A critical examination of the scientific credentials of Marine Protected Areas: sound science or a leap of faith?

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A critical examination of the scientific credentials of Marine Protected Areas: sound science or a leap of faith?

Alex J. Caveen

Supervisors: Nicholas V.C. Polunin, Selina M. Stead and Tim S. Gray

Abstract

Marine Protected Areas (MPAs) have been widely advocated as a tool to protect marine species and habitats and also as a precautionary measure to prevent overfishing. This thesis attempts to do two things: 1) explain the emergence of MPAs in international and national polices by applying three policy network models – the epistemic community, advocacy coalition, and discourse coalition; and 2) discuss the scientific and normative debates surrounding the designation of MPAs in England. In essence it is a critical analysis of how the natural science of MPAs has been produced, interpreted and applied to inform marine planning. The recurring argument throughout this thesis is that advocacy from scientists for MPAs, particularly no-take marine reserves (NMRs) on the basis of their benefits to fisheries, has caused the science-policy boundary to blur.

Chapters 3 and 4 examine the social context in which science on MPAs has been produced. Chapter 3 applies social network analysis to study co-author relationships in the MPA literature, and also examines paper citation networks between different research fields. The main findings were that 90% of scientists leading research on MPAs are marine ecologists and that MPA studies dominate the wider marine literature in terms of the number of publications and number of citations. It is speculated that the popularity of MPAs with marine environmental organisations has meant that a disproportionate amount of money has been spent on MPA research compared to other types of marine management intervention. Chapter 4 examines the

publication practices of scientists, and also their experiences of having articles rejected in the peer-review process. Ten percent of scientists who responded did indicate that they thought their manuscript had been rejected because of ideological bias (pro-MPA or anti-MPA) held by a peer-reviewer or editor, though no scientists admitted to self-censorship. Interestingly, a bias towards studies showing stronger effect sizes is likely to exist in the wider ecology literature due to the way that research is incentivised and how researchers prioritise their time; it is easier to get larger effect sizes published in higher impact journals, and it takes more time for a researcher to publish non-significant effects in lower impact journals. The ramification of this finding is that claims made by meta-analyses on the ecological effects of MPAs are likely to be exaggerated.

Chapter 5 systematically reviewes the literature showing the ecological effects of MPAs. The main finding was that the majority of studies have focused on the measurement of fish biomass within no-take marine reserves (NMRs), and that measurements have been mainly made on fish assemblages residing over reef type habitats. The evidence for the effect of MPAs on the recovery of temperate fin-fish species residing in soft sediment systems is less clear, thus it is problematic if scientists over-generalise claims on the benefits of MPAs, particularly NMRs, to commercial fin-fish fisheries found around England.

In chapter 6 key-informant interviews were carried out with leading members of the English policy community to examine competing worldviews on Marine Conservation Zones (MCZs). A discourse analysis was undertaken on the interview transcripts, and also relevant policy literature that has informed the planning of MCZs in England. Two general discourses were identified, one emphasising the establishment of MPA networks driven by ecological theory whose adherents consist mainly of conservationists, and another, whose adherents consist mainly of members of the fishing industry, emphasised the establishment of MPAs on a case-by case basis to protect habitats vulnerable to damage by mobile fishing gears. This study found that debates preceding the introduction of MCZs were heavily influenced by a popular discourse that documented the decline of English marine ecosystems and emphasised

the use of MCZs as a fisheries management tool to rebuild fish stocks. This subsequently caused confusion amongst stakeholders over what objectives MCZs are being designated to achieve, and in the confusion, important normative areas of debate such as equity and fairness issues were overlooked.

The concluding chapter focuses on the role of the scientist in the policy process, and discusses how the linear transfer of information from scientist to policy maker is undesirable. It argues that scientists need to be more reflexive in how their underlying worldview affects how they conduct their research, and also affects how they interpret the meaning of their research findings for policy makers. The thesis argues that institutions that encourage a two-way dialogue between scientists, managers, fishermen, and wider civil society need to form, thereby increasing the salience, credibility and legitimacy of scientific knowledge for policy.

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List of acronyms

AC	Advocacy Coalition
BACI	Before-After-Control-Impact experimental design
CBD	Convention on Biological Diversity
CEFAS	English Centre for Environment, Fisheries and Aquaculture Science
CFP	Common Fisheries Policy
CM	Co-management
DC	Discourse Coalition
DEFRA	UK Department for Environment, Food and Rural Affairs
EBM	Ecosystem Based Management
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
ENG	Ecological Network Guidance
ENGO	Environmental Non-Governmental Organization
EpC	Epistemic Community
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GES	Good Environmental Status
GBR	Australia's Great Barrier Reef
ICZM	Integrated Coastal Zone Management
IUCN	International Union for the Conservation of Nature
JNCC	UK Joint Nature Conservation Committee
LCS	Local Citation Score
MCAA	UK Marine and Coastal Access Act

MCBI	USA Marine Conservation Biology Institute
MCS	UK Marine Conservation Society
MCZ	English Marine Conservation Zone
MEO	Marine Ecosystem Objective
MMO	UK Marine Management Organisation
MPA	Marine Protected Area
MSD	European Marine Strategy Directive
MSP	Marine Spatial Planning
NCEAS	USA National Centre for Ecological Analysis and Synthesis
NE	Natural England
NFFO	National Federation of Fishermen's Organisations
NMR	No-take Marine Reserve
NOAA	National Oceanic and Atmospheric Administration
OSPAR	Oslo Paris Convention on marine protection of the NE Atlantic
PISCO	USA Partnership for Interdisciplinary Studies of Coastal Oceans
PTA	Prohibited Trawl Area
RCEP	UK Royal Commission on Environmental Pollution
RSPB	UK Royal Society for the Protection of Birds
SAP	English Science Advisory Panel for planning MCZs
SCA	Statutory Conservation Agency
STS	Science and Technology Studies
UNEP	United Nations Environment Programme
WoS	ISI's Web of Science
WSSD	World Summit on Sustainable Development

WT	UK Wildlife Trusts
WWF	World Wildlife Fund for Nature

Preface

It may be helpful for the reader if I explain my background, how I came to be involved with this project, the evolution of my views on marine protection, and how all this may have affected my interpretation of the information gathered for this thesis.

Firstly, since childhood, I've always had a strong interest in the natural world, particularly marine life, and this was reflected in my choice of subjects at school and ultimately leading me in 2004 to undertake a BSc at Newcastle University in marine biology. Combined with my interests in natural history I have also had a long-held interest in conservation. I was a child member of the Royal Society for the Protection of Birds (RSPB) encouraged by my parents, and I remember many trips to nature reserves. I was also interested in sea life, and I became a member of the Marine Conservation Society (MCS) which I retained until starting the PhD. My interests in conservation along with the natural sciences led me to undertake a MRes in Biodiversity and Conservation at Leeds University during 2007-2008.

An interest in the social sciences probably started during a visit to Dahab, Egypt when I helped a friend with her master's research project that examined the impact of SCUBA diving on several of the fringing coral reef dive sites. During the fieldwork I became much more aware of the social dimension of conservation issues, something that I realised was lacking from my undergraduate and masters level training. I came back to Newcastle in late 2008 to discuss the potential of building on the work I had done out in Egypt, however after discussing the practicalities of doing such work and the competitiveness for funding, one of my supervisors, Nick Polunin, suggested an alternative idea, an investigation into policy advocacy and marine protected areas, and tracking how the science and policy of Marine Protected Areas (MPAs) had developed over time.

This was a departure from the type of research project I had initially intended on undertaking in Egypt. I had little idea of what was meant by policy and advocacy, and a very naive understanding of how science related to policy. I was hesitant at first to become involved in such a project as it was a major departure from my previous training, and this made me feel slightly uncomfortable. However, after having the Christmas holiday to reflect on the potential opportunities that could arise from undertaking such a project I decided with the help of Professors Nick Polunin, Selina Stead, and Tim Gray to start work on a proposal to get funding.

One of the key aspects of this PhD is that it is an interdisciplinary research project that incorporates the methods of both the natural and social sciences. This has presented me with numerous challenges over the duration of the project – particularly with regards to how time was spread between the quantitative and qualitative aspects of my research, and also between reading and trying to make sense of existing information versus going out and collecting more data. Given the broad subject area 'science policy and MPAs', this research project could have progressed along many different paths, which, on the one hand, gave me the opportunity to get creative and experiment with different methods, but on the other hand, presented me with the challenge of staying focused and steering the project into something that was manageable within three years. The thesis argument did not really start to come into being until the final six months when I could finally see how the different chapters fitted together and how each one contributed to the overarching narrative. With the benefit of hindsight I would have spent more time on planning at the start of the project, though I guess doing a PhD is as much a learning experience as it is creating new knowledge - muddling through and learning from mistakes - so I probably shouldn't be too harsh on myself.

Given that this was my first step into the social sciences, it has been a steep learning curve trying to grasp the different approaches used by social scientists to make sense of the world. Undertaking this project has made me aware of the elusiveness of objectivity, how our underlying worldview shapes how we as scientists conduct our research and interpret our findings, and also in the context of making policy how it is 1) all too easy to make sweeping judgements and gross generalisations from limited evidence, or 2) sit back and do nothing. Indeed this is a major theme throughout this PhD, whether it is ever possible for our underlying prejudices to be jettisoned completely from our observations and advice we give to policy makers, and also what is the best way of providing information that is both relevant and timely.

Therefore a key question to ask is the extent to which my own underlying biases have affected the framing of my research questions, what I did to collect my data, and how I subsequently interpreted my results?

As mentioned, before undertaking this research project I had been trained in natural science research methods, with no formal training in the social sciences, or experience of working in any organisation with a policy role outside of university. Thus the observations made during this PhD have come very much from an “outsider’s” perspective. However on the counter-side I have been fortunate enough to get a broad experience whilst undertaking this PhD, including: a trawl and trammel survey of a North Sea MPA and nearby control area making me very much aware of the challenges facing researchers in measuring the ecological status of temperate ecosystems; sitting as an observer on the stakeholder meetings for the planning of North Sea Marine Conservation Zones (MCZs); being commissioned by the Sea Fish Industry Authority to undertake an appraisal of the evidence base for MCZs and likely impact on the fishing industry; and as I write this statement I’m currently writing a report for Marine Scotland on the evidence base for the ecological goods and services that will potentially be enhanced through their MPA network.

Given all that I have said, it is probably useful for the reader that I state my own view on the use of MPAs in marine resource management. I believe that MPAs have a useful role to play in marine resource management in certain ecological and social contexts. In the UK at least, I think MPAs can help to protect habitats that are sensitive to towed fishing gears and in some cases as a fisheries management tool. Science (including both natural and social sciences) can allow policy makers to make a case to the fishing industry for protecting a natural resource. Risk and uncertainty is best dealt with through an inclusive decision-making process that is undertaken at the appropriate scale. Emotionally-charged campaigns for networks of no-take marine reserves (NMRs) and/ or a rush to establish MPA networks more generally, may lead to opportunity costs for conservation, in that MPAs may be located in areas that cause developers less short-term inconvenience and from a conservation point of view achieve very little. I am not an ecosystem preservationist and accept that people are entitled to use the natural world to improve their lives. However a balance has to be struck between resource appropriation and conservation – there must be willingness on both sides for compromise, and also mutual respect for each group’s perspective on an issue.

Chapter 1

Introduction

Marine Protected Areas (MPAs): the solution to sustainable management of marine fisheries?

"I wish you would use all means at your disposal, films! expeditions! the web! more! – to ignite public support for a global network of marine protected areas, hope spots large enough to save and restore the ocean, the blue heart of the planet."

Sylvia Earle, oceanographer and recipient of the 2009 TED prize.

1.1 Thesis rationale

Marine Protected Areas (MPAs) have been around for a long time, Fort Jefferson National Monument being the world's first officially recognised MPA designated in 1935. MPAs have been primarily designated to conserve nature (Kelleher et al. 1995) or conserve fish stocks (Roberts & Polunin 1993)[1], frequently used in tropical countries to meet a mixture of nature conservation (Kelleher et al. 1995) and, to a lesser extent, fisheries management objectives (Roberts & Polunin 1991), albeit with mixed success, often resulting from lack of enforcement of rules by managers or compliance with rules by fishermen (Christie et al. 2003). A brief survey of marine environmental policy and the academic literature would suggest that MPAs should be a central tool in the management of marine resources. This thesis attempts to explain the emergence of the MPA concept (see 1.3.1 for definitions); is the idea rooted in scientific evidence, ideology, or a blurred combination of both? And which actors have been responsible for propagating the MPA concept?

A growing body of evidence documents the declining health of marine resources (Myers & Worm 2003; Worm et al. 2006). Simultaneously emerging with this storyline is a scientific literature documenting the effects of MPAs on fisheries. This juxtaposition of two prominent narratives could be summarised as: there is a growing ecological (and potentially socioeconomic) crisis and that we need new solutions (i.e. MPAs) to counter it. Indeed, MPAs have been rushed ahead of more holistic approaches such as Ecosystem Based Management (EBM), Integrated Coastal Zone Management (ICZM) and Marine Spatial Planning (MSP) that have been conceived to put the use of marine resources on a more sustainable footing (Halpern et al. 2010a)[2]. Are MPAs embedded within the rhetoric of these management paradigms or have they become a management paradigm in their own right (Russ & Zeller 2003; Lubchenco et al. 2003; Nelson & Bradner 2010)? Which drives which?

---

[1] The science conducted in MPAs/ closed areas also stretches back for a good 100 years (Fulton 1895).

[2] This is shown by the fact that a search for MPAs in *Web of Science* leads to a greater number of hits than a search for EBM or MSP, and that calls for MPAs have preceded the emergence of EBM or MSP in marine policy (see Figure 1.2, page 21).

Herein it is argued that marine ecologists have played a heavy role in the hegemony of the MPA idea in marine policy in both their production of the evidence base (Chapter 3) and dissemination of this evidence to decision-makers (Chapters 5 & 6). Requirements for MPAs written into international agreements such as the World Summit on Sustainable Development (WSSD) and Convention on Biodiversity (CBD), and recommendations made by the International Union for Conservation of Nature (IUCN) reflect the highly co-ordinated actions of a network of marine experts (scientists, lawyers, policy makers etc), perhaps best described as an epistemic community, an international elite who have pressured states to implement MPA networks.

The overly proactive involvement of some scientists in raising the profile of MPAs, particularly no-take marine reserves (NMRs[3]) (Chapter 3) raises issues surrounding the process through which science is used in policy debates on marine resource use. For instance it could be argued that much of the science on MPAs has been approached from too narrow a scientific perspective (i.e. effects of NMRs on previously exploited fish associated with reef habitats) and has limited applicability to non-reef habitats. Aside from questions over the generalisability of the ecological effects of MPAs (Chapter 5), many have argued that uncritical advocacy has led to MPAs being used as a prescriptive and oversimplified solution to an inherently complex problem (Degnbol et al. 2006; Pitcher & Lam 2010). EBM, ICZM and MSP were developed to take other streams of evidence into account in addition to natural science (e.g. socio-economic information and local knowledge) as well as people's value and belief systems, with the aim of providing a better solution than would be achieved by examining a problem through natural science alone.

In chapter 4 the socio-political factors that have affected the production of evidence on the ecological effects of MPAs are investigated through the analysis of responses from a questionnaire survey conducted through email. Has ideology led to bias in the scientific literature for studies that show positive results? Or is this bias more deeply rooted in how science is practised?

[3] See the scientific consensus statements on NMRs (NCEAS 2001; AMSA 2008; Roberts 2007a).

In chapter 5 the ecological credentials of the MPA are separated from the preservationist undertones that are hypothesised to have influenced the production and dissemination of much of the natural science documenting MPA effects. The following questions are considered. Is it politically significant that much of the evidence currently stems from studies that have investigated the effects of NMRs on fish? Have fisheries management objectives and nature conservation objectives been blurred? Is there some common ground between the two sets of objectives? When have MPAs been shown to benefit nature and fishermen? Is there an inherent trade-off between using MPAs as a fisheries management tool and a nature conservation tool? Is it wise to rush the establishment of MPAs?

Emerging themes from chapters 4 and 5 will then be examined in the context of a real world case study, an analysis of provisions made for Marine Conservation Zones (MCZs) in the United Kingdom's Marine and Coastal Access Act (MCAA) (Chapter 6). Here the focus is on the science-policy interface. Discourse analysis will be used to reveal the sets of assumptions that environmentalists, government, the fishing industry and some scientists have made regarding the use of MPAs in marine management.

The central argument of this thesis is that the science-policy boundary has become blurred by some scientists becoming proactively engaged in policy advocacy. This thesis is not critical of the idea of MPAs *per se*, but critically appraises how MPAs (particularly NMRs) have often been promoted solely on their (often rather limited) natural science credentials (NCEAS 2001). This thesis investigates how the mixing of environmentalism with environmental science has impacted decision making regarding the planning of MCZs. The concluding chapter reflects more generally on the implications of the research findings for the communication of environmental science to decision-makers and wider society.

1.2 Contested narratives on the state of the marine environment and implications for management

1.2.1 A litany of mismanagement and loss

There is no shortage of studies in the academic literature documenting the effects of fishing on marine ecosystems (Agardy 2000). Indeed many of these studies are amongst some of the most highly cited articles in the marine sciences over the past two decades, often being published in the prestigious journals *Science* (Worm et al. 2006) and *Nature* (Pauly et al. 1998; Pauly et al. 2002). Consequently, they receive considerable attention from the press, with their storylines such as "fishing down the food web" (Pauly et al. 1998) and "shifting baselines" (Roberts 2003; Jackson et al. 2001) becoming popularised by the mass media (e.g. *The End of the Line* 2009) and popular scientific literature (Clover 2004; Roberts 2007b; Roberts 2012). Broadcasters also bring the state of the oceans to our TV screens; the oceans are no longer "out of sight, out of mind", and perhaps there is a growing concern amongst wider society about how they are used.

Globally, there is strong evidence to suggest that marine ecosystems have changed considerably since the dawn of industrial fishing. Many marine species have already become extinct (Jackson et al. 2001) or are in the process of becoming extinct (Roberts & Hawkins 1999); there have been significant declines in large predatory fish (Pauly et al. 2002; Myers & Worm 2003); habitats have been destroyed (Dayton et al. 1995); and ecosystems have been changed either directly (Watling & Norse 1998) or indirectly (Pinnegar et al. 2000) through fishing. In addition to the loss of biodiversity (Worm et al. 2006), the most recent statistics from the FAO suggest that globally 32 percent of fish stocks are overexploited[4] (i.e. 28% depleted, 3% recovering, and 1% yielding less than their maximum potential production) 53% are estimated to be fully exploited; leaving only 15% of stocks estimated to be able to produce more than their current catches (FAO 2010). Some scientists argue that we are facing a fisheries crisis (Roberts 1997), with massive implications for long-term food security (Pauly et al. 2002; Smith

[4] According to some this is likely to be an underestimate. A recent study suggests that 37% of fish stocks now yield less than 10% of their historic maximum catches (Pauly & Froese 2012).

et al. 2010; Godfray et al. 2010) and that traditional fisheries management has failed and radical new solutions such as MPAs are needed to put fisheries on a more sustainable footing (Roberts 1997). Other scientists are, however, more wary of making such gross generalisations and of laying the blame squarely at existing fisheries science and associated management tools[5]; they acknowledge that there are many failed fisheries, but they also point to some successes (Hilborn 2007a; Hilborn 2007b). This thesis argues that this divide within the natural science community over the interpretation of the fisheries crisis is a result of research experience (marine ecologist or fisheries scientist)[6]; the associated research paradigms these social groups have traditionally worked under (Hilborn 2007b; Christie 2011); and underlying normative[7] commitments (e.g. preservationist or sustainable use).

Despite these different interpretations of the state of global fisheries, no doubt additionally driven by scientific uncertainty[8], it is the more pessimistic reports that often make the headlines of newspapers. Although refutations are sometimes made of high profile articles in *Science* and *Nature,* these are not reported in the news (Hilborn 2007b). Perhaps more disconcerting is that many of these refutations often go unnoticed by the wider scientific community (Banobi et al. 2011) as they are often published in less impactful journals, explaining why the storylines of many of the negative studies continue to persist (Hilborn 2007b). However, with an increasing emphasis from funders on cross-disciplinary collaboration, a more objective and nuanced picture of the reality of the state of global fisheries is slowly emerging (Worm et al. 2009).

[5] Indeed, the findings of many of these high impact studies have been shown to be grossly misleading; "closer inspection of this litany of papers shows them to be outright wrong or serious distortions of reality" (Hilborn 2006; Hilborn 2007b).

[6] See chapter 2 for a description of the different paradigms fisheries scientists and marine ecologists have historically worked under.

[7] Defined here, as a person's preferred condition that something ought to be in.

[8] Some scientists would argue that scientific uncertainty is enough reason to establish MPAs under the guise of the precautionary principal (Lauck et al. 1998).

1.2.2 MPAs and marine restoration?

Going hand-in-hand with this litany of reports of ecosystem destruction are calls for ecosystem restoration (Jackson et al. 2001). Whilst most scientists are generally in agreement that we should aim to move fisheries to lower fishing effort, higher stock abundance, less impact on marine ecosystems, higher economic profitability and more social sustainability (Hilborn 2007a), there is considerable disagreement over how this can be achieved. Again the conflict is largely between different disciplines, each one having their own priorities and preferred set of management tools to achieve different sets of objectives (Degnbol et al. 2006; Hilborn 2007a; Pitcher & Lam 2010). Khan & Neis (2010) identified two imperatives in the fisheries management literature, one of *recovery* and one of *rebuilding*[9]. The former takes a largely eco-centric approach focusing almost exclusively on reducing fishing effort and stock recovery, largely ignoring supply chain and governance issues which the latter takes into account (Khan & Neis 2010). It could be argued that MPAs belong to the recovery imperative, an approach that has been criticised for making largely reactive technical changes to management policies rather than attempting to address the deep rooted sociological causes of overfishing (Pitcher & Lam 2010).

Although there is growing emphasis by many social scientists on the need for institutional reform and for better fisheries governance (Osterblom et al. 2011), this thesis debates the argument that MPAs have become the dominant focus of attention within the scientific literature and wider societal discourse. It is telling that many of the most highly cited studies published in the marine sciences (all of which would be described as natural science) suggest that we ought to establish networks of MPAs explicitly or implicitly to *restore* ecosystems[10] (Table 1.1). The idea of networks of MPAs has been advocated in two recent popular science writing; two books, *The End*

[9] Though there is some overlap in the connotations of *recover* and *rebuild*, there is a subtle difference in the way the two terms have been used in the context of overfishing. *Recover* used to describe the return to a former position or normal state through the implementation of technical fixes, and *rebuild* with the emphasis on the restructuring or reorganisation of society.

[10] Only Pauly et al (1998) use the term *rebuild*, though in this context it means very much the same thing as *recover* since there is no mention of the social dimension of the ecosystem.

of the Line[11] (Clover 2004) and *The Unnatural History of the Sea* (Roberts 2007b) have entire chapters devoted to NMRs, and countless numbers of magazine and news articles have also popularised the MPA idea. It could be argued that MPAs have become a key component of a discourse documenting the wider demise of marine ecosystems that has been popularised by the mass media. Several commentators would argue that this is no bad thing (Russ & Zeller 2003); currently only 1.6% of Exclusive Economic Zones (EEZs) is designated as MPAs, and only 0.08%[12] as NMRs (Wood et al. 2008), and some scientists argue that designating more MPAs is simply the right thing to do (Davis 1999)[13]. But such a simplistic approach ignores controversies over what is the best way of designating MPAs, particularly with regard to their socio-economic implications (Agardy et al. 2003), and also the consideration of alternative or accompanying measures such as the restriction of certain fishing gears (McClanahan 2011). Moreover, this leads to an interesting question, does advocacy for MPAs based solely on empirical (largely ecological) evidence gloss over important normative areas of policy debate (e.g. justice, freedom, risk, equity etc), and does a zealous 'one size fits all' approach risk creating a policy backlash against a potentially useful management tool[14] (see Chapter 2 for theory and Chapter 6 for empirical data)?

[11] Which was subsequently released as a film in 2009.
[12] This is the latest published figure, though recently established no-take NMRs such as the Chagos Archipelago and Phoenix Islands will have increased this figure (Edgar 2011).
[13] However if a scientist is to become involved in policy debates it is important to distinguish between one's personal policy preference and role as a provider of policy-neutral advice (see 1.3.2), failure to do so could be considered unethical by some (Mills 2000).
[14] This issue is elaborated in the theory and methods section of chapter 2, and empirical evidence is shown for it in chapter 6 (the English case study).

Table 1.1 Some examples of high profile studies that make recommendations for MPAs. Citations data correct on the 20th April 2012, taken from ISI's Web of Science.

Study	Citations	Recommendations for MPAs
Jackson et al. 2001	1,706	(implied) **large-scale, adaptive experiments** for **ecosystem restoration**, exploitation, and management
Pauly et al. 1998	1,332	We suggest that in the next decades fisheries management will have to emphasise the rebuilding of fish populations embedded in functional food webs, **within large "no-take" marine protected areas**.
Pauly et al. 2002	736	Zoning the oceans into **unfished marine reserves** and areas with limited levels of fishing effort would allow sustainable fisheries, based on resources embedded in functional, diverse ecosystems
Worm et al. 2006	673	By **restoring marine biodiversity** through sustainable fisheries management, pollution control, maintenance of essential habitats, and the **creation of marine reserves**, we can invest in the productivity and reliability of the goods and services that the ocean provides to humanity.
Conover & Munch 2002	314	The establishment of **no-take reserves or marine protected areas** may, if properly designed, provide for the maintenance of natural genetic variation by allowing a proportion of the stock to express an unconstrained range of size and growth rates.

1.3 Marine Protected Areas (MPAs) and No-take Marine Reserves (NMRs)

1.3.1 MPA objectives and definitions

MPAs may be designated for the purpose of either ecosystem preservation or sustainable use (Polunin 2002; Ray 2004) (Figure 1.1), though many are generally advocated as an approach to meet both sets of objectives (Gaines et al. 2010), and the design of such a network will generally reflect trade-offs between ecological, socio-economic, and political interests (van Haastrecht & Toonen 2011).

Figure 1.1 The spectrum of underlying values that underpin MPA designation.

Under a purely nature conservation framework MPAs may be used to protect unique underwater features, biodiversity hotspots, and threatened or rare species (Kelleher et al. 1995), for their non-use and bequest value (Farrow 1996; Grafton et al. 2011)[15]. Historically, most MPAs have been designated for this purpose (Jones 1994) (Table 1.2). In a fisheries management context MPAs may be used as a conservation measure to protect essential fish habitat (Botsford et al. 2003), reduce fishing mortality on aggregations of spawning adult (Chiappone & Sealey 2000) and undersized juvenile fish (Schopka 2007). In certain circumstances MPAs may also be used to enhance fisheries yields (Russ et al. 2004) though empirical evidence for this is sparse (Chapter 5).

In a fisheries context, MPAs are also often advocated as a buffer against uncertainty (Lauck et al. 1998; Clark 1996). MPAs can be used as a risk management strategy for two reasons: 1) conventional management through catch or effort controls may fail due to stock assessment errors and an inadequate institutional framework (Finlayson 1994; Daw & Gray 2005); and 2) the functional roles a habitat and associated species assemblage have in contributing to valued ecosystem productivity are often not known (Frid & Paramor 2006). Given these uncertainties some scientists argue that it is wise to designate MPAs to protect part of a fish stock from exploitation (Lauck et al. 1998), and habitats and species that are sensitive to fishing (Watling & Norse 1998). Paradoxically, while MPAs have the potential to mitigate against uncertainty in the effects of management mistakes or loss of essential habitats/species, at the operational level often the lack of relevant biological knowledge to design MPAs to meet these objectives adds further uncertainty (Hilborn et al. 2004) (see Chapter 6 for a more detailed discussion).

[15] Though economic value may be derived from non-exploitive activities such as eco-tourism (Dicken 2010). MPAs established to conserve nature may also have wider societal value such as for the purpose of education and scientific research (Leisher et al. 2012).

Table 1.2 Timeline showing the major international events that have affected policy on MPAs (adapted from: (NRC 2001; Toropova et al. 2010a)). [Note: binding International agreements are highlighted in bold].

Date	Meeting/ event	Outcome
1935	President Roosevelt designates the world's first MPA through the US Antiquities Act 1906.	Establishment of Fort Jefferson National Monument, USA; the first formally designated MPA.
1958	Geneva Conventions on the Law of the Sea	Provided the international framework for the protection of living resources.
1962	First World Conference on National Parks	Led to the concept of protecting specific areas and habitats.
1971	**The Convention on Wetlands of International Importance Especially as Waterfowl Habitat (RAMSAR)**	Provided a specific basis for MPAs to protect wetlands.
1972	**Convention for the Protection of the World Cultural and Natural Heritage**	Provides a regime for protecting marine (and terrestrial) areas of global importance.
1972	UNEP establishes the Regional Seas Programme.	Provides a framework and information base for considering marine environmental issues regionally. MPAs were identified as one means of addressing some of these issues.
1973-1977	3rd United Nations Conference on the Law of the Sea.	Provides a legal basis upon which measures for the establishment of MPAs and the conservation of marine resources could be developed for areas beyond territorial seas.
1974	Meeting of Man and the Biosphere taskforce in Paris.	Prepared criteria and guidelines for the selection and establishment of biosphere reserves, embodying ecological and genetic principles of nature conservation.
1975	IUCN conducts a conference on MPAs in Tokyo.	Conference report calls for the establishment of a well-monitored system of MPAs representative of the world's marine ecosystems.
1979	Bern Convention	Aims to conserve wild flora and fauna and their natural habitats. Parties to the Bern Convention are required to nominate protected sites, which make up the 'Emerald Network'.
1982	IUCN Commission on National Parks and Protected areas organises a series of workshops on the creation and management of marine and coastal protected areas.	The outcome of these workshops was the publication (1994) of Marine and Coastal Protected Areas: A Guide for Planners and Managers.
1983	UNESCO organises the First World Biosphere Reserve Congress in Minsk, USSR	Meeting recognises that integrated, multiple-use MPAs can conform to all of the scientific, administrative, and social principles that define a Biosphere Reserve under the UNESCO Man and the Biosphere Programme.
1984	IUCN publishes Marine and Coastal Protected Areas: A guide for planners and managers	Guidelines describe approaches for establishing and planning protected areas.
1986-1990	IUCNs Commission on National Parks and Protected Areas creates the position of vice chair, (marine), with the function of accelerating the establishment and effective management of a global system of MPAs.	The world's seas divided into 18 regions based mainly on biogeographic criteria, and by 1990, working groups established in each region.
1987-1988	Fourth World Wilderness Congress passes a resolution that establishes a policy framework for marine conservation.	Resolutions adopted a statement of a primary goal, defined "marine protected area", identified a series of specific objectives to be met in attaining the primary goal, and summarised the conditions necessary for that attainment.
1992	Fourth World Congress on National Parks and Protected Areas in Caracas, Venezuela.	Recommended that a global system of MPAs representing all major biogeographic types and ecosystems should be established.
1992	United Nations Conference on Environment and Development, also known as the Earth Summit	Agenda 21 called on coastal states to maintain biological diversity and productivity of marine species and habitats under national jurisdiction

		through the establishment and management of protected areas.
1994	**United Nations Convention on the Law of the Sea (UNCLOS) and the Convention on Biodiversity (CBD) come into force.**	These two international conventions greatly increase the obligations of nations to create MPAs in the cause of the conservation of biological diversity.
1995	The GBR Marine Park Authority, the World Bank, and the IUCN publish a *Global Representative System of Marine Protected Areas*	Listed existing MPAs, and identified priorities for new ones in each region and costal country.
1997	The annual meeting of the American Association for the Advancement of Science (AAAS) in Seattle	Jane Lubchenco calls for protecting 20% of the surface area of the world's ocean as no-fishing zones by 2020.
1998	Troubled Waters	A call from the Marine Conservation Biology Institute for 20% of the world's seas to be protected from threats by 2020.
1999	IUCN publishes guidelines for marine protected areas.	Describes the approaches that have been successful globally in establishing and managing MPAs.
2000	The International Conference on the Economics of Marine Protected Areas	Held at the University of British Columbia, Canada, this conference aimed to establish the circumstances in which MPAs would likely benefit a fishery.
2001	Scientific consensus statement on marine reserves and marine protected areas	A call from the NCEAS working group of marine scientists for the establishment of a network of marine reserves.
2002	**World Summit on Sustainable Development (WSSD)**	Called for the establishment of marine protected areas consistent with international laws and based on scientific information, including representative networks by 2012.
2003	**Evian agreement, signed by G8 Nations in 2003**	Agreement of the terms set by the WSSD
2003	Durban Action Plan, recommendation of the 5th World Parks Congress	Calls for regional action and targets to establish a network of protected areas by 2010. Recommends establishing protected areas for 20-30% of the world's oceans by the goal date of 2012
2004	CBD adopted the programme of work on protected areas (POWPA)	Objective of POWPA is the establishment and maintenance by 2010 for terrestrial and by 2012 for marine areas of comprehensive, effectively managed, and ecologically representative national and regional systems of protected areas that collectively, inter alia through a global network contribute to achieving the three objectives of the Convention and the 2010 target to significantly reduce the current rate of biodiversity loss;
2006	**CBD adopts sub-targets and indicators for its strategic plans**	"at least 10% of each of the world's marine and coastal ecological regions to be effectively conserved" by 2010
2008	IUCN published a new set of Guidelines to Protected Area Categories, which included a new definition of a protected area, replacing the 1994 definition and the separate IUCN definition	MPAs were aligned more closely with terrestrial protected areas. Conservation aims within protected areas were strengthened.

Several definitions for MPAs exist, though the most commonly cited is that provided by the IUCN:

> 'any area of inter-tidal or sub-terrain, together with its overlying water and associated flora, fauna, historical, or cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment'
>
> (Kelleher & Kenchington 1991)

This 1992 definition has subsequently been revised by the IUCN and now states:

> 'a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values' (Dudley 2008)

An MPA can be summed up as a spatial management measure that places restrictions on certain user groups. Partially protected areas, fishery reserves, fishery closures, gear restriction zones, and buffer zones are all specific cases of MPA where one or more extractive uses are restricted or managed (Claudet 2011). A no-take marine reserve (NMR) (synonymous with no-take zones and fully protected areas) on the other hand is a specific type of MPA where all extractive uses are forbidden, and in some cases non-extractive uses (e.g. swimming, diving, boating) may also be excluded (Claudet 2011). In both IUCN definitions for MPAs, it is significant that reference is made to *cultural features/ values*[16]. Some authors argue that this aspect has been ignored in many cases during the planning of MPA networks (Christie et al. 2003), with pressure from some environmental groups (e.g. the PEW Conservation Trust) to establish very large NMRs. Such an approach has been criticised by some as the return to the fortress conservation paradigm (De Santo et al. 2011).

This thesis uses the term MPA to describe an area where some fishing may still be allowed, and the term NMR where all fishing is banned. It is also worth bearing in mind that terms describing different types of MPA are not used consistently internationally. For example, many countries in East Africa use the term 'marine reserve' to describe a less restrictive management measure, and 'marine park' to describe areas where all fishing is banned (McClanahan et al. 1999).

[16] The author attended a conference in Greenwich (May 2011) on this issue.

Evidently, then, MPAs can be used to accomplish a broad range of objectives and have different meanings to different people (Agardy et al. 2003). Significantly, these different interpretations may correspond to where an actor's environmental ethic falls on the spectrum shown in Figure 1.1[17]. For example, NMRs may be the only type of MPA recognised as legitimate by many people whose environmental attitudes lie towards the more preservationist end of the spectrum (Figure 1.1), with prohibited trawl areas (PTAs) being favoured by more moderate environmentalists, scientists, and some static gear fishermen.

One could argue that NMRs are associated with the preservationist mind set, and that less restricted MPAs are associated with sustainable use, but many scientists/ practitioners would say that this is a false dichotomy, since the type of restrictions that are put in place will depend on the management objectives of the MPA (Agardy et al. 2003). For example, from a nature conservation perspective, one may want to ban towed bottom gears to protect existing benthic habitats or allow benthic communities to recover from disturbance, but it may not make sense to ban static gear and pelagic gears due to the negligible impact of these on the conservation features (JNCC 2011). Likewise, in a fisheries management context, if one wanted to protect a proportion of a mixed species fish assemblage from harvesting then it might make sense to designate an NMR, on the premise that even light levels of selective fishing can truncate the natural age structure of a population (Di Franco et al. 2009a; McCook et al. 2010). Many would argue that policy makers should analyse a designated conservation feature's susceptibility to different types of human activity, and taking into account the management objectives for that feature scope out the range of human impacts that will need to be restricted or mitigated[18] (see Chapter 6 for further discussion). This discriminating approach differs significantly from that initially taken by many environmentalists who call for the blunt application of NMRs or PTAs often on the basis of the precautionary principle[19] (Appleby & Jones 2012).

[17] Though this is a hypothesis and not been empirically tested.
[18] This is the approach being taken by the English MCZ project, though in reality the situation is not this simple due to uncertainty and differences in stakeholder attitude's to risk.
[19] The 'precautionary principle' is the English translation of the term 'Vorsorgeprinzip' that evolved out of German socio-legal tradition in the 1930s. In an environmental context the 1992 Rio Declaration states that: *"in order to protect the environment, the* <u>*precautionary approach*</u> *shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall be not used as a*

MPAs are often cited as a key tool for the ecosystem-based approach to management (EBM) (Fraschetti et al. 2011), a view that considers the wider impacts of human use on an ecosystem other than just commercially important fish species (Fogarty & Murawski 1998) (see 1.3.3). In the revised MPA categories of the IUCN, areas designated at level VI should now only be considered MPAs if they 'have the sustainable use of natural resources as a *means* to achieve nature conservation' and 'protection of natural ecosystems and promotion of sustainable use must be integrated and beneficial'. Whilst this suggests that fishing and other forms of exploitation are consistent with this category of MPA, it does so, on the premise that current levels of exploitation are sustainable and that any damage to nature is mitigated. Many 'MPAs' currently recognised by national governments, would not be considered MPAs on this revised IUCN definition (Dudley 2008), because they just function as 'paper parks'. Evidently, then, MPAs face the same short-term political interests and apathy that has caused the perceived failure of other resource management tools (Christie et al. 2003; Kaiser 2004) (Table 1.3).

Table 1.3 Five potential shortcomings of MPAs with examples for each one (Agardy et al. 2011).

Shortcoming	Examples
Are ecologically insufficient by virtue of their small size or poor design.	Bloomfield et al (2012)
Are inappropriately planned or managed.	Gerhardinger et al (2011)
Fail due to the degradation of the unprotected surrounding ecosystems.	Mora et al (2009)
Do more harm than good due to displacement and unintended consequences of management.	Greenstreet et al (2009), Abbott & Haynie (2012)
Create an illusion of protection when in fact no protection is occurring.	Kareiva (2006)

reason for postponing cost-effective measures to prevent environmental degradation." The 'precautionary approach' is subtly different in that: (1) it recognizes that there may be differences in local capabilities to apply the approach, and (2) it calls for cost-effectiveness in applying the approach, e.g., taking economic and social costs into account." The 'approach' is generally considered a softening of the 'principle'(Garcia 1995).

1.3.2 The debate over advocacy

Because the successful implementation of MPAs to meet specified objectives has been shown to be highly dependent on local social, economic and environmental factors (Agardy 2000; Agardy et al. 2003), advocacy of NMRs by many scientists (NCEAS 2001; Lubchenco et al. 2003; Roberts 2007a) has caused a rift within the scientific community:

> "Full protection is critical to achieve this full range of benefits (i.e. rapid increases in abundance, diversity and productivity of marine organisms etc). MPAs do not provide the same benefits as NMRs (therefore)… existing scientific information justifies the immediate application of fully protected marine reserves." NCEAS (2001)

This rift is characterised by Agardy et al (2003) as "involving those scientists who argue that only no-take MPAs (i.e. NMRs) can confer important conservation benefits, and those who argue that MPA benefits are broader than what no-take areas alone can possibly confer." Indeed, it is unclear from the NCEAS statement as to what or who 'benefits' from an NMR; is it the fish, a fishery, or local fishermen?

Advocacy for NMRs has been met with cynicism by some members of the fishing industry who would argue that calls for NMRs are motivated by preservationist concerns (Jones 2009). Advocacy has also blurred the distinction between environmentalism (campaigners arguing for NMRs on a subjective basis) and environmental science (scientists arguing for them on an objectives basis drawing on ecological and social scientific evidence) (Polunin 2002; Jones 2006). Rather worryingly, in the UK at least, is that fishermen do not often make the distinction between environmental campaigners and scientists (Jones 2009), and the public at large make little distinction between a freshly graduated MSc student working for an ENGO and a well-trained, objective and internationally respected academic (Kaiser 2004). Kaiser (2004) sums up the implications of this: "to the public we are all scientists and to be trusted (or not) accordingly." This implies that *normative science*, science that is developed, presented, or interpreted based on a tacit, usually unstated, preference for a particular policy or class of policy choices (Lackey 2007), may have potentially damaging consequences for the public's image of the scientist as a purveyor of impartial information[20].

Percentage targets for MPAs are frequently cited in the scientific literature (Gell & Roberts 2003) and several international agreements calling for MPAs (Table 1.2). The US Coral Reef Task Force recommended that a minimum of 20% of the southern Atlantic coast of the United States should be included in NMRs on the basis that it would protect 20% of the spawning biomass, a threshold below which stocks were likely to collapse (Bohnsack et al. 2000). Some have argued that extrapolating this 20% rule-of-thumb and applying it to marine ecosystems other than coral reefs may be counter-productive if MPAs designed by such criteria do not meet expectations (Agardy et al. 2003). Despite warnings by some practitioners on the use of percentage targets, recent studies have claimed that setting aside 10-30% of sea as MPAs (in this case used synonymously with NMRs) in regions dominated by fishing impacts, can improve overall ocean health by reducing total cumulative impact on the ecosystem by 15-20% (Halpern et al. 2010). Apart from the fact that this would entail putting a substantial number of fishermen out of business, *ocean health* and *impact* are highly contested concepts that are invariably left undefined.

However some would argue that such percentage targets are necessary to pressure governments to act (Ray 2004; Wood 2011). Whilst targets may be established to create political will[21], environmentalists and scientists may attempt to justify such targets on a scientific basis to make them seem more rational (rather than arbitrary) to decision-makers. It is argued in chapter two that the rhetoric of evidence-based policy can lead to the scientisation of policy debate, whereby scientific evidence is used to gloss over normative considerations which are embedded in the way scientists and society think about the condition the marine environment should be in. Rather than discussing what really is at stake (i.e. decision makers having to adjudicate between opposed values and deal with preference trade-offs), the resulting policy debate often

[20] For example see the media stories documenting the 'Climategate' scandal.
[21] Though it's worth bearing in mind that we are still a long way off from meeting the CBD target of 10% (Wood et al. 2008), and even if much larger portions of the global ocean were protected within MPAs wider management goals would still remain unfulfilled (Halpern et al. 2010).

becomes heavily focused on disagreements over technical details. For example in the context of English MCZs the absence of specific official discussions concerning compensation to fisheries (Jones 2009). Indeed social and environmental justice issues have been largely overlooked in the policy debates (Chapter 6). When science acts as a surrogate for values, the resulting policy debate is opaque and confusing (Jones 2002; Lackey 2007).

The debate on policy advocacy by scientists has been ongoing in ecology and conservation for almost a century[22] (Brussard & Tull 2007; Nelson & Vucetich 2009). The purpose of advocacy is to stimulate action, and it has been encouraged by a substantial fraction of the scientific community (Marris 2006; Scott et al. 2007), though others argue strongly against it (Lackey 2007). Pressure from different social groups on scientists to fulfil advocacy roles, may put scientists in the untenable position where advocacy either intentionally or unintentionally is unavoidable (Steel et al. 2004; Gray & Campbell 2008). Thus some authors argue that the important question is not whether scientists should advocate but how (Nelson & Vucetich 2009), and that scientists need to think more reflectively on how they engage with decision makers and how their own background and research experience may influence their preferred policy choices (Degnbol et al. 2006). The next chapter examines the problem of advocacy in more detail, and tries to unravel the underlying assumptions that people on each side of the debate make, attempting to distinguish between situations where advocacy may be deemed acceptable from situations where it is not.

1.3.3 The wider management context

Ecological policy issues are often described by political scientists as being “wicked” or “messy” due to their inherent complexity (Jentoft & Chuenpagdee 2009). Such problems are hard to fix because they are often linked to broader social, economic and policy issues (Rittel & Webber 1973; Khan & Neis 2010). Whilst this thesis focuses mainly on the differences between nature conservationists and fishermen one cannot

[22] There was a debate in *Conservation Biology* 2006 volume 20(3), on this issue.

divorce this division from other policy drivers such as climate change, population growth, and middle class aspirations that affect a society's interaction with the marine environment - through activities as diverse as oil/ gas exploration, offshore renewables, aquaculture, shipping, and tourism.

Historically, management has typically focused on the short-term, providing for the immediate needs and wants[23] of commercial users. In an attempt to resolve the problems of political expediency in *user-environment* and *user-user* conflicts, new management approaches and strategies that take a long term perspective, such as ecosystem-based management (EBM), integrated coastal zone management (ICZM) and marine spatial planning (MSP) have been developed. EBM is probably best conceived as an approach that has emerged from the natural sciences to take the external environmental costs of fishing into account, i.e. habitat damage, by-catch etc that have often been overlooked by single species based management (Fogarty & Murawski 1998). ICZM and MSP are arguably more socio-economically focused concentrating on minimising resource-user conflict, and balancing the trade-off between economic efficiency and social justice (Christie 2005; Agardy et al. 2011).

Most studies conceptualise EBM as a goal, and MSP or ICZM as management strategies that will deliver EBM, with MPAs being one of a whole suite of potential tactics/ management measures that ICZM or MSP may employ to achieve specified ecosystem objectives (UNEP 2011) (Table 1.4). However, these terms are often used inconsistently (Douvere 2008); they are cross-cutting (Katsanevakis et al. 2011); and they mean different things to different people (Hilborn 2011) depending on how they conceptualise the environment (Christie 2011). Despite emerging concepts such as social-ecological systems which view ecosystems as units with ecological and social linkages (Berkes et al. 2008), however, the most favoured interpretation of EBM has been natural science-based, reflecting the fact that to date the natural sciences have played a dominant role in management (Christie 2011).

[23] This a politically divisive issue, as managing with a long-term perspective in mind will most likely cause a reduction in the standard of living of some users (at least in the short term). Strong political pressure by such users often results in the *status quo* being maintained even if this is detrimental to the long-term interests of society (e.g. see Daw & Gray 2005).

Table 1.4 The major components of the UK's marine policy statement.

Policy component	UK marine management	Description
Mission	Clean, healthy, safe, productive and biologically diverse oceans and seas[24]	End result of management.
Goal	EBM	The overarching goal of EBM is to sustain the long-term capacity of marine ecosystems to deliver a range of ecosystem services, such as seafood, clean water, renewable energy (e.g. wave, tidal, and biofuels), protection from coastal storms, and recreational opportunities, with a focus on both ecosystem health and human well-being (McLeod et al. 2005, Rosenberg et al. 2005).
Strategy	ICZM, MSP	Thoughtfully constructed cross-sectoral plans that are place based and encourage co-operation between stakeholders operating under different jurisdictions. ICZM focuses on the land side of the coastal zone and the nearshore marine environment. MSP covers the marine environment, either within a single jurisdiction or across many jurisdictions (Agardy et al. 2011).
Tactics	MPAs	Allow managers to safeguard areas most critical for ecosystem function and the delivery of ecosystem services (Agardy et al. 2011).

Although it is beyond the scope of this thesis to give a comprehensive overview of these different management paradigms, this review has highlighted the trend that MPAs have become *de rigueur* in terms of research focus (Figure 1.2 and also Chapter 3) and are prevalent in wider societal discourse (Clover 2004; Roberts 2007b; Roberts 2012). Are MPAs viewed as the primary tool to achieve EBM? Some argue that EBM has often been used synonymously with MPAs (Christie 2011), and from a view of the literature it is not clear which has driven which (e.g. Halpern et al 2010). A recent report of the United Nations Environmental Programme (UNEP) suggests that many successful examples of EBM have originated from MPAs, though the authors do stress that this is "not because MPAs are a necessary tactic or tool to employ in EBM, but because the discrete nature of protected areas allows *experimentation with EBM approaches and integration*[25]- and often represent where the first steps along the EBM journey are taken" (UNEP 2011). However, has environmentalism led to the blurring of strategy with tactics, with MPAs becoming the goal of management for some organisations, rather than viewed as a means through which to achieve certain nature

[24] The UK vision for the marine environment (UK marine policy statement, March 2011).
[25] Though it is not entirely clear what this actually means.

conservation and fisheries management objectives (see Chapter 6)? Whilst EBM was initially conceived to take into account the environmental externalities that were historically not taken into account in the management of human activities occurring in the marine environment, due to the complexity of modern day environmental problems, management cannot also divorce what happens in the sea from what happens on land (Brashares et al. 2004). Indeed, sustainability is probably best conceived as a balancing act between the environment, social and economic pillars, with decision makers having to carefully navigate the trade-offs between each (Marques et al. 2009).

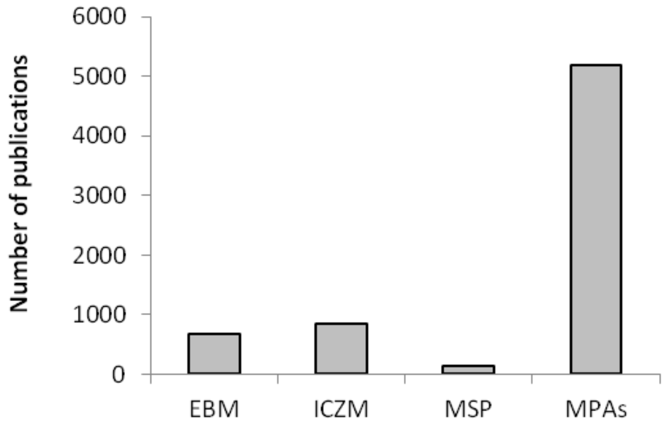


Figure 1.2 Number of publications for a management principle (EBM), two management frameworks (ICZM and MSP), and a management tool (MPA). The literature search was undertaken in ISI's Web of Science on 4th May 2012.

From reading the wider marine management literature it can be summarised that there is an idealist versus realist divide in the way discussions on EBM are framed (Hilborn 2011). There are several case studies that are good illustrations of EBM, though there remain questions over whether such practice can be scaled up or applied to regions where current spatial-temporal[26] information on habitats, species and human activities is poor (Hilborn 2011). I believe that understanding what underpins this divide is critical to the current problems facing the planning of MCZs in the UK (see chapter 6). Despite a growing emphasis on area-based management (Agardy et al. 2011; Katsanevakis et al. 2011) some authors are more cautious of the general applicability of such approaches like EBM to the real world. Hilborn (2011) sums up this

[26] It is important to note that many fisheries in the UK are seasonal.

caution succinctly, "if governments and fisheries agencies have been unsuccessful at implementing single-species management, should we expect them to successfully implement a necessarily more complex EBM?" Indeed in most cases costs may be prohibitively too high to achieve full EBM (Hilborn 2011), with funding for ecosystem monitoring often the first to go when economic times are tough (Agardy 2010).

In a UK context, the current *ad hoc* race for marine space (Jones 2010), inadequate implementation of management strategies (Shipman & Stojanovic 2007; Pitcher & Lam 2010) and critical information gaps suggest that we are still some way off achieving the management ideals of EBM often espoused in the academic literature. Perhaps the key question not asked by the UK government during the planning of MCZs in England was: do we have the information, money and time to attempt systematic conservation planning, or should we be less ambitious and prioritise sites for protection that are known to be vulnerable to fishing by working with the fishing industry (Chapter 6)?

1.4 Thesis terms of reference and structure

This PhD focuses on the applicability of MPAs as fisheries and nature conservation management tools. It is an interdisciplinary research project spanning the natural and social sciences, and investigates the current natural science evidence showing effects of MPAs on fish populations, identifying where key areas of uncertainty lie. It is also a sociological analysis of the science-policy interface and attempts to address the following four deceptively simple questions:

1. What is scientific evidence?
2. How does science relate to policy?
3. What factors influence the uptake of science into policy?
4. What do the above questions mean for a scientist's involvement in policy making, and how does a scientist's actions in policy making affect the above questions?

This thesis attempts to examine these questions in the context of MPA research and policy, moving from the international level to the UK Marine and Coastal Access Act[27] and legal provisions made for Marine Conservation Zones (MCZs) in England. The four primary data chapters deal with the three key stages of science-policy shown in Figure 1.3, with an overview of the objectives and questions asked by each chapter summarised in Table 1.6. The four data chapters will be used to gain evidence for and against two hypotheses - that with respect to the policy debates surrounding marine protection globally and in the UK: 1/ the scientific community has become politicised, and 2/ policy debates have become scientised. The former means that science has been manipulated in some way for political gain. The latter means that political debate becomes preoccupied with the discussion of technical details over the discussion of difficult value trade-offs.

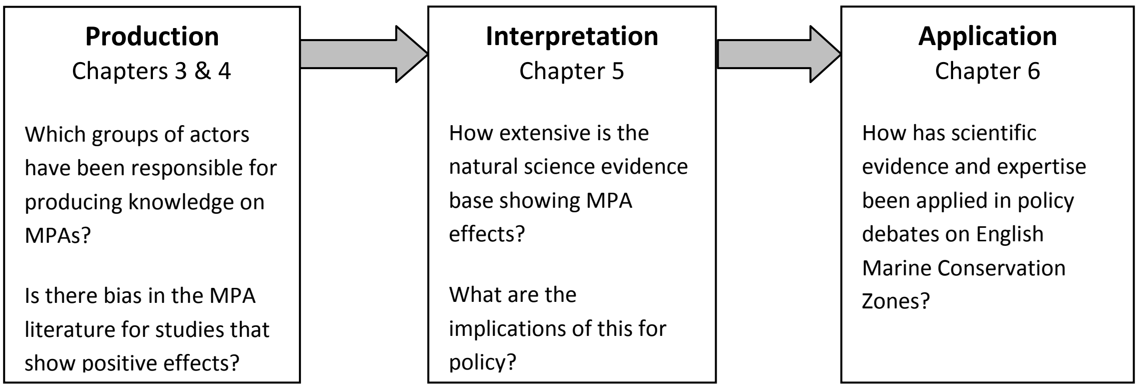


Figure 1.3 How each chapter relates to different aspects of the science-policy interface.

This way of structuring the thesis probably reflects the author's initial mental model of how science is translated into policy[28], summed up as:

Identify problem → do science or review literature → formulate policy.

Unfortunately (as this thesis demonstrates), reality is much more complex, and policy formulation is a messy, iterative, untidy process. Indeed policy formulation is rarely

[27] Each of the devolved administrations of Scotland, Wales and Northern Ireland has its own marine acts and process for establishing MPAs.
[28] This has been termed the deficit model, or linear model (Lawton 2007).

just about the science, different individuals have different legitimate interests that they will attempt to protect and promote (Sarewitz 2000). To quote John Lawton (2007) “it also involves economics, cultural values, tensions between institutions, different interpretations of what ‘the science’ actually tells us, the need to win political battles, vested interests and so on and so forth…” The linear model does not simply hold true in the real world; “science creeps into policy via indirect, cumulative and diffuse processes” (Radaelli 1995; Owens 2005), and may only start to change received political wisdom after many years (Lawton 2007).

Thus, whilst the focus of this thesis is very much on the science-policy interface, the wider political and institutional setting is kept in mind throughout. The following chapter 2 builds the theoretical framework on which the results of chapters 3, 4, 5 and 6 are framed, and discusses in more detail the wider governance issues that will have some bearing on the way science is used in policy debates.

In summary, the main purpose of this PhD is not to undermine people’s efforts for better marine protection, but to reflect that such policy debates can be heavily value-laden. The body of work presented critically appraises the central role natural science has often been granted in policy debates on MPAs.

Table 1.5 The objectives of each chapter and the questions asked (data chapters 3-6).

Data chapter	Objectives	Main questions asked
Chapter 1	Introduction	
Chapter 2	Theory and Methods	**1.** How does science relate to policy?
Chapter 3	To show the structure of the scientific community.	**1.** Which scientists have been most influential in terms of publications, citations, and networking? **2.** Which studies have been most influential?
Chapter 4	To show which social and ideological factors (if any) have affected the production of the evidence base.	**1.** Is there a bias for positive effects studies? **2.** Which factors influence where a scientist publishes their work?
Chapter 5	To overview the current ecological evidence showing MPA effects and identify information gaps.	**1.** Which habitats/ types of species have been most studied? **2.** How extensive is the empirical evidence showing the wider fisheries effects of MPAs?
Chapter 6	To interpret how science was used in decision making during the drafting of the UK Marine and Coastal Access Act (MCAA) and subsequent planning of English MCZs.	**1.** What science was used to inform the MCAA and planning of MCZs? **2.** What science did NGOs use to justify their policy agenda? **3.** What wider storylines were incorporated into the policy debates surrounding MCZs?
Chapter 7	Synthesis	

Chapter 2

Theory and methods

Evidence based policy making: rhetoric or reality?

“The environmental movement has abandoned science and logic in favour of emotion and sensationalism.”

Patrick Moore, co-founder of Greenpeace, 2005.

2.1 Introduction

This thesis presents a sociological analysis of the production, interpretation and application of natural science to policy debates regarding marine protection. I now lay out the theory and methods that will be used to frame the results and discussion of the subsequent data chapters.

Many would argue that it is appropriate for decision makers to strive to base their policies on evidence showing what policies/ management interventions have worked and which have failed elsewhere (Choi et al. 2005). This statement however begs the question of what actually constitutes evidence (Sutherland et al. 2012); is evidence synonymous with scientific knowledge? What about the evidence provided by tacit knowledge, experience and judgement of stakeholders and policy makers (Head 2008), that depending on context of the debate may be more useful than scientific knowledge? Whilst the focus of this thesis is on how scientific knowledge has been used to inform the development of policy on marine protection, I do not subscribe to the view that science should assume a privileged position in policy debates: which source of evidence should prevail depends on the context of the policy debate (Pitcher & Lam 2010). Moreover the term 'science' is many-sided: there is natural science, but there is also social science (including economics) that needs to be taken into account during policy formulation. So a trade-off may be required between the natural scientific and social science perspectives. Finally, it's not just science (natural or social) at stake, but also ethics- i.e. people's value and belief systems.

On the last point, science-based policy shifts the responsibility from policy maker to knowledge expert, and it can lead to the scientisation[29] of what can be often heavily value[30]-laden debates (Gray 2004). Uncritical application of the 'evidence base' fails to recognise the values and assumptions underlying so-called 'neutral' facts (Sarewitz 2000). An argument running throughout this thesis is that 'evidence based policy' makes it very easy 1) for decision makers to take expert opinion at face value without

[29] The framing of policy debate in a way that precludes discussion of contested values.
[30] A value is something a person holds to be important, and shows up in how a person devotes time and energy in their life.

being aware of alternative, dissenting perspectives (Haynes et al. 2011), 2) for decision makers to apply 'facts' in order to gloss over difficult value-laden debates (Sarewitz 2000), 3) for decision makers to use uncertainty to delay making difficult decisions, and 4) for evidence to be produced that supports a favoured policy (Haynes et al. 2011).

Policy that relies solely on the input of natural science has been criticised as being elitist, shutting out the public from decision making (e.g. Christie 2011). The traditional view of science being heavily associated with a central government authority has caused estrangement of wider society from the use of science in policy debates (see Table 2.1); for example see the disputes over the production and interpretation of scientific knowledge and its use in policymaking surrounding the UK controversies of vCJD/BSE and genetically modified organisms (Walls et al. 2005; Murphy et al. 2006; Kewell & Beck 2008). Indeed Parry (2009) says that "scientists, social scientists and policymakers alike have identified an increasing public ambivalence towards science and its institutions, sometimes referred to as a 'crisis of legitimacy'." To counter this crisis there has been a growing emphasis within both the academic literature and the policy discourse on participatory decision making (e.g. Gray 2006).

The engagement of informed citizens in policy debates could challenge this crisis by undermining the cognitive authority of scientists as knowledge producers *par excellence*[31] (Parry 2009). However, with an ever increasing 'grey' literature accessible to the public through the internet, as concerned citizens, to whom do they turn for reliable advice? Whilst science strives to produce information and knowledge objectively, does the public at large have the time, access and will to scrutinise different sources of information impartially to inform their policy stance? Does scientists' disagreement in public generate public mistrust or confusion? Do people change their minds based on the facts? The answers to these questions are probably negative; stakeholders are much more likely to assimilate 'facts' and information that support an explicit (material or ideological) or implicit bias (perhaps best conceived as a discourse- see Chapter 6) (Wilson 2009).

[31] In the case of UK MCZs some citizens (namely fishermen, and some wildlife enthusiasts) have challenged the evidence base and planning guidelines of the MCZ network based on their own local knowledge of the marine environment.

Table 2.1 Some of the reasons for the public's estrangement from evidence-based policy[32] (adapted from Lawton 2007).

Problem	Useful references
Scientists are not getting the message across clearly enough.	Rayner 2004, Owens 2005
There is too much science out there and politicians do not know where to go for the best or most relevant information.	Rayner 2002
Science is often ambiguous with politicians using this uncertainty to avoid difficult decisions.	Walton & Gray 1991, Gray 2004, May 2005
There is not sufficient support for what 'ought' to be done, because the necessary action threatens voters standard of living.	
Policy has to be formulated to take into account many other legitimate issues and constraints, not least the cost of various options.	
Ecologists and policy-makers work to very different time-scales. The latter want simple short-term solutions, while ecologists tend to offer advice that is complex and long-term.	Walton & Gray 1991
Politicians are caught between the policy options that emerge from science, and other powerful interest groups with different agendas- industry, campaigning charities etc.	
There is 'institutional failure'- we have the wrong decision making bodies, lack of integration between government departments, and contradictory policies in different parts of government.	Walton & Gray 1991
Effective solutions often require international agreement. The problem this poses has been termed the 'paradox of co-operation'; unless all nations act together the virtuous may be economically disadvantaged, so no nation wants to be first off the blocks.	Hass 1992b, May 2005
Scientific advice often flies in the face of received political wisdom, dogma, or other deeply entrenched beliefs.	May 2005

This chapter starts with three questions- 1) what is science?; 2) is science value free?; and 3) who is/ is not a scientist? I then discuss what this means for stakeholders' attitudes towards the use of science in policy debates, arguing that concepts such as 'science', 'evidence', 'scientist' and 'expert' are essentially contested- i.e. that their meaning is dependent on a person's underlying belief system - and that this is likely to affect stakeholder attitudes to the use of science in policy making, and to the issue of

[32] In the context of the article that this table is based on, science is used synonymously with the term 'ecology' (Lawton 2007).

whether scientists should become policy advocates (Steel et al. 2004; Pielke Jr 2007; Gray & Campbell 2008).

The chapter concludes with a discussion of two policy network theories; the epistemic community (Haas 1991; Haas 1992a,b) and the advocacy coalition (Sabatier & Pelkey 1987; Weible 2007), each suggesting different roles for scientists in policy debates, which frames the discussion of the co-author and citation networks in chapter three, and discussion of key-informant excerpts in chapter six.

2.2 The nature of science

2.2.1 What is science?

Simply put ‘science’ is the systematic pursuit of knowledge (Pielke Jr 2007); “a method or process through which scientists explain and predict natural phenomena, events, or behaviours in the biophysical or social world using a certain form of rigorous, quantifiable inquiry that involves the testing of researchable hypotheses” (Steel et al. 2004), and is arguably the best method we have for explaining how the world works. In their work, scientists move between theory and observation, testing models (abstractions of reality) with data from empirical observation, and in their purest form conducting the experimental manipulation of variables (Fischer 1990; Steel et al. 2004). One important aspect of the scientific process is repeatability of methods; research findings can be replicated by different scientists in different laboratories using different equipment (Steel et al. 2004). Another is science’s commitment to radical transparency, explaining how you know what you know (Wilson 2009). Only through a series of positive-outcome experiments can a hypothesis gain a measure of scientific support, always with the potential for failure in the next experiment (MacNeil 2008). Indeed, science advances through the testing of ideas and the process of falsification (Popper 1934).

However, what constitutes ‘science’ is contested both in practice and epistemology (Lovbrand 2007). Indeed the ability of science to explain the natural world has been debated by philosophers for centuries. Perhaps the most significant controversies to contemporary policy making are the debates between the positivists and social constructionists, known to some as the “science wars” (Brown 2001). Positivism is a belief of science that is widely thought to have emerged from the period known as the “Enlightenment”, a time of intense scientific discovery and philosophical reflection that occurred in Europe during the 17th and 18th centuries. Adherents of positivism support the view that science and the scientific method accurately and objectively predict various phenomena in the biophysical and social world- a view reflected in various ways in the writings of philosophers of Auguste Comte (Comte 1856), Ernst Mach, Francis Bacon (inductionism), David Hume (empiricism), Karl Popper (rational empiricism) (Popper 1934) and Carl Hempel (logical positivism) amongst others.

Steel et al (2004) summarise positivism as follows: (1) science can provide accurate information about the world; (2) the knowledge produced by science can be unbiased and value neutral; (3) the growth in scientific knowledge leads to general societal progress; (4) scientists must be free to follow the laws of reason in an open system or society; and (5) since science is a matter of truth that is independent of human thought, it is accessible to all peoples regardless of status, culture, belief, and background (Steel et al. 2004). Ultimately, the positivist world view holds that science is an objective and rational activity.

2.2.2 Is science value free?

Curiosity-driven science

It is useful to distinguish between curiosity-driven science (science for its own sake) and issue-driven science (science for action). This distinction is important as the production of the latter is much more likely to become influenced by socio-political factors, though the following literature review suggests that even curiosity-driven science is not immune from the influence of values.

Positivism claims to be value-free, though Robert Merton (1973) listed four epistemological values that characterise the scientific enterprise:

1. *Universalism*: the evidence is open to all; there are no privileged observers;
2. *Communism*: knowledge is collectively arrived at and is owned by all;
3. *Disinterestedness*: we approach nature without prior wishes that it be one way or another; and
4. *Organised scepticism*; nothing is immune from doubt.

Of course, many scholars argue that it is naïve to say that "objective" science is completely free of values, since every decision taken by a scientist can be shown to have a subjective element in it (i.e. why did they choose to prioritise one task over another, why did they choose one study area over another?). However, in this thesis when I say science is objective or value free, what I mean is that it is free from 'normative' values – i.e. values that impinge on science's objectivity and impartiality[33]. The reader's attention is drawn to Merton's two terms of "disinterestedness" and "organised scepticism", as these are both relevant to how scientists have conducted research on MPAs (Chapter 4).

Social constructionists challenge the positivist view of the world, arguing that scientific beliefs can also be explained in terms of social factors in addition to being grounded in evidence and reason. The 19th century philosopher Thomas Kuhn in his landmark book *The Structure of Scientific Revolutions* (Kuhn 1970) suggested that most of the time science is conducted within a paradigm; an accepted set of rules and theory agreed upon by the majority of the scientific community working within a discipline that guide a scientist's everyday research (termed normal science). Scientific revolutions occur when scientist's trade their existing theory for a new one which brings about entirely new ways of asking and answering questions. Kuhn argued that this is often done not solely on the basis of objective evidence, but also with a certain degree of faith on the part of the scientist; "the transfer of allegiance from paradigm to paradigm[34] is a conversion experience which cannot be forced" (Kuhn 1970). Kuhn argued that the rapid acceptance of a new paradigm within the scientific community is due to the peer

[33] A 'normative value' is defined as statement that reflects a moral principle such as 'equity' or 'liberty'.
[34] Some have termed this a 'paradigm shift', though not Kuhn himself.

pressure of scientists on one another. If a paradigm has forceful advocates, it is more likely to win widespread acceptance (Okasha 2002). Arguably, Kuhn was one of the forefathers of science and technology studies (STS). One of the most eminent of these scholars Sheila Jasanoff eloquently describes sciences relationship to society:

> "Scientific knowledge is not a transcendent mirror of reality. It both embeds and is embedded in social practices, identities, norms, conventions, discourses, instruments and institutions- in short, in all the building blocks of what we term the social".[35]
>
> (Jasanoff 2006)

The divide between the positivists and social constructionists is summed up by Brown (2001) as "between those who hold that science is to a significant extent (though perhaps not always) *objective* and those who hold that it is *subjective*". Some would argue that the doctrine of positivism is aspirational in that it guides scientists in how they *should* work, whereas social constructionism describes how scientists *do* work (Okasha 2002). Brown argues that any meaningful debate should not question whether science is value-free, but should question the status of particular values involved: are they non-normative (i.e. they do not violate Merton's principles)? Or do they reflect noncognitive interests (i.e. they reflect normative beliefs) (Brown 2001)?

The author believes that the positivist versus social constructionist debate has limited meaning until it is applied on a case-by-case basis. Indeed, like many areas of research it is difficult to generalise; the positivist view of science may describe how scientific beliefs are formed in certain circumstances (i.e. through evidence and reason), and the social constructionist view may better explain how scientific beliefs are formed in others (i.e. through social factors). What relevance then does STS have to MPA science and policy? The author believes that Kuhn's concept of a paradigm holds some resonance when explaining the emergence of the three scientific consensus statements for NMRs (see 2.3.3), in that some influential scientists' advocacy for NMRs has caused uncritical acceptance for NMRs/ MPAs as a management tool amongst a

[35] Kuhn's and Jasanoff's views of science are weak versions of the social constructionist school of thought, in that they avoid the more extreme forms of cultural relativism taken by some postmodern scholars. Cultural relativism is where truth is relative to a particular culture; there are no privileged observers. It is typically very anti-science, objecting to the exalted status that science is given in societies, arguing that it discriminates against alternative belief systems that are equally valuable (Okasha 2002).

wider community of marine scientists who may have little firsthand experience of studying NMRs/ MPAs.

Issue-driven science

Turning to issue-driven science, we find that normative values are even more intrusive. Sybille van den Hove (2007) suggests that in the case of issue-driven science the processes of selecting, framing and addressing a scientific problem as well as the design of potential solutions are linked to both scientific and political processes. Funding also has a strong bearing on what topics science focuses on and how science is disseminated to policy makers and wider society[36] (van den Hove 2007). Although the finding that MPAs could potentially increase fish abundance and biomass arose serendipitously from the study of small NMRs in the tropics (Nick Polunin, pers comm.), this thesis argues that MPA science has become heavily issue-driven and presents evidence to support this claim (Chapter 3). Recent critical analyses of the MPA literature show that MPAs have been more intensively studied compared to other management interventions both because their effects are relatively easy to measure (McClanahan 2011) and because MPAs have been at the top of the agenda for many funding agencies (Chapter 3). The first null hypothesis that this thesis attempts to test, therefore, is as follows:

H1/ There has been a similar research effort applied to the study of MPAs compared to other marine management interventions.

The main methods used to test this hypothesis have been a) literature searches (see Figure 1 in the previous chapter, and also chapter 3) to assess the quantity of MPA themed papers in the academic literature, and b) citations analyses to assess the influence of MPA papers within the wider marine literature.

A related question is whether science on MPAs has been produced objectively. Is there bias in peer-review for studies that show positive effects (Huntington 2003; Fanelli

[36] For example see the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCOs) booklet on marine reserves (PISCO 2011).

2012); if so, is this bias a result of social or ideological processes? Bias is used here to describe the situation where a person is partial to a particular research outcome. Some scholars have argued that the peer review process minimises bias through collective rationality (MacCoun 1998). However is this always the case? In her analysis of peer review and regulatory science, Jasanoff (1994) states:

> "Peer review appears not to be the objective, dispassionate process that its advocates represent it to be. Standards of validity in science are also revealed as somewhat fragile constructs that may hold up under friendly scrutiny, but are apt to disintegrate under controversy or critical review. Accordingly, the notion that science-based regulation can be lifted above politics and ideology through peer review appears seriously misguided".
>
> (Jasanoff 1994)

This leads to the second null hypothesis that this thesis hopes to test:

H2/ Science on MPAs has been conducted impartially.

The main method used to test this hypothesis is a questionnaire survey that was sent out to 200 leading MPA scientists through email to examine their experiences with publishing in peer-reviewed journals (Chapter 4 and Appendix 1 for full description). The questionnaire was designed to distinguish between natural-scientific reasons (e.g. poor methodology); social-scientific reasons (e.g. insufficient interest/ results), and political-ideological reasons (e.g. potential negative repercussions for policy) for some MPAs papers being rejected, not being submitted, or being resubmitted to a 'lesser' journal. If the results of the questionnaire suggest, for example, that there has been systematic bias by peer-reviewers or researchers during the production of their scientific evidence showing the ecological effects of MPAs, then this raises three questions for the thesis: 1) Is the bias for positive effect studies found only in MPA science, or does it occur in science in general? 2) Is it possible to distinguish between bias caused by social-scientific reasons (novelty of results, likely impact, esteem etc) from ideological reasons (results accepted or rejected because of normative opinions)? 3) Would an ideological bias be difficult to detect because scientists are unwilling to admit to self-censorship?

Whilst it is predicted that social factors (e.g. funding from conservation organisations) have affected the production of evidence, when information is interpreted into statements of fact another dimension comes into play, uncertainty. To quote one ex-scientific adviser to the UK Department for Environment and Rural Affairs (DEFRA) "evidence is never self-evident but requires interpretation and judgement" (Philip Lowe, pers comm.). Facts are negotiated between members of the scientific community, depending on the balance of empirical evidence that supports a given statement; indeed one government scientist argued that science doesn't deal with 'facts', only probabilities (Peter Wright pers comm), though this perception largely depends on the type of science in question, as will now be discussed.

2.2.3 Uncertainty

Uncertainty in fisheries science and models

Ecology is the science that deals with the distribution and abundance of organisms and the dynamics of ecosystems (Lawton 2007). Chance and randomness is a fundamental characteristic of life that ecology has had to learn to deal with, which sets it aside from the "hard" sciences such as physics and chemistry (Peters 1991). From an epistemological point of view, uncertainty is inherently greater for observational field studies than carefully controlled laboratory experiments, thus it cannot be guaranteed that unknown variables have not unduly influenced the data observed. This means observational field studies can only be subjected to the weakest possible form of inference (MacNeil 2008)[37]: whilst some sciences may deal in absolute facts (e.g. not many people would dispute the speed of light), observational ecology can only deal with probabilities based on where burdens of evidence lie for competing hypotheses/ explanations (Hobbs & Hilborn 2006).

Scientists studying the dynamics of populations in the marine realm have an additional area of uncertainty to deal with, the fact that in most cases they cannot directly observe the animals they are studying (Wilson 2009). Fisheries science is a good example of chronic uncertainty; seemingly simple questions such as how many fish are there? What should levels of fishing effort be to make fishing sustainable?, are

[37] This is why there has been a movement towards the testing of multiple hypotheses (competing plausible explanations of how the world works) (Hobbs & Hilborn 2006).

notoriously difficult to answer. As touched upon in the introduction there have been competing paradigms on the status of the world's fisheries (Branch et al. 2011) which are still not fully resolved (Hilborn 2007a).

Moreover, a further level of uncertainty is faced by modelling of fisheries stock assessment because of the choices of methods, and data, which are subjective choices made by the scientist that are themselves clouded in uncertainties. The output of a model is arguably a highly formalised expression of subjective uncertainty (Pielke Jr 2007), hence the often-cited adage that all models are wrong, though some are useful (see Holmes et al. 2009 for review). Again, this contradicts the positivist view of science, in that theoretical assumptions are inevitably affected by subjective judgements, and scientists sometimes do get the science wrong because their subjective judgements were unsound (Finlayson 1994).

A final level of uncertainty arises from the fact that environmental problems often stem from intricate interactions between biological, physical and social systems. Such problems are difficult to tackle because their solution depends on collaboration between scientists, policymakers and the public (Lemos & Morehouse 2005). So it is not just science at stake, but also people's value and belief systems, adding yet another layer of uncertainty to policy debates.

So in summary, although science can reduce uncertainty (see Table 2.2 for description of different types of uncertainty), rarely can it eliminate it; more often than not uncertainty is irreducible. Science in this case can quantify uncertainty with greater clarity, improving our qualitative and quantitative understanding of the probability of different outcomes occurring through risk assessment, but it cannot reduce the range of possible outcomes, due to the persistence of random effects and indeterminacy.

Table 2.2 Four types of uncertainty (from Yearley 2004).

Type of uncertainty	Description
Quantitative risk	Risk is estimated and characterised through science with statistical estimates of error, reliability, and precision.
Qualitative risk	The system is not understood well enough to have quantified its properties, but most of the main parameters likely to affect the outcome are known.
Ignorance	We do not know what we do not know.
Indeterminacy	It is impossible to know or predict how some systems will work.

Uncertainty over MPAs

Depending on the motivations of scientists conducting research on MPAs, some MPA science could arguably be labelled as normative science (see 2.3.4), in that some MPA science may have been done with the intention of making MPAs appear a more attractive management option (see 2.3.3), and so MPA scientists have intentionally or unintentionally reduced the scope of policy alternatives on offer to the manager (McClanahan 2011). Even without such manipulation, however, there is considerable uncertainty over what MPAs can achieve from an ecological perspective, particularly regarding time-frames of recovery (Russ & Alcala 2004) and wider effects on fisheries (Sale et al. 2005) (Chapter 5 for discussion), whilst socio-economic effects of MPAs are even more difficult to predict (Christie et al. 2003).

So, technical fixes (such as MPAs) that emerge from the narrow perspective of particular disciplines (e.g. ecological science) have often been criticised as being over simplistic (Degnbol et al. 2006). Most of the time policy debates are not just about information; people prioritise different objectives and goals, and hold conflicting values (Mee et al. 2008), and consequently in such a policy arena science will always be subservient to politics - the process by which who gets what, when and how (Pielke Jr 2007).

The truth is that several plausible perspectives/ solutions often exist on an issue (Dryzek 1997), and the role of science is to clarify alternative paths that a decision maker could take, by making predictions about probable effects of interfering in a given situation (Ghilarov 2001), for example by identifying potential risks, and the possibility of loss or harm to the interests of some social groups. However, subjectivity is an important factor in the search of consensus as some people may be more risk averse than others, and the policy-maker must find ways to reconcile, weigh, or adjudicate between different interpretations of available information (Stern 2005).

The precautionary principle/ approach

Any mentioning of risk requires at least some discussion of the precautionary principle/ approach, as this has been an important concept in environmental policy for two decades since the Rio Declaration, which states “in order to protect the environment the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of scientific certainty shall not be used as a reason for postponing cost effective measures to prevent environmental degradation (UNCED 1992).”

The precautionary principle first emerged from German social-legal tradition in the 1930s (Boehmer-Christiansen 1994), and was subsequently adopted by some environmental policies during the late 1970s. In essence it aims to shifts the burden of proof from the regulator to the user. For example, until a developer shows the extent of the impact of their activities on the environment then it is assumed that their activity needs to be regulated in some way. The precautionary principle appears frequently in the MPA academic literature with MPAs often being advocated on the basis of the principle (Hall 1998; Lauck et al. 1998). The Australian network of NMRs was also largely designated on a precautionary basis (Kearney et al. 2012). However in practice there is contention over how the precautionary principle should be implemented (Cross 1996). For instance a value-judgement has to be made on the long-term cost of not taking action (i.e. the likelihood of irreversible damage to the ecosystem occurring) against the immediate short-term costs of regulation to developers. Crucially the precautionary principle is absent from the UK Marine and Coastal Access Act (MCAA) that gives the UK government power to establish Marine Conservation Zones (MCZs) in England, thus removing one source of conservationist pressure on the government to press ahead with designating large numbers of MCZs in the absence of sound scientific justifications.

2.3 The science-policy interface

2.3.1 Who is/ is not a scientist?

First, in the discussion of the science-policy interface, it is necessary to define who is a scientist, because this is a central issue in examining the boundary between science and policy. According to Choi a scientist is a narrowly-focused knowledge expert (scientists are generally less interested in broad issues) and is preoccupied with publications, patents, and professorships; “a scientist publishes or perishes” (Choi et al. 2005). The knowledge generated by scientists becomes ever more esoteric, hence the adage “a scientific expert is someone who knows more and more about less and less, until finally knowing (almost) everything about (almost) nothing” (Choi et al. 2005). Good research often takes time, and scientists will usually spend their entire career in one narrow subject area, aiming to build expertise and a track record, as well as an international reputation (Choi et al. 2005).

However, Choi et al’s (2005) view of a scientist is something of a caricature, in that some scientists have wide rather than narrow interests, conservation biologists being a prime example. Moreover, many conservation biologists would argue that in addition to publishing, they are producers of evidence that will inform conservation practices, and they have a social obligation to participate in the public debate about the nature of ecosystem health (Norton 1988), and what *ought* to be done in terms of management.

In the field of marine research, there is a contrast between government fisheries biologists, who are scientists who exemplify the model defined by Choi et al (2005) in that they are focused mainly on the task of annual fish stock assessments[38]; and conservation agency/academic conservation biologists, who are scientists with wide research remits, including ecosystem approaches to marine health. This contrast reflects a disciplinary divide between fisheries sciences and marine conservation

[38] Though this depends on the scientist’s position, for example senior CEFAS and Marine Scotland scientists are on the end of a phone advising ministers especially those involved in ‘behind the door negotiations in catch quotas’ whereas a more junior scientist is doing the data crunching (Selina Stead, pers comm.).

sciences. As Salomon et al (2011) point out, the two disciplines have different histories, epistemologies, cultures, and priorities, which leads to the sometimes strikingly different views scientists have on the state of marine fisheries (see Chapter 1). “The separate professional societies, distinct journals, and different norms can impede communication, the sharing of scientific tools, and the acceptance of new ideas, which can lead to wildly different inferences made from the same data” (Salomon et al. 2011). In the UK, most fisheries science is typically carried out by scientists working as civil servants in the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) (England and Wales), and Marine Scotland Science. For nature conservation advice the government typically turns to experts in Natural England (NE), and the Joint Nature Conservation Committee (JNCC). The responsibility of management of MCZs in England will fall to the Marine Management Organisation (MMO). The different cultures these institutions work under have generated friction during the planning of MCZs (Chapter 6).

There is a further issue - that of the ‘grey’ scientific literature that is not subject to any, or not very rigorous peer review[39]. Scientists are employed in an array of different institutions such as universities, public and private research institutes, government agencies, and ENGOs, and may in work in several of these concurrently or sequentially (van den Hove 2007). In the UK context, policy relevant research that has informed the planning of MCZs is shown in Table 2.3, revealing that scientific evidence was produced by a variety of institutions, some of which was generated “in-house” and was not subject to the rigours of peer-review and quality assurance.

Moreover, the general public may apply the term “scientist” equally to describe the job role of a freshly graduated MSc student who works for an ENGO, and to describe the work of an internationally respected academic (Kaiser 2005). Thus what counts as good science, bad science, and non-science is a topic of much debate (Jasanoff 1994). Indeed, Wilson (2009) argues that we now live in a ‘post-modern’ society characterised by inescapable uncertainty due to both information overload and the loss of ability to

[39] Significantly, the ‘grey’ literature is increasingly accessible to a non-specialist audience on the web, which may increase the likelihood of people becoming misinformed about an issue if the source has not under gone rigorous peer-review (see Chapter 7 for discussion).

trust traditional sources of valid knowledge. The limitations of peer-review and the shifting of science from its permanent institutions have brought into question claims over science's credibility and legitimacy.

Table 2.3 Types of research institution and English examples that have had input into policy on Marine Conservation Zones (MCZs).

Research institution	UK examples
Universities	York, Plymouth, Newcastle, Bangor, Marine Life Information Network
Government	Centre for Environment, Fisheries and Aquaculture Science, Natural England, Joint Nature Conservation Committee, Natural Environment Research Council marine institutes
Private research	ABPmer
ENGOs	Royal Society for the Protection of Birds, Wildlife Trusts, Marine Conservation Society, Greenpeace, Client Earth

2.3.2 The scientist and the policy maker

Policymakers work in a constantly changing environment, responding to problems as they move up and down the political agenda. They work to tight time frames (e.g. see Chapter 6), with a significant part of their day being spent in meetings and briefings, with little or no time to read scientific reports. Time constraints mean that policy makers often have the capability to respond reactively rather than proactively to problems (Choi et al. 2005), decisions often having to be made without full knowledge and understanding because the needed information will be a long time in coming and there will be significant costs to postponing action (Stern 2005).

Scientists generally focus on the esoteric, whereas policy makers are interested in broad issues and they often have a short tenure in managing projects, supported by ambitious civil servants routinely moving between different government departments to build up a repertoire of expertise in a wide variety of different areas (Choi et al. 2005). The cultural differences between the scientific community and the policy community are well described in the "two-communities thesis" that suggests the two social groups often lack the ability to take into account the realities or perspectives of one another (Innvaer et al. 2002) (see Table 2.4 for summary of differences).

Put simply, science deals with *what is true* (positive), and policy with *what is right* (normative). It is a fallacy to think that one follows from another (Hume 1739). The long held appeal of science in public policy has been the assumption that scientific conclusions are value-free and thus independent of the use to which they are actually put (Lovbrand 2007). Traditionally, the authority of science was seen to depend on maintaining its independence from politics through separation, in what has been referred to as 'boundary-work' (Gieryn 1983). Many environmental science text books still give the impression of the linear transfer of science into policy (herein called the linear model); academic research is conducted on an environmental problem and the results are used to develop a solution (Withgott & Brennan 2006). STS has challenged this view, suggesting that science, politics, policy-making and society are heavily interconnected (Nowotny et al. 2001). Perhaps a cynic would argue that the linear model is desirable from a scientist's point of view; its essential premise is that improved policy results from more research to reduce uncertainty, which means more funding for the scientist (Wilson 2009). This has been criticised by some as a 'devils pact'[40], as scientists can use uncertainty to justify research budgets, and policy makers use it as an excuse to avoid making difficult policy changes (Shackley & Wynne 1996).

Ironically, some note that the appreciation of the limits of science as an impartial arbiter (e.g. see hypothesis one) among policy options comes at a time when demands for scientific input into policy are increasing (Bijker et al. 2009). The current trend to inflate the science boundary (i.e. use science to gloss over normative aspects of policy), as mentioned in the introduction of this chapter, has the potential to turn policy debates into debates over data, this commonly used as a stalling tactic by some interest groups to cover over more politically contentious areas of the debate (Sarewitz 2000).

[40] Also termed the "iron triangle"; in one corner, politicians do not want to make a difficult decision and are more than happy to pass the responsibility of resolving a highly political dispute to the scientist or information broker. In another corner is the scientific community, which is the recipient of the tremendous resources offered by policy-makers to perform research. In the third corner is the advocate of a special interest, with the advocate looking to science to provide a compelling justification for why their preferred policy ought to be adopted rather than an opponent's position (Pielke Jr 2007).

Table 2.4 A crude comparison of the contrasting characteristics of scientists and policy makers (after Choi et al. 2005).

Characteristic	Scientist	Policy maker
Career targets	High impact research, professorships	Solving problems, build up repertoire of expertise in different areas
Mental model	Reductionist	Holistic
Attitudes to time	Good science takes time	Work to a strict timetable
What is evidence?	Obsessed by research methodology and "levels of evidence" gathered through different study designs	Information often based on quick reflections of reality; e.g. poll results, opinion surveys, anecdotes, life stories
Communication of science	Often cannot explain their complex findings in simple language	Want quick, clear, simple answer
Criticisms of one another	Resent the power of policy makers to control research funding and the frequent misuse of scientific data to fulfil a political agenda	Perceive scientists as arrogant and esoteric

A key question to ask is whether science actually has an impact on political processes and the policies that emerge from them. A methodological issue facing the answer to this question is temporal scale. A recent review of the influence of international scientific assessments on policy revealed that the majority are not effective in influencing policy in the short term, and that even the most influential assessments do not directly determine policy choices (Clark et al. 2006). The process through which science does influence the direction of an issue is a lot more diffuse and happens over the longer term: science may influence an issue's visibility; key stakeholders who will take an interest; the way questions and objectives are framed; and the selection of management alternatives (van den Hove 2007) (see Table 2.5).

Table 2.5 The potential contributions of science to an environmental conflict (Cullen 2006).

Potential contribution of science	Relevance to this thesis
Problem identification- the scope and implications of a problem.	Show the extent of overfishing and ecosystem effects of fishing.
Contribute to getting an issue onto the political agenda.	Potential benefits of MPAs to fisheries.
Helping develop and evaluate appropriate strategies to deal with the problem.	Management measures to be implemented in MCZs.
Modelling likely futures with and without an intervention to help communities see the consequences of various actions.	Understanding the difference between proactive and reactive approaches to marine management.
Monitoring and reporting on what is achieved in any intervention to enable adaptive management to take place.	Evaluation of MCZs to show that they are meeting their conservation objectives.

Whilst this thesis has largely taken a broad-brush approach[41] to studying the relationship between science and policy with respect to the planning of the English network of MCZs (Chapter 6), it is also interesting to look at the inter-personal dynamics between scientist and policy maker. Of particular significance is the scientist's intimate relationship with uncertainty, and the communication of this to decision makers. When formulating scientific advice scientists can choose to minimise the uncertainty or they can choose to emphasise the uncertainty, both of which involve tradeoffs; if scientists choose to minimise the uncertainty, the caveats they offer may be ignored, but if they emphasise uncertainty their advice may be ignored entirely (Harwood & Stokes 2003). There is an often cited adage that ministers/ senior civil servants will only read something if it is on one-side of paper; this poses scientists with the very real challenge of drawing out meaningful and clear implications for policy from their research, particularly if their findings are clouded by high levels of uncertainty (Harwood & Stokes 2003; Hilborn 2007b).

Given that in most cases environmental scientists study highly complex, poorly-understood systems, with ways of knowing often contested (Hilborn 2007b), some argue that it would be more useful to policy makers if scientists were more explicit about the limits of knowledge, and about the type and amount of uncertainty in research findings (Kriebel et al. 2001). However, this can lead to what has been termed the 'paradox of transparency', that in an effort to be clear about the tools and methods (which a scientist spends years of training to master) that were used to create a claim of truth, the scientist succeeds in merely confusing the decision maker- 'transparency induced opacity' (Wilson 2009). This problem is not helped by the fact that the majority of Members of Parliament and civil servants (in the UK at least), have very little formal scientific training, compounding the language barrier between scientists and policy makers.

Another important question to ask is whether a decision is fundamentally made by the civil service, the politician, society, or the scientist (if an effective advocate). In the UK

[41] By broad brush I mean 1) looking at the relationship of science and policy through the interaction of different social networks; and 2) using a variety of sources (key informant interviews, grey literature, email correspondence, meeting minutes) to see who had influence on a decision outcome.

context, senior officials of the civil service normally advise the minister which policy option to pick, but (especially in highly political arenas), the politician ultimately has the final responsibility taking into account the interests of his/ her voters. Officially, the civil service will commission research reports to inform policy; unofficially the minister will also have his/ her own scientific advisers whom he/ she will informally consult[42]. This however reflects a highly top-down mode of governance and begs the question of what role wider civil society has to play in policy decisions (see section 2.4).

2.3.3 Scientific consensus

One way that the scientific community deals with uncertainty is through deliberation; “science makes progress by deliberating about the strength of evidence supporting theoretical claims, the quality of reasoning and the methodological adequacy of methods in scientific manuscripts, the importance and conclusiveness of findings, the implications of new findings for the strength of support for a theory, and many other matters” (Stern 2005). However, we cannot assume that there will be consensus after deliberation, because there will always be dissenting voices and alternative ideas- indeed, scientific progress depends on disagreement (Sarewitz 2011). Nevertheless, although complete scientific consensus is rarely achievable, there may be a majority agreement, and this is sufficient as the foundation for political action (according to the linear model).

In the context of this thesis, consensus (or majority agreement) statements on NMRs have been developed to create political will for NMR designation; e.g. “existing scientific information justifies the immediate application of fully protected marine reserves as a central management tool“, enhanced by the fact that (in 2001) less than 1% of the ocean was protected (NCEAS 2001). But the consensus/ majority statements have used science to gloss over what is arguably a heavily value-laden debate. Indeed this is a form of stealth-issue advocacy, and will be discussed more in the next section.

[42] One Defra civil servant hinted that one ex-fisheries minister was friends with an influential scientist who is a well known MPA advocate.

For whenever one invokes science as a justification for selecting one course of action over others, one is "politicizing science" (Pielke Jr 2007).

Table 2.6 sets out the conclusion from the NCEAS statement on NMRs. Most of the signatories to this consensus statement are marine ecologists. Indeed there has been increasing scientific controversy about the strength of the evidence base for the fisheries effects of NMRs (particularly points 1 and 6 in Table 2.6) (Agardy et al. 2003; Willis et al. 2003a). The signatories may have been motivated by preservationist concerns (Agardy et al. 2003), or they may constitute a 'thought collective' that was motivated by a common goal based on a subjective preference for NMRs over less restrictive MPAs and alternative management tools (Degnbol et al. 2006; Pitcher & Lam 2010).

Table 2.6 Conclusions from the scientific consensus statement on NMRs (NCEAS 2001).

Ecological effects *within* reserve boundaries:	
1)	Reserves result in long-lasting and often rapid increases in the abundance, diversity and productivity of marine organisms.
2)	These changes are due to decreased mortality, decreased habitat destruction and to indirect ecosystem effects.
3)	Reserves reduce the probability of extinction for marine species resident within them.
4)	Increased reserve size results in increased benefits, but even small reserves have positive effects.
5)	Full protection (which usually requires adequate enforcement and public involvement) is critical to achieve this full range of benefits. Marine protected areas do not provide the same benefits as marine reserves.
Ecological effects *outside* reserve boundaries:	
6)	In the few studies that have examined spillover effects, the size and abundance of exploited species increase in areas adjacent to the reserve.
7)	There is increasing evidence that reserves replenish populations regionally via larval export.
Ecological effects of reserve *networks*:	
8)	There is increasing evidence that a network of reserves buffers against the vagaries of environmental variability and provides significantly greater protection for marine communities than does a single reserve.
9)	An effective network needs to span large geographic distances and encompass a substantial area to protect against catastrophes and provide a stable platform for the long-term persistence of marine communities.

This brings me to the hypothesis that the thesis will test relating to the evidence base used in the debate on MPAs in the UK:

H3/ MPAs/ NMRs will have positive ecological effects comprehensively wherever they are established.

Some members of the scientific community have identified a weakness in some scientists' advocacy for NMRs - that their evidence has mainly come from tropical reef ecosystems (Horwood et al. 1998; Hilborn et al. 2004; Kaiser 2005). The above hypothesis has been tested quantitatively for the first time through a systematic review of the MPA ecological effects literature (see Chapter 5). Two contrasting schools of thought are emerging in this controversy: 1) that MPAs universally generate benefits (e.g. Halpern 2003); and 2) that any benefits that MPAs generate are site-specific (see recent critical reviews).

Adherents of the second view, argue that overgeneralisations about their effects are un-informative for policy as one cannot use such information to predict the time-scales and extent of recovery at the species/ habitat level (Edgar & Stuart-Smith 2009). Moreover, the first view blurs the science-policy boundary by giving the impression that NMRs necessarily have more benefits than less restrictive MPAs (see 1.3.2, Chapter 1).

Whilst this may be true for previously exploited fish species, for other aspects of biodiversity NMRs may have negative impacts through reverse trophic cascades (Hoskin et al. 2010; O'Sullivan & Emmerson 2011). Ecological evidence about NMRs has come from very specific localities (Chapter 5), and their benefits to fisheries are still very much debated, and highly dependent on their contexts (Bene & Tewfik 2003; Fanshawe et al. 2003). Moreover, from a social science perspective many MPAs have been shown to marginalise local resource users (Christie 2004), and some may exist only on paper (Kareiva 2006). Whether an MPA is the right tool to meet specified objectives, therefore, depends on circumstances.

2.3.4 Policy advocacy

Policy advocacy is the pursuit of influencing outcomes - including public-policy and resource allocation decisions within political, economic, and social systems and institutions - that directly affect people's lives (Cohen et al. 2001) (see Table 2.7). Many would argue that it is desirable for scientists to become more engaged with the policy process, though it remains unclear whether scientists should become policy advocates (Steel et al. 2004; Gray & Campbell 2008). For example in the UK the Research Excellence Framework (REF) requires academics to show the wider influence of their research on policy, thus pressuring academics to become more proactive in the dissemination of their research findings to their peers and also members of the wider policy community.

From an inspection of Table 1.2 in chapter 1, much of the underlying basis for scientist's advocacy for MPAs has been based on an underlying normative commitment to protect biodiversity. There are two difficulties with this position when scientists advocate MPAs/ NMRs for their fisheries effects. First, it blurs the distinction between biodiversity and fisheries conservation by implying that biodiversity benefit produces fisheries benefit. Second, it exemplifies what Pielke Jr (2007) calls 'Stealth Issue Advocacy'; "this is politically desirable because it allows for a simultaneous claim of being above the fray, invoking the historical authority of science, while working to restrict the scope of choice. The Stealth Issue Advocate seeks to "swim without getting wet". There is empirical evidence that shows that stealth issue advocacy is pervasive in the ecological and natural resource scientific literature (Scott et al. 2007).

It is argued in this thesis that stealth issue advocacy is counterproductive to good decision making as it leads to the conflation of scientific and political debates (Pielke Jr 2007). In addition to leading to the scientisation of decision making (Sarewitz 2000), where debates over 'facts' becomes surrogate for debates over 'values', it also can lead to the politicisation of the scientific community involved in policy relevant research (e.g. hypotheses 1 and 2) (Agardy et al. 2003). In chapter 6 the implications of this politicisation are discussed regarding how the policy debate over MCZs was initially framed, and how objectives of the network were poorly defined.

Table 2.7 A continuum of policy advocacy with examples of actions that conservation biologists might take in conducting and reporting research. Actions on the left represent policy advocacy, those on the right do not, and those in the centre may or may not. Taken from Scott et al (2007).

Policy advocacy?		
Yes	**Maybe**	**No**
• Stipulating preferred policy decisions • Supporting a class of policies based on only general beliefs or values • Conducting normative science • Lobbying for specific policies or management outcomes • Framing research questions or choosing study areas such that the outcome will support preferred policies	• Using language and words in ways that can be interpreted differently by different groups or stakeholders • Failing to acknowledge the full range of potential consequences of scientific uncertainty on interpretation of research • Sharing research results with one or a limited range of special-interest groups • Providing advice to one stakeholder about a controversial issue	• Conducting research on policy-relevant issues • Publishing results in scientific journals • Publishing results in non-technical outlets • Bringing relevant science to the attention of managers and policy makers • Providing results of research to all stakeholders and the public • Supporting the use of the best available science in decision making • Testifying before congressional committees • Giving interviews to the press about research results • Discussing conservation science on radio or television shows

Whilst this thesis aims to investigate the politicisation of MPA science in chapter 4 through a questionnaire study on the publication practices of scientists, there are other methods through which one could assess the extent to which MPA science has become politicised, such as conducting a content analysis of the MPA literature to examine the prevalence of normative language and policy advocacy (see Scott et al. 2007). Although it has been beyond the scope of this thesis to carry out such an exercise systematically, a cursory examination of the discourse in the literature reveals that there has indeed been some advocacy for MPAs/ NMRs from some of the scientific community. In the following quotations, the normative elements are highlighted in bold:

> "In light of new evidence, we argue that, **by integrating large-scale networks of marine reserves into fishery management, we could reverse global fishery declines** and provide urgently needed protection for marine species and their habitats… of course reserves on their own will not deliver sustainable fisheries… **but by protecting and restoring the productive capacity of marine ecosystems**, reserves can provide the bedrock on which other tools can build towards success." (Gell & Roberts 2003)

> "As fishery management moves towards ecosystem-based management approaches, the **use of marine reserves will undoubtedly play a critical role**." (Fogarty 1999)

> "The **surest way to achieve fishery and conservation goals will be to establish dense networks of reserves** that incorporate a wide variety of habitats and locations. We create source areas when we create no-take reserves… Reserve creation in areas of degraded habitat can help begin the slow process of recovery. In heavily fished locations, even reserves in marginal or degraded habitats may outperform fished areas in terms of reproduction." (Roberts 1998)

> "MPAs can serve to hedge against inevitable uncertainties, errors, and biases in fisheries management. **MPAs may well be the simplest and best approach** to implementing the precautionary principle and achieving sustainability in marine fisheries." (Lauck et al. 1998)

> "**MPAs can be an important bet-hedging strategy** in an uncertain world and could act as an effective insurance policy that would not only protect the long-term future of stocks, but also yield higher average catches." (Hall 1998)

> "**Marine reserves also may be the only practical way** to allow ecosystems to exhibit the full range of natural variability essential for their persistence." (Bohnsack 1998)

> "The **weight of recent evidence strongly supports the value of marine reserves as a tool for both fisheries management and conservation**… It is time to trust the insights of ecologists for once, press for the establishment of marine reserves and place fisheries management and marine conservation on a sound basis at last" (Roberts 1997)

The above analysis raises another important question: if a scientist's advocacy for an MPA is based on compelling evidence does this make advocacy acceptable? The answer to this question is that it all depends on the decision-making context and scale. For example, government fisheries scientists working on a narrowly defined problem such as finding the best management tool to meet a specified list of objectives[43] in a given locality may well recommend a closed area over other policy alternatives. In essence they are advocating one management intervention over other alternatives because the scientific evidence is compelling.

This raises a question, is advocacy acceptable or even desirable when scientists work closely with policy makers to identify possible solutions to pre-specified policy objectives? "Good"[44] policies don't arise from science (as the linear model suggests)

[43] However, is it up to a government/ society/ scientist (see 2.4 and Chapter 6) to set objectives, and determine whether these objectives prioritise the ecological, social or economic dimensions of a policy?
[44] "Good" is highly subjective and largely dependent on a stakeholder's perspective (Mee et al. 2008) (also see Chapter 6).

but through a line of two-way communication between society, policy makers, and scientists (Nowotny et al. 2001; Nowotny et al. 2003). One answer to the question of whether advocacy could be classified as acceptable or unacceptable is that it is heavily dependent on context (Figure 2.1). Given current tensions at the science-policy interface (see 2.3.2), advocacy in the majority of cases probably verges towards the right-hand side of the spectrum in Figure 2.1.

One problem with much of the MPA literature is that the assumptions used in many modelling studies are too broad and abstract to have any meaningful use in informing policy at the local level (Willis et al. 2003a). Much of this science seems to have been produced within a wider environmental discourse that has simply concluded that global fish stocks are in decline and that NMRs are the much needed solution (see 1.2 Chapter 1). In their production of the science, scientists have intentionally/ unintentionally restricted the scope of choice to the decision maker by focusing their efforts almost exclusively on NMRs. This was what happened in the UK - initial discussion around the Marine and Coastal Access Act (2009), during which scientists gave the impression that fish stocks were collapsing and NMRs were the only answer (Chapter 6) (Lawton 2007).

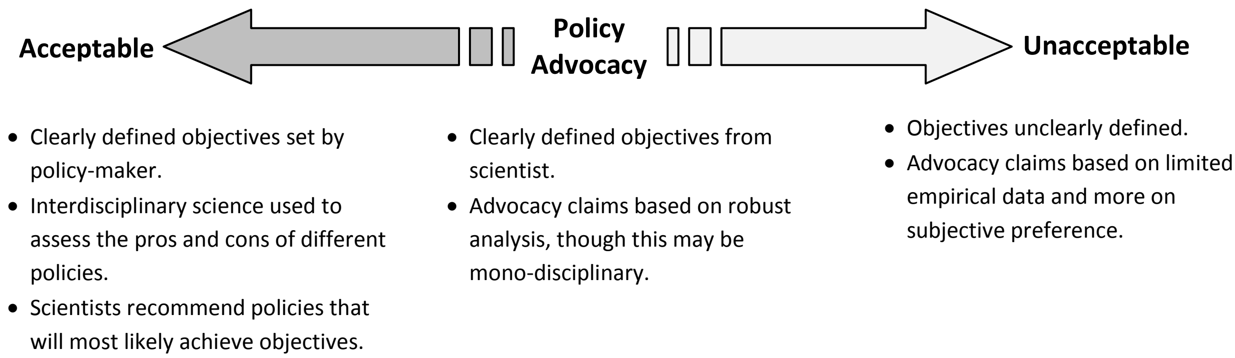


Figure 2.1 In what cases is policy advocacy by scientists acceptable (from summary of literature review)?

This thesis argues that the promotion of the primacy of NMRs over MPAs based primarily on their fisheries benefits (often perceived rather than proven) has caused the science-policy boundary to blur. This leads to the final hypothesis that this thesis will attempt to examine:

H4/ Policy advocacy by scientists has confused the science-policy boundary with regards to the interpretation of evidence showing the fisheries effects of MPAs.

This hypothesis will be examined in chapter 6 through interviews with UK stakeholders and a desk-based study of the grey scientific literature, policy documents and meeting minutes relevant to the planning of the English network of MCZs. Aside from identifying confusion caused amongst stakeholders on what MPAs have been shown to do for fish, fishermen and fisheries, the findings present evidence to support the argument that uncritical advocacy for NMRs glossed over critical information gaps in the evidence base and that it would have useful to discuss these gaps upfront before the planning process was undertaken (e.g. susceptibility of different habitats to different fishing pressures, disproportionate impacts on inshore fishermen etc).

In the debate over whether scientists should advocate (Nelson & Vucetich 2009), studies have shown there may be pressure put on scientists from certain stakeholder groups (such as environmentalists) to become advocates (Gray & Campbell 2008). The current culture of decision making that calls for science-based policy also puts pressure on the scientist to play down scientific uncertainty and advocate policies that are speculative (at best) or based on bias (at worst). These pressures have led to a widely held belief within the scientific community that science compels action (e.g. Davis 1999)[45]. This may explain why advocates for NMRs have largely focused their attention on gaining and overstating evidence to show the fisheries benefits of NMRs, because that makes MPAs appear a more attractive tool to decision makers as it is implies that there will be less disadvantage caused to fishers. However, scientists stand to risk losing their credibility if they are not clear whether they are advocating for normative

[45] Davis (1999) says "If science similarly shows essential functions of unimpaired, untrammeled, marine ecosystems, perhaps those holding beliefs of the sea's inexhaustibility and denying human culpability for collapsed fished populations can embrace new knowledge and modify their beliefs to everyone's benefit. Simply challenging one set of untestable beliefs with another is futile. Only new information, knowledge, can break the deadlock. Science as a process for learning can do that. Science as a source of light in the darkness of ignorance can help us change the way we allocate, restore, maintain, and protect marine resources to assure that future generations will still have options to exercise."

or scientific reasons (Scott et al. 2007), though as will be shown the distinction between normative and scientific dimensions of policy is often unclear (see Chapter 6).

One way to avoid the problem of advocacy, particularly the stealth-issue advocacy described here, is to require that scientists, when recommending policies to decision makers should always provide a range of options based on scientific evidence so they are not reducing the scope of choice and being partial to one particular outcome (Pielke Jr 2007). However, there is another issue – the issue of good governance[46] – which involves factoring in the contribution of the public to the debate on MPAs (see Chapters 6 and 7 for detailed discussion). Pielke Jr (2007) argues that publics' and scientists' views on the role they should take in decision making are related to their beliefs about two relationships: (a) the role of science in society, and (b) the role of the expert in a democracy. This brings me to the final part of this chapter; the discussion of two contrasting policy network models 1) the epistemic community and 2) the advocacy coalition that will act as lenses to explain how the science-policy interface was conceptualised during the planning of MCZs. In particular the following question will be asked; what role should science have in the planning process given that stakeholder buy-in into decision making is an important determinant of management success (Christie et al. 2003)?

2.4 Governance setting

2.4.1 General overview

In his book *The Honest Broker* Pielke (2007) suggests that most people generally hold one of two views on how experts should participate in democracy. The first view, which Pielke (2007) terms as *Schattschneiderian democracy*[47] is that the public participate in democracy by voicing its views on alternatives presented to it by the political process; "such alternatives do not come up from the grassroots any more than

[46] Jones (2012a) defines governance as 'steering human behaviour through combinations of people, state and market incentives in order to achieve strategic objectives'.
[47] Based on the writings of the political scientist E.E. Schattschneider in his book *The Semi-Sovereign People* (1975).

you or me telling a mechanic what the options are for fixing a broken car" (Pielke Jr 2007). The second view is termed *Madisonian democracy*[48] , also known as "interest group pluralism", according to which experts best serve society simply by aligning themselves with their favoured faction or interest group; "it is a virtue for scientists to take a more proactive role as advocates in political debates seeking to use their authority and expertise as resources in political battles" (Pielke Jr 2007).

There is a related distinction between the linear model of the link between science and policy, and the stakeholder model. The widely held "linear model" suggests that knowledge flows from basic research to applied research to development and ultimately societal benefits; "specifically, the linear model is often used to suggest that achieving agreement on scientific knowledge is a prerequisite for a political consensus to be reached and then policy action to occur (Pielke Jr 2007)". However, the linear model of science-policy has been heavily challenged by many STS scholars (Jasanoff 1994; Sarewitz 1996; Nowotny et al. 2001; Wynne et al. 2005) who suggest that the users of science should have some role in its production (termed the "stakeholder model"), and also that considerations of how science is used in decision-making are an important aspect of understanding the effectiveness of science in decision-making (Pielke Jr 2007). Nevertheless, the linear model probably still represents the view that the majority of scientists and society have on how science relates to policy (Sarewitz 1996; Pielke Jr 2004), and forms the basis of how the link between science and policy is conceptualised by both the epistemic community (EpC) and the advocacy coalition (AC).

These twin sets of opposed concepts can be linked to two generalised policy network models of decision making/ governance described below. 1) the epistemic community (top down, Schattschneiderian, linear-model) that suggests that policies stem from scientific consensus: and 2) the advocacy coalition (bottom up, Madisonian, stakeholder model) that suggests that policies stem from political compromise with science in the service of an AC's preferred policy (see Table 2.8).

[48] Based on the writings of James Madison (1787).

Table 2.8 Characteristics of the two networks.

	Epistemic community	Advocacy coalition
Membership	Scientists/ experts, and senior bureaucrats	Scientists, bureaucrats, elected officials, lobbyists, grass-roots activists, industry, wider civil society
What binds members together?	Common body of knowledge	Principled beliefs
Decision making model	Consensus	Compromise
Science-policy model	Linear model	Stakeholder model
How does policy change occur?	Integration of experts of the international regime into their respective national governments, and who hold their own governments to account	Policy change reflects the influence of competing advocacy coalitions, and unless one coalition is overwhelmingly dominant, a policy compromise usually results
Influence of the scientist	The scientist is central to policy change; they analyse the problem and set the policy agenda	Scientists align themselves with their preferred interest groups and offer their expertise in policy debate
Examples	Mediterranean pollution control; control of CFCs	MPAs in California; tropical deforestation

2.4.2 Epistemic communities

Overview

Peter Haas (1989) first coined the term 'epistemic community'[49] to describe the emergence of some international environmental regimes. An important feature of such regimes, in addition to their embodiment of rules and norms (Krasner 1983), is that they facilitate international learning and produce convergent state policies (Haas 1989). Typically the notion of an epistemic community has been used to explain the co-ordinated response of states to a collective action problem that has arisen at the regional level (e.g. pollution control in the Mediterranean) or global level (e.g. the regulation of CFCs) level (Haas 1989; Haas 1991). At the heart of the EpC is a group of experts who form around consensual knowledge, and share a policy enterprise (the action that needs to be taken to resolve an issue; e.g. the regulation of a hazardous chemical). The EpC is a useful theory for explaining policy responses to highly technical international problems where official decision makers are unfamiliar with the technical details, and thereby unable to define state interests and develop viable solutions (Haas

[49] Epistemic communities is a way of trying to make sense of the fact that hard-to-grasp decisions may move actual, although not necessarily formal, power from elected representatives (or dictators for that matter) to elites acquainted with the subject in a transnational setting (Sundstrom 2000).

1992b). This opens the door for a group of motivated individuals who through their expert understanding of the problem area, technical credentials, and common policy enterprise can offer potential solutions. The members of the EpC who are initially responsible for bringing states together to negotiate the regime have sufficient influence within their own governments to introduce regulation to their own domestic policy agenda (Haas 1989).

The EpC is a good demonstration of the linear model in action, in that science is its fundamental bedrock (Table 2.8), bringing to light new environmental problems and helping decision makers to grasp their underlying causes; EpCs set the policy agenda. However, EpCs have had mixed success: for example, the Montreal Protocol has been viewed by some as very successful in limiting CFC emissions[50], but the Kyoto Protocol has failed to curb global CO_2 emissions.

Application to thesis

In the context of this thesis evidence for the influence of the EpC comes from the fact that in the processes of getting provisions for MPAs written into international regimes and agreements, leading roles were taken by a group of like-minded individuals in UNEP, FAO, IUCN, secretariat members of current regimes, marine scientists, and MPA planners and managers (Kelleher & Kenchington 1991; Salm et al. 2000; IUCN 2008). This community was united in its recognition of the MPA as an approach to protect marine biodiversity, with the aim of systematically protecting representative habitats across each of the major marine provinces (OSPAR 2003b; Toropova et al. 2010b). The policy recommendations of this EpC have been extensive: a number of guidelines and best practices have been provided by academics, environmental non-government organisations (ENGOs), research consultancies, and individual governments for the planning, development, management and evaluation of such an MPA network (Pomeroy et al. 2004). As members of this network became integrated into advisory committees in their own governments, the domestic policies of these countries began

[50] Though Pielke Jr (2007) argues that it was not scientific information that led to political consensus, the introduction in the mid-1970s of creative policy options that distinguished essential from non-essential uses of CFCs both depoliticized the issue and stimulated the search for chemical substitutes, even as ozone science remained uncertain.

to reflect the policies of the initial group of experts, i.e. through designing networks of MPAs to conserve nature by adopting ecological criteria (Airame et al. 2003; Roberts et al. 2003a,b). This is reflected in England through the adoption of Natural England's (England's statutory conservation agency) Ecological Network Guidance (Ashworth et al. 2010) (Chapter 6).

This MPA-EpC also has a normative commitment to the protection of marine biodiversity. Although best practice guidelines for setting up networks of MPAs have no doubt arisen from the empirical observations made by scientists and MPA practitioners, the imperative to protect biodiversity is largely a moral one (i.e. protecting species for future generations) rather than a scientific one. However, scientists understanding of how concepts such as biodiversity, ecosystem resilience and ecosystem productivity relate to one another is weak; there is a trade-off between the protection of biodiversity and maintaining or increasing food supplies from the sea[51] (Peterson & Lipcius 2003; Brander 2010), though it is well known that the productivity of some habitats is highly dependent on their static structure (e.g. coral reefs, scallop beds and associated habitat) (Jennings & Polunin 1996; Thurstan & Roberts 2010; Howarth et al. 2011). Given this normative dimension of biodiversity and ecosystem well-being, an important question to ask is what value one ecosystem state has over another, and who/ what benefits from protecting an ecosystem in a certain state by imposing an MPA on it.

In a biodiversity context, the effects of this EpC have so far been minimal because of the difficulties associated with protecting nature for nature's sake (its bequest value). Perhaps realising this, a significant fraction of the scientific community began to frame the debate around what MPAs, particularly NMRs could achieve for fisheries (Roberts 1997; NCEAS 2001), with the emergence of the American consensus statement on the fisheries benefits of NMRs published in 2001 (NCEAS 2001) (see 2.3.3). In relation to Haas' theory on epistemic communities this is important as it suggests a significant

[51] Though many would argue that current levels of exploitation are too risky; given all the unknowns we should err on the side of caution during exploitation (Lauck et al. 1998).

divide within the scientific community regarding the use of MPAs and NMRs in a fisheries management context (see 2.3.4).

The scientific justification of certain percentage targets (i.e. 20-30% rule of thumb) for NMRs is based on the findings of abstract modelling studies. Several authors have tried to show through modelling exercises that 10-50% (modal value of 30%) of the oceans should be designated as NMRs to sustain fisheries. However, Agardy et al (2003) have pointed out that this 'rule of thumb' has originated from modelling studies that have principally focused on tropical coral reefs (Bohnsack et al. 2000). Thus the scientific basis for NMRs as a preferred tool in the management of temperate marine resources seems to be lacking. It may be, therefore, that while NMR advocates have aspired to form an epistemic community, they are more aptly described as a stealth issue advocacy coalition[52] using science to gloss over their value preferences.

2.4.3 Advocacy coalitions

Overview

Epistemic communities are successful when their core policy enterprise remains unchallenged at all levels of government, and little significant opposition exists to refute their causal and normative assumptions. They are less successful where the problem area is less clearly defined with respect to its causal underpinnings or where irreconcilable differences exist in actors' fundamental normative beliefs (e.g. on commercial whaling). In such cases, the advocacy coalition (Sabatier 1988; Keck & Sikkink 1998)[53] is likely to be more effective (Sabatier 1998; Weible & Sabatier 2005). Unlike epistemic communities, ACs are not limited to 'knowledge experts' (i.e. academics, elected officials and civil servants) but also include non-governmental organisations (NGOs), think tanks, journalists, celebrities and members of civil society.

[52] Pielke Jr (2007) argues that whenever science is invoked (or information more generally) as a justification for selecting one course of action over others, then one is "politicizing science", thus by its very nature an EpC is acting as a stealth issue advocate.

[53] The term 'advocacy coalition' has been used by Sabatier (1988) and other authors to explain the actions of advocacy networks solely at the domestic level. However, this article uses the term to explain the actions of international advocacy groups that are named elsewhere as 'transnational advocacy networks' (Keck & Sikkink 1998).

Whereas the social norms of the EpC manifest themselves in a ‘regime’ that imposes its rules and regulations on others, the norms of the AC are manifested in a less formal ‘common cause’. Nevertheless, actors belonging to the AC are bound together by shared values, dense exchanges of information and services, and a shared discourse (Stone 2002), and the coordinated action of all these actors can be a powerful stimulus to policy change. Typically, however, there will be several ACs within the policy community competing to get their voices recognised by government, and policy change is a result of shifts in power between competing ACs (Schlager 1995). The relationship between knowledge and power in the AC reflects the notion of “interest group pluralism” where scientists best serve society by aligning themselves with their favoured faction or interest group, offering their expertise as an asset in political battle (Stone 2002; Pielke Jr 2007).

Application to thesis

At the international level evidence of ACs for and against MPAs is found in the highly coordinated networking that has occurred within both the global environmental movement (e.g. IUCN, WWF, PEW trusts) and the opposed (if much weaker) networking in the global fishing industry manifested in the International Coalition of Fisheries Associations which met on 13-14th November, 2007 to identify and address issues of common interest in international fisheries and called on their governments to recognise the limitation of MPAs as a fish stock protection measure. For example the pro MPA-AC has had impact through the Pew Environmental Trust’s global ocean legacy scheme which aims to establish a worldwide system of very large (>300,000 km^2) NMRs, four of which have now been established. In terms of influence on framing policy debates, the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) has also run a campaign for NMRs, producing a series of educational booklets showing their ecological effects (PISCO 2011).

Domestically, the AC framework has been used previously to explain the decision making process during the establishment of a network of NMRs in California (Weible 2007). Here in England two ACs have had influence on government during the planning of the MCZ network (Chapter 6 for details), one representing environmentalists (including the Marine Conservation Society (MCS), the Friends of the Earth Marine Group (Marinet), the Wildlife Trust, WWF, RSPB, Natural England and committed scientists), and the other representing the fishing industry (centred mainly on the MPA Fishing Coalition, headed by Dr Stephen Lockwood, an ex-CEFAS fisheries scientist). From a science-policy point of view, the pro-MPA AC pressed the scientific credentials of MPAs, while the fishing industry's AC criticised the policy recommendations of the environmentalists, pointing to the ecological impacts and socioeconomic costs of the displacement of fishing effort after an MPA is established (Chapter 6). In both ACs, science was viewed as a resource for enhancing their ability to bargain, negotiate, and compromise in pursuit of their special interests[54]. This strategy followed the pattern described in chapter six that the lack of information and modelling exercises undertaken at the local scale to inform policy (i.e. tactical modelling) meant that as stakeholders turned to heavily generalised science based on case-studies elsewhere to enhance their political standing, the result was that political battles were played out in the language of science, resulting in policy gridlock precluding any meaningful discussion of different values.

Comparing the impacts of EpCs and ACs, the MPA-EpC was successful when its core policy enterprise was unchallenged. But other policy networks challenged the prevailing MPA discourse (Chapter 6) on the grounds that MPAs may not be the only tool to achieve a given objective (McClanahan 2011), i.e. there are problems associated with enforcing large MPAs (De Santo et al. 2011), and as a result there is an ongoing debate between environmentalists and the fishing industry over how much we need to protect (NFFO 2011c); and there is rarely consensus amongst stakeholders over the objectives managers should be striving to achieve (Mee et al. 2008). So the effort by the MPA-EpC to get its policy enterprise recognised has been limited (Spalding et al. 2011; Wood 2011). Particularly at the domestic level in the UK where the fishing industry has some political power, the policy community became

[54] In Chapter 6 I also introduce a new concept, the 'discourse coalition' to explain the idea that facts and values are sometimes inseparable.

fragmented, with challenging ACs putting pressure on central government to get their interests realised.

However, whilst the concepts of epistemic communities and advocacy coalitions serve as useful lenses to view the process of decision making, their drawback is that they suggest a dichotomy between "top-down" and "bottom-up" mechanisms for decision making (Fig 2.2). But the most important part of any analysis of the science-policy interface is the balance of power between experts and wider civil society, and finding the middle ground where science can be used most productively in the political process leads to the notion of co-management.

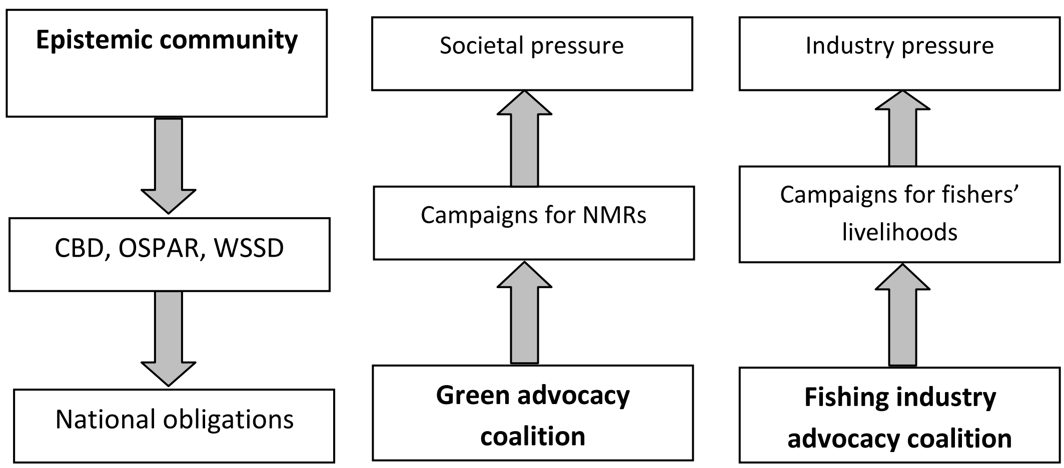


Figure 2.2 Effects of the MPA Epistemic Community and Advocacy Coalitions on influencing UK policy on MCZs.

2.4.4 Co-management

The two different models – EpC and AC – that have been used to explain the decision making process during the planning of MCZs focus on two different goals. The EpC model focuses on the outcome to be achieved – i.e. making sure that MCZs are located in places that are ecologically important which requires strong input from the state. This is important, in order to increase the likelihood of an MPA network meeting its ecological objectives (Ashworth et al. 2010; Jones 2012b). The AC model focuses on the process of decision making – the state largely mediating the interactions between competing interest groups. This is important to increase the likelihood of an MPA being accepted as a legitimate management tool and subsequently increase compliance amongst stakeholders (Weible 2008). Commonly there is a trade-off between the two (Chapter 6), with adherents emphasising the importance of one aspect over another.

The middle ground between these two extremes of top-down and bottom-up management has been termed co-management (CM) (Pomeroy & Berkes 1997), and generally interpreted as the sharing of power and responsibility between the state and resource users to make decisions regarding natural resource use (Berkes et al. 1991; Pinkerton 1992; Kaplan & McCay 2004). The argument that this thesis intends to make is that when science is mapped onto existing political perspectives (i.e. in advocacy coalitions) it leads to the twin trends of the scientisation of political debate (Chapter 6) and the politicization of science (Chapters 3-5). Science simply becomes viewed as an instrument for politics, and this becomes problematic when scientific information can help decision-makers select among different courses of action (Pielke Jr 2007). CM does not devalue the important contribution good science can make to decision making; on the contrary, it recognises that the scientific method is the best tool we have for finding out what is true or false about the world, "that given the growing realisation of the complexity and uncertainty of the world we live in, three qualities-scepticism, creativity, and reflexivity are prominent and recurring themes in the history of science, and arguably it is these characteristics that unify and define both what good science is and what good scientists do" (Robertson & Hull 2003). But CM also recognises that non-scientific inputs are also valuable. This has given rise to what has been termed post-normal science, that while recognising the importance of scientific information to the decision making process, other sources of information need to be recognised; "we need deliberative norms and institutions that emphasise the centrality of scientific information, while recognising the variety of sources of decision-relevant information and the critical contributions of non-scientists" (Stern 2005). CM also recognises that in many situations decision making is not only about the science, indeed in situations of gridlock, policy makers frequently need new options, and not more science (Pielke Jr 2007).

Pielke Jr (2007) argues that we desperately need organisations and individuals who are willing to expand the range of options available to policy-makers by serving as "Honest Brokers of Policy Alternatives". Rather than scientists limiting the scope of choice through stealth issue advocacy there needs to be a two way dialogue between society, the policy maker, and the scientist, with the scientist providing credible policy options that a decision maker can choose from. This may require the role of an intermediary or knowledge broker who can work across the science-policy divide and communicate to both audiences effectively (Meyer 2010).

Additionally, there is a growing emphasis on interdisciplinary and trans-disciplinary research whereby scientists from the natural and social sciences, and also local experts combine their expertise to develop a more holistic understanding of a problem, potentially coming up with novel solutions (Nowotny et al. 2003). The shift of science away from its original institutions (see 2.3.1) has created both potential tensions and opportunities at the science-policy interface, with implications for the *credibility*, *legitimacy* and *salience*[55] of knowledge for policy making (Cash et al. 2003) (see 7.3.3 Chapter 7 for discussion). The governance landscape of the UK regarding marine science is changing, with an increasing emphasis by funders on collaborative research between scientists, fishermen, managers and conservationists[56] (DEFRA 2010a).

However, the UK still has some way to go before reaching the co-management ideal (Phillipson & Symes 2010). Historic power relations still have a strong influence on decision outcomes; it remains too easy for the politician to take a short-term rather than a long-term perspective (Daw & Gray 2005). Although the MCZ process attempted to bring stakeholders together, some had more influence on decision outcomes than others. Also, despite evidence contradicting their beliefs, entrenched viewpoints still exist amongst some fishers and environmentalists (Chapter 6).

[55] Cash *et al* (2003) defines *credibility* as the scientific adequacy of the technical evidence and arguments; *salience* deals with the relevance of the assessment to the needs of decision makers; and *legitimacy* reflects the perception that the production of information and technology has been respectful of stakeholders' divergent values and beliefs, unbiased in its conduct, and fair in its treatment of opposing views and interests.
[56] For example see the fisheries science partnership run by CEFAS.

2.5 Chapter summary

This chapter has raised three questions that the subsequent data chapters will explore in more detail.

1) What is the sociological explanation for the rise of the MPA?
2) What normative and scientific reasons are there for and against establishing MPAs?
3) Have calls for evidence-based policy inflated the science boundary; if so, is this good or bad for science-policy relations?

For the first question it is argued here and in chapter three that a community of scientific experts has been highly influential in getting MPAs written into international policy. Whether this community is best conceived as an epistemic community, or perhaps more appropriately as an advocacy coalition is a matter of debate (see Chapter 3). If it is found that the scientific basis for MPAs is lacking, then arguably, advocacy for MPAs (particularly NMRs) has been driven by some scientists' subjective preferences for them over alternative management tools (McClanahan 2011).

For the second question, the normative rationale for establishing MPAs is that there is a growing awareness amongst society that we need to do more to protect marine biodiversity; many would argue that establishing more MPAs is morally the right thing to do (Russ & Zeller 2003). The scientific rationale for establishing MPAs is that it makes sense to protect certain habitat features that may underpin ecosystem function (Fogarty 1999; Tupper 2002), NMRs established over reefs have in many cases been shown to increase exploited fish species, however only a few studies have provided empirical evidence for their wider fisheries benefits (e.g. Russ et al. 2003). On the other side of the argument here is also a normative rationale for not establishing MPAs as they may have inequitable socio-economic impacts on certain parts of the fishing fleet (Mangi et al. 2011), likewise science has shown that MPAs may have unanticipated consequences through the displacement of fishing effort on to previously undisturbed habitats (Greenstreet et al. 2009) or increase in the bycatch of non-target species (Abbott & Haynie 2012), and their use as a tool to conserve mobile fish species is still widely debated (Chapter 5).

With regards to the third question it has been argued here that the view held by the majority of conservationists and some scientists on the relationship between science and policy resembles that of the linear model (Sarewitz 2000; Pielke Jr 2004); science should drive policy[57]. Such an attitude has been problematic with regards to MPAs, as it has brought politics into science; arguably, in some cases evidence has been produced to serve a political agenda (i.e. *normative science*), and this has been counter-productive to MPA science's legitimacy (science is partial to a scientist's preferred outcome) and salience (most of the science is irrelevant to the terms of reference of current policy debates) (Chapter 5).

The thesis argues in the discussion of chapter five and the real world case study of chapter six that effective objective setting is a key determinant of how science is used in policy debates (see 1.3 Chapter 1). In chapter six it is argued that ill-defined objectives from the start of the development of the Marine and Coastal Access Act meant that science became a surrogate for the interests of competing stakeholder groups. It is argued in chapter six that objectives should be set from the start through deliberative discussion between stakeholders and experts, since only when objectives are clearly defined can science be legitimately used as a tool by decision makers to weigh up the benefits and costs of alternative courses of action.

Questions 1-3 will be explored through the hypotheses shown in Table 2.9 that will now be tested in chapters 3-6.

[57] Moreover, when one senior representative from the fishing industry was asked about this in the context of setting the total allowable catch (TAC) through the EU's Common Fisheries Policy he said "when you talk to ICES scientists, very senior ICES scientists they are horrified at the prospect of following the science because it would politicise the working groups. I think that is a very important point, scientists are much more comfortable of giving a range of policy options, and then it's for the managers or politicians to decide, and that is a perfectly legitimate, because then there is a democratic element. But some of the NGOs are quite uncomfortable with that, they see in kind of a very simplistic way see final decisions on TACs differing from the science".

Table 2.9 Summary of hypotheses that will be investigated in the thesis.

Hypothesis	Method	Chapters
H1/ There has been a similar research effort applied to the study of MPAs compared to other management interventions.	Bibliometric analysis	1 & 3
H2/ Science on MPAs has been conducted impartially.	Questionnaire survey	4
H3/ MPAs/ NMRs will have positive ecological effects comprehensively wherever they are established.	Systematic review	5
H4/ Policy advocacy by scientists has confused the science-policy boundary with regards to the interpretation of evidence showing the fisheries effects of MPAs.	Key informant interviews and contents analysis of the literature	6 & 7

Chapter 3

Who's who in MPA science? A bibliometric analysis of the peer-reviewed MPA literature

ABSTRACT

The influence an international network of scientists has had on driving international policy on MPAs is examined through applying the tools of social network analysis to examine co-author relationships in the MPA peer-reviewed literature. Three co-author networks were constructed to show the evolution of co-author relationships within the scientific community. This facilitated the identification of scientists who are leaders in the field. Paper citation networks were determined to show the most highly cited studies on MPAs and the extent to which the MPA literature overlaps with other research fields. The two main findings that have arisen from the study are that around 90% of scientists leading research on MPAs are marine ecologists, and MPA studies dominate the wider marine management literature. From the empirical results shown here and using the theories of the epistemic community and advocacy coalition, I explain how an influential group of scientists mainly from the USA became involved in advocacy for MPAs/ NMRs, and I speculate on the extent to which members of this group influenced international policy, and have framed debate on MPAs more generally. I conclude by suggesting that a greater involvement of the social sciences in MPA research may identify the political contexts where MPAs work best, and that funding for research on other management measures should be encouraged so as to diversify the portfolio of potential policy options from which policy makers can choose.

3.1 Introduction

Whilst the push to establish an international network of MPAs has only recently started gathering momentum (Wood et al. 2008; Toropova et al. 2010a), international policy supporting MPAs stretches back to the early 1970s (see Table 1.2 Chapter 1), reflecting the influence of the growing environmental movement in the 1960s. It was however not until 1983 that the first paper documenting the effect of protection on a rocky reef fish assemblage was published in the international scientific literature (Bell 1983). Arguably, early evidence for the potential fisheries effects of MPAs arose serendipitously from studies of small-scale NMRs protecting coral reef fish assemblages in the Philippines (Alcala 1988; Russ & Alcala 1989; Russ 1989). A spate of reviews documenting the use of NMRs[58] in a fisheries management context during the 1990s (Roberts & Polunin 1991; Carr & Reed 1993; Dugan & Davis 1993; Rowley 1994) paved the way for an ever increasing number of empirical and theoretical studies that have examined the effects of NMRs on fisheries (Chapter 5).

This chapter argues that the social context surrounding production of knowledge on the effects of MPAs has influenced the way contemporary policy debates on MPAs have been framed. Social scientists have suggested that a scientist's disciplinary background is strongly associated with his/her preference for certain types of management tool (Degnbol et al. 2006; Christie 2011). Here I show which types of scientist (i.e. natural vs social, conservationist vs fisheries) have dominated the production of knowledge on MPAs; which scientists have become involved in advocacy for NMRs and where these scientists reside; and additionally which papers have been most cited. This will provide important contextual information on which the following data chapters will build.

Haas' theory of epistemic community (EpC) (Haas 1989) has been used to describe the influence that a network consisting primarily of marine natural scientists has had on driving policy on MPAs forward at the international through to the domestic level (Christie et al. 2003). The central characteristic of the EpC is that as scientists work to

[58] See Chapter 1 section 1.3.1.

reduce uncertainty (see 2.2.3 Chapter 2) and identify causes of a problem they can start to develop solutions; an EpC comes into existence when scientists persuade decision makers that their solution is the best one, and start to set the policy agenda- in this case the development of MPA networks to halt declines in marine biodiversity (e.g. CBD, WSSD, OSPAR, MSFD etc) (see Table 1.2 for definitions).

However, some recent studies have suggested that current thinking on marine environmental problems has been too compartmentalised within disciplines (Degnbol et al. 2006; Hilborn 2007a; Pitcher & Lam 2010; Christie 2011). Research carried out on MPAs has been stated as an example, with the natural sciences dominating the research agenda, defining management success (Christie et al. 2003), and also shaping how policy discussions are framed (Chapter 6). The theory of the EpC implicitly entails that a problem is resolved through improved information when there is general consensus over objectives, values, and priorities amongst different social groups (Haas 1992a). However, debates over marine protection are typically heavily value-laden[59] (Brander 2010; Salomon et al. 2011) and often become contested between resource users and conservationists (e.g. Jones 2006, 2008, 2009). In such a scenario the role of the expert changes, and the political process works to achieve a compromise between the interests of competing stakeholder groups (van den Hove 2006) (Chapter 6), perhaps best explained by the advocacy coalition (AC) framework (Weible 2007).

Although the two concepts of the EpC and AC are distinct (see 2.4 Chapter 2), it is argued that at the international level they may become interlinked. For example, while officially MPAs are regarded as tools to protect biodiversity, conserve essential ecosystem functions (Toropova et al. 2010a) and protect representative habitats, advocacy from some scientists for NMRs based on their potential fisheries benefits (the stealth-issue AC) has caused the science-policy boundary to blur[60] (see 2.3.4 Chapter 2). By 'blur' I mean that arguments based on personal ethical views may underlie scientific arguments, and that the degree of uncertainty concerning the latter

[59] E.g. sustainable use may lead to general reductions in biodiversity; preservationists would argue that this is bad; whilst exploiters would argue that they are not doing any damage to the long-term productivity of the ecosystem.
[60] Jones (2002) says "whilst it is important for scientists to engage in debates concerning MPAs, it is equally important that arguments based on personal ethical views are distinguished from those based on scientific evidence, and that the degree of uncertainty concerning the latter is made clear. Statements which are implicitly influenced by a personal ethical stance potentially exacerbate conflicts and confuse issues."

is played down (Jones 2002). This is exemplified by the 2001 consensus statement that "existing scientific information justifies the immediate application of fully protected marine reserves as a central management tool" (NCEAS 2001), which caused a divide within the wider scientific community (Agardy et al. 2003), because uncertainty on the evidence of NMR fisheries effects outside a warm water reef context was ignored, with personal ethical views of scientists implicitly running underneath the scientific statements (see Caveen et al. 2013).

The overarching objective of this chapter is to examine how an international network of scientists who have studied MPAs has evolved through time, and will provide answers to the following questions; which scientists have the highest publication output; which scientists are most connected with their peers through research collaboration; and which scientists have become involved with advocacy? A secondary objective of this chapter is to look at which MPA papers have been most cited, and in which journals they have been most published. Thirdly, the chapter will look at the extent to which there is crossover in the most highly cited papers between different research fields through a comparative analysis of paper citation networks. Finally, the chapter will then interpret this information in light of policy development on MPAs at the international level.

3.2 Methods

3.2.1 Literature search

The search string *Marine AND ("marine reserve*" OR "marine protected area*" OR "park*" OR "sanctuar*" OR "no take zone*" OR "special area* of conservation" OR "conservation zone *" OR "specially protected area*" OR "refugia" OR "box" OR "closed area*")* was used to source all literature published on MPAs (1972-2010) from ISI's Web of Science (WoS). This search string was developed following a critical appraisal of the different terms used to describe MPAs (see section 1.3 Chapter 1), and through carrying out searches using different combinations of terms in WoS. Records were imported into HistCite^{TM} and authors ranked according to their publication count.

Records from the search included empirical and theoretical natural and social science articles, as well as opinion pieces and reviews. Following a preliminary analysis of the quality of the data and its readiness for analysis it was decided not to clean the data as the amount of time required to do this would be unlikely to have led to an improvement in the quality of inference drawn from the results.

3.2.2 Social network analysis

Construction of co-author networks

Authors who were chosen to be included in the network had to meet the following criteria: 1) they had a minimum of 10 peer-reviewed publications, 2) they had a minimum local citation score (LCS) of 100, and 3) they were connected to at least one other author. From these criteria, a total of 52 authors were identified. The resulting network was laid out using the Pajek 1.24 (Batagelj & Mrvar 2004) network visualisation package. Admittedly, these cut-offs were arbitrary, however, if for example the number of peer-reviewed publications was reduced to nine the network would become too cluttered, making visualisation difficult.

An additional two networks were drawn for the 52 authors for an additional two time periods, 1972-2000, and 1972-2005[61]. This enabled an analysis of the evolution of the co-author network through time. Whilst networks could have been constructed separately for each period (i.e. 1972-2000, 2001-2005, 2006-2010), for the purpose of this analysis doing this would make it more difficult to examine the evolution of networks through time, as historic collaborations may still hold significance even though authors have stopped publishing work together.

A fourth network was plotted to allow the identification of scientists who were signatories to the North American (NCEAS 2001) and European (Roberts 2007b) consensus statements. This was done to investigate whether there was any relationship between network structure and those scientists who have become explicitly involved in advocacy for NMRs.

Data analysis

The three time periods were analysed separately. For each time period, contemporary data from HistCite™ was taken on the Local Citation Score[62] (LCS) for the ten most productive (in terms of publications) authors of that period (i.e. 1972-2000, 2001-2005, 2006-2010). The LCS score can be used as a measure of a scientist's influence within their 'local'[63] science community. Information on journal statistics and institutional affiliations for each time period were also derived from HistCite™. Additional information on funding sources was derived from the acknowledgements section of each study.

Two measures of centrality, closeness and betweeness, of the authors in each network were derived from Pajek (Batagelj & Mrvar 2004). *Closeness centrality* $c(i)$ is a measurement of the total distance between one vertex and all other vertices, with larger distances yielding lower closeness centrality scores (Equation 3.1).

[61] These intervals were chosen arbitrarily and for convenience to show the evolution of the network over two five-year time periods (2001-2005, and 2006-2010).
[62] This score reflects the number of times a paper has been cited within the sample literature.
[63] Defined by the search terms used to source publications in WoS. The most highly cited scientists who were identified by the original search term are likely to have research interests outside of MPAs.

$$c(i) = \left[\sum_{i} d_{ij}\right]^{-1} \qquad \text{(Equation 3.1)}$$

Where d_{ij} is the number of links in a shortest path from node *i* to node *j*.

Betweeness centrality $b(i)$ is a measurement of the extent to which an actor is an intermediary between pairs of vertices (Equation 3.2), or put another way, the number of times a node needs a given node to reach another node.

$$b(i) = \sum_{j,k} g_{jik} \,/\, g_{jk} \qquad \text{(Equation 3.2)}$$

Where g_{jk} is the number of shortest paths from node *j* to node *k*, and g_{jik} is the number of shortest paths from node *j* to node *k* passing through node *i*.

3.2.3 Citation analyses

Paper-citation networks

Using the same search term and time period as for the construction of the co-author networks (see 3.2.1), all records were imported from WoS into HistCite™. A graph was plotted for the top 20 most highly locally (using the LCS score) cited papers contained within the database.

Comparative analysis of different research fields

A comparative analysis of the original search term (X) with seven additional search terms ($N_{1\text{-}5}$) (Table 3.1) was undertaken to examine the similarity in publications found between different research fields. The rationale for this was to get a rough estimate of the proportion of literature on MPAs that existed in other research fields, thus attempting to gauge how prominent MPAs had become in the wider marine literature.

The search terms N_{1-5} were decided on to illustrate the crossover between the MPA literature and other areas of marine research. For example *Marine AND fisher** was chosen to examine the extent to which the MPA literature crossed over with the literature on marine fisheries, and *Marine AND management* was chosen to examine the extent to which the MPA literature crossed over with the general body of knowledge dealing with all marine management issues. A more thorough analysis might consider how trends in different types of spatial management measure (i.e. MPAs vs NMRs) and non-spatial measures (i.e. days at sea, quota allocation etc) in the literature change over time, but this was beyond the scope of this chapter.

If all publications to search N were unique from search X then the expected number of publications found in WoS by combining the two searches would be $X + N_{(exp)}$. In reality there is likely to be some crossover between the publications found using search string X and search string N. The number of publications that N has in common with X is expressed by:

$$(X + N_{(exp)}) - (X + N_{(ob)}) \qquad \text{(Equation 3.3)}$$

Where $(X + N_{(ob)})$ is the actual number of publications observed in WoS when the two searches are combined into one search string. The proportion of publications search N has in common with X is expressed by:

$$\frac{((X + N)_{(exp)} - (X + N)_{(ob)})}{N} \qquad \text{(Equation 3.4)}$$

Paper citation networks were also drawn for searches N_{1-5} to examine the extent to which papers in the citation network for search X were present in these five additional networks. The rationale for this was to examine the extent to which the MPA literature also dominated other research fields.

Table 3.1 A summary of the number of publications for different search terms (1972-2010), and percentage overlap between search X with searches N_{1-5}.

Search	Term	Number of records (end 2010)	Percentage of shared records with search term X
X	Marine AND ("marine reserve*" …)	5,465	n/a
N_1	Marine AND fisher*	6,872	22.83%
N_2	Marine AND conservation	4,509	29.92%
N_3	Marine AND ecology	6,387	5.64%
N_4	Marine AND management	8,348	24.65%
N_5	Marine AND policy	1,839	17.13%

3.3 Results

3.3.1 The structure of the scientific community

Period one: 1972-2000

The co-author network can be partitioned into two sub-networks, one consisting of a group of scientists in the USA and another consisting of a group of scientists in Europe (Figure 3.1). The USA network has been particularly influential in the numbers of both publications and citations (Table 3.3). Influential institutions include the National Oceanic and Atmospheric Administration (NOAA), James Cook University, and the University of Auckland.

Looking at the impact of individual scientists, TR McClanahan (Wildlife Conservation Society, USA) has the greatest number of publications (14) and CM Roberts (York University, UK) has the greatest Local Citation Score (LCS) (167) (Table 3.2). In terms of network structure NVC Polunin has the greatest centrality scores for both measurements of closeness (0.220) and betweeness (0.110). M Zabala and E Sala could be considered to be key intermediaries, between USA and European sub-networks, each having betweeness values of 0.108 and 0.101 respectively. There are also four unconnected sub-networks (Figure 3.1). The network consists mainly of scientists who would be best described as marine ecologists. Only two social scientists, A White (The Nature Conservancy, USA) and P Christie (University of Washington, USA) whose work focuses more on the social aspects of marine resource management have enough publications to be included in the three network graphs.

The most published in journals include the *Bulletin of Marine Science* (47) (which published a special issue on MPAs in 2000), and *Marine Ecology Progress Series (MEPS)* (37) (Table 3.4). The most studied MPAs were all NMRs mainly located over tropical reefs (Leigh, NE New Zealand being the exception) (Figure 3.2).

Table 3.2 Bibliometric attributes of the ten most published authors from 1972-2000, (Author nationality in brackets). Sources of funding for each author are also indicated (though this list is not exhaustive).

Author	Publications (1972-2000)	LCS (1972-2000)	Centrality measures (1972-2000)		Sources of funding
			Closeness	Betweeness	
McClanahan T (USA)	14	112	0.154	0	IUCN, East African Wildlife Society, PEW trust, Eppley foundation
Polunin N (UK)	11	146	0.220	0.110	MRAG Ltd, WWF Indonesia, UK Overseas Development Agency
Roberts C (UK)	10	167	0.158	0	WWF, UK Overseas Development Agency
Russ G (Aus)	10	131	0.043	0.020	UNEP, Natural Resources Management Centre of the Philippines, GBR Marine Park Authority, Australian Research Council, CRC Reef Research Centre, Fishing Industry Research and Development Council
White A (USA)	10	21	0.043	0	UNEP coral reef monitoring programme
Morton B (UK)	9	5	0	0	
Alcala A (Phl)	8	158	0.043	0	UNEP, Natural Resources Management Centre of the Philippines
Bohnsack J (USA)	7	55	0.133	0	
Davis G (USA)	7	72	0.133	0	
Jennings S (UK)	7	38	0.154	0	UK Overseas Development Agency

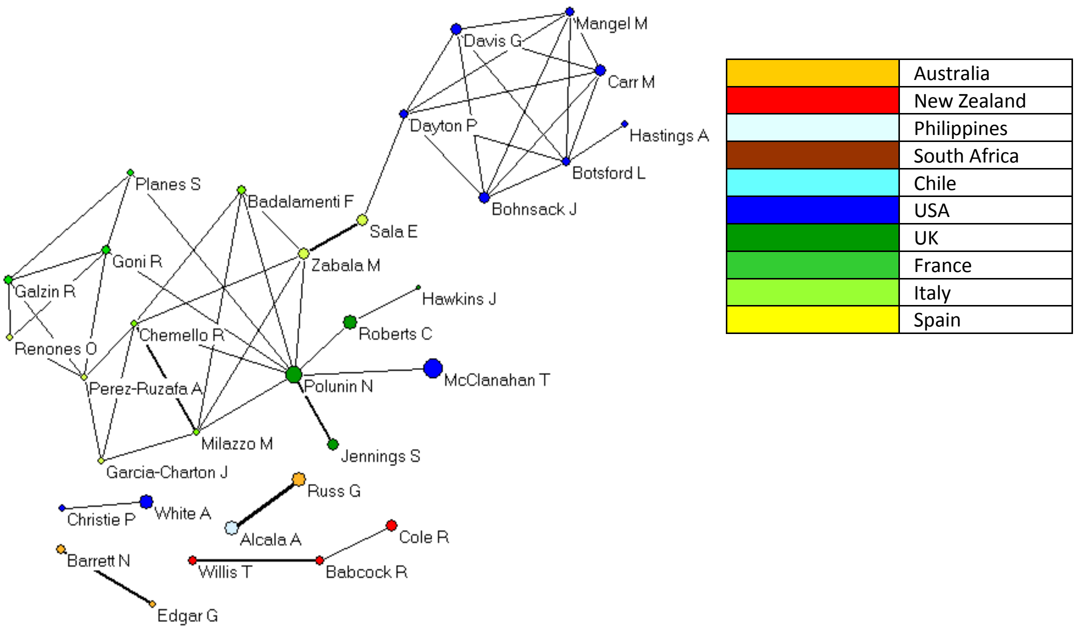


Figure 3.1 Co-author network of the most productive authors in MPA science from **1972-2000 (n=32)**. Vertex size indicates the relative number of publications for an author, and edge-width the number of times an author has collaborated. Vertex colour indicates author nationality.

Table 3.3 Bibliometric attributes of the ten countries and institutions with the highest number of publications from 1972-2000.

Country	Publications	LCS		Institute	Publications	LCS
USA	321	565		NOAA	35	71
Australia	115	223		James Cook University	24	51
UK	98	250		Univ East Anglia	19	15
Canada	80	88		Univ Hong Kong	19	6
France	49	86		Univ Miami	19	32
Spain	28	38		Univ British Columbia	18	33
New Zealand	27	79		Univ Auckland	17	69
Italy	20	16		Univ Washington	14	8
South Africa	16	97		CSIRO	11	11
Kenya	12	88		Univ Calif Davis	11	31

Table 3.4 Bibliometric attributes of the ten journals with the highest number of publications from 1972-2000.

Journal	Pubs	LCS	Special issue (SI) / highly cited publications
Bull Mar Science	47	38	SI (2000, 66:3)
MEPS	37	247	Russ & Alcala (1989, 1996), Roberts & Polunin (1993)
Ocean & Coastal Management	31	55	Jones (1994), Alcala (1998)
Mar Poll Bulletin	27	14	White (2000)
Coastal Manag	24	46	Christie & White (1997)
Coral Reefs	20	67	McClanahan (1994 & 1999)
Env Conservation	18	27	Pinnegar *et al* (2000)
Biol Conservation	16	67	McClanahan *et al* (1999)
Oceanus	25	84	Bohnsack (1993)
Aquat Conserv	14	77	Dayton *et al* (1995)

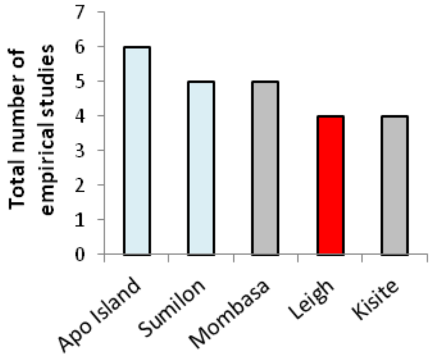


Figure 3.2 Most studied MPAs during 1972-2000; coloured by country (see Fig 3.1 key), MPAs shaded grey are in Kenya.

Period two: 2001-2005

During this five year period the two sub-networks are substantially better connected. The USA is still hugely influential with 566 publications and a LCS score of 2333. Indeed eight of the top 10 institutes are based in the US, with six conducting their work largely on the west coast (Table 3.6).

G Russ (James Cook University, Australia) is the most published author (17), and CM Roberts has the greatest LCS score (611). It is interesting to note that in this five year period, eight of the most published authors are US nationals (Table 3.5), many receiving funding through the US National Centre for Ecological Analysis and Synthesis (NCEAS). The closeness scores for many scientists have increased; CM Roberts being the most central actor in the network (0.373). Both NVC Polunin (Newcastle University, UK) and CM Roberts are key intermediaries (information brokers?)[64] in the network (with scores for betweeness of 0.278 and 0.233 respectively). Roberts in addition to E Sala (Scripps Institute of Oceanography, USA) is also a key intermediary between the US and European networks. Several authors from Australasia are still unconnected to the main network (i.e. Barrett-Edgar, Willis-Babcock-Cole). During 2001-2005 the two social scientists, A White and P Christie have become incorporated into the main network through collaboration with G Russ and his work in the Philippines (Figure 3.3).

MEPS is the most published in journal (Table 3.7). *Ecological Applications* published a special issue on NMRs in 2003 that was a result of a working group convened in 1999 at the NCEAS and also supported by the University of California (Table 3.6). Apo Island is still the most studied NMR (Figure 3.4).

Table 3.5 Bibliometric attributes of the ten most published authors from 2001-2005, (Author nationality in brackets).

Author	Publications (2001-2005)	LCS (2001-2005)	Centrality measures (1972-2005)		Sources of funding
			Closeness	Betweeness	
Russ G (Aus)	17	342	0.274	0.079	UNEP, PEW Trust
Gaines S (USA)	14	63	0.251	0.002	NCEAS (through the National Science Foundatiion)
Botsford L (USA)	13	250	0.266	0.031	California Sea Grant
Roberts C (USA)	13	444	0.373	0.233	UK Darwin Initiative, NERC, PEW trust, UK Department for International Development, NCEAS
Babcock R (NZ)	12	267	0.055	0.001	NZ Department of Conservation
Warner R (USA)	12	157	0.304	0.028	NCEAS, PISCO (David and Lucille Packard Foundation)
McClanahan T (USA)	11	278	0.314	0.021	WCS, PEW trust, Eppley Foundation, NERC, UK Expeditions Council
Halpern B (USA)	10	74	0.301	0.023	NCEAS
Palumbi S (USA)	10	29	0.251	0.004	NCEAS, Andrew Mellon Foundation, PEW trust, Packard Foundation
Hastings A (USA)	8	121	0.246	0.001	NCEAS

[64] I.e. they form important linkages in the network between different research clusters.

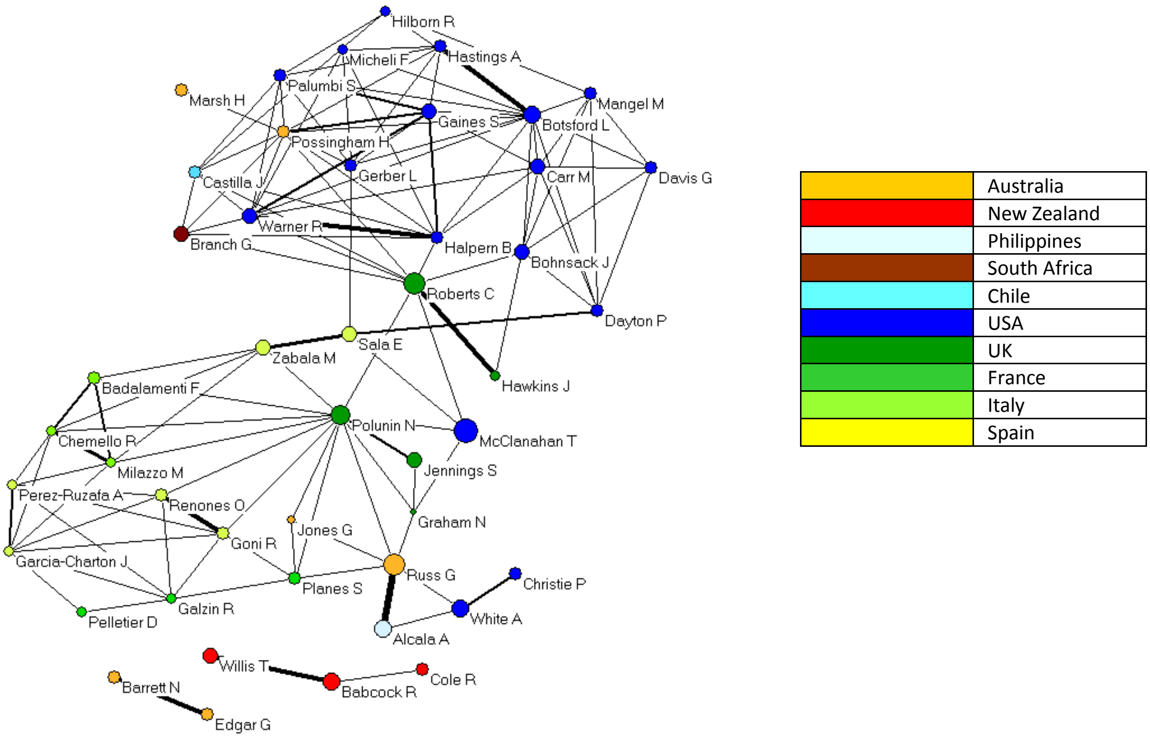


Figure 3.3 Co-author network of the most productive authors in MPA science from **1972-2005 (n=41)**.

Table 3.6 Bibliometric attributes of the ten countries and institutions with the highest number of publications from 2001-2005.

Country	Publications	LCS		Institute	Publications	LCS
USA	566	2333		James Cook University	48	290
Australia	195	828		NOAA	47	238
UK	150	762		Univ Calif Santa Barbara	42	361
Canada	131	604		Univ Washington	34	108
France	73	243		Univ Calif Davis	31	230
Italy	55	113		Univ Miami	31	117
Spain	54	218		Oregon State University	28	19
New Zealand	28	344		Univ Calif Santa Cruz	27	157
South Africa	23	203		Univ British Columbia	26	283
Philippines	20	182		Univ Calif Santa Cruz	27	157

Table 3.7 Bibliometric attributes of the ten journals with the highest number of publications from 2001-2006.

Journal	Pubs	LCS	Special issue (SI) / highly cited publications
MEPS	65	573	Shears & Babcock (2003)
Mar Poll Bulletin	36	45	
Ecol Applications	35	236	SI (2003, 13:1)
Conserv Biology	33	208	Fernandes *et al* (2005)
Aquat Conserv	32	231	Agardy *et al* (2003)
Coastal Manag	26	126	White *et al* (2002)
Bull Mar Science	25	448	
Can J Fish Aqu Sci	25	284	Holland (2000)
Biol Conservation	23	252	Gladstone (2002)
Ocean & Coastal Management	21	135	Hilborn *et al* (2004)

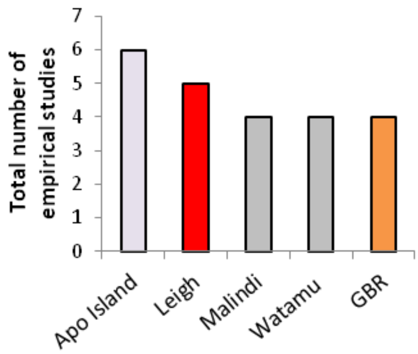


Figure 3.4 Most studied MPAs during 2001-2005.

Period three: 2006-2010

Research output for the period 2006-2010 seems to be less biased towards the USA, with scientists from Australia, the UK and continental Europe having a notable publication output (Tables 3.8 & 3.9).

The most published author for this five year time period is T McClanahan with 31 publications, and G Russ has the greatest LCS score (1086). Whereas closeness measures for all scientists have increased, betweeness measures have declined, indicating that no one person can considered to be a key intermediary between different clusters. T McClanahan who conducts his research in the Western Indian Ocean has the highest scores for both closeness (0.512) and betweeness (0.147) centrality measures. The five scientists from Australia and New Zealand (i.e. Barrett-Edgar, Willis-Babcock-Cole) have finally become integrated in the main network though remain very much on the periphery, as do the social scientists A White and P Christie. The 1972-2010 network graph shows also considerable integration between the European and USA sub-networks (Figure 3.6). Figure 3.7 used signatories to the American (NCEAS 2001) and European (Roberts 2007b) consensus statements calling for NMRs to identify which scientists in the network had become involved in advocacy for NMRs. Twenty two scientists, mainly from the USA had explicitly become involved in advocacy for NMRs (Figure 3.7).

MEPS remains the journal most published in. *Marine Policy* also enters the top 10, ranked third in terms of publication output (Table 3.10). The most heavily studied MPAs in this period are located in sub-tropical Western Australia (Abrolhos), Tasmania (Maria Island), and the Mediterranean Sea (remainder) (Figure 3.5).

Table 3.8 Bibliometric attributes of the ten most published authors from 2006-2010, (Author nationality in brackets).

Author	Publications (2006-2010)	LCS (2006-2010)	Centrality measures (1972-2010)		Sources of funding
			Closeness	Betweeness	
McClanahan T (USA)	31	470	0.512	0.147	WCS, IUCN, David & Lucille Packard Fund, PEW trust, FSBI, Leverhulme trust
Possingham H (Aus)	22	107	0.412	0.049	NCEAS,ESRC, NERC, Ruffard Foundation, Conservation International, David and Lucile Packard Foundation
Graham N (UK)	21	170	0.416	0.031	National Geographic, Leverhulme trust, WCS, PEW trust
Mumby P (UK)	19	113	0.391	0.014	US EPA, NOAA, NERC, Royal Society
Russ G (Aus)	18	613	0.412	0.038	Australian Institute of Marine Science, ARC, CRC Reef Research Centre, PEW trust
Planes S (Fr)	16	237	0.469	0.100	ARC, NSF, Nature Conservancy, Total Foundation, JCU, WHOI
Guidetti (It)	15	121	0.362	0.007	ICRAM, MATTM
Polunin (UK)	15	376	0.479	0.101	Italian Ministry of University and Research
Edgar (Aus)	14	154	0.354	0	ARC, Wilderness Ecosystem Baseline studies programme, CERF, National Geographic Society, US AID, Charles Darwin Foundation
Gaines S (USA)	14	239	0.391	0.002	PEW trust, PISCO, NSF, Andrew Mellon Foundation

Table 3.9 Bibliometric attributes of the ten countries and institutions with the highest number of publications from 2006-2010.

Country	Publications	LCS		Institute	Publications	LCS
Australia	806	436		Univ Calif Santa Barbara	51	748
USA	714	4863		NOAA	62	410
UK	268	2059		Univ Washington	47	384
Canada	167	1175		Univ Queensland	37	330
Italy	126	508		Univ Calif Davis	35	473
Spain	106	571		Univ Tasmania	35	238
France	102	765		Univ British Columbia	33	418
South Africa	70	227		Wildlife Conserv Soc	28	419
New Zealand	67	503		James Cook University	26	985
Netherlands	37	74		Oregon State University	26	140

Table 3.10 Bibliometric attributes of the ten journals with the highest number of publications from 2006-2010.

Journal	Pubs	LCS	Special issue (SI) / highly cited publications
MEPS	158	1023	Guidetti & Sala (2007)
Ocean & Coastal Management	88	1003	
Marine Policy	68	106	Degnbol *et al* (2006)
ICES	62	198	
Aquat Conserv	56	340	Abesamis *et al* (2006)
Mar Poll Bulletin	54	106	
Biol Conservation	54	494	Claudet *et al* (2006)
Coral Reefs	50	336	
Marine Biology	44	194	
Coastal Manag	41	240	

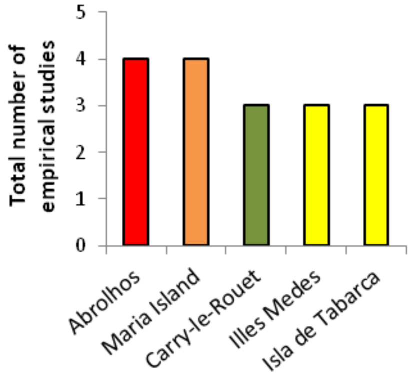


Figure 3.5 Most studied MPAs during 2006-2010.

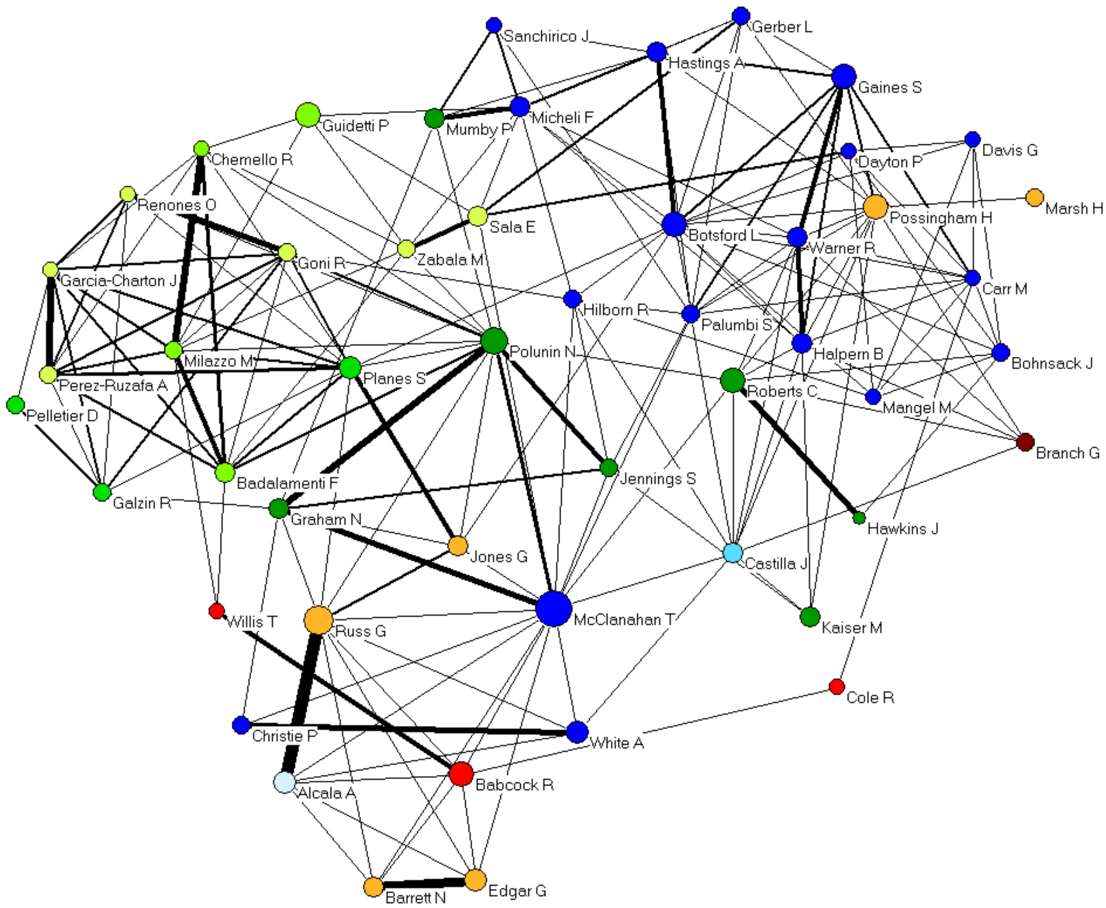


Figure 3.6 Co-author network of the most productive authors in MPA science from **1972-2010 (n=48)**. Vertex size indicates the relative number of publications for an author, and edge-width the number of times an author has collaborated. Vertex colour indicates author nationality.

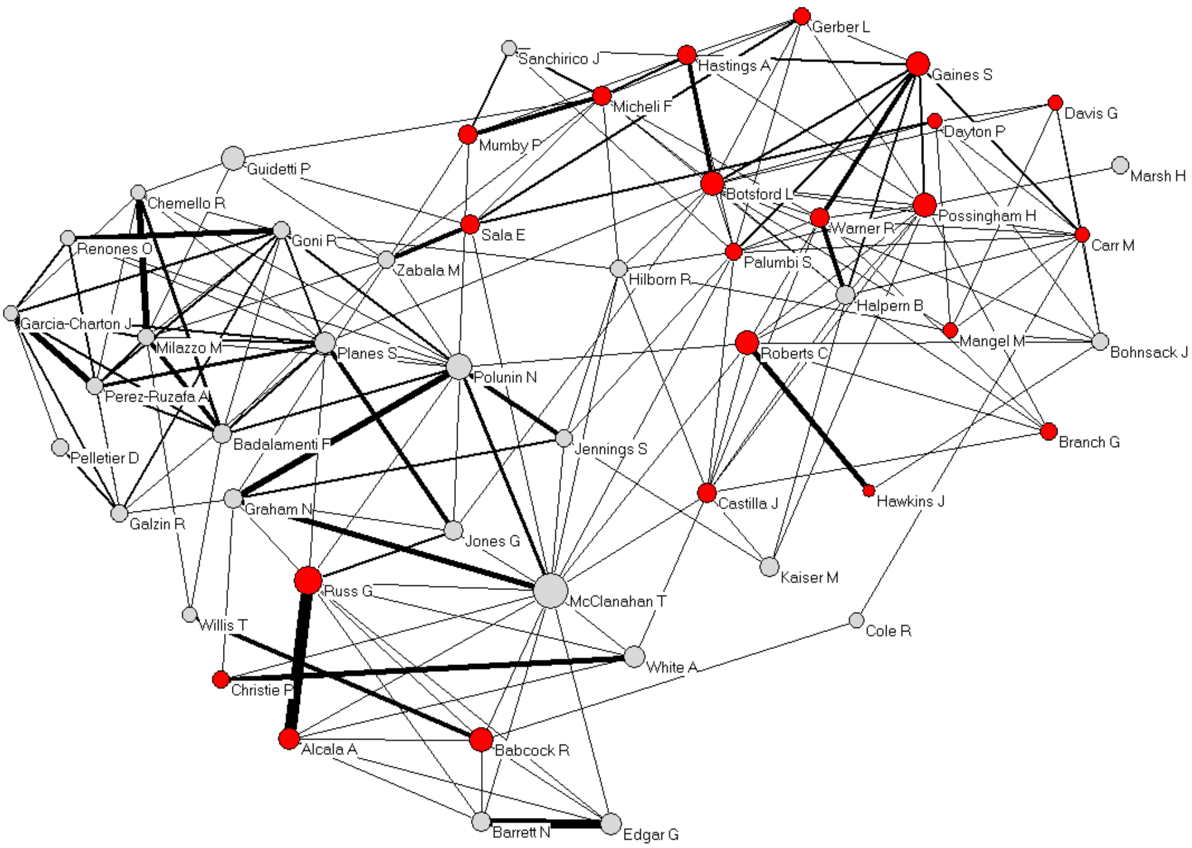


Figure 3.7 Co-author advocacy network of the most productive authors in MPA science from **1972-2010 (n=48)** as in Figure 3.5. Vertices are coloured red according to whether the scientist was a signatory to the American and European consensus statements on NMRs (NCEAS 2001; Roberts 2007b).

3.3.2 Citation analyses

Paper citation networks

Of the 20 most highly cited papers in marine protected area (MPA) science (Table 3.11), eight are reviews, eight are empirical, three modelling, and one a meta-analysis. Roberts *et al's* (2001) study on the effect of NMRs in St Lucia and Florida on local fisheries is the most heavily cited paper by 78 citations (LCS= 234), with the study by Russ and Alcala (1996) on the effect of the Apo Island NMR in the Philippines second most cited paper (LCS= 156).

The paper citation network (Fig 3.8a) shows how these 20 papers relate to one another through citations. There are more highly cited papers published before 2000 simply due to the fact that these papers have had more time to accumulate citations.

Figures 3.8a-f show the extent to which the papers in Fig 3.8a are present in other research fields. *Marine AND fisher** (Fig 3.8b), *Marine AND management* (Fig 3.8e) have 14 publications in common with the original search term (*"marine reserve*" …* Figure 3.8a), and *Marine AND conservation* (Fig 3.8c) has eight publications in common with Figure 3.8a.

The original search term has 30%, 25% and 23% of publications in common with the research fields *Marine AND conservation*, *Marine AND management*, and *Marine AND fisher** respectively (Fig 3.9).

Table 3.11 Brief description of each of the 20 most highly cited papers on MPAs.

Author, date, and (LCS score)	Journal	Context	Findings
Roberts *et al* 2001 (234)	Science	Empirical research on the effects of NMRs on local fisheries in St Lucia (coral reef) and Florida (estuarine).	Enhanced catches of artisanal and recreational fishermen.
Russ & Alcala 1996 (156)	MEPS	Empirical research on the effect of Apo Island (coral reef) on local fisheries.	Enhanced catches of local fishermen.
Halpern & Warner 2002 (148)	Ecology Letters	Meta-analysis of the biological response of fish (coral reef) to protection in NMRs.	Density, biomass, average organism size, and diversity reach mean levels within 1-3 years of MR establishment.
Dugan & Davis 1993 (133)	Can J Fish Aqu Sci	Review of the use of NMRs in a reef fisheries management context.	
Roberts & Polunin 1993 (133)	MEPS	Empirical research on the effect of Saba and Hol Chan MRs on reef fish biomass and commercial value.	Within both MRs the biomass and value of commercial fish increased.
Gell & Roberts 2003 (123)	TREE	Opinion piece on the use of NMRs in fisheries management.	
DeMartini 1993 (122)	Fishery Bulletin	Modelling study on predicting the effects of NMRs on coral reef fish.	NMRs most likely to benefit the SSB/R of reef fish with moderate vagility.
Russ & Alcala 1996 (120)	Ecological Applications	Empirical research on the effect of Sumilon and Apo NMRs on large predatory coral reef fish.	Relative short periods of unregulated fishing can eliminate density and biomass gains of large predatory fish.
McClanahan & Kaunda Arara 1996 (119)	Conservation Biology	Empirical research on the effects of a Mombasa marine park on the catches of adjacent reef fisheries.	The establishment of the park lead to a reduction in the total catch.
McClanahan & Mangi 2000 (119)	Ecological Applications	Empirical research on the effects of Mombasa marine park on the catches of adjacent reef fisheries.	The establishment of the park lead to a reduction in the total catch, at least in the short term.
Rowley 1994 (117)	Aquat Conserv	Review of the use of NMRs in fisheries management.	
Hastings & Botsford 1999 (116)	Science	Modelling study to predict the difference between NMRs and effort controls on fisheries yields.	For sedentary species NMRs may make a better management tool than effort controls.
Carr & Reed 1993 (113)	Can J Fish Aqu Sci	Review of the use of NMRs in the management of temperate reef fisheries.	

Kramer & Chapman 1999 (113)	Environ Biology of Fishes	Review of the implications of coral reef fish home range size has on NMR function.	
Edgar & Barrett 1999 (106)	Journal of Exp Mar Biol and Ecol	Empirical research on the effects of Tasmanian NMRs on reef fishes, invertebrates and plants.	The number of fish, invertebrate, and algal species increased significantly within the Maria Island NMR. The effectiveness of NMRs corresponded with NMR size.
Murray *et al* 1999 (106)	Fisheries	Review of the use of NMRs in marine management.	
Botsford *et al* 2001 (103)	Ecology Letters	Modelling study to predict how the design of NMR networks and function relates to larval dispersal distance.	The fraction of natural larval settlement is greater for species dispersing shorter distances.
Rakitin & Kramer 1996 (102)	MEPS	Empirical study of the abundance and size of reef fish across the boundary of the Barbados NMR.	The abundance of large, trappable fish of all species combined was higher in the NMR than outside. Trap catches decreased gradually with distance from the NMR centre.
Pauly *et al* 2002 (102)	Nature	Review of the sustainability of global fisheries.	
Sale *et al* 2005 (102)	TREE	Review of the gaps in the knowledge base that are impeding the effective use of NMRs	

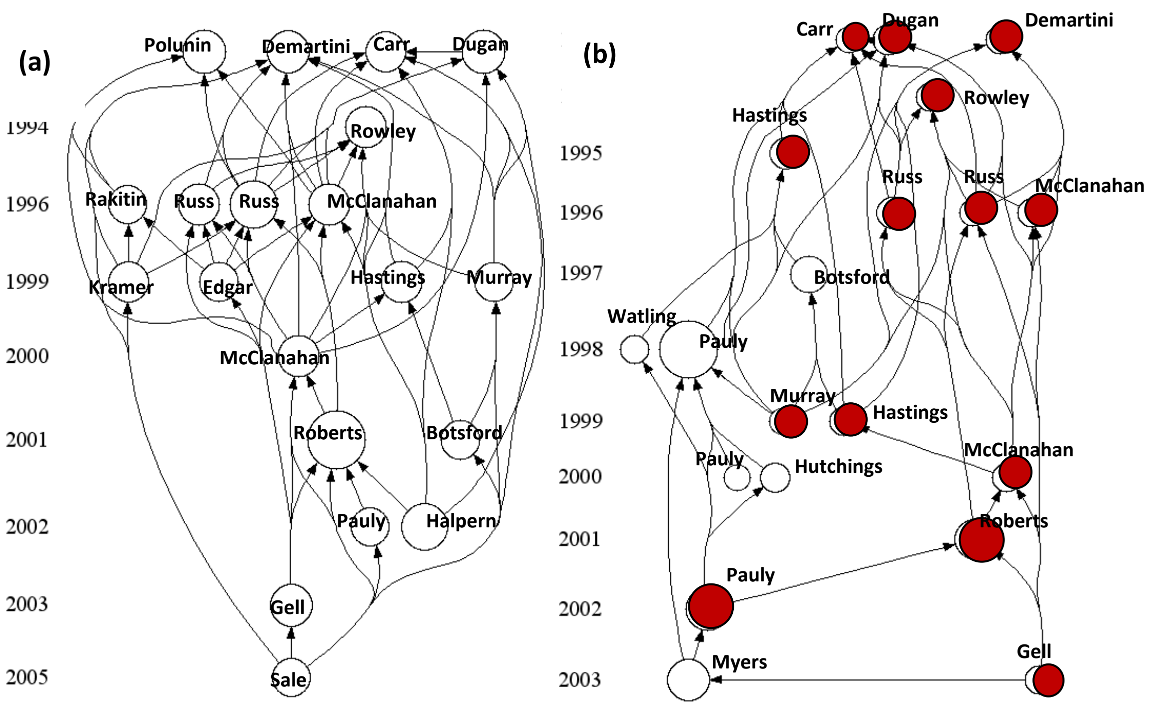
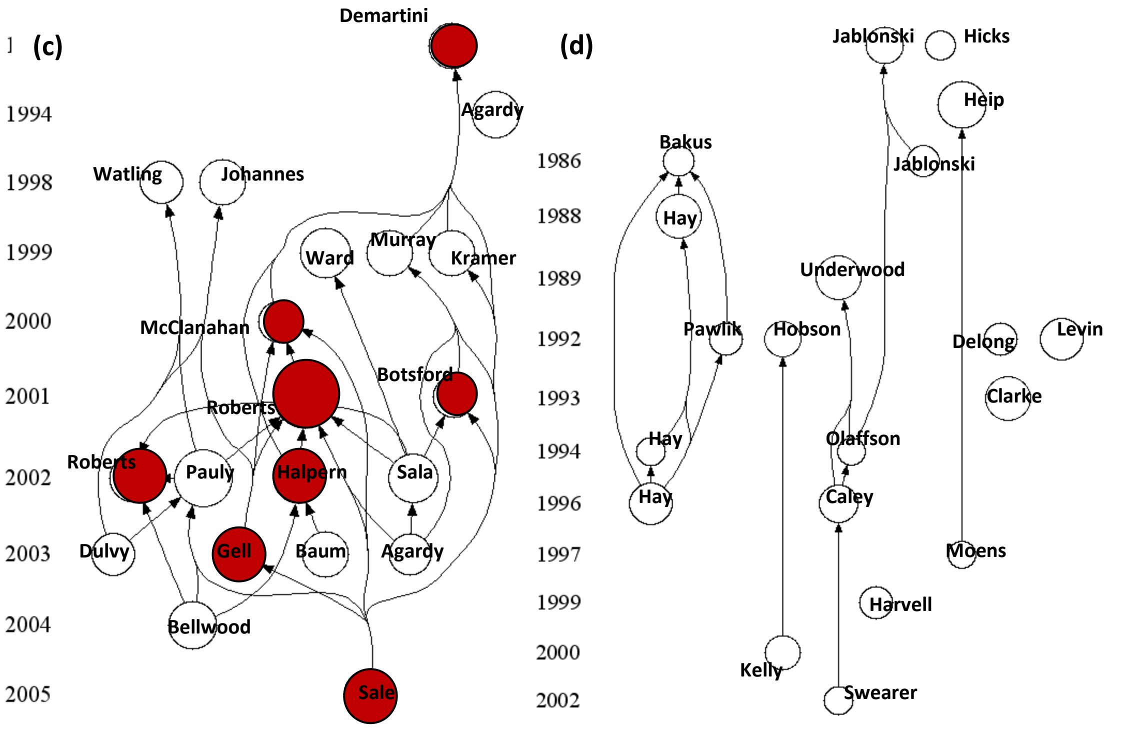
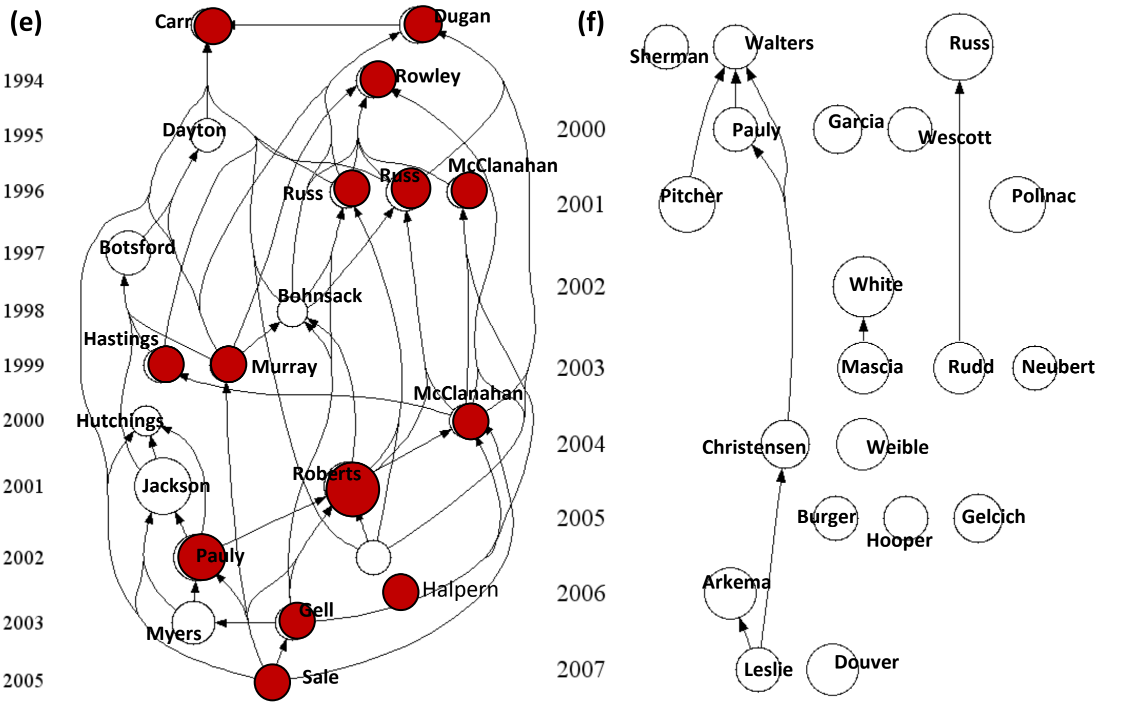


Figure 3.8 (a) Paper citation networks of the most highly cited papers for *Marine AND ("marine reserve*" …)* threshold 100 citations within the dataset), and **(b)** *Marine AND fisher** (threshold 90 citations within the dataset). The node size denotes the number of citations, the arrows refer to citations. Highlighted nodes in Figure 3.8 (b-f) indicate papers that are present in Fig 3.8 (a).



Figures 3.8 (c) Paper citation networks of the most highly cited papers for *Marine AND conservation* (threshold 50 citations within the dataset), and **(d)** *Marine AND ecology* (threshold 35 citations within the dataset). The node size denotes the number of citations, the arrows refer to citations.



Figures 3.8 (e) Paper citation networks of the most highly cited papers for *Marine AND management* (threshold 86 citations within the dataset), and **(f)** *Marine AND policy* (threshold 6 citations within the dataset). The node size denotes the number of citations, the arrows refer to citations.

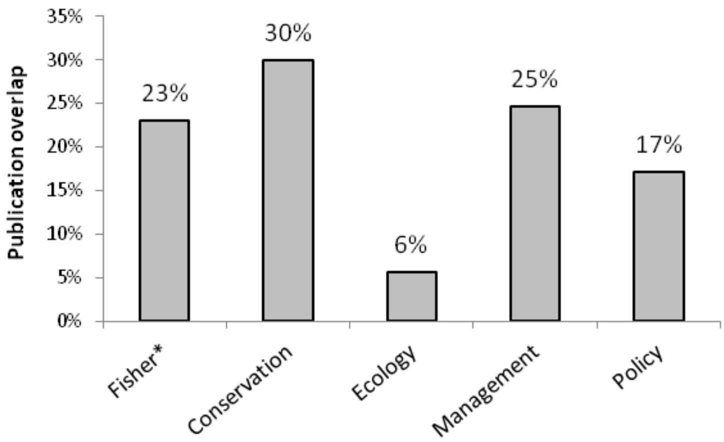


Figure 3.9 Percentage overlap in the total number of publications between **Marine AND ("marine reserve*" …)** and the five search terms shown in the graph and Table 3.1.

3.4 Discussion

3.4.1 A retrospective analysis of the development of the evidence-base

Research on MPAs has dominated the wider literature on the conservation of marine natural resources, both in terms of publication output and number of highly cited studies (Figures 3.8a-f). The discussion here takes a retrospective look at how the evidence base developed over three time periods 1972-2000, 2001-2005, and 2006-2010. In keeping with the main theme of this thesis, key developments in international policy for each period are critically appraised followed by speculation about underlying drivers using the explanatory models provided by the epistemic community (Haas 1989; Haas 1992b) and advocacy coalition (Sabatier 1988).

1972-2000

Internationally, the MPA first gained recognition as a tool to protect marine resources during the early 1970s through the United Nations Environmental Programme (UNEP), and the 3rd United Nations Convention on the Law of the Sea (UNCLOS). A conference was also held by the International Union for the Conservation of Nature and Natural Resources (IUCN) in Tokyo during 1975 calling for the establishment of a well-monitored system of MPAs representative of the world's marine ecosystems. However it was not until the later 1980s that research on MPAs started to take effect (Bell 1983; Alcala 1988; Russ & Alcala 1989).

During the 1990s studies of MPAs predominantly examined the effect of small-scale NMRs on reef fish assemblages, and were undertaken by a fragmented group of scientists from the United States (Carr & Reed 1993; Dugan & Davis 1993; Bohnsack 1996; Hastings & Botsford 1999; Dayton et al. 2000), Europe (Garcia-Rubies & Zabala 1990; Roberts & Polunin 1993; Garcia-Charton et al. 2000; Pinnegar et al. 2000) and Australia (Russ & Alcala 1996a; Russ & Alcala 1996b; Russ & Alcala 1998; Zeller & Russ 1998; Edgar & Barrett 1997; Edgar & Barrett 1999) (Figure 3.1). A number of highly influential papers were published during this period (Figure 3.7); five of which were reviews of the application of NMRs in fisheries management. Influential empirical studies include the work undertaken by Russ and Alcala in the Apo and Sumilon NMRs in the Philippines (Russ & Alcala 1996a; Russ & Alcala 1998), and the work undertaken by McClanahan in East African marine parks (McClanahan & Kaunda Arara 1996; McClanahan et al. 1997).

Coinciding with the expansion of the MPA literature during the 1990s there were significant developments in international policy for MPAs (Table 1.2 Chapter 1). The Earth Summit in 1992 called for coastal states to maintain biological diversity and productivity of marine species and habitats through the establishment and management of protected areas. The later 1990s were also characterised by a growing advocacy literature for NMRs from scientists (e.g. Roberts 1997; Lauck et al. 1998). Involvement of some high profile scientists in advocacy for NMRs, for example Jane Lubchenco's (currently head of the NOAA) call in 1997 for protecting 20% of the ocean as no-fishing zones by 2020 led the scientific community to become politicised with respect to the use of MPAs as fisheries management tools (Agardy et al. 2003). Reflecting the efforts of a transnational advocacy network of scientists, in 1998 the US Marine Conservation Biology Institute (MCBI) issued *Troubled Waters: A Call for Action*, a statement signed by 1,605 scientists across the globe bringing to the world's attention the damage being caused to the oceans. Two of its five recommendations have relevance to this thesis, the first being to increase the number and effectiveness of MPAs so that 20% of EEZs and the High Seas are protected from threats by the year 2020 (restating Jane Lubchenco's plea one year previously): and secondly to ameliorate or stop fishing methods that undermine sustainability by harming the habitats of economically valuable marine species and the species they use for food and shelter. This statement coincided with a highly influential research paper funded by the MCBI that documented the global impact of bottom trawling on seabed habitats (Watling & Norse 1998).

The first special issue on MPAs was published in a 2000 edition of the *Bulletin of Marine Science* (66:3) and focused on the uses of NMRs to protect essential fish habitat. The increase in the number of studies published on NMRs during the 1990s (see Chapter 5) reflected the emergence of a new paradigm in fisheries management during this decade that was risk-averse, realising that it is only human activities that can be managed, and recognised the impacts of fishing gear on habitats and the by-catch of non-target species (Conover et al. 2000)[65]. In 2000 a heavily cited report from WWF which showcased the fisheries effects of NMRs (Roberts & Hawkins 2000), preceded a flurry of academic publications in the early 2000's that documented the potential of NMRs to benefit fisheries. This shaped the climate of thinking for the next decade; with scientific debate becoming heavily focused on what MPAs could do for subsistence and commercial fisheries rather than their wider potential benefits for the conservation of non-commercial species (Edgar 2011).

2001-2005

The World Summit on Sustainable Development (WSSD) in 2002 called for the establishment of representative[66] networks of MPAs to be established by 2012. Some scientists (e.g. Figure 3.6) may have had influence on this WSSD commitment to adopt MPAs as an approach to conserve marine biodiversity. However networks shown here (Figures 3.1, 3.3 and 3.6) are constructed from bibliometric information only; the

[65] Probably best summarised as the ecosystem approach to fisheries management (Charles 2001).
[66] Stevens (2002) says "representativeness" means that a sample of each habitat occurring in the area under consideration should be included in a MPA, though he points out that this implies, controversially, that each habitat type has an intrinsic functional position in marine ecosystems and thus has intrinsic conservation value irrespective of characteristics such as diversity, uniqueness, and endangered species habitat (Stevens 2002).

representation of the MPA scientific community shown here is a gross simplification of the social reality, and may have overlooked/ underestimated the significance of some actors who focus their energies more in a policy rather than academic setting, and therefore have more direct influence on politicians (e.g. Jane Lubchenco as director of the NOAA).

There was a proliferation of research effort on NMRs during this five-year period (also see chapter five), though sites in the Philippines (Russ et al. 2003; Russ et al. 2004) and Eastern Africa (McClanahan & Arthur 2001; McClanahan & Graham 2005) still dominated the literature (Figure 3.4). Six highly influential papers were also published (see Figure 3.8a), two of which focused on the benefits of NMRs to fisheries (Roberts et al. 2001; Gell & Roberts 2003)[67]. Indeed the underlying political agenda of these highly cited studies seems all too clear; Gell and Roberts (2003) argued that to reverse global fishery declines we need to integrate large-scale networks of NMRs into fisheries management. In his highly influential piece for *Nature* Daniel Pauly implied that we must zone large areas of the oceans as NMRs for fisheries to be sustainable (Pauly et al. 2002). Additionally, a meta-analysis by Halpern and Warner (2002) showed that the responses in terms of density, biomass and mean size of fish and invertebrates to protection in NMRs appears to develop quickly, the authors then concluding that this result should facilitate the use of NMRs in the management of marine resources (Halpern & Warner 2002).

A second special issue on NMRs published in *Ecological Applications* was the result of the Working Group on Marine Reserves that convened in 1999 at the US National Center for Ecological Analysis and Synthesis (NCEAS) and was charged with the task of developing the theory on NMRs, particularly regarding the practical design of NMR networks[68] (Airame et al. 2003; Botsford et al. 2003; Carr et al. 2003; Hastings & Botsford 2003; Roberts et al. 2003). The output of this special issue is heavily cited in the ecological guidance that Natural England (England's statutory conservation agency) used as the basis to plan the UK MCZ network (see Chapter 6 for further details), and

[67]The Roberts et al (2001) paper has been challenged both from a methodological and ideological standpoint (see *Science* 15th February 2002, vol 295(5558): 1233-1235)

[68] Many of these papers were focused on California, where in 1999 the construction of a network of coastal protected areas was begun.

again is evidence of an MPA EpC that has shaped the development of policies at the domestic level.[69]

Scientists from the US, Australia, and Europe are still driving MPA research and during this time period two distinct research networks were developing- one comprising scientists mainly from the US and the other comprising scientists mainly from Europe. This is significant as a high a proportion of scientists belonging to the US network have become involved, to a greater or lesser extent in advocacy for NMRs (Figure 3.7). In 2001 the release of the scientific consensus statement on NMRs (a summary of the findings of the NCEAS working group) at the "The Science of Marine Reserves" symposium held by the American Association for the Advancement of Science (AAAS) coincided roughly with the WSSD, and may have been a politically astute decision by these scientists to have greater impact on shaping the climate of thinking on the use of MPAs/ NMRs around this event. However, the WSSD (2002) only makes provisions for the use of time/ area closures (MPAs?) in a fisheries context to protect nursery grounds[70] , and NMRs are not explicitly mentioned in this policy, nor any other international agreements.

The heavy involvement of US scientists in advocacy for NMRs (Figure 3.7) may stem from the more deeply rooted commitment by the US to marine protection (i.e. Sloan 2002), compared to countries in Europe that are just in the process of establishing MPA networks (e.g. Natura 2000). For instance the US Magnuson-Stevens Fishery Conservation and Management Act (1996) provided the legal means of using NMRs as a management tool to protect essential fish habitats, and the Marine Sanctuaries Act (1972) provided the means to protect unique habitats. A strong conservation ethic appears to be more prevalent in ecologists from the USA (Sloan 2002), explaining why they may be more willing to become involved in policy advocacy for NMRs/ MPAs than

[69] Indeed there were two visits by US academics at two conferences held by Natural England as the MCAA was being passed through parliament. The first by Prof Steve Gaines at the conference 'Towards a Coherent network of Marine Protected Areas' held in October, 2007; and the second by Prof Mark Carr at the 'Sea Change' conference held in December, 2009.

[70] "Develop and facilitate the use of diverse approaches and tools, including the ecosystem approach, the elimination of destructive fishing practices, the establishment of marine protected areas consistent with international law and based on scientific information, including representative networks by 2012 and time/area closures for the protection of nursery grounds and periods" (Para. 32c).

their European counterparts[71]. However, the politics of fisheries management in the European Union (EU) has meant that EU member states through the adoption of the Common Fisheries Policy (CFP) have conceded their territorial use rights for their Exclusive Economic Zones (EEZs) outside of the 12nm limit. This has posed a unique collective action problem for EU fisheries management and conservation in terms of establishing MPA networks (Fock 2011). Indeed, MPA networks are more easily (and successfully[72]) applied in countries that have full control over their EEZs (e.g. the USA, New Zealand, and Australia). This is another reason why more scientists from these countries have become involved in MPA advocacy (e.g. Ballantine 1991; Lubchenco et al. 2003; Russ & Zeller 2003) (Figure 3.7).

Despite the emphasis during this time period on the use of NMRs as fisheries management tools, it is important not to overlook the growing scepticism among some scientists regarding the use of NMRs in this role (Hilborn et al. 2004; Kaiser 2005). Criticisms aimed at uncritical advocacy for NMRs highlight six problems: 1) that NMRs will not meet their objectives unless scientists have a good understanding of the local ecological and socio-economic context (Christie 2003; Weible 2008); 2) that the assumption that NMRs will bring more benefits than MPAs may make stakeholders suspicious of scientists' underlying motivations for establishing them (Jones 2002; Agardy et al. 2003); 3) that claims for NMRs may be based on over-generalised science regarding their fisheries effects (Hilborn et al. 2004; Kaiser 2005) (see Chapters 5 and 6); 4) that claims for NMRs may not be backed by robust empirical evidence (Willis et al. 2003a); 5) that alternative management options may be more appropriate to achieve certain objectives (Steele & Hoagland 2004; McClanahan 2011); and 6) that the heavy focus on establishing MPAs, may ignore wider environmental problems (Mora & Sale 2011).

[71] For example the three leading conservation journals *Conservation Biology*, *Biological Conservation*, and *Conservation Letters* are associated with the Society for Conservation Biology which is based in Washington, DC.
[72] In terms of compliance and enforcement.

2006-2010

In 2006 the CBD updated its statement on MPAs by adding a target, saying that 10% of each of the world's marine and coastal ecological regions needs to be effectively conserved by 2010. Also during this time period advocacy for MPAs has continued, and gained increasing momentum: The MCBI along with the PEW environmental group in 2006 and 2009 persuaded President Bush (2001-2009) to establish three large MPAs in the tropical Pacific Ocean. The PEW trust[73] also championed the protection of the Chagos archipelago, for which the Blue Marine Foundation[74], a UK-based environmental group, secured financing for the first five years of protection of the Chagos (Roberts 2012)[75]. Amongst the ambassadors of this organisation is Dr Sylvia Earle, who made an impassioned plea for the protection of the ocean at the TED[76] conference in 2009.

It is worth mentioning briefly the controversy surrounding the designation of the Chagos NMR by the British government in 2010, as it is a good illustration of the conflict between competing philosophies underpinning the designation of MPAs (see Chapter 1). One group wanted to preserve the currently pristine ecosystem (Sheppard et al 2012) and another group supported the Chagossians right to return to the islands, who were exiled by the UK government between 1965 and 1973 after Mauritius conceded the islands to the UK after gaining independence. Aside from protecting the marine life surrounding the Chagos archipelago some commentators have noted that the UK and US government have a vested interest in the archipelago being designated as an NMR as this status currently prevents exiled Chagossians from returning, which might have posed a threat to the strategic military interests of the US that has an airbase on the largest island Diego Garcia.

Another significant development during this period was the popularisation of the MPA idea within wider society, and the key role that scientists took in this. The marine conservation scientist Callum Roberts has a chapter devoted to NMRs in his highly

[73] The PEW have now set their sights on Australia's Coral Sea and New Zealand's Kermadec Islands.
[74] This group was initially conceived by the people who were behind the film The End of the Line.
[75] Roberts himself is a trustee of the organisation.
[76] Technology, Entertainment, Design; a non-profit that organises biannual conferences devoted to Ideas Worth Spreading that are accessible to the general public.

influential[77] book *The Unnatural History of the Sea*, in which he says that the "majority of governments still see NMRs as the pinnacle of protection to be applied to only 5 per cent[78] or 10 per cent of the sea… emerging scientific understanding of human activities on the oceans suggests that we need to flip this management paradigm around… NMRs must be extensive, covering between 20 and 40 per cent of the sea, in order to sustain ecological processes and services – like fisheries – that are vital to humanity" (Roberts 2007a, pg 382). The US based Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) also released a booklet on the *Science of Marine Reserves* with the intention of making NMR science accessible to a lay audience (PISCO 2011).

During this time period the co-author network (Figure 3.6) has become increasingly well connected and there is no longer a clear divide between the US and European Scientists. Scientists from Australasia have also become integrated into the main network, indicating an increase in research collaboration across continents. Since papers from this time period have had less time to accrue citations, there are fewer highly cited articles from this period and none in the top 20. There is an inherent weakness in using citations analysis to judge the influence of science on policy makers, as it will overlook recently published studies that are perhaps doing the rounds with policy makers that have not had enough time to accrue a critical number of citations.

Though MPA science has during this time period become more critical of the broad use of MPAs in marine management, significant policy-relevant information gaps still exist, including: the susceptibility of different habitats to different methods of fishing; information on time-scales of recovery of the seabed once fishing has stopped; and local information on the ecological linkages between different areas of sea (see Chapters 5 and 6).

This chapter has provided the international and historical context of MPA science-policy for the next three chapters (4-6). MPA publications have been highly influential within the marine science community as measured by the number of citations, and

[77] For example this book was mentioned in the House of Lords debates on the UK Marine and Coastal Access Act as it was being passed through parliament.
[78] Though we are currently still way short of even this target (Wood et al. 2008; Toropova et al. 2010a).

cross over with other research fields (Figure 3.8). A community of experts, some of whom are part of the co-author network shown here are believed to have had significant influence on persuading politically influential people (e.g. politicians, advisers, and funders) to establish MPA networks. Whether this community is more appropriately perceived as an EpC or an AC is a matter of debate, though given that the imperative to protect biodiversity is a moral as well as scientific issue, and is heavily contested, the EpC is probably redundant. Arguably, under the rubric of science-based policy a group of scientists (largely from the US) has attempted to use the authority of science to gloss over a heavily value-laden debate, and unintentionally or intentionally has become a network of stealth-issue advocates (see 2.3.4 Chapter 2).

One can look at the effect of the MPA advocacy coalition (AC) from either an optimistic or pessimistic perspective. From the former, undoubtedly, the effort of a transnational network of MPA advocates has put significant pressure on national governments to establish MPAs, and within the last decade large areas of ocean have received protection (e.g. the Hawaii Islands, Chagos Archipelago). From the pessimistic perspective society is still well behind meeting current international targets for MPAs (Wood et al. 2008), and around one third of MPAs are not meeting their objectives[79] (Kelleher et al. 1995). However, despite the problems surrounding the management of MPAs, this chapter has shown that the lobbying activities of a highly influential network of scientists and environmentalists has influenced the climate of thinking around MPA policy debates at the international level.

[79] Though Jones (2002) says this statistic needs to be treated with caution as Kelleher et al.'s review did not address the level of protection which was afforded by different types of MPA designation. For instance an MPA with ambitious management objectives may be classified as not meeting them, despite doing more for nature conservation than an MPA that is meeting more modest objectives.

3.5 Conclusion

Of the 48 scientists identified in the co-author network the majority (around 90%) are solely natural scientists. The dominance of marine ecologists within the network is telling, and reflects the views of some authors that MPAs are a tool largely born from the paradigm (the concepts, theories and values) in which marine ecologists have been trained to think (Degnbol et al. 2006). However, mono-disciplinary approaches to natural resource management have been largely discredited because that they are not often attuned to the empirical realities of management (Degnbol et al. 2006). This is not to say that MPAs are not a potentially useful tool, but that MPA research needs to significantly embrace a social science perspective (Christie et al. 2003; Blount & Pitchon 2007; Voyer et al. 2012). Another revealing finding from this study is the number of highly cited MPA studies that are also found in other research fields (Figures 3.8b, c, e), suggesting that a disproportionate amount of funding has been spent on MPA and NMR research over alternative management interventions.

A more integrated social science understanding may help resolve some of the main social problems that have hindered the successful implementation and management of MPAs, and also identify the political contexts where MPAs work best. Moreover the study of other management measures should also be encouraged, so as to not restrict the development of alternative policies that a decision-maker can choose from.

Chapter 4

Examining evidence for bias in publications showing the ecological effects of MPAs

ABSTRACT

Two key questions form the basis of analysis in this chapter: 1) Is there any evidence to suggest that a pro/anti-MPA bias exists amongst scientists? 2) If so, does this bias affect the type of results published in the MPA literature? A short questionnaire was sent to 200 leading scientists who have studied the ecological effects of MPAs to examine this question. The questionnaire focused on two areas 1) scientists' experience of having publications rejected, and 2) scientists' attitudes towards publishing non-significant research findings. Evidence of bias towards positive or negative results caused by an explicit pro-MPA/ anti-MPA belief held by editors and/or peer reviewers was limited; only around 10% of respondents seemed to believe that their manuscript had been rejected for such a reason. No scientists admitted to self-censoring results because of a bias for or against MPAs, though one respondent was fairly certain that this had occurred amongst some of his peers. A few respondents pointed out that bias for positive results is still likely to occur because of the way hypothesis testing is set up in ecology in general; that an author has to prove that s/he sampled sufficiently to detect an effect, and this makes it more difficult to get non-significant findings published. The claims of meta-analyses would be confounded by such bias, since, for example, if it reinforced a pro-MPA belief held by a significant fraction of the scientific community, it would make it more difficult for a scientist to get counter-intuitive results published.

4.1 Introduction

Values, something that a person views important and devotes time and energy to in their life (Farber et al. 2002), are likely to drive a conservation scientist's research efforts, and shape their views on the management of human activities (Meine et al. 2006; Noss 2006). Policy advocacy based on such values is the attempt to influence management outcomes. Studies have shown that policy advocacy has been pervasive within conservation-orientated journals (Scott et al. 2007), and there is an ongoing debate over whether policy advocacy by scientists is legitimate (Lackey 2007; Nelson & Vucetich 2009). Some scholars suggest that advocacy is acceptable if scientists are open about their values, address counter-arguments and admit uncertainty (Foote et al. 2009). However, the claims of scientists who advocate policies on scientific evidence alone should be treated with caution. Indeed, those who argue against such advocacy claim that when scientists suggest that science compels a particular course of action it brings politics into science (Sarewitz 2000; Pielke Jr 2004)[80]. Some scholars (e.g. Rice 2011) argue that this not only affects the credibility of the scientific enterprise but is thereby counter-productive to the role of science in decision making (Sarewitz 2004; Pielke Jr 2007). Nevertheless the view that science should compel action (also known as the linear model) is still held by a significant number of scientists and environmentalists (Sarewitz 2000). Although many scholars argue that it is undesirable for scientists to remain detached from the policy process, there are ways in which scientists can meaningfully participate in policy debates without becoming policy advocates (Pielke Jr 2007; Gray & Campbell 2008).

One important issue raised by the controversy over scientists' policy advocacy is whether there is bias in the way in which scientific research is published. Does policy advocacy mean that papers which support the growing orthodoxy in favour of MPAs are more likely to be published than papers which question it? This is the focus of the present chapter. A significant number of marine scientists have stated that the available scientific evidence justifies the use of one subset of MPA, the no-take marine reserve (NMR) as a central tool in marine management (NCEAS 2001). Moreover, Willis

[80] See the debates surrounding Bjorn Lomborg's controversial book *The Skeptical Environmentalist* (Pielke Jr 2004).

et al (2003a) argue that the *raison d'etre* behind much primary ecological research published on MPAs, NMRs in particular, has been for the purpose of advocacy. This has been termed ‘normative’ science (Lackey 2007), or stealth issue advocacy, and some scientists view it as being politically desirable, as from their point of view it allows them to remain above the fray of political debate while invoking the historical authority of science to advance their cause (Pielke Jr 2007), though this usually results in politics creeping into science (Sarewitz 2000; Pielke Jr 2004). Few studies have attempted to examine systematically the question of whether policy advocacy has influenced publication of scientific knowledge. This question is explored against a backdrop of the highly politicised research field of marine protected area (MPA) science (Agardy et al. 2003).

In the marine natural resources literature some authors have been critical of the peer-review process arguing that it may not always be a guarantee of objectivity (Hilborn et al. 2004; Kaiser 2004; Banobi et al. 2011). In MPA science some authors have pointed out that there is publication bias in the MPA literature in favour of studies that show positive ecological effects (Huntington 2003; Hilborn 2006). But is there evidence to support such claims about bias? And if so, where does the bias lie? For example, does it reside in the hands of journal editors and reviewers who reject studies that they think may interfere with the uptake of the MPA as a management tool? Or does it reside in the hands of the scientists who choose not to publish certain research findings, or frame their research questions in a way that precludes the discussion of non-significant and/or negative effects?

If a bias for positive results exists in MPA research, it may simply reflect a more general problem in science (Fanelli 2012), the under-reporting of non-significant ($P>0.05$) results (the ‘file drawer problem’) (Rosenthal 1979), which generally reflects a bias towards *intuitive* results (Tomkins & Kotiaho 2004) that support a researcher’s hypothesis. MPA science (natural and social) is clearly issue-driven in that it is charged with finding the social-ecological contexts in which MPAs work and where they don’t. Issue-driven science becomes normative science when a researcher holds a bias towards a certain results outcome, which may manifest itself at any stage of research such as the study design, data collection and analysis, interpretation and publication (Fanelli 2012). Researcher bias may result because of self-interest (funding, to get published in high impact journals), or for political reasons (preferred policy drives research to show policy in a favourable light). Is there any evidence to suggest that a stronger bias exists in MPA research than in other scientific disciplines? To investigate these issues, a survey questionnaire was sent to leading scientists to ascertain their experiences of publication bias in MPA science.

4.2 Methods

4.2.1 Questionnaire design

The search string 'Marine AND ('reserve*' OR 'protected area*' OR 'park*'OR 'sanctuar*' OR 'no take zone*' OR 'conservation zone*'OR 'refugia' OR 'closed area*')' was used to source all literature published on MPAs (1972-2010) from ISI's Web of Science (WoS). Records were imported into HistCite™ and authors ranked according to their publication count. The two hundred leading scientists in MPA research were identified through their number of publications. The questionnaire was initially piloted to ten scientists randomly chosen from this sample and a few of the questions reworded after some suggestions by respondents. The final questionnaire was then sent out via email to the remaining 190 scientists between April-June 2012. If a scientist hadn't responded within one month a reminder email was sent with the questionnaire reattached. The questionnaire comprised eleven questions that were designed to explore a scientist's experience with publishing ecological effects studies on MPAs. Questions were deliberately broad, and left open to interpretation (e.g. what is meant by 'bias' or 'positive effect') so as not to lead the respondent.

Its primary purpose was to determine if a scientist had had work rejected on MPAs, and if so, what reasons the scientist believed were behind the paper's rejection. Two additional questions were asked about whether scientists chose not to submit particular research findings, and their reasons for doing so.

4.2.2 Data analysis and interpretation

From an examination of the variety of questionnaire responses given by scientists for the reason(s) why their paper was rejected, three categories were identified: methods, interest, and ideology (see Table 4.1 for description). These categories may not be mutually exclusive, and sometimes scientists gave or hinted at two reasons for the rejection of their paper; in such cases both reasons were tagged.

Table 4.1 Description of the categories that were used to code each scientist's response.

Reason for rejection	Description
Methods/ quality	Unsound methodology, poor write-up
Interest	Insufficient interest to the journal, because results were too local- i.e. not generalizable or not novel enough
Ideological bias	Paper rejected because reviewers/ editor thought findings would affect the MPA cause
Personal bias	Paper rejected because of reviewer's/ editor's personal agenda against the author, or competing research programmes

Scientists were chosen by their publication count; the rationale for this was that it was thought that it would be better to send the questionnaire to people who have worked more extensively with MPAs to maximise the likelihood of a response. Unfortunately it was not possible to know *a priori* whether the views of this sample of scientists would be representative of the whole scientific community that have studied MPAs, so it is not possible to quantify the extent of any 'bias' occurring in the MPA scientific literature. Moreover, there is no way of testing the validity of any anecdotal statements. The reader therefore should treat the findings of this study with caution: the purpose is to stimulate debate, rather than give a definitive account of scientists' production of knowledge on MPAs. It is hoped that the anecdotal statements presented here will provide a useful insight into the mechanisms that might allow different forms of bias to potentially affect the scientific process.

4.2.3 Journal information

Given some of the questionnaire responses, I thought it would be interesting to examine the spread of MPA publications across the journals. The database constructed to answer questions in Chapter 5 (see methods) was used to quantify the number of ecological MPA studies per journal. Each journal was labelled according to its main audience; "Conservation" (applied science but not specifically fisheries), "Fisheries" (fisheries science), and "Ecology" (general ecology), to examine the number of publications across these general research themes.

4.3 Results and Discussion

One hundred and four scientists out of 200 responded to the survey; the majority (42%) of respondents were from the USA, with the remainder coming from Spain (9%), Australia (8%), Canada (8%), New Zealand (8%), UK (8%), and Italy (7%). Twelve scientists did not complete the questionnaire but did express their viewpoints. In total 92 fully completed questionnaires were collected; of these, 50 scientists (54%) said that they had papers on MPAs rejected.

4.3.1 Journal editor and reviewer bias

Of those scientists who gave a reason for their paper being rejected, 47% said that this was due to the paper having flawed methods or not being of sufficient interest to the journal that they submitted to. Eleven per cent of respondents believed that their paper had been rejected for ideological reasons (Figure 4.1).

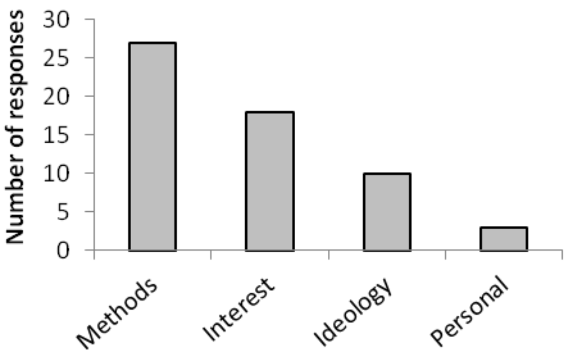


Figure 4.1 Reasons given by author for their paper's rejection.

Ideological reasons for rejection

Whilst figure 4.2 should not be over-interpreted due to the very small sample size (n=10) and statistical non-significance, of the ten scientists who thought their paper had been rejected because of ideological bias, seven seemed to suggest that this was due to the bias of the reviewer/editor against a negative/non-significant result, and three seemed to suggest that it was the result of reviewer/ editor bias against a positive result (Figure 4.2).

Both perceived biases – towards and against MPAs – provide some evidence for the view of some authors, that the scientific community has to some extent become politicised with regards to the use of the MPA as a management tool (e.g. Agardy et al. 2003).

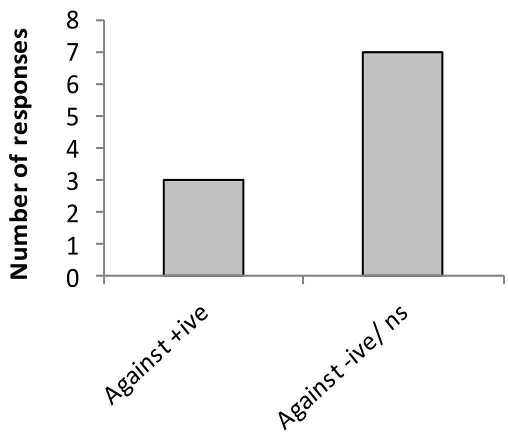


Figure 4.2 Scientists' perceived political bias amongst editors for their paper being rejected.

Though the quotes below are anecdotal, they are used as qualitative data to illustrate the fact that some scientists surveyed thought they had experienced some ideological bias from peer-reviewers or editors. One scientist said:

> "We were saying MPAs did not prevent declines in coral cover and associated declines in fish richness and abundance. One of the reviews seemed to circulate around the fact that we could not / should not be publishing bad news stories about MPAs."

Another said:

> "Well, I do think that one reviewer had a publication bias against papers showing that MPAs don't work… s/he made a remark along the lines that s/he did not feel a paper showing that MPAs don't work should be published in a high-profile journal…"

Though the same scientist did suggest that there may have been some legitimate methodological reasons why the paper was rejected:

> "To be fair, there were some issues that we addressed before re-submitting to the next journal and quite frankly, I don't think of this as a systemic bias, but rather one poor reviewer and that journal typically rejects anything that does not have a unanimous consensus among reviewers."

Moreover, a respondent detected an anti-MPA bias in one prestigious journal:

> "A very clear anti-MPA bias on the part of the editors (one of whom publishes anti-MPA papers)."

A number of respondents hinted at a potential ideological divide between conservation and fisheries journals. For example, one respondent implied that there were some methodological tensions between conservation and fisheries journals:

> "conservation scientists get away with slightly less rigorous quantitative analyses and hence get their papers published slightly more easily, whereas fisheries modellers may not find any significant positive effects because of the messy data associated with this type of research."

This respondent interpreted "positive effect" to mean

> "a significant improvement of catch rates of target species outside an MPA which offsets the loss incurred by the closure of proportion of fishing ground"

This is known as the "spillover effect" (see Chapter 5). Another scientist, whose theoretical work challenges some of the assumptions made about the spillover effect, expressed his frustrations at having his manuscript rejected from three different conservation/ ecology journals:

> "For our theoretical paper on spillover these reviews completely missed the point of our manuscript and provided incorrect technical critique as a justification for why they were not considering our manuscript… I am sure the associated editors fully believe that their critiques are correct, but it seems they have read our theoretical paper with their own preconceptions at the front of their mind and no matter how explicit we are, we cannot break them down. I also get the feeling that because we are challenging beliefs about MPA's that may undermine some of the previous evidence about their benefits (i.e. spillover), that it is especially hard to communicate our point."

This tension reveals a deep rooted ideological divide between the conservation-orientated and the fisheries-orientated journals, with positive effects being interpreted by the former as

> "the return of populations of ecosystems to pre-exploitation levels, increased abundance of top predators etc."

whereas the primary focus of fisheries scientists is to find ways of improving fisheries yields. This divide goes back to the long-standing differences that fisheries and conservation managers have had over objective-setting (Brander 2010; Salomon et al.

2011), the former prioritising sustainable use and the latter the protection of biodiversity. Unsurprisingly, therefore, the view was expressed that

> "MPAs are somewhat of a political football, especially in the developed world. The main issue seems to be conflict between fisheries and conservation managers over control."

One reason for this divide is historical:

> "MPAs have been first implemented with a conservation focus rather than a fisheries focus[81]. Consequently, the MPA literature has had a strong conservation slant for some time (see Table 4.2 and Figure 4.3)."

Another reason is the reluctance of fisheries managers to concede fishing grounds to nature conservationists on the basis of their largely unproven wider fisheries benefits. One respondent took a benign view of this controversy, arguing from a pluralistic perspective that one bias balances out another:

> "I don't think there is this bias. While each individual carries a bias, this is balanced by others with opposite bias. On average, there is no or very little bias in peer review, taken as a whole. That's why, if a paper is rejected in one case, another journal with different reviewers will likely respond differently, as long as the underlying science etc, is up to scratch."

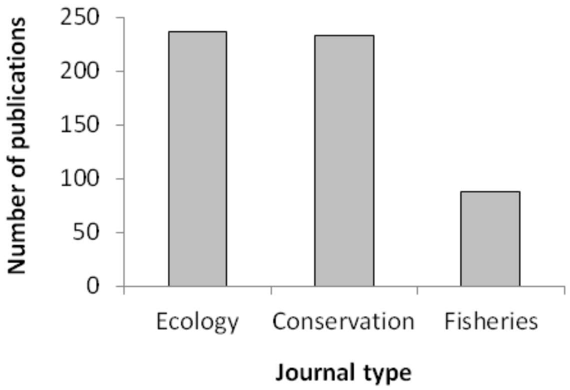


Figure 4.3 The total number of ecological MPA studies by general journal type.

[81] This is interesting as the predominant focus of the empirical literature on MPAs is the effects of NMRs on fish (see Chapter 5).

Table 4.2 The top 20 journals where ecological studies of MPAs have been published. Each journal is labelled according to its general audience: 'E'= Ecology, 'C'= Conservation, and 'F'= Fisheries.

Journal	Type	Publications	Impact factor (2011)
Marine Ecology Progress Series	E	92	2.7
Ecological Applications	C	52	5.1
Aquat Conserv: Marine Freshwater Ecosystems	C	44	1.9
Biological Conservation	C	41	4.1
ICES Journal of Marine Science	C	40	2
Can Journal of Fisheries and Aquatic Sciences	F	39	2.2
Bulletin of Marine Science	E	39	1.1
Conservation Biology	C	34	4.7
Fisheries Research	F	27	1.6
Environmental Conservation	C	22	1.9
Marine and Freshwater Research	E	18	1.6
Coral Reefs	E	17	3.9
Biologia Marina Mediterranea	E	13	1.4
Ecology Letters	E	13	17.6
Marine Biology	E	13	2.3
Fishery Bulletin	F	12	1.1
Journal of Exp Marine Biology and Ecology	E	12	1.9
Journal of Applied Ecology	E	10	5
Reviews in Fish Biology and Fisheries	F	10	2.5
African Journal of Marine Science	E	10	1

Paper rejected because of insufficient interest

The journal an author initially submits to is likely to have a relatively high impact factor and subsequently have high rates of rejection, with even methodologically sound papers being rejected if not of sufficient interest (see Figure 4.1). For example one scientist said:

> "For example, our best work, submitted to Ecology, Science and Nature, was rejected, not on the grounds of quality of the science; rather, they felt that MPA related issues were not enough of popular interest to their readership."

Whether a particular finding is deemed enough of popular interest may depend to some extent on external political factors. For instance the salience of an issue on the political agenda (in this case overfishing and MPAs) may have more influence on whether an editor chooses to accept an article, than the quality or finding of the paper (Hilborn et al. 2004; Hilborn 2007a).

The definition of sufficient popular interest may be used synonymously with 'importance'. One MPA study that did get published in *Science* and received considerable press attention was that by Roberts et al (2001)[82]. One of the co-authors of this paper initially said:

> "our work on the effect of the Merritt Island reserve in Florida on the catches of trophy fish was initially rejected by Science, however when it was combined with work by Callum Roberts on the effect of reserves on coral reef fishes, the combined work achieved the journal's threshold of importance."

One of the key dimensions of importance is that a result is deemed to be generalisable beyond the local or regional level. Furthermore two respondents gave the following reasons for why their paper was initially rejected:

> "referees and editors don't like local papers"

> "the result was too regional, and not important enough"

Another criterion of importance is a study that shows a 'statistically significant effect'[83]: one scientist (who is also a journal editor) was quite candid about turning around MPA studies that showed no significant effects:

> "As an editor of leading journals it is common to send back papers with no significant effect and ask the authors to send to a lower impact journal. This is just the hierarchy that exists in journals and is well known by those who handle papers. Nevertheless, a very well replicated and designed study that shows no effect on something that has been commonly stated as having an effect would also attract these same high impact journals."

One more criterion of 'importance' could be that of counter-intuitive results. A study that showed counter-intuitive results – such as that an NMR that is fully enforced demonstrates non-significant or negative effects on a species that has been shown to increase elsewhere – might attract publication in the top journals. However, on the

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[82] This paper has been heavily criticised by some (see *Science* 15th February 2002, vol 295(5558): 1233-1235) (also Hilborn 2007).

[83] Some studies have also suggested that there is a bias in higher impact factor journals towards studies that show stronger effects sizes (Barto & Rillig 2012), though this remains to be tested with respect to the literature on MPAs.

flip-side, if a belief is so deeply engrained within the scientific community a counter-intuitive result may be more difficult to publish.

Table 4.3 Description of criteria (derived from questionnaire responses) that may affect the likelihood of a study being published in a top journal.

Criteria	Description
External political reality	Salient political issues may have some bearing on whether an editor chooses to accept or reject a study.
Generalisable	Result is likely to be applicable in a variety of contexts. Studies carried out at the local scale may only succeed in being published in a local journal.
Statistically significant	Result shows that a positive effect is highly likely to be attributed to the affect of protection.
Strong effect	The stronger the effect size the more likely the finding will be published in a top journal.
Counter-intuitive	Result contradicts a previously held belief.

Methodological reasons for rejection

There are several legitimate methodological reasons for which a paper showing non-significant MPA effects may be rejected. For instance a paper may not replicate treatment, or may not control for factors such as time, age, poaching, or recreational fishing activity - all of which will have a strong bearing on the study outcome. However, one author said that even here there may be a bias, in that reviewers may be much more critical of methodological flaws in papers that denigrate MPAs:

> "I think in most cases you will not find clear cut cases of rejection just because papers have null or negative results for MPAs. Rather these factors raise the bar for acceptance and make reviewers more likely to attack other weaknesses in the paper (that always exist in any publication)… Often MPA papers that are less than flattering get knocked down a notch - rejected instead of revisions, revisions instead of accepted. Generally, journals advise publishing in a more "specific" journal that always has a lower impact factor"

So MPA studies that show strong significant effects may be less severely scrutinised in high impact journals (Hilborn et al. 2004), despite having flawed designs, and poor data quality on which to draw robust inferences (Willis et al. 2003a). This causes a bias in the literature towards studies that show positive effects, which is problematic when meta-analyses[84] are conducted on the literature to make generalisations about the strength of MPA effects:

> "One meta-analysis clearly demonstrated a strong bias in NMR-related publications towards only positive results, the severe failure of studies to employ a BACI approach, and the very selective focus of many studies towards focusing only on a species expected to change, or where a static comparison is made (snapshot) in cases where there is a clear pattern that just needs quantifying to get a publication… I think even the simplest of folks know it takes time for things to grow bigger, or to increase in numbers"

Another respondent said:

> "NMRs obviously work… The problem is unwarranted claims about the speed at which they work- very rapid responses and things that NMRs trigger; trophic cascades and increased "resilience", whatever that may mean, are the issue. The appreciation of NMRs is reduced as people make unsubstantiated claims about their efficacy."

However the assumption that "NMRs obviously work" has been criticised by some as misleading, one scientist from New Zealand said:

> "some people have expressed surprise that NMRs didn't produce clear results for all species, but I think that indicates superficial thought (not all fish are fished, not all fish stay in one place…). I think one of the things that's come from the New Zealand experience is the variety of responses: snapper at Poor Knights responded with a bang within 2 years, at Goat Island they dribbled gradually in over decades, and they simply won't do so in the northern South Island because all the snapper migrate into deep water in winter."

Another scientist said they had shown both positive and negative effects for different species:

> "Some of the papers I have submitted have shown positive and others negative and others no effects at all of NMRs on different species. The direction of the effect or whether or not any effect is actually detected at all depends on the position of the species within the complex web of interactions making up the marine ecosystem of interest and how the species being analysed either clearly interacts (or not) with species that are targeted by fishers."

Moreover, the strength of an MPA effect is heavily dependent on methodological factors such as time, the level of fishing that occurred pre-designation, and the current level of fishing.

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[84] It has been shown in other research fields in ecology that meta-analyses, in seeking to make generalisations from multiple studies of single scientific phenomenon are often confounded by such publication bias (Murtaugh 2002). Therefore the claims made by meta-analyses on the universality of MPA effects must be treated with caution.

Personal reasons for rejection

Two respondents indicated that they thought their paper had been rejected because of personal competiveness from some of their peers, but not because of any pro or anti-MPA bias. One of them said:

> "alleged poor quality, e.g., the assholes did not like natural history and worse, we know who they were, and our paper was much better than anything that they have published! We finally got it published and it is an excellent paper, but positive MPA effects had nothing to do with the rejections. NO (not due to the result outcome), it was more personal and competitive."

Another respondent suggested that an editor had a personal grudge against them, this perhaps underpinned by ideological differences:

> "I have been told I am not a true conservationist, and a friend of the enemy!"

4.3.2 Author bias

Values may affect a scientist's everyday decision making - what tasks they choose to prioritise over others. Of significance to this study is whether some authors self-censor their results due to a belief that they will have negative repercussions for a preferred policy.

Of the 92 responses, 16 scientists said that they had not submitted or prioritised work on MPAs that showed non-significant or negative effects. This is likely to be an underestimate, because scientists may be unwilling to divulge that they do this. Indeed two respondents said:

> "No! No self-respecting scientist would do anything like that."

> "No, this would be clear bias by the scientist and be a violation of professional ethics."

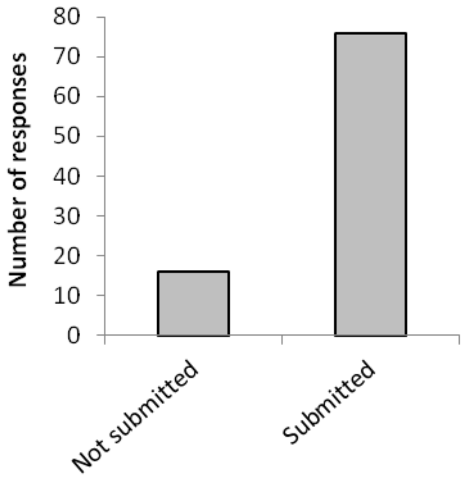

Figure 4.4 Number of scientists who admitted that they did not submit or prioritise work showing non-significant or negative MPA effects.

Nevertheless 16 scientists said they did not submit/ prioritise work on MPAs that showed non-significant or negative MPA effects, some suggesting that it is because of the set-up of science in general:

> "Yes, that is normal because it is not going to interest the top journals, but most studies show effects. One is trying to get into leading journals and then I am very busy, so putting effort into a paper that will not get into a leading journal and that takes so much time is not a high priority."

A few respondents also suggested that if the finding of a study on MPAs is non-significant this increases pressure on the scientist to show that they have sampled sufficiently to detect an effect. One reviewer said that:

> "I have not received articles to review that concluded "no effects" of MPAs. Rather, I have rejected articles that purported MPA effects that I thought were not well founded. Importantly, I believe I have not received and reviewed articles concluding "no effects" of MPAs for the same reason I don't receive many articles concluding "no effects" on any topic. I believe that authors hesitate to submit such articles for the same two reasons of "no effects" studies: (1) they don't think readers will find it as interesting, and (2) they need to demonstrate that the result is simply not due to insufficient sampling (i.e. statistical power) to detect an effect. This problem (potential bias) is common to many ecological topics (e.g., historic reviews by Connell or Schoener in the 70's on the perceived importance of competition), where the literature tends to publish only those studies that demonstrate effects and therefore provide insight into the mechanisms or conditions under which a response (MPA effect) is identified."

But this scientist denied that this tendency was confined to MPA studies:

> "I'm not convinced (yet) from my experience that this is a social bias specific to the topic of MPAs."

A similar view was expressed by another respondent:

> "In general (including MPA studies), statistically non-significant results in ecological studies usually have insufficient statistical power to determine whether or not there is substantial type 2 error (i.e., there is no way of knowing whether the negative results are real). This is not an inherent bias of MPA studies."

However a key part of my study was to see if there was any evidence to suggest that a scientist's decision not to submit non-significant/ negative findings was a result of ideological bias. Although getting scientists to admit to self-censorship is challenging, one scientist said that:

> "I have never personally had a paper rejected that was critical of MPA policy or practice, but I have seen evidence of self-censorship by scientists who believe strongly in the value of MPAs that they refuse to say anything critical of their use or their success. My experience of this attitude came in disagreements with co-authors on how to say things we wanted to say in a paper, and I am sure the attitudes that warned against criticism would also cause them to soft-pedal any negative data they had."

Another scientist did indeed say he didn't bother submitting a study showing negative MPA effects, because he felt it didn't warrant the effort in trying to get such work published:

> "Yes, but more negative as opposed to just not significant, MPA effects…Likely rejection because of the results was definitely a factor in the decision. In some cases, it felt a bit like a Don Quixote'esque battle with wind mills, promising a long battle for publication and potential for exclusion from certain collaborations because of the perception of my not being "onboard" when it comes to MPAs..."

Another scientist expressed similar perceptions:

> "There may be more people working on illustrating/ reinforcing their intuitions that MPAs are always beneficial than there are people working to illustrate any negative impacts… there is some kind of band wagon that many people appear to believe they must jump on if their work is to be published"

4.3.3 Summary of bias

There were two components of this chapter's study of possible bias; first an examination of the extent to which a potential bias towards positive results was due to the actions of editors/ peer reviewers, and secondly, the extent to which the same bias is due to the actions of scientists.

Editors and peer-reviewers

Only a minority of responses (n=10) suggested that their paper had been rejected because of a 'rogue' reviewer/ editor's belief that a study showing non-significant or negative findings would affect the cause of the MPA (defined here as an ideological bias). These respondents did say that they managed to get their work published elsewhere which would suggest that any ideologically held bias on behalf the editor/ reviewer would likely have little effect on the literature overall.

Nevertheless several respondents were keen to point out that there is bias in the literature towards positive results due to the way hypothesis testing in ecology is generally setup; namely, the rejection of a null hypothesis due to an arbitrary cut-off ($P>0.05$) that is used to determine whether the null hypothesis is rejected or accepted. If a study's research finding is non-significant the author has to prove that this result is not an artefact due to insufficient sampling, and therefore it may be scrutinised more closely than a poorly designed study that still manages to show a positive effect (Willis et al. 2003a).

With respect to interest, other studies have shown that stronger effect sizes are more likely to be published in higher impact journals (Barto & Rillig 2012). This hypothesis still has to be tested with respect to MPAs, though if it turns out to be true this would be a form of dissemination bias, in that studies that show larger effects are disseminated to a wider audience[85].

[85] If one makes the assumption that higher impact journals typically have a larger readership.

Authors

One scientist believed that some of his peers had self-censored results due to their belief that it would affect the cause of the MPA. Not surprisingly, no authors admitted to such self-censorship.

Rather, a number of scientists admitted to not submitting or 'seeking to publish' non-significant results due to the perception that such a result wouldn't be of interest to the high impact journals to which they prioritise their time to achieve publication. Therefore many scientists deemed it not to be worth the effort in trying to get non-significant results published.

4.4 Conclusion

This chapter has shown that whilst a pro-MPA ideology is likely to exist amongst some members of the scientific community who study MPAs, it remains unclear whether this belief has led to significant bias within the MPA literature for studies documenting positive effects. Indeed such a bias may not manifest itself explicitly, but occur more at a sub-conscious level (Table 4.4), perhaps akin to Kuhn's idea of a paradigm, a set of widely-held assumptions in the scientific community that make it hard for any counter-intuitive result to be initially published (Kuhn 1970; Koricheva 2003).

The prevalence of null-hypothesis testing in ecology has been largely blamed for the accumulation of studies that positively support a research hypothesis (Koricheva 2003). Thus the culture of science, and incentives on behalf of the author to go through with publication (use of time to maximise citations and funding) may lead to the 'file-draw' problem where non-significant results remain unpublished. Meta-analyses amplify the effect of this positive bias, and so their findings must be treated with caution.

One cannot, however, divorce science from the external political reality. Clearly there has been advocacy for MPAs amongst several environmental organisations (Chapter 3). Tentatively, the responses of some scientists suggest that ideology (to some extent) has affected the production of scientific knowledge potentially violating two of Merton's principles of good scientific practice: disinterestedness and organised scepticism (see 2.2.2 Chapter 2).

Table 4.4 Summary of how ideological bias may influence publication of positive outcome studies. Rows shaded grey indicate how ideology may implicitly influence an editor/ reviewer/ author's decision making when deciding to publish a scientific study.

Reason for rejection/ non-submission	Editor/ reviewer	Author
Methodological	Non-significant results more likely to be rejected due to the convention of null hypothesis testing.	Does not submit non-significant result because it will take more work/ effort/ time to get the result published.
	Pro-MPA bias leads editor/ reviewer to be less critical of the design of studies that show positive results.	n/a
Ideological bias	Rejects studies that show non-significant or negative effects due to pro-MPA bias.	Does not submit non-significant finding due to pro/anti-MPA bias.
	Editor may be affected by external political situation and chooses studies that are politically contentious to increase readership.	Does not submit non-significant bias due to a belief that there is a pro-MPA bias amongst editors/ reviewers for positive results.
Interest	Studies that show strong positive effects are more likely to be published in higher impact journals.	Does not submit non-significant finding because it is not a priority compared to other papers that are 'more interesting'.

Chapter 5

Information spillover: are the scientific foundations of temperate marine protected areas too warm and too hard?

"What we have now — a world without marine reserves — is like a debit account where we withdraw all the time and we never make any deposit. Reserves are like savings accounts."

Enric Sala, TED conference (2010)

ABSTRACT

There is a push globally by developed nations to establish networks of MPAs in their EEZs. In this chapter the scientific literature showing the ecological effects of MPAs was systematically reviewed and categorised according to literature type (empirical, theoretical, or review), locality, and focus species. Quantitative analyses were then carried out to assess where the balance of empirical evidence for the effects of MPAs lay. Three hundred and ten papers have studied the ecological effects of MPAs; however the majority of these studies (n=228) have largely focused on measuring the effects of NMRs on tropical coral and warm temperate rocky reef fish assemblages. Despite the majority of studies showing increases in fish biomass within the NMR, there are questions over the contextual factors such as place and scale that these findings have been measured under, and whether such results are generalizable to cold temperate marine ecosystems such as those found in the UK. With the English MCZ network being designed to meet biodiversity conservation objectives there remain key information gaps in the scientific literature regarding the effects of MPAs on the recovery of non-target species found in English waters. In keeping with the main theme of the thesis, this chapter discusses the extent to which policy advocacy from scientists for NMRs derived mainly from data in tropical cases has been too readily transferred to MPAs in temperate cases, and as a result the uncritical implementation of MPAs could have unintended effects.

5.1 Introduction

Few issues in marine management have received as much attention and stimulated such a protracted discussion as the two decade debate (1990-present) on the potential of marine protected areas (MPAs) in particular no-take marine reserves (NMRs) to make significant contributions to conservation and management of fisheries. Globally, MPAs are being established through a nature conservation framework to reduce the impact of human activities on threatened species and habitats (Hilborn et al. 2004). The establishment of MPAs has continued apace with an increasing uptake of MPA-based management in temperate waters, largely to meet nature conservation objectives (Harmelin 2000; Agardy 1994). Some scientists claim that much of the ecological literature on MPAs has focused heavily on their effects on fish and fisheries, and largely neglected their effects on threatened non-target species and habitats with implications of this for current planning of Marine Conservation Zones (MCZs) in England (Gerber et al. 2003; Edgar 2011). For example information on the effects of MPAs on mobile species (in addition to fish, birds, cetaceans, and sharks), information on impact of fishing on different habitats, and information on time-scales for ecosystem recovery is currently salient for the English Marine Conservation Zones (MCZ) project. In this chapter, the UK is used as a case study in which the ecological evidence on MPA effects is reviewed and current information gaps highlighted, particularly those relevant to fisheries management and nature conservation in cold temperate ecosystems.

Traditionally, the overarching goal of fisheries management is to maximise economic rent from a fishery whilst ensuring its long term sustainability (Caddy & Mahon 1995). Fundamentally, MPAs may serve two roles in fisheries management; 1) to mitigate against overexploitation and; 2) to enhance surrounding fisheries through the export of adults and larvae (Sale et al. 2005). Both of these roles are a function of MPA size and shape in relation to fish species life history characteristics, mobility, layout of habitat (Claudet et al. 2010), and wider management context (Bloomfield et al. 2012). Marine conservationists on the other hand want to use MPAs to maintain “natural” age or community structure and increase resilience in the ecosystem (Rice & Ridgeway 2010), irrespective of effects on particular fish species. This latter approach can be considered precautionary, protecting vulnerable habitats and species from the impact of certain fishing gears, and it explains why MPAs are often marine ecologists' tool of choice. There may be some common ground between fisheries and conservation objectives, in that the protection of certain habitats may be necessary to sustain a fishery (Fogarty 1999; Conover et al. 2000), but, traditionally, there has been a divide between fisheries managers and conservationists; fisheries management and environmental protection generally running under different legislative mandates, by different branches of government and advised by different groups of scientists (Brander 2010).

A proliferation of studies has investigated NMRs' potential in rebuilding fish populations within their boundaries, most of them documenting increases in target species abundance, biomass, individual size and egg reduction following the cessation of fishing (Halpern 2003). Several frequently cited meta-analyses have suggested that NMRs will have rapid fisheries effects (Halpern & Warner 2002) in tropical and also temperate ecosystems (Lester et al. 2009; Stewart et al. 2009). However such conclusions are largely based on studies that have measured the effect of protection on relatively site-attached species in reef habitats (Horwood et al. 1998). Few studies have investigated the effects of large scale fisheries closures that restrict mobile gears in cold temperate ecosystems, and the findings of those few studies are often ambiguous (Fisher & Frank 2002). This uncertainty is confounded by large declines in fishing effort occurring at the time of closure (Murawski et al. 2005), regional environmental change (Pastoors et al. 2000), and static gear fishing still being allowed in the closed area. Some authors suggest that not enough research has been undertaken in temperate ecosystems to draw conclusions based on robust scientific evidence about the effect of closed areas on commercial fin-fish (Auster & Shackell 2000).

For information on effects of NMRs beyond their boundaries there are some studies that have tested for spillover, which is the idea that there is a net movement of fish across the boundary of an NMR into a fished area (Lizaso et al. 2000). However, very few studies have shown that such spillover compensates the catches of fishermen that are affected by loss of fishing area due to the implementation of the NMR (Sale 2002). Likewise, empirical evidence for NMRs enhancing fisheries through larval export is even scarcer (Gell & Roberts 2003): increased larval production due to an increase in spawning stock biomass within the reserve is often simply inferred (Beukers-Stewart et al. 2005) since to measure such an effect directly is difficult[86] (Hedgecock et al. 2007). Indeed some authors acknowledge that NMRs are often too small and too few to affect fisheries in ways that are detectable at the management level (Russ 2002). So despite calls from some scientists that significant areas of sea should be set aside as NMRs to reverse the alleged overexploitation and collapse of world fisheries (Pauly et al. 2002; Pauly 2003), there is considerable controversy in the wider scientific community over how exactly NMRs can be used in non-reef based commercial fisheries characteristic of cold temperate ecosystems (Hilborn et al. 2004).

MPAs have often been advocated more generally as tools to reconcile fisheries management with nature conservation objectives (Roberts 1997)[87]. Historically, fisheries management has largely failed to deal with negative impacts of fishing on habitats and non-target species that build resilience into marine ecosystems contributing to the productivity valued by humans (Jennings 2009; Pitcher & Lam 2010), and it is thought that the implementation of spatial management measures such as MPAs within the context of ecosystem-based management (EBM) could lead to more sustainable fisheries (Halpern et al. 2010a). Some studies suggest that MPAs can have long-term benefits for both fisheries and nature conservation (e.g. Stelzenmuller et al. 2009; Halpern et al. 2010b), though there is doubt about how generalisable these effects are or whether they are just case specific (Greenstreet et al. 2009). Other studies suggest that networks of MPAs are needed to meet a range of biodiversity and fisheries management objectives (Gerber et al. 2003), though usually there will be trade-offs between the two objectives (Meester et al. 2004) meaning that the design of the MPA network will reflect negotiations between the competing interests of the fishing industry and nature conservationists (Villa et al. 2002; Kjaersgaard & Frost 2008).

[86] Though there are recent studies that have tried to do this (Cudney-Bueno et al. 2009a; Christie et al. 2010).
[87] There was a conference in Bergen, Norway (April 2011) on this theme.

This chapter seeks to build on existing studies that have highlighted information gaps within the ecological literature on MPAs (Willis et al. 2003a; Sale et al. 2005; Edgar 2011) and provides a quantitative overview of the ecological literature from 1970-2010; showing which ecosystems, marine reserves, habitat types and species have been most studied, and discussing the implications of this for strategic and tactical policy development on MPAs.

5.2 Methods

5.2.1 Data collection

The following word string; Marine *AND ("marine reserve*" OR "marine protected area*" OR "marine park*" OR "marine sanctuar*" OR "no take zone*" OR "special area* of conservation" OR "conservation zone*" OR "specially protected area*" OR "refugia" OR "box" OR "closed area*")*[88] was used to source all records published on MPAs between 1970 and 2010 from ISI's *Web of Science (WoS)* online interface. Eight hundred and thirteen ecological studies were identified after manually checking through abstracts to confirm that the MPA was the main focus of the study; all socio-economic and governance literature was excluded as not relevant to the objectives of this study.

5.2.2 Literature classification

Initially the literature was classified as empirical (n= 448), theory (n= 193) or reviews/ notes (n= 172) (Willis et al. 2003a). Depending on its theme each study was categorised as 'MPA effect', 'MPA design', or 'methodological'; this was done to distinguish empirical field studies that had measured an effect of protection (n= 310) from field studies that had collected data on species distributions (Vanderklift et al. 1998; Curley et al. 2002) and species movements (n=123) (Holland et al. 1996; Meyer et al. 2000; Willis et al. 2001; Chateau & Wantiez 2009) that aimed to inform MPA design. Methodological studies on monitoring of MPAs were also distinguished (n=15) (Mouillot et al. 1999; Rudershausen et al. 2010). Only 'MPA effect' studies are analysed in detail in the results section.

All MPA effects studies were categorised by marine ecoregion or marine province using the Marine Ecoregions of the World (MEOW) biogeographic framework (Spalding et al. 2007) and these were defined as 'tropical' where coral reefs were present, 'warm temperate' when average winter sea surface temperatures (SSTs) exceeded 10°C, and

[88] This search term will have overlooked studies that have measured the impacts of fishing through methods that did not incorporate protected areas into their design (e.g. Hall-Spencer & Moore 2000).

'cold temperate' where average winter SSTs were <10°C. Studies that were undertaken in the Arctic and Southern Ocean realms were classified as "polar".

Habitat was categorised in terms of the dominant substratum as hard or soft[89]. Most studies concentrated on one of these two gross habitat types; however, when both hard and soft habitats were sampled the study was counted twice. Occasionally studies did not explicitly state habitat type. In these cases habitat type was inferred from study species (e.g. lobsters associated with reef) and or areas (e.g. estuarine and offshore areas were considered to be soft).

The type of MPA studied was recorded; NMRs were distinguished from MPAs that placed restrictions on certain users only (e.g. no trawl, recreational fishermen only) and temporary closures. The focus species of the study were also recorded (e.g. coral reef fish, soft bottom fish community, grouper etc).

The theoretical literature was classified as either 'strategic' or 'tactical' (Gerber et al. 2003). Strategic models have been developed to answer broad, over-arching questions, such as what fraction of a given area should be placed in the reserve system, how many reserves do we need, which types of data are most critical to obtain. Tactical models are generally more complex, containing details about specific situations, and used to inform local decisions on how MPAs can be designed to meet specific objectives (Gerber et al. 2003) (see Table 5.3 for examples). The study sought to answer the following questions: 1) what is the proportion of strategic to tactical models, 2) for what types of ecosystem/ species are strategic models most well developed, and 3) in which localities have tactical models been best developed?

[89] In reality the hard-soft dichotomy is a gross simplification. Here hard habitats were defined as reef, and soft habitats as everything else (though this would also include a diversity of bottom types from mud and sand through to gravel and cobbles).

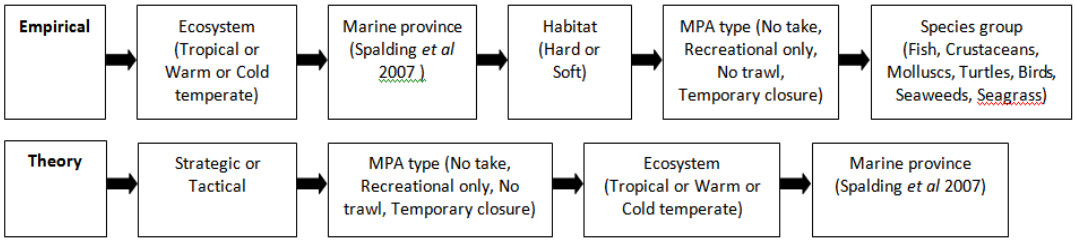

Figure 5.1 Classification scheme for the MPA biological literature.

The “quality” of MPA effect studies was also assessed through recording whether a study measured the effect of protection over a period <1 year (“snap-shot” studies), >2 years (“time series”), or had gathered information before and after an MPA had been implemented (“before-after”). Also recorded were studies that had measured habitat and used this as a co-variable in their analysis.

Defining empirical research effort

The number of empirical “MPA effect” studies was recorded for each of the 62 marine provinces (Spalding et al. 2007). This information was incorporated into ArcGIS 9.3 to show visually from which marine provinces most of the empirical evidence has come, and in which regions evidence is currently lacking.

5.3 Results

5.3.1 Literature typology

Number of empirical studies

While literature on MPAs continues to expand exponentially, the proportion of empirical studies has increased relative to review and note type literature (Figure 5.2). This was observed for all empirical field studies that have been undertaken in MPAs (n= 448) and for those empirical studies that have examined the effect of protection only (n=310) (Figure 5.3). The annual publication rate of theoretical-based papers seems to have been increasing at the same rate as that of empirical studies since 2000, following a leap in the publication of modelling studies in 1999-2000.

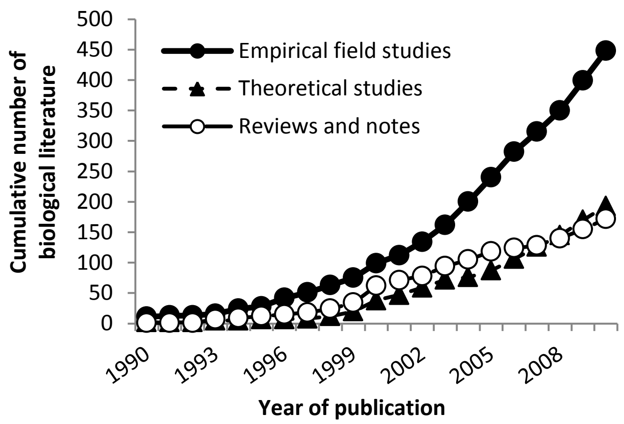

Figure 5.2 Publications concerned with the biology of MPAs in the published literature, 1990–2010: comparison of the number of field and desktop studies. To aid visualisation, papers 1977-1989 (n=8) were categorised as 1990.

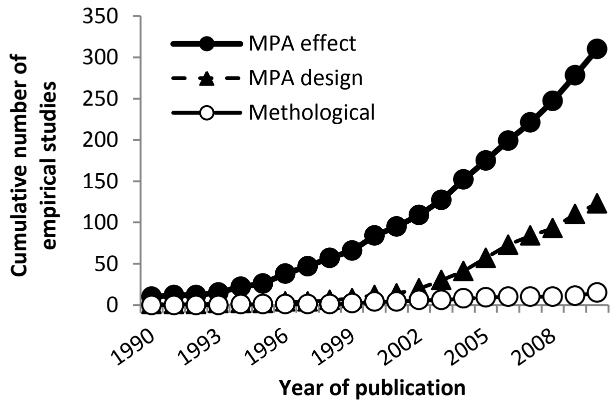

Figure 5.3 Empirical studies broken down by type; whether they investigated the effect of protection (MPA effect), gained evidence on the movement/ distribution of species/ habitats to inform MPA design (MPA design), or investigated a methodological problem (Methodological).

Type of MPA studied

Eighty seven percent of the empirical literature has focused on effects of NMRs (Figure 5.4). The remaining 13% of studies have mainly focused on effects of closed[98] no-trawl areas predominantly established over soft bottom habitats in temperate seas (e.g. Murawski et al. 2000; Jaworski et al. 2010), or MPAs that only allow recreational users (Denny & Babcock 2004; Shears et al. 2006). Twenty five percent of the empirical literature has come from the 10 NMRs shown in Figure 5.5. As of 2010 around 170 NMRs have been studied, 30 of which are located in the Mediterranean Sea.

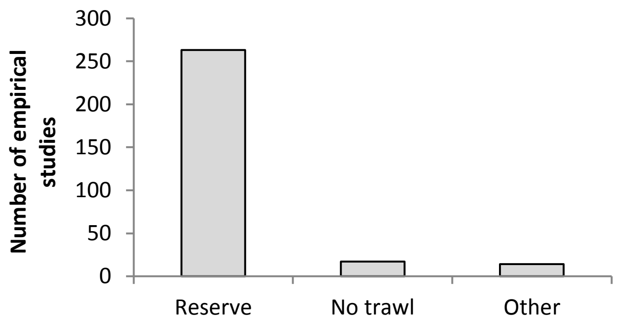

Figure 5.4 Type of MPA studied; 'Reserve' defined as an area where no fishing occurred, 'No trawl' as an area where towed ground gear was prohibited, and 'Other' containing studies that looked at the effects of MPAs that only allowed recreational users.

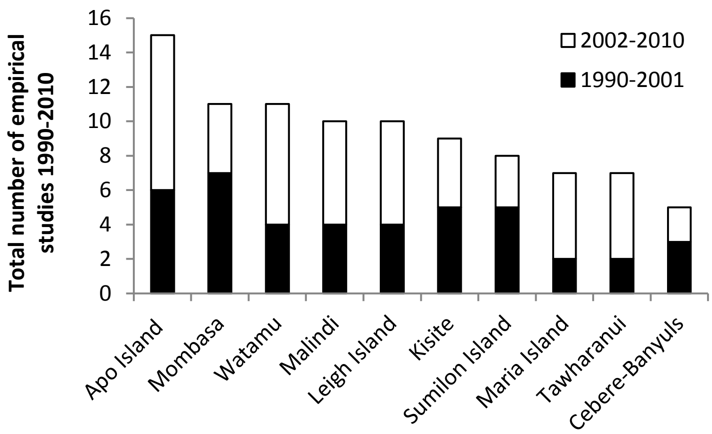

Figure 5.5 Top 10 MPAs studied 1990-2010. Note that all are NMRs.

98 The difference between "closed area" and "marine protected area" may carry political significance. One delegate raised this issue at a conference in Bergen 2011 suggesting that the term "closed area" (rather than marine protected area) is less politically contentious in fisheries management.

Ecosystems and habitats studied

When the empirical literature is broken down by ecosystem type, more studies have been undertaken in the tropics (n= 119) and warm temperate ecosystems (n= 116), although more than half of this research effort has been undertaken in 25 NMRs in the Mediterranean Sea. The publication rate of cold temperate research lags well behind that of tropical and warm temperate ecosystems (Figure 4.6).

Reef type habitats have been most studied (Figure 5.8a, n=228) with only 16% of studies being carried out over soft habitats (Figure 5.7b, n=43 including no-trawl areas). There has been roughly the same research effort applied over soft habitats in both warm temperate and cold temperate ecosystems, though this is mainly due to the study of the effects of large scale groundfish closures that are predominantly located over soft ground (Figure 5.7b).

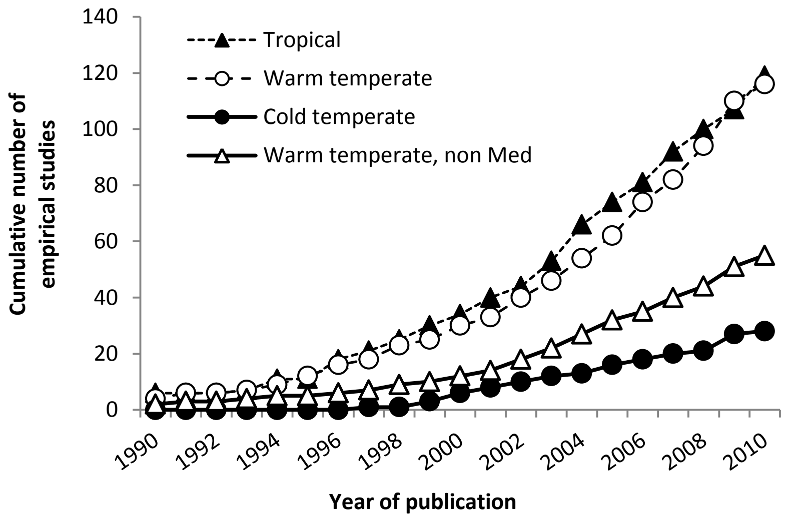

Figure 5.6 Number of empirical field studies undertaken in NMRs only by ecosystem type. The subset of Warm Temperate studies conducted outside the western Mediterranean Sea is plotted separately.

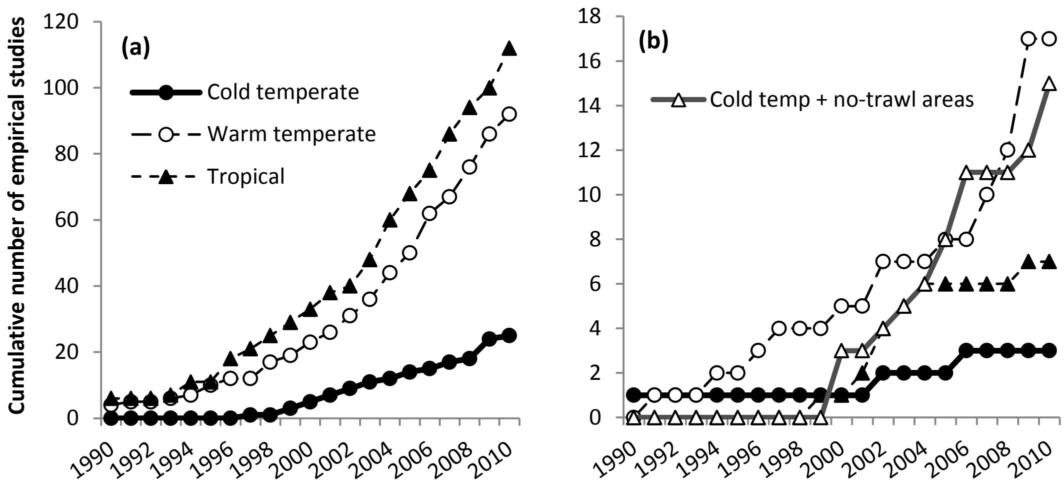

Figure 5.7 Number of empirical field studies that have measured the effect of an NMR over hard habitats (a), and soft habitats (b) (with studies that have examined cold temperate no-trawl areas also shown).

Main species groups studied

Reflecting the type of habitat surveyed the predominant group of species studied are coral and rocky reef fish communities (Figure 5.8), which comprise 45% of the focus species of all empirical studies. Reef crustaceans (n=22), coral reef fish predators (n=22) and molluscs (n=19) have been the focus of 20% of empirical studies. Temperate soft bottom fish communities have only been the focus of 5% of empirical studies. Significantly, no MPA effect studies were found for charismatic marine megafauna; though a few studies relevant to the design of MPAs did have empirical data showing the distribution and movement of turtles (de Segura et al. 2003), birds (Louzao et al. 2006; Terauds et al. 2006), and cetaceans (Canadas et al. 2005; Slooten et al. 2006) in MPAs and their surrounds.

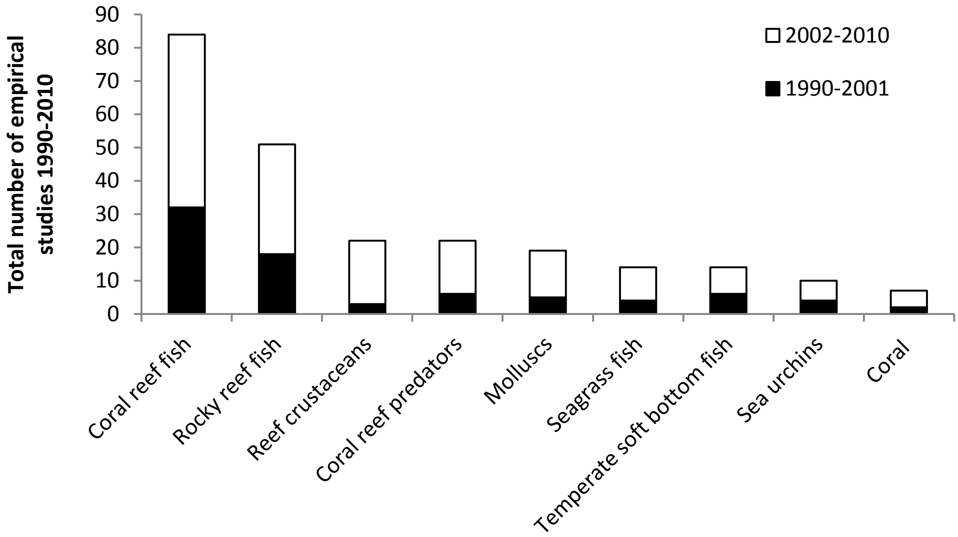

Figure 5.8 Main focus organism(s) of MPA effect studies.

Empirical research effort per marine province

Four marine provinces stand out in terms of the number of empirical studies that have been published on MPAs located in these provinces (Figure 5.9); the Mediterranean Sea (n=70), the Tropical Northwest Atlantic (n=33), the Western Indian Ocean (n=24), and the Western Coral Triangle (n=23). Cold temperate marine provinces that have been moderately studied (between 6-11 publications) include Northern European Seas, the Cold Temperate Northwest Atlantic, and the Cold Temperate Northeast Pacific.

Around half of the marine provinces have not been studied, and there are notable information gaps for Asia, Western Africa and the Southern Ocean.

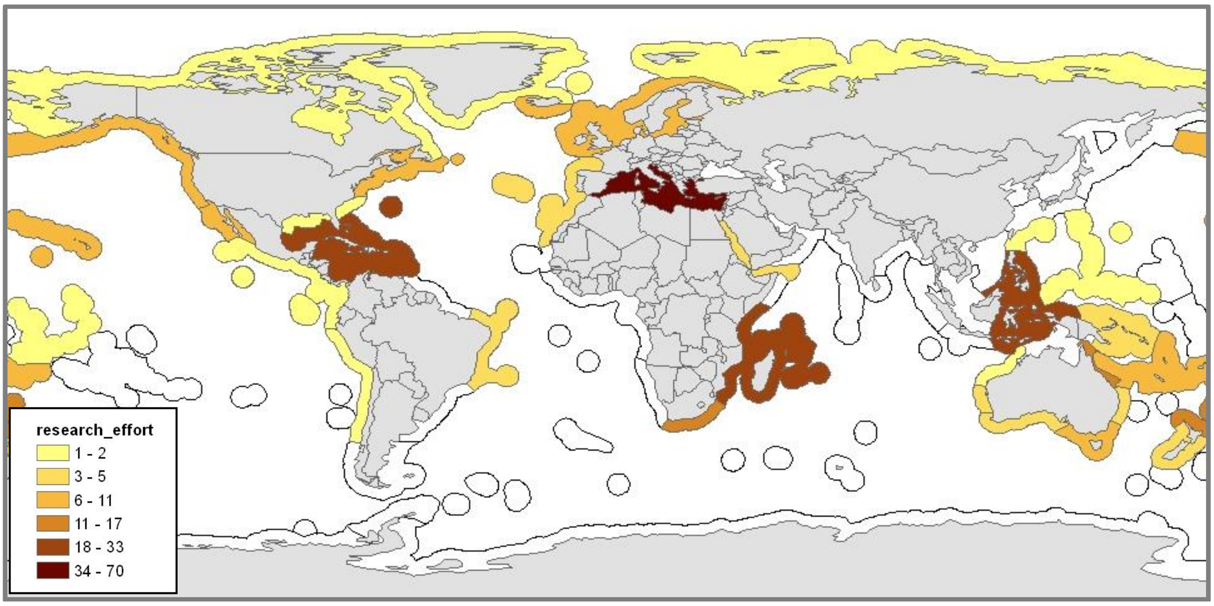

Figure 5.9 Research effort (defined as number of empirical studies) per marine province; marine provinces with no colour have no MPA effect studies.

"Quality" of empirical field studies

Fifty four percent of empirical NMR studies are only presenting a snap-shot, having only measured the effect of protection at a single point (i.e. a season) in time. Of these snap-shot studies 25% have only used one fished control area to attribute a difference between sites to an effect of protection, and less than half of these have explicitly tried to take into account effects of habitat in their survey design.

Forty six percent of studies have taken inter-annual variation into account in their design (Figure 5.10), however only 12% have measured effects of protection over time periods >10 years.

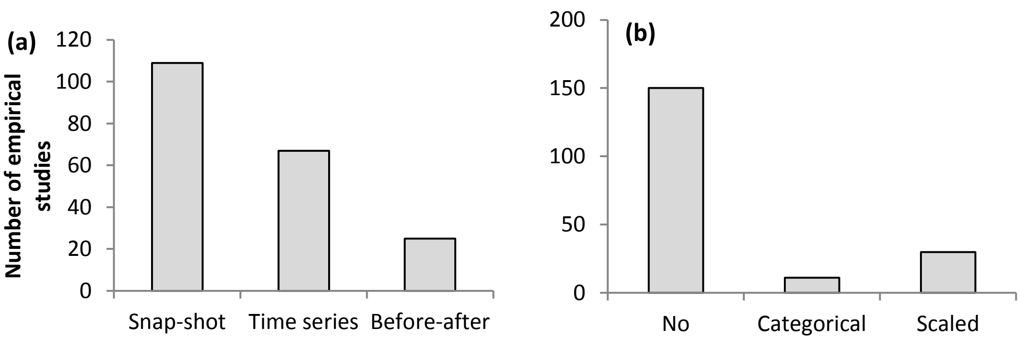

Figure 5.10 Temporal aspects of empirical literature investigating NMR effects (a), and number of studies that quantified habitat and used this as a covariate in their analysis (b).

Table 5.1 Summary of before-after studies of marine reserves, and number of temporal replicates per study (minimum two).

Reference(s)	Location	No. Reserves	No. temporal replicates	Study focus
Russ & Alcala (1989, 1998, 2003, 2004)	Sumilon and Apo Islands, Philippines	2	2, 5, 13	Coral reef fish species richness, density and biomass.
Bennett & Attwood (1991)	De Hoop, South Africa	1	3	CPUE of rocky reef fish assemblage.
Wantiez *et al* (1997)	New Caledonia	5	2	Coral reef fish species richness, density and biomass.
Galal *et al* (2002)	Nabq, South Sinai, Egypt	5	3	Density and size structure of commercially targeted grouper, emperor and snapper.
Nardi *et al* (2004)	Houtman Abrolhos Islands, Western Australia	4	6	Density of coral trout and a wrasse.
Claudet *et al* (2006)	Couronne, France	1	3	Rocky reef fish species diversity and abundance.
Hawkins *et al* (2006)	St Lucia, Caribbean	4	7	Commercial coral reef fish species biomass.
Lincoln-Smith *et al* (2006)	Solomon Islands	1	6	Abundance and size of commercial coral reef invertebrate.
Francini-Filho & Moura (2008)	Eastern Brazil	1	5	Biomass, size, and spillover of coral reef fish.

Table 5.2 Factors affecting the likelihood of whether an MPA will meet its management objectives.

Factor	Comments
Habitat heterogeneity	MPAs may be located over habitats that are comparatively resource rich (Hilborn 2002) or resource poor (Edgar et al. 2009). An ecological effect could be attributed to protection when it is instead due to habitat differences. To counter this, studies should use BACI designs (Underwood 1993) to increase the strength of their inference.
Biological life histories	Individual species life-history traits strongly affect how they will respond to protection. Species may grow slowly meaning that any significant change won't be detected for years (Barrett et al. 2007). Alternatively, fish species may be highly mobile, meaning that an MPA has little or no protection effect (Shipp 2003). Survey designs and the amount of sampling effort needed to detect an effect will need to take species movement into account (Rotherham et al. 2007).
Environmental change	Regional environmental change and its effect on fish growth and recruitment may confound the interpretation of the effect of a closed area (Holland 2000). Such a problem could only be overcome through long-term monitoring.
Past management history	The extent to which a fish stock has been exploited and habitat modified by fishing will influence the size of an ecological effect detected in an MPA relative to control locations and baseline at t=0.
Current management history	Displaced fishing effort outside the MPA may lead to a greater intensity of fishing in its surrounds and lead the researcher to detect a greater effect of protection due to the deterioration of fish stocks and habitat outside (Hilborn 2002). Illegal fishing may also reduce the size of ecological effects (Bloomfield et al. 2012).

Twelve percent of studies have before-after data; the design and focus of these studies are summarised in Table 5.1. The majority of before-after studies have measured effects of protection on abundance and biomass of coral reef fish species. Interestingly only one before-after study measured the effect of spillover (Francini-Filho & Moura 2008). Habitat has been categorised (n=11) or scaled (n=30) by only 21% of empirical studies. Table 5.2 summarises the factors that will determine the strength of an MPA effect that should be taken into account in the design of a monitoring programme.

Extent of theoretical/ modelling studies

There is a greater abundance of strategic (n= 130) than tactical models (n= 56). The publication of strategic models increased rapidly during 1999-2000, whereas it was not until 2008-2009 that the publication rate of tactical models started to match that of strategic models, roughly a nine year lag (Figure 5.11). Seventy percent of the strategic models are not calibrated to specific species: however, for those that are, 13% explicitly derive their parameters from tropical species (mainly coral reef fish), compared to 7% from warm temperate species, and 8% from cold temperate species (mainly cod). Twice as many papers showing tactical models have been published for temperate ecosystems (n=40 vs n=20 for strategic models) (Figure 5.12), many of these informing the design of MPA networks along the northeast Pacific coast of the US (Ban 2009; Ban & Vincent 2009; Airame et al. 2003), and predicting the effects of groundfish closures (Horwood et al. 1998; Holland 2000) (Figure 5.13 and Table 5.3).

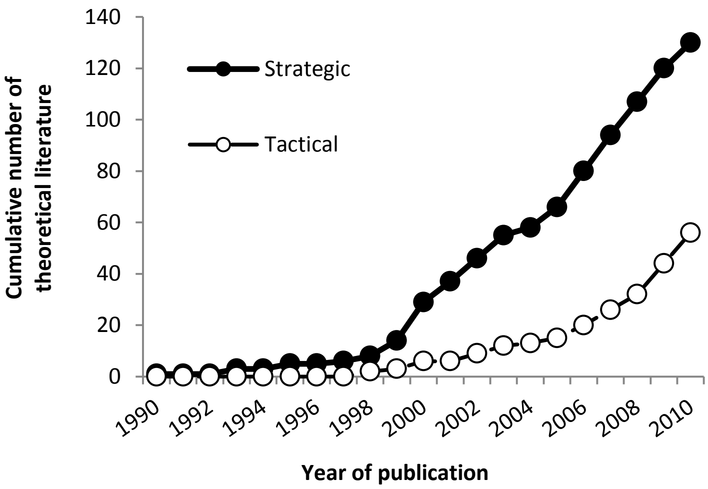

Figure 5.11 Number of theoretical studies by model type.

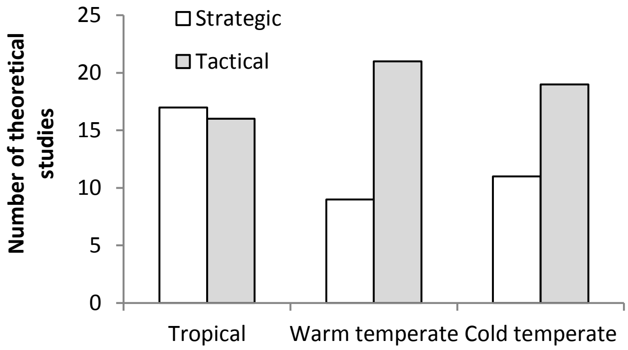

Figure 5.12 Total numbers of theoretical studies by ecosystem. Note that 70% of strategic models are completely abstract. By their very nature all tactical models have been developed for real world problems.

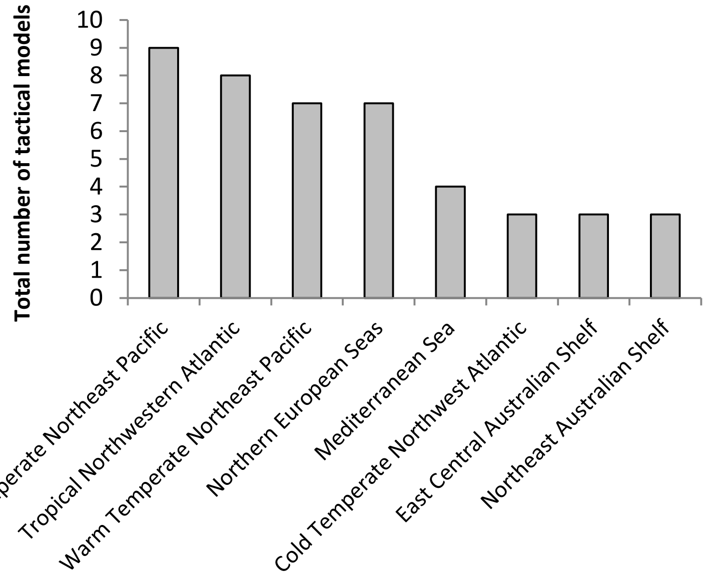

Figure 5.13 Total numbers of tactical models per marine province.

Table 5.3 Some examples of tactical models potentially used to inform local fisheries and biodiversity conservation policy.

Reference	Area/ MPA	Findings
Horwood et al. 1998	Trevose spawning grounds for Sole, Celtic Sea	Found that the closure of a sole spawning ground may be ineffective if sole remain free to be caught elsewhere, and the catch of sole outside the closed area is still high. Closed areas will be useful in protecting aggregations of juvenile fish.
Holland et al. 2000	New England groundfish closures	Impacts of closures will vary across species, sometimes increasing yields for some and decreasing yields for others.
Airame et al. 2003	California Channel Islands	Identified reserve network scenarios that would represent all habitats whilst minimising socio-economic costs to stakeholders.
Stewart et al. 2003	South Australia	*Ad hoc* placement of marine reserves may compromise effective conservation of marine biodiversity.
Kjaersgaard & Frost 2008	Plaice box, North Sea	Plaice box largely ineffective; need to reduce the fishing effort of smaller vessels still fishing in the closed area to achieve a profitable fishery with a biomass above the reference point Bpa.

5.4 Discussion

5.4.1 Wider management context

Although few would argue that MPAs are a panacea for all marine resource management problems (Roberts 1997; Lubchenco et al. 2003; Pitcher & Lam 2010; Mora et al. 2011), there is no escaping the fact that MPAs have dominated the literature on marine resource management (see Chapters 1 and 3) and also discussions in global marine policy circles over the last 20 years (Chapter 1). Indeed it could be argued that MPAs have been advocated ahead of more integrated management strategies such as marine spatial planning (MSP) and ecosystem based management (EBM) (Halpern et al. 2010a).

Some have observed an *ad hoc* race for marine space (Jones 2010) that has preceded attempts by government for a co-ordinated response to manage marine resource use through developing MSP and adopting EBM. Spatial management measures such as MPAs that are currently being established to meet nature conservation objectives, along with the increased leasing of marine space by offshore developers, has meant that fishers have been pushed into smaller pockets of sea. Understandably fishermen are going to be reluctant to concede more space if they do not see themselves benefiting from such measures (NFFO 2010e). Despite the rhetoric and good intentions of the academic literature, many MPAs function only as “paper-parks” (Dudley 2008). The implementation of new management tools such as MPAs face the same socio-political problems that have made existing tools largely ineffective (Pitcher & Lam 2010). Many social scientists would argue that the potential solution to overfishing and conservation of ecosystems lies with governance and the process through which decisions are made and enacted; institutional setting is key (Khan & Neis 2010), as poor management decisions are often due to misunderstanding resulting from a breakdown in communication between different social groups (Finlayson 1994). So the success of MPAs will depend on the way in which they are introduced.

Only 1.6% of the ocean is designated as MPA and as little as 0.2% NMR (Wood et al. 2008), thus society is a long way from meeting current international targets for meeting MPAs (e.g. CBD calls for 10% of the oceans to be designated as MPAs by 2010). Indeed there is a conflict between the time-frames and strategies adopted by environmentalists on the one hand and environmental scientists on the other to implement MPAs[99]: whilst the former stress the urgent need to meet deadlines and to designate MPAs on current best available knowledge, accepting that this may compromise on quality (Wood et al. 2008), many scientists advocate a highly analytical approach (drawing on sociology, economics and ecology) to mount a robust argument for the designation of MPAs on a site-by-site basis (Bloomfield et al. 2012). However, such an approach may be virtually impossible to achieve at the scale MPA networks are being proposed (see Chapter 6). This implies there is a potential paradox facing policy-makers concerning risk; the risk of rushing ahead with the implementation of MPAs, accepting that they could be put in sub-optimal locations and have unanticipated socio-economic and ecological impacts (Hilborn 2011), or alternatively holding back until more information is available, missing international deadlines (and subsequently facing EU sanctions) and still allowing the continued access of potentially damaging activities to vulnerable habitats.

However, despite an influential environmental movement calling for more MPAs to be designated (see Chapter 3), some have argued that the current rate at which we are implementing MPAs[100] is still too slow, which means that additional solutions need to be developed to halt biodiversity loss (Mora & Sale 2011). This has led many authors to conclude that MPAs are necessary but not sufficient for marine conservation (Allison et al. 1998), and must be used along with other management measures to prevent declines in, for example, certain fish species (Blyth-Skyrme et al. 2006; Pastoors et al. 2000; Little et al. 2010). Given these observations, the implications of the chapter findings for the implementation of MPA networks in a temperate context are now discussed.

[99] See chapter 6. Many environmentalists have been quite critical of the UK government stalling the designation of MCZs because there are gaps in the evidence, whereas many scientists have been more cautious saying that a robust scientific argument has to be made to fishermen to explain why they are being restricted from a certain site.
[100] As things stand currently we will not achieve the 10% target until 2050 (Wood et al. 2008).

5.4.2 Balance of the literature

Provisionally, the recommendation of Willis et al (2003a) for more empirical research on MPAs seems to have been realized. The proportion of empirical studies has increased relative to review and note literature, suggesting a more balanced knowledge gain than in previous years. However most empirical literature has focused on effects of NMRs (Figure 5.4) established over reef type habitats in tropical and warm temperate ecosystems (Figure 5.7a), and has measured effects of protection on fish (Figure 5.8), with an information shortfall for NMR effects on non-target species and habitats (Edgar 2011). This is worrying, considering that many international policy drivers pressure governments into establishing MPAs to protect wider marine biodiversity (e.g. CBD, OSPAR).

Temperate vs tropical

The dominance of tropical and warm temperate NMRs in the literature (Figure 5.6) indicates that understanding the effects of NMRs in cold temperate ecosystems and polar ecosystems may be problematic, because the ecology changes with latitude as a function of climatic and biogeographic patterns, and environmental governance regimes also differ.

Many temperate fish species demonstrate extensive seasonal movement (Willis et al. 2003b); gene flow and connectivity are likely to be higher with the extended larval duration observed at higher latitude; while many life history characteristics, such as growth rate, age at maturity, longevity and maximum body size, are often correlated with latitude (Blanck & Lamouroux 2007; Hutchings & Griffiths 2010; Sumpton & Jackson 2010). Similar latitudinal differences also exist in marine management, because the more limited financial, human and information resources available in developing countries diminish their capacity to do fisheries research and management in the tropics (Jones et al. 2002; Sale 2002; Salomon et al. 2011). Thus, some authors argue that NMRs have been established in the tropics because it is relatively simple to manage an NMR rather than enforce restrictions on gear or impose effort and catch controls, as traditionally happens in many high latitude countries (Sale et al. 2002; Shipp 2003).

Another important issue is the recovery of fish within a reserve. Whilst some authors have suggested that NMRs have rapid ecological effects (Halpern & Warner 2002; Halpern 2003), others are more wary, suggesting that responses to protection (in temperate Australian NMRs at least) are often slow, complex and species-specific (Barrett et al. 2007). Indeed a recent meta-analysis of the seven Mediterranean and Lusitanian MR stressed that management should adopt an extended timeframe (>30 years) to evaluate their fisheries' effects (Vandeperre et al. 2011).

Hard vs soft

Lester et al (2009) suggested that ecological effects of marine reserves may be similar between tropical and temperate regions; however their meta-analysis examined few highly mobile or migratory species, and the vast majority of reserves were protecting nearshore rocky or coral reef habitat. This study reinforces the perceptions that the scientific support for temperate MPAs is strongest for similar hard complex nearshore habitats, and that data from soft sediment systems at temperate and tropical latitudes is severely lacking in NMR science (Lester et al 2009). This is an important gap in knowledge, given the predominance of such habitat in all seas: the majority of continental shelf seabed is sediment; sediment covers 90% of the shelf in the Antarctic, *c.* 95% of the Great Barrier Reef Marine Park and > 99% of the proposed English North Sea Marine Conservation Zones network.

Interestingly, whilst the majority of published studies of tropical or warm temperate MRs have focused on fish assemblages, studies on cold temperate NMRs have focused predominantly on invertebrates. The current lack of information on NMR effects on fish assemblages over soft habitats and low-topography continental shelf systems (which are important to large-scale fisheries) is problematic because an incomplete understanding limits development of appropriate management measures. The advocacy for the wider use of NMRs by many environmental organizations and some marine scientists thus far appears to have little empirical basis. That said, without the establishment of NMRs in such habitats, the potential effectiveness of spatial protection measures in soft sediment systems cannot be measured[101].

A number of factors that vary between sediment and reef-based systems may influence NMR effects. Fish species associated with reefs are generally more site attached (Barrett 1995; Zeller 1997; Tolimieri et al. 2009), as are individuals within species that range over both soft and hard bottoms (Attwood & Bennett 1994; Willis et al. 2001), and they are therefore likely to experience greater protection than those of sedimentary systems. This site attachment is a function of multiple behaviours, including territoriality (Barrett 1995) aggregation around structure (Grossman et al. 1997; Franks 2000) or predator avoidance. The greater uniformity of habitat in soft-sediment systems may also increase the likelihood of transboundary movements, whereas reserve boundaries that fall along discontinuities in habitat are more likely to retain habitat-dependent species (Freeman et al. 2009). These factors may mean either that less effort has been put into soft-sediment systems because of preconceptions that such habitats will not retain biomass, or that studies conducted have not yielded statistically significant differences between protected and unprotected areas, and have therefore not been published (see Edgar 2011 for a discussion of such publication bias).

It can also be argued that the lack of NMRs established over soft sediment bottoms in cold temperate ecosystems may be the main reason why studies on reserve effects are limited to fauna associated with reefs (Lester et al. 2009). Another methodological problem could be the difficulty of making direct observation in cold temperate waters due to poor visibility (Polunin et al. 2009), and also the fact that soft bottom communities are often found in deeper water or intertidal areas. Fishes not associated with structure tend to move over much wider areas, meaning soft sediment habitats need surveys over much larger spatial scales (see Rotherham et al. 2007 for discussion). It is easier to show an effect of protection on a relatively sedentary

[101] In the UK a government report entitled *Net Benefits* (2004) made the recommendation that to resolve this issue the fishing industry should engage with the conservation sector to do some large scale no-take trials to see what the benefits were- these currently have not been done.

invertebrate species associated with reefs than on more mobile fish species where a more intense (and costly) sampling effort will be needed to overcome high spatial and temporal variability in the fish assemblage (Rotherham et al. 2007). Indeed, perhaps large seasonal closures (Dinmore et al. 2003) and partially protected areas (Frank et al. 2000; Murawski et al. 2000; Sweeting et al. 2009) are more common than NMRs in cold temperate ecosystems owing to the increased mobility of exploited species (Shipp 2003), and also because it is currently not politically feasible to designate such large areas as no-take zones (see 6.4.1 Chapter 6).

5.4.3 Quality of evidence

General design of MPA effect studies

The increase in the quantity of empirical evidence is not necessarily reflected in an improvement in scientific rigour. Despite earlier calls for more rigour in experimental design (namely spatial and temporal replication) when empirically assessing NMR effects (see for example Guidetti 2002; Willis et al. 2003a), a high proportion of empirical studies are snap-shot (Figure 5.10a) with 25% of these studies being spatially confounded by only using one fished control area. Very few studies have implemented a fully replicated BACI design (Underwood 1993), though moves in this direction are occurring for example, through the application of fully replicated asymmetric monitoring (Hoskin et al. 2010). Some recent reviews have attempted to mitigate such design-related bias by weighting studies according to the strength of their experimental design (see Claudet et al. 2008). However this limited amount of mitigation cannot counter the effect of potential publication bias on the results (Edgar 2011); an increased likelihood of positive effects studies being published compared to those showing neutral or negative NMR effects (Huntington 2003).

There are also very few studies that have long-term monitoring data, a concern given some senior scientists believe that such long-term studies are needed to inform strategies for sustainable development (Dan Laffoley, pers comm.) (Agardy 2010). Only 20% of empirical studies have measured habitat and included this as a co-variable in their analysis (Figure 5.10b). There has been debate on the extent to which effects of habitat and also illegal fishing may have influenced the magnitude of the ecological effects documented in snap-shot studies; effect size may be overestimated if an NMR was located over more productive habitat (Hilborn 2002), or underestimated if illegal fishing still occurs in the MPA (Guidetti et al. 2008). Few studies have tried to quantify fishing effort occurring inside (i.e. through illegal fishing) and outside MPAs (Bloomfield et al. 2012). Indeed the magnitude of fishing effort outside the MPA and inside before designation will play a key role in determining the direction and magnitude of the reserve response (Lester et al. 2009). Recent evidence suggests that newly established NMRs are often located in resource-poor areas due to socio-political factors, and when surveyed have significantly fewer fish than nearby control locations (Edgar et al. 2009) (see Table 5.2).

Fisheries effects of cold temperate MPAs

As mentioned earlier, studies that have measured the effects of cold temperate NMRs have predominantly focused on invertebrates, particularly shellfish and lobsters (Rogers-Bennett & Pearse 2001; Rowe 2002; Jamieson 2000; Hoskin et al. 2010). No trawl areas have been used to protect scallop grounds (*Placopecten magellenicus*) on Georges Bank (Murawski et al. 2000) and around the Isle of Man, UK (*Pecten maximus*) (Beukers-Stewart et al. 2005) with considerable success, and scallop fishermen are now experiencing at first-hand the benefits that closed areas can make to their catches (Beukers-Stewart, pers comm.). In closures on the Georges Bank, the total scallop biomass increased by a factor of 14, and harvestable biomass increased by a factor of 15 over a four-year period (Murawski et al. 2000). In the Isle of Man the exploitable biomass of scallops increased by a factor of 11 over approximately a 14-year period, with circumstantial evidence for larval spillover from the closed area (with scallop densities increasing in adjacent fishing grounds), and anecdotal evidence for the spillover of adults over the closed area boundaries (Beukers-Stewart et al. 2005).

There is a growing body of literature that has studied the effects of large area closures that typically restrict mobile ground gear and set nets with the intention of allowing demersal fish stocks to recover (Murawski et al. 2005). Whilst it could be argued that these areas still allow some fishing activity (Pastoors et al. 2000; Frank et al. 2000), meaning the ecological effects of such closures may not be as large as that if a NMR of comparative size had been surveyed (Lester & Halpern 2008), their effects do not seem to be as universal (Frank et al. 2000; Fisher & Frank 2002; Holland 2000) as those for NMRs that have been located over reef type habitats. Scale seems to be an important issue, Blyth-Skyrme et al (2006) showed that a 500km² inshore no-trawl area in southern England failed to protect above average size plaice (*Pleuronectes platessa*) and seabass (*Dicentrarchus labrax*)[102] which showed similar rates of decline in the no-trawl area compared to the fished controls. Likewise, the North Sea Plaice Box[103] has failed to stop the decline in the SSB and yield of plaice despite significant reductions of fishing effort within the closed area (Pastoors et al. 2000). The effects of large-scale ground gear closures in the Northwest Atlantic on the recovery of previously targeted commercial fish species is also unclear, positive effects seeming to be highly site-dependent (Murawski et al. 2005). Evidence suggests that MPAs can be strategically placed to protect mobile species during key stages of their life cycle; e.g. the protection of nursery grounds for juvenile cod (Schopka et al. 2010). The interpretation of many of these large-scale studies is further confounded by regional environmental change (Pastoors et al. 2000), and reductions in fishing effort occurring at the time of survey (Murawski et al. 2005; Holland 2000).

Evidence of the spillover of adult fish across MPA boundaries that compensates the catches of local fishermen is generally limited to small-scale NMRs (Vandeperre et al. 2011) – studies of the wider fisheries effects of cold temperate MPAs are much sparser and generally inconclusive. There is some evidence for the net movement of fish from inside cold temperate MPAs to fished areas outside (Cole et al. 2000; Fisher & Frank 2002), and a few studies suggest that MPAs have the potential to increase catch per unit effort (Guidetti et al. 2010; Murawski et al. 2005), though no cold temperate

[102] These two species undertake seasonal spawning migrations.
[103] The ‘‘plaice box’’ is a partially closed area established in 1989 to reduce the discarding of undersized plaice (*Pleuronectes platessa*) in the main nursery areas, and thereby to enhance recruitment to the fishery.

studies have shown MPAs to increase fisheries yields through spillover[104]. Some argue that the 'fishing-the-line' phenomenon is an indication that catches are greater next to MPA boundaries (Dan Laffoley, pers comm.), and there is some empirical evidence to suggest that this may be true in certain cases (Murawski et al. 2005). Detecting spillover effects and MPA effects on fisheries requires methodologies that are expensive and not necessarily straight forward to implement (Sale 2002). Yield is a contentious issue, as how can one be sure that fisheries yields prior to the establishment of a closed area were sustainable over the long-term (Halpern et al. 2010)? The prevailing consensus seems to be that MPAs can improve yields in fisheries that have been recruitment-overfished (Hilborn et al. 2004) and sometimes growth-overfished (Murawski et al. 2000), though it could be argued that such an objective could also be met with a reduction in fishing effort[105] (Hilborn et al. 2004). Providing definitive evidence for larval export from NMRs is also extremely difficult (Russ 2002), though there is a mounting body of circumstantial evidence to suggest that this does occur (Beukers-Stewart et al. 2005; Roberts 2003), and also some recent direct measurements of enhanced larval recruitment downstream of a NMR (Cudney-Bueno et al. 2009a). Indeed current evidence suggests that the fisheries effects of MPAs are highly dependent on scale and local ecological conditions, making it very difficult to generalise from one case-study to another (Holland 2000; Bloomfield et al. 2012).

5.4.4 Implications for planning MPAs

It is generally held that the objective of maintaining or restoring marine biodiversity conflicts with the objective of maintaining or increasing food supplies from the sea, with levels of fishing from the latter typically compromising the former (Brander 2010). Traditionally, fisheries scientists, fisheries managers and the fishing industry aim to maintain or maximise yields, whereas environmental scientists, managers, and environmentalists have concentrated more broadly on the conservation of marine ecosystems and their health (Rice & Ridgeway 2010). Although advocates for MPAs

[104] The only evidence for increased/ maintained yields come from a handful of studies of tropical and warm temperate MRs (Rakitin & Kramer 1996; Russ et al. 2004; Abesamis & Russ 2005; Ashworth & Ormond 2005).
[105] Some scientists still argue that there is still overcapacity in the EU fishing fleet. I.e. there is too much fishing power for too few fish (Thurstan et al. 2010).

belong primarily to the latter group of marine experts - MPAs have often been promoted on the basis that they will meet both biodiversity and fisheries management objectives (Roberts & Hawkins 2000; NCEAS 2001; Roberts et al. 2001; Leisher et al. 2007). However, these claims have mainly stemmed from science that has been generated from small-scale NMRs (e.g. Stelzenmuller et al. 2009), and may not be applicable at a larger scale (Greenstreet et al. 2009). The design of an MPA network inevitably depends on its overarching objectives (Hastings & Botsford 2003). Whether an area is fully or partially protected depends on the decision context; e.g. fisheries or habitat conservation. Some scientists would argue that to maintain the age-structure of part of a population of a fish species requires the implementation of fully-protected NMRs as even weak levels of fishing can fish out larger more mature individuals (McCook et al. 2010). However if the goal of management is restricted to reducing fishing mortality of certain species, then restrictions on certain gear types may suffice (e.g. Murawski et al. 2000). Likewise if the primary objective is to protect habitat, decision-makers are going to find it difficult to justify the implementation of NMRs, because not all fishing methods will interact with habitat features requiring protection (Chapter 6).

Both empirically and theoretically, this chapter has shown that the science of MPAs has focused heavily on the fisheries effects of no-take NMRs. One could argue that this is a result of the linear model of science-policy and stealth issue advocacy[106] (Pielke Jr 2007), reflecting the belief of at least some scientists and many environmentalists that generating evidence on the fisheries effects of NMRs (particularly through spillover and enhanced yields) will lead to their greater acceptance by the fishing industry (currently their biggest opponents) (PISCO 2011). But this strategy glosses over an underlying value-judgement that trades-off fisheries productivity with the maximum protection of biodiversity (i.e. through NMRs) (Table 5.4)[107].

[106] When a scientist claims to focus "only on the science"; Pielke Jr (2007) argues that this is politically desirable for some scientists because it allows for a simultaneous claim of being above the fray, invoking the historical authority of science, while working to restrict the scope of choice (pg 7, para 2).

[107] Indeed the UK National Federation of Fishermen's Organisations says "scientists advocating MPAs have often shown graphs of increasing biomass within an MPA, as major evidence of their success. However, it would be clear to the average layman that this would be the most likely response to the removal of human activity from the marine environment and such evidence offers nothing to a reasoned analysis of where the balance between human use of marine resources and conservation should lie" (NFFO 2009c).

Attitude to risk is another crucial factor influencing management objectives. MPAs (particularly NMRs) are often advocated on the basis of the precautionary principle (Lauck et al. 1998; Jones 2002), whereby conservationists argue that variability and uncertainty in any scientific assessment[108] means it is better to err on the side of conserving stocks and biodiversity. In contrast fisheries management aims to balance concrete short-term adverse impacts of reductions in fishing opportunity with less quantifiable conservation and economic benefits in the long-term (Salomon et al. 2011). Reconciling short-term with long-term objectives is a problem; policies that create jobs and revenue today are pitted against policies that would protect biodiversity and generate revenue and employment opportunities in the future (Salomon et al. 2011). The social costs of MPAs to fishing communities are real; their designation may cause fishers to travel further to unfamiliar grounds, posing significant risk to the lives of crews on smaller vessels (Hannesson 1998), impact immediate local food needs (Pitcher & Lam 2010) and put fishers who were only making marginal profits out of business (NFFO 2009d).

Some have argued that there is a problem if scientists unintentionally/ intentionally over-generalise current ecological evidence (which is more nuanced than a cursory glance at the literature would lead us to believe) to gloss over important normative areas of debate (Table 5.4). When scientists over-generalise on “benefits” to persuade decision-makers to adopt MPAs this may lead to critical information gaps being overlooked that are essential to inform planning of MPAs at the local level (Sale et al. 2005; Edgar 2011), and also mislead stakeholders on potential benefits (Bloomfield et al. 2012).

However, decision making is not just about the science (see chapter 2); effective objective setting requires an inclusive stakeholder process that encourages people with different world views to engage with one another to navigate trade-offs that are associated with any vision for the state and use of the marine environment (Salomon

[108] Scientists can and do get the science wrong, as shown by Canadian scientists’ overoptimistic assessments and projections of Newfoundland cod stocks (Finlayson 1994).

et al. 2011). Indeed some would argue that protection of the marine environment is a societal, not just a scientific decision, in that establishing MPAs to protect nature may be what society judges to be the right thing to do (Callum Roberts, pers comm.). If the wider society wants more sea to be protected as NMRs then who is to say that this is wrong? However, the emphasis on the increased role of wider civil society in decision making has important implications for the role of expertise in decision making, and some would argue that it flies in the face of government rhetoric on evidence-based policy (though see Chapter 7). Criticism of evidence-based policy includes the charge that it may encourage the scientization of political debate whereby stakeholders "cherry pick" facts to gloss over politically contentious value-laden arguments (Pielke Jr 2004; Sarewitz 2004), which goes hand-in-hand with the politicization of the scientific enterprise[109].

Table 5.4 An example of two gross generalisations that environmentalists have often used to gloss over normative aspects of debate.

Generalisation	Ecological evidence	Normative debate	Implications for science-policy
NMRs will increase fisheries yields through spillover.	Evidence restricted to small-scale NMRs in tropical and warm temperate ecosystems. For some species (e.g. the scallop *P. magellenicus*) rotational closures rather than NMRs may lead to greater increased yield per recruit (Murawski et al. 2000). MRs less productive in certain cases (e.g. abalone and sea otters) (Fanshawe et al. 2003). Lower growth rates of Queen Conch in a Caribbean MR (Bene & Tewfik 2003).	Preservationism vs sustainable use	**Risk management** How much of a fishery should be exploited? (growth vs recruitment debate) Will the implementation of NMRs increase resilience in marine ecosystems to cope with catastrophic events?
NMRs will have rapid ecological effects.	Meta-analyses have shown conflicting results over time-scales for recovery (Vandeperre et al. 2011). Conservation benefits may not be distributed evenly, i.e. some species may decline in abundance (O'Sullivan & Emmerson 2011; Klinger et al. 2006).	Short term costs vs long term benefits	**Intergenerational equity** Do the potential long-term benefits of MPA establishment (potential increase in economic returns) outweigh short term costs (decline of fishing communities, decline in food production)?

[109] Political debates on climate change are a good example of this (Pielke Jr 2007).

However, whilst findings herein indicate that ecological evidence generated on MPAs has been used for the purpose of advocacy[110] (Willis et al. 2003a; Agardy et al. 2003), it is encouraging to see that the scientific debate on the use of MPAs in marine management is maturing and becoming less polarised; e.g. the social equity issues that arise through their designation are being considered (Halpern et al. 2011). Interestingly, empirical evidence from the social sciences views MPAs in a less flattering light (Blount & Pitchon 2007; Jones 2009). For example, whether MPAs can benefit fishing communities has been shown to be a matter of local social (Mascia et al. 2010) and ecological context (this chapter). One could argue that the erosion of disciplinary barriers between fisheries science and environmental science (Worm et al. 2009), each with their own biases and value systems (fishermen vs fish) is conducive to better policy making, by making both groups of scientists aware of their underlying assumptions and values (Christie 2011).

Like much of the empirical research undertaken on MPAs the output of strategic theoretical studies has often shown MPAs in a favourable light compared with other management tools, and again, it could be argued that such research was developed for the purpose of advocacy (Willis et al. 2003a). But some theoretical models are a gross simplification of reality, relying on assumptions that may not hold true (Willis et al. 2003a). Studies that have recommended certain percentage areas (i.e. 20-40%) of sea to be designated as MPAs often ignore the fact that fishing effort (Jennings & Lee 2012) and habitat quality are not homogenous (Roberts 2000), and do not take into account externalities such as the displacement of fishing effort that are associated with MPA designation (Horwood et al. 1998; Dinmore et al. 2003; Greenstreet et al. 2009; Abbott & Haynie 2012). Indeed a study of the southwest coast of England showed that 90% of fishing effort occurs in 50% of the sea (Jennings & Lee 2012); fishing activity is patchy. This is significant as it suggests that in reality there is a trade-off between using MPAs as a tool to reduce fishing mortality and as a tool to minimise fishing effects on benthic communities (Hiddink et al. 2006; Greenstreet et al. 2009). If

[110] The partiality of several scientists towards NMRs is illustrated by the following statement, "*Full protection is critical to achieve this full range of benefits (i.e. rapid increases in abundance, diversity and productivity of marine organisms etc). MPAs do not provide the same benefits as NMRs (therefore); existing scientific information justifies the immediate application of fully protected marine reserves*." (NCEAS 2001)

MPAs are located in areas that are subject to high levels of fishing effort the subsequent displacement of vessels will lead to a more homogeneous distribution of fishing effort in a region, potentially having significant impact on previously undisturbed benthos (Hiddink et al. 2006; Hiddink et al. 2007).

Strategically, it may be morally justifiable that society does more to protect the ocean. However at the tactical level robust analysis and critical appraisal of evidence is needed to ensure that the unintended consequences of designating an area as an MPA are avoided. As an example of how science can be integrated into MPA decision making there is a growing literature documenting the use of tactical models in the planning of MPA networks (Figure 5.11). Decision support tools such as MARXAN (Ball & Possingham 2000) have been developed to inform policy makers where the optimal placement of MPAs should be to meet defined fisheries and conservation objectives and minimise costs to stakeholders (Klein et al. 2008a,b), and are being used extensively to inform the design of MPA networks in the USA (Klein et al. 2008a,b; Ban 2009) and Australia (Game et al. 2008). The information needs for such a process are vast[111], requiring spatial information on habitat, species distributions, larval, juvenile, and adult movements and source-sink dynamics of larval production and recruitment (Jones & Carpenter 2009), and additional spatially explicit socio-economic data often derived from fishing effort (Bloomfield et al. 2012). Ultimately, the MPA network will still need to be negotiated due to political debates over intra and intergenerational equity, though output from decision support tools is a useful starting point for such discussions (Smith et al. 2009).

5.5 Conclusion

This chapter has argued that MPA science has developed from observations made largely from NMRs protecting tropical and warm temperate reefs. For these ecosystems evidence for their conservation effects (i.e. increases in abundance and biomass) on targeted fish and invertebrate species is relatively extensive. However, the

[111] In data poor situations the use of MARXAN should be avoided as output will be meaningless (Jeff Ardron, pers comm.).

evidence showing their wider fisheries effects through the net export of larvae and adults to surrounding fisheries is sparse (see 5.4.3), and such effects are species specific (e.g. Beukers-Stewart et al. 2005; Goni et al. 2010), and dependent on habitat structure (Freeman et al. 2009) and scale (Halpern et al. 2010). There is also a critical information gap for the effects of MPAs on the recovery of non-target species and also benthic habitats.

Referring back to the title and opening quote of this chapter, there has been a "spillover" of information in two senses: 1) that the relatively robust results showing the fisheries effects of MPAs located in warm reef type habitats have been used to promote MPAs as a management tool in ecosystems where such evidence is currently lacking; and 2) that MPAs have often been promoted for their wider fisheries benefits without considering that such benefits are highly dependent on ecological and social context. This raises implications for the way science is communicated to non-experts; with popular science having huge potential to influence around an issue (see Chapter 1).

With the focus of many scientists' efforts on fisheries effects of NMRs, the science-policy boundary has been blurred with respect to the distinction between fisheries management and biodiversity conservation. By focusing their research efforts on the fisheries effects of NMRs the scientific community has unintentionally/ intentionally limited the scope of natural science that decision makers can draw upon to make a decision. For example they do not investigate whether all types of fishermen have to be restricted for a closed area to meet its objectives.

The next chapter will examine how MPA science has been communicated to stakeholders in the context of the UK's Marine and Coastal Access Act and subsequent planning of a network of Marine Conservation Zones (MCZs), and also how science has been used to inform the design of the MCZ network.

Chapter 6

Effectiveness of systematic planning in marine conservation: a discourse analysis of stakeholder dialogues on English Marine Conservation Zones (MCZs)

"Fishing has possibly the single biggest direct impact on the marine environment… we have to achieve the transition to sustainable fisheries that safeguard not only fishermen's livelihoods (and their dependent communities), but also reduce their impact on non-target species and damage to the marine habitats that support them. Possibly the most effective way both to instigate appropriate prudence and enable a substantial degree of recovery of existing stocks is to have a large-scale network of marine reserves where fishing is excluded."
(HRH the Prince of Wales, 2005)

ABSTRACT

In the context of increased media attention on promoting higher levels of protection on marine environments, this chapter examines effectiveness of planning in achieving marine conservation goals. A case study approach using England's recent experiences on the consultation process surrounding designation of Marine Conservation Zones (MCZs) is analysed using discourse analysis. From a contents analysis of the 'grey' literature and through key-informant interviews with 21 members of the English policy community who have had input into the policy debates on MCZs, two general policy discourses were identified; one deconstructing the worldview of conservationists and the other, that of developers. These two discourses were then used as lenses to discuss diverging views on four themes regarding the planning of the MCZ network: objectives, information needs, time-scales, and fairness. The findings of the analysis suggest that policy-makers should become more aware of on the ground practical realities that may have a strong bearing on planning success (e.g. impact on local communities, distribution of costs etc), especially if such policy is based heavily on ecological theory.

6.1 Introduction

Marine ecosystems have changed considerably since the start of industrial fishing (Pauly et al. 1998; Pauly et al. 2002; Roberts 2007; Pitcher & Lam 2010); some species have been driven to extinction (Roberts & Hawkins 1999; Jackson et al. 2001) or are critically endangered (Kappel 2005), and biologically diverse habitats have disappeared (Watling & Norse 1998; Jackson et al. 2001). In many situations this decline in natural resources has also had a damaging impact on the socio-economic welfare of coastal communities (Khan & Neis 2010; Perry et al. 2010). Overfishing is widely cited as one of the primary drivers of this decline (Jackson et al. 2001; Coleman & Williams 2002), and has been estimated to have cost the global economy annually $50 billion (Arnason et al. 2008).

Many of these global trends can be observed in the UK. For example, the landings per unit of fishing power of UK bottom trawl fisheries have been reduced by 94% since the late 1800s (Thurstan et al. 2010), and industrial fishing has caused significant declines in the biodiversity of some of the UK's marine ecosystems (Thurstan & Roberts 2010) as well as the loss of large predatory fish (Jennings & Blanchard 2004). Indeed one UK Government report concluded that "there are likely to be few areas of marine habitats in the UK which remain unchanged by human activities" (DEFRA 2005a)[112].

This general decline in the productivity of UK marine ecosystems (e.g. Thurstan et al. 2010) has been coupled with the socio-economic decline of many UK fishing communities (Stead 2005). Although it is the ecological symptoms that are often emphasised, overfishing has deep rooted socio-economic effects that have often been overlooked by decision-makers during the setting of policy objectives (Symes & Phillipson 2009).

One mode of dealing with effects of fishing and development on biodiversity is through the establishment of networks of MPAs across the territorial waters of a country through a process known as systematic conservation planning (Margules &

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[112] *Page 109, para 6.18*

Pressey 2000 for review; Maiorano et al. 2009). Such technical approaches to management have been criticised by some for being a reactive measure to a storyline that predicts a crash in fish stocks and large declines in global marine biodiversity (Hilborn 2007a), but praised by others as a proactive management strategy (Agardy 1993; Shih & Chiau 2009).

The UK has been heavily criticised by the environmental lobby for falling behind other developed nations in its efforts to conserve marine nature and fish stocks (Roberts & Mason 2008; Wright 2010; Monbiot 2012), though the latter is heavily under the jurisdiction of the European Commission's Common Fisheries Policy (CFP). Following 10 years of international pressure (e.g. OSPAR) and sustained pressure from the UK environmental lobby, a UK Marine and Coastal Access Act (MCAA) was granted royal assent on the 12th November 2009 to help the UK achieve "*clean, healthy, safe, productive and biologically diverse oceans and seas" (DEFRA 2002)*[113]. A key feature of the MCAA is that it places a statutory duty on the UK government, and governments of the devolved administrations (Scotland, Wales, and Northern Ireland through their own respective marine acts) to establish networks of MPAs (or MCZs in England, see Figure 6.1) to protect a range of representative UK habitats (see 6.4.1).

Before the designation of Marine Conservation Zones (MCZs), around 30% of the territorial waters around England and Wales were under some type of spatial management[114] either in the form of fisheries closures administered through the Common Fisheries Policy (Rogers 1997) or existing MPAs administered through the Birds and Habitats Directives (Natura 2000 sites), RAMSAR[115], and Marine Nature Reserves (essentially an NMR). Despite this, however, less than one per cent of UK waters are currently designated as NMRs (RCEP 2004), with only three statutory marine nature reserves being designated. Though many environmental non-governmental organisations (ENGOs) believe that NMRs should take a more central

[113] *Page 5, para 1.8*
[114] Though some argue that 'spatial management measures' are not the same as MPAs (Lawton 2007), and that attempts to protect UK marine biodiversity by these spatial management measures have largely been inadequate (DEFRA 2004).
[115] The Convention of Wetlands of International Importance (1971).

role in marine management (Roberts & Hawkins 2000; Wright 2010), there is no explicit call for NMRs in the MCAA.

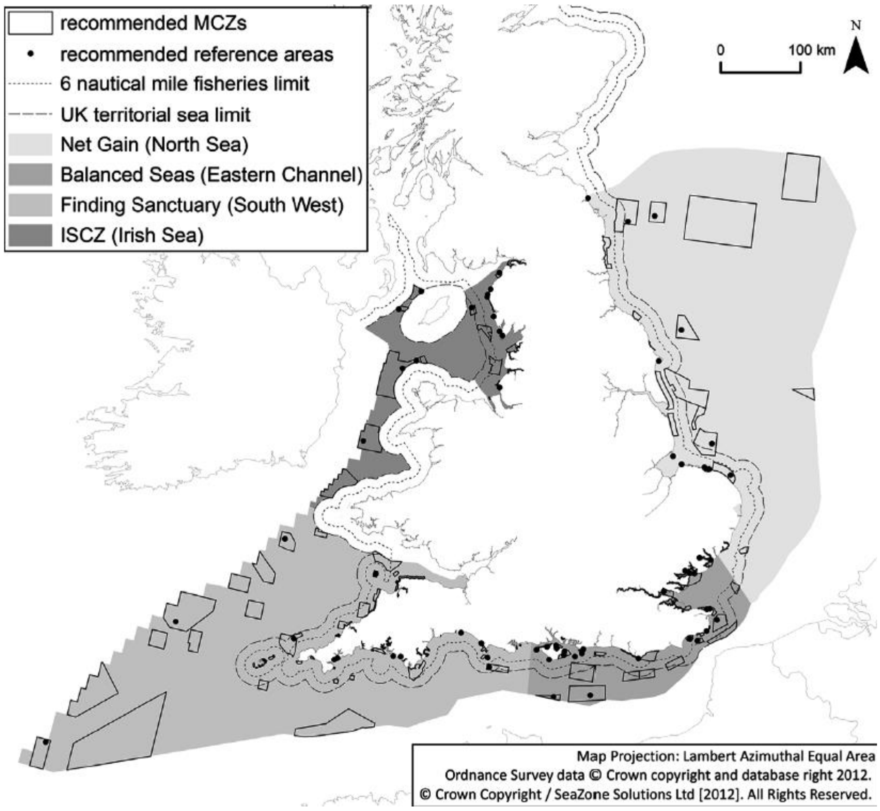

Figure 6.1 Map of the proposed MCZ network (from Jones 2012).

The MCAA has been criticised from both sides of the debate: from the environmental lobby for not providing adequate protection to UK habitats from damaging fishing activities and developers, and from the fishing industry for having socio-economic impacts on fishermen (Jones 2007). Whilst the design and management of the English MCZ network (see Figure 6.1) is now likely to reflect a compromise between the interests of the environmental and fishing lobbies, the question may be asked whether the resulting output is desirable from either set of interests. Behind this conflict of interest lies a clash of perspectives or discourses, and it is the tension between competing discourses on the issue of the MCZ network in England that informs the present chapter.

Given that many natural resource problems have been characterised as 'wicked' or 'messy'[116] (Jentoft & Chuenpagdee 2009; Khan & Neis 2010; Pitcher & Lam 2010), there may be several credible solutions to a problem depending on one's underlying worldview (Dryzek 1997). The term 'discourse' is used here to characterise a worldview; 'discourse' being defined as a shared set of storylines that helps a person make sense of the world (Hajer 1995; Dryzek 1997). The discourse coalition's approach (see 6.3.2) to policy change uses discourse analysis to describe the competing understandings that different social groups have of a problem, and then attempts to explain policy change as a result of conflict between competing discourses (Bulkeley 2000; Mander 2008). This is not to abandon the two policy network approaches described in chapters two and three (epistemic community and advocacy coalition), but to add to them the idea that language is an important factor in determining how people construct their understanding of a problem and subsequently act in policy debates.

Herein the balance of power between two discourse coalitions (conservationists versus developers (see 6.3.1)) surrounding the use of MCZs in the context of marine management in England is discussed; and the empirical, conceptual and normative barriers that have affected the implementation of MCZs, particular NMRs, given the considerable advocacy in the scientific literature for them (see 2.3.4 Chapter 2) is highlighted. This chapter deconstructs the policy debates over MCZs and NMRs through an analysis of the antecedent documents to the Marine Bill[117], and through an analysis of reports, news articles, and key-informant interviews to build a picture of contentious areas as the Marine Bill was being written and passed through parliament. Using the discourse approach differences between conservationists and developers (primarily the fishing industry) are explained on four key themes associated with the implementation of MCZs:

1. Objectives of MCZs

[116] Mander (2008) characterises such a problem as that "that crosses the boundaries of government departments and policy communities and is therefore vulnerable to coordination problems, conflicts between policy communities, and tensions between areas of policy".
[117] A bill is a proposed law to Parliament. Once that bill has passed both House of Commons and House of Lords, and has been assented to by the executive (in the UK the monarch), it becomes an Act of Parliament.

2. Data needs and planning
3. Time-scales and costs
4. Equity and fairness

For 1) debates over the wording of clauses for MCZs in the MCAA are analysed. For 2) the controversy surrounding the use of the precautionary principle/ approach[118] is discussed: first in relation to the reversal of the 'burden of proof' in fisheries management; and secondly in relation to the debates surrounding the planning of the MCZ network at the scale proposed in the MCAA. Fundamentally, the precautionary principle is linked to concepts such as risk and cost-effectiveness, two heavily value-laden concepts. Stakeholders' views of these two concepts are also connected to the scale of the planning process and interpretation of the 'best available' evidence. For 3) two pressures that have affected the agreed timeline for designating MCZs are discussed; external pressure from international regimes and conservationists to establish MPA networks, and costs associated with planning activities, both having important bearing on the detail that planning can encompass. And finally, for 4) normative problems that affect the planning of MPAs (especially NMRs) are discussed, including the issue of fairness and transparency through which decisions are made (procedural justice), and fairness in the allocation of resources (distributive justice) (also see Jones 2002; Jones 2009).

The reader should also note that the more generic term 'MPA' is sometimes used rather than MCZ when the discussion touches on the wider UK context rather than specifically dealing with England.

[118] The precautionary approach and principle are often used interchangeably, but there is subtle difference between the two terms (see footnote 19), the 'precautionary approach' is generally wider to greater interpretation and takes into account cost effectiveness of implementing a management measure; i.e. where there are serious threats of serious or irreversible environmental damage, lack of full scientific certainty shall not be used as a reason for postponing cost effective measures to environmental degradation (see the 1992 Rio Declaration on Environment and Development).

6.2 Methods

6.2.1 Data collection

Desk-based study

The Marine and Coastal Access Act (MCAA) was informed by several public consultation exercises and expert reports from the early 2000's. These documents were sourced from the Defra website[119] and acted as 'seeds' for other relevant documents through an examination of their bibliographies.

Other sources of information such as press releases, and environmental non-governmental organisation (ENGO) reports were obtained through internet searches. Hansard (the verbatim report of proceedings of the UK parliament's House of Commons and House of Lords) was sourced from the internet. From systematically going through all these documents I Identified four themes (see page 155) that I thought were most pertinent for the discussion. Relevant sections of these documents were coded according to theme, and a record made of the page number and paragraph in my research notebook. This material was used alongside interview data to illustrate opposing viewpoints of developers and conservationists on each theme.

Key-informant interviews

Key-informant interviews were undertaken from June 2010 – Sept 2012. Twenty one people were interviewed from the following sectors: Members of Parliament (MPs), civil servants, University scientists, ex-government scientists, ENGOs, statutory conservation agencies (SCAs), fishing industry, renewables, and media. Unfortunately due to time constraints no interviews were undertaken with stakeholders in shipping, recreation, or oil and gas.

Interviewees were identified from their authorships of policy reports, key-note speeches at conferences, and occasionally through 'snow-balling' (an interviewee

[119] <http://archive.defra.gov.uk/environment/marine/legislation/mcaa/key-docs.htm>

would recommend speaking to a particular person). It was thought that this approach would allow the identification of 'gate-keepers' who had a good overview of policy and insight into the workings of their respective institutions, as well as giving insightful opinions on the MCZ process. Interviews were 30-60 minutes long and were transcribed, annotated in Word and sections coded accorded to the following themes; objectives of MPAs, data needs, time-scales and costs, equity and fairness issues. Standard questions included: can MPAs play a role in fisheries management in the UK? Do MPAs need conservation objectives? Should we designate MPAs when there is uncertainty in the underlying data? Will MPAs have any benefits to fishermen? The interview format was not rigid so as to allow a natural conversation develop between the researcher and the interviewee. Transcripts were sent back to each interviewee for them to check accuracy, and make changes if necessary.

In the analysis, interview quotes are integrated with the contents analysis of government reports to illustrate key points. For anonymity only broad stakeholder categories (e.g. marine conservation scientist, fisheries scientist, civil servant, ENGO policy officer etc) were used to identify interview data. Content of quotations was also occasionally reworded to avoid revealing any identifying affiliations of the respondent.

6.3 Analytical approach

6.3.1 Policy networks

This chapter builds on the work undertaken in chapters 2 and 3 that attempted to explain the role two policy network models - the epistemic community (EpC) and advocacy coalition (AC) - had on influencing policy-makers who work at the international level to write recommendations for MPA networks. It was suggested in chapter 3 that the push to establish MPAs was largely due to the initial efforts of a committed group of marine experts (EpC), later the debate on MPAs infiltrated wider civil society and the green lobby became progressively more involved (AC). These two models are now applied to explain the actions of institutions that have directly influenced English policy on MCZs.

Some scholars have suggested that in order to fully understand policy change one should look retrospectively at the interactions between institutions and policy networks preceding a new piece of legislation over a decade or more (Sabatier 1988). In the case of the MCAA the policy networks are made up of the following six components:

1. Central government institutions (i.e. Defra and statutory advisers)
2. International regimes (i.e. OSPAR, European Commission)
3. Green lobby (i.e. ENGOs including the Marine Conservation Society, Royal Society for Protection of Birds, Greenpeace, World Wildlife Fund for Nature etc)
4. Fishing industry (i.e. National Federation of Fishermen's Organisations, New Under Ten Fishermen's Association, Seafish)
5. Wider marine industry (offshore renewables, oil and gas, telecommunications etc)
6. Media (e.g. national newspapers, TV programmes)

The respective influence of these six groups on the content of the MCAA and subsequent outcomes with respect to MCZs will be inferred from a contents analysis of key-informant interviews and the policy literature (see section 6.4).

Crucially the network approach places emphasis on the actions and relationships between stakeholders, rather than focusing on the details of their cases for or against MPAs.

6.3.2 Discourse analysis and discourse coalitions

The discourse approach emphasises the role of language and argumentation in policy making: it views language not just as the medium through which learning is communicated but also as the medium through which actors actively create the world (Hajer 1993; Dryzek 1997; Fischer 2003). A discourse is a set of storylines which gives meaning to 'facts' that would otherwise remain random data, and a discourse coalition

(DC) is a social group that shares a particular set of storylines to help it understand an issue (Dryzek 1997; Gray et al. 2008).

Through the application of the EpC and AC models I have shown the difficulty of separating facts from values in the debates over MPAs. Indeed 'facts' alone rarely compel political action (Pielke Jr 2007). As Fischer (2003) states: "The hallmark of political argument is the near-impossibility of marshalling evidence that can persuade everyone. Pervasive in such argumentation are contradictions, ambiguities, and rhetorical evocations that reflect the material situations and ideological orientations of the political participants. In short, it is not reality in an observable and testable sense that shapes social consciousness and political action, but rather the ideas and beliefs that political language helps evoke about the causes of satisfactions and discontents" (Fischer 2003, page 58, para 1). Discourse analysis will allow policy arguments on English MCZs to be de-constructed, showing "how seemingly technical issues can conceal normative commitments, as well as what sorts of institutional arrangements make this possible" (Fischer 2003, pg 85, para 4). Indeed, discourse analysis shows that the issue is less the *fact* of ecosystem change than its *meaning* — including its extent, cause, implications and remedy. The framework provided by Gray et al (2008) was selected because of its elegant simplicity in breaking down a discourse into three dimensions. In the context of debates over MPAs, there may be 1) *empirical disputation* - disputes over 'facts' (e.g. the extent to which an MPA can benefit a fishery, debate over time-scales of habitat recovery); 2) *conceptual disputation* - disputes over terms (e.g. what actually constitutes a MPA, what is ecosystem based management?); and 3) *normative disputation* - disputes over values (e.g. why is an ecosystem worth protecting)?

Like Foucault, Fischer (2003) describes policy change as resulting from the competition between a challenging discourse and a hegemonic discourse embedded in existing institutions. This builds on the idea by Hajer (1995) who suggests that politics is an argumentative struggle in which actors not only try to make their opponents see the problem according to their viewpoint, but also seek to position or portray other actors in specific ways; e.g. "struggling brave fishermen versus unhelpful environmentalists"

(Lawton 2007) , or alternatively, "fish robbers vs well intentioned European Commission" (NFFO 2011a). From analysis of relevant policy documents and grey literature available online going back to 2002, key-informant interviews, and peer-reviewed science, two competing discourse coalitions over how MPAs/ MCZs should be used in marine management emerged; one comprising conservationists and one comprising developers.

Several sources of information in addition to the interview data were used to construct the two discourses because of the small sample size of interviewees. The two discourses are quite broad, and could have been subdivided into more nuanced discourses, but I did not have sufficient primary interview data with which to undertake this task. In order to address the main objectives of this chapter (and also for the sake of simplicity) it was also not thought necessary to do so. The main purpose of this chapter was to deepen understanding of the main issues and conflicts of the policy debate on MCZs rather than quantify the extent of different viewpoints.

Interestingly, both the conservationist and developer discourses claim to have a strong scientific foundation. Throughout the Results and Discussion section those scientific claims that are based on robust empirical evidence are distinguished from those that are less well grounded in reality (see Chapter 5). I also look at how different stakeholders view the term 'science'. And then look at the extent to which the policy debate became 'scientised' with respect to the planning of MCZs; the use of technical jargon by government to intentionally (i.e. to avoid discussion of contentious issues) or unintentionally (i.e. through lack of critical thinking) gloss over divisive issues, such as: why does a particular habitat need protecting, who/ what benefits from stopping fishing over an area of seabed; and which groups of stakeholders stand to lose the most?

Another important aspect of the Results and Discussion section is an examination of how and where advocacy has caused the scientific and normative beliefs of institutions and individuals to blur.

6.4 Results and Discussion

6.4.1 Provisional planning work preceding the drafting of the Marine Bill (1999-2006)

1999-2005 Foundations laid for improved marine nature conservation

Campaigns for a Marine Bill by the UK green lobby got underway in the late 1990s. During 2000, an advocacy coalition, the Wildlife and Countryside Link composed of organisations including the Marine Conservation Society (MCS), Royal Society for the Protection of Birds (RSPB), the Wildlife Trust, the Whale and Dolphin Conservation Society (WDCS), and WWF formed a Marine Task Force to campaign for a Marine Act. Around this time there were growing calls for NMRs internationally (Chapter 3), epitomised by a WWF report that synthesised the current evidence (Roberts & Hawkins 2000).

Responding to the efforts of persistent campaigning by the green lobby and increasing coercion from the international marine conservation community through regimes such as OSPAR, CBD and the WSSD, in the late 1990s the UK Department for Environment Food and Rural Affairs (DEFRA) started laying the foundations for the Marine Bill by commissioning a series of reports that set out the UK's vision and strategy for improved marine environmental management. The first of these reports, *Safeguarding our Seas* stated that the UK government was committed to an ecosystem-based approach to management (EBM) (see Chapter 1), a key element of which "is the conservation and where possible, enhancement of marine ecosystems in a way that conserves biological diversity and ensures the sustainable development of our marine resources" (DEFRA 2002)[120]. This document states six principles that will affect the government's approach to EBM, three of which have direct relevance to the science-policy interface and are shown in Table 6.1 below, though all of them are heavily contested (see 6.4.2).

[120] *Page 9, para 1.32*

Table 6.1 Principles of the UK marine strategy that have some bearing on the science-policy interface.

Principle	Description	Conflicts
Robust science	Understanding the processes and influences that impact on the marine environment and using research to inform policy-making and marine management	Science is open to varying degrees of interpretation, particularly regarding the debates surrounding the efficacy of NMRs and sensitivity of different habitats to different fishing pressures.
Precautionary principle	Sensibly erring on the side of caution where the scientific evidence is not conclusive	Members of the fishing industry argue that it is unrealistic to shift the burden of proof on to fishermen for practical reasons. How do you prove a gear has no impact?
Stakeholder involvement	Involving all stakeholders so that they are an integral part of the decision-making process	Does making decision-making inclusive diminish the role of the expert? Who is a stakeholder?

DEFRA pledged its commitment at the *5th North Sea Conference* (held in Bergen 2002) to identify and designate MPAs by 2010 with decisions being based on a "clear understanding of natural processes and the ecological requirements of marine species, habitats and ecosystems" (DEFRA 2002)[121]. The following year the Oslo Paris Convention (OSPAR) adopted MPAs as an approach to protect marine biodiversity in the NE Atlantic: "the Commission will, *inter alia*, promote the establishment of a network of MPAs to ensure the sustainable use, protection, and conservation of marine biological diversity and ecosystems" (OSPAR 2003a). Such a network will be ecologically coherent and restore and prevent further degradation of species and habitats. The UK government's commitment to OSPAR was the main driver behind the push by the devolved administrations to establish an MPA network (DEFRA civil servant), and it was the job of the Joint Nature Conservation Committee (JNCC) to advise government on the designation of the UK-wide network of MPAs[122].

In late 1999 the UK Government and devolved administrations commissioned a working group of the statutory conservation agencies and commercial and recreational

[121] *Page 9, para 1.33*
[122] The four devolved administrations of England, Wales, Scotland, and Northern Ireland have each used different approaches to setting up their respective MPA networks.

interests, to conduct a pilot study in the Irish Sea that was charged with developing a framework for planning that would reconcile nature conservation objectives with those of development in the marine environment that could operate across multiple spatial scales (Vincent et al. 2004). The subsequent report, *Review of Marine Nature Conservation* (DEFRA 2004), concluded that the current legislative framework was insufficient for the UK to achieve its commitments to protect marine biodiversity. From the Irish Sea pilot the review concluded that the successful implementation of the ecosystem approach requires the identification of the range of five spatial scales at which to identify and undertake appropriate management (Table 6.2). One of the main recommendations of the review was to establish an ecologically-coherent network of marine protected areas designed according to five principles (Table 6.3): connectivity, representation, replication, sufficiency, and practicality adapted from experiences of designating NMRs in New Zealand (Ballantine 1999). These principles formed the basis for England's approach to setting up MCZs. Interestingly, the only mention of NMRs within these background documents is the call by the review for the establishment of large-scale trial NMRs to test their fisheries benefits. Thus it is presumed that the term MPA in these documents is used synonymously with the broad IUCN definition:

> 'any area of inter-tidal or sub-terrain, together with its overlying water and associated flora, fauna, historical, or cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment'
>
> (Kelleher & Kenchington 1991)

The UK government response to the *Review of Marine Nature Conservation's* recommendation for NMR trials was that it is "currently assessing the lessons learnt from existing protected areas (such as fisheries no take zones) and considering the scope for further trials of marine protected areas to improve our understanding of their costs and benefits" (DEFRA 2005b).

Table 6.2 Different spatial-scales suggested for marine planning (DEFRA 2004).

Spatial scale	Description
The Wider Sea	NE Atlantic biogeographic region. The management of human activity in the UK's seas and their adjacent waters is often largely outside the competence of national authorities.
Regional Seas	E.g. the Irish Sea. The biogeographic Regional Seas should be considered as the basis for strategic planning and management of national and adjacent waters.
Marine Landscapes	Broad-scale habitats identified from modelling geophysical and hydrographical information with biological data. The purpose of this approach is to enable appropriate action to be taken to benefit nature conservation in circumstances where biological data are limited.
Important marine areas	Areas that are important for a specific feature (i.e. species, habitats, or landscapes), may also incorporate important areas for aggregations of mobile species (i.e. important spawning, nursery, calving, feeding or nesting areas, and migration bottlenecks).
Priority marine features	Threatened or rare species and habitats prioritised for conservation action, that unless action is taken, such species and habitats could either be driven to extinction.

Table 6.3 Principles of an ecologically coherent network of important areas (DEFRA 2004, adapted from Ballantine 1999).

Design principle	Description
Connectivity	Networks should be designed to ensure that areas are mutually supporting (i.e. populations of animals and plants in one area should be capable of supporting, and be supported by populations in other areas). The need to protect vulnerable life stages of highly mobile species, including their movement between breeding and feeding grounds, should be taken fully into account.
Representation	Networks should seek to incorporate the full spectrum of biological diversity (not just that subset which relates inter alia to rarity, endangerment, or other pre-selected importance values.
Replication	Examples of habitats (or concentrations of species) should be replicated in separate areas to insure against loss due to catastrophic events whether from natural or human-induced causes.
Sufficiency	The total area of the network, and its distribution in terms of individual component areas, should be capable of meeting the objective of sustaining species and their habitats in perpetuity.
Practicality	The best available information should be used in site selection, but the development of the network should not be delayed pending action to collect further information. Practical considerations, including those which support sustainable development, should be taken into account in site selection.

NMRs were however clearly on the agenda of the statutory conservation agency English Nature (now Natural England). In a report giving English Nature's take on the ecosystem approach (Laffoley et al. 2004), the organisation argues that sustainable development will require 1) recovering and safeguarding ecosystem structure and function; 2) recovering and safeguarding biodiversity from the gene pool through to populations; 3) increasing resilience of the ecosystem to impacts; and 4) defining what the 'natural condition' is, thereby enabling an improved understanding of the type and severity of human impacts and of the level of benefits that ecosystems could safely provide if properly managed (Laffoley et al. 2004). The report states that "excluding all extractive pressures from well-defined areas, as part of a wider-sea management process, appears to be the only way that such benefits can be delivered with any degree of certainty. Experience is beginning to show that even modest erosion of the principle of excluding all extractive uses (e.g. prohibiting commercial fishing in an area but allowing recreational angling) reduces the benefits that could be accrued, and any recovery that might be achieved… If sustainable development is the ultimate goal, then higher levels of protection for biodiversity and ecosystems are required" (Laffoley et al. 2004)[123].

However, by implying that full protection through NMRs leads to increased benefits, Natural England set itself up to be challenged on empirical grounds, because the relationship between productivity and biological diversity for marine ecosystems is poorly understood (Frid & Paramor 2006; Jones 2008) (also see 5.4.4 Chapter 5). Generally, more fish will be found in areas where fishing is completely prohibited, though how this relates to the wider productivity of a fishery depends on local ecological and social factors (Chapter 5). Of course, given this uncertainty, many advocates of this conservationist discourse argue that it is better to err on the side of caution (Clark 1996; Lauck et al. 1998), though without considering the economic impact of this precautionary action on developers.

2004-2006 Recommendations made for the large-scale designation of NMRs

A new storyline surrounding MPAs emerged in the UK in 2004. Whilst many of the key documents that lay the foundations for the Marine Bill were heavily focused on the reconciliation of nature conservation objectives with development objectives through a framework of marine planning (Vincent et al. 2004; DEFRA 2004), there seemed to be

[123] *Page 32, para 2*

a growing bias within the national UK media[124] for stories that reflected negatively on activities of the fishing industry, to quote one journalist:

> "I would say generally that the media, especially the national press, the national media and the TV, are very much on the environmental bandwagon. They'll always tend to be interested in stories that show fishermen in a bad light. I would say that's not probably true of regional news[125], some of the regional newspapers in the areas where fishing is strong, tend to be much more on the side of the fishermen. But the national media in general tend to be pretty anti. We've got guys like Charles Clover, at The Telegraph, and from The Times Frank Pope, they're very much wedded to the environment and very anti-fishermen. I think that is a significant change that's happened over the last 10 or 20 years, the public's view of fishermen. At one time they were pretty well respected; they were guys who went to sea and did a tough job and put food on the table; horny handed heroes, salty sons of toil. But I'm afraid now, many people just think of them as brigands and vandals, destroyers of the earth, sadly. And I think the media's had quite a large part to play in promoting that image of fishermen. It's sad."

Two influential reports examined the impact of fisheries on UK marine ecosystems. Herein the rationale for establishing NMRs becomes ambiguous, between protection of nature for its own sake and reduction of fishing mortality to increase fish stocks.

The *Net Benefits* (2004) report from the Prime Minister's Strategy Unit states that "commercial fishing has had the largest single negative impact on the marine environments sustainability" (Strategy Unit 2004)[126]. It listed 33 recommendations that would facilitate the reform of the UK fishing industry, one of which was for a trial run of MPAs. It is unclear in this report what a MPA actually refers to, though the context seems to suggest an area where there is at least a ban on towed bottom gear. Despite acknowledging the uncertainties of using MPAs in UK waters it states that "as with other aspects of fisheries management, a lack of perfect knowledge should not lead to inaction and maintenance of the status quo, but to an adaptive and precautionary approach" (Strategy Unit 2004)[127]. Given this caveat, the report then recommends that "MPAs should therefore be established on an experimental basis, and their economic and biological impacts carefully studied. This process should begin in areas which give multiple benefits to multiple users of the marine environment, where possible"

[124] For example, see the recent headlines in *The Daily Telegraph* and *Sunday Times* that report that there are only 100 cod left in the North Sea (Leake 2012). Also see "Fishing, the environment and the media" *Fisheries Research* 73: 13-19 (Symes 2005).
[125] This is interesting as it ties in with the conflict between national and regional scales of governance - i.e. that the fishing industry has more power regionally than nationally.
[126] *Page 10, para 5*
[127] *Page 93, para 6*

(Strategy Unit 2004)[128]. Multiple benefits to multiple users seems to suggest that MPA trials should be undertaken in areas where there is heavy fishing activity to measure the effect of protection when fishing is stopped[129].

The recommendation for MPAs by *Net Benefits* was further strengthened by the scientifically-authoritative Royal Commission on Environmental Pollution (RCEP) report *Turning the Tide* (2004) that called for 30%[130] of UK waters to be set aside as NMRs. The RCEP report states "that the UK government is not committed to implementing any of the recommendations of the Net Benefits report", and that it views the recommendations of the *Net Benefits* report to be "too tentative and too slow" (RCEP 2004)[131]. The RCEP report says that:

> "Firm evidence exists that NMRs can provide habitat protection and form part of an effective response to the effects of over-fishing… and we have sufficient information to identify some of the most vulnerable sites that could form the basis of future networks"[132]… "there is sufficient information to design comprehensive, representative, and adequate networks of marine protected areas for UK waters… there is certainly more information available for UK waters than for the Australian Great Barrier Reef where the Marxan model was used successfully to rezone the park to establish a practical management programme"[133]. (RCEP 2004)

However, many of the scientific claims made in the RCEP report are not from peer-reviewed sources and are not founded on robust scientific evidence; for instance the report extrapolates the current trend in UK catch value from £800 million in 1995 to £400 million in 2003, to around £20 million in 2022, and claims that "if a marine reserve network were implemented in 2005 across 30% of UK waters, catches could be expected to dip initially before swinging upwards as populations of commercially important species rebuild and productivity recovers"[134], this statement referencing unpublished work, the full reference of which cannot be found (i.e. Roberts & Mason 2004). Indeed Symes (2005) feels it is a pity that the calculations behind the costs of

[128] *Page 93, para 7*
[129] There wouldn't be much point in establishing these trial NMRs where fishing is limited as the magnitude of a potential reserve effect would be less than that of an NMR established in a heavily fished area; the allocation of fishing effort in UK waters is patchy (Jennings & Lee 2012).
[130] See section 1.3.2, chapter 1, for discussion of percentage targets.
[131] *Page 205, para 8.95 & 8.96*
[132] *Page 205, para 8.96*
[133] *Page 204, para 8.90*
[134] *Page 202, para 8.83*

implementing and managing the marine reserve network were not presented in more transparent detail.

Additionally the RCEP says "it has generally been envisaged that the ecosystem approach would be implemented on an incremental basis over an extended period, in part because an evolutionary rather than revolutionary move towards the ecosystem approach would be less likely to paralyse the fisheries management decision-making process and would maintain broad-based support"[135]. So, the RCEP views its recommendation for 30% of UK seas to be designated NMR as incremental rather than revolutionary, though many members of the fishing industry thought differently (Symes 2005; Jones 2007). In summary the RCEP report provided a storyline in which fish stocks are crashing and NMRs are needed to deliver stock recovery and ensure that fish populations are sustainable in the long term (Lawton 2007). This storyline was adopted by a large majority of the green lobby in their attempts to persuade the UK government to establish networks of NMRs, and forms part of the conservationist discourse (see Table 6.4). Symes (2005) says "the style of the report and more particularly the media's strident reaction (e.g. front page headlines on 'The dying sea' and 'Huge no-fishing zones offer the only hope of saving marine ecosystems from disaster' in *The Independent*) will have set back the gradual and hard won progress made in recent years in bridging the differences between the fishing industry and environmental interests", and "the immediate effect has been to drive the protagonists (i.e. conservationists and the fishing industry) further apart. It has, in particular, forced the industry onto the defensive and intensified its suspicions over the role of science" (Symes 2005).

In response to *Turning the Tide,* the UK government stated that it was "developing plans for a controlled trial of MPAs which aim to have both fisheries and wider marine conservation benefits" (DEFRA 2006c)[136]. However as of 2012 this has yet to be carried out. The failure of the UK government to progress the repeated recommendations by

[135] *Page 172, para 7.47*
[136] *Page 9, para 8.96*

advisers for large-scale trials of NMRs has been blamed on the uncooperative attitude of the fishing industry, as one conservationist recalls :

> "So what would the effect be of putting large no-take zones, well it's a general strategy that the fishing industry has decided not to do despite being repeatedly recommended that it should do this. We made the recommendation that to resolve this issue once and for all the fishing industry should engage with the conservation sector to do some large-scale no-take trials to see what the benefits were - they haven't done it. The RCEP did an enquiry into fishing and also recommended that they do it, and they haven't done it. What you also hear is that NMRs displace fishing effort, so how come when you close a fisheries area under fisheries management it doesn't displace effort? You can't have it both ways. So the reality is that the displacement of fishing effort by putting in no-take NMRs is a fait accompli caused by the fishing industry deciding that it will not engage with spatial management under its broad-scale responsibilities that it has for most of the ocean." (Marine conservation scientist)

There are however economic reasons why these trials for NMRs did not go ahead. A report by WWF identified money as a critical issue to recovery that is too often overlooked (MacGarvin & Jones 2000); if such a large-scale trial was to be undertaken there would have to be some reassurances by government that fishers' loss of profit (which may be marginal anyway) would be fully compensated for. Whilst both reports touch on the issue of compensation, Jones (2009) argues that the absence of specific discussions by government on compensation is attributed to three things: 1) UK marine fisheries are common property therefore those exercising their right to use the resource are not eligible for compensation from the public purse; 2) fishers can switch to alternate grounds to maintain their income, and 3) that it is very difficult to distinguish which fishermen have a legitimate right to compensation from those who lie about fishing in a certain area to get compensation (Jones 2009). Another compensatory issue arises from the fact that fisheries management is under the exclusive legislative jurisdiction of the European Commission through the Common Fisheries Policy (CFP)[137], so if NMRs are to be implemented in the UK EEZ compensation for the economic impact on other fishing fleets would also be need to be taken into account (Symes 2005). Some conservationists are opposed to the claims of compensation by the fishing industry on principle, one saying:

> "From a societal perspective the tax payer has already paid for subsidies to keep the towed sector of the fishing fleet in profit. Overexploitation by the fishing industry has

[137] The CFP makes provisions for area closures for the protection of nature under its emergency measures; i.e. 'if there is evidence of a serious threat to the conservation of living aquatic resources, or to the marine ecosystem resulting from fishing activities and requiring immediate action' (EC 2002).

> left us in the position we are currently facing, therefore they should not be compensated." (ENGO policy officer)

Another area of contention arose over the suspicion of the motives of those proposing specific percentages of NMRs on 'scientific' grounds. Defra's response to the RCEP recommendations was cautious, stating that it was uncertain of the scientific basis for designating 30% of the UK's EEZ as NMRs (DEFRA 2006c), perhaps on the basis of the findings of three studies it had commissioned to review the lessons learned from MPAs in Northern European waters, and analysis of the potential contribution that MPAs could make to the recovery of specific fish stocks (CEFAS 2005; Pascoe & Mardle 2005; Sweeting & Polunin 2005). The general theme that emerged from these reports suggested that internal and external factors needed to be taken into account during the planning of MPAs, and that MPAs should be assessed for their merit on a case-by-case basis (Sweeting & Polunin 2005).

However many conservationists subscribe to the view that a significant percentage of the oceans should be designated as MPAs or NMRs. Gell & Roberts (2003) from their review of modelling studies suggest that between 20 and 50% of the ocean should be designated as NMRs (mode 30%). When one scientist was asked specifically about these targets he said the following:

> "More generally, the percentage targets if you look at it from a range of scientific angles, whether it is on the grounds of increasing the spawning stock biomass of target fish species, maximising long term yields, minimising loss of genetic heterogeneity, ensuring that you have all species protected somewhere and replicates of them in different protected areas. If you look at it from all these different perspectives the answers that you get on how much you need are in the tens of percent not just percent (as currently). It's not single figures it's 10s of percent, and the answers are entirely consistent between those different questions. You know 20, 30, 40 it's not 2, 3 or 4. So we know that we are in the wrong order of magnitude in terms of delivering what we could from a network of MPAs when we currently have 1, 2 or 3% of the sea protected and most of it rather weakly protected. So those scientific studies are leading us to the view that we need a much greater area protected." (Marine conservation scientist)

However there are important aspects of reality that such studies do not take into account such as the patchy distribution of fishing effort (Jennings & Lee 2012), the complexity of the fishing industry (Phillipson 2002), and habitat heterogeneity (Greenstreet et al. 2009). The trawling footprint of waters in England and Wales has been estimated to be between 5.4 and 21.4%[138] for English and Welsh waters (Eastwood et al. 2007; Stelzenmuller et al. 2008; Jennings & Lee 2012). Such evidence suggests that large portions of seabed are not trawled regularly, if at all and that *de facto* NMRs still exist in English waters. Advocacy for NMRs to reduce fishing pressure also ignores the fact that the UK fishing fleet has contracted by 26% and consequent fishing power has fallen by 23% since 1996 with a parallel reduction in pressure upon the marine environment (Elliott et al. 2012).

There are two discourses identified herein: the dominant[139] discourse whose main adherents are environmentalists and some scientists, calls for the systematic protection of representative habitats at a national level, and emphasises the use of ecological criteria to lead site designation. The challenging discourse whose main adherents are the fishing industry and are not necessarily anti-MPA but keen to minimise their impacts on current or future activities, through emphasising that socio-economic evidence must be taken into account during site designation, with such planning being best done at the local level (Table 6.4).

It should be noted that within each of these discourses, there are extremist views. For instance extreme conservationists advocate NMRs at all costs on the belief that they are the best solution to allowing fish stocks to recover (e.g. Wright 2010). Conversely, some fishermen would contest the notion of having to establish MPAs at all (see Jones 2008)

The influence of these two discourses on the wording of the nature conservation section of the MCAA, and the subsequent planning of MCZs is now discussed.

[138] Though this is likely to be an underestimate for several reasons: effort is likely to shift on a year-to-year basis, their analysis excludes static and pelagic gears, and only VMS data (only required for vessels >15m) was used thus ignoring the distribution of effort by smaller trawlers (Jones 2008).

[139] 'Dominant' in the sense that the conservationist discourse coalition has been successful in influencing the UK government to establish networks of MPAs, however conservationists would contest this saying that they have by no means had in all their own way – particularly with regards to deciding what management measures should be implemented in MCZs.

Table 6.4 Characteristics of the two discourses surrounding the use of MCZs and NMRs in English waters.

	Conservationists	**Developers**
Objectives of MCZs	To systematically protect representative habitats and species through networks	To protect habitats and species vulnerable to fishing
Main criteria for MCZ designation	Representative habitats	Vulnerable habitats/ species
Approach	Systematic conservation planning	Local planning
Governance process to set MCZ objectives	Top-down objectives, with some input from stakeholders	Bottom-up objectives, decided through deliberative discussion between stakeholders
Attitudes towards science-policy	Natural science criteria to lead process; socio-economic evidence to choose between similar sites.	Natural science and socio-economic evidence treated equally. Political compromise necessary.
Attitude towards science and the precautionary approach	Decisions based on ‘best available science’. Burden of proof on the fishing industry to show that activities don’t cause damage to a conservation feature.	Decisions based on robust scientific evidence. Burden of proof on conservationists to show that a feature sensitive to fishing exists.
Attitude towards conservation	Ecosystem preservation necessary for sustainable use	Some impact inevitable, though should protect sensitive habitats
Scale	National/ regional	Local
Time frame	Relatively short	Long
Storylines from scientific literature	Spillover benefits, ecological coherence, habitat destruction	Displacement, impact on local communities, wider economic impacts (e.g. food supply, and developers moving elsewhere)
Criticisms from opposing discourse	Preservationist, inhumane, ignores the needs of local people	Favours short-term economic interests, potentially could miss strategic conservation goals

6.4.2 Planning of Marine Conservation Zones (MCZs) (2006-present)

Objectives of MCZs

This section highlights the political battles fought between conservationists and developers over the wording of the clauses written in the Marine Bill for MCZs, the former using ecological criteria and the latter using socio-economic criteria to determine site selection. This conflict of opinion between conservationists and developers is empirical – i.e. a factual dispute over what ecological and economic benefits would be delivered by MCZs. A second category of conflict is conceptual - i.e. an interpretive dispute over the meaning of contested concepts such as ecosystem health, good environmental status, and sustainable development, which have very different meanings to different people. A third category of conflict between conservationists and developers is normative — i.e. disputes over the value of marine resources. One such dispute is about distributional justice - even if there were to be net fisheries benefits from MCZs (through an increase in non-use, indirect use, and direct use values), such benefits may be distributed unequally across different stakeholder groups.

The government made a manifesto commitment to a Marine Act in 2005, with cross party support. Background documents preceding the Marine Bill emphasise integrated management and marine spatial planning (MSP) as the tool to achieve sustainable development of UK seas (section 6.4.1). MSP seeks to use marine space more efficiently, reducing user conflict, and balance environmental, economic and social objectives in a better way than currently. These documents claim that environmental limits have often been exceeded, and that the aim of planning should be to increase ecosystem resilience through taking into account environmental considerations more seriously during development (DEFRA 2002; Laffoley et al. 2004; DEFRA 2005a). MPAs are a central part of the Marine Bill and the first consultation in 2006 shows the government intent on establishing a network of MPAs to promote the recovery of vulnerable species and habitats, representative species and habitats, physical marine features and ecological processes, and the protection of spawning and nursery areas (DEFRA 2006b). There was an overwhelming response to the consultation by the green lobby (MSC, WT, and RSPB) which contributed 74% (916) of the replies that the government received, in stark contrast to the fishing industry which contributed only 1% of responses. Interestingly 30% of respondents made a case for NMRs with no business sectors opposing (DEFRA 2006a). This confirms the fears of some members of the fishing industry, that the industry had been too slow to engage with the consultation process on the content of the Marine Bill to make sure its interests were taken into account during consideration of nature conservation proposals[140].

Jones (2006) summarised the consultation, saying that the *status quo* favours neither conservationists nor developers, with a growing tension between calls for stricter marine nature conservation (through the implementation of MCZs) and for more streamlined consents procedures and more certainty for developers (Jones 2006). Although the summary of responses to the consultation indicate that both conservationists and developers recognise that “the UK Government should be seeking win-win situations with benefits to all three pillars of sustainable development (economic, social and environmental) or, at the very least, should be striking a reasonable balance between them” (DEFRA 2006a)[141], there remained fundamental conflict over what sustainable development actually meant to each side, together with the anxiety that the other side’s interpretation would prevail. The green lobby “emphasised putting biodiversity, nature conservation and protection at the heart of marine management decisions. However they expressed concerns that the consultation would happen as long as it did not affect economic development” (DEFRA 2006a)[142]. By contrast “businesses, in particular the renewables and fishing industries, expressed the opposing concern that nature conservation would take precedence over economic development and large areas of the sea would be closed to activity” (DEFRA 2006a)[143].

Most of the documentation preceding work on the Marine Bill sought a compromise between these two opposed interests - conservationists and developers, though

[140] As the MCAA was being drafted a collaboration between the MCS, the Co-operative Society and the public aquaria collected more than 500,000 signatures and addresses from the public in support of NMRs (http://www.mcsuk.org/mpa/mcs-position-statement).
[141] *Page 6, para 2.9*
[142] *Page 6, para 2.10*
[143] *Page 6, para 2.11*

largely calling for increased protection of the environment through the adoption of EBM (e.g. Laffoley et al. 2004). For example, one document emphasised the need to develop marine ecosystem objectives (MEOs) which would clarify the environmental limits within which development needs to operate, and also set measurable objectives for key components of ecosystem health and biodiversity (DEFRA 2005b).

One scientist was also critical of the lack of the consideration of socio-economic objectives at the level of the EU:

> "I think one of the problems with the current systems that have been put in place to set these things up is that the EU which is driving the whole process, puts the criteria entirely on conservation criteria, so in the drawing up of MPAs there's no consideration of the exploitation, what's going on in the areas, it's just purely on which areas need to be conserved because they've got certain species or organisms, and I think that's what worries many of the fishermen, they feel that the focus is on conservation only."
>
> (Fisheries scientist)

The NFFO was also sceptical of the way MCZs were promoted widely on their long-term benefits to fisheries over the course of the planning of the Marine Bill (NFFO 2009d; NFFO 2011c), despite limited evidence.

> "There is a lack of clarity in what MCZs are for. Certainly the claims made about their capacity to rebuild commercial fish stocks are hugely overblown and mainly depend on evidence from tropical reef fisheries whose relevance to most of the species is slight"
>
> (NFFO 2009d)

The heavy promotion of MPAs/ particularly NMRs for their expected fisheries benefits (e.g. RCEP 2004) caused confusion in parliament (and perhaps amongst the wider policy community) over the purpose of the MCZ network, summarised quite aptly by this statement from a member of the House of Lords, who revealed that he had read the book *Unnatural History of the Sea* that promotes NMRs for their fisheries management benefits (Roberts 2007):

> "the primary purpose of this legislation is to ensure the conservation of our fish stocks so that they can develop and rebuild after centuries of depredation by man… the fish stock that is built up successfully within the marine reserve area will spread out beyond that and provide happy hunting ground for fishers. It is natural that this should happen and I do not deny that it will happen."
>
> Lord Eden, member of the House of Lords on the UK's Marine Bill Committee stage (6th day) (Eden 2009)

The regulatory impact assessment for the Marine Bill also suggests that there would be net fisheries benefits from MCZs, and although the report concedes that the extent of off-site benefits (i.e. through spillover) is highly uncertain, it still provided an estimated net benefit of £16.8 million per year[144] (DEFRA 2008)[145]. It is difficult to know what such a figure means, since even at the local level, economic assessments are particularly difficult to undertake, and results are widely disputed[146] (e.g. Fleming & Jones 2012).

The divide between conservationists and developers becomes apparent in the debate over wording of particular clauses of the Marine Bill as it was being passed through parliament. Conservationists called for additional wording to be added to clauses 116 and 117 that explicitly mention NMRs, or implicitly through "conserving the ecosystem as a whole" (MARINET 2009).

Despite considerable pressure from several conservation organisations for NMRs the government did not concede to the conservationists' demands, but maintaining its stance that "the management measures needed for MPAs may vary widely depending on the objectives of each site and the sensitivity of the protected features to different activities and levels of disturbance. In some cases this may mean that only seasonal or time limited restrictions are required, if any. In others it could lead to complete restriction of activities on a site, which is commonly referred to as a highly protected marine reserve" (DEFRA 2006b)[147]. The government did not want a two-tier system of protected areas, as one civil servant said:

> "The greens lost the argument and quite rightly too. The act allows us to set up NMRs because we can simply ban everything if we want to, and it is accepted that we will in some cases. But the argument that they wanted the phrase in the bill was just unnecessary really, and it also implies if you've got NMRs that the other marine areas are second class… These other sites are likely to be the larger ones, if you add it all up they are likely to be the ones that give you the biggest ecosystem services, the highly protected ones by their very nature must be much smaller because you can't afford just to exclude everything from lots of the areaIt wasn't as if the greens were asking for all

[144] Though this figure is likely to be highly dependent on where MCZs are designated and what management measures are put in place.
[145] *Page 59, para 237*
[146] For example the economic impact of the MPA proposals at Lyme Bay, Devon was estimated via four independent reports, with the estimates differing by an order of magnitude (Rees et al. 2010).
[147] *Page 101, para 10.65*

> areas to be highly protected[148], it was just they wanted the phrase in there. You know it was up to stakeholders looking at the various bits of guidance that they were working to, through the regional project process to say that this area needs to be completely protected. You know, you can call it a highly protected marine area if you want to but it's not just going in the legislation thanks. It was a bit of an argument about nothing. It did raise some heat though." (civil servant)

The extent to which the designation of MCZs would be natural science led was also debated. Developers were particularly concerned with the wording of clause 117(7) of the Marine Bill:

> "In considering whether it is desirable to designate an area as an MCZ, the appropriate authority may have regard to any economic or social consequences of doing so." (DEFRA 2009)

Developers wanted "may" to be changed to "must", in order to place a statutory demand on the government to take into account socio-economic activities during the designation on MCZs. Conservationists, on the other hand lobbied government to remove the clause altogether:

> "We were asking for this clause to be removed on the basis that sites should be selected purely on science that it would create a weaker site selection process than currently used for European sites, and we felt the process should be very much equivalent, we were also concerned of the danger it would create regarding, basically repeating the same weaknesses of the marine nature reserve legislation through the poor drafting of the Wildlife and Countryside Act 1981. So were basically looking for some clarity that science and biodiversity needs would be the pure designating factor for the sites rather than socioeconomics." (ENGO manager)

However this clause remained unchanged in the final MCAA (DEFRA 2009).

In summary, the differences of opinion in the setting of wider strategic marine objectives between the two discourse coalitions, conservationists on the one hand and developers on the other, arise from the two different imperatives identified in the fisheries management literature by Khan & Neis (2010): the natural science focused *recovery* imperative that emphasises ecological objectives: and the social science-focused *rebuild* imperative that emphasises socio-economic objectives (see chapters 1 and 7). Scholars have expressed their concern at the dominance of natural science orientated epistemic communities in resource management in general, because they claimed this approach had largely failed to prevent the decline of the marine

[148] Though evidently some greens were (e.g. MARINET 2009).

environment (Christie 2011). Conservationists would argue that this is because short-term interests prevail in decision-making, and there is a lack of political will in politicians to upset powerful interests. Developers would argue that if socio-economic objectives are considered on a par with environmental objectives then this would lead to more meaningful dialogue in policy debates between environmentalists, government and developers, with the increased likelihood of 'win-wins' for both sides (see chapter 7), arguing that people's livelihoods need to be treated equally with environmental concerns.

Data needs, the precautionary principle, spatial scale, and 'ecological guidance'

During the early stages of the planning of the Marine Bill, Defra revealed that "respondents across all sectors expressed a desire to see clear objectives, goals, targets and indicators for social, economic, and environmental elements. A 'cost-benefit' analysis based on sound science was suggested as a valuable tool upon which to base decisions" (DEFRA 2006a)[149]. Whilst this statement may seem sensible, in reality, rarely is there such comprehensive data coverage available for policy makers to draw upon to make a fully informed decision: decision-makers have to deal with uncertainty.

In the context of marine protection, uncertainty over the natural science manifests itself in three ways 1) not knowing precisely the location of the conservation feature that needs protecting, 2) not knowing the conservation status of the feature that needs protecting, and 3) not knowing the impact of a given pressure on the feature that needs protecting. Given this triple uncertainty, documents preceding the draft Marine Bill stressed the need to adopt the precautionary principle to protect the environment:

> "Although the UK does have many good data resources, it is widely acknowledged that our understanding of the marine environment is not complete. In such circumstances, where there is a risk of significant (direct or indirect) impact, particularly where mitigation measures are not appropriate or possible, 'Securing the Future' states that the precautionary principle will be adopted to protect the environment and its resources. Therefore, some decisions are and will continue to be taken on the basis of best

[149] *Page 6, para 2.12*

> available, but incomplete, knowledge, taking into account the uncertainties".
> (DEFRA 2006b)[150]

The precautionary principle was also an integral part of the official documents preceding the draft Marine Bill (DEFRA 2004; Laffoley et al. 2004). In a fisheries context the RCEP recommended that "the presumption in favour of fishing should be reversed. Applicants for fishing rights (or aquaculture operations in the marine environment) should have to demonstrate that the effects of their activity would not harm the seas' long-term environmental sustainability" (RCEP 2004)[151].

However, despite the emphasis on the precautionary principle in the documentation leading up to the Marine Bill, Appleby and Jones (2012) observe that the White Paper seemed to adopt the evidence-based approach, with the final MCAA making no reference whatsoever to the precautionary principle. With regard to the planning of NMRs this meant that the 'burden of proof' was placed on the conservation agencies to justify them on current knowledge alone. As a result it is highly likely that NMRs will only form a small part of the MCZ network (Appleby & Jones 2012), which conflicts with some conservationists' interpretation of MPAs (Eades 2012).

The idea of the 'reversal of the burden of proof' in fisheries management – i.e. that fishers should have to prove that they are not damaging the environment is heavily contested between conservationists and the fishing industry. Whilst it is a statutory requirement for developers to undertake an Environmental Impact Assessment (EIA) before starting a project, this is currently not required of fishers, something that some conservationists are trying to change (RCEP 2004). However, the fishing industry argues that there are some practical reasons why this should not be the case – such as the fact that the costs of fishing would become prohibitively expensive if every fishermen were required to undertake an EIA prior to fishing (NFFO 2012d)[152]. Common sense would suggest that a trawl gear towed across the seabed will have some impact, but to show that this impact is not causing irreversible damage depends

[150] *Page 13, para 4.9*
[151] *Page 175, para 7.59*
[152] Though a related tool, the Strategic Environmental Assessment (SEA) has been employed by some of the English Inshore Fisheries and Conservation Authorities (IFCAs) to systematically assess the environmental impacts of fishery, the outputs of which would inform management.

on context (i.e. trawling over mobile sediments has little evident long-term impact, but trawling over a cold water coral reef may have long-term effects)[153].

The planning of English MCZs has been based on the widely accepted idea of 'systematic conservation planning'[154] (Smith et al. 2009) – i.e. the protection of around 20-30% of each of the UK's 20 broad-scale habitats[155] that represents its marine biodiversity, through a policy document called the Ecological Network Guidance (ENG) (Ashworth et al 2010). This approach has relied heavily on modelled habitat data, as though adherents of this method would argue that planning at this scale means that applying the criteria described (Table 6.4) means that even if the precise location of sensitive habitats is not known it is likely that some patches will be captured in the network. One conservation scientist said:

> "Yes, I think we should designate MPAs where there is uncertainty. Where there is the problem is if you're designating MPAs for a particular focal species, and you're not really sure if that focal species actually occurs there, then you are going to have very particular expectations on what it is going to do. Let's say it is to protect a population of fan mussels, and there weren't any fan mussels there in the end because your data were poor, or they were collected 20 years ago and actually since then they have been trawled away. That is where risk comes in, but if you are protecting broad scale habitats you can't really go wrong, except in the sense that you can put things demonstrably in the wrong areas on the basis of where the productivity is, by avoiding areas that are important fishing grounds you perhaps end up with more marginal habitats, but wherever you establish them, and if you were to protect that area well you would create the conditions for change in a whole range of different species. You know I've seen them work in so many places around the world that I'm not particularly fixated on saying that it has to be here because as long as you are resolute in your implementation of your protection then you will find that the biology follows." (Marine conservation scientist)

This statement implies first that important fishing grounds are associated with better habitat, and secondly, that the *ad hoc* placement of MPAs will work as well (also see Roberts 2000). Both propositions however would be hotly contested by some scientists (Dinmore et al. 2003; Kaiser 2004; Greenstreet et al. 2009; Abbott & Haynie 2012).

The fishing industry has been critical of the approach taken to planning MCZs, particularly of the quality of data on which to undertake planning at such a scale:

153 Though a century of trawling has caused fundamental changes to seabed habitats in certain areas (Jennings & Kaiser 1998), and trawling should be stopped to allow these habitats to recover (MCBI 1998; Roberts 2007).
154 This concept was originally used to plan networks of terrestrial protected areas (Margules & Pressey 2000).
155 There are 26 broad-scale (EUNIS level 3) habitats that are found in English waters. Level 3 introduces energy into the classification for hard substrata, and splits the softer substrata by different sediment types.

> "When in the majority of the planning areas there is very limited ecological data that identifies what is actually there to protect, you know that decisions cannot be robust and this calls into question what scientific purpose these areas could really serve." (NFFO 2011c)

Another scientist said:

> "Say you were going to close off an area just because you think that it might be an area where there's a delicate species, or there are species that need conserving, but then that area is also an important area for a fishery. I think that you'd have a hard job selling it to the fisherman that they should close this area off if you couldn't actually point to real reasons why you were going to do it, because they would say you're shutting us out of this area with no particular evidence of importance, so how do you justify that, and I don't think you could. If you're going to ask fishers to reduce their impact, then I think you've got to have good evidence that it's going to make a difference; otherwise you're essentially just arbitrarily closing them out from their living." (Fisheries scientist)

An alternative approach would be to look at the distribution of pressures in the marine environment.

> "I think that there's a case for vulnerable habitats for measures. I think the case becomes much more difficult to argue when we're talking about representative habitats. The problem has always been there's never an attempt to understand the distribution of pressures on the marine environment in the first place. That would be a sensible approach from our point of view, in terms of defining what interventions you maybe want to make." (Fishing Industry representative)

The above quote suggests there is a mixed message coming from the fishing industry regarding the use of fishing data: 1) whether data provided by the industry could be used alongside habitat data as the above quote suggests to work out the vulnerability of habitats to different levels of fishing, or 2) whether such data should instead be used to identify sites which should not be designated as MCZs. Indeed the fishing industry on numerous occasions has stated that data on the distribution and intensity of fishing activity should not be used against them (NFFO 2009a), making the second point more likely. In this sense data may be viewed as a political resource that the fishing industry can use to bargain with.

Another area of uncertainty is the impact that different fishing gears have on the seabed. Whilst some conservationists have abandoned the idea of having a substantial part of the MCZ network designated as NMRs, some still strongly hold the idea that trawling in all MCZs should be prohibited (e.g. Monbiot 2012).

A conservation scientist also argued:

> "the most damaging gears for my money are dredging and trawling and they've done immense harm both to the sustainability of the stocks that they catch but also the habitats that those stocks occupy so I think we need to shrink the footprint of these mobile fishing gears by a lot and there are conservation benefits to be had from static gear only areas… for me an MCZ that doesn't protect against mobile gears is not worth having, it will just be a paper park." (Marine conservation scientist)

These beliefs stem from high profile studies that have been critical of trawling as a fishing method (e.g. Watling & Norse 1998). However, whilst trawling has undoubtedly changed many UK seabed habitats (Jennings & Kaiser 1998), the fishing industry contests the current severity of its impact. A new fishing industry body the MPA Fishing Coalition was established in January 2010 at the start of the MCZ planning process to try and ensure that MCZs are introduced in a way that minimises adverse consequences for fishermen. One ex-fishermen said

> "I suppose trawling causes damage, you can't drag a trawl and a couple of tonnes of fishing gear over the seabed without it having an effect. But the thing is, fishermen return to the same fishing grounds year after year and they catch fish there. So you have to ask yourself, how much damage does it really do? You could say it's almost like ploughing the land. Farmers plough up the land, and of course in doing so, no doubt, they kill millions of bugs and worms and things in the soil, but it is part of the process of harvesting the produce, and I suppose you could say the same with fishing. The trouble with some of these environmentalists is that they've got this vision of returning the seas to the pristine state they were in before industrialisation. That's no more realistic a prospect than it would be to return the land to its preindustrial state. We are where we are."

Again this comment raises the issue of what MCZs are actually for; should they be designated in areas where trawling activity is at its greatest intensity to allow the recovery of the seabed, or should they be designated to protect habitats and species that exist now that are currently vulnerable to trawling? Different habitat types also have different sensitivities to trawling/ dredging, and the fishing industry argues that a blanket ban on trawling in MCZs is indiscriminate, and disproportionate (NFFO 2012d). Moreover, uncritical advocacy of the precautionary principle by environmentalists to rule out trawling overlooks fishing effort displacement and wider socio-economic impacts of closing an area of seabed (NFFO 2012d). The Ecological Network Guidance (ENG) has been heavily criticised by the fishing industry for being a theoretical construct that ignores important aspects of reality; when one scientist was asked to explain the meaning of ecological coherence, he was remarkably candid:

> "Nobody really knows (laughs). So what ecological coherence means is a number of things, it basically comes down to good principles of network design. That your areas are large enough to sustain a large enough fraction of the species within a site but obviously there are species that are going to fall outside the ambit of a protected area because of their movement on dispersal characteristics and so on. So they need to be networked with other protected areas. So you've got the adequacy of the MCZ sites which is one of the cornerstones of ecological coherence, there is the spacing of those MCZs which is another one of those corner stones and they need to be sufficiently close so they can exchange offspring of various things, and they need to be sufficiently replicated so that you have a range of different examples of the species being protected, and they need to be representative of the totality of the ecosystems and biogeographic areas within a region. So when you add all of those things together you have this cook book that says the protected areas need to be bigger than this and they're closer together than this, and that they encompass these sorts of habitats and that those sorts of habitats are replicated within these areas, and if you do all of those things then you have ecological coherence[156] even though nobody actually knows what that is… I think what it means is a self-sustaining network of sites that are going to act as long term refuges of the species involved." (Conservation scientist)

This confirms the NFFO's suspicions of the ENG and the scientists behind it:

> "It seems a relatively small clique of eco-scientists and MPA advocates, having realised their MPA cause celebre, have been given the freedom to construct an elaborate policy vision (the ENG) virtually as a scientists' writ. The certainty that this vision will deliver an ecologically coherent network apparently no-one is to question, nor give consideration to other important needs such as sustainable fisheries. It is about time that those hiding behind this "science is right" charade began to recognise that humans do form part of the marine ecosystem." (NFFO 2011c)

There were also concerns whether the ENG could actually be understood by some stakeholders, one fisherman when asked for his thoughts on the ENG said:

> "The ENG - Jesus Christ - makes me dizzy to sit down and digest it." (Static gear fisherman)

The same fisherman also seemed quite sceptical of the science behind it:

> "It was their (Natural England and JNCC) brainchild, it was their criteria - all generated from their viewpoints, based on papers not even published yet. It was based on "in-house" science, that didn't just add up." (Static gear fisherman)

Whilst this fisherman's concerns over the 'quality' of the science may be exaggerated, for instance the ENG cites numerous peer-reviewed sources from the special issue of the journal *Ecological Applications* (2003) that focused on the planning of a network of

[156] Though some scholars have questioned whether ecological coherence can actually be achieved due to gaps in our knowledge regarding the distribution and movement of species found in UK waters at different stages of their life-cycle (Jones & Carpenter 2009).

MPAs in California, his concern over the ENG being derived from a particular viewpoint is perhaps well founded; the dispute over the ENG also reflects more fundamentally what stakeholders view as science. A member of the NFFO hinted that there was a fundamental misunderstanding of how science is construed by conservationists and government:

> "I think I've got a problem with the word science, it's been corralled by biologists, whereas if you look at the work by Elinor Ostrom, the social and the economic sciences of resource management are every bit as valid, and I think that's an important point that the very word science kind of indicates biology or at its is very widest ecology but not taking into account economic or social consequences, and of course, especially within government there is sometimes a reaction against the word socioeconomic because they are seen as special pleading from parties/ interests to prevent measures that are necessary from being implemented, as opposed to an integral understanding of what the processes are and therefore if you are going to intervene, what the consequences of an intervention will be[157]." (Fishing Industry representative)

The fishing industry has also voiced its concerns about the unanticipated consequences of externalities, such as the displacement of fishing effort that may be unpredicted if robust socio-economic and ecological evidence is not taken into account:

> "After repeatedly raising the issue of displacement, there is a growing appreciation that the impacts of vessels displaced from their customary fishing grounds may not only be felt in local communities but also on adjacent grounds and sometimes quite distant areas. Not only that but they can be displaced into pristine areas previously never, or only very lightly fished. There are therefore economic, social and ecological reasons to take this issue very seriously. We now have secured some level of understanding that with close discussion and good information it is possible to protect vulnerable features within MPAs without displacing fishing operations by careful, focused design of boundaries and management measures." (NFFO 2011b)

The spatial scale at which decision-making is undertaken is therefore a major issue of contention between the conservationists and developers. The former would argue that planning with the detail proposed by the fishing industry would go against widely accepted best practice (Ardron 2008; Smith et al. 2009), particularly given the widely cited benefits of designing MPAs as networks (e.g. McCook et al. 2010). Indeed the RCEP states that the planning of the network of NMRs in the GBR went ahead with less data than the UK, though the RCEP overlooks the lack of similarities between the different ecosystems (one predominantly reef based and the other soft bottom[158]),

[157] For example an understanding of issues such as compliance, enforcement, displacement, and justice issues.
[158] See Charting Progress 2 (DEFRA 2010a).

and applies this planning model elsewhere on the same underlying causal assumptions (see Chapter 5). A smaller minority of scientists are inclined to establish MPAs on a more incremental case-by-case basis (Sweeting & Polunin 2005), though many conservationists still argue that it is necessary to shift away from more 'piecemeal' approaches towards wholesale conservation (Katsanevakis et al. 2011), despite glossing over glaring inconsistencies in such an approach.

In summary, the balance between objective (evidence based) and subjective (precautionary approach) considerations in decision making is heavily dependent on context, taking into account the following issues; scale of policy implementation, extent and quality of data, cost-effectiveness, attitudes towards risk (damage to the environment vs damage to livelihoods), and mode of governance.

Time-scales and costs

Following closely the discussion of the data needs and spatial scale issues surrounding the planning of MCZs is the issue of time-scale. Several international regimes have explicit deadlines for the designation of MPA networks[159], the WSSD (2002) calls for the establishment of MPA networks by 2012, and the legally binding EC's Marine Strategy Directive (2008) has incorporated this target. The OSPAR convention also says that an ecologically coherent network of MPAs should be established by 2012, and by 2016 that it should be well managed (OSPAR 2010)[160]. Interestingly these international commitments to timelines for MCZs precede the likely implementation of marine spatial plans, as one civil servant said:

> "The ambition to have a network in by 2012[161], was partly driven by ministers just wanting to get on with it and do it, and because as they would put it protection of the sea was lagging behind terrestrial protection. Also partly because the OSPAR target is 2012, I don't know why that particular date was chosen, and the timetable for marine planning was beyond that. So yes it was deliberate, MCZs could be designated before wider marine plans went through, yes that was quite controversial in itself as it is saying that we are prioritising one outcome over some of the others."
> (civil servant)

[159] Some authors have been critical of such targets - that they can undermine conservation efforts (Wiersma & Nudds 2012).
[160] OSPAR 10/23/1, Annex 7, section 2.2
[161] Though now after another public consultation (end-2012), Defra anticipates designating the first tranche of MCZs in summer 2013 (JNCC 2012).

The rush to establish MCZs was also partly due to the pressure applied on the UK government by an advocacy coalition of ENGOs (section 6.4.1). The NFFO observed:

> "A classic and largely artificial moral panic about the supposed imminent demise of hundreds of thousands of marine species, and the widespread collapse of commercial fish stocks, floated the Marine Act through parliament. It also led the Government into a rushed and deeply flawed process of establishing a network of MPAs through a *big bang* process. Instead of an incremental, steady, approach where one MPA would be trialled and necessary lessons learned before going onto the next MPA, armed with that experience, we are in the middle of a headlong rush on all fronts at once". (NFFO 2010a)

A MP who has a fishing constituency also noted that:

> "My impression of the process was that it was a rush of virtue to the head from those keen on marine conservation, but the fishermen weren't taken enough into account and haven't been generally. There is a kind of wildly misinformed view that the fishing industry is damaging the stocks, and damaging the seas, and damaging the environment and therefore we need to protect the sea from the fishermen, crazy!"

The proposition that UK fish stocks are crashing, and that there is imminent species extinction is misleading and exaggerated (Hilborn 2007a), not helped by sensationalistic science (Worm et al. 2006), sloppy journalism (e.g. Leake 2012), and endorsement by high profile conservationists[162]. It could also be argued that conservationists cut corners when, having been campaigning a long time for a MCAA, they had to come up with MCZ proposals at very short notice:

> "The time scales… the full process, in terms of getting the legislation through has been long and frustrating. We have been campaigning for a decade for the MCAA to come through, so that has been a very long, a long process to deal with, in terms of the identification of the MCZs that has been much more rapid… So I think a year was about enough, the issue in reality was delays in guidance and delays in data that caused problems and resulted in a lot of key decisions being made very late on in the process." (ENGO manager)

The fishing industry has raised two criticisms of the rushed time frame for designating MCZs: 1) the 'best available data' cannot be robustly analysed, and 2) 'trust' takes time to build between stakeholders – a factor which social scientists argue is essential for successful planning (Glenn et al. 2012). Conservationists themselves also noted that it took time for stakeholder stereotypes to break down:

> "But one of the major barriers to the whole process that has just been undertaken is people already have opinions what people are and what they stand for before they

[162] For example at the end of the MCZ planning process, high profile broadcaster Sir David Attenborough, vice president of the Wildlife Trusts said "I urge the government to designate the full list of 127 sites now, for day by day the wildlife in these sites is being destroyed and damaged. Time is running out for us to save our fragile seas."

> entered into the process. So even when you go into something new with completely new people, it was very much, you are a fishermen you do this, you're an NGO you're one of these greenies you do this, you know, and breaking that barrier down to start working with people was quite challenging as well, and quite easily provoked into you know a negative or positive mood depending on how the people were facilitating that going ahead." (ENGO manager)

The same person also noted that there were problems over how the natural science and ecological data were used in the process and lack of any clear rationale why stakeholders were to protect certain areas and not others:

> "I think there were several problems the way science was presented to stakeholders, one it was too late, one it was present in different ways as it was dependent on individual organisations at the end of the day actually submitting data, we submitted a lot of data to the processes because the national contracts failed to submit data that showed sufficient amounts of information to make decision. Obviously when you are a NGO submitting data to a project and it's not being submitted with a statutory stamp on it, it gathers a different level of respect from people, and it makes it harder to use that information. In terms of actually communicating science to people there was very little of that done through this process from start to finish, at no one point were the benefits of MPAs highlighted, when asked why the process was being undertaken the response was because it's law and we have to. There was limited time and limited will from project teams and statutory agencies to really promote why this was happening, why the science was important, and why it should be used, and then there were difficulties in terms of people's understanding of what was being presented to them in terms of science. The main bulk of information that was used throughout the regional projects to identify MPAs was Eunis level 3 habitat data layers, which if you look at just looks like a rainbow map, and you know it was a case of picking out lots of different colours to meet targets, and there was a kind of naive very limited view from people in the room why that was happening. It never took an ecosystem approach; it never looked in detail at different data layers that present a picture of specific habitats. It never looked at it from the view of why, why are you doing this, what are you trying to protect, what does the feature need to protect it, why is this feature particularly sensitive, anything like that, the focus was very much target driven. We need a bit of that habitat that happens to be that colour, so there was a real lack of communication about what the science actually was, why it was needed, and the science of MPAs in general."
> (ENGO manager)

Despite these reservations about time constraints, many conservationists argue that the government should still go ahead with the designation of MCZs on an adaptive basis (JNCC 2010). Moreover, adaptive management requires information from monitoring to feed-back results into the management process (Woolmer 2012), but there are significant uncertainties surrounding the monitoring of MCZs, including whether there will be money available to conduct survey work, given the significant costs entailed.

On the subsequent introduction of no-take 'reference areas' (where all extractive activities will be banned) which the UK government will use as control areas to monitor MCZs, the Wildlife and Countryside Link say the following:

> "Reference areas are useful for scientific research, as they allow the study of ecological changes resulting from human pressures, by comparing sites of minimal impact (the reference, or control areas) with sites subject to greater impacts and/or the wider marine environment." (LINK 2011)

But the fishing industry seems suspicious of the true rationale for establishing reference areas:

> "There is absolutely no need for draconian areas of "no-man's land" for the purpose of measuring ecological improvement in MPAs which would be readily evident from any general time-series programme of monitoring. Such proposals are ill thought through and show a careless disregard for people's livelihoods in order simply to give a free reign to conservation scientist's experiments… In many respects they represent the epitome of the conservation land grab, anti-people philosophy that has never been far below the surface amongst parts of the conservation lobby and patently within the government's conservation agencies which are prescribing such areas. This is just one of a range of shortcomings in the government's MCZ policy that has so far failed to give careful consideration to balancing sustainable marine use with conservation." (Rodmell 2011)

Paradoxically the rush to establish MCZs, and reference areas, may go against the conservationists' own interests. Several interviewees (both conservationists and developers) noted that crucial ecological information was brought too late into the MCZ process, by which time many MCZs had been designated on the modelled habitat data alone. In the absence of reliable ecological information (i.e. the precise location of vulnerable habitats) on which conservationists could negotiate with the fishing industry, the designation of some MCZs may have been driven by socio-economic interests. Had the process been less rushed, the MCZ network might have reflected the interests of conservationists more, although ENGOs might not have had large enough budgets to contribute much to an extended planning process:

> "I mean throughout this process you've got to bear in mind that although a lot of industry stakeholders were financially funded or offered expenses for their time or money incurred, NGOs have had to fund it another way. We actually sort funding from charitable trusts to employ staff to do the role but it's been a very, very financial heavy process for a lot of organisations and there has been an expectation of project teams that NGOs would just supply people and information up front to do what was needed without necessarily the respect that we are a charitable membership organisation and that's not something that comes easy." (ENGO manager)

Equity and fairness issues

Because of the lack of social science input, and poor communication between Defra and the fishing industry during the planning stages of the Marine Bill (DEFRA 2006a), equity and fairness issues seem to have been underplayed. In the Regulatory Impact Assessment for the Marine Bill, Defra says "It is not envisaged that any equity and fairness issues will arise as a result of Marine Bill policy proposals. In line with the principles of sustainable development, social, economic and environmental considerations will all be taken into account for any decision-making involved in the Bill proposals" (DEFRA 2008)[163]. Another reason for this underplaying is the way MCZs or MPAs were often 'sold' by conservationists to decision makers on their net benefits to the fishing industry (also see Chapters 1 and 2). For example, when one conservation scientist was asked about the potential impact of MCZs on inshore fishermen they said that the long-term impact would be positive:

> "Well you won't benefit from a MCZ if you don't have them and I think the inshore fleet will stand to gain a great deal from well enforced and protected MCZs even if they don't currently believe it. The evidence from other parts of the world is that those artisanal vessels end up getting good local catches from good local protection. So I think their fears are unfounded." (Marine conservation scientist)

Compounded by the antipathy amongst some conservationists and civil servants to fishers using mobile gears, this rhetoric of the fisheries benefits of MPAs obscured from view the severe and, some would argue, disproportionate, short-term (if not long-term) impacts of MCZs on the activities of smaller fishing vessels[164] - impacts which were glossed over when the Marine Bill was being passed through parliament. Indeed, some denied that even the short-term impact would be negative:

> "Well they just fish somewhere else. We are not shutting down the whole coast by establishing these MCZs, it is just a matter of moving your fishing from one place to another, and there's no constraint on how much they can catch, they have the same quota to catch what they did before, it's just that they are moving the fishing around, and whether that reduces yields or increases costs, there may be some effects on some people but the price is worth it." (Marine conservation scientist)

The lack of clear social objectives within the final MCAA may have also contributed to the lack of thinking within Defra about the potential implications of MCZs for the

[163] *Page 23, para 6.3*
[164] The English fishing fleet is dominated by (<10m) vessels that are largely confined to inshore waters (< 6nm), with 5326 such vessels comprising 82% of the English fleet in terms of vessel numbers in 2011 (Elliott et al. 2012).

activities of the small-scale fishing fleet and associated onshore activities that contribute to local economies (see DEFRA 2008). A study of the impact of 12 months of closure at Lyme Bay indicates that the impact on scallop fishermen's profits has been marginal, though says that Lyme Bay fishermen have had to work harder and use more fuel to maintain their profit margins (Mangi et al. 2011). The study also highlights potential long-term negative impacts of the closure such as increased conflict between towed and static gear fishermen, and concern over whether the smaller area now targeted by dredgers will be able to sustain the current number of vessels on a full-time basis over the long term (Mangi et al. 2011). More broadly, the Lyme Bay study highlights the uncertainty surrounding the long-term impacts of MCZs, as opposed to the short-term costs that are often thought to be an initial barrier to the establishment of MPAs (Rees et al. 2010).

The closure of Lyme Bay also raised issues of procedural justice due to the lack of transparency[165] in the planning process. This issue first came to prominence during the final stages of the planning of the Marine Bill when mobile fishing gears were banned from Lyme Bay[166] in 2008 due to the presence of pink sea fan, *Eunicella verrucosa* (a listed UK species) in the area. Natural England has faced significant criticism from the fishing industry for lack of transparency over the evidence it provided to government as the basis for the closure. The NFFO accused Natural England of "deliberately withholding scientific evidence on the abundance of pink sea fans that would have undermined and run contrary to its own preconceptions and political objectives" (NFFO 2010d).

> "Natural England couldn't demonstrate how it had arrived at its decisions, and so I think there is, I think Natural England recognises that it has been deficient. Some people in the fishing industry who have looked into this particularly on the pink sea fan and other things have shown a very slapdash attitude to the evidence, again very much erring on the advocacy side of things… they felt that the values they held gave them a right to an involvement on the policy side and then moving onto the advocacy of particular policies. I think there is a maturity there now that there wasn't at the beginning, so I think it has been quite a hard learning period for them." (Fishing Industry representative)

[165] Transparency requires that the paper trail that led to a particular decision being made can be comprehensively audited.
[166] Lyme Bay, situated in the English Channel in South West England, is considered as one of England's most important areas for marine biodiversity (Hiscock & Breckels 2007). The closed area is 206 km² making it one of the largest MPAs in the UK.

The Lyme Bay controversy damaged the already tentative relationship between the statutory conservation agencies and the fishing industry (Fleming & Jones 2012) when from the perspective of the NFFO "one thing was said, and another thing was done" (NFFO 2008). Indeed the suppression of evidence to achieve political objectives threatened to further undermine public trust in environmental organisations following the 'climategate' scandal[167]. Moreover, members of the fishing industry are now concerned that the failures of procedural justice at Lyme Bay will be repeated during the decision-making process on the management measures to be put in place in designated MCZs (Fleming & Jones 2012).

Procedural justice requires that decision-making processes take into account both top-down and bottom-up approaches to governance; Jones (2012) says that the designation of MCZs combined the two approaches, with the ENG (a top-down policy document) being used to instruct the planning of the MCZ network, and the stakeholder meetings (a bottom-up process) obliged to meet certain criteria (e.g. certain percentage areas of habitats to protect) set out by the ENG. From his observations of the *Finding Sanctuary*[168] process Jones (2012) argues that as both fishers and conservationists have similar concerns of a like gravitas but opposite nature, a balance between top-down and bottom-up approaches in UK MPA governance has probably been achieved (Jones 2012). However, the fishing industry has voiced concern that the balance has been struck too much in favour of the conservationists:

> "Well, I feel that there's a bit of an imbalance between the interests of the fishers and the conservationists. I'm not against conservation, but I think that the conservationists don't have a direct personal stake in fishing, to them fishing is just the enemy. And to fishers of course, this is the inshore guys who are operating small boats, it's their livelihood, and if they are arbitrarily shut out of large areas where they fish, they could well have to give up fishing and change their whole lives. Whereas for conservationists, closing off areas is no skin off their nose personally, and they might even get promoted for having done a good job! And I think this sort of imbalance between the true stakeholders and those who claim to be stakeholders through their general belonging to the population of Great Britain is very unbalanced. The conservationists are full time people working on this all the time, they can often make their voice heard over and above fishers who after all are having to attend meetings and so on in their spare time when they've probably been at sea all day plugging away in their job, so that's what I was trying to put over, but I don't think it got listened to." (Fisheries scientist)

[167] E.g. see the impact the 'climategate' scandal had on the credibility of the IPCC (Beck 2011).
[168] The regional planning workshops that led to the designation of MCZs off the south west coast of England.

Fishermen have pointed out that although they were paid to attend the meetings, on a good fishing day they could have been out at sea earning more. However, for their part, the conservationists have argued that the MCZ planning process was biased towards industry representatives:

> "So would say the process has been very much driven by socio-economics in terms of data but also in the terms of representatives in the room, so the way in which MCZ planninghas been brokered there have been four individual hub groups and the stakeholder advisory panel at any one time there have been between 20-40 representatives within a room. I think the most at any one meeting would have been five conservation orientated people, with you know anywhere up to 35 stakeholder representatives from an industrial/ socioeconomic background, although the process doesn't on the face of it say voting comes into account when identifying sites, it is very clear that five people in the room saying one thing and 35 in the other then the process is not fairly weighted, the other problems have been whoever speaks the loudest gets heard, whoever creates the greatest fuss gets heard, the project team have undertaken facilitations themselves which in the cases of using liaison officers, people who were originally set up to liaise with the industry, mainly people who come from industry backgrounds- they were ideal to do that job, then facilitating a room of people has basically become an extra industry rep around the table and entered bias into that view. We've also had problems of NGO staff basically been threatened by other stakeholders in meetings and the project team in fact telling NGO staff they don't want to hear from them anymore in meetings, so I'll generally say it's an unfair process with an awful lot of bias towards industry." (ENGO manager)

As of September 2012 the first round of MCZs is anticipated to come into place in summer 2013 (JNCC 2012), however it is not yet clear what management measures will be implemented as these are still being discussed by the fishing industry, statutory conservation agencies and Defra. Thus from a distributive justice standpoint it is difficult to judge whether or not there will be a disproportionate burden placed on the inshore fishing sector.

In addition to the political battles fought between the fishing industry and conservationists, the offshore fishing industry faces a loss of fishing grounds through the continued expansion of offshore development. Jones (2010) has likened this to an *ad hoc* race for marine space, whereby extensive offshore development[169] (particularly of renewable energy installations) is taking place before regional marine spatial plans are developed. Offshore fishermen are thus unlikely to concede the further loss of

[169] There is a potential conflicting policy as the government is committed to generating 15-20% of its electricity from marine renewable energy resources by 2020 (Mander 2008).

fishing grounds willingly, and are probably weary of government bias towards the interests of energy companies due to the GDP they bring to the UK economy.

It is also worth bearing in mind that there is an on-going debate between offshore wind energy companies, government, and the fishing industry regarding the co-location of windfarms with MCZs and/ or certain types of fishing activity. Regarding the latter, an activity may be compatible as long as there is no chance that it could cause damage to cables that run along the seabed (Blyth-Skyrme 2011).

6.5 Conclusion

Jones (2012) argues that “as both fishers and conservationists have concerns of a similar gravity but opposite nature, a balance between top-down and bottom-up approaches in UK MPA governance has probably been achieved”. However the question has to be posed in whether the MCZ process was ill-conceived from the start, not achieving the appropriate balance between ecological and socio-economic objectives, and largely reflecting the interests of an epistemic community composed of mainly natural scientists (Chapter 3) and a related advocacy coalition of green NGOs (see section 6.4.1) whose core beliefs were biased towards ecosystem preservation and recovery.

Systematic approaches to conservation have become dominant in the discourse of modern day conservationists (Margules & Pressey 2000; Ban 2009; Maiorano et al. 2009; Smith et al. 2009; Hansen et al. 2011). The evidence presented in this chapter to an extent challenges this view; clear objectives, a thorough understanding of the scale of the planning process and data needs, and the time and costs required to achieve successful outcomes need to be seriously considered before systematic approaches to conservation are undertaken. Arguably these factors were not properly considered before the planning of MCZs started, the process being driven by a ‘moral’ crusade by conservationists who adopted the storyline of collapsing fish stocks and the continued destruction of UK marine ecosystems.

The ecological guidance used as the basis for the planning of the MCZ network was also too abstract for some stakeholders to grasp, and could indeed be challenged on empirical grounds due to the lack of understanding of the distribution of habitats, species and dynamics of UK marine ecosystems. From the fishing industry's perspective the lack of consideration of social objectives by the MCZ process, along with the lack of robust evidence to support the ecological basis for the MCZ network meant that they could mount a strong argument to counter the dominant conservationist discourse. Indeed conservationists have by no means had it all their own way in the planning of MCZs, and the realisation that many MCZs have been designated with little knowledge of what they are protecting begs the question of whether the time and money spent on the planning process would have been better used for another purpose.

In the final chapter I discuss whether there needs to be a redress of the balance between the ecological and social aspects of natural resource management, and whether there needs to be a shift in marine natural resource policy from one that emphasises conservation outcomes to one that focuses more on the process of planning. I also argue that there needs to be a fundamental rethink of what is meant by 'science'.

Chapter 7

Synthesis

Making sense of science-based advocacy and ‘good’ decision-making, how did the science-policy boundary blur?

“Sustainability is about being nimble, not being right.” Rayner & Malone (1998)

7.1 Introduction

Whilst this thesis has been critical of the scientific-evidence base for establishing MPAs, it does not ignore the evidence that marine ecosystems are facing ever-increasing demands from human activities (Mora & Sale 2011). The research presented herein recognises the need for improved management of marine natural resources that may entail use of MPAs in places to restrict particular users when appropriate to meet two broad objectives: 1) stop damage to a habitat or species, or 2) restrict current use to allow a habitat or species to recover[170].

There is however a risk of a policy misfit if the social-ecological context within which MPAs are supposed to function are not taken into careful consideration (Jentoft et al. 2007), and, this thesis is critical of the way the ecological effects of MPAs and NMRs have been exaggerated (Chapter 4), over-generalised (Chapter 5), and sometimes ‘sold’ to decision makers on claims unsubstantiated by robust empirical evidence (Chapter 6), often juxtaposed with a storyline suggesting the imminent collapse of global fisheries (Chapters 1 and 6). I also point out that a significantly greater research effort has been devoted to NMRs compared to alternative management tools (Chapter 3), because of the influence of MPA advocates who have pushed MPAs up the policy agenda and subsequently attracted funding from ENGOs and governments (see section 7.2) to do more research to increase the ‘attractiveness’ of MPAs (particularly NMRs) to decision makers.

In this final chapter, I first draw on the three policy network models selected to summarise my research findings. I argue that an epistemic community (EpC), a network of senior scientists and managers, was responsible for getting clauses calling for MPAs written into the policy enterprise of several international environmental regimes. Cross collaboration between scientists belonging to the EpC and ENGOs led to more funding being available for marine scientists to conduct MPA-related research.

[170] For example Special Areas of Conservation (SAC) implemented under the EC’s Habitats Directive are used to maintain or recover some types of habitat to ‘favourable’ status which means that (i) a habitats extent is stable or increasing, (ii) the specific structure and functions necessary for its long-term maintenance exist and are likely to exist for the foreseeable future; and (iii) populations of typical species associated with the habitat are viable in the long-term.

This, along with the subsequent campaigning by an advocacy coalition (AC) of ENGOs and scientists for NMRs and the use of science to support their campaigns suggests that much research done on MPAs is partial to a particular policy outcome (i.e. establishment of NMRs) – which has been termed by some as *normative* science (see 2.3.4 Chapter 2). I believe the MPA-EpC and pro-MPA AC are heavily interlinked (see Table 7.1 for summary).

Table 7.1 Summary of the members and role of the EpC and AC in the planning of English MCZs.

	Epistemic community	Advocacy coalitions
Membership	OSPAR, IUCN, JNCC, NE, English SAP, university academics	**Pro- MPA**; ENGOs (e.g. WWF, Greenpeace, RSPB, MCS, WTs etc), media, and university academics **Pro-fishing;** NFFO, MPA fishing coalition, producer organisations, Seafish, wider industry
Role in planning MCZs	Responsible for the approach taken to planning the MCZ network (i.e. the ENG)	**Pro-MPA**; pressured government for higher levels of protection **Pro-fishing**; pressured government to make sure MCZs had minimum impact on the fishing industry
Role of science in policy	Strong emphasis on technical guidance can lead to scientisation of policy debates, ignoring implicit normative core (essentially stealth-issue advocacy)	Normative beliefs more explicit in terms of language used. Science is used to bolster each ACs policy preference

The EpC uses science as a tool to reduce uncertainty around the causes of and solutions to a problem and helps decision makers identify the best course of action; and the AC 'cherry picks' science (often out of context) to support its policy interests. When the EpC tries to impose its policy enterprise in a highly political arena which is composed of competing ACs, it causes the *scientisation* of policy debates, in that competing ACs – one pro-environmental and the other pro-industry engage in politics through science[171]. The approach to decision making that the EpC takes is that political consensus and recognition of a common interest is achieved through scientific consensus (Haas 1989). However such an approach is problematic if a common interest does not exist. In political arenas where interests cannot be consensually

[171] For example in the context of climate change see the role of the IPCC, and debates over the Bjorn Lomborg's controversial book *The Skeptical Environmentalist* (Pielke Jr 2004).

reconciled, compromise-orientated negotiation should be aiming to adjust particular interests rather than seek consensus (van den Hove 2006).

Strong adherents of the linear-model argue that science should play a (if not the) central role in political battles (Pielke Jr 2004). Indeed, claiming to have a campaign based on sound scientific credentials is strategically advantageous for any AC to support their case with the facts (Turnhout et al. 2007). However, robust empirical evidence for the fisheries effects of MPAs in a temperate setting is lacking (Chapter 5), and there are conceptual and normative aspects of a policy that are often not openly discussed (Chapter 6). For example: What values should be taken into account in setting policy objectives; what roles should different stakeholder groups have in decision-making (Reed et al. 2009); and how should the costs and benefits of a decision be distributed? The third policy network - the discourse coalition (DC) approach - suggests that the conceptual and normative aspects of policy cannot be separated from the facts, and that there is often more than one plausible solution to a problem.

A common problem facing policy makers is not insufficient science but limited solutions (Sarewitz 2004). Many scholars have argued that good policy is more likely to result when a plurality of perspectives are involved in decision making (Berkes 2009). In a fisheries context there is a current emphasis in the academic literature on a concept known as co-management as a form of fisheries governance[172] (Phillipson 2002) that reflects a plurality of perspectives, especially interests and values of local users in addition to the views of strategic policy makers, including scientists (Berkes 2010). This pluralistic perspective reassesses the role scientists should take in policy debates, and the role of science in helping solve marine conservation problems.

[172] Broadly, 'governance' deals with how decisions are made, and 'management' with how decisions are implemented.

7.2 Reintroducing the policy networks

7.2.1 Epistemic communities

The theory of epistemic communities has been used to explain the influence of an elite network of international knowledge experts whose common policy enterprise manifests itself in an international regime (Haas 1989). Convergent state policies emerge (i.e. MPA networks designed by a universal set of criteria to protect representative habitats) due to international level commitments driving national policy priorities, with members of the EpC helping develop policy guidelines to allow their policy enterprise to be realised at the national level of their respective countries (Figure 7.1). In the case of English MCZs this was achieved through the development of JNCC's and Natural England's Ecological Network Guidance (ENG) (Ashworth et al. 2010).

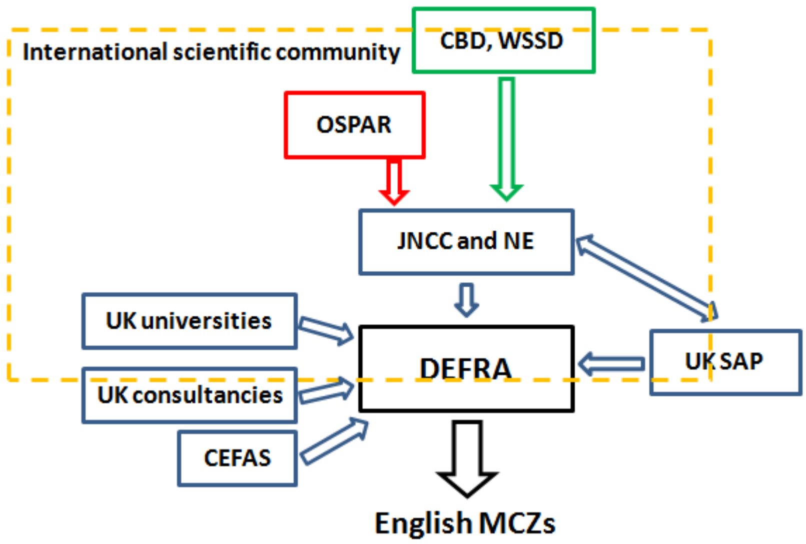

Figure 7.1 The epistemic community that developed the planning guidelines for the network of English MCZs. Blue boxes indicate UK science advisers who have helped shaped policy on MCZs. The OSPAR convention, CBD, and WSSD are the international drivers. The dashed orange box indicates the reach of the international scientific community on influencing MCZ policy.

The ENG was derived from a considerable international literature that has largely been based on planners/ managers/ scientists' experiences of developing networks of MPAs in California (Airame et al. 2003) and Australia (Fernandes et al. 2005), and how such networks can be best designed according to ecological (Airame et al. 2003; Roberts et al. 2003) as well as socio-economic criteria (Lundquist & Granek 2005). Several papers from the Working Group on Marine Reserves published in a special issue of *Ecological Applications* (2003) were used to inform the ENG that provided the principles for the design of the English MCZ network, and at least two scientists from the USA - S Gaines and M Carr - visited England to disseminate their experience of being involved in the planning of the Californian MPA network.

The English MCZ planning process was largely modelled on that used in California[173]. The implementation of MCZs involved four regional stakeholder workshops whose output (i.e. proposed sites for MCZs) were scrutinised by an independent science advisory panel (SAP) (see Jones 2012 for detailed review), two members of which, CM Roberts and M Kaiser have published extensively on MPAs (see Figure 3.6 Chapter 3). Roberts was also a member of the NCEAS Working Group on Marine Reserves and was consulted by Natural England during the drafting of the ENG.

Thus there has been considerable expert input internationally into the development of universal guidelines for planning MPAs (Kelleher & Kenchington 1991; Kelleher 1999; Salm et al. 2000), which has manifested itself nationally in England in the ENG (see Chapter 6). However, some critics have argued that such guidance has come largely from an ecologist's perspective, in which there are implicit assumptions made (biases?) on how humans and marine ecosystems relate to one another (Christie 2011). In the social-ecological context of the UK there are also concerns, given the uncertainties surrounding the ecological functioning of UK marine ecosystems and the political context of the CFP, whether an ecologically coherent network of MPAs can be planned (Jones & Carpenter 2009), let alone enforced (Le Quesne 2009).

Haas' theory of the EpC has been used to explain the successful negotiation of the Montreal Protocol that mandated the phasing out of stratospheric-ozone-depleting chlorofluorocarbons (CFCs) (Haas 1989). Though Haas emphasises the role of scientific learning in the success of the Protocol, Sarewitz (2004) argues otherwise, suggesting

[173] For a detailed discussion of the California process for setting up an MPA network see Weible (2004, 2005, 2007, 2008) and Hilborn (2012).

that the ozone story is less one of controversy resolved by science than of positive feedback from convergent scientific, political, diplomatic, and technological trends. Perhaps more important was that the main commercial interest (DuPont) was eventually aligned with the main objective of the policy, that of phasing out CFCs, after it had developed CFC alternatives. Moreover, the EpC was successful in reducing the damage done to the ozone layer not just because of its scientific credentials but because there was a values consensus between different actors. By contrast, a barrier affecting the implementation of MPAs, despite the influence of a network of marine scientists calling for MPA networks, is that often a values consensus between conservationists and resource users does not emerge, and the top-down design and implementation of the EpC's MPA policy calling for the systematic designation of representative habitats is likely to be met with much resistance from resource users if the main objective of the MPA network is for the conservation of nature (e.g. as in England).

The call made by some members of this EpC explicitly for NMRs (Figure 3.7 Chapter 3) is a form of stealth issue advocacy where science is used to justify one policy over others (i.e. the NMR over multi-use MPAs). This attitude stems from the belief that NMRs have a greater effect on increasing fish abundance and biomass than MPAs that still allow some fishing (Di Franco et al. 2009b), but this observation has largely been derived from coral and rocky reef habitats where fish remain largely site attached (Chapter 5), and there are uncertainties over the scale NMRs would need to be to have similar effects in systems dominated by soft sediments (Shipp 2003). The significance of the observation that there are more fish in highly protected areas for wider fisheries management is also unclear (NFFO 2009d), and it by no means follows that NMRs are the 'best' policy (e.g. Fanshawe et al. 2003; Bene & Tewfik 2003). The problem of stealth issue advocacy was compounded when scientists extolled the benefits of MPAs to fisheries (presumably to downplay the trade-off between nature conservation and sustainable use discussed above), on the basis of the findings of abstract modelling studies, and limited robust empirical evidence (Willis et al. 2003a). Whilst at the local level some NMRs have undoubtedly benefited local fisheries (Russ et al. 2004), there is much uncertainty over whether such effects can be scaled up (Holland 2000).

Additionally, the technocratic style of governance of the EpC, particularly when more emphasis is placed on ecological criteria[174] often means that there is lack of cohesion between strategic (i.e. resource conservation) and local level (i.e. continued use) priorities (Jones 2012). Historically, disciplinary boundaries between the natural and social sciences have exacerbated this problem (Charles 1995). Despite this there is a growing body of MPA planning literature that stresses the importance of socio-economic[175] information in network design (Lundquist & Granek 2005), and there are reportedly many examples of successful examples of MPA planning in the literature (Day 2008; Klein et al. 2008). However, the definition of "success" is subjective and largely dependent on one's point of view (Christie 2004; Murray 2005), and there are many MPAs that have failed to adequately take into account social factors during the planning process (Christie et al. 2003). This reflects an assumption made by some members of the MPA-EpC that humans are separate from and outside of nature (Campbell et al. 2009), with the ring-fencing of sites for protection being likened by some scholars as a return to the fortress conservation paradigm; a land-grab where even sustainable use is ruled out (De Santo et al. 2011).

Another important criticism of the MPA-EpC is that in its attempts to find universal solutions to the biodiversity crisis, it overlooks important factors such as funding, pre-existing governance structures, and information needs that form the basis of successful MPA planning at the local level (Berkes 2010). However, despite the current emphasis in marine conservation on systematic planning of MPAs (Maiorano et al. 2009), some scientists have suggested that an opportunistic approach may be valuable where biophysical data is sparse and community acceptance is a critical factor (Hansen et al. 2011).

[174] For example see the ecological objectives of the European MSD.
[175] Some would argue there is a strong bias towards economics.

7.2.2 Advocacy coalitions

In addition to the formal rules laid out by the MPA-EpC through international regimes, a transnational advocacy coalition consisting of internationally renowned academics and ENGOs has collaborated to lobby national governments to implement MPA networks (see Chapter 3). Such networks have also taken a wider role in educating the public on the ecological effects of MPAs, particularly NMRs (Grorud-Colvert et al. 2010; PISCO 2011).

Whereas the EpC has been used to explain the emergence of a highly rational, technical response to a problem, whose policy enterprise on the surface appears value-free (see Table 6.3 Chapter 6) though implicitly impregnated with many normative assumptions (see 7.3.1), the AC explicitly places greater emphasis on values, and organises itself around a common ethical cause (Keck & Sikkink 1998; Stone 2002), to quote the oceanographer Sylvie Earle at the annual TED conference in 2009[176]:

> "I wish you would use all means at your disposal, films! expeditions! the web! more! – to ignite public support for a global network of marine protected areas, hope spots large enough to save and restore the ocean, the blue heart of the planet."

The use of informal avenues for communication has also been important for the international influence of this MPA-AC. In addition to popular conferences such as TED where several other scientists and policy makers who have worked on MPAs have given talks[177], there are other forms of media through which environmentalists can communicate their research findings and beliefs: the internet (e.g. Google Earth in conjunction with IUCN set up a layer showing MPAs, and freely available 'grey' literature), films (e.g. the *End of the Line*), magazines (e.g. *BBC Wildlife*), and books (e.g. *The Unnatural History of the Sea*, *Ocean of Life*) (see 1.2.1 Chapter 1).

However, this transnational advocacy coalition is not a separate policy network from the EpC described above but rather it is an extension of it. The MPA-EpC is embedded in the more inclusive AC and there are strong flows of information and finance

[176] Earle won the Technology, Entertainment, and Design prize in 2009 and with TED's support has launched Mission Blue that aims to establish MPAs around the globe.
[177] E.g. Enric Sala, Jeremy Jackson, Stephen Palumbi, Kristina Gjerde, and Daniel Pauly.

between the two. Additionally, a scientist may have roles in both networks; sometimes offering technical guidance to officials (the EpC) and sometimes offering scientific credentials to the campaigns of ENGOs (the AC). The interconnectedness between the two networks particularly with regards to the funding of MPA-related research and dissemination of findings mean it is no longer possible to divorce politics from science (also see Chapters 3 and 4).

With regards to the planning of MCZs there is a national pro-MPA AC in the UK (see 6.4.1 Chapter 6) comprising national ENGOs, some scientists and perhaps more controversially England's statutory nature conservation adviser, Natural England (Figure 7.2). This network has lobbied the UK government for a Marine Act since the late 1990s, and run several public campaigns calling for NMRs over the years[178]. Currently, the UK-based Marine Reserves Coalition[179] is campaigning for more than 30% of the oceans to be designated as NMRs, and is also pressuring the UK government to establish Highly Protected Marine Conservation Zones[180].

On the opposing side of the MPA debate, the fishing industry and other resource users have also attempted to influence government. Initially, the fishing industry collectively was slow to recognise the potential impacts of MCZs on their interests, perhaps because of poor lines of communication between DEFRA and the fishing industry as the Marine Bill was being planned (see Chapter 6). Latterly, the fishing industry has made up for lost ground by challenging the scientific and democratic basis of the MCZ network through the MPA Fishing Coalition (Chapter 6).

With respect to how each of these two ACs has influenced outcomes on MCZs, Figure 7.2 gives a basic representation of the author's understanding. The relative size of each

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[178] E.g. the Marine Reserves Now campaign run by the MCS and Co-op group (2007-2009), and the Friends of the Earth Marine groups campaign for NMRs.

[179] A partnership of six organisations: the Blue Marine Foundation, ClientEarth, Greenpeace UK, MCS, Pew Environmental Group, and Zoological Society London.

[180] On UK MPAs, the coalition says "A well designed and effectively managed network of MPAs around the UK will be a great step in the right direction towards conserving our marine life. However, we believe it does not go far enough. To truly restore and protect our seas and the resources they provide, some areas of considerable size must be fully protected from all extractive and damaging activities. These areas (marine reserves) will serve to protect and restore fragile habitats and species, replenish the seas around them, and act as insurance against further destruction and disaster."

of the dashed boxes and positions are used to illustrate (based on the author's experience gained during this PhD) how they are related to the wider scientific community. I believe that currently there is a stronger pro-conservation storyline running through the national media than there is a pro-fishing storyline (though this needs to be empirically tested), and a greater number of marine scientists have allied themselves with the pro-conservation faction of the press.

Nevertheless, scientists can be found offering their expertise to both the pro-conservation and pro-fishing coalitions. Information is used to bolster the credibility of the cause of each coalition, and influence public opinion (Grorud-Colvert et al. 2010). Stakeholders of each coalition may spin or distort information to their advantage (Turnhout et al. 2007; Weible 2007), though evidence of this happening in the debates surrounding MCZs is patchy (see Chapter 6). In addition to information, Weible (2007) cites public support, financial resources, and skilful leadership as being key factors in determining the influence of an AC in developing a network of MPAs in California.

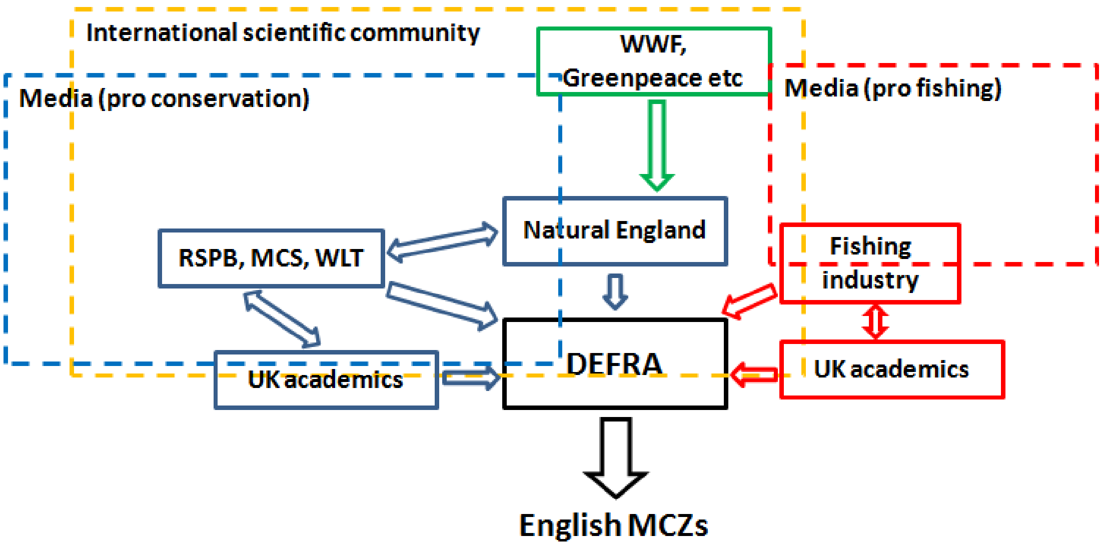

Figure 7.2 The advocacy coalitions that have shaped outcomes on the design and management of MCZs. The green box indicates international ENGOs that have influenced thinking on MPAs both internationally and nationally. Blue boxes indicate the pro-NMR advocacy coalition; red boxes indicate a coalition (anti-NMR) formed between members of the fishing industry.

Regarding MCZs there is still uncertainty over the respective influence of the pro-MPA and pro-fishing ACs on government, since what types of fishing activity will be excluded from MCZs will not be decided until mid-2013. It is predicted that the final management measures are likely to reflect a compromise between the two factions.

7.2.3 Discourse coalitions

The discourse coalition's approach places a greater emphasis on the analysis of language and how an issue is framed; i.e. the assumptions, beliefs, norms, and values that filter a person's experience and how they understand the world (Fischer 2003). From an analysis of key-informant interviews and contents analysis of relevant 'grey' literature (see page 157) two competing broad discourse coalitions were identified; conservationists versus developers (Chapter 6).

Whilst a realist epistemology would argue that there is something called 'facts' and something called 'values' (see 2.2.2 Chapter 2), this view has been challenged by scholars who suggest that external political reality does to varying degrees influence the type of knowledge produced (Jasanoff 2006). Discourse analysis emphasises the subjectivity involved in policy making, noting that any complex problem has multiple features, each of particular concern to a specific group of people (Dryzek 1994). The discourse approach also scrutinises the meaning of facts for policy, to quote the NFFO:

> "Scientists advocating MPAs have often shown graphs of increasing biomass within an MPA, as major evidence of their success. However, it would be clear to the average layman that this would be the most likely response to the removal of human activity from the marine environment and such evidence offers nothing to a reasoned analysis of where the balance between human use of marine resources and conservation should lie."
> (NFFO 2009d)

The two opposing discourses in chapter 6 select different combinations of facts to strengthen their narrative and underlying worldview (see Table 6.4 Chapter 6). The principal message of each one bears some resemblance to the two imperatives in fisheries management identified by Khan and Neis (2010) that they term *recover* and *rebuild* (1.2.2 Chapter 1). The conservation discourse emphasises technical measures (based largely on natural science) to allow the recovery of marine ecosystems, while the developers' discourse emphasises the need for an improved decision-making process and restructuring of governing institutions - the fishing industry in particular emphasising the importance of the principles of good governance[181] for achieving stock rebuilding outcomes.

In essence, through a critical analysis of stakeholder dialogues, I have found that the DC approach provides a more nuanced understanding of a problem than that provided by the AC approach which seems to mainly focus on the interests and core beliefs of stakeholders (Weible & Sabatier 2005).

7.3 How did advocacy cause the MPA science-policy boundary to blur?

As was shown in chapter six, policy debates over marine protection are usually characterised by controversies over values as well as over information, though, overtly the debates are heavily focused on scientific evidence rather than on normative issues. In this section I briefly restate the complexity of overfishing and biodiversity loss, reiterating that the problem is multidimensional, often involving complex interactions between resource users, managers, scientists, policy makers, and consumers (Caddy & Seij 2005), as well as the environment. I then distinguish between situations where policy advocacy from scientists can be counter-productive to rational decision-making and situations where it may be productive.

7.3.1 The nature of the biodiversity and overfishing problem

General overview

In chapters one and five I mention that there is a trade-off between the conservation of biodiversity for its own sake and conservation for sustainable use. MPAs, particularly NMRs, are sometimes promoted as providing benefits for *both* biodiversity conservation *and* fisheries (Roberts & Hawkins 2000; Leisher et al. 2007). But such an outcome is heavily dependent on social-ecological context (Pitcher & Lam 2010), and if

[181] Includes the following principles: responsibility, participatory and inclusive decision-making, effective communication, efficiency, precaution, effectiveness, legitimacy, equity and justice (Constanza et al. 1998; Khan & Neis 2010).

the fishery is already well managed (in terms of achieving sustained yields over time), NMRs may not contribute any significant fisheries benefits (Hilborn et al. 2004).

Many scientists would however argue that 'well managed' fisheries are the exception rather than the rule (Hilborn 2007a; Pauly & Froese 2012), and MPAs/ NMRs are promoted as a risk-averse management strategy to guard against stock collapse in the face of uncertainty (Clark 1996; Lauck et al. 1998). Such arguments are supported by claims that human exploitation has caused global declines in marine biodiversity from loss of habitats (Watling & Norse 1998; Jackson et al. 2001) to loss of species (Roberts & Hawkins 1999), with wider implications for ecosystem resilience and productivity (Hughes et al. 2005). More radically, there have been a growing number of studies advocating the idea of marine restoration (Pitcher 2001; Pitcher 2005). However, Pitcher (2001) describes three ratchet-like processes that make the past hard to restore: 1) selective exploitation by fishing causing declines and even localised extinctions in *k*[182]-selected species (Christensen & Pauly 1997); 2) overcapacity in fishing power (Ludwig et al. 1993); and, 3) shifting baselines (Pauly 1995). Moreover, alternative stable ecosystem states may exist (Zaitsev 1992; Rudstam et al. 1994; Hughes et al. 2005) that may make attempts to restore an ecosystem to a previous state impractical and too expensive.

In addition to technical uncertainty over ecosystem restoration (i.e. will a habitat recover, how long will recovery take?) that may be resolvable by further research (Peterson & Lipcius 2003), the multidimensional nature and 'wickedness' (Khan & Neis 2010) of the overfishing problem means that management approaches which have emerged largely from single disciplines have often failed if applied too rigidly (Pitcher & Lam 2010) without considering local social contexts (Campbell et al. 2009). Given the connectedness of marine ecosystems with terrestrial food webs, and the implications of fisheries management for global food security (Smith et al. 2010), concepts such as ecosystem-based management (EBM) that deal with the wider effects of fishing on ecosystems also need to take into account the wider needs and values of society (Campbell et al. 2009) – i.e. normative considerations.

[182] Large slow-growing organisms, which typically mature late, and may have relatively low levels of fecundity.

Further normative issues include the question of what kind of ecosystem we want to protect. Some scholars have argued that policy debate on marine restoration needs to explicitly recognise the value-judgements inherent in deciding both what past ecosystems looked like and whether or not and how we might reconstruct them (Campbell et al. 2009). Also, given that increased protection is likely to entail some short-term cost, the discussion of 'spillover benefits' to fisheries from NMRs raises contentious issues of compensation and who should pay for habitat recovery. Inevitably, if compensation to local resource users is out of the question, then it follows that practicable conservation measures may be weaker than those initially proposed by conservationists (MacGarvin & Jones 2000) (Chapter 6)[183].

The fact is that the rationale for establishing MPAs is at least as much of a moral argument as a scientific one. For example the numerous studies which suggest that certain percentage areas of ocean should be protected (Bohnsack et al. 2000; Gell & Roberts 2003; Halpern et al. 2010) make implicit value-judgements about the intrinsic worth of a species or ecosystem. Although, some scholars have argued that the amount of conservation necessary for the survival of a species or the integrity of ecosystems can be determined through objective, evidence-based science (Svancara et al. 2005), such approaches make normative assumptions about human relationships with the environment – e.g. that humans should choose to protect particular species or ecosystems – which illustrate the trade-off between development objectives and conservation objectives (Miller et al. 2011) (see Chapter 6), and the conflict between the protection of nature for its intrinsic value and its instrumental value, showing that at the heart of virtually every environmental issue is the question of what is best for people (Rykiel Jr 2012).

[183] Jennings & Rice (2011) argue that given the current state of European fish stocks and the marine environment, achieving a viable balance between productivity of the environment and human needs will require high short-term transition costs.

English social-ecological context

This thesis arose from the concern of some scientists, that most of the thinking on MPAs and empirical evidence for their effects has come from tropical ecosystems (e.g. Agardy 2000). In a fisheries context there are potential problems in applying this evidence base to cold temperate ecosystems such as those of the UK (Chapter 5). Whilst MPAs have been successfully used in the management of scallop fisheries in the UK (Beukers-Stewart et al. 2005) (Chapter 5), their use as tools to conserve more mobile fin-fish is debated both empirically (Bloomfield et al. 2012) and politically (see Chapter 6).

The main driver for introducing MPAs to UK waters has been the recognition of the wider impacts of fishing on UK marine ecosystems (Jennings & Kaiser 1998), and that ecosystem change in some cases has been considerable (Thurstan & Roberts 2010). Moreover, the MCAA developed against a backdrop of heavy advocacy from UK ENGOs who warned of an impending fisheries collapse and continued habitat destruction (Chapter 6). On the back of a heavy pro-MPA international scientific literature (PISCO 2011) (Chapter 3), and specific UK case studies e.g. Lundy Island (Hoskin et al. 2010) and the Isle of Man (Beukers-Stewart et al. 2005) a case was made by this pro-MPA AC for the widespread designation of NMRs (a campaign that is still ongoing), on a widely-held belief that NMRs will have similar fisheries effects wherever they are established (Roberts 2007a). This caused some confusion at the start of the planning process over whether MCZs would be implemented as a tool to reduce fishing mortality on commercial fish stocks in addition to protecting habitats. With regards to using NMRs as a tool to allow recovery of fish stocks, there remains uncertainty over whether there is overcapacity within the English fishing fleet, given the optimism within the fishing industry that fish stocks are slowly rebounding (NFFO 2012b). The fishing industry also argues that it is slow, carefully thought out, incremental change that is needed rather than radical new policies (see Chapter 6).

There are also issues of governance to be addressed in this MPA debate in England. Many scholars argue that collective action problems can be solved through improved governance, which makes decision making more inclusive, encouraging interaction between different stakeholders (Jones & Burgess 2005), that ultimately means some responsibility being devolved from the central state to the regional and local levels. However, traditionally in England, nature conservation and fisheries conservation have been managed through laws and institutions that are highly centralised. The weak relationship between the fishing industry, central government and the nature conservation agencies (i.e. JNCC, and Natural England) has meant that management measures have often been poorly implemented. Moreover, approaches to both nature and fisheries conservation have been implemented through European (e.g. the Birds and Habitats Directives, and the Common Fisheries Policy), and now national (i.e. the MCAA) legislation – i.e. a top-down system of governance (though with some concessions to consultative and participatory processes as in the MCAA case, see Jones 2012), often ignoring the views of local users as well as local ecological conditions (e.g. the CFP).

Jones (2009) also notes a general feeling of disempowerment among UK fishermen that goes against the emerging idea of co-management (see 2.4.4 Chapter 2) – a feeling also applicable to other regions of the world (Pinto da Silva & Kitts 2006; Glenn et al. 2012). Part of the fisher's feeling of alienation comes from their perception of the growing power of the environmental movement in the UK over the last decade - there are now several ENGOs lobbying government on a wide variety of marine issues. For example a coalition of ENGOs have been successful in persuading government that more stringent regulations should be put on fishing occurring in European marine sites[184]. The growing intervention by ENGOs in fisheries management issues has led to many objections from the fishing industry (Fleming & Jones 2012), including criticisms that ENGOs have a poor understanding of the details of how the fishing industry works. Whilst some would argue that the wider environmental impacts of fishing need to be taken into account, in England at least, there have been serious questions posed over the conduct and role of some environmental organisations in marine policy and management (see Chapter 6).

[184] <http://www.bluemarinefoundation.com/home/news-index/news-detail.aspx?newsStory=Scallop-dredgers-and-trawlers-face-expulson-from-a-quarter-of-inshore-waters>

In addition to the relationship between the fishing industry and ENGOs, offshore wind energy companies (amongst other offshore developers) are also competing for marine space. As a result, debates on the use of marine environment now have an additional layer of complexity beyond that of food production vs biodiversity conservation, and new strategies such as MSP are being advocated as the means through which to resolve these broader conflicts (Agardy et al. 2011).

7.3.2 Role of the scientist in MPA debates

General

Scientists' involvement in policy making can range from reporting research findings to being fully responsible for making a decision (Steel et al. 2004) (see Table 7.2). Some empirical studies have shown that interest group representatives and the public encourage scientists to assume advocacy roles in policy debates (see 1.3.2 Chapter 1). Scientists themselves, however more wary of adopting an advocacy role due to their appreciation of the limitations of the scientific method to accurately describe the world (Steel et al. 2004). Few scholars would argue against the view that there needs to be greater involvement of scientists in policy making, but defining this role is proving to be tricky (Nelson & Vucetich 2009). Nevertheless, as this thesis has shown, MPAs have become prominent in marine policy due to the efforts of some scientist's advocacy for them. I now go on to discuss why some scholars view this as problematic.

Table 7.2 Potential roles scientists can take in policy debates (adapted from Steel et al 2004).

Role	Description
Report	Scientists limited to reporting results and letting others make resource decisions, the "traditional paradigm".
Interpret	Scientists interpret scientific results so that others can use them. This is often expressed as a scientist's promise to granting organisations that the results will be "translated" for non-scientific users.
Integrate	Scientists work closely with managers to integrate scientific results into resource policies and decisions: i.e. through "adaptive management".
Advocate	Scientists recommend specific policies they prefer or believe flow from their scientific findings.
Make final decision	In the face of highly technical and complicated issues scientists make resource decisions themselves.

There is a fine line between scientists seeking to impartially provide advice to policy-makers, and becoming issue advocates (Pielke Jr 2007; Scott et al. 2007). One reason why many scientists are reluctant to become involved with policy-making is because they perceive it will have a negative impact on their credibility (Lackey 2007), though some scholars argue that if scientists make their underlying values explicit when they advocate policies then this makes advocacy more acceptable (Nelson & Vucetich 2009); scientists are citizens after all. However, the distinction between 'facts' and 'values' is often not clear cut, because scientific information can be interpreted in different ways, depending on one's underlying worldview[185] (see Hilborn 2007b). Indeed, scientists may not be even aware of the values that underpin their 'objective' advice, to quote one marine scientist cum-advocate:

> "the problem is that those who are against advocacy think that any scientist who speaks about something is suddenly abandoning their scientific objective and principles because they are speaking out, but actually no, you can promote your findings and say that look we have found in this particular area, this is what the science says more broadly about the outcomes of the implementation of protection, and therefore we can frame this as a solution to some of the problems that we know exist in the oceans and that is a perfectly legitimate use of science in my view, and in the view of a lot of other scientists like me who speak out about these things. You know I don't see it as lacking objectivity, you know it would be if I was to suddenly start twisting the science around and saying well, you know, ignoring all the contrary evidence, or been very much cherry picking about the examples that I was using, that then goes from scientific and objective from simply being an advocate, that is unhelpful. I feel strongly that if experts don't speak out on these things who is going to decide on them and who is going to be able to judge the validity of the arguments? Well it's going to be non-experts and if the expert voices don't get across the information or the evidence you know in a powerful or effective way we will make decisions that are based on less good evidence and on opinions, though ultimately that may happen still if the good science is out there then the chances of bad decision making will be reduced." (Marine conservation scientist)

The problem that this thesis has examined is that science-based policy advocacy from scientists, the belief that policies flow from their scientific findings (a belief associated in this thesis with the term 'stealth issue advocacy'), can lead to the politicisation of science. Whilst the anecdotal evidence presented in chapter four on scientists' experiences with peer-review is by no means conclusive, there was some circumstantial evidence to suggest that ideology had affected the judgements of at least some peer-reviewers (and possibly editors) in rejecting manuscripts (see 4.3.1

[185] This is why the scientific community deliberates with the aim of achieving consensus (see section 2.3.3, Chapter 2).

Chapter 4) both in support of and critical of MPAs. This supports the belief of some scientists that science-based advocacy is inherently bad and should be avoided (Lackey 2007; Pielke Jr 2007; Rice 2011), and that in some cases ideology has caused the peer-review process to fail (Hilborn 2006). Additionally, I showed in chapters one and three that there seems to have been a disproportionate research effort on MPAs (see Fig 1.2 Chapter 1), and studies on MPAs also have a disproportionately high number of citations (see Fig's 3.8a-f Chapter 3) compared to the wider fisheries and conservation literature (see McClanahan 2011).

However I hinted in section 2.3.4 (Chapter 2) that science-based advocacy in certain contexts may be acceptable – for example if policy objectives are clear from the start (which have necessarily involved the discussion of normative values), then tactical modelling exercises drawing on robust data-sets can show the manager which set of management interventions may best achieve the policy objectives in a given locality. However, such an approach does not necessarily take into account the socio-economic costs associated with implementing a new policy and the decision-maker may deem it not cost effective. This deficiency has often been noted in natural resource management in general – i.e. that natural science has exclusively been the basis for the decision-making (Christie 2011), and there has been far too little systematic integration of social and economic information to allow for the analysis of trade-offs (Rice 2011). There are also questions of whether the resolution and coverage of local ecological and socio-economic information is sufficient to undertake robust quantitative modelling, and whether policy-makers have the time, funds, information or expertise to carry out such focused assessments.

I do believe that there is a crucial difference between the scientific research described in the above paragraph that critically appraises the socio-economic costs and benefits of different management options before arriving at a recommendation, and that calling for the uncritical application of MPAs on the assumption that current fisheries management tools have failed without analysing the wider socio-economic and governance issues that led to the failure of many of these management interventions in the first place (Le Quesne 2009). Indeed it is apparent that the designation of MPAs has become an end in itself (e.g. Wood 2011) rather than a means through which to achieve certain well thought out objectives. The dogmatic pursuit of MPAs by some scientists (e.g. NCEAS 2001) has led to the development of an advocacy-based scientific literature (see 2.3.4 Chapter 2, and Chapters 3 & 4), and goes against the principles of scepticism, creativity, and reflexivity that constitute good scientific practice (Robertson & Hull 2003).

English social-ecological context

Nevertheless, uncertainty over the fisheries and socio-economic benefits of MCZs has clearly not impeded the designation of English MCZs (Chapter 6). Indeed, debate over whether MPAs/ NMRs have long-term benefits to fisheries (the primary basis for their initial promotion) and thereby socio-economic benefits, and the counter-argument of some scientists that this may not hold true in a UK context has become redundant, as in the UK the primary goal for establishing MPAs (MCZs in England) has now become habitat protection.

Uncritical advocacy for MPAs/ NMRs at the international level on their widely-cited fisheries benefits has been transported to the national and local level in England. JNCC and Natural England (NE) are the statutory advisers to government, providing the scientific evidence for marine conservation issues, but NE in particular was perceived by the fishing industry during the early stages of planning MCZs to have assumed a policy advocacy role resembling that of an ENGO (see Chapter 6). Whilst many officers in NE and JNCC have doctorate level degrees in science-related disciplines, access to the peer-reviewed literature is rather limited:

> "It's difficult if your science just gets put in peer-reviewed papers. For us it's really hard to access the peer-reviewed literature. We're not a university; we don't have access to all the journals. We don't necessarily know if new articles have come out, because we're not always in those circles. So unless people tell us what the research is or we have a specific project, so we'll then go and do a literature review to it, it's really hard to use that. So having people making their science communicated in different ways is immensely valuable, and it was really helpful to us, and all sorts of other things."
>
> (Statutory conservation agency scientist)

This statement is interesting as it raises the question of how an institution chooses which scientist to approach for advice. There is a conundrum here in that ‘independent’ research scientists willing to engage with official policy advisers may be more likely to have a policy agenda; i.e. they may be partial towards a particular outcome and more likely to couch their advice (subconsciously or consciously) in a way that reflects favourably on their interests. Thus boundary organisations such as NE would do well to consult with scientists who come from a variety of disciplines and perhaps have different perspectives on an issue, reversing the tendency of such organisations to consult with like-minded scientists.

The advocacy role initially assumed by NE may have caused confusion over what MCZs were actually for - as a tool to reduce mortality on fish stocks or a tool to protect habitats from damaging fishing methods. In response to the prevailing narrative of collapsing fisheries, conservationists initially wanted to establish MCZs to increase fish stocks through reducing fishing mortality, which ultimately would require MCZs to be placed in areas where fishing mortality is the highest[186] (Chapter 6). However the fishing industry was quick to point out that MCZs were not legally a fisheries management tool, but a tool to protect vulnerable habitats. Also, aside from the socio-economic impact of designating an MCZ in an area that is intensively fished, the fishing industry also pointed out that the displacement of fishing activity outside the MCZ could lead to the loss of biodiversity in habitats that were previously un-trawled (NFFO 2010a). Moreover, the absence of fine-scale ecological and socio-economic information, as well as the extensive spatial scale and short timeframe of the planning process has ruled out the production of robust analyses that could be used to determine the likely ecological and socio-economic impact an MCZ would have (Chapter 6). To quote the NFFO:

> "Such areas were identified in haste with minimal knowledge of what was actually located in the areas; more akin to a pin the tail on the donkey approach to Marine Protected Area (MPA) planning." (NFFO 2012c)

Aside from the problems of incomplete local information on which to base robust planning decisions, there has also been an ongoing value-laden debate over trawling since the start of the MCZ planning process. Initially, the majority of conservationists wanted a blanket ban on trawling and dredging in all MCZs because in their view if this

[186] See initial advice from the SAP (Ryder, 18th August 2010).

did not happen, MCZs would merely be 'paper parks' (e.g. Monbiot 2012). Scientific studies showing the impact of bottom trawling on the seabed have become more numerous over the last decade; in some cases, studies have suggested that trawling has a negative impact on habitat structure (Watling & Norse 1998; Hall-Spencer & Moore 2000), and benthic invertebrate productivity (Hiddink et al. 2006), though other cases suggest that any impact is negligible (Hiddink et al. 2007). The fact that the susceptibility of different habitats to trawling (JNCC 2011) along with the potential effects of displacement were initially overlooked by MPA advocates, is testament that advocacy campaigns have been more heavily driven by their own agendas than by robust evidence.

On the realisation that in many cases no-trawl MCZs could not be justified on evidence, conservationists reframed the debate calling for no-take reference areas to be established to allow the recovery of the seabed for research purposes. But the fishing industry was also unwilling to accept this argument:

> "There is absolutely no need for draconian areas of "no-man's land" for the purpose of measuring ecological improvement in MPAs which would be readily evident from any general time-series programme of monitoring. Such proposals are ill thought through and show a careless disregard for people's livelihoods in order simply to give a free reign to conservation scientists' experiments… One has to seriously question whether this is really what society wants from Marine Protected Areas; scientific playgrounds and barren fishing communities that were once vibrant?" (NFFO 2011c)

In the face of scientific uncertainty, divergences in stakeholder attitudes to risk have also become apparent in the discussions of the management measures that should be put in place in MCZs. For example several MCZs were designated on the basis of rather limited evidence of the presence of a habitat/ species vulnerable to fishing[187]. This raises the normative issue that when it comes to deciding management measures and which fishing activities to restrict, conservationists argue that imperfect knowledge is reason enough to invoke the precautionary principle so that restrictions are placed on potentially damaging fishing methods (e.g. dredging/ trawling), whereas the fishing industry claim that the absence of robust conservation evidence in support of placing a restriction on fishing is reason enough to allow current fishing to continue (Chapter 6).

[187] Indeed some MCZs missed their intended conservation feature altogether (NFFO 2012a).

Some scientists are sympathetic to the fishermen's point of view – if you are going to implement a management measure that is going to harm fishers' livelihoods, conservationists need robust evidence on which to negotiate management measures with the fishing industry (see section 7.4).

This section has mainly discussed advocacy in the context of scientists being integrated into official policy networks and offering their expertise to policy advisers (i.e. JNCC and NE) and makers (i.e. DEFRA). But there is also an important debate about scientists' communication of MPA research to the media and general public, which may contribute significantly to how an issue is framed, and whether it generates a critical mass of public support causing government to act. A potential problem here is that inaccurate reporting and sensationalism from the media (Ladle et al. 2005), can result in over-simplistic solutions to a complex problem becoming part of popular discourse (e.g. calls for an indiscriminate ban on discarding) (see Chapter 1).

7.3.3 Potential effects of science-based policy advocacy on the *salience*, *credibility* and *legitimacy* of science

Aside from causing confusion amongst stakeholders over what MCZs are for, I believe that stealth-issue advocacy from scientists can have a more pervasive effect on the science-policy interface. Three characteristics that some scholars believe are essential to influence the up-take of science into policy; *salience*, *credibility*, and *legitimacy* (Cash et al. 2003) were briefly mentioned in chapter two (see Table 7.3 for definition). Some studies have suggested that the production of information which possesses these characteristics is crucial to sustainable development (Cash et al. 2003). I now draw on my research findings to suggest how policy advocacy from scientists may undermine these characteristics in the context of MPA science and policy in England.

I showed in chapter five that the science produced on MPAs was heavily focused on the effects of NMRs on fish, with the wider implications for fisheries management often discussed. This has had implications for the salience of information available to policy makers. I argued that advocacy for NMRs is largely on the basis of their fisheries benefits and has caused a disproportionate research effort on the fisheries' effects of NMRs at the expense of more policy relevant information: for example, their effects on recovery of different habitats, and on the vulnerability of different marine species and habitats to different fishing methods. Indeed, these are critical information gaps with regard to the planning of MCZs in England (see Chapter 6).

Table 7.3 Definitions of salience, credibility and legitimacy (from Cash et al. 2003), and implications for MPA science and policy.

Concept	Description	Application to MPA science
Salience	Deals with the relevance of the assessment to the needs of decision makers.	Research predominantly fisheries focused. Ignored actual policy needs (i.e. MPA effects on different habitats, and time-scales of recovery).
Credibility	Involves the scientific adequacy of the technical evidence and arguments.	Questions over the robustness of inferences made in some studies.
Legitimacy	Reflects the perception that the production of information has been respectful of stakeholders' divergent values and beliefs, unbiased in its conduct, and fair in its treatment of opposing views and interests.	MPA science has been heavily funded by ENGOs that obviously have an interest in research that reflects favourably on their preferred policy.

Advocacy has arguably also reduced the credibility of the scientific information produced. The credibility of a study rests on whether the evidence it presents supports its conclusions (i.e. that it is scientifically defensible). Though the evidence I have presented in this thesis of advocacy affecting the credibility of science is anecdotal, some scientists are of the opinion that the peer-review process has failed in some cases and has overlooked possible flaws in the design and interpretation of studies that have purportedly shown localised fisheries benefits from NMRs (Chapter 4) (Willis et al. 2003a; Hilborn 2006). Moreover, the recommendation of the Royal Commission on Environmental Pollution (RCEP) for NMRs in UK waters does not stand up to scientific scrutiny (Chapter 6).

Evidence suggests that the scientific norms of 'disinterestedness' and 'organised scepticism' (see 2.2.2 Chapter 2) have been violated during research on MPAs raises question marks over the legitimacy of information provided to decision makers.

Inevitably MPA advocacy by scientists brings the legitimacy of MPA science into question, since stakeholders will question the motivations of scientists for conducting a particular study. Given that a lot of MPA science has been funded by ENGOs and trusts which are sympathetic to the MPA cause (Chapter 3), this raises serious questions about the purpose for which knowledge on MPAs is being produced.

In the next section, I discuss how these potential problems can be resolved by policy makers better communicating their information needs to scientists, and by scientists not assuming that they know what information the policy maker requires – thus increasing the salience of information for a problem. The legitimacy of the information produced may be increased by including a plurality of perspectives and disciplines in the design of a research project (see Berkes 2009). However the increasing emphasis from funders on collaborative and interdisciplinary research poses new challenges for the credibility of knowledge – due to the different approaches taken to research by the natural and social sciences, and the different languages and different notions of validity used to assess knowledge claims (Wear 1999).

7.4 What do the research findings mean for MPA science-policy?

In policy debates that are characterised by high levels of scientific uncertainty and conflicting interests there needs to be a shift towards more deliberative models of policy making that embrace the messiness and complexity of such problems (Stern 2005), and that recognise that it is difficult for any single group or agency to possess the full range of knowledge needed to manage resources (Berkes 2009). As Berkes (2009) says “knowledge for dealing with ecosystem dynamics, resource abundance at various scales, trends and uncertainties, is dispersed among local, regional, and national agencies and groups”.

In this last section, I argue that there needs to be a shift in UK government policy towards longer-term strategic planning and capacity building[188] that is process orientated, rather than focused on the quick implementation of technical measures to meet pre-specified targets. An incremental process working towards long-term goals may be consistent with the concept of ecosystem-based management (EBM) (depending on how EBM is interpreted) (see 1.3.3 Chapter 1) – that will necessarily involve the devolution of some power from elites to stakeholders (Frid et al. 2006) thereby incorporating the idea of co-management (see 2.4.4 Chapter 2).

7.4.1 Moving beyond ecological ideals

The problem of ecological coherence

This thesis has shown that ecologists have been at the forefront of advocacy and research on MPAs – with boundaries between science and policy blurring (previous section) (also see Chapters 4 and 6). A management intervention cannot be legitimised on scientific grounds alone. For example, the ongoing scientific debate on the fisheries benefits of NMRs (e.g. Fenberg et al. 2012) will do little to resolve the problem that the establishment of an NMR disadvantages some user groups and benefits others. Some scientists advocate multi-use MPAs that are designed to meet multiple ecological and social objectives (Agardy 2003), but the question needs to be asked whether there actually needs to be an MPA implemented in the first place. For example some MCZs in England may be designated over largely featureless mobile sediments that are not sensitive to towed bottom gears, and not regularly trawled – this to meet the targets set by the ENG to achieve an ecologically coherent network of MPAs. Crucially the ENG ignores two key aspects of the human side of marine management; 1) that fishing effort is not homogenously distributed, and 2) that different habitats have different sensitivities to different fishing gears (NFFO 2011c).

[188] Though this may be easier said than done, in that most of a policy makers time is spent reactively dealing with problems as they emerge rather than having time to deliberatively mull over a problem. In the case of MPAs there are statutory targets that need to be met.

There is also the danger that management has been too centralised, with the traditional model of scientific expertise associated with central government outdated (Parry 2009), and undesirable as stakeholders become wary of the credibility and legitimacy of advice that is offered to decision makers. Indeed, the approach taken in England to create an ecologically coherent network of MCZs can be challenged from empirical (also see Jones & Carpenter 2009), conceptual, and normative standpoints (see Chapter 6), and also criticised by the fishing industry for being too top-down, elitist, and ignoring the concerns of resource users (NFFO 2012c). Aside from the usually cited problem of a management tool failing because of overriding short-term interests (Brandt 2005; Heyman & Granados-Dieseldorff 2012), from speaking to people in the fishing industry I think there is a genuine lack of acceptance of the process for establishing particular MCZs, rather than rejection of MCZs *per se*, and that the bureaucratic and technocratic process for establishing MCZs does not make sense in terms of how fishermen view the marine environment.

The persistent notion held by many conservationists regarding the planning of MPAs, that such a process should be natural science-led, reflects their attitude that 'politics' is somehow bad for the conservationists' desired outcome, in that politics has meant that many MCZs were put in undesirable places (see Chapter 6). The problem that this thesis has hopefully brought to attention is that the widely held view by many conservationists of scientists speaking truth to power is misconceived, that some scientists often hold a bias towards a preferred policy in the way they frame their research and interpret their findings (Degnbol et al. 2006). As Frid (2006) says "the internal reports, refereeing, distillation into briefing papers/ advice, and the interpretation of this by civil servants all dilute the power of the science and, in our opinion, remove the ability to seek alternatives". The ENG made unhelpful assumptions that humans are separate from nature, and that nature is more amenable to bureaucratic management than it really is. Many social science studies have shown that ignoring the democratic element of decision making during the planning of MPAs is detrimental to the MPA achieving its objectives (Voyer et al. 2012). The blunt application of an MPA can be costly for enforcement (Hanna 2003), and overlooks the fact that creative solutions to a problem can emerge when scientists, policy-makers and resource users engage in a two-way dialogue with one another (Jasanoff 2006a; Pielke Jr 2007). For example, gear modifications (Worm et al. 2009), gentlemen's agreements (Woodhatch & Crean 1999), and market incentives (Hilborn 2011), can all encourage environmentally responsible behaviour if introduced with stakeholder engagement.

Improved integration of environmental concerns with fisheries management concerns in decision-making

Traditionally, in many areas of the world including the UK, government institutions which deal with the conservation of fisheries and marine nature have been departmentalised, with little interaction between different disciplines (Salomon et al. 2011). This has not been conducive to successful management as policy debates become heavily polarised, and the persistence of 'tribalism' – opposing groups thinking they know better than one another - fostering an 'us-versus-them' attitude (Agardy et al. 2011).

There is a growing literature stressing the need for policies dealing with nature conservation concerns to be integrated with those policies catering for the needs of the fishing industry, through concepts such as ecosystem based management (EBM) that provide a framework for explicitly dealing with trade-offs between resource use and conservation (Katsanevakis et al. 2011). The MCZ process was heavily led by ecological theory (the ENG) that had been developed during the planning of the Californian network of MPAs, and ignored the fact that governance structures and stakeholder relationships differ across different regions of the world. The persistence of some conservationists in associating EBM with the establishment of MPAs, particularly NMRs (Wright 2010) through a top-down (central government led) approach to governance conflicts with the principle of good governance. MPAs are currently being established through a legal framework whose primary objective is to conserve nature for its intrinsic value meaning that the voice of local resource users is marginalised in the process.

Jentoft et al (2007) argue that the MPA literature is univocal about the need to involve user-groups and stakeholders in the decision-making process, and that MPAs should preferably be co-managed, but what could this mean? Co-management involves the devolution of some power from centralised government to local resource users and managers. Having stakeholders actively participating in regional and local decision making forums increases the legitimacy of a decision, whereas central government acts as 1) a *co-ordinator*, making sure national policy objectives are achieved across different regions, and 2) an *adjudicator*, making sure conflicts irresolvable at the regional/ local levels (e.g. disputes between English and foreign fishing vessels) are resolved (Phillipson 2002). But does co-management requires more stakeholder participation than this? From the fishing industry's perspective, the introduction of piece after piece of regulation (in their eyes often ill-conceived) means that they are constantly struggling to fight regulators, with no certainty of allowing the development of long-term business strategies that would incorporate environmental concerns (Deas 2011). Some of the more ardent advocates of the co-management narrative argue that stakeholder participation should be viewed as a process through which objectives and actions are not settled in advance but emerge from the act of participation itself (Habermas 1984; Goodwin 1999). However, this stance has fundamental implications for the nature conservation agencies and UK government, who have to meet European targets. Indeed, the statutory conservation agencies may be sceptical of the greater involvement of resource users in decision making due to their fear that if local parochial self-interests triumphed, this could undermine strategic nature conservation objectives (Jones & Burgess 2005). Jones and Burgess (2006) argue that the European Court of Justice is unlikely to accept a government's defence that statutory nature conservation objectives were not fulfilled because they were not consistent with objectives that emerged from local participation processes. This dilemma suggests that local social objectives should be included in the wording of strategic pieces of nature conservation legislature, which some social scientists argue is necessary (Symes & Phillipson 2009) to increase the sustainability of EU fisheries.

What other changes could be made to achieve a better reconcilliation of conservation and fisheries concerns in the development of strategic national and international objectives? One useful improvement would be institutional reform. Government departments need to consciously make an effort to employ people who have a different perspective on an issue, or have a non-traditional background[189] for the job on offer. Having a mix of people from different backgrounds may increase the likelihood of many potential problems associated with the implementation of a policy being identified (e.g. the potential negative consequences of the displacement of fishing effort, social equity issues etc). Some scholars have argued that this mix increases the capacity of an organisation to meet its long-term strategic goals (Hatch & Cunliffe 2006). Employers would have to accept that this may involve choosing people who do not have the desired technical expertise to meet the exact specification of the job, thus involving short-term costs on training – though it may be more conducive to improved, streamlined decision-making in the long-term due to cost savings, with obvious problems being spotted and phased out during the development of the policy. There also needs to be greater integration across different offices in a government department, with the regular exchange of staff between different offices (i.e. biodiversity and fisheries departments of DEFRA). Having a range of people with different perspectives working on a particular piece of policy may also foster reflexivity and creative thinking within the department, making policy-makers aware of the assumptions and values underpinning their approach, and better able to understand the reasons behind the actions taken by others (Hatch & Cunliffe 2006). The MCZ process (see Chapter 6) has shown, for instance, that there are numerous conceptual and practical problems associated with the implementation of the ENG which might have been avoided had there been greater input from social scientists and the fishing industry during the development of the ENG. Moreover, the MCZ process has shown that bringing conservationists and fishermen together can breakdown pre-conceived notions of what each other stand for (Kirsten Smith, pers comm), and allow mutual respect to develop between different stakeholders.

[189] In England this has already started to an extent; the conservation agency Natural England has recruited people who have experience working in the fishing industry, and the local Sea Fisheries Committees recently changed to Inshore Fisheries and Conservation Authorities and have begun to employ more officers with an environmental background.

Successful co-management is fundamentally dependent on trust that is formed between all levels of the decision hierarchy and different stakeholders (Rydin & Holman 2004). For example, fishermen need to trust government that they are not going to give in to the demands of more radical members of the green lobby, and conservationists need to trust fishermen that they will comply with the agreed rules and not free-ride. The social bonds that form between people to build 'trust' take time to form, but are easily broken by decisions that lack transparency and are skewed towards the interests of one stakeholder group (e.g. Lyme Bay, see Fleming & Jones 2012), or by acts of rule-breaking (e.g. illegal fishing, Carrell 2010).

However, the move towards co-management is by no means straight forward; co-management is an essentially contested concept as people will have different views on the extent of the state's involvement to guarantee that strategic objectives are met (Jones 2012a), and a move towards co-management will re-distribute economic and administrative resources which will be contested by managers who are having their budgets squeezed (Jentoft et al. 1998). Whilst it is beyond the scope of this thesis to undertake a full critique of the concept of co-management, there are numerous challenges that determine its success such as: getting the right people together, achieving a balance of power across different partners, and having good facilitators to make sure negotiated compromises are fair (FAO 2005).

The problem of non-matching spatial and temporal scales of activities on achieving the co-management ideal

A growing body of literature deals with spatial and temporal issues of scale, the former often stressing the need for natural resource management to be complementary to the spatial scale at which fundamental ecological processes occur (e.g. the space occupied by a target species over its life-cycle), and the latter often highlighting the need for natural resource management to be responsive to ecological change (e.g. see Cumming et al. 2006).

One particular challenge facing the co-management paradigm is the frequent mismatch between spatial and temporal scales of marine activities. In a fisheries context, different types of fishing vessel operate at different scales. For example, in the UK, outside the six nautical mile limit fisheries are open access and under the remit of the EC's Common Fisheries Policy (CFP) with vessels from other EU countries permitted to fish inside UK waters. Aside from the challenges of co-operation between national governments with different capacities and variable levels of willingness to enforce CFP rules, there also remain challenges at more localised scales of governance. For example at a national level, there are potentially conflicting interests between those vessels fishing locally often operating out of a single home port, and larger vessels that have the capacity to fish more widely and move around the UK coast. Whilst smaller scale fishermen have an incentive to conserve the local environment to maintain their livelihood, larger vessels are less dependent on the state of local resources. Indeed the emphasis of the latter may be to maximise profits (possibly at the expense of the environment) to make a return on large initial capital investment (e.g. a skipper may need to pay off large bank loans over a short time period).

Whilst MPAs/ NMRs may form part of a co-management strategy, with the above conflicts in mind there is an underlying equity issue. NMRs in particular discriminate against local resource users in the short-term, or even indefinitely if anticipated 'spillover' benefits do not materialise.

7.4.2 Rethinking the role of the scientist in the policy process

Two key issues of relevance to the governance of the science-policy interface emerged from my discussions with stakeholders: the quality of the spatial-resolution and coverage of data needed for planning MPAs, and the time-scales needed to conduct effective impact assessments (see Chapter 6). In this final section I briefly discuss the implications of these findings for the social system governing the use and conservation of marine natural resources in England. In keeping with the co-management paradigm I argue that there needs to be a rethink of what is meant by the term 'science'; how science is applied in the policy process; and how scientists interact in policy debates.

Moving on from 'the science is right' to making sense together

At the end of chapter one I posed four questions:

1. What is scientific evidence?
2. How does science relate to policy?
3. What factors influence the uptake of science into policy?
4. What do the above questions mean for a scientist's involvement in policy making?

There has been a push by some conservation scientists to follow the example set by evidence-based medicine (Sutherland et al. 2004), that conservation practices should be based on the 'best available evidence'. However, as this thesis has shown, what constitutes the 'best available evidence' is contested (Chapters 5 and 6). Whereas in medicine, the evidence generated by carefully designed randomised trials will be robust and universal in its applicability, the evidence generated from the study of conservation interventions in the real world cannot be as robust (MacNeil 2008), nor as universal - given the importance of local context in determining the 'success' of a management intervention (Christie 2003).

Crudely put, uncertainty in marine natural resource management results from: 1) the problem of not having the data and tools to do robust population assessments, and 2) the difficulty of predicting the impact of a management intervention due to the additional challenge of predicting human behaviour (e.g. Fulton et al. 2011). Ignoring/ downplaying this uncertainty in order not to confuse decision-makers is problematic if one conceptualises the role of the scientist as speaking truth to power, because it leads to the scientisation of policy debates (see Chapter 6). Some commentators claim that such scientization is already pervasive, since aside from the usual publicly-funded knowledge institutions (i.e. universities, government run laboratories, and statutory conservation agencies) and private research consultancies, one can now expect to find scientists in the service of the larger ENGOs and the fishing industry. So scholars 'science' may have become merely a tool to allow different institutions to construct a version of nature that fits their needs[190] (Hoefnagel et al. 2006).

If it is accepted that information is inherently politicised, with scientific objectivity virtually impossible to achieve in such an uncertain and politically contested arena, where does this leave the scientist? How do we move from a heavily politicised system where science is in the service of different interests, to one where science is integrated into the decision-making process and actively used to solve problems and to predict the outcomes of alternative courses of action? The linear model of science-policy (see Figure 1.3 Chapter 1): that science provides disinterested 'facts' that are subsequently taken up by policy-makers and applied to solve a problem, or where scientists become advocates, suggests a line of one-way communication between science and policy-maker which is not desirable (Pielke Jr 2004; Sarewitz 2004). If scientists presume that they know best, they may voice their policy preferences through the science they produce (see Chapter 4). These considerations indicate that as much attention needs to be spent on the structure and interaction of institutions that produce knowledge and use it, as upon the production of more knowledge *per se* (Berkes 2009).

It is widely claimed that better integration of science into policy that simultaneously enhances the salience, legitimacy and credibility of information, requires a two-way communication between knowledge-producing and knowledge-using bodies (Cash et al. 2003). Many scholars argue that wider civil society needs to become involved in 1) debates of policy for science to increase the salience of scientific information for policy; e.g. focusing on where key information gaps lie, and what data is needed to make better decisions; and 2) collaborative research projects (e.g. fisheries science partnerships) to increase the legitimacy of scientific information for policy (e.g. Sweeting et al. 2011) - though the inclusion of wider society in the production of scientific knowledge may have implications for the credibility of quality control (Funtowicz & Ravetz 1991). Additionally some scholars have recognised the need for

[190] For example (a) scientists working in, or in the service of, management agencies tend to construct a picture of nature that is more amenable to bureaucratic management than it really is; (b) environmentalists, who always have to solve the problem of mobilising their constituents, tend to construct a picture of nature that is more threatened than it really is; and, (c) fishers tend to construct a picture of nature that can sustain more fishing than it really can (from Hoefnagel et al. 2006).

intermediaries to bridge the somewhat diverging cultures scientists and policy-makers work under (see 2.3.2 Chapter 2). For example a knowledge broker could be used to find out what expertise is required; who can provide it; and how can it be transmitted into a form of value to the decision maker (Michaels 2009).

In an ideal world the approach taken to planning MPAs would follow three steps: 1) a case is made for protection using scientific evidence showing the rarity and distribution of a species and its susceptibility to a fishing gear; 2) that before an MPA is implemented an interdisciplinary impact assessment is conducted to allow decision-makers to predict what the likely ecological and social consequences of an intervention will be (i.e. a risk assessment); and 3) once an MPA is in place, its impact on the ecology and society is monitored over the long-term (Woolmer 2012). Unfortunately this approach is probably too costly at the scale at which the MCZ network is currently being planned, and even on a site-by-site basis it is rarely achieved (see Chapter 5). Whether such an idealised notion of the science-policy interface can ever actually be achieved in practice given current cost restraints, in a time of economic crises (Agardy 2010), is a moot question.

Often the issue facing decision-makers is not the need for more science, but the shortage of affordable options (Sarewitz 2004; Pielke Jr 2007). The quote at the beginning of the chapter, “sustainability is about being nimble, not being right” (Rayner & Malone 1998), reflects the idea that given the complexity and chaotic nature of many social-ecological systems (Acheson et al. 1998), it is necessary to have a system of decision-making that is flexible to change (i.e. less bureaucratic), as well as one that comes up with creative solutions to problems that can be funded.

A concept known as ‘post-normal science’, which has gained prominence in recent years, embraces decision contexts where uncertainty and political stakes are high (Funtowicz & Ravetz 1991), and acknowledges that in addition to systematic ‘scientific’ knowledge, there are other sources of potentially useful information for planning, including local knowledge and unpublished research that can fill critical gaps and allow decision-makers to make a more informed judgement than would be provided by a formal scientific assessment (Funtowicz & Ravetz 1991). Regarding the role of scientists in such a process, many scholars argue that there needs to be a shift away from the deficit model of public engagement where scientists are 'educators' of the general public to one where scientists debate, listen and learn with the public, collectively solving problems with them instead of imposing solutions (Jensen & Holliman 2009)[191]. Essentially, post-normal science is a model of decision-making that is pluralistic and deliberative, and that encourages open communication between resource users, conservationists, managers and scientists. On the basis of the idea of communicative rationality (Habermas 1984), open communication between stakeholders increases understanding and trust (perhaps facilitating the sharing of data), and more likely to lead to the widely cited ideal of adaptive management (Hoefnagel et al. 2006).

7.5 Thesis conclusion

This thesis has provided some empirical evidence (sometimes inconclusive – e.g. Chapter 4) of what several scientists who have worked in the field of MPA research have perhaps long suspected (Agardy et al. 2003; Willis et al. 2003a; Degnbol et al. 2006; Hilborn 2006; Hilborn 2007a; Christie 2011) – namely that the headlong rush to the establishment of a network of MPAs around the coastline of England may have been premature, founded on inadequate empirical evidence and un-discussed value-judgements. I have tried to tie together my empirical findings within a narrative that attempted to explain the influence an epistemic community of marine experts has had on pushing forward the imperative to establish networks of MPAs both at the international (Chapter 3) and national (Chapter 6) level; how science-based advocacy for no-take marine reserves from leading scientists has unwittingly caused the science-policy boundary to blur (Chapters 4 and 6); and what serious implications this has had on the planning of the English network of MCZs (Chapters 6 and 7). In England, the approach of resolutely sticking to the principles of ecological theory in designing the

[191] However a survey of the Royal Society concluded that "there was concern that many scientists still see the main reason for engaging with the public as the need to "educate" them rather than to debate, listen and learn as part of a genuine dialogue" (The Royal Society 2006).

MCZ network has been criticised heavily by the fishing industry. Many MCZs have been designated in areas where there is little knowledge of what is actually being protected, and may have little fishing occurring in them anyway. Extending the focus of my research to international, national, and local levels has revealed several planning problems, perhaps the most interesting of these being the issue of scale. The local information needs required to design MPA networks at the scale currently being proposed by international policy are vast.

Had government and the conservation agencies been more pragmatic, and instead of focusing on fulfilling an obligation to meet an ecological ideal, worked with the fishing industry to identify vulnerable habitats and prioritise these areas for protection, this may have produced more 'win-wins' for both conservationists and fishermen[192]. In such a scenario, while the area designated by the MCZ network may have been far less extensive than it is now, it would have allowed fishermen more freedom to fish where they want, but with sensitive habitats being prioritised for protection. However, the influence of the prevailing discourse of using MPAs to achieve ecosystem recovery, a discourse to which the fishing industry is fundamentally opposed, has meant that a common understanding and the trust needed by the fishing industry to divulge their local knowledge to conservationists for a more localised approach to planning has not been achieved.

[192] See the fishing industries take on the process taken by Marine Scotland in establishing MPAs.

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Appendix 1

Questions on MPA scientists' experiences publishing work showing the ecological effects of MPAs

I'm a PhD student at Newcastle University undertaking a sociological analysis of the application of science to inform UK policy on MPAs.

Among other things I'm looking at the extent of the peer-reviewed scientific literature on ecological effects of MPAs. As part of my research, I am keen to hear the views of scientists on their experience of the peer review process and whether they think there is a bias amongst reviewers and journal editors towards empirical or other studies (e.g. reviews, meta-analyses) that show positive MPA effects, and also whether there is a perceived bias by authors that non-significant effects won't be accepted or are less valuable. I would really appreciate if you could answer the eleven questions below.

Your response, even if "no" to questions 1 and 11 would be really appreciated as I would like to try and gauge whether there is some truth to the statement that there is a bias towards MPA studies that show positive effects, or whether this is just an 'urban myth'.

Thanks for your help, and look forward to hearing your thoughts on this issue.

Kind regards

Alex

Questions on publication bias

1. Have you ever had a paper/ papers on the biological effects (empirical or theory) of MPAs accepted?

2. Have you ever had a paper/ papers on the biological effects of MPAs rejected?

3. If so, what reasons (other than poor quality or being outside the remit of the journal) were given?

4. Would you be willing to name the journal(s) which rejected your paper(s)?

5. What do you think the reason was for your paper being rejected?

6. Did you get your rejected paper(s) published elsewhere?

7. If your answer to 6 was 'yes', could you say which journal you finally published in, and what the reference of the paper is?

8. How frequently has the above happened to you?

9. Do you view this experience as indicating a bias in favour of studies showing positive MPA effects in the peer review system?

Questions on author bias

10. Have you ever not submitted (or not prioritised) work showing non-significant MPA effects?

11. If so, what were your reasons for not submitting (or not prioritising)?