	0.5503*	0.5196*	0.2704
Conservation professional (INGO)	Local	0.5537*	0.0561	0.0521	0.5702*
Visiting scientist (biology), international university (P)	International	0.6073*	0.4945*	0.2082	-0.2230

*Indicates that a sort loads significantly at the $P < 0.01$ level; (P) indicates an individual who carried out a postal Q sort

by researchers on Galápagos, as one participant commented: "They [scientists] should be playing an important role, but right now they're not." It is not the role of scientists to be trying to create culture [5]: "I agree there is a need for island culture... [but] what role does science have in that?" The zero score given to statement [33] (in contrast to the negative score this statement was awarded by the other factors) and to statement [30] suggest that proponents of this view are relatively more uncomfortable with some of the political implications of the levels of international involvement on Galápagos. As one participant put it: "What other place in the world are we going to have some foreign institution telling us what to do? Of course not, we're going to use our local people you know?"

DISCUSSION

Understanding different views of/in science

In the conflicting social contexts that characterise many areas of conservation concern, it is common for researchers to examine and expect to find deep-seated differences between more evidently conflicting interest groups such as 'fishermen', 'developers' or 'environmentalists' (e.g., Marshall et al. 2007). However, this study turns the lens of investigation toward an apparently more homogenous group—scientists and conservation managers utilising science—in order to examine internal differences and tensions between alternative perspectives within this group, and consider the implications of these differences for conservation.

One of the central debates that emerged from this analysis concerned the nature and relative worth of so-called 'pure' or 'applied' science. However, this debate is by no means new, or unique to Galápagos. Roger Pielke (2007) traces the divide back to the late nineteenth century, during which time there was a strong sense in the scientific community that the pursuit of knowledge for knowledge's sake represented the 'higher calling' of the scientist, a view which conflicted with the priorities of policy makers who were almost exclusively focused on whether practical benefits emanated from scientific discoveries. This 'pure science ideal' (Daniels 1967) has been, and remains, an influential construct in western views of science. Likewise, conflict between this ideal and management or policy needs, was described more than 40 years ago by Daniels, who points out:

> [t]he pure science ideal demands that science be as thoroughly separated from the political as it is from the religious or utilitarian. Democratic politics demands that no expenditure of public funds be separate from political...accountability. With such diametrically opposed assumptions, a conflict is inevitable (Daniels 1967: 1704, cited in Pielke 2007: 90).

In the factors emerging from this study, the pure science ideal can most easily be mapped onto factor 2 (Freedom of science), while the view emphasising the need for science to serve policy needs can most easily be mapped onto factor 1 (Science for management). A factor 2 participant for example referred to 'individuality, initiative, and creativity' as the "most important parts of a scientific investigation", and several participants loading on factor 2 also cited Charles Darwin (the embodiment of the pure science ideal as well as one of the main reasons for Galápagos' fame) in order to rebuff perceived charges of irrelevance coming from management circles. On the other hand, a factor 1 participant working to investigate invasive wasps vocalised his frustration with pure science by characterising the problem thus: "Pure scientists would investigate why wasps are yellow, what good is that to me? Knowing why they're yellow doesn't help me figure out what to do with them!"* However neither these caricatures, nor the implication that the differences within the scientific community on Galápagos are understandable as a straightforward pure versus applied science debate are entirely accurate. In order to understand the various nuanced ways in which perspectives towards science on Galápagos differ, a brief examination of the science-policy literature is necessary.

Following the Second World War, in an influential report to the US president entitled *Science: The endless frontier*, Bush (1945) emphasised the way in which all research could be potentially useful to society, and maintained that therefore governmental support for pure or 'basic' research should be a priority, and scientists should be free from political accountability. Not only did this view reinforce the pure science ideal, but also made concrete a 'linear model' view of the relationship between science and policy, namely that pure or basic research leads to applied research which results in societal benefits. Although this view is still prominent in society today, it has been extensively argued to be misleading and incomplete on a number of levels. Pielke (2007) argues that this view of science builds an assumption that "achieving agreement on scientific knowledge is a pre-requisite for a political consensus to be reached and then policy action to occur", or in stronger form that "specific knowledge or facts compel certain policy responses" (2007: 13). According to Pielke, this is a fundamentally flawed view of the relationship between science and policy, which conflates two distinct types of inquiry: questions which can be answered with facts, and questions about what should be done about these facts. The latter are policy questions, and are resolved through political processes of negotiation about desired outcomes, which in turn depend on particular social values. It is therefore a mistake to conflate a reduction in scientific uncertainty with a reduction in political uncertainty, a vision that has been labelled a technocracy (Jasanoff 1990), and is visible in attempts to consider policy making as a technical exercise with a minimal need for political debate (e.g., Weingart 1999). In the majority of cases, scientific facts cannot overcome, and may even exacerbate or reinforce value or interest differences. As Daniel Sarewitz points out, the richness and diversity of nature, coupled with the wide variety of methodological and disciplinary lenses for investigating it, mean that science produces a diverse "proliferation of facts...in ways that can legitimately support, and are causally indistinguishable from, a range of competing value-based political positions" (2004: 386).

Furthermore, aside from the flawed conflation of scientific and political uncertainty supposed by technocratic arguments, the vision of science implied by technocracy is also vulnerable to critique: i.e., the idea of scientific knowledge as an unproblematic source of objectivity and political neutrality, and of the practice of science as separate from its social or institutional context, has been challenged on a number of fronts since the 1960s (e.g., Ravetz 1971; Bloor 1976; Barnes and Edge 1982; Gieryn 1983; Latour 1987; Haraway 1991; Collins et al. 1993; Jasanoff 1995).

Despite these critiques, this view of science is still widespread, and within this study, factors 1, 2, and 4 all appear to support a linear view of science's relation to policy. In particular, factor 1, with its focus on the need for more science for management, embodies a particularly technocratic view of policy making. This could partly be explained by reference to the Galápagos National Park Management Plan, in which these concepts are also very much in evidence:

> Only through scientific knowledge...can we attain a sustainable use of the goods and services, of the natural capital of Galápagos and at the same time ensure the conservation of the islands' biodiversity (PNG 2006: 254).

Here, it is apparent that science is considered key to decision making about sustainability, with the implication that an increase in scientific knowledge will clarify desired outcomes (presumably by leading to a decrease in political uncertainty or value conflicts). Clearly, scientific input to certain decisions is unquestionably important in many cases, but this linear view of science and policy which posits science as the basis for decision making may run the risk that questions of science "end up serving as a surrogate polemic for the inability (or unwillingness) of decision makers to adjudicate unpleasant value and preference tradeoffs" (Lackey 2007: 11).

The results of a linear conception of the relationship between science and policy is evident in the following quote from a visiting scientist with several decades of experience working on Galápagos who loaded on factor 1: "If you have scientific data, and data you can indicate, okay species X should not be exploited any more and that is scientific data, then that is the basis, politics has to change and go over to conservation, right?" Here, scientific data is assumed to compel a particular policy outcome. In this instance, it is clear that the speaker is conflating factual and normative statements, science is claimed to be able to dictate that a species 'should not' be exploited, not just that it is declining or endangered. This is an example of what Pielke (2007) would call 'stealth advocacy', or what Lackey (2007) would call an inappropriate blending of science and advocacy.

Factor 2's emphasis on the importance of freedom of science is also consistent with a linear view of the relationship between science and policy, but in this view, science is portrayed more as "the upstream end of a one way process by which useful discoveries and inventions eventually 'flow' to an application home" (Roux et al. 2006: 16). As this quote from a factor 2 participant reveals: "You never know when pure science becomes applied, and most of the great findings start usually with pure science, and then you find out, wow, this is going to help me with doing something." However, this factor appears more aware than factor 1 of the limitations of science, as one participant expressed: "A common vision of where to go with Galápagos cannot be built only on the results of science, and managers should not always blame the scientists because of the divergent nature of the problem."

Factor 4 is also perhaps more conscious than factor 1 of the pitfalls of conflating scientific arguments with policy preferences, and keen to point out that providing scientific data is just one part of a decision making process, not the only factor: "I just come in and say my piece and you know, try not to put my natural human tendencies to put an emotive layer in it, and people respect me for it. And then they can take it or leave it."

Factor 3's conception of the nature of science in policy is different again:

> I completely reject any suggestion that science can remain politically neutral, but I also reject the idea that 'science' or the scientists should decide the fate of Galápagos. Scientists need to play a political role, not to substitute for the community, but as one more part of the community.

Here, science appears to be understood as inescapably part of the political process (remaining unengaged in politics is not an option), however the speaker also appears to suggest a more humble role for scientists, whose contributions to the political debate, while valuable, cannot substitute for the debate itself. Thus, factor 3 can be understood as a rejection of the technocratic position outlined above, and in fact defines itself in strong opposition to the idea that "the problem of Galápagos is that there's too much politics and not enough science in decision making about the future of the islands." This view is more in line with Pielke who points out that "in situations of political conflict about the means or ends that a policy is to achieve, politics will always and necessarily 'trump' science simply because science does not compel action" (Pielke 2007: 35).

Different understandings of the boundary between science and conservation

The various different views of the relation of science to policy outlined above are further complicated by divergent understandings of conservation itself. Depending on the particular view that is taken of conservation, a blending of the roles of scientist and conservationist is seen as more or less problematic. For example, several respondents who loaded on factors 1, 2, and 3 referred to conservation or 'being conservationist' as a lifestyle choice, with little or no political component. Thus, a factor 1 participant defined being conservationist in very general terms as "not throwing litter, saving energy, looking after the environment, being considerate with other people."* With this apolitical take on conservation, it is easy to understand the view espoused by a factor 3 participant, that "everyone, not just scientists, should be conservationists." However, for other individuals (notably those loading on factor 4), conservation is considered an inherently political activity, more akin to political activism than green lifestyle choices. Here, a strict division between the roles is felt to be necessary to maintain the legitimacy of science and to avoid bias within investigations. As one participant put it responding to statement 27:

> If an investigator discovers that sea cucumber can be fished, and that there's no problem, they have to say it. But if they're an activist as well, there's a bias… an ideal investigator... doesn't have to practice what they preach because they don't preach anything, they just inform.

Similarly, another factor 4 participant highlights:

> [T]he thing we try and say is the Charles Darwin Foundation isn't, we're not a conservation agency, we're a science agency. You know, CI or WWF play advocacy roles and often roles in politics, whereas our role is to provide information, you know, scientific based information, that´s it... It's just not an advocacy role.

However, despite efforts by certain individuals and institutions to maintain a separation, the boundary between the two concepts is intrinsically blurred, not least because the mandate of the Charles Darwin Foundation is to "provide knowledge and assistance through scientific research...to ensure conservation of the Galápagos islands" (CDF 2006: 9; Author emphasis). As Sheila Jasanoff has illustrated in her detailed examinations of scientific advisers and the policy making processes in the US, in practice it is unrealistic to assume that the subjective values of scientists play no part in decision making, and furthermore, the advisory process itself is appears "increasingly important as a locus for negotiating scientific differences that have political weight" (Jasanoff 1990: 249). Maintaining this separation therefore requires constant 'boundary work' (Gieryn 1983) by scientists in order to try and distinguish real science from non-science or conservation, and furthermore, to communicate the difference to a community that quite reasonably associate the two.

Different understandings of humans in ecosystems and resulting disciplinary frameworks

Linked to the diversity of views of conservation that emerged, a variety of different perspectives towards humans and ecosystems was also evident from the analysis, and exploring these can be revealing of different perspectives towards science. For example, a concept that has been influential on Galápagos in recent years has been that of Galápagos as an integrated 'socio-ecological system' (Berkes et al. 1998; González et al. 2008). This concept was one of the defining frameworks for the development of the 2006 Galápagos Park Management Plan. Viewed through this lens, Galápagos is: "an ecological system that is linked to and interacts with a social system, which can be subdivided into a series of social subsystems with particular characteristics that self organise on each of the four populated islands" (PNG 2006: 44). The application of this concept was felt to be appropriate, given that all of the conservation problems facing the National Park were understood to emanate from the populated areas, and thus a framework focusing solely on the protected areas and not encompassing the people was seen to miss the point. However, the application of this framework has been controversial, and goes to the heart of another division within the scientific community on Galápagos, namely the natural/social sciences divide. Again, this conflict is not unique to Galápagos, and conservation managers and academics from various disciplines have been struggling with the challenges of interdisciplinarity in conservation for many years (Norgaard 1992; Mascia et al. 2003; Brosius 2006), often leading to what Mulder and Coppolillo call "predictable and deeply engraved interdisciplinary skirmishes" (2005: 50).

Ironically, the application of the socio-ecological system model to Galápagos has been criticised from both camps. For example, Matthias Wolff, head of Marine Sciences at the FCD, suggests that the application of this framework (which he considers to be advocated by the 'social science realm') is linked to a suggestion that the science that natural scientists on Galápagos have been providing for years is not sufficient to confront the problems of Galápagos. The problem, according to Wolff, is not that the science is or has been inadequate, but that science (whether the 'traditional natural sciences' or a 'more modern holistic science approach') alone cannot solve all the problems facing Galápagos (Wolff pers. comm. 2010). On the other side, certain social scientists (most notably Christophe Grenier, head of social sciences also at the FCD) have suggested that the socio-ecological system model represents an effort by natural scientists to 'do social science', meanwhile ignoring the vast corpus of previous human-environment research in the social sciences, that by subsuming societies into natural systems and attempting to study them with the tools of natural sciences, is 'not good science', and furthermore, represents a 'slide back towards an early twentieth century environmental determinism' that has long been refuted in most social science circles (Grenier pers. comm. 2010). Meanwhile, however, the framework continues to be influential, being the "unit of planning and management of the archipelago of Galápagos" (PNG 2006: 46), as well as the guiding framework for the types of scientific investigations prioritised by the Galápagos National Park. With regard to the factors emerging from this study, the divisive nature of the socio-ecosystem concept is clearly visible, being accepted by factors 1 and 4, rejected by factor 3, and neither strongly positive nor negative for factor 2.

Another powerful and divisive concept on Galápagos is the idea of humans as an 'invasive species', an opinion that defines factor 2 and with which factor 1 was also in agreement.

Several attempts were made by individuals to justify the categorisation of humans on Galápagos as invasive in purely scientific or technical terms. For example, this factor 2 participant: "[f]rom a technical standpoint they are an invasive species, they came to Galápagos un-naturally… You know, we used mechanical means to come here, we didn't come only with the wind or only with the current." Aside from any other critique, this statement is somewhat ironic given the fact that the discoverer of the Galápagos Islands, Tomas de Berlanga, did in fact arrive on the islands carried by the currents, arriving purely by chance when his ship drifted off course in 1535 (Larson 2001: 21). These attempts to define humanity's presence on Galápagos in scientific terms as 'invasive' are akin to attempts to use purely scientific criteria to delineate the bounds between 'nature' and 'culture', a Western dualism which is far from universal as numerous anthropological works have shown (e.g., Smith 1996; Egri 1999; West 2006). In fact, 'nature', which has been called the "most complex word in the English language" (Williams 1976), consistently resists universal definition, and within social science circles is widely understood as being more akin to a social category or construct, like 'art' or 'morality' (Lukacs 1986; Procter 1998), a "complex web of ideas that expresses the views of a society" (Takacs 1996: 103). Claims to define humanity as 'invasive' using purely scientific arguments can thus be read as appeals to 'nature' in order to support a particular historically and culturally specific view of what the Galápagos (or the world) should look like, without appreciating that there is "no single un-interpreted nature capable of putting an end to political dispute" (Dryzek 1997: 12). With regard to Galápagos, the argument that maintenance of 'naturalness' should be the end goal of conservation has been critiqued by Grenier (2007: 339), who points out that considerable human effort and conservation interventions have already been required to effectively 're-wild' Galápagos, and that the islands are thus already profoundly humanised. Ospina (2000: 8) summarises the argument by asking what the real difference in 'naturalness' is between species which required human intervention in order to colonise the islands, and those which require human intervention in order to continue inhabiting the islands, i.e., to be conserved.

The problematic nature of appeals to scientific definitions of 'naturalness' is further evident in resulting claims that (as well as being profoundly misanthropic) are also extremely difficult to defend rationally. For example, one participant who argued that humanity's invasiveness was a question of scientific fact due to the fact that humanity has modified ecosystems wherever 'it' went, ended up arguing that therefore, "strictly speaking", the only place in which it would be possible to say that humans weren't invasive was where modern *Homo sapiens* had first evolved in central Africa.

CONCLUSION

This study answers calls for research into the "cultures of diverse scholarly disciplines and the way they frame the worldviews of research practitioners" (Head et al. 2005: 10) by attempting to shed light on the diverse perspectives on the role of science in conservation currently present within the scientific and conservation practice communities on Galápagos. The results illustrate a range of divergent views of the nature of both science and conservation and the boundaries between them, and show that despite concerted efforts by certain groups, it is difficult or impossible to draw an unproblematic and universally accepted line between the conservation and science sectors on Galápagos. Not only is there considerable diversity of opinion as to the role of science in conservation and in policy making more generally, there are also divergent views about exactly what conservation is, based on deeply entrenched differences regarding conceptualisations of humans and nature.

While the debate between the 'pure' scientists on the one hand and 'managers' on the other is clearly present and influential in Galápagos, it would be overly simplistic to describe the situation solely in these terms, and this study has put forward Q methodology as a tool to provide a more detailed and richer account of the characteristics of science and conservation on Galápagos as it is understood by those practicing both science and conservation on the islands. By critically examining the structure of the perspectives that emerged from analysis, it is hoped that the results will contribute to greater self-awareness between proponents of the various views and thus facilitate more meaningful dialogue and interdisciplinary collaboration in conservation.

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Notes

1. Figures from the 2006 census available to download from the website of the Instituto Nacional de Estadística y Censos (http://www.inec.gov.ec).
2. In a controversial decision, the islands were removed from the in danger list by UNESCO in July 2010.
3. Sorts loading at > ±0.44 on a given factor were considered significant at the $P<0.01$ level. This was based on the equation: $2.58(1/\sqrt{n})$, where n=the number of statements in the Q sample: $2.58(1/\sqrt{34}) = 0.44$ (for statistical details see Brown 1980: 283).

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